This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

University of Virginia Library
VK144 .R6 1796 V.2
ALD The elements of navigation;
NX 001 131 264

Digitized by Google

BOOKS BOUND BY US ARE
BOUND
BY
CHAS. W. PRUFER
STAUNTON
VA.
Digitized by Google

Digitized by Google

Digitized by Google

Jamy Macully Novr 1st 1822

THE ELEMENTS OF NAVIGATION;

CONTAINING THE

THEORY and PRACTICE.

With the neceſſary TABLES,

And COMPENDIUMS for finding

The LATITUDE and LONGITUDE at SEA.

To which is added,

A TREATISE OF MARINE FORTIFICATION.

Compoſed for the Uſe of

The ROYAL MATHEMATICAL School at CHRIST'S HOSPITAL,

The ROYAL ACADEMY at PORTSMOUTH,

And the GENTLEMEN of the NAVY.

VOL. II.

By J. ROBERTSON,

Late Librarian to the Royal Society, and formerly Head-Maſter of the Royal Academy, at Portſmouth.

The SIXTH EDITION, with ADDITIONS.

Carefully reviſed and corrected by

WILLIAM WALES,

Maſter of the Royal Mathematical School, Chriſt's Hoſpital, London.

LONDON:

Printed for F. WINGRAVE, Succeſſor to Mr. NOURSE, in the Strand; G. G. and J. ROBINSON, and T. N. LONGMAN, Pater-noſter-Row; W. RICHARDSON, Royal Exchange; and J. SCATCHERD, Ave-Maria-Lane.

M.DCC.XCVI.

James Macully's Book.

James Macully's Book.

UNIVERSITY OF VIRGINIA GENERAL LIBRARY 181?

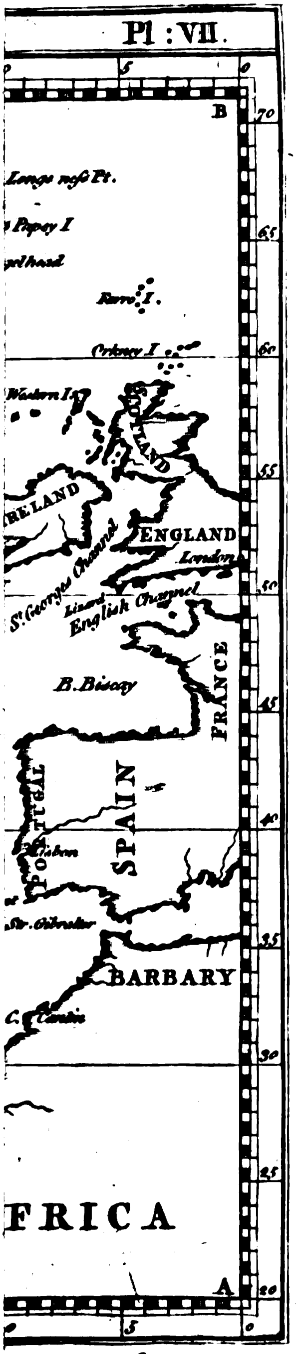
Digitized by Google

GI
JAN 9 '36

VK
144
RG
1756
203259
v.2

Digitized by Google

Digitized by Google


Pl : VII.
B
Longe nese Pt.
Papey I
Barro I.
Orkney I
Western I.
ENGLAND
London
St. Georges Channel
Lizard
English Channel
B. Biscay
FRANCE
PORTUGAL
SPAIN
Lisbon
Str. Gibraltar
BARBARY
C. Cantin
FRICA
A

Page 1.

THE

ELEMENTS

OF

NAVIGATION.

BOOK VII.

OF PLANE SAILING.

SECTION I.

Definitions and *Principles*.

1. NAVIGATION is the art of conducting a ship from one port to another.

This art may be divided into two parts; namely, Mechanical and Theoretical.

MECHANICAL, or WORKING NAVIGATION, comprehends the art of working a ship; that is, of causing it to observe such motions and directions as are assigned by the Navigator.

This art must be learned on shipboard, and in the practice of sailing.

THEORETICAL NAVIGATION, or the art of Piloting, concerns those methods by which the Navigator, or Pilot, discovers in what track the ship must steer, so as to arrive save at the intended port.

The art of Piloting is either common or proper.

COMMON PILOTING is that knowledge which teaches how to coast along shore, or to sail within sight of land.

PROPER PILOTING is the art of sailing to distant places through the ocean, and out of sight of land.

The art of proper Piloting, (which partly includes that of common piloting) chiefly depends on a right application of the principles contained in the preceding books.

Digitized by Google

2. The navigating or conducting of a ship through the Ocean to distant countries, depends on the navigator's being beforehand furnished with the following elements.

1st. A Table of the latitudes and longitudes of the most remarkable parts of the Sea-coasts, Islands, Rocks, Shoals, &c. in the frequented parts of the world.

2d. Maps or Charts of the Seas and Lands; together with the depths of water, and the times and setting of the tides, upon the coasts which he may have occasion to approach.

3d. The use and application of several Instruments necessary to point out the way the ship is to steer, to measure the rate she runs at, and to find the place she is in at any time.

4th. A sufficient stock of mathematical learning to enable him rightly to use the observations that may be deduced from the preceding elements.

The latitudes and longitudes of places cannot be otherwise obtained, than from proper observations made by persons who have been in those places: consequently, the collecting of a sufficient number of these must be the work of many ages. And hence arises the great uncertainty of the position of many places, and even of the little knowledge we have of many parts on the surface of the Terraqueous globe. See the Geographical Table at the end of Book VI.

3. The Maps of Countries, and the Charts of the Oceans and their boundaries, are made chiefly from the catalogue of the latitudes and longitudes of places. But where these are partly wanting, and a good collection of the positions and distances of places can be obtained, those places may be inserted in the map as truly as the others, the latitudes and longitudes of which are known.

The most natural way of delineating the surface of the Earth, is to do it on a sphere; for then every place in the Globe, laid down by its latitude and longitude, will have the same position with respect to other places, which they really have on the surface of the Earth. But as a Globe is a bulky thing, and not so easily managed, or worked upon, as a plane, therefore has the representation of the surface of the Earth been made on planes, and these are called *Maps* or *Charts*.

In the constructing Maps and Charts great care should be taken, that the several parts in them preserve their position one to the other in the same order as they do on the Earth; and it is likely, that the finding out of proper methods to do this gave rise tothe several methods of projection.

4. There are many ways of constructing Maps and Charts; but they chiefly depend on two principles.

Digitized by Google

First, From considering the Earth as a large extended flat surface: The Charts made on this supposition are usually called PLANE CHARTS.

Secondly, From considering the Earth as a sphere: The Charts made on this principle are sometimes called GLOBULAR CHARTS, or MERCATOR'S CHARTS, or REDUCED CHARTS, or PROJECTED CHARTS.

Plane Charts, when made for any large extent of several degrees in high latitudes are very erroneous; for in them the difference of longitude between any two Meridians, taken at the Equator, is used as the distance of those meridians in all latitudes; and consequently the distances of places in high latitudes will be too great, and their due positions will not be preserved: but Charts made for a small part, as a degree or two in length and breadth, may be reckoned as tolerably exact, especially if those places be within the *Torrid Zone*; nay, a Plane Chart made of all this Zone will differ but little from the truth.

SECTION II.

5. *The Construction and Use of the Plane Charts.*

CONSTRUCTION.

1st. Having determined the limits of the Chart, that is, how many degrees of latitude and longitude, or meridional distance (they being in this Chart the same), it is to contain: Suppose from the lat. of 20° N. to the lat. of 71° N.; and from the longitude of London in 0 deg. to the lon. of 50° W.; then chuse a scale of equal parts, by which the Chart may be contained within the size of the sheet of paper on which it is intended to be drawn. In the Chart annexed, see Pl. VII. the scale is such, that each degree of latitude and longitude is $\frac{1}{8}$ part of an inch.

2d. Make a parallelogram (II. 69) ABCD, the length of which AB from north to south shall contain 51 degrees, the difference of latitude between the limits of 20° and 71°; and the breadth AD from east to west shall contain the proposed 50 degrees of longitude, the degrees being taken from the said scale of 8 degrees to an inch; and this parallelogram will be the boundaries of the Chart.

3d. About the boundaries of the Chart make (II. 81) scales containing the degrees, halves and quarters of degrees (if the scale is large enough); drawing lines across the Chart through every 5 or 10 degrees; let the degrees of latitude and longitude have their respective numbers annexed, and the sheet is then fitted to receive the places intended to be delineated thereon.

4th. On a strait slip of pasteboard, or stiff paper, let the scale of the degrees and parts of degrees of longitude, in the line AD, be laid close to the edge; and the divisions numbered from the right hand towards the left being all west longitude.

 5th. Seek

Digitized by Google

5th. Seek in the Geographical Table (at the end of Book VI.) for the latitudes and longitudes of the places contained within the proposed limits; and let them be written out in the order in which they increase in latitude.

6th. Then, to lay down any place, lay the edge of the pasteboard scale to the divisions on each side the Chart, shewing the latitude of the place; so that the beginning of its divisions fall on the right hand border AB; and against the division shewing the longitude of the given place make a point, and this gives the position of the place proposed; and in like manner are all the other places to be laid down.

7th. Draw waving lines from one point to the other, where the coast is contiguous, and thus the representation of the lands within the proposed limits will be delineated.

8th. Write the names to the respective parts, and in some convenient place insert a compass, and the Chart will be completed.

The Use of the Plane Chart.

6. *To find the lat. and long. of any proposed place in the Chart.*

Take with a pair of compasses the least distance between the given place and some parallel of latitude; this distance applied (the same way) to the graduated meridian on the border of the Chart, keeping one point on the same parallel of latitude, the other point will shew the degrees of latitude the proposed place is in.

And in like manner, the distance between the given place and some meridian, applied (the same way) to the graduated parallel on the top or bottom of the Chart, will shew its degrees of longitude.

Thus the distance between Cape Finisterre and the parallel of latitude of 40°, laid on the border from 40° upward, gives 43° 15′ N. for Cape Finisterre's latitude: And the distance of the Cape from the meridian passing through 10° of longitude, being laid on the bottom border from 10° toward the right, gives 9° 20′ W. for the longitude.

7. *Two places being given, suppose Cape Clear and the Island of St. Michael's, one of the Azores, to find the bearing and distance between them.*

Lay a ruler by the two places, C. Clear and St. Michael's, take the nearest distance between the center of the compass and the edge of the ruler; in this position slide one point along the ruler, and the other point will run along the point of the compass shewing the bearing, which in this case is S. W.; that is, St. Michael's lies to the S. W. of C. Clear, or C. Clear to the N. E. of St. Michael's.

The distance between the two places applied to the graduated parallel from 0 degrees, will give the number of degrees, which converted into miles shews their distance.

Thus the distance from Cape Clear to St. Michael's will be found to be about 17° 10′, which multiplied by 60 gives 1030 miles.

8. The

Digitized by Google

8. *The distance sailed on a given course, and from a given place, being known, to find the place the ship is in. Thus suppose a ship sails from Cape Clear S. W. for 1030 miles: Required her present place.*

Reduce the given miles (1030) into degrees and minutes, and take them (17° 10′) with one pair of compasses from the graduated scales.

Lay a ruler by the center and the given point of the compass (S. W.); take the nearest distance between (Cape Clear) the place sailed from and the edge of the ruler with another pair of compasses; in this position, slide one point along the ruler until the other point has got as far distant from the given place as is the given distance, which is found by applying the opening of the other pair of compasses from (Cape Clear) the given place, till the points of both pair of compasses meet; and that will give the present place of the ship, which will be found in the latitude and longitude of St. Michael's; and these are known by Art. 6.

The Mariner working by the preceding precepts, will preserve his chart free from a multitude of lines: But when this is not regarded (as indeed it is scarcely worth while), the operations will become somewhat shorter.

9. *The latitude of a place* (A), *and its bearing from a given place* (B) *being known; to find the place* (A) *on the chart, and its distance from* (B).

Through the given place B draw a line parallel to the given point of the compass or bearing; then an east and west line drawn through the latitude of A, its intersection with the former line will give the place sought. The distance may be measured, as in Art. 7.

10. *The latitude of a place* (A), *and its distance from a given place* (B) *being known; to find the place of* A *on the chart.*

Draw an east and west line through the latitude of A; take the given distance in degrees from the graduated scale; then this distance being applied from the given place B, will cut the said east and west line in the required place of A.

11. *The longitude of a place* (A), *and its distance from a given place* (B) *being known; to find the place of* A *on the chart.*

Draw a meridian through the longitude of A; then the given distance taken as before, and applied from B, will cut the said meridian in the required place of A.

12. *The longitude of a place* (A), *and its bearing from a given place* (B) *being known; to find the place of* A *on the chart.*

Through the given place B draw the given bearing. (7)

Draw a meridian through the longitude of A, and its intersection with the said bearing will be the place of A.

And in this manner may every possible case of sailing by the plane chart be readily solved. But as the accuracy of these solutions cannot be depended upon nearer than five or six minutes more or less than the truth; the more careful Navigators depend on the computations given in the following sections.

Digitized by Google

SECTION III.

Of Plane Sailing.

13. Plane Sailing is the art of navigating a ſhip upon principles deduced from the notion of the Earth's being an extended plane.

On this ſuppoſition, the meridians are eſteemed as parallel right lines, the parallels of latitude are at right angles to the meridians, the lengths of the degrees on the meridians, equator, and parallels of latitude, are every where equal; and the degrees of longitude are reckoned on the parallels of latitude as well as on the equator.

14. The Plane Chart is a map, or repreſentation, of the ſeveral parts of the Earth laid down from theſe principles, according to their latitudes and longitudes, on a ſheet of paper, or other flat ſurface. (5)

When the parts of the Earth are thus delineated on a plane, it is eaſy to ſee the track by which the ſhip may go from one place to another; and alſo what angle this track makes with the meridian: ſhips at ſea are kept in this track, or path, by the help of an inſtrument called the Mariner's Compaſs.

15. The Mariner's Compass is an artificial repreſentation of the horizon of every place, by the means of a circular piece of paper called a Card, divided like the horizon into degrees and points, which are called Rhumbs. Now the card being properly fixed to a piece of ſteel called a Needle, that has been touched with a loadſtone, (the property of which is to cauſe one end of the needle, ſo touched, to point towards the north, when turning freely on ſomething ſupporting it), all the points of the card will be directed toward their correſponding points of the horizon.

From this conſtruction of the Mariner's Compaſs it follows, that in every place the north point of the card ſhews the poſition of the meridian in that place; and ſome one rhumb, or point of the card, will coincide with, or be directed along, the track that makes any given angle with the meridian: Conſequently, by the help of the card, or compaſs, a ſhip may be kept on any propoſed track, or courſe.

16. A Rhumb Line is a right line drawn from the center of the compaſs to the horizon; and is named from the point of the horizon it falls in with.

17. The Course is an angle which the Rhumb line the ſhip ſails on makes with the meridian, and it is ſometimes reckoned in degrees, and ſometimes in points of the compaſs.

18. Distance is the number of leagues, miles, &c. intercepted between two places reckoned on a Rhumb; or it is the way or length a ſhip has gone on a direct courſe in a given time.

19. Difference of Latitude is the diſtance which a ſhip has made north or ſouth of the place ſhe ſet out from; and it is reckoned in miles and parts of a mile on a meridian.

20. Departure is the eaſt or weſt diſtance which a ſhip has made from the meridian of the place ſhe departed from, reckoned on the parallel of latitude which ſhe is arrived in, and in the plane chart it is the ſame as the difference of longitude.

21. If

Digitized by Google

21. If a ſhip ſails either due north or ſouth, ſhe ſails on a meridian, makes no departure, and her diſtance and difference of latitude are the ſame.

If a ſhip ſails either due eaſt or weſt, ſhe runs on a parallel of latitude, makes no difference of latitude, and her departure and diſtance are the ſame.

The difference of latitude and departure always make the legs of a right-angled triangle, the hypothenuſe of which is the diſtance the ſhip has ſailed.

When the courſe is 45 degrees, or 4 points, the difference of latitude and departure are equal.

When the courſe is leſs than 45 degrees, or 4 points, the difference of latitude is greater than the departure.

But when the courſe is greater than 4 points, or 45 degrees, the departure is greater than the difference of latitude.

22. When a figure relating to a ſhip's courſe is to be conſtructed, it muſt firſt be conſidered whether the ſhip is ſailing northward or ſouthward; and whether ſhe goes to the eaſtward or weſtward of the place ſhe departed from; for the lines in the figure muſt be drawn accordingly.

Thus. Let the upper part of the paper, or what the figure is drawn on, always repreſent the north, then the lower part will be ſouth, the right hand ſide eaſt, and the left hand ſide the weſt.

Draw a north and ſouth line to expreſs the meridian of the place the ſhip ſails from; then if the courſe is to the ſouthward, mark the upper end of the line for the place ſailed from; but if the courſe is northward, mark the lower end for that place.

Through the point ſailed from draw a line perpendicular to the meridian to repreſent the parellel of latitude of that place; and from the ſame point, with the chord of 60 degrees, deſcribe a quadrantal arc on the eaſt ſide of the meridian, if the courſe is eaſtward, or on the weſt ſide, if the courſe is to the weſtward.

When the courſe is given, the chord of the degrees, or points expreſſing it, is to be taken with a pair of compaſſes, either from the ſcale of chords or of rhumbs *: and is always to be laid off on the quadrantal arc, beginning at the meridian.

The line expreſſing the diſtance the ſhip has run, is always to be drawn from the center of the quadrant, or point ſailed from, through that point of its arc which limits the courſe.

The difference of latitude, in leagues or miles, taken with the compaſſes from a ſcale of equal parts, is ever to be laid on the meridian, reckoning from the center of the quadrant.

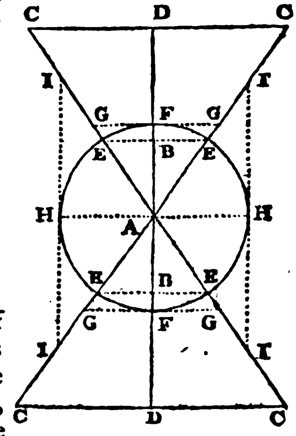
---

* A quadrant, or arc of 90°, being divided into eight equal parts, and each of theſe into quarters; then if from one end of the arc the ſeveral diviſions be transferred to the chord of 90°, as in Book III. Art. 18. a line of rhumbs is conſtructed, the uſe of which is the ſame as that of the chords, namely, to make an angle whoſe meaſure is given in points inſtead of degrees.

Digitized by Google

The departure is a right line parallel to the eaſt and weſt line before drawn, joining the ends of the lines expreſſing the diſtance and difference of latitude.

23. In the annexed figure, ſuppoſe the circle FHFH to repreſent the horizon of the place A, from whence the ſhip ſails; AC the rhumb ſhe ſails on, and C the place come to; then HH repreſents the parallel of latitude ſhe ſailed from, CC the parallel of the latitude arrived in: So that AD becomes the difference of latitude, DC the departure, AC the diſtance ſailed, the angle DAC is the courſe, and the angle DCA is the complement of the courſe.



Theſe particulars will be alike repreſented, whether the ſhip ſails in the N. E. or N. W. S. E. or S. W. quarter of the horizon.

Hence it is evident, that the difference of latitude, departure, and diſtance, form the ſides of a right-angle triangle, whoſe angles are the courſe, its complement and the right-angle, whoſe ſine is radius; therefore among theſe four things, *courſe*, *diſtance*, *diff. lat.* and *departure*, any two of them being given, the reſt are to be found by plane trigonometry.

24. *Of the Traverſe Table.*

For the ready working of any ſingle courſe, there is a table, called the *Traverſe Table*, uſually annexed to Treatiſes of this kind; which is ſo contrived, that by finding in it the given courſe and a diſtance not exceeding 100 miles, the diff. lat. and departure is had by inſpection. The courſe is to be found at the top of the table, when under 4 points, or 45 deg.; but at the bottom of the table when it exceeds 45 deg. Each column ſigned with a courſe conſiſts of two parts, one for the diff. lat., marked *Lat.*: the other for the departure, marked *Dep.*; which names are both at the top and bottom of theſe columns. The diſtance is to be found in the column marked *Diſt.* next the margin of the page.

This table will ſerve for greater diſtances, by taking their halves, thirds, fourths, *&c.* and doubling, tripling, quadrupling, *&c.* the diff. lat. and departure found to thoſe parts of the diſtance.

The traverſe table contained in this Treatiſe, at the end of Book VII. has the diſtances continued to 120, which is a number more capable of ſubdiviſions than 100: Beſides, the table is divided into two parts; the firſt contains the whole points and quarter points in a quadrant; and the ſecond part is fitted to every degree and quarter of a degree in the quadrant; whence the courſe and diſtance, reſulting from a day's work, is more accurately obtained than by the common traverſe tables.

25. All the proportions that can ariſe in plane ſailing are exhibited in the following table; they refer to the preceding figure, where AE, AF, or AH repreſent the radius of the tables, EB the ſine of the courſe, GF its tangent, and AG its ſecant; AB ſtands for the ſine of the complement of the courſe, HI its tangent, and AI its ſecant.

These proportions are here inserted, to exercise the learner in reasoning on the relations subsisting between these lines and those representing the distance, departure, and difference of latitude: but in what follows, only the analogies in the first column, and one against the last case in the second column, will be used; the others being rather matters of curiosity than use.

Case	Given	Req.	Solutions by sines	Solutions by tangents and secants	
—	——	—	by sim. $\triangle$ ADC, ABE	by sim. $\triangle$ ADC, AFG	by sim. $\triangle$ ADC, AHI
1	$\angle$A, AC	AD DC	AE : AB : : AC : AD AE : EB : : AC : DC	AG : AF : : AC : AD AG : FG : : AC : DC	AI : IH : : AC : AD AI : AH : : AC : DC
2	$\angle$A, AD	AC DC	AB : AE : : AD : AC AB : BE : : AD : DC	AF : AG : : AD : AC AF : FG : : AD : DC	IH : AI : : AD : AC IH : AH : : AD : DC
3	$\angle$A, DC	AC AD	BE : AE : : DC : AC BE : AB : : DC : AD	FG : AG : : DC : AC FG : AF : : DC : AD	AH : AI : : DC : AC AH : HI : : DC : AD
4	AD, AC	$\angle$A DC	AC : AD : : AE : AB AE : EB : : AC : DC	AD : AC : : AF : AG AF : FG : : AD : DC	
5	AC, DC	$\angle$A AD	AC : DC : : AE : EB AE : AB : : AC : AD		DC : AC : : AH : AI AH : HI : : DC : AD
6	AD, DC	$\angle$A AC		AD : DC : : AF : FG AF : AG : : AD : AC	DC : AD : : AH : HI AH : AI : : DC : AC

26. To assist the learner, the proportions hereafter used are given in their nautical terms.

Case	Given	Required	SOLUTIONS.	
1	Course & Distance	Diff. lat. Depart.	Rad. : Dist. : : Cos. Cou. : Diff. lat. Rad. : Dist. : : sin, Cou. : Depart.	N° I. N° II.
2	Course Diff. lat.	Distance Depart.	Cos. Cou. : Diff. lat. : : Rad. : Distance. Cos. Cou. : Diff. lat. : : sin. Cou. : Depart. or by	N° III. N° II.
3	Course Depart.	Distance Diff. lat.	Sin. Cou. : Depart. : : Rad. : Dist. Sin. Cou. : Depart. : : Cos. Cou. : Diff. lat. or by	N° V. N° I.
4	Distance Diff. lat.	Course Depart.	Dist. : Rad. : : Diff. lat. : Cos. Cou. Rad. : Dist. : : sin. Cou. : Depart. by	N° VII. N° II.
5	Distance Depart.	Course Diff. lat.	Dist. : Rad. : : Depart. : sin Cou. Rad. : Dist. : : Cos. Cou. : Diff. lat. by	N° IX. N° I.
6	Diff. lat. Depart.	Course Distance	Diff. lat. : Depart. : : Rad. : tan. Cou. Sin. Cou. : Depart. : : Rad. : Dist. by	N° XI. N° V.

These proportions (or Canons as they are usually called by Mariners) are applied to the numeral solutions of all the varieties of single courses in the following section.

The numbers I, II, &c. placed at the end of these Canons, shew which proportion they refer to in the upper table; reckoning two in each case.

27. A

Digitized by Google

27. A Table of the angles, which every rhumb, or point of the compass, makes with the meridian.

NORTH.	SOUTH.	Points.	D.	M.	NORTH.	SOUTH.
		0 ¼	2	49		
		0 ½	5	37½		
		0 ¾	8	26		
N. b E.	S. b. E.	1 0	11	15	N. b. W.	S. b. W.
		1 ¼	14	04		
		1 ½	16	52½		
		1 ¾	19	41		
N. N. E.	S. S. E.	2 0	22	30	N. N. W.	S. S. W.
		2 ¼	25	19		
		2 ½	28	07½		
		2 ¾	30	56		
N. E. b N.	S. E. b. S.	3 0	33	45	N. W. b. N.	S. W. b.S.
		3 ¼	36	34		
		3 ½	39	22½		
		3 ¾	42	11		
N. E.	S. E.	4 0	45	00	N. W.	S. W.
		4 ¼	47	49		
		4 ½	50	37½		
		4 ¾	53	26		
N. E. b. E.	S. E. b. E.	5 0	56	15	N. W. b. W.	S. W. b. W.
		5 ¼	59	04		
		5 ½	61	52½		
		5 ¾	64	41		
E. N. E.	E. S. E.	6 0	67	30	W. N. W.	W. S. W.
		6 ¼	70	19		
		6 ½	73	07½		
		6 ¾	75	56		
E. b. N.	E. b. S.	7 0	78	45	W. b. N.	W. b. S.
		7 ¼	81	34		
		7 ½	84	22½		
		7 ¾	87	11		
EAST.	EAST.	8 0	90	00	WEST.	WEST.

Before the learner begins to work the cases of plane sailing, he should be so well acquainted with the compass, or this table, as to be able readily to tell how many points any of these courses or rhumbs are distant from the meridian, or from the parallel.

SECTION

Digitized by Google

SECTION IV.

Of Single Courses.

28. CASE I. Given the course steered, and the distance run: Required the difference of latitude and departure.

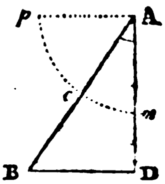
EXAM. *A ship from the latitude* 47° 30′ N. *has sailed S. W. by S.* 98 *miles: What lat. is she in, and what dep. has she made?*

By the TRAVERSE TABLE.

Find the given course at the top or bottom of the table among the points or degrees; and in that column, right against the distance taken in its column, stand the diff. lat. and departure in their columns.

Thus the course is S. W. by S. or 3 points, in which column, and against the distances 98 in the column of distances, stand 81,5 miles for the diff. lat; and 54,45 miles for the departure.

By CONSTRUCTION. (22)



1. Draw the meridian AD, and make the quadrant A*mcp*.
2. Make *mc*=rhumb of 3 points, and through *c* draw AB equal to 98 miles.
3. Draw BD parallel to *p*A, meeting AD in D.

Then AD, the diff. lat. measures about 81½ miles.
And DB, the departure, measures about 54,4 miles.

By COMPUTATION.

The course being 3 points = 33° 45′.			
To find the diff. latitude.			
As rad.	= 90° 00′	10,00000	
To diff.	= 98 m.	1,99123	
So co-f. co.	= 33° 45′	9,91985	
To diff. lat.	= 81,48	1,91108	

The comp. course is 5pts. = 56° 15′			
To find the departure.			
As rad.	= 90° 00′	10,00000	
To dist.	= 98 m.	1,99123	
So sin. co.	= 33° 45′	9,74474	
To dep.	= 54,45	1,73597	

By GUNTER'S SCALE.

On the line of sine Rhumbs*, the extent from Radius, or 8 points, to 3 points, applied to the line of numbers, will reach from 98, in either interval, to 54,4.

And the extent from 8 points, to 5 points among the Rhumbs, reaches from 98 to 81,5 on the line of numbers.

Or thus. The extent from Radius, or 8 points, in the S. R. to 98 in the Numb. will reach from 3 points in the Rhumbs to 54,4 in the Numb. and the same extent will reach from 5 points in the Rh. to 81,5 in the Numb.

	The lat. from	47°	30′	N.
$\frac{81}{60}$ = 1° 21′. ——— diff. lat.		1	21	S.
	Lat. in	46	9	N. Dep. 54,4 miles West.

* The lines on the Gunter's scale marked S. R. and T. R. signifying *Sine Rhumbs* and *Tangent Rhumbs*, are the logarithmic sines and tangents answering to the degrees and minutes in each point and quarter point of the Compass, transferred from the scales of log. sines and log. tangents.

29. CASE

29. Case II. Given the course steered, and difference of latitude: Required the distance run, and the departure.

Exam. *A ship has sailed S. E. by S. from the lat. 47° 30′ N. to the lat. 46° 08′ N. What distance has she run, and what departure has she made?*

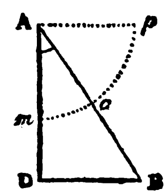
By the Traverse Table.

Find the course among the degrees, and the diff. lat. in its column, right against which stand the departure and distance in their columns.

Now taking 46° 08′ from 47° 30′, remains 1° 22′ = 82 m. the diff. lat.

Then the course S. E. b. S. is 3 points, under which in the column of lat. the nearest number to 82 is 82,3, the corresponding departure is 55, and the distance 99 miles.

By Construction.



1st. Describe the quadrant A*mcp*.

2d. Make *mc* = rhumb of 3 points, and continue A*m* till AD = 82 miles.

3d. Through D draw DB parallel to A*p*, meeting the line AB drawn through *c* in the point B.

Then the distance AB measures about 99 miles.

And the departure DB measures about 55 miles.

By Computation.

The course 3 points = 33° 45′			The comp. course is 5 pts. = 56° 15′		
To find the distance.			To find the departure.		
As co-s. co.	= 33° 45′	0,08015	As co-s. co.	= 33° 45′	0,08015
To diff. lat.	= 82 m.	1,91381	To diff. lat.	= 82 m.	1,91381
So rad.	= 90° 00′	10,00000	So sin. co.	= 33° 45′	9,74474
To dist.	= 98,62	1,99396	To dep.	= 54,79	1,73870

By Gunter's Scale.

On the line of sine rhumbs, the extent from 5 points to 8 points, or radius, will, on the line of numbers, reach from 82 to 99.

And the extent from 5 points to 3 points on the S. R. will reach from 82 to 55 on the line of numbers.

Or thus. The extent from 5 points in the sine rhumbs, to 82 miles in the line of numbers, will reach from 8 points in those rhumbs, to 99 in the numbers; and the same extent will reach from 3 points in the rhumbs to 55 in the numbers.

Note. In all these cases, wherever the co-s. course is used, the deg. put down is the course itself, yet the log. belongs to the comp. of that course.

30. Case

30. CASE III. Given the course steered, and the departure; Required the dist. run, and diff. latitude.

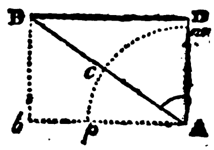
EXAM. *A ship from lat. 47° 30′ N. sailing N. W. b. W. finds she has made 82 miles of departure: What is her distance run, and what lat. is she now in?*

By the TRAVERSE TABLE.

Find the course among the degrees, and the departure in its column; right against which stand the difference of latitude, and the distance in their respective columns.

Now the course N. W. b. W. is 5 points, over which, in the column of departure, the nearest number to 82, is 82,3; and the corresponding diff. latitude is 55 miles, and the distance is 99 miles.

By CONSTRUCTION.



1st. Describe the quadrantal arc A*mcp*.
2d. Make *mc* = rhumb of 5 points, and continue A*p* till A*b*=82 miles.
3d. Through *b* draw *b*B parallel to A*m*, meeting the line AB drawn through *c*, in B.
4th. Through B draw BD parallel to *b*A, meeting A*m* continued, in D.
Then the distance AB measures about 99 miles.
And the diff. lat. AD measures about 55 miles.

By COMPUTATION.

The course 5 points is 56° 15′
To find the distance.

As sin. co.	= 56° 15′	0,08015
To dep.	= 82 m.	1,91381
So rad.	= 90° 00′	10,00000
To dist.	= 98,62	1,99396

The comp. course is 3 pts. = 33° 45′.
To find the diff. latitude.

As sin. co.	= 56° 15′	0,08015
To dep.	= 82 m.	1,91381
So co-s. co.	= 56° 15′	9,74474
To diff. lat.	= 54,79	1,73870

By GUNTER'S SCALE.

On the line of sine rhumbs, the extent from 5 points to 8 points, or radius, will, on the line of numbers, reach from 82 to 99.

And the extent from 5 points to 3 points on the line S. R. will reach from 82 to 55 on the line of numbers.

Or thus. The extent from 5 points in the sine rhumbs to 82 miles in the line of numbers, will reach from 8 points in the rhumbs to 99 in the numbers: And the same extent will reach from 3 points in the rhumbs to 55 in the numbers.

Lat. from	47° 30′ N.
Diff. lat.	0 55 N.
Lat. in	48 25

31. CASE

31. Case IV. Given the diſtance and difference of latitude: Required the courſe and departure.

Exam. *A ſhip from lat.* 47° 20′ *N. ſails between the north and eaſt* 98 *miles, and is arrived in lat.* 48° 42′ *N. What courſe did ſhe ſteer, and what departure has ſhe made?*

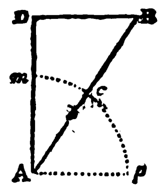
By the Traverse Table.

Seek in the table, till againſt the diſtance taken in its column be found the given diff. lat. in one of the following columns; and adjoining to it ſtands the departure, which, if leſs than the diff. lat. the courſe is found at the top of the column; but if greater, the courſe is found at the bottom.

Now having taken 47° 20′ from 48° 42′, leaves 1° 22′=82 m. the diff. lat.

Then ſeeking till againſt diſt. 98 ſtands lat. 82, the neareſt will be lat. 81,95, and here the departure is 53,73 m. and the courſe is 33° 15′.

By Construction.



1ſt. Deſcribe the quadrant A*mcp*.
2d. Continue A*m*, till AD=82 m.
3d. Through D draw DB parallel to A*p*.
4th. On A with the diſtance 98 cut DB in B.
Then the departure DB meaſures about 53 m.
And the courſe DAB is meaſured by the arc *mc* of about 33°.

By Computation.

To find the courſe.			To find the departure.		
As diſt.	= 98 m.	8,00877	As rad.	= 90° 00′	10,00000
To rad.	= 90° 00′	10,00000	To diſt.	= 98 m.	1,99123
So diff. lat.	= 82 m.	1,91381	So ſin. co.	= 33° 12′	9,73843
To co-ſ. co.	= 33° 12′	9,92258	To dep.	= 53,66	1,72966

By Gunter's Scale.

On the line of numbers, the extent from 98 m. to 82 m. will, on the line of ſines, reach from 90, or radius, to about 57 degrees.

And the extent on the line of ſines, from 90° to 33°, will reach on the line of numbers from 98 m. to about 53½ miles.

Or thus. The extent from 98 m. in the line of numbers, to 90° in the line of ſines, will reach from 82 m. in the numbers to about 57° in the ſines: And the ſame extent will reach from about 33° in the ſines, to about 53½ in the numbers.

So that the courſe is N. 33° 12′ E. or N. E. b. N. nearly.

And the departure is N. 53,66 miles to the Eaſtward.

Digitized by Google

32. CASE V. Given the diſtance and departure:
Required the courſe, and difference of latitude.

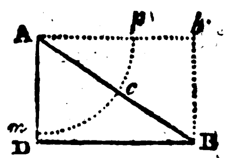
EXAM. *From the lat 50° 13′ N. a ſhip, in ſailing between the ſouth and eaſt 98 miles, makes her departure 82 miles: What courſe did ſhe keep, and what lat. is ſhe arrived at?*

By the TRAVERSE TABLE.

Seek in the table, till againſt the diſtance, taken in its column, be found the given departure in one of the following columns, and adjoining to it ſtands the diff. lat. which if greater than the departure, the courſe is found at the top of the column; but if leſs, the courſe is found at the bottom.

Now ſeeking till againſt the diſt. 98 ſtands 82, the neareſt will be 81,95, ſigned Dep. at bottom; and here the diff. lat. is 53,73 m. and the courſe is 56° 45′.

By CONSTRUCTION.



1ſt. Deſcribe the quadrant *Amcp*.
2d. Continue *Ap*, till *Ab*=82 m.; and through *b* draw *b*B parallel to A*m*.
3d. From A with the diſt. 98 m. cut *b*B in B.
4th. Through B draw BD parallel to A*b*, meeting A*m* continued, in D.
Then the diff. lat. AD meaſures about 53 miles.
And the courſe DAB is meaſured by the arc *mc* of about 57°.

By COMPUTATION.

To find the courſe.			To find the diff. lat.		
As diſt.	= 98 m.	8,00877	As rad.	= 90° 00′	10,00000
To rad.	= 90° 00′	10,00000	To diſt.	= 98 m.	1,99123
So dep.	= 82 m.	1,91381	So co-ſ. co.	= 56° 48′	9,73843
To ſin. co.	= 56° 48′	9,92258	To diff. lat.	= 53,66	1,72966

Then 50° 13′ N.—0° 54′ N.=49° 19′ N. For 53,66 m. is neareſt 54.

By GUNTER'S SCALE.

On the line of numbers, the extent from 98 m. to 82 m. will, on the line of ſines, reach from 90°, or radius, to about 57 degrees.

And the extent on the line of ſines, from 90° to 33°, will reach from 98 m. to about 53½ m. on the line of numbers.

Or thus. The extent from 98 m. in the line of numbers to 90° in the line of ſines, will reach from 82 m. in the numbers, to about 57° in the ſines: And the ſame extent will reach from about 33° in the lines, to about 53½ m. in the numbers.

So that the courſe is S. 56° 48′ E. or S. E. b. E. nearly.

And the latitude arrived in is 49° 19′ N.

33. CASE

33. CASE VI. Given the difference of latitude and departure: Required the course and distance.

EXAM. *A ship from lat. 48° 32′ N. is arrived in lat. 49° 54′ N. and is got 54 miles to the westward of her departed meridian: What course did she steer, and what is the direct distance she has run?*

By the TRAVERSE TABLE.

Seek in the table till the given diff. lat. and departure are found together in their respective columns: then right against them will be found the distance in its column, and the course stands among the degrees at the top or bottom of the column, where the diff. lat. and depart. were found.

Now 48° 32′ taken from 49° 54′, leave 1° 22′=82 m. the diff. lat.

Then in the table it will be found, that the numbers standing together the nearest to 82 and 54, are 81,95 and 53,73; the distance answering to these is 98 m. and the course is 33° 15′.

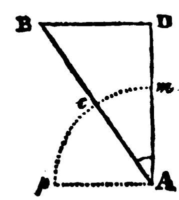
By CONSTRUCTION.

1st. Describe the quadrant A*mcp*, and continue A*m* till AD=82 m.

2d. Through D draw BD parallel to A*p*, and equal to 54 miles, and draw AB.

Then the distance AB measures about 98 miles.

And the course DAB is measured by the arc *mc* of about 33°.



By COMPUTATION.

To find the course.			To find the distance.		
As dif. lat.	= 82 m.	8,08619	As sin. co.	= 33° 22′	0,25964
To depart.	= 54 m.	1,73239	To depart.	= 54 m.	1,73239
So rad.	= 90° 00′	10,00000	So rad.	= 90° 00′	10,00000
To tan. co.	= 33,22	9,81858	To dist.	= 98, 18	1,99203

By GUNTER'S SCALE.

On the line of numbers, the extent from 82 m. to 54 m. will reach on the line of tangents from 45° to about 33°.

And the extent on the line of sines, from about 33° to 90°, will reach on the line of numbers from 54 m. to about 98 m.

Or thus. The extent from 82 on the line of numbers to 45° in the line of tangents, will reach from 54 in the line of numbers, to about 33° in the line of tangents.

Also, the extent from about 33° in the sines to 54 in the numbers, will reach from 90° in the sines to about 98 m. in the numbers.

So the course is N. 33° 22′ W. or N. W. b. N. nearly.

And the distance is 98,18 miles.

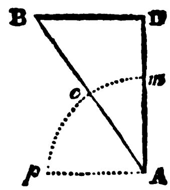
34. Que-

Digitized by Google

34. *Questions to exercise the foregoing Cases.*

QUEST. I. *Four days ago we were in lat.* 3° 25′ *S.; and have since that time run on a direct course NW. by N. at the rate of* 8 *miles an hour: Required our present latitude and departure?*

One day = 24 hours: Then 24 × 4 = 96 hours.
And 96 × 8 = 768 miles, the whole distance.



CONSTRUCTION.

1st. Draw the meridian AD, and describe the quadrant A*mp*.
2d. Lay off the course 3 points from *m* to *c*, and draw the rhumb line AB.
3d. On the rhumb line lay the distance from A to B, and draw DB parallel to *p* A.

COMPUTATION.

As rad.	= 90° 00′	10,00000	As rad.	= 90° 00′	10,00000
To dist.	= 768 m.	2,88536	To dist.	= 768 m.	2 88536
So cos. co.	= 33° 45′	9,91985	So sin. co.	= 33° 45′	9,74474
To diff. lat.	= 638,6 m.	2,80521	To dep.	= 426,7 m.	2,63010

Now $\frac{639}{60}$ = 10° 39′

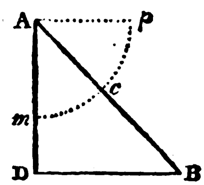
Then lat. from 3° 25′ S.
diff. lat. 10 39 N.

Answer { Lat. in 7 14 N.
Depart. 426,7 miles.

QUEST. II. *Yesterday noon we were in lat.* 38° 32′ *N.; and this day at noon we were in lat.* 36° 56′ *N. we have run on a direct course between the S. and E.* 5½ *knots* * *an hour: Required our course and departure?*

Lat. from 38° 32′ N.
Lat. in 36 56 N.
Diff. lat. 1 36 = 96 m.

24 hours.
5,5 = 5½
120
120
Dist. = 132,0 m.



CONST. Describe the quadrant A*mp*: draw the meridian AD = 96, and draw DB parallel to A*p*; with 132 m. from A, cut DB in B.

COMPUTATION.

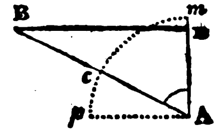
As dist.	= 132 m.	7,87943	As rad.	= 90° 00′	10,00000
To rad.	= 90° 00′	10,00000	To dist.	= 32 m.	2,12057
So diff. lat.	= 96 m.	1,98227	So sin. co.	= 43° 20′	9,83648
To cos. co.	= 43° 20′	9,86170	To dep.	= 90,58	1,95705

Answer { Course is S. 43° 20′ E. or SE. by S. ¾ E. nearly.
Departure 90,58 miles to the Eastward.

* A knot is the same as a sea mile, 60 to a degree.

Digitized by Google

QUEST. III. *A ship in lat. 3° 52′ S. is bound to a port bearing NW. by W. ½ W. in lat. 4° 30′ N.: How far does that port lay to the westward, and what is the ship's distance from it?*



Lat. from	3° 52′ S.
Lat. to	4 30 N
Diff. lat.	8 22=502 miles.

CONST. Describe the quadrant A *m p*: Draw the meridian AD=502, and through D draw DB parallel to A *p*: make *mc*=5¼ points: Through *c* draw AB meeting DB in B.

COMPUTATION.

As cos. co.	= 61° 52′	0,32650	As cos. co.	= 61° 52′	0,32650
To diff. lat.	= 502 m.	2,70070	To diff. lat.	= 502 m.	2,70070
So rad.	= 90° 00′	10,00000	So sin. co.	= 61° 52′	9,94540
To dist.	= 1065	3,02720	To dep.	= 938,9	2,97260

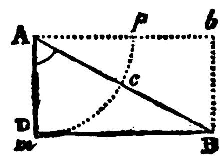
Answer { The port lies 938,9 m. to the westward.
The direct distance is 1065.

QUEST. IV. *A ship from lat. 30° 14′ N. sails SE. by E. ½ E.; and four days after meets a sloop who had sailed directly east at the rate of 6 miles an hour, she having been, four days before, under the meridian the ship departed from: Required the difference of their rates of sailing, and their present latitude?*

As the ship and sloop sailed from the same meridian, and the sloop runs directly east; therefore her distance will be the ship's departure.

Now in 4 days are 96 hours.

And 96×6=576 miles of departure.



CONST. Describe the quadrant A *m p*.
In A *p* continued take A *b*=576, and draw *b* B parallel to A *m*.
Make *m c*=5½ points, and through *c* draw A *c*, meeting *b* B in B.
Through B draw BD parallel to *b* A meeting A *m* continued in D.

COMPUTATION.

As sin. co.	= 61° 52′	0,05460	As sin. co.	= 61° 52′	0,05460
To dep.	= 576 m.	2,76042	To dep.	= 576 m.	2,76042
So rad.	= 90° 00′	10,00000	So cos. co.	= 61° 52′	9,67350
To dist.	= 653,2 m.	2,81502	To diff. lat.	= 308 m.	2,48852

Now 96)653,2(6,8 m. per hour the ship's rate.
772

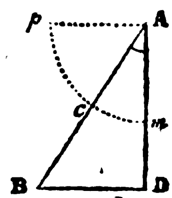
And 6,0)30,8(Then lat. fr. 30° 14′ N.
5 8 diff. lat. 5 08 S.
Lat. in 25 06

So the difference of their rates of sailing is $\frac{2}{10}$ or $\frac{1}{5}$ of a mile per hour.

QUEST.

QUEST. V. *A ship from the lat. 48° 17′ N. sails SW. by S. until she has depressed the north pole two degrees: What direct distance has she run, and how many miles is she got to the westward?*

To depress the pole two degrees, the ship must sail southward until her diff. lat. is 2 degrees, or 120 miles.



CONST. 1st. Draw AD=diff. lat. 120 m.
2d. Describe the quadrant Amp, and make mc=3 points.
3d. Through c draw AB, meeting DB, drawn through D, parallel to Ap.

COMPUTATION.

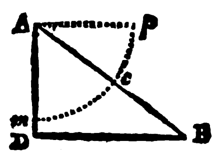
As cos. co.	= 33° 45′	0,08015	As cos. co.	= 33° 45′	0,08015
To diff. lat.	= 120 m.	2,07918	To diff. lat.	= 120 m.	2,07918
So rad.	= 90° 00′	10,00000	So sin. co.	= 33° 45′	9,74474
To dist.	= 144,3	2,15933	To dep.	= 80,18	1,90407

Answer { Ship has run 144,3 miles.
And has got to the westward 80,18 miles.

QUEST. VI. *Two ports lie under the same meridian, one in latitude 52° 30′ N. and the other in latitude 47° 10′ N. A ship from the southernmost sails due east 9 knots an hour, and two days after meets a sloop that had sailed from the northernmost port: Required the sloop's direct course and distance run?*

Here the distance which the ship sails east is the sloop's departure.
Now 2 days=48 hours.
Then 48×9=432 m.=departure.

Sloop's lat.	52° 30′ N.	
Ship's lat.	47 10 N.	
Diff. lat.	5 20	=320 m.



CONST. In the meridian, take AD for the diff. lat. 320 m. and perpendicular to AD draw the departure DB=432 m. and draw the distance AB.

COMPUTATION.

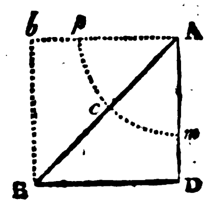
As diff. lat.	= 320 m.	7,49485	As sin. co.	= 53° 28′	0,09501
To depart.	= 432 m.	2,63548	To depart.	= 432 m.	2,63548
So rad.	= 90° 00′	10,00000	So rad.	= 90° 00′	10,00000
To tan. co.	= 53 28	10,13033	To dist.	= 537,6	2,73049

Answer { The sloop has sailed S. 53° 28′ E. or SE. ½ E.
And has run 537,6 miles.

 QUEST.

Digitized by Google

Quest. VII. *A ship from a port in latitude 38° 25′ S. sails between the S. and W. at the rate of $7\frac{1}{2}$ knots an hour; three days after meets a sloop, who two days before had sailed from a port under the same meridian which the ship departed from, and kept on a west course 8 miles an hour: Required the ship's direct course and present latitude?*



Now 3 days is 72 hours, which, at $7\frac{1}{2}$ knots an hour, makes 540 miles for the ship's run.

And 2 days is 48 hours, which, at 8 knots an hour, makes 384 miles for the sloop's run, and is equal to the westing, or departure of the ship.

Const. Having described the quadrant Amp, make Ab=384; from A, with 540, cut bB parallel to AD, in B; draw AB, and BD parallel to Ap.

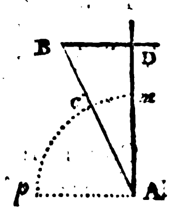
Computation.

As dist.	= 540 m.	7,26761	As rad.	= 90° 00′	10,00000
To rad.	= 90° 00′	10,00000	To dist.	= 540 m.	2,73239
So depart.	= 384 m.	2,58433	So cos. co.	= 45° 20′	9,84694
To sine co.	= 45° 20′	9,85194	To diff. lat.	= 379,6	2,57933

6,0)38,0(6° 20′
And (38° 25′+6° 20′=) 44° 45′ S.

Answer { Course S. 45° 20′ W. or SW.
Present latitude is 44° 45′ S.

Quest. VIII. *A brig from a port in latitude 28° 38′ N. sails due N. at the rate of $8\frac{1}{2}$ knots an hour; after three days she meets a ship who had run due W. 342 miles from a port 30 leagues to the eastward of the meridian that the brig's crew thought themselves under; who also found, they had not increased their latitude so much by 24 leagues as by their account: Required the true course and distance the brig has made?*



Now $8\frac{1}{2}$ knots an hour for 3 days, is 612 miles for the brig's apparent northing; from which taking 24 leagues, or 72 m. her error in account, there remain 540 miles for her true diff. lat.

And as the ship's departed meridian is 30 leagues, or 90 miles to the eastward of the brig's; these 90 m. being taken from 342, leave 252 m. for the westing from the brig's meridian.

So that the brig having made 540 m. northing, and 252 m. westing; her course and distance, found by the 6th case (33), will be

Course N. 25° 01′ W. or NNW. ¼W. nearly.
Distance 595,9 miles.

It may be proper to observe, that when radius is one of the three terms given, and not the first; then the log. of the first term being subtracted from the log. of the other term (radius excluded), leave the log. of the 4th term; by which means the trouble of taking the arith. comp. of the 1st term is avoided.

SECTION

SECTION V.

Of Compound Courſes.

35. A Compound Course is an irregular track which a ſhip makes in a known time, by ſailing on ſeveral different courſes: Or where two or more caſes of Plane Sailing are concerned.

A Traverse is a compound courſe, wherein ſeveral different ſucceſſive courſes and diſtances are known.

36. To work a Traverse,

Or, to reduce a compound courſe to a ſingle one.

1ſt. Make a table of ſix columns, title them Courſe, Diſtance, N. S. E. W. Begin at the left ſide, and write the given courſes and diſtances in their reſpective columns.

2d. Seek in the traverſe table the given courſes and diſtances, and let the correſponding differences of latitude and departures be written in their proper columns in the table made for the queſtion.

3d. Add up the columns of northing, ſouthing, eaſting, and weſting; then the difference between the ſums of the northing and ſouthing will be the whole difference of latitude, of the ſame name with the greater: and the difference between the ſums of the eaſting and weſting will be the whole departure, of the ſame name with the greater alſo.

4th. The whole diff. of lat. and departure to the compound courſe being found, the direct courſe and diſtance will be found as in Caſe VI. of ſingle courſes.

37. To construct a Traverse.

1ſt. Deſcribe a circle with the chord of 60 degrees, and divide it into 4 quadrants; marking the north point with N.

2d. Lay off each courſe on the circumference, reckoned from its proper meridian; and from the center to each point draw ſo many blank radii; mark theſe with the proper number of the courſe.

3d. On the firſt radius, lay the firſt diſtance, mark its extremity; through this extremity, and parallel to the ſecond radius, draw the ſecond diſtance of its proper length; through the extremity of the ſecond diſtance, and parallel to the third radius, draw the third diſtance of its proper length: and thus proceed until all the diſtances are drawn.

Digitized by Google

4th. A line drawn from the extremity of the laſt diſtance, to the center of the circle, will repreſent the diſtance made good; and a line drawn from the ſame point, perpendicular to the meridian (lengthened if neceſſary) will repreſent the departure.

38. When a ſhip is bound from a given place to a known port; and on ſome occaſion is obliged to run on one or more different courſes, not in the direct one to the port; and then wants to find the direct courſe and diſtance ſhe muſt run to gain her port, obſerve the following precepts.

1ſt. Find the diff. lat. and dep. between the ſhip's firſt place and the port bound to.

2d. Find the diff. lat. and dep. between the ſhip's firſt place and the place ſhe is to come to.

3d. If theſe differences of latitude are both of the ſame name, take their difference for a new diff. lat.: But if of contrary names, take their ſum.

4th. If the departures are both of the ſame name, take their difference for a new departure: But take their ſum, if of contrary names.

5th. To this new difference of latitude and departure, find the courſe and diſtance (33).

6th. If between the place failed from, and the place come to, there has been more than one courſe: To each courſe let the diff. lat. and departure be found; and let their ſum or difference be taken according as they are, of the ſame, or of contrary names; and this will give the diff. lat. and departure between the place failed from, and the place come to: Then proceed by the 3d, 4th, and 5th precepts.

39. To construct a Compound Course.

See any of the figures after Queſtion VII.

1ſt. Deſcribe a circle, in which draw the meridian and parallel of the place failed from.

2d. Conſtruct the triangle between the place failed from, marked A, and the place bound to, marked B; and let the interſection of the diff. lat. and departure be marked D.

3d. Conſtruct the figure between the place failed from, or A, and the place come to, marked C; and let the interſection of this diff. lat. and departure be marked E.

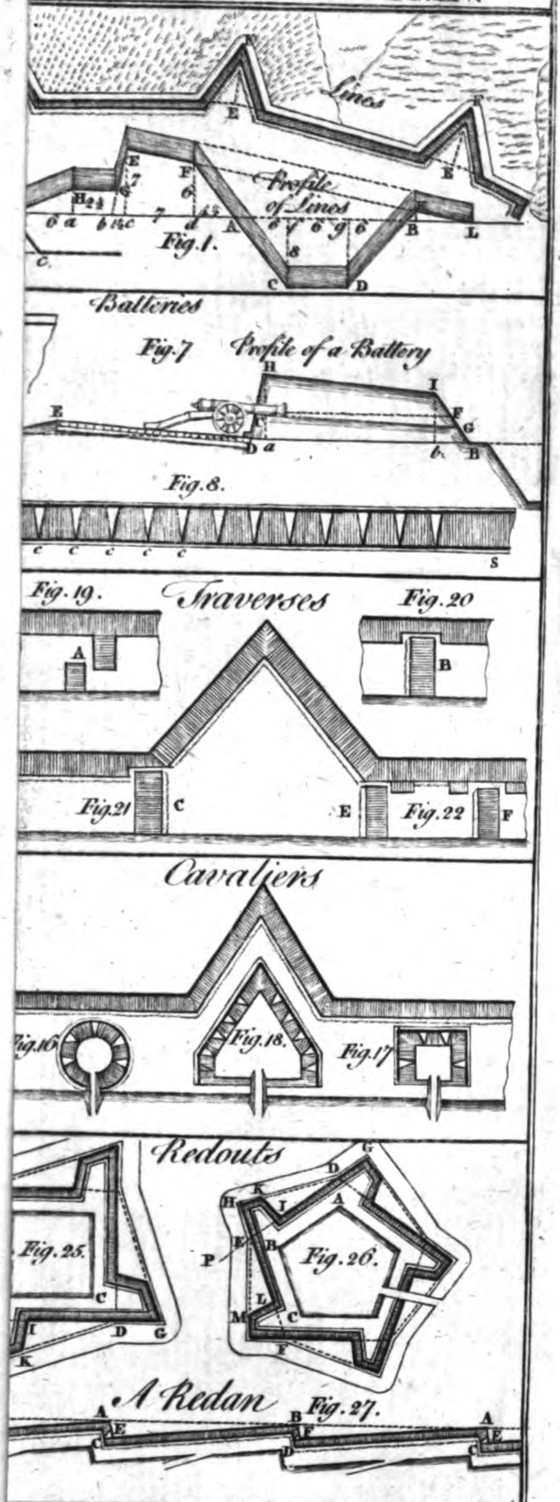
4th. Through C draw CF parallel to AD, meeting BD, continued, if neceſſary, in F; and draw CB.

5th. Then in the triangle CFB, the lines CF, FB, CB, will repreſent the diff. lat. departure, and diſtance between the place come to, and the place bound to.

6th. From the center A draw a line parallel to CB, in the direction from C to B, and this ſhews the courſe wanted.

40. Ex-

Digitized by Google



Digitized by Google

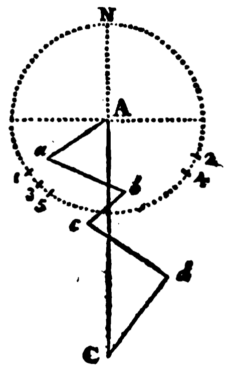
Digitized by Google

40. *Examples to exercise Traverse Sailing.*

QUESTION I. *A ship sails from a place in latitude 24° 32′ N. and has run the following courses and distances, viz.*
1st. SW. b. W. dist. 45 m. 2d ESE. dist 50 m. 3d. SW. dist. 30 m.
4th. SE. b. E. dist. 60 m. 5th. SW. b. S. ¼W. dist. 63 m.
Required her present latitude, with the direct course and distance between the place sailed from, and the place come to?

Construct the traverse table by art. 36, and the figure by art. 37.

TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
SW. b. W.	45		25,0		37,4
ESE.	50		19,1	46,2	
SW.	30		21,2		21,2
SE. b. E.	60		33,3	49,9	
SW. b. S. ¼W.	63		50,6		37,5
			149,2	96,1	96,1



The traverse table being completed; the sum of the southings is 149,2 miles, and so far the ship has got to the southward, or altered her latitude.

The lat. from	24°	32′N.
Diff. lat. $\frac{149}{60}$ =	2	29 S.
Present lat.	22	03 N.

The miles of departure in the east column are 96,1; and those in the west column are also 96,1: But as the east and west departures are directly opposite, they destroy one another, and the ship in her present station has made no departure; therefore she is under the same meridian which she sailed from: Consequently her course made good is directly south; and her distance is the same as the difference of latitude, which is 149,2.

In this figure the circle, which is described with the chord of 60°, represents the horizon, the center of which is the place the ship sailed from; through that place are drawn two diameters, at right angles to one another; the one representing the meridian, the other the parallel of latitude which the ship departed from: On the circumference are laid the several courses, and numbered 1, 2. 3, 4, 5. On the first rhumb A 1, is laid the first distance A*a* = 45; through *a*, and parallel to the rhumb A 2, is drawn the second distance *ab* = 50; through *b*, and parallel to the rhumb A 3, is drawn the third distance *bc* = 30; through c, and parallel to the rhumb A 4, is drawn the fourth distance *c d* = 60; through *d*, and parallel to the rhumb A 5, is drawn the 5th distance *d*C = 63.

Digitized by Google

QUEST. II. *A ship from the latitude 28° 32′ N. has run the following courses, viz.*

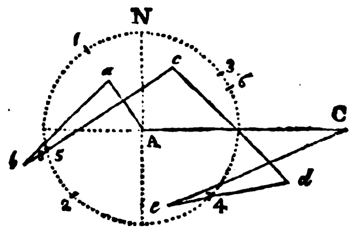
1st. NW. b. N. dist. 20 m. 2d. SW. dist. 40 m. 3d. NE. b. E. dist. 60 m. 4th. SE. dist. 55 m. 5th. W. b. S. dist. 41 m. 6th. ENE. dist. 66 m.

Required her present latitude, with the direct course and distance between the place sailed from and the place come to?

Construct the traverse table by art. 36, and the figure by art. 37.

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
NW. b. N.	20	16,6			11,1
SW.	40		28,3		28,3
NE. b. E.	60	33,3		49,9	
SE.	55		38,9	38,9	
W. b. S.	41		8,0		40,2
ENE.	66	25,3		61,0	
		75,2	75,2	149,8	79,6
				79,6	
				70,2	Dep.



The traverse table being filled up, the sum of the northings and southings are both 75,2 miles; which, being of contrary directions, shew that the ship has returned to the same parallel of latitude which she sailed from.

The sum of the eastings is 149,8, and that of the westings is 79,6; their difference 70,2 shews that the ship has gained so much to the eastward, that being greatest.

Here A is the place sailed from; and C is the place the ship is come to, by sailing along the lines A *a*, *a b*, *b c*, *c d*, *d e*, *e* C.

The distance she is got from A, is represented by A C; which also expresses the rhumb between A and C.

Consequently the course made good is due east.

And the distance is 70,2 miles.

Although the figures in both the traverse tables, at the end of this book, contain two decimal places, besides the whole numbers, yet only one decimal place is used in these traverse questions, and that place is increased by 1, if the place omitted exceeded 5: Thus, the course SW. dist. 40, gives 28,28; for which it is set down 28,3; because 28,28 is nearer to 28,30 than to 28,20: And so of others.

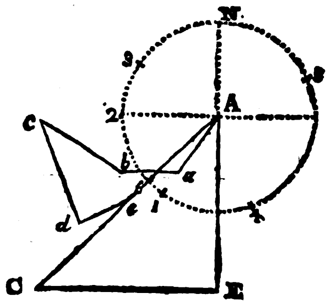
QUEST.

Digitized by Google

QUEST. III. *Since yesterday noon we have run the following courses:*
1st. SW. b. S. 20 m. 2d. W. 16 m. 3d. NW. b. W. 28 m.
4th. SSE. 32 m. 5th. ENE. 14 m. 6th. SW, 36 m.
What diff. lat. and departure has the ship made, and what is her direct course and distance?

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
SW. b. S.	20		16,6		11,1
W.	16				16,0
NW. b. W.	28	15,6			23,3
SSE.	32		29,6	12,3	
ENE.	14	5,4		12,9	
SW.	36		25,5		25,5
		21,0	71,7	25,2	75,9
			21,0		25,2
		D. lat.	50,7	Dep.	50,7

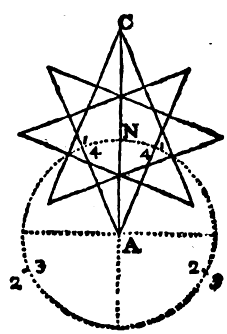


As the diff. lat. and dep. are equal, the course is S. 45° W. or SW.
And, as s. ∠ A : CE :: s. ∠ E : AC. Or s. 45° 00′ : 50, 7m. :: s. 90° 00′ : 71,7m.

QUEST. IV. *Two ships,* A *and* B, *part company in lat.* 31° 31′ *N. and meet together again at the end of two days, having run as follows:*
A. 1st. NNE. 96m. 2d. WSW. 96m. 3d. ESE. 96m. 4th. NNW. 96m.
B. 1st. NNW. 96m. 2d. ESE. 96m. 3d. WSW. 96m. 4th. NNE. 96m.
Required the lat. arrived in, with the direct course and dist. of each ship?
As the courses steered by both ships are equally distant from the meridian; therefore one traverse will serve for both.

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
NNE.	96	88,7		36,7	
WSW.	96		36,7		88,7
ESE.	96		36,7	88,7	
NNW.	96	88,7			36,7
		177,4	73,4	125,4	125,4
		73,4			
		104,0	D. lat.		



There being no departure, and the diff. lat. being N.
Therefore the course made good is N. and the distance is 104 miles.
The lat. arrived in is 33° 15′ N.

QUEST.

Digitized by Google

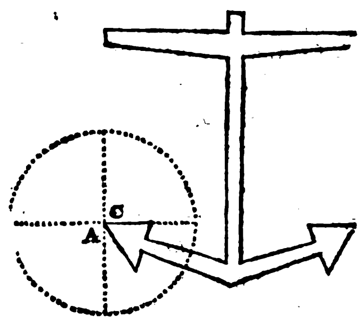
QUEST. V. *Suppoſe a ſhip from the lat. of 40° 00′ N. ſails as follows.*

1ſt.	SE. b. S.	29 m.	2d.	NNE.	10 m.	3d.	ESE.	50 m.
4th.	ENE.	50 m.	5th.	SSE.	10 m.	6th.	NE. b. N	29 m.
7th.	Weſt	25 m.	8th.	SSE.	10 m.	9th.	WSW. ½ W.	42 m.
10th.	North	110 m.	11th.	E. ¼ N.	62 m.	12th.	North.	7 m.
13th.	Weſt	62 m.	14th.	North	10 m.	15th.	Weſt	8 m.
16th.	South	10 m.	17th.	Weſt	62 m.	18th.	South	7 m.
19th.	E ¼ S.	62 m.	20th.	South	110 m.	21ſt.	WNW. ½ W.	42 m.
22d.	NNE.	10 m.	23d.	Weſt	25 m.			

Required the ſhip's place, with the direct courſe and diſtance?

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
SE. b. S.	29		24,1	16,1	
NNE.	10	9,2		3,8	
ESE.	50		19,1	46,2	
ENE.	50	19,1		46,2	
SSE.	10		9,2	3,8	
NE. b. N.	29	24,1		16,1	
Weſt.	25				25,0
SSE.	10		9,2	3,8	
WSW. ½ W.	42		12,2		40,2
North.	110	110,0			
E. ¼ N.	62	9,1		61,3	
North.	7	7,0			
Weſt.	62				62,0
North.	10	10,0			
Weſt.	8				8,0
South.	10		10,0		
Weſt.	62				62,0
South.	7		7,0		
E. ¼ S.	62		9,1	61,3	
South.	110		110,0		
WNW. ½ W.	42	12,2			40,2
NNE.	10	9,2		3,8	
Weſt.	25				25,0
		209,9	209,9	262,4	262,4



As the ſums of the North and South difference of latitudes are equal, and the Eaſt and Weſt departures are equal; therefore the ſhip is returned to the place ſhe ſailed from.

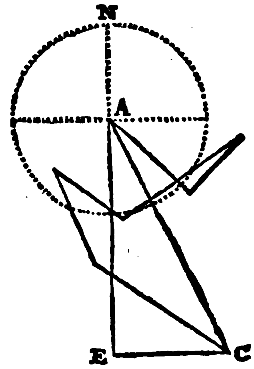
QUEST.

Digitized by Google

QUEST. VI. *The last 24 hours we have run the following courses, viz.*
1st. SE. 40 m. 2d NE. 28 m. 3d. SW. b. W. 52 m.
4th. NW. b. W. 30 m. 5th. SSE. 36 m. 6th. SE. b. E. 58 m.
Required the diff. latitude, departure, direct course, and distance?

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
SE.	40		28,3	28,3	
NE.	28	19,8		19,8	
SW. b. W.	52		28,9		43,2
NW. b. W.	30	16,7			24,9
SSE.	36		33,3	13,8	
SE. b. E.	58		32,2	48,2	
		36,5	122,7	110,1	68,1
			36,5	68,1	
		D. lat.	86,2	42,0	Dep.

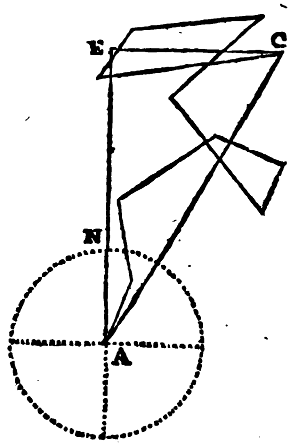


For the course. As 86,2m. : 42m. : : rad. : t. 25° 59′. Or SSE. ¼ E. nearly.
For the distance. As s. 25° 59′ : 42 m. : : rad. : 95,87 m.

QUEST. VII. *Yesterday noon we were in lat. 3° 18′ S. and since then we have plied on the following courses, viz.*
1st. NNE. 22 m. 2d. N. b. W. 30 m. 3d. NE. b. E. 40 m.
4th. ESE. 25 m. 5th. SSW. 18 m. 6th. NW. b. N. ½ W. 50 m.
7th. NE. ½ E. 42 m. 8th. W. b. S. ½ W. 45 m. 9th. SW. b. S. 20 m.
10th. E. b. N. ¼ E. 62 m. *Required our present lat. and departure with the course and distance made good?*

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
NNE.	22	20,3		8,4	
N. b. W.	30	29,4			5,8
NE. b. E.	40	22,2		33,3	
ESE.	25		9,6	23,1	
SSW.	18		16,6		6,8
NW. b. N. ½ W.	50	38,6			31,7
NE. ½ E.	42	26,6		32,5	
W. b. S. ½ W.	45		4,4		44,8
SW. b. S.	20		16,6		11,1
E. b. N. ¼ E.	62	9,1		61,3	
		146,2	47,2	158,6	100,2
		47,2		100,2	
		99,0	D. lat.	58,4	Dep.

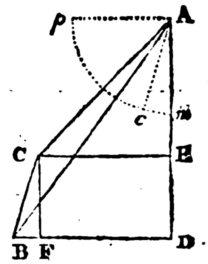


For the course. As 99 m. : 58,4 m. : : rad. : t. 30° 32′. Or NNE. ¾ E.
For the dist. As s. 30° 32′ : 58,4 m. : : rad. : 115, the distance.
And 3° 18′—1° 39′=1° 39′ S. the present latitude.

QUEST.

QUEST. VIII. *Yesterday noon we were in lat. 33° 15′ N. and bound to a port in lat. 28° 35′ N. lying 196 miles to the west; and this day at noon we were in lat. 30° 20′ N. having made 168 miles of westing: Required the direct course and distance to our intended port?*

Lat. from	33° 15′ N.		Lat. from	33° 15′ N.	
Lat. to	28 35 N.		Lat. in	30 20 N.	
Diff. lat.	4 40=280 m.		Diff. lat.	2 55=175	



The figure is constructed by art. 39.

Thus. In the meridian take AD=280, AE=175; in DB, EC, drawn parallel to the parallel of lat. A*p*, take BD=196, EC=168; draw AB, AC, CB; and draw CF parallel to AD, and A*c* parallel to CB.

Then A is the place sailed from; C the place come to; B the place bound to; CB the distance the ship has to sail; and the arc *mc* measures the angle of the course she must sail on.

From AD	= 280	From DB	= 196
Take AE	= 175	Take CE=FD	= 168
Leaves ED=CF	= 105	Leaves BF	= 28

In the triangle CFB.

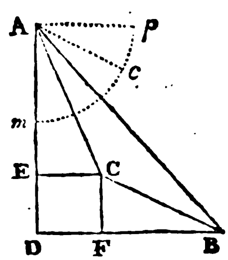
To find the course.			To find the distance.		
As CF, diff. lat.	=105	7,97881	As sin. co.	=14° 56′	0,58889
To BF, dep.	=28	1,44715	To dep.	=28 m.	1,44716
So rad.	=90° 00′	10,00000	So rad.	=90 00	10,00000
To t. ∠ BCF, t.co.	=14 56	9,42596	To dist.	=108,6	2,03605

Answer: Course is S. 14° 56′ W. or S. b. W. ¼ W. Dist. 108,6 miles.

QUEST. IX. *A ship from latitude 14° 25′ N. and bound to a port in latitude 5° 18′ N. lying 476 miles to the eastward, finds she has made 400 miles of southing, and 150 of easting: Required the course and distance she has to sail, to reach her intended port?*

The figure is constructed by art. 39.

Lat. from	14° 25′ N.
Lat. to	5 18 N.
Diff. lat.	9 7=547 miles.



AD	= 547	DB	= 476
AE	= 400	EC=DF	= 150
ED=CF	= 147	FB	= 326

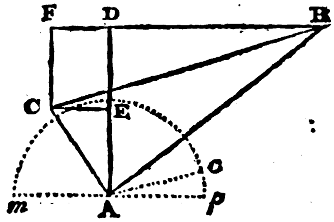
Then CF : FB : : rad. : t. ∠ BCF. Or 147 : 326 : : t. 45° : t. 65° 44′.

And s. ∠ FCB : FB : : rad. : CB. Or s. 65° 44′ : 326 : : s. 90° : 357,6.

Answer. Course is S. 65° 44′ E.; or SE. b. E. ¾ E. Distance 357,6 m.

Digitized by Google

QUEST. X. *Four days ago we were in lat. 4° 39′ S. long. 83° 16′ E. of London; and now we are in lat. 0° 35′ N. having made 200 miles of westing: Required our present course and distance to Achen in the Island of Sumatra?*



The fig. is constructed by art. 39.

Lat. from	4° 39′ S.	
Lat. to	5 15 N.	
Diff. lat.	9 54 = 594 miles.	

Lat. from	4° 39′ S.		Long. from	83° 16′ E.	
Lat. in	0 35 N.		Long. to	95 55 E.	
Diff. lat.	5 14 = 314 miles.		Diff. long.	12 39 = 759 miles.	

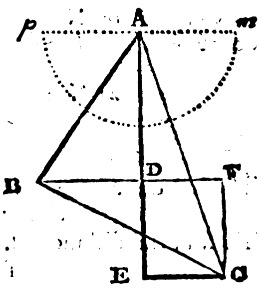
AD = 594 DB = 759
AB = 314 FD = 200 = CE

ED = 280 = CF. FB = 959

In the triangle CFB, to find the course and distance.
As CF : FB : : rad. : t. ∠FCB. Or 280 : 959 : : t. 45° 00′ : t. 73° 43′.
As s. ∠FCB : FB : : rad. : CB. Or s. 73° 43′ : 959 : : s. 90° 00′ : 999.

Answer { The course is N. 73° 43′ E. or ENE. ½ E.
The distance is 999 miles.

QUEST. XI. *A ship from the lat. 10° 38′ N. and bound to a port lying 282 miles to the S. W. b. S. after three successive days of bad weather, finds herself in lat. 3° 58′ N. and 120 miles to the eastward: Required her present course and distance to her intended port?*



The figure is constructed by art. 39.

In the triangles ABD, find AD and BD.

As rad. : AB : : s. ∠B : AD.
Or rad. : 282 : : s. 56° 15′ : 234,5.
And rad. : AB : : s. ∠BAD : BD.
Or rad. : 282 : : s. 33° 45′ : 156,6.

Lat. from	10° 38′ N.	AE	=400	BD	= 156,6
Lat. in	3 58 N.	AD	=234,5	EC = DF	= 120
Diff. lat.	6 40 = 400 m.	DE = CF	=165,5	BF	= 276,6

In the triangle CFB find the course and distance.
As CF : FB : : rad. : t. ∠FCB. Or 165,5 : 276,6 : : rad. : t. 59° 6′.
As s. ∠FCB : FB : : rad. : CB. Or s. 59° 6′ : 276,6 : : rad. : 322,4.

Answer { Course is N. 59° 6′ W. Or NW. b. W. ¼ W.
Distance is 322,4 miles.

QUEST.

QUEST. XII. *A ship in the lat.* 17° 10′ *N. is bound to a port in the lat. of* 13° 10′ *N. the departure being* 180 *miles westward, sails these courses.*

1st. SW. b. W. 27 m. 2d. WSW. ½ W. 30 m. 3d. W. b. S. 25 m.
4th. W. b. N. 18 m. 5th. SSE. 32 m. 6th. SSE. ¼ E. 27 m.
7th. S. b. E. 25 m. 8th. South. 31 m. 9th. SSE. 39 m.

Required her present latit. and the direct course and distance to the desired port B.

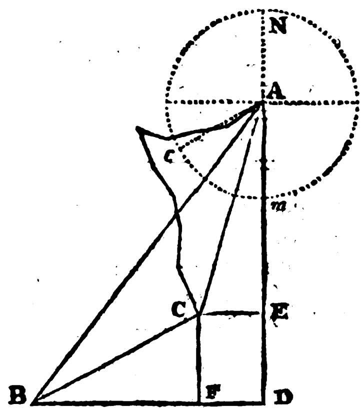
The figure is constructed by art. 39.

Departed lat. 17° 10′ N.
Lat. bound to 13 10 N.

Diff. lat. 4 00 = 240 m.

TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
SW. b. W.	27		15,0		22,4
WSW. ½ W.	30		8,7		28,7
W. b. S.	25		4,9		24,5
W. b. N.	18	3,6			17,7
SSE.	32		29,6	12,2	
SSE. ¼ E.	27		23,1	13,9	
S. b. E.	25		24,5	4,9	
South.	31		31,0		
SSE.	39		36,0	14,9	
		3,6	172,8	45,9	93,3
			3,6		45,9
		D.lat.	169,2	Dep.	47,4



Now 17° 10′ N. = Dep. lat.
60) 169 (2 49 S. = Diff. lat.

14 21 N. = Pres. lat.

And AD = 240,0
AE = 169,2

CF = ED = 70,8

Also BD = 180,0
CE = 47,4 = FD

BF = 132,6

In the triangle CFB;

To find the course. CF : FB : : rad. : t. ∠ FCB.
Or, 70,8 : 132,6 : : rad. : t. 61° 54′.

To find the distance. s. ∠ FCB : FB : : rad. : CB.
Or, s. 61° 54′ : 132,6 : : rad. : 150,3.

Answer { The present latitude is 14° 21′ N.
Course is S. 61° 54′ W. or SW. b. W ½ W.
Distance is 150,3 miles.

In this question A is the place the ship sails from.
B is the place she is bound to.
C is the place come to by the traverse.
And CB is the rhumb she must sail on to come to B.

QUEST.

Digitized by Google

QUEST. XIII. *Yesterday at noon we were in latitude* 0° 15′ *S. and bound to a port bearing NE. b. N.* ½ *E. in latitude* 2° 15′ *N.; by the log we have run the following courses, viz.*

NW. 25 m.	NE. b. E. 28 m.	E. b. S. ¾ E. 32 m.	NNE. 41 m.
ESE. ½ E. 24 m.	NE. b. N. 39 m.	WSW. 24 m.	

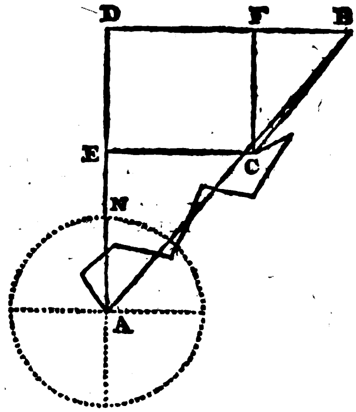
Required the ship's place, with the direct course and distance to the intended port?

The diff. lat. AD = 150 m.

In the triangle ADB, the departure DB will be found to be 123 m.

In the traverse, the diff. lat. AE = 82,6; and the departure EC = 75,5 miles.

In the triangle CFB, where CF = 67,4; FB = 47,5; the course is N. 35° 14′ E. or NE. b. N. ¼ E.; and the distance is 82,51 miles.



QUEST. XIV. *A ship from the latitude of* 18° 14′ *N. is bound to a port bearing SW. b. S.* ½ *W. and* 138 *miles to the westward; having sailed the following courses, viz.*

SSW. 22 m.	S. b. E. ½ E. 38 m.	NNE. 30 m.	WSW. 57 m.
NNW. 45 m.	S. b. W. ½ W. 50 m.		

Required the ship's place, with the direct course and distance to the desired port?

In the triangle ADB, the diff. lat. AD will be found to be 168,2 miles.

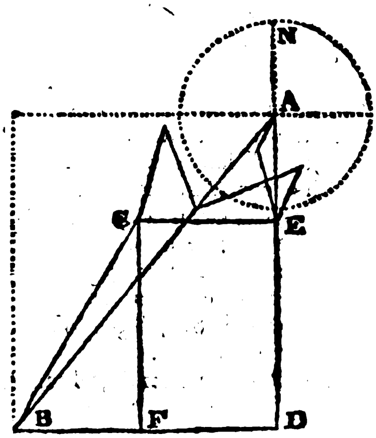
In the traverse, the diff. lat. AE = 57 m. and the departure CE = 70,3 m.

In the triangle CFB, where CF = 111,2; FB = 67,7.

The course is S. 31° 20′ W. or SSW. ¼ W.

The distance is 130,2 miles.

Latit. from	18° 14′ N.
Diff. of lat.	0 57 S.
Latit. in	17 17 N.



QUEST.

QUEST. XV. *A ship in the lat. 1° 00′ S. is bound to a port in lat. 1° 10′ N. distance 220 miles in the NW. quarter; and meeting with contrary winds, runs the following courses, viz.*

NE. b. N. 63 m NW. ¼ W. 85 m. North 96 m. NNW. 87 m.

Required the ship's place, and the course and distance to her port?

In the triangle ADB, the course DAB will be found = 53° 47′; and the departure DB = 177,5 miles.

In the traverse, the difference of lat. AE = 285,9.

The depart. BC = 61,3,

In the triangle CFB.

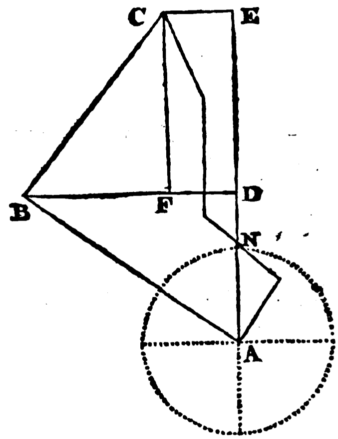
Where CF = (AE—AD =) 155,9.

BF = (DB—CE =) 116,2.

The course FCB = 36° 42′.

The dist. CB = 194,4.

Answer { The pres. lat. 3° 46′ N. The course SW. b. S. ¼ W. Distance 194,4 m.

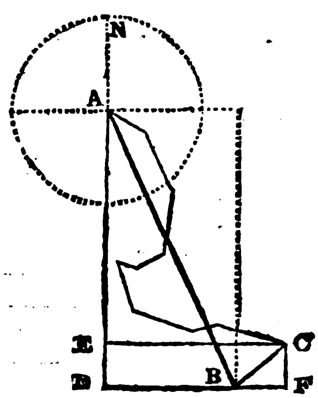


QUEST. XVI. *A ship in the lat. 1° 36′ N. is bound to a port lying to the S. eastward, distant 420 miles, and 180 to the eastward; and having plied on the following courses, viz.*

SE. b. E. 59 m. SSE. ½ E. 84 m. S. ¼ W. 92 m. WSW. 43 m.
W. b. N. 25 m. S. b. E. ½ E. 62 m. ESE. 89 m. E. b. N. 37 m.
ESE. ½ E. 95 m.

Desires to know her place, and the direct course and distance to her port?

In the triangle ADB.
The course is S. 25° 23′ E.
The diff. lat. AD = 379,5.
In the traverse AEC.
The diff. lat. AE = 324,2.
The depart. EC = 247,4.
The pres. lat. is 3° 48′ S.
In the triangle CFB.
The diff. lat. CF = 55,3.
Departure FB = 67,4.
Course is S. 50° 38′ W.
Or SW. ½ W.
The distance CB = 87,18 miles,

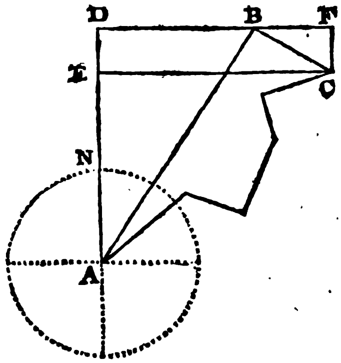


QUEST.

Digitized by Google

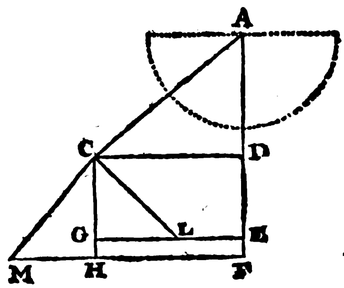
QUEST. XVII. *A ship from the latitude of 4° 10′ N. being to make an Island that bears NE. b. N. distant 196 miles, and having run these courses, viz.* NE. ½ E. 75 m. ESE. ¼ E. 42 m. NNE. ¼ E. 52 m. N. b. W. 34 m. ENE. ½ E. 49 m. *It is desired to know her present latitude, with her direct course and distance to the Island?*

In the triangle ADB.
The diff. lat. AD=163.
The depart. BD=108,9.
In the traverse AEC.
The diff. lat. AE=128.
The depart. EC=160.
And the present lat. 6° 18′ N.
In the triangle CFB.
The diff. lat. CF=35.
The depart. FB=51,1.
The course is N. 55° 36′ W.
Or NW. b. W. nearly.
The distance CB=61,93 miles.



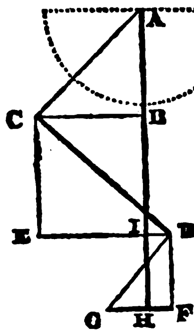
QUEST. XVIII. *Two ships take their departure from the Lizard in latitude* 49° 57′ *N.; one bound to St. Michael's which lies* 715 *m. to the S. and* 745 *m. to the west; the other bound to Lisbon, lying* 661 *m. to the S. and* 215 *m. to the west, reckoning from the Lizard; they sail in company SW.* ½ *W.* 610 *miles, and then part: What is the direct course and distance of each ship to her port?*

In the triangle ADC.
The diff. lat. AD=387 m.
The depart. DC=471,5 m.
In the triangle CGL.
The course is S. 43° 07′ E.
Or SE. b. S. ¼ E. nearly.
The distance CL=375,3. m.
In the triangle CHM.
The course is S. 39° 49′ W.
Or SW. b. S. ½ W. nearly.
The distance CM=427,1 m.



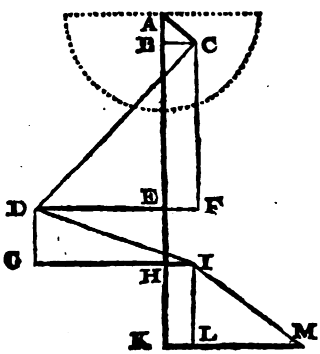
Digitized by Google

QUEST. XIX. *A ship in lat. 43° 20′ N. long. 15° 10′ W. is bound to St. Michael's, bearing S. 46° 16′ W. in the lat. 37° 45′ N; and from thence she is bound to Madeira, in lat. 32° 25′ N. and distant from St. Michael's 514 m. in the SE. quarter: Required the distance to St. Michael's, the course from thence to Madeira, together with the course and distance from Madeira to the Island of Palma, in lat. 28° 36′ N. long. 18° 00′ W.*



In the triangle ABC.
The distance to St. Michael's, AC=484,6 m.
The departure BC=350,1 m.
In the triangle CED.
The course from St. Michael's to Madeira is S. 51° 30′ E. or SE. ½ E. nearly.
The depart. ED=402,3 m.
In the triangle DFG.
The course from Madeira to Palma is S. 44° 07′ W. or SW. nearly.
The distance DG=318,9 m.

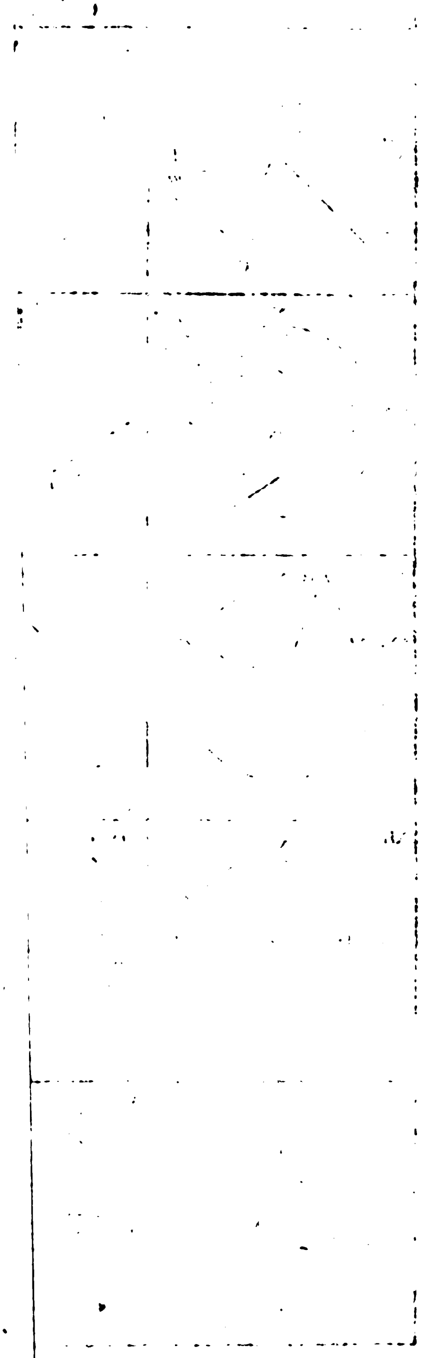
QUEST. XX. *Departing from St. Mary's, one of the Azores, and bound to the river Sierra Leon, after running SE. 36 hours, at 7 knots an hour, my sea compass was spoiled by a flash of lightning; then after 8 days direct run between the S. and W. I met a ship in lat. 20° 00′ N. long. 36° 10′ W. and bound to Mayo, one of the Cape Verd Isles, to which I sailed in her company: Required my course and distance in the 8 days run; also the same, while I sailed in company; and the same, from Mayo to Sierra Leon.*



In the triangle ABC.
The diff. lat.=depart. or AB=BC=178,2 m.
In the triangle CFD.
The course was S. 43° 13′ W. or SW. b. S. ¾ W. nearly.
The distance CD=1195 m.
In the triangle DGI.
The course to Mayo at I, was S. 69° 56′ E. or ESE. ¼ E. nearly.
The distance DI=836,8 m.
In the triangle ILM.
The course to Sierra Leon at M was S. 58° 29′ E. or SE. b. E. ¼ E. nearly; and the dist. IM=770.7 m.

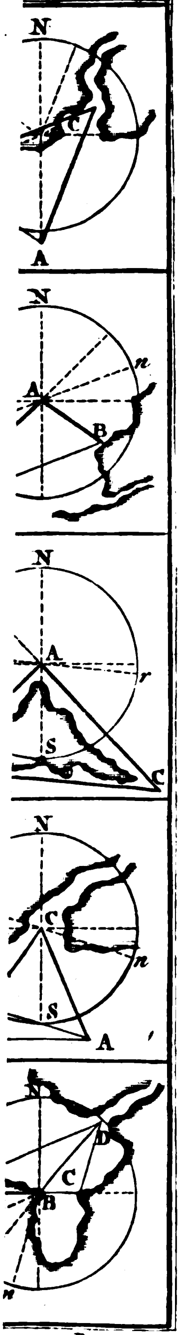
SECTION

Digitized by Google



Digitized by Google

Pl. VIII.



Page 36

Digitized by Google

SECTION VI.

41. *Of oblique Sailing.*

In the preceding ſections the bearing and diſtances of places were determined by the ſolution of right-angled triangles; but at ſea there being many caſes in which only oblique poſitions can be obſerved, therefore it is neceſſary to ſhew how ſuch caſes are to be ſolved; which will be amply illuſtrated in this, and ſome of the following ſections.

To ſet an object is to obſerve what rhumb or point of the nautical compaſs is directed to it.

The bearing of an object is the rhumb on which it is ſeen; and the bearing of one place from another, is reckoned by the name of the rhumb paſſing through thoſe two places.

In every figure relating to any caſe of plane ſailing the bearing of a line, not running from the center of the circle or horizon, is found by drawing a line parallel thereto, from the center, and toward the ſame quarter.

The figures belonging to the queſtions in this ſection are in Plate VIII. at the end, in which the figures are referred to by the number of the queſtion.

QUEST. I. *Two ſhips,* A *and* B, *ſail from two Iſlands bearing the one from the other NE. and SW. their diſtance being* 76 *miles;* A *ſails S. b. E. and* B *runs E. b. S. at laſt they meet: How far has each ſailed?*

CONSTRUCTION. With the chord of 60° deſcribe a circle repreſenting the horizon of one of the places ſailed from, ſuppoſe of A, the northern; draw the meridian NS, and at right angles to it draw the parallel of latitude EW.

In this circle lay off the *SW.* rhumb S *o*, the *S. b. E.* rhumb S *p*, and the *E. b. S.* S *m*: through *o* draw AB equal to 76 miles.

Through B draw BC parallel to A *m*, meeting A C drawn through *p*.

Then A and B repreſent the places ſailed from; AC and BC the diſtances, and the angles S A C and S A *m* the courſes which the ſhips had ſailed when they met at C.

The diſtances AC and BC may be meaſured on the ſcale which AB was taken from.

COMPUTATION. In the triangle ABC there is given one ſide AB, and all the angles, to find the other ſides.

Thus, ∠A=5 pts.=56° 15. For S *o* and S *p* make 5 pts. meaſ. ∠A.
∠B=5 pts.=56 15. For BC is paral. A *m*; and ∠B=∠BA*n* (II. 95)=5pts.
∠C=6 pts.=67 30. For BC is paral. A *m*; and ∠C=∠CA*m* (II. 95)=6pts.

Therefore the ſolution belongs to Problem I. Book III. 45.

And ſ. ∠C : AB :: ſ. ∠A : BC. Or, As ſ. 67° 30′ : 76 m. :: ſ. 56° 15′ : 68,4 m.

Now as ∠B=∠A: Therefore AC is equal to BC. (II. 104)

ANSWER. { A ſails S. b. E. 68,4 miles.
B ſails E. b. S. 68,4 miles.

 QUESTION

Digitized by Google

QUESTION II. *Coasting along shore, a headland bore NE. b. N.; then having run E. b. N. 15 miles, the headland bore WNW.: Required the distance from the headland at each time of setting.*

The construction and computation of this question is made as in Quest. I.; C being the headland, and AB the ship's run.

ANSWER, the distance is { 8,496 m. at first setting. / 10,81 m. at second.

QUESTION III. *In doubling a cape, I observed a castle up a river bore due N.; then running NW. 6 miles, the castle bore NNE.: Required my distance from the castle at each time of setting.*

Here C is the castle, and AB the ship's run.

ANSWER, the castle's distance at { first is AC = 14,48 m. / last is BC = 11,08 m.

QUESTION IV. *At noon a headland bore NW. b. W.; then sailing NNE. 5 miles an hour, we anchored at 9 in the evening in a creek 18 leagues distant from the headland: Required its distance at noon, and bearing from the creek.*

CONSTRUCTION. Having described the horizon, and drawn the meridian and parallel, in the meridian take any point A for the ship's place at first: draw the NW. b. W. and NNE. rhumbs, and parallel to them draw AB, AC.

Make AC=45m. (=9h.×5 m.): and from C with 54 m. (=18 l. ×3) cut AB in B. Then is B the headland, and C the creek.

COMPUTATION. Here is given the side AC=45 m.; the side CB =54 m. and the ∠A=78°.45=7pts. for NW. b. W. + 2 pts. for NNE. =7 points.

Therefore the solution falls under Problem I. Book III. 45.

And ∠B=54° 49′; therefore ∠C=46° 26′; and AB=39,9 miles.

Draw *ao* parallel to CB, then ∠CBA=∠*oan*=54° 49′.

Therefore ∠*oan*—∠*naw*=∠*oaw*=21° 04′; which taken from 90° 00′ leaves 68° 56′.

ANSWER, the headland's { distance at noon is 39,9 miles. / bearing from the creek is S. 68° 56′ W. or WSW. ¼ W. nearly.

QUESTION V. *A ship, after sailing SE. b. S. 62 leagues from her port in lat. 29° 16′ N. met a sloop that had run 124 leagues from a place bearing W. b. N. of the port the ship departed from: What was the sloop's course, and the distance of the two ports?*

The construction and computation being made as in the last, A and B represent the ports sailed from; and C the place where the vessels met.

ANS. { The distance of the ports 72,18 leagues. / The sloop's course along CB is S. 58° 03′ E. or SE. b. E. ¼ E. nearly.

4 QUEST.

Digitized by Google

QUESTION VI. *A merchant ship meeting with a ship of war which had sailed SE. b. E. 39 leagues from the latitude of 45° 30′ N. informed them, that she had been plundered the day before in the same latitude; and had since run 67 leagues on a direct course between the south and west; aud that the pirates were cruising about the place where they robbed her: What course must the man of war steer to come up with them?*

Suppose A the place the man of war sailed from, B the place where the merchantman was robbed, C the place where they met; then the man of war must sail along CB to meet the pirates; which course will be shewn by *c n* drawn parallel to CB.

Here the given distance AC is not drawn from the center of the circle representing the horizon, but parallel to *co* the given course; this was done, to prevent the figure from being so small as it must otherwise have been.

Here are two given sides and an angle opposite to one of them, to find the angle B opposite to the other side A C.

Then CB : s. ∠A :: AC : s. ∠B. That is, As 67 l. : s. 33° 45′ :: 39 l. : s. 18° 52′.

ANSWER. The course which the man of war must steer is N. 71° 08′ E.

For ∠*nc*B = ∠CB*c* (II. 95); and 90° — ∠*ncn* = ∠N*cn*.

QUESTION VII. *Two ships sail at the same time from one port; one sails ESE. and the other SSE.: Required their bearing and distance when each has run 37½ miles.*

Here AB = AC; therefore ∠B = ∠C. Now ∠A = 4 points; then ∠C = ∠B = 6 points.

ANSWER. B bears from C, N. 45° E. distant 28,7 miles.

QUESTION VIII. *Sailing on a SW. course at the rate of 4½ miles an hour, at 9 o'clock in the forenoon a cape bore SE. b. E, distant 15 miles: Required its bearing and distance at 4 o'clock in the afternoon.*

ANSWER. The cape B bears N. 68° 08′ E. distant 37,44 miles.

Here the ship is at A at 9 o'clock, and at C at 4 o'clock: the two sides AC, AB, and the contained angle A = 9 points, are given, to find the rest.

QUESTION IX. *Wanting to know the breadth of a river in the mouth of which are several islands; from a cliff on the eastern side, I sailed NNW. 50 miles; and then running SSW. 35 miles, I reached the western shore: Required the breadth between those places.*

Here AB = 50 m. BC = 35 m. and ∠B = 4 points; required AC.

ANSWER. The breadth between A and C is 35,35 miles.

Digitized by Google

QUESTION X. *From two ports, lying under the same meridian, and distant 236 miles, two ships sail toward the east, and meet when each has run 372 miles: Required the course of each.*

In Fig. X. A and B are the ports sailed from, and C the place where the ships met. Here are given the three sides; but two of them being equal, the solution is easily found by drawing the perpendicular CD. (III. 49)

ANSWER. A's course is S. 71° 30′E. and B's course N. 71° 30′ E.

QUESTION XI. *Two ships meeting at sea, find they had sailed from two ports in the same latitude, and distant 576 miles: the ship from the western port had run between the N. and E. 328 miles, and the other had sailed 416 miles: Required the course steered by each ship.*

A and B are the ports sailed from, and C the place where the ships met. From the three given sides, the angles may be found by B. III. 49 or 50.

ANSWER. The course from A is N. 44°49′E. and from B is N. 55°59′W.

QUESTION XII. *A sloop in three days coasted round a triangular-shaped island: the first day she ranged along one side, and her courses reduced to one was SW. distance 64 miles; the second day's distance was 106 miles between the S. and E.; and that of the third day was 83 miles: Required the direct courses of the second and third days.*

In Fig. XII. The first day's distance is AB, the second BC, the third AC. And the figure is thus constructed.

Having described the horizon, and drawn the meridian and parallel (22), their intersection A is taken for the place which the ship sailed from; draw the SW. rhumb AB=64 miles; from A and B describe arcs with the radii 106 and 83; to their intersection C, draw the lines BC, AC.

Draw the line A *r* parallel to BC, and continue CA to *o*.

Then the arc S *r* measures or gives the second day's course.

And the arc N *o* the course of the third day.

Now the angles being found by either method, as in Book III. 62.; the courses will be thus obtained.

From ∠BAC take 4 points=∠SAB, there remains ∠SAC.

Then arc S *r*, or ∠SA*r*=∠SAC+∠C (=∠CA*r* by II. 95) for the second course.

And arc N *o*, or ∠NA*o*=∠SAC (II. 93) is the third day's course.

ANSWER. The second day's course is S. 83° 29′E. and the third day's N. 46° 21′ W.

The directions given for this 12th question may be applied to the two preceding ones.

QUEST.

Digitized by Google

QUESTION XIII. *Sailing into a harbour I observed two landmarks, the one bore E. the other W.; and after running S. 3,3 miles, the eastern one bore N. 58° 30′ E. and the western one N. 47° 20′ W.: Required my distance from those landmarks at each time of setting them.*

The ship is supposed first at A, and to see the landmarks C and D in the lines AC, AD; then sailing to B, she sees the same marks in the lines BC, BD, drawn parallel to the given rhumbs A *n*, A *o*.

Here are two right angled triangles BAC, BAD to work in; there being known in each, the side AB, and all the angles; whence the solution will be as in Book III. 45.

ANSWER. AD=3,58 m. AC=5,385 m. BD=4,87 m. BC=6,316 m.

QUESTION XIV. *Coasting along shore I observed two islands, the one bore E. and the other W.; then sailing SSE. ½ E. 16½ miles, the western island bore NW. b. W. ½ W. and the eastern bore NE. ½ E.: Required their distance at each time of setting them.*

Here are two oblique angled triangles to work in; and the solution will be as in Book III. 54; there being one side AB and all the angles known.

ANWSER. AC=19,45 m. AD=25,51 m. BC=30,88 m. BD=22,94 m.

QUESTION XV. *Three ships,* B, C, D, *sail from the same road* A, *and bound to different ports lying in the same parallel of latitude;* B'*s course is NW. b. N. distance* 12 *miles;* C'*s course NE. b. E.; and* D'*s course is ENE. ½ E.: Required the distance of* C *and* D *from their ports, and also the distance of those ports from one another.*

Having described the horizon, and drawn the meridian and parallel, let their intersection C represent C's port, draw the given rhumbs C *o*, C *n*, C *r*: make C *o*=12 miles; produce *n*C towards A, and parallel to *n*A draw *o* B, meeting the west line in B; draw BA parallel to *o* C, and draw AD parallel to C *r*, meeting the east line in D: then A is the port sailed from, and B, C, D, are the ports bound to.

The solutions of these triangles are the same as in Book III. 54; there being given one side and all the angles.

Thus ∠BAC=8 points, ∠B=5 points, ∠BCA=3 points.

The ∠BAD=9½ points, ∠D=1½ point.

ANSWER. AC=17,96 m. AD=34,36 m. BC=21,6 m. BD=39,56 m.

Digitized by Google

QUESTION XVI. *Two ships,* A *and* B, *sail from the port* C; A *sails SSE.* 50 *miles, and* B *SW. b. S,* 40 *miles: Required their bearing and distance; and how far* A *is to the southward and eastward of* B.

Describe the horizon, draw the meridian and parallel, and their intersection C represents the port sailed from.

Draw the given rhumbs, in which take CA=50, CB=40: then A and B represent the places to which the ships are come.

Draw AB; and through B draw the meridian BD, meeting the parallel AD drawn through A: then BD is the difference of latitude, DA the departure, and BA shews the bearing and distance sought.

In the triangle CBA, find the unknown angles, and side BA by art. 60. Book III.

Draw C*n* parallel to BA; then ∠SCA + ∠CAS (= ∠ACn (II. 95)) gives ∠SCn the bearing from B to A: and ∠SCn taken from 90° leaves ∠BAD: hence BD, DA, are found by art. 52. Book III.

ANSWER. BA=43,33 miles, BD=12,93 miles, DA=41,36 miles.
And the bearing from B to A is S. 72° 38′ E.

QUESTION. XVII. *At sun-rise, being four o'clock, a ship saw a sloop to the WNW. and a brig to the E. b. N.; they all came to anchor along-side one another at nine o'clock, each having run since sun-rise five knots an hour, and the ship's course was due north: Required the courses sailed by the sloop and brig, and their distance from the ship in the morniug when she set them.*

Draw the *WNW.* and *E. b. N.* rhumbs *ao, an*; assume any point D in the meridian line for their anchoring place, and in the same line take DA=25 miles=the distance each sailed; through A draw AC, AB, parallel to *a o, a n*, and on D with the radius DA describe a circle cutting AC, AB, in C, B: then A is the ship's place, C the sloop's, and B the brig's, at four in the morning.

Now ∠C=∠DAC=∠D *ao*=6 points; therefore ∠ADC=4 points.
And ∠B=∠DAB=∠D *an*=7 points; therefore ∠ADB=2 points.
The sides AC, AB, will be found by art. 56. Book III.

ANSWER. { CA=19,13 miles, and C's course is NE.
BA=9,755 miles, and B's course is NNW.

QUESTION XVIII. *Having dropped anchor in a very deep water, in a river, with a buoy and rope of* 50 *fathoms fixed to it, I fell down the stream till I had veered out* 140 *fathoms of cable, and then the buoy was* 120 *fathoms a-head of me: Required the depth of water.*

Construct the triangle ABC with the three given sides, letting CA=120 be horizontal to represent the surface of the water.

Draw

Digitized by Google

Draw BD perpendicular to CA continued; then B represents the anchor, A the buoy, C the ship, and BD the depth of the water.

In the triangle ABC find (III. 50) the angle ACB; then in the right angled triangle CDB, the side CB and all the angles being known, the side BD may be found, as in art. 52. Book III.

ANSWER. The depth of water DB is 48,71 fathoms.

QUESTION XIX. *Coming within sight of two headlands bearing North and South of each other, the southern one bore from the ship due East, and the other NE. b. E.; and after sailing due East 5 miles, the northern headland bore NE. b. N. ½ E.: Required the distance of those headlands from one another, and their distance from the ship at each time of setting them.*

In the east and west line take BA=5 miles; draw the *NE. b. E.* and *NE. b. N.* ½ *E.* rhumbs B*n*, BD; through A draw AD parallel to B*n*, meeting BD in D; draw DC perpendicular to AB continued.

Then D and C are the headlands; A, B, are the ship's places at the times of setting them, and AB the distance sailed.

Now ∠A=(∠CB*n* by II. 95=) 3 points; the ∠DBC=4½ points.

Then ∠ ABD=11½ pts. (II. 91); ∠ADB=½ pt. and ∠ BDC=3½ pts.

In the triangle ABD having the side AB, and the angles given, find the sides AD, BD, by art. 52. Book III.

And in the right angled triangle BCD, knowing the side BD, and all the angles, find the sides BC, CD.

ANSWER. AD=13,31 m. BD=9,565 m. BC=6,07 m. CD=7,395 m.

QUESTION XX. *Having cast anchor, I observed the bearings of a tower, a mill, and a lighthouse, known to lie due east and west of one another; the tower bore WSW. the mill SW. b. S. ½ W. and the lighthouse S. b. W. ½ W.; the distance of the tower from the mill is 5½ miles: How far are each of those objects distant from the place where I anchored?*

Draw the given rhumbs B*r*, B*o*, B*n*; make BA=5½ miles; continue CB till it meets AD, drawn parallel to B*r*, in D; draw DC parallel to B*n*: then D represents the ship's place, A the tower, B the mill, and C the lighthouse.

The angles are made out, and the triangles are solved, as in the last question.

ANSWER. DA=9,021 m. DB=4,46'. m. DC=3,608 m. and BC=1,785 miles.

SECTION

Digitized by Google

SECTION VII.

Of Sailing to Windward.

42. When the wind is directly, or partly, against a ſhip's direct courſe to the place ſhe is bound to, ſhe reaches her port by a kind of zigzag, or z like courſe; which is made by ſailing with the wind firſt on one ſide of the ſhip, and then on the other.

In a ſhip, and looking toward the *ſtem* or *head*,

STARBOARD ſignifies the right hand ſide.

LARBOARD the left hand ſide.

FORWARD or AFORE, is toward the head or ſtem of the ſhip.

AFT or ABAFT, is toward the hinder part, or ſtern.

The BEAM ſignifies *athwart*, or acroſs, the middle of the ſhip.

43. When a ſhip ſails the ſame way that the wind blows, ſhe is ſaid to ſail or run before the wind; and the wind is ſaid to be *right aft*, or *right aſtern*; and her courſe is then 16 points from the wind.

When the ſhip ſails with the wind blowing directly acroſs her, ſhe is ſaid to have the *wind on the beam*; and her courſe is eight points from the wind.

When the wind blows obliquely acroſs the ſhip, the wind is ſaid to be *abaft the beam*, or *before the beam*, according as her courſe is more or leſs than eight points from the wind.

When a ſhip endeavours to ſail towards that point of the compaſs from which the wind blows, ſhe is ſaid to *ſail on a wind*, or to *ply to windward*.

A veſſel ſailing as near as ſhe can to the point from which the wind blows, is ſaid to be *cloſe hauled*. The generality of ſhips will lie within about ſix points of the wind; but ſloops, and ſome other veſſels, will lie much nearer.

44. The *windward*, or *weather ſide*, is that ſide of the ſhip on which the wind blows; and the other ſide is called the *leeward*, or *lee ſide*.

Tacks and *ſheets* are large ropes made faſt to the lower corners of the fore and main ſails, by which either of theſe corners is hauled fore or aft.

When a ſhip ſails on a wind, the *windward tacks* are always hauled forward, and the *leeward ſheets* aft.

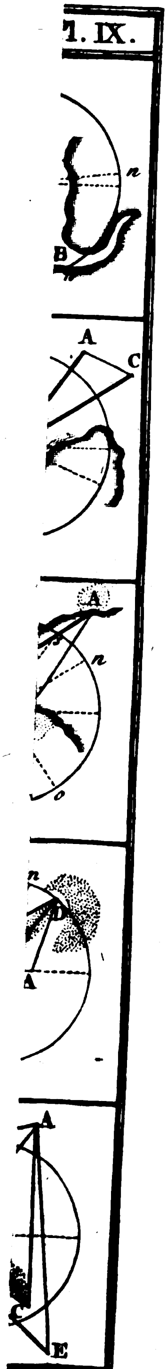
The *ſtarboard tacks are aboard*, when the ſtarboard ſide is to windward, and the larboard to leeward.

And the *larboard tacks are aboard*, when the larboard ſide is to windward, and the ſtarboard to leeward.

45. To know how near the wind a ſhip will lie; obſerve the courſe ſhe goes on each tack, when ſhe is cloſe hauled; then half the number of

Digitized by Google

Digitized by Google



Page 43.

Digitized by Google

of points between the two courses, will shew how near the wind that ship will lie.

46. The most common cases in turning to windward may be constructed by the following precepts:

Having drawn the meridian and parallel of latitude (or east and west line) in a circle representing the horizon of the place, mark the place of the wind in the circumference; draw the rhumb passing through the place bound to, and lay on it the distance of that place from the center.

On each side of the wind, lay off, in the circumference, the points or degrees shewing how near the wind the ship can lie; and draw these rhumbs.

Now the first course will be on one of these rhumbs according to the tack the ship leads with. Draw a line through the place bound to, parallel to the other rhumb and meeting the first, and this will shew the course and distance on the other tack.

The figures referred to in this section are in Plate IX. at the end; where they are marked by the number of the question.

QUESTION I. *The wind is at north, and I am bound to a port 25 miles directly to windward, being on my starboard tacks, and can lie within 6 points of the wind: What must be my course and distance on each of two tacks to reach my port?*

The construction being done as above directed, N is the place of the wind, A the port bound to, and B the place where the ship is supposed to be, when the port is 25 miles to windward of her.

Now as the ship leads with her starboard tacks, that is, has the wind blowing on her starboard side, she must first sail along the line BC drawn parallel to the rhumb A*n*, which is 6 points from the wind; and the place where the other rhumb A*o*, also 6 points from the wind, being produced from A toward C, meets with BC in the point C, is the place where she must tack about to reach her port within 6 points of the wind on her larboard tack.

Here BC being parallel to A*n*, the ∠B=(∠NA*n* by II. 95=) 6 points.

And the ∠BAC=(NA*o*, by II. 93=) 6 points; hence ∠C=4 points.

Therefore, as ∠B=∠BAC; the side BC=side CA. (II. 104)

Now as one side AB, and all the angles are given, the solution falls under Article 45. Book III.

Therefore, As sin ∠C : AB : : sin. ∠BAC : BC.

Or, As sin. 45° 00′ : 25 m. : : sin. 67° 30′ : 32,66.

ANSWER, the ship sails { on her starboard tacks *WNW*. 32,66 miles.
{ on her larboard tacks *ENE*. 32,66 miles.

QUESTION

QUESTION II. *A ship that is bound to a port 80 miles directly to windward, then at NE. b. N. ½ E. proposes to reach her port at two boards each within 6 points of the wind: Required her course and distance on each tack, so as to double a rocky shelf lying in the NW. quarter.*

As the wind is in the *NE.* quarter, and the ship is to double a shelf in the *NW.* quarter, she must lead with her starboard tacks; and running from B, her present place, to C in a parallel to the rhumb A *n*, 6 points from *w* the place of the wind, she then tacks for her port A, in the direction of the rhumb A, *o*, 6 points from *w*.

The manner of solution is the same as in the last question.

ANSWER, she runs on her { starboard tacks NNW. ½ W. 104,5 miles.
larboard tacks ESE. ½ E. 104,5 miles.

QUESTION III. *A ship bound to a port bearing NNE. ½ E. must double a cape to the eastward. Now she having run on her larboard tack 15 leagues within 6 points of the wind then at N. b. E. the port bore NW. b. W. ¼ W.: It is required, how near the wind she must lie on her starboard tack, and what is the distance of the port at each time of setting it?*

Here A is the place of the ship at first, B the port bound to; AC is the run on the larboard tack, and CB that on the starboard tack.

ANSWER. { The distance AB from the port is 10,08 leagues.
The run CB is 11,61 leagues, and 6¼ points from the wind.

QUESTION IV. *A ship being bound to a port bearing SSE. and directly to windward, having run on her larboard tack 83¼ miles within 6¼ points of the wind, on tacking about falls in with a rock at the same distance from her port. What course must she run on her starboard tack, how near the wind, and what was the port's distance at first?*

Here the side AC = CB; therefore ∠B = ∠BAC = 6¼ points.
Hence ∠C = 2½ pts. Also ∠B = ∠BA*n* = 6¼ pts. Therefore ∠NA*n* = 7¾ points.

ANSWER. { Starboard course E. b. N ¼ E. 6¼ points from the wind.
The port's distance at first was 40,47 miles.

QUESTION V. *A privateer lying by with the wind at NNE. sees a sloop on her starboard tacks, that had just doubled a point 18 miles to the W. b. N.; the sloop run for her port within 6 points of the wind; the privateer gave chace at the rate of eight knots an hour, and in four hours came up with her: Required the sloop's rate of sailing, and also the courses of both vessels.*

Draw BA to the *E. b. S.* and equal to 18 miles; on A with 32 m. = 8 × 4, cut the rhumb BC, drawn six points from the wind, at *w*. Then the

the privateer is first at A, sees the sloop at B, gives chace along the line AC, and takes the sloop at C; and B *o* drawn parallel to AC shews the privateer's course from the north.

Here are known two sides, AB, AC, and the ∠ ABC = 13 points.

ANSWER. { The sloop sails NW. at the rate of 3,86 m. per hour $=\frac{BC}{4}$.
The privateer's course N. 63° 12′ W. }

QUESTION VI. *Being within sight of my port, bearing N. b. E. ½ E. distant 18 miles, a fresh gale sprung up at N. E.; then running 48 miles on my larboard tacks within six points of the wind, I tacked about: Required the course and distance to my port.*

From any point A draw AB, AC, parallel to *a o*, *a n*, the *N. b. E.* ½ *E.* and *ESE.* rhumbs, the latter being six points from the wind at *NE.*

Make AB = 18, AC = 48, and join BC. Then the ship, at A, first sees her port at B, and sailing from A to C on the larboard, must go from C to B on the starboard tacks.

Here then are known two sides, and the included angle A = 8½ points. Therefore the solution will be as in Article 48. Book III.

ANSWER. The ship has to sail 52,89 miles on a course N. 47° 42′ W.

QUESTION VII. *A ship bound to a port met a sloop, that had sailed from thence SSW. ½ W. 325 miles, the wind being at N. b. E.; afterward, the ship having plied on her larboard tack for three days, met a vessel which had sailed on a direct course SE. b. E. ½ E. 412 miles, since she departed from that port: Required the ship's course and distance between her meeting those vessels, and how near the wind she lay.*

Here B is the port bound to, A and C are the points where the ship met the vessels, and AC the distance run; parallel to which, a line B *n* being drawn, will shew the course and distance from the wind.

ANSWER. The distance AC = 524,8 m. The course is N. 79° 51′ E. 6¼ points from the wind.

QUESTION VIII. *Having my starboard tacks on board, I met a snow that had sailed NE. b. N. 284 miles from the port I am bound to, and next day I met a brig which had sailed from thence 326 miles, with the wind then at S. b. E., two points abaft the beam: Required my course and distance between the meeting these vessels, and how near the wind I had lain.*

Here B is the port, A and C the places of meeting.
There are known two sides and the contained angle.

ANSWER. { The ship had sailed S. 64° 6′ E. 4¾ pts. from the wind.
The distance run was 125,9 miles. }

QUESTION

QUESTION IX. *The wind at SW. and a ship plying to windward, after running 450 miles on her larboard tacks, and 450 on her starboard tacks, finds she has got 300 miles directly to windward: What were her courses, and how near the wind?*

From any point A draw AB=300 miles, and parallel to the wind rhumb sw; on A, B, with 450 miles, describe arcs cutting in C; then the lines AC, CB, being drawn, will shew the distances run on each tack.

The point C is taken towards the *NW.* quarter, as the ship leads with her larboard tacks; but had she led with her starboard, the point C must have been taken toward the *SE.* quarter.

The rhumbs *a o*, *a n*, being drawn parallel to AC, CB, will shew the courses on each tack.

Here are the three sides given to find the angles; but two of the sides being equal, the solution is readily performed, as in Art. 64. Book III.

ANSWER. { Course on larb. is N. 64° 28′ W. / Course on starb. is S. 25 32 E. } $6\frac{1}{4}$ pts. from the wind.

QUESTION X. *A pirate gave chase to a sloop, 15 miles a-head to the WSW. and both on their starbord tacks, the wind at NW.; the sloop finding she lost way, tacked about for an island in the NW. quarter, 11 miles distant from her, and 13 from the pirate: Required how near the wind the sloop must run to fetch the island, and whether the pirate can lie up for it or not.*

ANSWER. { The sloop's course is N. 10° 05′ E. 5 pts. from the wind. / The pirate's course is N. 66° 54′ W. 2 pts. from the wind. / Therefore he cannot fetch the island. }

QUESTION XI. *Being on a NE. course with my larboard tacks on board, an island bore SW. distant 12 miles, and my port bore NNW.; the distance of the island and port is 40 miles: now the wind is at NNW. ½ W. and I can lie no nearer the wind than 6½ points: Required how far I must run on my present course before I tack about, and also the course and distance I have then to steer.*

In a *SW.* rhumb, from any point A, take AC=12 miles; and on C with a distance of 40 miles cut AB drawn parallel to the *NNW.* rhumb *a n*; now the rhumb *a o* being taken $6\frac{1}{2}$ points from the wind, through B draw BD parallel to *a o*, meeting CA continued in D.

Then A is the ship's place, C the island, B the port bound to; AD is the distance to run on her larboard tacks, and BD on the starboard.

In the triangle CBA there are known CA, CB, and ∠CAB=∠C*an*=10 pts.; then finding AB (III. 57) in the triangle ABD, one side and all the angles being known, the sides AD, DB, are found, as in Art. 54. B. III.

The ∠D=C*ao*=3 pts. ∠BAD=∠D*an*=6 pts. ∠ABD=7 pts.

ANSWER. { The distance run on the NE. course is 59,75 miles. / On the starboard she must run W. b. S. dist. 56,28 miles. }

QUESTION

Digitized by Google

QUESTION XII. *A ship sailing close by a point sees two lighthouses, one 18 miles to the NE. b. E. the other eight miles to the SE. b. S.; the ship is on her larboard tacks, within 6¼ points of the wind, then at SE. b. E.: Required how far she must run to bring the lighthouses to bear in one line; and what will be the bearing and distances of them from the ship at that time.*

From any point C draw CA parallel to *a n* the NE. b. E. rhumb, and equal to 18 miles; also draw CB parallel to *a o* the SE. b. S. rhumb, and equal to eight miles; join AB, and produce it until it meets the line CD, drawn parallel to *a r*, a rhumb 6 ¼ points from the wind at SE.

Then C is the ship's place at first; A, B, are the lighthouses; CD the distance run to see them in one right line DBA; then a rhumb *a s*, drawn parallel to DA, shews their bearing at that time.

In the triangle ACB, knowing two sides and the included ∠C=∠*nao* =8 points, the other angles and side AB is found, as in Art. 46. B. III.

In the triangle ACD, knowing CA, the ∠ACD=∠*nar*=13 ¾ points; also the ∠A found before; the distance CD, AD, are found, as in Art. 55. Book III.

ANSWER. { The ship runs on her larboard S. b. W. ¾ W. dist. 23,38 m.
Then the lighthouses bear N. 32° 17′ E.
The distance of A being 38,66 miles, and of B, 18,96 miles.

QUESTION XIII. *A ship wants to reach a port bearing SW. b. S. at two boards, but must double a point bearing S. b. E. the point being 25 miles to the NE. b. E. of the port; the ship can lie no nearer the wind, now at SW. than 6½ points: Required her course and distance on each tack.*

Take C the point, 25 miles to the NE. b. E. of B the port; through C draw CA parallel to B*n* the S. b. E. rhumb, and its meeting with *o*B the SW. b. S. rhumb produced northward, gives A the ship's place; then AD and DB being drawn in the direction of the rhumbs B*s*, B*r*, 6 ½ points from the wind at *w*, shew the runs on each tack.

In the triangle ABC, there are known BC, ∠BAC=∠*o*B*n*=4 points, ∠ABC=2 points, ∠C=10 points; then AB is found, as in Art. 55. B. III.

In the triangle ABD, AB is now known, ∠BAD=∠*o*B*s*=5 ½ points, ∠ABD=∠*o*B*r*=7 ½ points, ∠D=3 points; hence AD, DB, are found, as in Article 55. Book III.

ANSWER. { Course on starboard is SSE. ½ E. distance 58,51 miles.
Course on larboard is NW. b. W. ½ W. dist. 51,85 miles.

QUESTION XIV. *A privateer lying behind a low point which was 6 miles to the SW. b. W. of her, sees a ship to the SSE. coming out of a port 18 miles distant from the point; the ship steered NW. with a brisk gale at SSW.; the privateer slipt his cable, and gave chace within 6 ½ points of the wind, and takes her: How far had each run when they met?*

Take A, 6 miles to the NE. b. E. of C the point; from C with 18 miles cut AB, drawn parallel to C*o* the SSE. rhumb, and B is the port the ship

Digitized by Google

ship sailed from; then AD drawn 6 ½ points from the wind, meeting BD, drawn NW. the intersection D is the place where the privateer meets the ship.

In the triangle ACB, is given AC, CB, and ∠CAB = ∠nCo = 7 points, to find AB.

Then in Δ ABD, where ∠DAB = ∠rCo = 10½ points, ∠DBA = 2 points; ∠ADB = 3½ points; find the sides AD, BD, as in Article 55. Book III.

ANSWER. { The ship had sailed NW. distance 25,27 miles.
The privateer sailed W. b. N. ½ W. distance 10,96 miles.

QUESTION XV. *A ship that can lie within 6 points of the wind, sees a headland 21 miles to the NE. which she is to weather, in order to reach an island, 9 miles to windward thereof; the wind being at east: What course, and how far must she go on each tack, she leading with the starboard?*

Draw BA = 21 m. to the SW. BC = 9 m. to the East, join AC; draw AD, CD, each 6 points from the wind; then A is the ship's place, B the headland, C the island, AD the run on the starboard tack, and DC that on the larboard.

In the Δ ABC, is given BA, BC, ∠ABC = 12 points to find the other ∠s, and AC.

Then in the Δ ACD, is known AC, and all the angles, to find AD, DC.

Thus ∠D = 4 pts.; ∠DCA = DCB + ∠BCA; ∠CAD = ∠BAD + ∠BAC.

ANSWER. { On the starboard she runs 39,19 miles on the NNE. rhumb.
On the larboard she runs 23,12 miles on the SSE. rhumb.

QUESTION XVI. *There is a certain port, to sail into which you must bring the port and a mill, 4 miles to the east thereof, to bear due west; at which time a beacon, 5 miles to the NE. b. N. ½ E. of the mill, must bear N. b. E. ¾ E; you then steer directly for the beacon, and from thence to the port: Required the best wind, in the NW. quarter, for a ship that goes equally well on both tacks, together with the distance she must run on each tack from the said situation to the port.*

In the W. rhumb take BC = 4 miles, and in the NE. b. N. ½ E. rhumb take BD = 5 miles, join DC, and parallel to the N. b. E. ¾ E. rhumb Bn, draw DA, meeting CB continued in A.

Then C is the port, B the mill, D the beacon, and A the ship's place.

In the Δ BAD, is given BD and all the angles, to find AD.

In the Δ CBD, is given BC, BD, and angle CBD, to find the other angles and DC.

Draw the rhumb Bo parallel to DC; then the ∠nBo being bisected, will give the place of the wind as required.

ANSWER. { She will run on her larb. N. b. E. ¾ E. distance 4,105 miles.
And on her starb. S. 61° 40′ W. distance 8,145 miles.
The best wind is that blowing from the NW. ½ W. nearly.

Digitized by Google

QUESTION XVII. *A ship in doubling a point directly to the east of her port, sees a lighthouse bearing NNW. ½ W. which she knows lies NE. b. N. ½ E. from the port, and is 10 miles to the NE. by E. ¼ E. of a beacon bearing due north of her port; the wind is at W. by N. ½ W. and she can lie within five points: Required her distance on each tack, supposing that she leads with the larboard, and keeps close to the lighthouse when she tacks.*

Let D be the beacon; make DC=10 miles in the *NE. b. E. ¼ E.* rhumb, and C will be the lighthouse; draw CB parallel to the *NE. b. N. ½ E.* rhumb D*n*, and its intersection B with the *S.* rhumb DB is the port; through B and C, lines being drawn parallel to the *E.* and *NNW. ½ W.* rhumbs, their intersection A is the place of the ship.

In the △ CBD there is given DC, and all the angles; hence BC may be found. (III. 55.)

In the △ CBA there is known CB, and all the angles; hence AC is found, as in Article 55, Book III.

Here ∠DBC=$3\frac{1}{2}$ points, ∠BDC=$10\frac{1}{4}$ points, ∠DCB=$2\frac{1}{4}$ points.
And ∠ABC=$4\frac{1}{2}$ points, ∠BAC= $5\frac{1}{2}$ points, ∠ACB=6 points.

ANSWER. { The distance on the larboard tack is 12,49 miles.
The distance on the starboard tack is 14,25 miles. }

QUESTION XVIII. *A ship that can lie on either tack within six points of the wind, then at ESE., having her starboard tacks aboard, sees her port directly to windward, and a headland that lies 6 miles to the NW. of her port, bore E. b. N.; now she wants to reach her port at two boards: Required her course and distance on each, and also the bearing and distance of the headland when she tacks.*

Let C be the headland, and B, six miles to the *SE.* be the port; through C and B draw lines parallel to the *E. b. N.* and *ESE.* rhumbs, their intersection A is the ship's place; lines drawn through A and B, parallel to the rhumbs, six points from the wind, will meet in D, the place where the ship must tack; draw DC, and this shews the position and distance of the headland from the ship when she tacks.

In the △ ACB is given BC and all the angles; find AB=8,979.
In the △ ABD is known AB and all the angles; find AD, BD.
In the △ BCD is known BC, BD, and ∠ CBD; find the other angles and CD.

Here ∠ACB=11 points, ∠CAB=3 points, ∠ABC=2 points.
The ∠BAD= 6 points, ∠ABD=6 points, ∠ADB=4 points, and ∠CBD=4 points.

ANSWER. { Ship runs on starboard 11,73 miles NE.
larboard 11,73 miles S.
Headland bears when she tacks S. 29°32′W. dist. 8,607 m. }

Question XIX. *A ship, on her starboard tacks, passing by a point, saw her port eight miles to the E. b. N. and at the same time a cliff, which lay to the NW. b. W. of the port, bore N. b. E.; the ship could lie within 6½ points of the wind, then at NE. b. E. ½ E. on her starboard tack, and within seven points on the larboard; she proposes to reach the port on two boards: Required her course and distance on each, together with the bearing and distance of the cliff when she tacks about.*

Here the point c is taken for the cliff, in order to bring the figure within the limits; but if A, representing the ship's place, was taken at the center, the construction would be more simple.

In the *E. b. N.* rhumb, take c*a*=8 miles; draw *a*B parallel to the *S. b. W.* meeting CB, drawn *SE. b. E.* in B, which is the port bound to; draw BA parallel to *a*c, meeting the *S. b. W.* rhumb in A, which is the ship's place; through A draw AD, parallel to a rhumb 6½ points from the wind, and through B draw BD parallel to a rhumb seven points from the wind, their meeting D is the place where the ship is to tack; then DC being drawn, shews the bearing and distance of the cliff from the ship when she tacks.

In the △ CAB, is given BC=AB and all the angles, to find CA=6,123.

In the △ ABD, is given AB and all the angles, to find AB, BD.

In the △ ACD, is known AC, AD, and ∠CAD, to find the other angles and CD.

Answer. { Course on starboard is N. b. W. distance 14,96 miles.
Course on larboard is SE. b. S. ½ E. distance 16,97 miles.
The cliff on tacking bore S. 25° 21′ E dist. 9,596 miles.

Question XX. *A sloop at sea discovers two beacons at the extremities of a shoal, the one bearing W. b. S. and the other, which bore S. was nine miles to the S. E b. S. of the northern beacon; the port bound to is known to lie W. b. N. of one beacon, and S. b. W. of the other, and the vessel can lie within 6½ points of the wind, then at SW.: Required the course and distance on each of two boards to gain her port; and also her bearing and distance from the port when she first saw the beacons.*

The construction and solution of this question being not much unlike the two last, are omitted here, to exercise the learner's skill.

Answer. { Course on starboard is SSE. ½ E. distance 16,785 miles.
Course on larboard is NW. b. W. ½ W. 16,054 miles.
Port bore S. 40° 48′ W. distance 9,56 miles.

SECTION

James Macully's Book.

Digitized by Google

SECTION VIII.

Of Sailing in Currents.

47. A Current or Tide is a progressive motion of the water, causing all floating bodies to move that way toward which the stream is directed.

The *setting of a tide*, or *current*, is that point of the compass toward which the water runs; and the *drift of a current* is the rate it runs per hour.

The setting and drift of the most remarkable tides and currents are pretty well known; but in unknown currents the usual way to find the setting and drift, is thus:

Let three or four men take a boat a little way from the ship; and by a rope, fastened to the boat's stem, let down a heavy iron pot, or loaded kettle, into the sea, to the depth of 80 or 100 fathoms, when it can be: the boat will by this means ride almost as steady as at anchor. Then heave the log, and the number of knots run out in half a minute will give the miles which the current runs per hour; and the bearing of the log shews the setting of the current.

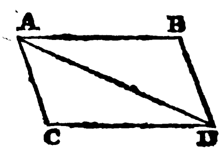
48. A body moving in a current may be considered in three cases:
Namely, Moving with, or the same way the current sets.
Moving against, or the contrary way to that which the current sets.
Moving obliquely to the current's motion.

When a ship sails with the current, it's velocity will be equal to the sum of it's proper motion and the current's drift.

When a ship sails against a current, its velocity will be equal to the difference of the current's drift and its own motion.

So that if the current drives stronger than the wind, the ship will drive astern, or lose way.

When the course set is oblique to the motion of the current, the ship's real course, or that made good, will be somewhere between that in which the ship endeavours to go, and the track in which the current tries to drive it: that is, it will always be along the diagonal of a parallelogram, in which one side represents the distance run by the ship, and the other adjoining side is the current's drift in the same time.



For suppose ABDC be a parallelogram, the diagonal of which is AD.

Now if the wind alone would drive the ship from A to B, in the same time as the current alone would drive it from A to C.

Then as the wind neither helps nor hinders the ship from coming toward the line CD, the current will bring it there in the same time as if the wind did not act.

And as the current neither helps nor hinders the ship from coming toward the line BD, the wind will bring it there in the same time as if the current did not act.

Therefore the ſhip muſt, at the end of that time, be found in both thoſe lines, that is, in their meeting D.

Conſequently the ſhip muſt have paſſed from A to D in the diagonal AD.

49. When the ſhip's courſe and diſtance by account, and the ſetting and drift of the current, are given, the true courſe and diſtance of the ſhip may be found, either by working a traverſe, in which the ſetting and drift of the current are uſed as a courſe and diſtance; or by a trigonometrical ſolution of the triangles forming the figure: which is thus conſtructed.

From the center of a circle draw the ſhip's proper courſe and diſtance, and the current's ſetting and drift; with theſe two lines form a parallelogram, and from the center draw a diagonal, which will ſhew the ſhip's real courſe and diſtance.

50. It may frequently happen, that a ſhip is plying to windward acroſs a tide's way. In ſuch caſes,

Firſt conſtruct the figure for the plying to windward.

Then with the courſe on each tack, and the ſetting of the current, form parallelograms; in each of which one ſide muſt be the ſhip's rate, and the other the current's drift.

And lines drawn to meet one another from the center and port bound to, parallel to the diagonals of thoſe parallelograms, will ſhew the courſes and diſtances which the ſhip muſt run on each tack.

The figures referred to in this ſection are at the end, in Plate X, where they are marked by the number of the queſtion.

QUESTION I. *A ſhip ſails E. five miles an hour, in a tide ſetting the ſame way four miles an hour: Required the ſhip's courſe, and the diſtance made good.*

The ſhip's motion is	5 m. E.
The current's motion is	4 m. E.
The ſhip's true run is	9 m. E.

In this caſe, as the ſhip ſails from A, the ſame way the tide ſets; therefore her motion will be quickened as much as the tide's motion is.

QUESTION II. *A ſhip ſails SSW. with a briſk gale, at the rate of nine miles an hour, in a current ſetting NNE. two miles an hour: Required the ſhip's courſe, and the diſtance made good.*

The ſhip's motion is SSW.	9 m.
The current's mot. is NNE.	2 m.
The ſhip's true run is SSW.	7 m.

Here, becauſe the ſhip ſails in a contrary direction to the tide, its real motion will be ſlower than it appears to be by the drift of the current.

QUESTION

QUESTION III. *At ten o'clock in the forenoon, a ſhip that was running four miles an hour, came in ſight of her port, bearing ENE.; but finding, at three o'clock in the afternoon, that ſhe had made no way, ſuſpected a current, which on trial was found to ſet WSW. five miles an hour: What had been the courſe and real run of the ſhip during that time?*

In this caſe, had there been no current, the ſhip in five hours would have gone a-head 20 miles from A to B: and had ſhe been becalmed, ſhe would have driven with the current 25 miles from A to C: conſequently the difference, AD, of theſe two motions, is the diſtance the ſhip has run; that is, ſhe has driven aſtern five miles.

QUESTION IV. *A ſhip in doubling a cape meets a ſtrong tide ſetting SE.; after running SW. 18 miles by the log, the cape bore N. ¼ E.: Required the diſtance of the cape, and the drift of the current.*

From A the cape, and center of the horizon, draw AB the *SW.* rhumb, equal to 18 miles; through B draw BC parallel to the ſetting of the tide, or *S. E.* rhumb A*n*; then AC being drawn *S. ¼ W.*, its interſection, C, with BC, ſhews the ſhip's place; and that ſhe has run the line AC while the tide ran the length of BC, or A*n*.

In the triangle ABC there is given AB and all the angles, to find AC, BC.

The ∠B=8 points, ∠BAC=3¾ points, ∠ACB=4¼ points.

ANSWER. { The ſhip has run 22,41 miles S. ¼ W.
The tide has run 13,35 miles SE.

QUESTION V. *A ſhip falling in with a current that ſet NNW. ½ W. diſcovers a riff of rocks on the larboard, the eaſtern point of which is nine miles to the NE. b. N. ½ E.; and can be weathered by ſteering E. b. S.: Required the diſtance the ſhip muſt run by the log, and alſo the drift of the current.*

Here A is the ſhip's place, C the eaſtern point of the rocks to be weathered, AB the courſe ſhe muſt ſhape in order to run along the line AC, which is the diagonal of the parallelogram formed by AB, the ſuppoſed run of the ſhip, and A*n*, the current's drift.

ANSWER. { The apparent run by the log is 10,76 miles.
And the drift of the current is 10,27 miles.

QUESTION VI. *A ſhip in croſſing the mouth of a river, into which the tide ſet due eaſt, ſails from a buoy on the ſouth ſide, NE. 10 miles, and then falls in with another buoy on the north ſide, diſtant from the firſt 15 miles: Required the ſhip's courſe, with the drift of the current.*

Digitized by Google

In the *SW.* rhumb take BA=10 miles; on A, with 15 miles, cut the *E.* rhumb, BC, in C: then A represents the southern buoy, C the northern one; AB is the ship's supposed run, AC the real run, and BC the drift of the tide.

Here there are given AB=10, AC=15, the ∠B=12 points.

ANSWER. { The ship's course is N. 61° 52′ E.
The tide's drift is 6,161 miles.

QUESTION VII. *At 11 o'clock in the evening, a lighthouse bore SW. b. S. and a strong tide was setting WSW. ½ W. at the rate of 3½ miles an hour; we steered directly for the lighthouse, and at four in the morning we passed over a sandy point 28½ miles from the cape: Required the distance between the lighthouse and cape, also the course the ship has run.*

In the *ENE. ½ E.* rhumb, take BA=17½ miles (=3½ × 5) for the tide's drift. On A with 28½ miles cut the *SW. b. S.* rhumb in C the sandy point; through A and C draw lines parallel to BC, AB, and their intersection D is the lighthouse.

ANSWER. { The distance AD or BC is 12,72 miles.
The ship's course along AC is S. 56° 41′ W.

QUESTION VIII. *A ship running south at the rate of five miles an hour, in ten hours crosses a current, which all that time was setting east at the rate of three miles an hour: Required the ship's true course and distance sailed.*

Here the ship is first supposed to be at A, her imaginary course is along the line AB; but her real course is along the line AC, the diagonal of the parallelogram, the known sides of which are AB=50 miles (=10 × 5), and BC=30 (=3 × 10.)

ANSWER. The course is S. 30° 58′ E. distance 58,31 miles.

QUESTION IX. *Suppose that in 24 hours a ship sails NE. 100 miles by the log, in a current setting E. b. S. 1¾ miles an hour: What is the course and distance made good?*

Draw AB *NE.* and equal to 100 miles, through B draw BC parallel to the *E. b. S.* rhumb, and make it 42 miles (1¾ × 24); then draw AC, which shews the true run of the ship from A.

Here are given two sides, AB, BC, and ∠B=11 points.

ANSWER. The course is N. 60° 49′ E. distance 128,2 miles.

QUESTION

Digitized by Google

QUESTION X. *A ship departs from her port at 8 o'clock in the evening, and sails before the wind, then at NNW. at the rate of $3\frac{1}{2}$ knots an hour, in a tide which runs at the same rate toward the eastward; and next day at noon she found herself 84 miles from her port: Required the ship's true course, and the setting of the tide.*

In the *NNW.* rhumb take BA = 56 miles (= $3\frac{1}{2} \times 16$ h.); on A, with 84 miles, cut an arc described from B with 56 miles, their intersection C is the place the ship is come to, A being the port sailed from, AB the imaginary run before the wind, BC the drift of the current, and AC the real run of the ship.

Here BA = BC, and the solution is as in Article 63. Book III.

ANSWER. { The ship's true course is S. 63° 55′ E.
The setting of the current is N. 74° 40′ E.

QUESTION XI. *A ship departs in the evening for an island, 46 miles to the WSW. but by a strong tide running to the southward, she found herself next morning on a shoal 65 miles from her departed port, and 34 miles from the island: Required the bearing of her port, and the setting of the tide.*

Here A is the port sailed from, B the island bound to, C the shoal come to; the construction is as in the last. and the solution as in Art. 62. III.

ANSWER. { The port bears N. 37° 37′ E.
The current sets S. 4° 46′ E.

QUESTION XII. *A ship, in latitude 41° 18′, is bound to a port in latitude 46° 30′ N. lying 258 miles to the west; where being arrived, she finds by her dead reckoning that she has made 384 miles of northing, and 206 miles of westing: Required the setting and drift of the current that occasioned this difference.*

Here, by the dead reckoning, the ship should have gone from A to B; but she being arrived at the port C, the drift of the current will be represented by the line BC, and its setting by the angle FBC in the right angled triangle BFC; the legs of which, BF, FC, being the differences between the real and imaginary differences of latitude and departures.

For, the current setting southward, will cause the ship to be longer in getting to the northward, and increase her account of northing; and by its setting westward, it will quicken the ship's motion that way more than her account will shew.

ANSWER. The current's course is S. 35° 50′ W. and drift 88,82 m.

Digitized by Google

QUESTION XIII. *A ſhip from a place in latitude 37° 40′ N., ſails SSW. diſtance 48 miles in 10 hours; then ESE. 72 miles in 14 hours; and has all the time been in a current ſetting SSW. 1½ mile an hour: Required the ſhip's preſent latitude and departure, together with the direct courſe and diſtance ſhe has ſailed.*

As the current has run 1½ mile an hour for 24 hours, its whole drift is 36 miles.

The beſt way of ſolving this queſtion is to conſider the current as another courſe and diſtance, and then with the three courſes and diſtances form a traverſe table, as ſhewn in Article 36.

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
SSW.	48		44,3		18,4
ESE.	72		27,6	66,5	
SSW.	36		33,3		13,8
			105,2	66,5	32,2
				32,2	
				34,3	

The ſouthing and eaſting which the ſhip has made being thus known, the direct courſe and diſtance will be found as in Art. 33.

Here the ſhip departs from A, and is come to C; AB being the diff. lat. and BC the departure.

ANSWER. { The preſent latitude is 35° 55′ N. departure 34,3 miles. Direct courſe is S. 18° 3′ E. diſtance 110,7 miles.

QUESTION XIV. *Yeſterday noon we were in latitude 28° 14′ N. and have ſailed till this day noon the following courſes, viz. SSE. ½ E. 24 miles; NE. b. E. ½ E. 15 miles; ESE. ¼ E. 45 miles; and all this time were in a current, ſetting S. b. W. 1¾ miles an hour: Required the ſhip's preſent latitude, departure, direct courſe, and diſtance.*

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
SSE. ½ E.	24		21,2	11,3	
NE. b. E. ½ E.	15	7,1		13,2	
ESE. ¼ E.	45		15,2	42,4	
S. b. W.	42		41,2		8,2
		7,1	77,6	66,9	8,2
			7,1	8,2	
		D. lat.	70,5	58,7	Dep.

Here the current being conſidered as a courſe, the traverſe table gives the diff. lat. = 70,5 miles.

And the departure = 58,7 miles. And hence the direct courſe is S. 39° 47′ E. and the diſtance is 91,73 miles.

In any queſtion, where there are given one or more courſes and diſtances ſailed, and alſo the ſetting and drift of the current, the work may be performed as above.

The reaſon of this is pretty evident; for as each courſe and diſtance is affected by the current, therefore inſtead of correcting them one by one, as ſhewn in moſt of the preceding queſtions, they may be all allowed for together, by making a courſe and diſtance of the ſetting and drift of the current.

Digitized by Google

QUESTION XV. *At eight o'clock in the evening, a ship sailed from her port on a SSW. course, four miles an hour; a strong tide was then setting between the S. and W.; and at six o'clock in the morning she passed by a rock 70 miles to the westward, and 60 miles to the southward of her port: Required the setting and drift per hour of the tide.*

With 60 miles as a diff. lat. and 70 miles as a departure, find the place of the rock at C; A being the place sailed from; in the *SSW.* rhumb take AB=40 (=4 × 10); draw BC, AC: then AB is the supposed run, AC the real run, and BC the drift of the tide.

In the △ADC, is given AD, DC, ∠D; to find the ∠A and AC=92,2.

In the △ABC, is known AC, AB, ∠CAB; to find ∠C and BC=59,37.

ANSWER. The tide set S. 67° 09′ W. and ran 5,937 miles an hour.

QUESTION XVI. *At six o'clock in the forenoon a ship weathered a cape in latitude 46° 32′ N.; and having run SE. b. S. 24 miles by the log in a current, found herself at noon in latitude 46° 17′ N. and the cape bore WNW.: Required the setting and drift of the current.*

Make AD=the diff. lat.; draw the departure DC, meeting the *ESE.* rhumb in C; draw AB, *SE. b. S.* and equal to 24 miles, and join BC.

Then A is the cape, C the place come to, AB the supposed run, BC the drift of the current, and AC the real run.

In the △ADC, there is given AD and the angles; to find AC=39,2.

In the △ABC, there is known AB, AC, ∠BAC; to find the angles, and BC=23,41 m.

Then drawing the rhumb A *n* parallel to BC, it shews the setting of the current.

ANSWER. The current sets N. 77° 47′ E. and runs 3,9 miles an hour.

QUESTION XVII. *A ship being bound from Dover to Calais, which lies 21 miles to the SE. b. E. ½ E.; and the tide of flood setting NE. ½ E., 2½ miles an hour: Required the course she must steer, and the distance she must run by the log, at the rate of six miles an hour, to reach her port.*

In the position of the *SE. b. E. ½ E.* rhumb draw DC=21 miles; and parallel to the *NE. ½ E.* rhumb draw DE=2½ miles; on E, with six miles, cut DC in F; draw DB parallel to EF, meeting CB, drawn parallel to DE.

Then D is Dover, C Calais; and the ship, by trying to sail along the line DB, will be driven between it and the direction of the current in the line DC.

ANSWER. The ship must sail S. 39° 14′ E. and will run by the log 19,4 m.

Digitized by Google

QUESTION XVIII. *Yesterday noon we were in latitude 42° 20′ N. and this day at noon find ourselves in latitude 41° 10′ N.; by our account we have sailed SW. b. S. 189 miles, and all the time have been in a current setting NW.: Required the ship's direct course and distance, with the current's drift per hour.*

Take AD=70 miles, the diff. lat.; draw AB parallel to *a n*, the *SW. b. S.* rhumb, and equal to 189 miles; through B draw BC parallel to the *NW.* rhumb *a o*, meeting the departure DC, and join AC.

Then the ship from A supposes herself sailing along AB; but by the action of the current is driven along AC.

In the △ ADB, there is given AD, AB, ∠ BAD: Required the angles and DB=136,4.

In the △ DBC, there is known DB and the angles; to find DC=192 and BC 123,1.

In the △ ADC, there is known AD, DC, ∠ ADC; to find the angles and AC=204,4.

ANSWER. { The course is S. 69° 58′ W. distance 204,4 miles. The current's drift per hour is 5,13 miles.

QUESTION XIX. *There are two ports which lie 270 miles to the north and south of one another; a ship sails from the northern port, with her starboard tacks aboard, within 72 degrees of the wind, then at S., at the rate of four miles an hour, in a current that sets south, two miles an hour: Required her course and distance on each of two tacks to reach the southern port.*

Draw the line AD through F, the center of the horizon, S. 72° E. and from any point, A, in that line, draw AB, due south, and =270 miles; through B draw BD parallel to F *n*, a rhumb 72° from the wind; then if there were no current, the ship must have sailed from A to D on the starboard, and from D to B on the larboard tacks: but to allow for the current, take F *a*=2 miles, draw *a c*, *a c*, parallel to F D, F *n*, and make *a c*, *a c*, each =4 miles; draw the diagonals F *c*, F *c*, of those parallelograms; then through A and B, lines drawn parallel to F *c*, F *c*, meeting in C, will shew the run of the ship on each tack.

Here the triangles F *a c*, F *a c*, being congruous by construction, therefore the ∠ CAB (= ∠ *a* F *c*) is equal to ∠ CBA (*a* F *c*).

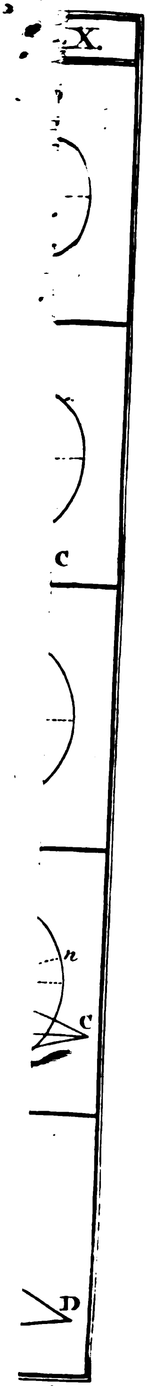
Now in the triangle *a* F *c*, there is given *a* F, *a c*, and F *a c*=108°; from whence the other angles are known; *viz.* ∠ *a* F *c*=49° 37′. And in the triangle ABC there are known the side AB, and all the angles, whence the sides AC and CB are easily found.

ANSWER. { The course on starb. is S. 49° 37′ E. distance 208,4 miles. The course on larb. is S. 49° 37′ W. distance 208,4 miles.

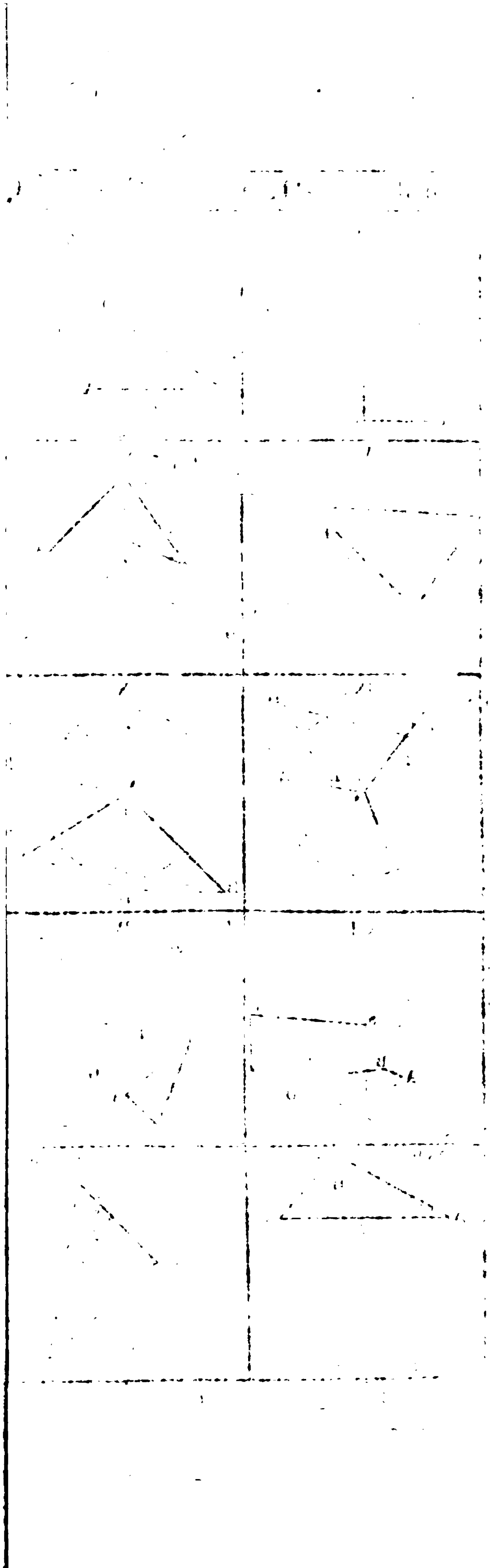
QUESTION

Digitized by Google

Digitized by Google



...e 51.



Digitized by Google

QUESTION XX. *A ship that makes her way good within $6\frac{1}{2}$ points of the wind, is bound to a port bearing SW. b. S. $\frac{1}{4}$ W. distant 476 miles: Now the wind being S. b. W and a current setting S. b. E. $2\frac{1}{4}$ miles an hour, and the ship sailing $7\frac{1}{2}$ miles an hour: Required the course and distance she must sail on her starboard and larboard tacks to gain the port.*

In the *SW. b. S. $\frac{1}{4}$ W.* rhumb, take AB=476 miles; and, through A and B, draw the lines AD, BD, in the direction of rhumbs $6\frac{1}{2}$ points from the wind at *S. b. W.*; then, were there no current, the ship would sail on the lines AD, DB.

With the drift of the current aA$=2\frac{1}{4}$, and the run of the ship $7\frac{1}{2}$ miles an hour, taken in rhumbs Ao, Ab, $6\frac{1}{2}$ points from the wind; complete the parallelograms, the diagonals of which Ac, Ad, shew the courses the ship will move in, with the compound motions of the current's drift and ship's run.

Then AC and BC, drawn parallel to ac, will shew the run of the ship on the starboard and larboard tacks.

In the $\triangle$ Aad are given Aa, ad, $\angle$Aad; to find the $\angle d$Aa= 37° 41′.

In the $\triangle$ Aac are given Aa, ac, $\angle$Aac; to find the $\angle c$Aa=74° 54′.

Then $\angle$BAC=$\angle$BAn+$\angle$CAn=} 85° 30′.

Also $\angle n$Ac—$\angle n$AB=BAo,=$\angle$ABC=27° 05′. (II. 93)

Consequently in the triangle ACB, there are known one side AB, and all the angles; by which the sides AC, CB, may be found.

ANSWER. { The course on the starb. is S. 48° 56′ E. dist. 234,7 miles.
The course on the larb. is S. 63° 39′ W. dist 514 miles.

Most of the Questions in the three preceding sections, although not of such common use at sea, as those in sections the IVth and Vth, yet have their uses on various occasions, as will evidently appear from many of the questions themselves. But there is another excellent use to be derived from their solution, that does not appear at first sight so evident to *learners*; which is, the furnishing them with an agreeable opportunity of exercising their talents in the application of Geometry and plain Trigonometry. For it should be well observed, that as all the operations relating to sailing depend chiefly on the principles of Trigonometry; so the persons, to whom these principles are most familiar, will with the greatest readiness not only apply them to the cases of sailing, but also see more clearly the reason of every step they shall find themselves necessitated to take. And as a further exercise for the understandings of those who are desirous of extending their notions this way, it has been thought proper to annex the Questions in the following section, with their solutions.

SECTION

Digitized by Google

SECTION IX.

51. *A Collection of Practical Questions.*

The figures belonging to the questions in this section are in Pl. XI. and numbered the same as the questions.

QUESTION I. *A ship in latitude 47° 30′ N. and bound to a port in latitude 42° 00′ N. and 120 miles to the west, proposes to reach her port by running equal distances on each tack, the first to be on the meridian: What must the course be on the second tack, and how far on each?*

SOLUTION. With the given difference of latitude = 330, and the departure = 120, construct the triangle ABC; from E, the middle of AC, draw ED at right angles to AC: then drawing DC, the lines AD, DC, will be the distances the ship must run on each tack.

For ADC is by construction an isosceles triangle. (II. 93)

In the triangle ABC, find the angle A (III 46) = 19° 59′ = ∠ ACD; the ∠ ACD + ∠ CAD = ∠ BDC = 39° 58′, the second course, in the SW. quarter.

In the triangle CBD, find (III. 45) DC = 186,8.

ANSWER. The first course is S., the 2d S. 39° 58′ W.; and the distance on each tack 186,8 miles.

QUESTION II. *A ship having sailed NE. b. E. from a port in latitude 42° 18′ N., met a sloop which had sailed from a port in the same latitude, lying 92 miles to the east of the ship's port: the sum of their distances made 159 miles: Required their respective courses and distances.*

SOLUTION. In an east and west line take BA = 92 m., from B draw on the *NE. b. E.* rhumb BC = 150m. join CA; then ED, drawn at right angles to CA, from E, the middle, gives D, so that DA = DC. (II. 93)

In the triangle ABC, find (III. 48) the ∠ BAC = 114° 27′, and ∠ ACD = ∠ CAD = 31° 47′.

Then ∠ BAC — ∠ CAD = ∠ BAD = 82° 40′; hence ∠ BDA = 63° 35′.

In the triangle BAD, find (III. 45) BD = 101,9 m., and AD = 57,7 m.

ANSWER. The ship sailed NE. b. N. 101,9 miles, and the sloop sailed N. 7° 20′, W. 57,7 miles.

QUESTION III. *Two ships A, B, sail from one road, their courses making an angle of 50° 00′; A sails between the S. and W. 40 leagues, B sailing between the S. and E. 50 leagues, has got 15 leagues to the southward of A: Required the course of each ship, also the bearing, distance, and departure from A to B.*

SOLUTION. With the given sides and included ∠ A, construct the triangle ACB: On A, with 15 leagues, describe an arc at D, and from E, the middle of AB, with the radius EA, cut the former arc in D (II. 131;) draw the given diff. lat. AD, and the required departure DB: then C is the port sailed from, A one ship's place, B the other's.

In the triangle ACB, find (III. 48) the ∠ CAB = 78° 24′, and ∠ CBA = 51° 36′; the side AB will be found 39,1 leagues. In the triangle ADB, where AB, AD, are known, find ∠ DBA = 22° 34′, ∠ DAB = 67°, 26′, and BD = 36,1.

ANSWER. A's course is S. 34° 10′ W. B's is S. 15° 50′ E.; B bears from A S. 67° 26′ E. departure BD is 36,1 m. the dist. AB is 39,1 miles.

QUESTION

Digitized by Google

QUESTION IV. *From two ports, bearing NW. b. N. and SE. b. S. two ships sail, the one NE. the other N. b. E.; they meet, and find that the sum of their distances added to the distance of the ports made 148 miles: Required the distance of the ports, and the run of each ship.*

SOLUTION. Make a triangle ADE equiangular to the triangle required, in which one side, as AD, shall be of any assigned length, as 30; and by Art. 45. Book III. find DE=41,61; AE=23,57; and the sum of the three sides of the triangle ADE will be 95,18: then say,

As 95,18 : 148 :: AD=30 : AC=46,65.
And as 95,18 : 148 :: DE=41,61 : CB=64,70.

Then the other side AB will be 36,25 miles.

ANSWER. { The distance of the ports is 36,25 miles.
One ship's run is 46,65 miles, the other's 64,7 miles.

QUESTION V. *Two ships meet at sea, bound to two ports distant from one another 12 miles: Now if one sails NW. b. N. six miles an hour, and the other NE. eight miles an hour, they will arrive at their respective ports at the same time: Required the distance each ship must run, and the bearing of those ports from one another.*

SOLUTION. With the courses and rates of sailing make the triangle ADE, A representing the place of meeting; parallel to DE draw AG= 12 miles; through G draw GC parallel to AD, meeting AE produced in C; through C draw CB parallel to AG, meeting AD produced in B; then B and C are the ports. For AB : AC :: 6 : 8; and BC=12=AG, BG being a parallelogram.

In the triangle ADE, knowing AD, AE, and ∠A, find ∠D=60° 30′, ∠E=40° 45′, and DE=9,015 miles; then DE : BC :: AE : AC= 10,65; :: AD : AB=7,988.

ANSWER. { One runs NE. 10,65 m; the other NW. b. N. 7,988 m.
C bears from B, N. 85° 45′ E.

QUESTION VI. *A fleet of ships steering SW. b. S. four miles an hour, on seeing a sail, detached a cruiser, which gave chase SE. five hours at the rate of seven miles an hour, comes up with, and takes the chace. After an hour's time spent in adjusting matters on board the prize, she steers for the fleet, which still kept on the same course and rate: Required the course the cruiser must shape, and the distance she must run at seven miles an hour, to join them.*

SOLUTION. Let C be the first place of the fleet, draw CD, *SW. b. S.* and CB, *SE.*; make CB=35 (=7×5), CA=24 (=4×6), and draw AB; then B is the place where the cruiser took the chace, and A the place where the fleet was when she left the chace: make AF=4, FE=7, draw BD parallel to FE, and D is the place where the cruiser joined the fleet.

In the triangle ACB, find ∠CAB=63° 25′, and ∠CBA=37° 49′, and AB=38,39. Then (II. 91) ∠FAE=116° 35′. In the triangle FAE, find ∠E=30° 44′ and ∠F=32° 41′.

In the triangle ADB, simiiar to AFE, find BD=63,58 miles.

ANSWER. The cruiser must steer S. 66° 26′ W. and run 63,58 miles.

QUESTION

Digitized by Google

QUESTION VII. *A ship, sailing on a WSW. course, can sail from the port* A *to the port* B *in six days: But sailing at the same rate (by the log) on a NE. b. N. course, she goes from* B *to* A *in three days, a current setting all the way between the ports east, half a mile an hour: Required her dead reckoning outward and homeward, also the bearing and distance of* A *from* B.

SOLUTION. In the nine days outward and homeward-bound, the current runs at $\frac{1}{2}$ mile an hour, 108 miles east, that is 72 m. for outward, and 36 homeward. In an east and west line take AD=36, Dd=72; through A draw a *WSW.* rhumb, and through d draw a *NE. b. N.* and *SW. b. S.* rhumb, cutting the former in E: Through D, E, draw parallels to dE, dA, cutting in B; join AB, and draw BF parallel to EA, meeting dA produced in F; then A and B represent the two ports, AE the outward dead reckoning, BD the homeward, and AB the true distance.

For if AF=BE=Dd=72 is the drift of the current in the outward account, and the course shaped is along AE, the ship must run between AF and AE. Also if BC=AD=36 is the current's drift homeward, and the course shaped is along BD, the ship must run between BC and BD. But AB is the only common diagonal to the parellelograms FE and DC; consequently A and B are the ports.

In the triangle AdE, find (III. 45) AE=161,6; and Ed=BD=74,39 m.

In the triangle ADB, find (III. 48) ∠DAB=39° 39′, and ∠DBA=17° 36′. Also (III. 45) find AB=99,04.

ANSWER. { The dead reckoning outw.=161,6 m. homew.=74,39 m.
The true course is S. 21° 21′ W. distance 99,04 miles.

QUESTION VIII. *A ship, after doubling a cape and sailing NE. b. N. 45 miles, receives in the night considerable damage from a storm; she then bore directly toward a lighthouse lying 24 miles to the NW. of the cape, and having run 40 miles, and the day breaking, she discovers a port 42 miles to the north of the cape: What was her course and distance to that port?*

SOLUTION. Draw AD, *NE. b. N.* 45 m.; AB, *N.* 42 m.; AC, *NW.* 24 miles; join DC, make DE=40 m. and draw AE, EB; then A is the cape, C the lighthouse, and B the port.

In the triangle CAD, with the given sides and included angle A, find the ∠C=70° 58$\frac{1}{2}$′, ∠D=30° 16$\frac{1}{2}$′, and the side CD=46,69 miles.

In the triangle ADE, with the given sides and included angle D, find the ∠DEA=87° 08′, ∠DAE=62° 36′, and AE=22,71 miles.

In the triangle BAE, with the known sides AB, AE, and included ∠EAB, find ∠BEA=124° 47′, ∠B=26° 22′, and EB=24,67 miles.

ANSWER. { The course from E to B is N. 76° 22′ E.
And the distance E B is 24,67 miles.

QUESTION

Question IX. *A ship running at the rate of 4½ miles an hour, with the wind then at E. b. N., blowing two points abaft the beam; at five in the evening, being two leagues to the W. b. S. of a headland, she met the tide of flood setting SSW. at the rate of 1¾ miles an hour, and at nine that evening, a lighthouse which lay to the NNE. ½ E. of the headland, bore ENE. ¼ E.: Required the ship's course and her distance from the lighthouse.*

Solution. From five to nine is four hours, in which time the ship runs 18 miles, and the tide seven miles; also two points abaft the beam, or 10 points from the wind, is *NW. b. N.*

Suppose the ship at A; then in the *E. b. N.* rhumb take AE=6, and E is the headland; in the *NW. b. N.* take AB=18; through B draw BC parallel to the *SSW.* rhumb, and equal to 7, join CA, CE; through E draw a *NNE. ½ E.* rhumb, meeting in D, an *ENE. ¼ E.* rhumb, drawn from C. Then C is the place which the ship arrives at, AC is her real run, and D the place of the lighthouse.

In the triangle ABC, where two sides AB, BC, and the included ∠B, are known; find ∠BCA=101° 19′, ∠BAC=22° 25′, and the side AC=15,26 miles.

In the triangle CAE, where there are known AE=6, AC=15,26, ∠CAE=134° 55′; find ∠AEC=32° 47′, ∠ACE=12° 18′, and the side CE=19,94 miles.

In the triangle CED, where there are known CE=19,94 m. ∠D=47° 49′, ∠DCE=35° 36′, and ∠DEC=96° 35′; the side ED will be found 15,67 miles, and the side CD=26,74 miles.

Answer. The ship's true course is N. 56° 10′ W.; dist. from the lighthouse 26,74 miles.

Question X. *Two ships departed from a port at the same time, and after one had sailed SE. b. E. 40 miles, and the other SW. 50 miles, they were equally distant from a rock which lies directly south of their port: Required the bearing and distance of each from the rock.*

Solution. From A, the port, draw AB *SW.* 50 miles, AC *SE. b. E.* 40 miles, join BC, and from F, the middle, draw FD at right angles to BC, meeting the meridian in D, the place of the rock, and join DB, DC, which are equal by Article 103, Book II.

In the triangle BAC, where there are known AB=50, AC=40, ∠BAC=101° 15′; find ∠ACB=44° 35′, ∠ABC=34° 10′, and BC=69,86 miles.

In the triangle AEC, where there are known AC=40, ∠EAC=56° 15′, ∠ACE=44° 35′, ∠AEC=79° 10′; find EC=33,86 miles.

Then CF=(½ BC)—EC=FE=1,07.

In the right angled triangle FED, where are known FE=1,07, and ∠FED=79° 10′; find the side DF=5,591.

In the right angled triangle DFC, where DF=5,591, FC=34,93; find the ∠FDC=80° 54′, and DC=35,38 miles.

Answer. { The ship at B is 35,38 m. to the S. 88° 16′ W. of the rock.
The ship at C is 35,38 m. to the N. 70° 04′ E. of the rock.

Digitized by Google

QUESTION XI. *Sailing E. b. S. $7\frac{1}{2}$ knots an hour, we saw two islands, one bearing SE. b. S. the other E. b. N.; the tide was then running SW. b. W. $2\frac{1}{2}$ miles an hour: two hours after, the first island bore W. b. S. and the other N. W. b. N.: Required the ship's course and distance, together with the bearing and distance of those islands from one another.*

SOLUTION. In an *E. b. S.* rhumb, take AC = 15 miles, ($= 7\frac{1}{2}$ m. × 2); through A, draw AB, AE, parallel to the *E. b. N.* and *SE. b. S.* rhumbs; draw CD *SW. b. W.* and equal to five miles, which the tide runs in two hours; through D, lines being drawn parallel to the *NW. b. N.* and *W. b. S.* rhumbs, their intersections with AB, AE, will give E, the place of the southern island, and B, the place of the northern one; join AD, BE.

In the triangle ADC, where AC = 15, DC = 5, and ∠ACD = 45° 00′; find the ∠CDA = 117° 52′, ∠CAD = 17° 08′, and AD = 12 miles.

Now as ED is parallel to AB, and BD parallel to AE, therefore ABDE is a parallelogram; and so AB = ED, AE = BD.

In the triangle AED, where AD = 12 miles, ∠AED = 112° 30′, ∠DAE = 27° 52′, and ∠ADE = 39° 38′; find AE = 8,286 miles, and ED = 6,072 miles.

In the triangle ABE, where AE = 8,286 miles, AB = 6,072 miles, and ∠EAB = 67° 30′; find ∠ABE = 69° 15′, the ∠AEB = 43° 15′, and the side BE = 8,186 miles.

ANSWER. { The ship's course was S. 61° 37′ E. distance 12 miles.
The N. isle bore from the S. isle, N. 9° 30′ E. dist. 8,186 m.

QUESTION XII. *Coming out of a port, into which the tide of flood was then setting, I saw two headlands, the northern one, which bore ENE. $\frac{1}{2}$ E. was known to be 15 miles to the NNE. $\frac{1}{2}$ E. of the other, which then bore S. b. E.: after running E. b. S. $\frac{1}{2}$ E. 24 miles by the log, the northern headland bore NW. and the other W. b. S.: Required the setting and drift of the tide.*

SOLUTION. In a *NNE. $\frac{1}{2}$ E.* rhumb take AB = 15 miles; through A draw AC *N. b. W.* and AD *E. b. N.*; also through B draw BC *WSW. $\frac{1}{2}$ W.* and BD *SE.*; then C, the intersection of AC, BC, is the ship's place at first, and D, the meeting of BD and AD, is the ship's place at last: from C draw an *E. b. S. $\frac{1}{2}$ E* rhumb CE = 24 miles, and join ED.

In the triangle ABC, where AB = 15 miles, ∠ACB = 95° 38′, and the ∠CBA = 45° 00′; find AC = 10,66 miles.

In the triangle ABD, where AB = 15 miles, ∠ADB = 56° 15′, and the ∠ABD = 73° 08′; find AD = 17,26 miles.

In the right angled triangle CAD, where AC = 10,66, and AD = 17,26; find ∠ACD = 58° 19′, ∠ADC = 31° 41′, and CD = 20,29 m.

In the triangle CDE, where CE = 24, CD = 20,29, and ∠DCE = 14° 49′; find ∠CED = 52° 42′, and DE = 6,522 miles.

ANSWER, The tide set S. 42° 55′ W. and its drift is 6,522 miles.

QUESTION

Digitized by Google

QUESTION XIII. *A ship running five knots an hour, discovers Scilly lights bearing NE. b. N. distant six leagues, the flood tide being just made, and setting ENE. two miles an hour: Required what course she must steer, and how far by the log, to bring herself five leagues to the south of the Lizard, which lies 11 leagues to the E. b. N. ½ E. of Scilly.*

SOLUTION. Draw SL *E. b. N ½ E.* 33 miles, LE *S.* 15 miles, and SA *SW. b. S.* 18 miles; join SE, AE: Draw AB *ENE.* two miles, and on B with BC=5 miles cut AE in C, join BC; draw AD parallel to BC; and ED parallel to AB; then A represents the ship's place at first, S Scilly, L the Lizard, E the ship's place at last, and AD the rhumb and distance she must sail.

In the triangle SLE, where SL=33 miles, LE=15, and the ∠SLE =84° 22′; find ∠LES=70° 18′, ∠LSE=25° 20′, and SE=34,89 m.

In the triangle ASE, where AS=18, SE=34,89, and the ∠ASE= 104° 02′; find ∠SAE=51° 59′, ∠SEA=23° 59′, and AE=42,96 m.

In the triangle ABC, where AB=2, BC=5, and ∠BAC=18° 14′; find ∠C=7° 11′.

Now in the triangle ADE, similar to the triangle ABC, are known AE=42,96 miles, ∠DAE=7° 11′, ∠AED=18° 14′, and the ∠D= 154° 35′; hence the side AD will be found=31,32 miles.

ANSWER. The ship must sail S. 87° 05′ E. distance 31,32 miles.

QUESTION XIV. *At six o'clock in the evening a privateer saw a ship directly to windward bearing NE. about three leagues distant, they were both close hauled, on their starboard tacks; the privateer having sailed 18 miles, at nine o'clock the ship bore E. b. N. ½ E. Now the privateer finding he got a-head, would speak with the ship at two o'clock in the morning: Required at what rate the privateer must sail, and at what time tack about, keeping six points from the wind, supposing the other ship does not alter her course and rate of sailing.*

SOLUTION. Six points from the wind at *NE.* on starboard tacks is *NNW.*; then in a line AF parallel to a *NNW.* rhumb take AC=18 m. draw AI *NE.* in which take AB=9; also BG=3, GI=5, representing the times between six and nine, and nine and two o'clock; draw BE parallel to AF, and through C draw an *E. b. N. ½ E.* rhumb CD; join DG, draw IE parallel to DG; through E draw EF six points from the wind, and join EC, CB: then the privateer tacking at F, will meet the ship at E.

In the triangle ABC, find ∠ABC=82° 46′, ∠ACB=29° 44′, and CB=16,76.

In the triangle CBD, find BD=12,04, and DC=8,689.

Then BG : GI : : BD : DF=20,07 miles, the ship sails from nine to two.

In the triangle CDE, find ∠C=81° 31′, ∠E=25° 21′, and EC= 19,42 miles.

In the triangle CEF, find FE=11,76, and FC=25,87 miles.

Digitized by Google

Now FE+FC=37,63 m. which run in five hours, is 7,12 m. an hour. And FC at 7,12 m. per hour gives 3 h. 37 m. 48 s. after nine o'clock.

ANSWER. The privateer must tack at 12 h. 37 m. 48 s. and sail 7,12 miles an hour.

QUESTION XV. *Two ships steering between the S. and W. parted company in latitude 20° 15′ N. one going 2 ¾ points more westerly than the other; next day at noon they arrived at two ports in latitude 16° 16′ N. and distant 45 miles: Required the course and distance which each ship sailed after they parted.*

SOLUTION. In an east and west line take CB=45 miles; on CB describe (II. 89) the segment CBA of a circle that shall contain an angle equal to 30° 56′=2 ¾ points; in the meridian take BH=59 miles, the diff. lat.; through H draw HA parallel to CB, meeting the circle CBA in A; draw AF parallel to HB, meeting CB produced in F, join AB, AC, and from E, the center of the circle CBA, draw EA, EB; EG parallel to CB, and ED parallel to BH.

In the right angled triangle EBD, where ∠DEB= (∠CAB=) 30° 56′, and DB=22,5 miles; find ED=FG=37,54, and EB=EA=43,77 m.

In the right angled triangle AEG; find ∠AEG=29° 22′, and EG=38,15.

In the right angled triangle AFB, where AF=59 miles, BF=DF (=EG)—DB=15,65; find ∠BAF=14° 51′, and AB=61,06 miles.

In the right angled triangle AFC, where AF=59, CF=CB+BF=60,65 miles, and ∠CAF=45° 47′; find AC=84,62 miles.

ANSWER. { The course of one ship is S. 14° 51′ W. dist. 61,06 m.
The course of the other is S. 45° 47′ W. dist. 84,62 m. }

QUESTION XVI. *Two ships,* A *and* B, *both going at the rate of six knots an hour, parted company in the latitude of 45° N.* A *steering in the NE. and* B *in the NW. quarter; next day at noon they both arrived at their ports,* A *in lat. 45° 58′ N.* B *in lat. 45° 36′ N. and the sum of their departures was 64 miles: At what hour did they part, and what was the course and distance each ship had sailed?*

SOLUTION. Make the departures FG=64 miles, the diff. lat. FB=58, and GC=36 miles; draw BC, and from K, the middle of BC, draw KE at right angles to BC, meeting FG in A, and BF produced in E; join AC, AB; then draw AH parallel to FB; and CD, BH, parallel to FG, meeting AH in I and H.

In the right angled triangle BDC, where DC=64, DB=22; find ∠DBC=71° 02′, ∠DCB=18° 58′, and BC=67,69 miles: Hence BK=KC=33,84.

In the right angled triangle BKE, where ∠E=18° 58′, KBE=71° 02′, and KB=33,84 miles; find BE=104,1: Hence BE—BF=FE=46,1 miles.

In

In the right angled triangle EFA, find FA=15,84 miles: Hence AG =48,16.

In the right angled triangle AIC, where AI=(GC=) 36, IC=48,16; find ∠IAC=53° 13′, and AC=60,13 miles.

In the right angled triangle AHB, find ∠BAH=15° 17′.

Now AC or AB=60,13 divided by 6 gives 10,02 hours=10h. 1 m. 12 s.

ANSWER. { The ships parted at 1 h 58 m. 48 s. in the morning. A's course is N. 15° 17′ W. B's is N. 53° 13′ E.; dist. run by each is 60,13 miles.

QUESTION XVII. *Passing by a rock which lies off the mouth of a harbour, the breadth of which is* 12 *miles, the western point bore NNW. and is nine miles distant from the town; the eastern point bore NE. b. N. and is six miles from the town: Required the distance of the rock from the western and eastern points, and also from the town, which bore N. b. E.*

SOLUTION. With the three given sides, 12, 9, 6, having constructed a triangle where A and C are the western and eastern points of the harbour's mouth, and B the town; make the ∠ACD=3 points,=∠between the bearings of A and B; also make the ∠CAD=2 points=∠between the bearings of C and B; through ADC describe a circle, and through D and B draw the right line BF, meeting the circumference of the circle again in F, the place of the rock.

For the ∠AFD=∠ACD=3 pts.; and ∠CFD=∠CAD=2 pts. (II. 129)

In the triangle ABC, find ∠BAC=28° 57′, the ∠BCA=46° 33′, and the ∠ABC=104° 30′.

In the triangle ACD, where ∠ADC=123° 45′, ∠DCA=3 points, ∠DAC=2 points; find DA=8,018 miles.

In the triangle ADB, where AB=9, AD=8,018, and ∠BAD=6° 27′; find the ∠ABD=41° 05½′: Hence ∠CBD=63° 24½′.

In the triangle ABF, find AF=10,65 miles, and FB=15,64 miles.

In the triangle FBC, find FC=14,02 miles.

ANSWER. FA=10,65, FB=15,64, FC=14,02 miles.

QUESTION XVIII. *At night, having cast anchor among a cluster of islands, I observed three lighthouses,* A, B, C; A *bore NNE.* B *bore SSE ½ E. and* C *bore west; the distance from* A *to* B *is* 94 *miles, from* B *to* C 78 *miles, and from* A *to* C *is* 59 *miles: Required my distance from each lighthouse.*

SOLUTION. Let ABC be the triangle formed by the distances of the three lighthouses; on CB, CA, describe (II. 89) segments of circles that shall contain the angles included between the bearings of C and B, and of C and A; and the intersection D of these circles, is the point where the ship cast anchor: through the centers H, K, draw *a*E, *b*G, at right angles to CB, CA, meeting the circumferences of the circles in E and G; and draw EB, EC; HB, HC; GC, GA; KC, KA; and join KH cutting CD in *m*.

Now

Now because CD is a chord common to both circles, therefore HK bisects it in m: also, because ∠CDB and ∠CEB together are measured by half the circle (II. 128); therefore ∠CEB$=180°-$∠CDB; and for the same reason, the ∠CGA$=180°-$∠CDA; therefore the angles CEB, EGA, are known; and (II. 127) so are their equals ∠CH$a$$=61° 52\frac{1}{2}'$, CK$b$$=67° 30'$.

In the triangle CAB, from the given sides find ∠CAB$=55° 48'$, ∠CBA$=38° 44'$, and the ∠ACB$=85° 28'$.

In the right angled triangle CaH, where C$a$$=39$ m. ∠CH$a$$=61° 52\frac{1}{2}'$; find CH$=44{,}22$ miles.

In the right angled triangle CbK, where CB$=29\frac{1}{2}$ m. ∠CK$b$$=67° 30'$; find CK$=31{,}93$ miles.

In the triangle KCH, where KC$=31{,}93$, CH$=44{,}22$, the ∠KCH$=136° 06'$ (=∠KCA+∠ACB+∠BCH); find ∠CKH$=25° 40'$, and ∠CHK$=18° 14'$.

In the right angled triangle CHm, where ∠CH$m$$=18° 14'$, and CH $=44{,}22$m.; find C$m$$=13{,}84$ miles, which doubled gives CD$=27{,}68$ miles.

In the triangle ACD, where CD$=27{,}98$ m. ∠CAD$=25° 40\frac{1}{2}'$, and ∠ACD$=41° 49\frac{1}{2}'$; find AD$=42{,}6$ miles.

In the triangle ADB, where AB$=94$ miles, ∠BDA$=129° 22\frac{1}{2}'$, ∠DAB $=30° 07\frac{1}{2}'$; find DB$=61{,}03$ miles.

ANSWER. The distance from D to { A is 42,6 miles. B is 61,03 miles. C is 27,68 miles.

QUESTION XIX. *In latitude 48° 50′ N. we were attacked by a privateer, who upon receiving our broadside lay to, and we stood away NNW.; some time after the privateer bore away NE. b. N. and two hours after, he having by our estimation run ten miles, was seven miles directly east of us. Now by our account we had sailed four leagues since the action, and the tide all the time had run two miles an hour: Required the setting of the tide, the time the privateer lay to, our rate of sailing, and each ship's direct course and distance.*

SOLUTION. Suppose the action at A, then parallel to the *NNW.* and *NE. b. N* rhumbs, draw AB$=12$ m. AC$=10$ m. and join BC; through C draw CD$=7$ miles due west; join BD, and in this line produced take DI$=4$ miles, the tide's drift in two hours; draw CF parallel and equal to DI; through F draw a west line FG, meeting BI in I, and a meridian through A, in G; and draw AF, AI, which represent the runs of the two ships, F being the place of the privateer, when she was seven miles east of the other ship, then at I.

In the triangle ABC, where AB$=12$, AC$=10$, and ∠BAC$=56° 15'$; find ∠ACB$=71° 31\frac{1}{2}'$, ∠ABC$=52° 13\frac{1}{2}'$, and BC$=10{,}52$ miles.

In the triangle BCD, where BC$=10{,}52$ m. CD$=7$ m. ∠BCD$=15° 16\frac{1}{2}'$ ($71° 31\frac{1}{2}'-56° 15'$); find ∠BDC$=138° 40'$, ∠DBC$=26° 04'$, and BD$=4{,}197$ miles, which is the tide's run while the privateer lay by.

In

In the triangle ACF, where CA=10 m. CF=4 m. and ∠ACF=82° 25′ (=∠DCF—∠DCA); find ∠AFC=74° 52½′ ∠CAF=22° 42½′. and AF=10,27 miles, the distance failed by the privateer.

In the right angled triangle AGF, where AF=10,27, the ∠FAG=(∠GAC+∠CAF=) 56° 27½′ find AG=5,675, and GF=8,561 miles.

In the right angled triangle AGI, where AG=5,675, GI=(GF—(IF=) 1,561; find ∠GAI=15° 23′, and AI=5,886 miles.

Now 4,197 m. divided by 2m. per hour, gives 2,098 h.=2h. 5 m. 52 s.

ANSWER. { The privateer lay by 2h. 5 m. 52 s. nearly.
The tide sets S. 48° 40′ E.
The privateer failed N. 56° 27′ E. distance 10,27 miles.
The other ship failed N. 15° 23′ E. distance 5,886 miles. }

QUESTION XX. *From the ports* A, B, C, *lying under the same parallel of latitude,* B *being* 60 *miles, and* C 160 *miles to the east of* A, *three ships sail toward the NW. quarter and meet together,* B *having failed two points, and* C 3½ *points farther from the meridian than* A *had: Required the course and distance each ship has run.*

SOLUTION. In an east and west line CD, take CA=160 m. AB=60 m. make the angle ACE=2 points=22° 30′, the angle CAE=1½ points=16° 52′; and join EB.

Through the points AEC describe a circle, cutting the line EB produced in H, and join HA, HC.

Now ∠AHE=∠ACE; and ∠BHC=∠BAE. (II. 129)

Therefore ships sailing from A, B, C, and meeting in H, their course will differ by the quantities proposed.

For drawing a meridian HD, the angles DHA, DHB, DHC, will respectively represent the angles which the ship's courses make with the meridian.

In the triangle ACE, where AC=160 miles, ∠EAC=1½ points, ∠ECA=2 points, and ∠AEC=12½ points; find the side EC=73,21 miles.

In the triangle BCE, where BC=100 m. CE=73,21, and the included ∠BCE=22° 30′; find the angle CEB=116° 37′, and ∠CBE=40° 53′.

Hence ∠ABH=40° 53′ (II. 93); the ∠HAB=116° 37′.

In the triangle AHB, where AB=60, and all the angles are known, find HA=102,6 miles, and HB=140,2 miles.

In the triangle AHC, where AC=160, and all the angles are known, find HC=225,5 miles.

ANSWER. { A's course is N. 26° 37′ W. distance 102,6 miles.
B's course is N. 49 07 W. distance 140,2 miles.
C's course is N. 65 59 W. distance 225,5 miles. }

SECTION X.

Of the ſurveying of Coaſts and Harbours.

From what has been already ſaid in the preceding ſections, an intelligent reader would ſee how the buſineſs of taking the bearings of part of a coaſt, and of plotting or delineating it, might be done. But as there are ſome particulars, which can be gained only by experience in the art of ſurveying, it will not be improper to apprize the learner concerning them, to qualify him to go more readily to work.

52. *To take the Draught of part of a Coaſt in ſailing along it.*

1ſt. Having brought the ſhip to a convenient place, from which the principal points of the coaſt, or bay, may be ſeen, either caſt anchor, if it is convenient, or *lie to* as ſteady as poſſible; or if the coaſt is too ſhoal, let the obſervations and meaſures be done in a boat. Then while the veſſel is ſtationary in that ſituation, take the bearings in degrees of ſuch points of the coaſt, as form the moſt material projections, or hollows, with the azimuth compaſs; write down theſe bearings, and make a rough ſketch of the appearance of the coaſt, obſerving carefully to mark the points, the bearings of which had been taken, with letters, for the ſake of reference.

2d. Then let the ſhip or boat run in a direct line, which muſt be very carefully meaſured by the log, or otherwiſe, one, two, or three miles, more or leſs, until ſhe comes into a ſituation from which the ſame points before obſerved can be ſeen again. There let the veſſel lie ſteady, as at the foregoing ſtation, and obſerve again the reſpective bearings in degrees of the ſame points, which are alſo to be written down; and a rough ſketch of the coaſt ſhould alſo be taken from this ſtation. But while the veſſel is running the *baſe line* from ſtation to ſtation, a more accurate drawing of the appearance of the coaſt ſhould be made.

3d. *To map theſe obſervations.* In ſome convenient part of a ſheet of paper deſcribe a circle, draw the magnetic meridian, lay off the ſeveral bearings taken from the firſt ſtation, and let them be numbered 1, 2, 3, &c. on the outſide of the circle: lay down alſo the ſeveral bearings taken from the ſecond ſtation, let theſe be numbered 1, 2, 3, &c. on the inſide of the circle, obſerving that the bearings of the ſame points are numbered with the ſame figures.

4th. Draw a line to expreſs the ſhip's run both in length and courſe; and from that end of the line expreſſing the firſt ſtation, draw lines parallel to the reſpective bearings taken from that end, and marked on the outſide of the circle: alſo from the other end, draw lines parallel to the bearings taken at that end, and noted on the inſide of the circle; mark the interſection of each pair of lines, directed to the ſame point, with the number annexed to their bearing; and through the interſections, ſo marked, draw, by hand, a curved line, obſerving to wave the line in and out, as near as can be, like the bending of the coaſt itſelf. Laſtly, Set off the variation of the compaſs from the north end of the magnetic meridian toward the right hand, if it be eaſt, or toward the left hand, if it be weſt, and draw the true meridian through that point and the center of the circle.

5th. Againſt

Digitized by Google

5th. Againſt each part draw the appearance of the elevated, or low ground, as marked in the ſketches, diſtinguiſhing rocks, cliffs, high-land, low-land, ſand-hills, &c. If there are any currents, or eddies, expreſs them in their proper places by darts, or arrows, the points being turned that way the current ſets. Put in the ſeveral ſoundings at low water in ſmall figures, diſtinguiſhing whether they are fathoms or feet; ſhew the time of high-water on the full and change days by Roman figures, and tell the riſe in feet. Put in a compaſs, and a ſcale of miles or leagues, ſuch as the veſſel's run was laid down by; add the name of the place, the coaſt, and the latitude and longitude, as true as can be obtained.

6th. If there are ſhoals, or ſands, on the coaſt, let them be taken by a boat ſailing round them, and keeping an account of the courſes, diſtances, and ſoundings. But to put them in the draught, the boat muſt take the bearings of two points on the coaſt, the bearings of which have been taken from the ſhip, from ſome part of each ſand or ſhoal ſo ſailed round. Or, the bearing of the boat at ſome part of the ſhoal, or of ſome beacon in that place, muſt be taken by the ſhip at each of the ſtations where ſhe took the bearings of the ſhore; for by either of theſe means one point of the ſand being obtained, the reſt of it can be laid down from the boat's account.

7th. If the coaſt to be ſurveyed is a bay or harbour, winding in ſuch a manner that all its principal points cannot be ſeen at two ſtations, let as many baſes, or lines, be run and meaſured exactly, as may be found neceſſary; obſerving that theſe ſeveral baſes run join to one another in the nature of a traverſe, and that each new ſet of objects, or points, obſerved, be taken from two ſtations at the end of a known diſtance. Or, look out for three or more remarkable objects on ſhore, which lie as far out of a right line as poſſible, and may be ſeen from every part of the bay or harbour which is to be ſurveyed. From any convenient ſtation let the bearing of one of theſe objects be taken with the compaſs, and the angles which are ſubtended by this and each of the others, be obſerved with Hadley's quadrant. Let the ſhip run from this ſtation, in a direct line, as far as the nature of the place will admit of, meaſuring the diſtance run by the log. Bring the ſhip to, or come to an anchor, and let the angles which theſe objects ſubtend be again meaſured with the quadrant, and the bearing of that object be ſet with the compaſs, which was ſet before. By theſe means, the ſituations of the objects on ſhore will be had with reſpect to one another, and to the baſe line; after which the poſition of any point may be obtained, by meaſuring the angles ſubtended at that point, by any two pairs of them, with Hadley's quadrant.

8th. If any particular parts of the harbour cannot be conveniently ſeen from either of the ſtations, take the boat into thoſe places, and having well examined them, make ſketches of them, eſtimating the lengths and breadths of the ſeveral inlets, either by the rowing, or ſailing of the boat, taking as many bearings, ſoundings, and other notes, as may be thought neceſſary; then annex theſe particular views in their proper places in the general draught.

9th. If there are any dangerous ſands, or rocks, beſides inſerting them in their proper places, there ſhould be a double line drawn through that point and one or more objects aſhore; and for this purpoſe, chuſe a

Digitized by Google

church, mill, houſe, noted tree, a cliff, or any other remarkable thing that can be diſtinctly ſeen at ſea, and which can be brought to bear in the ſame right line with the point to be avoided. But if that point is under water, there muſt be two land-marks brought to bear with the danger, in the ſame right line; and alſo two others which are in a direction, as nearly at right angles as can be to the former two; and that thoſe land-marks may be put down in their proper places in the chart, their bearings muſt alſo be taken from two of the ſhip's ſtations.

10th. It ſhould be remarked in the draught what places are unfit for anchorage, and what are fit, by writing *rocky ground*, *foul anchorage*, *good anchorage*, &c.; and in the latter to draw the figure of an anchor. Alſo, if there is any particular channel more convenient to ſail through than another, it is to be pointed out by lines drawn to its entrance from two or more noted marks aſhore.

The foregoing method of ſurveying a coaſt ſuppoſes in general, that it is taken by a ſhip in her paſſage along, not having an opportunity of going aſhore. But when the circumſtances will permit the meaſures and obſervations to be made on land, the ſurvey can be taken more accurately than on the water.

53. *To ſurvey a Harbour by Obſervations on Shore.*

1ſt. Make an eye-draught of the place to be ſurveyed; and in going round its coaſts, fix ſtation ſtaves, or ſtraight poles, tall enough to be ſeen at a conſiderable diſtance, in the moſt remarkable points and bendings of the ſhore; but if at any of thoſe places there is a noted tree, houſe, or any other remarkable thing, that object may ſerve inſtead of a ſtation ſtaff; and it will be convenient to black the ſtaves, and tie a piece of white bunting to the top of each. Then in the eye-draught put letters at the noted points, or marks, for the ſake of diſtinction.

2d. Chuſe the moſt extenſive and level ſpot of ground you can meet with, to meaſure your baſe line on, which ſhould not be leſs than a tenth part of the diſtance of the two extreme objects which are to be obſerved; and let the direction of the meaſured baſe line be ſuch, that as many of the ſtations as poſſible may be ſeen from each end of it. The bearing, or poſition, of this baſe, muſt be well determined in degrees and minutes; and its length accurately meaſured, either by a meaſuring chain, or by a piece of log line.

3d. From each end of the baſe, obſerve with Hadley's quadrant, the angles ſubtended between the other end and each of the ſtation ſtaves, or objects which had been before remarked at each point or bending of the coaſt; and write them down orderly in your book, or mark them on the eye draught.

4th. Then theſe meaſures and angles being plotted, or laid down, will give the moſt conſpicuous points of the ſhore; the intermediate ſpaces are to be filled up from the ſketches of them made on the ſpot, as in 8th of Article 52.

5th. But if any of theſe objects ſhould ſpread on either hand ſo far beyond the limits of the baſe, that at either end the other end and thoſe objects or ſtaves ſhould appear nearly in the ſame direction, or to make angles not exceeding 10 degrees: or, if ſome of the remarked objects can be ſeen only from one end of the baſe; then let the bearings of ſuch objects be taken from a place, the poſition of which has been determined from both ends of the meaſured baſe: or, if there are ſeveral remarked objects which cannot be ſeen from either end of the baſe line, let the bearings of ſuch objects be taken from each of two points, the poſitions of which have been taken from both ends of the baſe: or, it may on ſome occaſions be proper to chuſe another place, on which another baſe of a convenient length may be meaſured, and from the extremities of which the ends of the firſt baſe may be ſeen; and alſo, as many as can be of the remaining objects which lay too oblique for the firſt baſe, or which could not be ſeen from it: in ſuch manner proceed until the bearings are taken of all the points that are judged neceſſary for completing the ſurvey of the harbour.

If a baſe of a ſufficient length cannot be meaſured in one right line, it may be taken in two adjoining lines, as the two ſides of a triangle; the included angle being accurately taken, and the bearing of either line.

The poſitions of objects taken by a magnetic compaſs being liable to great uncertainties, as is well known to thoſe who have had any experience, eſpecially at ſea; the mariner has therefore been directed, in the foregoing inſtructions, to take as many of the angular poſitions as may be, by the Hadley's quadrant, the deſcription and uſe of which will be given in the IXth Book.

54. When the outlines, or limits of an harbour, bay, road, &c. are delineated by the preceding precepts; the appearances of the ſhores, with the adjacent remarkable objects, correctly drawn; a compaſs with the variation and ſcale properly fitted to the plan; the iſles, rocks, ſands, &c. marked in their proper places; the ſetting and drift of the currents, and tides; the times of high-water on the days of new and full moon, with the riſe of water at thoſe times, and whether whole tide, or tide and part; the beſt anchoring places, with their ſoundings at low water, and the winds open to them; the beſt track, with the ſoundings all the way to thoſe anchoring-places; the proper ſailing marks to avoid dangers; the winds, if there are any troubleſome ones, which prevail, and at what ſeaſons; the places where freſh water can be got, and the time in which a boat's crew can fill a number of hogſheads at thoſe places; the name of the place, the country in, on what ſea, the latitude and longitude; a ſketch of the appearance the place makes at ſea upon a known rhumb, and at an eſtimated diſtance; and whatever elſe a judicious ſeaman ſhall think proper to inſert; then is the plan fit for all nautical purpoſes. But as it is uſual to embelliſh ſuch drawings with proper colours, the following obſervations may be uſeful to beginners.

55. A draughtſman ſhould be furniſhed with ſome, if not all, of theſe particulars, *viz.* 1ſt. Black-lead pencils: 2d. One pair of hair pencils, with the quill about the ſize of a common pen, and the hairs not ſhorter than $\frac{1}{2}$ an inch, nor longer than $\frac{2}{3}$ inch; another pair or two of a ſize or two ſmaller; they ſhould all draw to a fine point when wetted; and that wet point be drawn through the margin of the flame of a candle, to take off the ends of ſtraggling hairs, if there are any: 3d. A marble of five or ſix inches ſquare, and about $\frac{1}{4}$ inch thick, in which are four, or ſix, or more little round cavities, or cells of about $1\frac{1}{4}$ inch diameter,

diameter, and ¼ inch deep, to put liquid colours in when uſing; or, for want of a marble, a few horſe-muſcle, or ſuch like, ſhells: 4th. A cake of good Indian ink: 5th. A little paper of carmine, which is a fine red colour: 6th. A piece of prepared indigo, which is a blue: 7th. A piece of prepared yellow: 8th. A piece of a ſap-green: 9th. A piece of Spaniſh liquorice, or ſome liquid brown, made by a ſtrong ſolution of tobacco in boiling water: 10th. A ſmall vial of diſtilled verdigriſe, which is a fine ſea-green: 11th. Some gum Arabic diſſolved in water. Theſe particulars are to be had at colour ſhops: where the colours in lumps, or liquids, are generally prepared with a ſufficient quantity of gum in them; but thoſe in powders muſt have a pencilful or two of gum water put to them, when they are uſed.

The colours in lumps are beſt uſed by rubbing one end of the lump gently in a cell in the marble (or on a tile) till as much is wore off as is judged neceſſary for the preſent uſe; and it is beſt to rub off freſh colour as it is wanted, and not to have too much at a time. If the colour firſt rubbed up is too ſtrong, as it generally is (unleſs for finiſhing touches) put one or two pencils full of that colour into another cell, and lighten it with one or more pencils full of water; remove ſome of this ſecond colour into a third cell, and lighten this with water; and ſo to a fourth cell; by this four different tints of that colour will be had, which will be found quite ſufficient in the moſt finiſhed piece; in moſt caſes two tints will do.

In the uſing of liquid colours the pencil ſhould be well wetted with the colour, and then gently drawn acroſs the edge of the cell, to bring the pencil to a point, and free it of ſome of the colour; for the pencil ſhould not be quite full, unleſs it be to cover a large ſpot of the drawing.

56. When a perſon, unaccuſtomed to the uſe of colours, begins to work with them, he may acquire by degrees a facility in laying them well on paper. Thus, with a black-lead pencil draw two parallel lines at about ¼ inch apart, and with the lighteſt of the aforeſaid tints (ſuppoſe of Indian ink) let him try to colour the ſpace between theſe lines; and repeat the trial with other lines, until he finds he can cover the ſpace with an uniform tint, and keep exactly between the lines. Let him try in like manner with all the tints gradually to the deepeſt (which is about as black as good writing ink) and the moſt difficult to uſe; and when he finds he can ſucceed in all the tints, and his hand is accuſtomed to keep the colour exactly to a line, which he may acquire in a few days, he may proceed thus: With a pair of pencils fitted on a ſtick, one for colour, and the other for fair water, let him lay a tint cloſe to a ſingle line, and ſoften off the other margin with the water-pencil; let him try to do this in ſeveral examples, ſome on one ſide, and ſome on both ſides, of the colour, taking of different tints, until he finds that he can ſucceed ſo, that the colour ſhall, from the deepeſt, gradually become fainter and fainter, until it loſes itſelf in the whiteneſs of the paper; obſerving, 1ſt. not to lay on a tint longer than 1½ or 2 inches, before the water-pencil is applied to ſoften its margin, leſt the colour ſhould dry too faſt: 2d. not to have the water-pencil too wet, leſt it run into the tint too much: 3d. at each length the water-pencil is uſed to, let its point be ſtroked on the hand, or on a waſte-paper, to take off the colour it had imbibed in waſhing that length; otherwiſe the next length might be of a different tint.

The

Digitized by Google

The foregoing observations being well attended to, will enable a beginner to work properly with colours, in plans. But it must be confessed, that half an hour employed in seeing these operations performed by an artist, will furnish more knowledge in these matters, than can be drawn from a multitude of verbal instructions only.

57. The young artist knowing how to use his colours, and graduate their tints, may proceed to colour the plans of harbours, and their coasts, thus:

The shores on the land-side are to be shaded with Indian ink; the breadth of the tint being within the limits of about $\frac{1}{8}$ and $\frac{1}{4}$ of an inch, and laid on at three times; *viz.* 1st. A light tint laid close to the shore, with the margin on the land-side softened off: 2d. A deeper middle tint, laid also close to the shore, but of a less breadth than the former, and the inside margin also softened off within the first washing: 3d. A fine line traced on the said shore, with a hair pencil charged with the deepest tint, and not softened on either side.

Th shores on the water-side are to be shaded with distilled verdigrise; the breadth of the tint about $\frac{1}{4}$ inch, and laid on at twice; for the first tint, about half water and half colour, laid close to the shore, and the water-side margin washed; the second tint of verdigrise only, narrower than the former, laid close to the shore, and not washed.

Sands, dry at low water, to be covered pretty thick with fine black points (see figures 12, 16, 18, 20, in Plate IX.) the sand coloured with brown, and the borders on the water-side shaded with verdigrise washed or softened.

The plans of buildings on the land to be coloured with a light tint of carmine, and the limit, on the inside, touched round with a deeper tint.

Fresh waters to be expressed by a colour of half verdigrise and half fair water, shaded with a light tint of indigo; or with a tint of indigo alone, of a light sky-colour, interspersed with fine streaks of white.

Green colours of various tints may be made with sap-green, yellow and blue rubbed together, with a pencil-full of verdigrise among them; and with such colours woods and grass lands may be expressed, when properly broken in with trees, bushes, and little irregular dashes with Indian ink.

Arable or ploughed land is expressed by covering the spot in the drawing with a kind of broken parallel lines, done by a hair pencil dipt in a brown or clay colour.

Muddy shores at low-water are shewn by laying on a middling tint of Indian ink, and laying over that a tint of light verdigrise.

The drawing and colouring of rocky shores, steep banks, hills, marshy ground, and the manner of breaking the ground in plans, &c. are best gained from examining a coloured plan done by a proper proficient; but where that is wanting, a pretty good taste may be gained by consulting printed plans and views, such as are in Lord Anson's voyage round the world.

Sea-

Digitized by Google

Sea-draughts taken according to the preceding precepts, and neatly drawn and coloured, besides the real use they may be of, cannot fail to recommend the young mariner, who surveys and constructs them, to the notice of his superiors.

SECTION XI.

To estimate Distances.

Besides the method of finding the distances of remote objects by trigonometrical computations, there are two other means which may be usefully applied when the former cannot; and these are, the *motion of sound*, and the *curvature of the earth*.

58. *Of the Motion of Sound.*

It is a well known observation, that the noise or sound arising from any blow or shock, made at a distance, is always heard some time after the stroke is seen, or known to be given; and hence it is generally concluded, that the seeing of any act done within view is instantaneous, but that sound travels at a perceptible rate.

Some of the most eminent philosophers, judging that the knowledge of the flight of sound might be of use on various occasions, have been at extraordinary pains and expence to measure the rate at which it moved; and the result of their experiments, particularly of those which were best conducted, is as follows.

1st. That the velocity of sound is the same, whether by sea or by land, in dry or in rainy weather, by day or by night, in winter or summer.

2d. That sound, whether more or less strong, flies with the same swiftness. For, by experiments, a cannon fired with a half-pound charge of powder was heard at about the distance of 17 $\frac{1}{2}$ miles in the same time after the flash was seen, as it was when fired with a charge of 6 lb.

3d. That the times in which sound is heard are proportional to the distance; that is, at a double distance it is heard in twice the time; at a triple distance in thrice the time, &c.

4th. That sound flies quicker or slower by just the velocity of the wind, according as it blows with or against the motion of the sound.

5th. That sound travels at the rate of about 1142 feet, or 380 yards in one second of time; so that

Sound moves in 1 second, 1142 feet, or 380 yards.
1 minute 22840 yards, or about 13 miles.
Which is about a miles in 4,6 seconds, or about a league in 14 seconds.
But sea miles are to land miles nearly as 7 to 6. (V. 73.)
Therefore sound runs a sea league in about 12 seconds of time.

It is a common observation, that persons in good health have about 75 pulsations, or beats, of the artery at the wrist in a minute.

59. There-

Digitized by Google

59. Therefore in 75 pulsations sound flies about 13 land miles, and about 11 $\frac{1}{7}$ sea miles; which is about one land mile in six pulses, and about one sea mile in near seven pulses, or a league in 20 pulses.

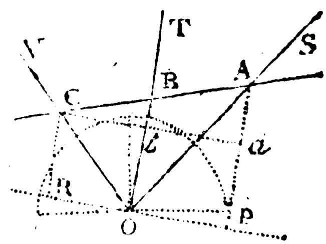
And hence the distance of objects may be found, by knowing the time which sound takes to move from those objects to an observer.

EXAMPLE. *Upon seeing the flash of a gun at sea, I counted 56 beats of the pulse at my wrist before I heard the report: How far was that gun from me?*

Now 56 divided by 20 gives 2,8 leagues, or about eight miles.

60. *To find the Course steered by a Ship seen at a distance.*

A ship lying to (at O,) may discover the course (AC,) which a vessel seen at a distance is going on; by taking, at two known intervals of time, three bearings (OS, OT, OV) of that vessel; thus:



In a line POR, drawn at right angles to the middle bearing OT, take OP, OR, as the given intervals of time, in minutes, taken from any scale of equal parts; and through P, R, draw lines parallel to OT, cutting OS, OV, in A, C.

Then a right line drawn through A and C, cutting OT in B, will shew the position, or the course, that vessel was sailing.

For drawing C*a* parallel to RP, and cutting PA, OB, in *a*, *b*; then *ab*, *b*C, equal to PO, OR, are as the times; and so are the lines AB, BC, by similar triangles.

Although by this method the apparent course may be determined, and also the relative distances at any proposed times; and among others, the nearest or least distance; yet the absolute distances are not hence to be found; and if the observing ship should change its place in the mean time, the position of AC will become uncertain.

61. *Of the Curvature of the Earth.*

Most persons know, that if they are raised above the surface of the adjacent land or water, they can see not only distant objects that lie on that surface better, but also see those which are more and more remote, as they advance higher. The irregularity of the surface of the land will not be subjected to any one rule, that will give the distance to which objects may be seen at different elevations; but at sea, where there is generally an uniform curvature of the surface of the water, the spherical figure of the Earth being admitted, those distances may be easily computed.

62. Let (see fig. 12. Pl. XIV.) the eye at E be raised the height ES above the surface S of the water; then it will see an object at *f* on the surface, in the tangent E*f*, which is the distance of that object from the eye.

Now

Digitized by Google

Now in the triangle EfC, right angled at f, there are known the side Cf=semidiameter of the Earth, and the side CE equal to the semidiameter CS increased by SE the height of the eye: to find the tangent Ef.

$$\text{Then (II. 113.) } Ef = \sqrt{\overline{CE}^2 - \overline{Cf}^2} = \sqrt{\overline{CS+SE}^2 - \overline{Cf}^2}$$
$$= \sqrt{\overline{2CS+SE} \times SE}.$$

That is, *To the Earth's diameter add the height of the eye, multiply the sum by that height; then the square root of the product is the distance, at which an object on the surface of the water can be seen by an eye so elevated.*

And by this Rule was the table at Article 65 computed, the diameter of the Earth being taken at 41798117 feet, according to Sir Isaac Newton's numbers.

This table may be usefully applied to estimate the distance of an object at sea, the elevation of that object above its horizon being known.

Example I. *Sailing towards a headland, on which is a lighthouse, elevated* 600 *feet above the surface of the water, we saw the lights at night just appearing in the horizon: How far were we at that time distant from the lighthouse?*

Seek in the table at Article 65 for 600 feet in the column signed *height in feet*, and right against it, in the column signed *distance in miles*, stands 29,994; so that the distance may be reckoned about 30 miles.

Example II. *Being walking on a sandy beach, in company with some merchants who were looking out for a vessel which was then expected, and whose top-gallant mast was* 140 *feet above the surface of the water, we observed, with a telescope, a ship's vane just appearing in the horizon: How far off was that ship, supposing it the vessel expected?*

Answer. Against 140 feet, the height, stands 14,448; that is, her distance is $14\frac{1}{2}$ miles.

63. Here is no allowance made for the height of the eye above the horizon; but it is obvious, that the higher the eye, the farther it can see. Now as objects are seen in a straight line, and that line is a tangent to the earth's surface, therefore it follows, that *to find the distance of two elevated objects, when the right line joining them touches the surface of the Earth, between those objects seek the distance answering to each height, and the sum is the distance sought.*

Thus in Example II. suppose the eye is raised six feet above the water's edge, it can see an object on the surface 2,999, or three miles off; this distance being added to the $14\frac{1}{2}$ miles, makes the distance of the ship to be $17\frac{1}{2}$ miles.

Exam-

Digitized by Google

Example III. *A man being on the main-top-gallant maſt of a man of war,* 200 *feet above the water, ſees a* 100 *gun ſhip ſhe had engaged the day before,* hull to: *How far were thoſe ſhips diſtant?*

A ſhip of 100 guns, or a firſt rate man of war, is about 60 feet from the keel to the rails; from which deduct about 20 feet for the draught of water, leaves 40 feet for the height of her quarter above water: now a ſhip is ſeen *hull to*, when her upper works juſt diſappear.

Then 200 feet high give	17,316 miles.
And againſt 40 feet ſtand	7,744 miles.
Their ſum, which is	25,060 miles, is their diſtance.

64. It might perhaps hereafter be found uſeful to mariners, could a liſt of the moſt conſiderable lighthouſes, and other elevated objects in different parts of the world, be obtained, together with their heights above the water. For as ſome of theſe objects are ſo high as to be ſeen at the diſtance of 30 or 40 miles, and even more; and as their diſtances upon being firſt ſeen could be known near enough by the table at Art. 65. were their heights known; therefore ſuch a liſt might, on ſeveral occaſions, not only give much ſatisfaction to a ſeaman, but even become of great uſe to know his diſtance from thoſe objects, as he could thereby know how to increaſe or ſlacken ſail in order to ſave his tide, or other emergency; alſo he would know better how to lay down the diſtances of rocks or ſhoals that lie off a coaſt, &c. But as ſuch a liſt is not eaſy to be come at, unleſs ſkilful mariners would be at the trouble of procuring ſuch as occured to them in their voyages, and on their return communicate them to ſome public body; therefore the curious in thoſe matters muſt be contented at preſent with what is here already ſaid.

Art. 65.

Digitized by Google

Art. 65. *A* Table *for finding the Distance of observed terrestrial Objects at Sea.*

Height in Feet	Dist. in miles.	Height in feet	Dist. in miles	Height in feet	Dist. in miles.	Height in feet	Dist. in miles.	Height in feet	Dist. in miles.
1	1,224	53	8,914	240	18,909	760	33,756	2250	58,083
2	1,732	56	9,163	245	19,165	780	34,197	2300	58,725
3	2,121	59	9,405	250	19,360	800	34,633	2350	59,360
4	2,449	62	9,641	255	19,553	820	35,063	2400	59,988
5	2,738	65	9,8[illegible]	260	19,7[illegible]3	840	35,488	2450	60,609
6	2,999	68	10,[illegible]7	265	19,93[illegible]	860	35,908	2500	61,225
7	3,239	71	10,317	270	20,119	880	36,323	2550	61,834
8	3,463	74	10,533	275	20,305	900	36,734	2600	62,437
9	3,673	77	10,745	280	20,489	920	37,140	2650	63,035
10	3,872	80	10,952	285	20,671	940	37,541	2700	63,626
11	4,061	83	11,156	290	20,851	960	37,938	2750	64,213
12	4,242	86	11,355	295	21,030	980	38,332	2800	64,794
13	4,415	89	11,552	300	21,208	1000	38,721	2850	65,37
14	4,581	92	11,745	310	21,558	1030	39,297	2900	65,941
15	4,74[illegible]	95	11,932	320	21,903	1060	39,866	2950	66,507
16	4,898	98	12,121	330	22,243	1090	40,426	3000	67,068
17	5,04[illegible]	101	12,306	340	22,578	1120	4[illegible],978	3050	67,625
18	5,195	104	12,487	350	22,907	1150	41,524	3100	68,177
19	5,33[illegible]	107	12,666	360	23,232	1180	42,062	3150	68,725
20	5,476	110	12,842	370	23,553	1210	42,593	3200	69,268
21	5,611	113	13,016	380	23,869	1240	43,118	3250	69,807
22	5,743	116	13,188	390	24,181	1270	43,636	3300	70,342
23	5,872	119	13,357	400	24,489	1300	44,149	3350	70,8[illegible]3
24	5,999	122	13,525	410	24,793	1330	44,655	3400	71,[illegible]00
25	6,122	125	13,690	420	25,004	1360	45,156	3450	71,92[illegible]
26	6,243	128	13,853	430	25,391	1390	45,651	3500	72,443
27	6,362	131	14,015	440	25,684	1420	46,141	3550	72,958
28	6,479	134	14,174	450	25,974	1450	46,629	3600	73,470
29	6,594	137	14,332	460	26,261	1480	47,106	3650	73,979
30	6,709	140	14,488	470	26,545	1510	47,581	3700	74,484
31	6,817	143	14,642	480	26,826	1540	48,052	3750	74,985
32	6,928	146	14,795	490	27,104	1570	48,517	3800	75 484
33	7,034	150	14,995	500	27,379	1600	48,979	3850	75,979
34	7,140	155	15,244	510	27,65[illegible]	1630	49,436	3900	76,471
35	7,244	160	15,488	520	27,922	1660	49,889	3950	76,959
36	7,347	165	15,728	530	28,189	1690	50,338	4000	77,445
37	7,44[illegible]	170	15,965	540	28,454	1720	50,782	4050	77,927
38	7,548	175	16,198	550	28,716	1750	51,223	4100	78,407
39	7,647	180	16,427	560	28,976	1780	51,661	4150	78,884
40	7,744	185	16,654	570	29,233	1810	52,094	4200	79,35[illegible]
41	7,840	190	16,878	580	29,489	1840	52,524	4250	79,829
42	7,935	195	17,098	590	29,742	1870	52,951	4300	80,297
43	8,029	200	17,316	600	29,994	1900	53,374	4350	80,762
44	8,122	205	17,531	620	30,489	1930	53,793	4400	81,225
45	8,214	210	17,[illegible]44	640	30,976	1960	54,210	4450	81,685
46	8,305	215	17,95[illegible]	660	31,457	2000	54,761	4500	82,143
47	8,394	220	18,16[illegible]	680	31,930	2050	55,441	4550	82,598
48	8,483	225	18,36[illegible]	700	32,390	2100	56,113	4600	83,051
49	8,57[illegible]	230	18,569	720	32,855	2150	56,777	4650	83,501
50	8,6[illegible]	235	18,7[illegible]	740	33,309	2200	57,434	4700	83,949

66. A

66. A TRAVERSE TABLE

To every Point and Quarter Point of the Compafs or Horizon:

In FOUR PAGES.

AND ALSO,

67. A TRAVERSE TABLE

To every Degree and Quarter Degree of the Compafs or Horizon:

In FORTY-FIVE PAGES.

Digitized by Google

Distance	0 Point ¼ Lat.	0 Point ¼ Dep.	0 Point ½ Lat.	0 Point ½ Dep.	0 Point ¾ Lat.	0 Point ¾ Dep.	1 Point 0 Lat.	1 Point 0 Dep.	1 Point ¼ Lat.	1 Point ¼ Dep.	1 Point ½ Lat.	1 Point ½ Dep.	1 Point ¾ Lat.	1 Point ¾ Dep.	2 Points 0 Lat.	2 Points 0 Dep.	Distance
1	1,00	0,05	0,99	0,10	0,99	0,15	0,98	0,20	0,97	0,24	0,96	0,29	0,94	0,34	0,92	0,38	1
2	2,00	0,10	1,99	0,20	1,98	0,29	1,96	0,39	1,94	0,49	1,91	0,58	1,88	0,67	1,85	0,77	2
3	3,00	0,15	2,99	0,29	2,97	0,44	2,94	0,59	2,91	0,73	2,87	0,87	2,82	1,01	2,77	1,15	3
4	4,00	0,20	3,98	0,39	3,96	0,59	3,92	0,78	3,88	0,97	3,83	1,16	3,77	1,35	3,70	1,53	4
5	4,99	0,25	4,98	0,49	4,95	0,75	4,90	0,98	4,85	1,21	4,78	1,45	4,71	1,68	4,62	1,91	5
6	5,99	0,29	5,97	0,59	5,93	0,88	5,89	1,17	5,82	1,46	5,74	1,74	5,65	2,02	5,54	2,30	6
7	6,99	0,34	6,97	0,69	6,92	1,03	6,87	1,37	6,79	1,70	6,70	2,03	6,59	2,36	6,47	2,68	7
8	7,99	0,39	7,96	0,78	7,91	1,17	7,85	1,56	7,76	1,94	7,66	2,32	7,53	2,69	7,39	3,06	8
9	8,99	0,44	8,96	0,88	8,90	1,32	8,83	1,76	8,73	2,19	8,61	2,61	8,47	3,03	8,32	3,44	9
10	9,99	0,49	9,95	0,98	9,89	1,47	9,81	1,95	9,70	2,43	9,57	2,90	9,42	3,37	9,24	3,83	10
11	10,99	0,54	10,95	1,08	10,88	1,61	10,79	2,15	10,67	2,67	10,53	3,19	10,36	3,71	10,16	4,21	11
12	11,99	0,59	11,94	1,18	11,87	1,76	11,77	2,34	11,64	2,92	11,48	3,48	11,30	4,04	11,09	4,59	12
13	12,98	0,64	12,94	1,27	12,86	1,91	12,75	2,54	12,61	3,16	12,44	3,77	12,24	4,38	12,01	4,97	13
14	13,98	0,69	13,93	1,37	13,85	2,05	13,73	2,73	13,58	3,40	13,40	4,06	13,18	4,72	12,94	5,36	14
15	14,98	0,74	14,93	1,47	14,84	2,20	14,71	2,93	14,55	3,64	14,35	4,35	14,12	5,05	13,86	5,74	15
16	15,98	0,79	15,92	1,57	15,83	2,35	15,69	3,12	15,52	3,89	15,31	4,64	15,06	5,39	14,78	6,12	16
17	16,98	0,84	16,92	1,67	16,82	2,49	16,67	3,32	16,49	4,13	16,27	4,93	16,01	5,73	15,71	6,51	17
18	17,98	0,88	17,91	1,76	17,81	2,64	17,65	3,51	17,46	4,37	17,22	5,22	16,95	6,06	16,63	6,89	18
19	18,98	0,93	18,91	1,86	18,79	2,79	18,64	3,71	18,43	4,62	18,18	5,51	17,89	6,40	17,55	7,27	19
20	19,98	0,98	19,90	1,96	19,78	2,93	19,62	3,90	19,40	4,86	19,14	5,81	18,83	6,74	18,48	7,65	20
21	20,98	1,03	20,90	2,06	20,77	3,08	20,60	4,10	20,37	5,10	20,10	6,10	19,77	7,07	19,40	8,04	21
22	21,97	1,08	21,89	2,16	21,76	3,23	21,58	4,29	21,34	5,35	21,05	6,39	20,71	7,41	20,33	8,42	22
23	22,97	1,13	22,89	2,25	22,75	3,37	22,56	4,49	22,31	5,59	22,01	6,68	21,65	7,75	21,25	8,80	23
24	23,97	1,18	23,88	2,35	23,74	3,52	23,54	4,68	23,28	5,83	22,97	6,97	22,60	8,08	22,17	9,18	24
25	24,97	1,23	24,88	2,45	24,73	3,67	24,52	4,88	24,25	6,07	23,92	7,26	23,54	8,42	23,10	9,57	25
26	25,97	1,28	25,87	2,55	25,72	3,81	25,50	5,07	25,22	6,32	24,88	7,55	24,48	8,76	24,02	9,95	26
27	26,97	1,33	26,87	2,65	26,71	3,96	26,48	5,27	26,19	6,56	25,84	7,84	25,42	9,10	24,95	10,33	27
28	27,97	1,37	27,87	2,74	27,70	4,11	27,46	5,46	27,16	6,80	26,79	8,13	26,36	9,43	25,87	10,72	28
29	28,97	1,42	28,86	2,84	28,69	4,25	28,44	5,66	28,13	7,05	27,75	8,42	27,30	9,77	26,79	11,10	29
30	29,96	1,47	29,85	2,94	29,67	4,40	29,42	5,85	29,10	7,29	28,71	8,71	28,25	10,11	27,72	11,48	30
31	30,96	1,52	30,85	3,04	30,66	4,55	30,41	6,05	30,07	7,53	29,66	9,00	29,19	10,44	28,64	11,86	31
32	31,96	1,57	31,84	3,14	31,65	4,70	31,39	6,24	31,04	7,77	30,62	9,29	30,13	10,78	29,56	12,25	32
33	32,96	1,62	32,84	3,23	32,64	4,84	32,37	6,44	32,01	8,02	31,58	9,58	31,07	11,12	30,49	12,63	33
34	33,96	1,67	33,84	3,33	33,63	4,99	33,35	6,63	32,98	8,26	32,54	9,87	32,01	11,45	31,41	13,01	34
35	34,96	1,72	34,83	3,43	34,62	5,14	34,33	6,83	33,95	8,50	33,49	10,16	32,95	11,79	32,34	13,39	35
36	35,96	1,77	35,83	3,53	35,61	5,28	35,31	7,02	34,92	8,75	34,45	10,45	33,90	12,13	33,26	13,78	36
37	36,96	1,82	36,82	3,63	36,60	5,43	36,29	7,22	35,89	8,99	35,41	10,74	34,84	12,46	34,18	14,16	37
38	37,95	1,87	37,82	3,72	37,59	5,58	37,27	7,41	36,86	9,23	36,36	11,03	35,78	12,80	35,11	14,54	38
39	38,95	1,91	38 81	3,82	38,58	5,72	38,25	7,61	37,83	9,48	37,32	11,32	36,72	13,14	36,03	14,92	39
40	39,95	1,96	39,81	3,92	39,57	5,87	39,23	7,80	38,80	9,72	38,28	11,61	37,66	13,48	36,96	15,31	40
41	40,95	2,01	40,80	4,02	40,56	6,02	40,21	8,00	39,77	9,96	39,23	11,90	38,60	13,81	37,88	15,69	41
42	41,95	2,06	41,80	4,12	41,54	6,16	41,19	8,19	40,74	10,20	40,19	12,19	39,54	14,15	38,80	16,07	42
43	42,95	2,11	42,79	4,21	42,53	6,31	42,17	8,39	41,71	10,45	41,15	12,48	40,49	14,49	39,73	16,45	43
44	43,95	2,16	43,79	4,31	43,52	6.46	43,16	8,58	42,68	10,69	42,11	12,77	41,43	14,83	40,65	16,84	44
45	44,95	2,21	44,78	4,41	44,51	6,60	44,14	8,78	43,65	10,93	43,06	13,06	42,37	15,16	41,57	17,22	45
46	45,95	2,26	45,78	4,51	45,50	6,75	45,12	8,97	44,62	11,18	44,02	13,35	43,31	15,50	42,50	17,60	46
47	46,94	2,31	46,77	4,61	46,49	6,90	46,10	9,17	45,59	11,42	44,98	13,64	44,25	15,83	43,42	17,99	47
48	47,94	2,36	47,77	4,70	47,48	7,04	47,08	9,37	46,56	11,66	45,93	13,93	45,19	16,17	44,35	18,37	48
49	48,94	2,41	48,76	4,80	48.47	7,19	48,06	9,56	47,53	11,91	46,89	14,22	46,14	16,51	45,27	18,75	49
50	49,94	2,45	49,76	4,90	49,46	7,34	49,04	9,79	48,50	12,15	47,85	14,51	47,08	16.84	46,19	19,13	50
51	50,94	2,50	50,75	5,00	50,45	7,48	50,02	9,95	49,47	12,39	48,80	14,80	48,02	17,18	47,13	19,52	51
52	51 94	2,55	51,75	5,10	51,44	7,63	51,00	10,15	50,44	12,63	49,76	15,09	48,96	17,52	48,04	19,90	52
53	52,94	2,60	52,74	5,19	52,43	7,78	51,98	10,34	51,41	12,88	50,72	15,38	49,90	17,86	48,97	20,28	53
54	53,94	2,65	53,74	5,29	53,41	7,92	52,96	10,54	52,38	13,12	51,67	15,67	50,84	18,19	49,89	20,66	54
55	54,93	2,70	54,73	5,39	54,40	8,07	53,94	10,73	53,35	13,36	52,63	15,96	51,78	18,53	50,81	21,05	55
56	55,93	2,75	55,73	5,49	55,39	8,22	54,92	10,92	54,32	13,61	53,59	16,25	52,73	18,87	51,74	21,43	56
57	56,93	2,80	56,72	5,59	56,38	8,36	55,91	11,12	55,29	13,85	54,55	16,54	53,67	19,20	52,66	21,81	57
58	57,93	2,85	57,72	5,68	57,37	8,51	56,89	11,31	56,26	14,09	55,50	16,84	54,61	19,54	53,59	22,20	58
59	58,93	2,90	58,72	5,78	58,36	8.66	57,87	11,51	57,23	14,34	56,45	17,13	55,55	19,88	54,51	22,58	59
60	59,93	2,95	59,71	5,83	59,35	8,80	58,85	11,71	58,20	14,58	57,42	17,42	56,49	20,21	55,44	22,96	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	7 Points ¾		7 Points ½		7 Points ¼		7 Points 0		6 Points ¾		6 Points ½		6 Points ¼		6 Points 0		

Digitized by Google

Distance	0 Point						1 Point								2 Points.		Distance
	¼		½		¾		0		¼		½		¾		0		
	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,93	2,99	60,71	5,98	60,34	8,95	59,83	11,90	59,17	14,82	58,37	17,71	57,43	20,55	56,36	23,34	61
62	61,93	3,04	61,70	6,08	61,33	9,10	60,81	12,09	60,14	15,06	59,33	18,00	58,38	20,89	57,28	23,73	62
63	62,92	3,09	62,70	6,17	62,32	9,24	61,79	12,29	61,11	15,31	60,29	18,29	59,32	21,22	58,21	24,11	63
64	63,92	3,14	63,69	6,27	63,31	9,39	62,77	12,48	62,08	15,55	61,24	18,58	60,26	21,56	59,13	24,49	64
65	64,92	3,19	64,69	6,37	64,30	9,54	63,75	12,68	63,05	15,79	62,20	18,87	61,20	21,90	60,05	24,87	65
66	65,92	3,24	65,68	6,47	65,28	9,68	64,73	12,88	64,02	16,04	63,16	19,16	62,14	22,23	60,98	25,26	66
67	66,92	3,29	66,68	6,57	66,27	9,83	65,71	13,07	64,99	16,28	64,11	19,45	63,08	22,57	61,90	25,64	67
68	67,92	3,34	67,67	6,66	67,26	9,98	66,69	13,27	65,96	16,52	65,07	19,74	64,02	22,91	62,82	26,02	68
69	68,92	3,39	68,67	6,76	68,25	10,12	67,67	13,46	66,93	16,77	66,03	20,03	64,97	23,24	63,75	26,40	69
70	69,92	3,44	69,66	6,86	69,24	10,27	68,66	13,66	67,90	17,08	66,99	20,32	65,91	23,58	64,67	26,79	70
71	70,92	3,48	70,66	6,96	70,23	10,42	69,64	13,85	68,87	17,25	67,94	20,61	66,85	23,92	65,60	27,17	71
72	71,91	3,53	71,65	7,06	71,22	10,56	70,62	14,05	69,84	17,49	68,90	20,90	67,79	24,26	66,52	27,55	72
73	72,91	3,58	72,65	7,15	72,21	10,71	71,60	14,24	70,81	17,74	69,86	21,19	68,73	24,59	67,44	27,94	73
74	73,91	3,63	73,64	7,25	73,20	10,86	72,58	14,44	71,78	17,98	70,81	21,48	69,67	24,93	68,37	28,32	74
75	74,91	3,68	74,64	7,35	74,19	11,00	73,56	14,63	72,75	18,22	71,77	21,77	70,62	25,27	69,29	28,70	75
76	75,91	3,73	75,63	7,45	75,18	11,15	74,54	14,83	73,72	18,47	72,73	22,06	71,56	25,60	70,21	29,08	76
77	76,91	3,78	76,63	7,55	76,17	11,30	75,52	15,02	74,69	18,71	73,68	22,35	72,50	25,94	71,14	29,47	77
78	77,91	3,83	77,62	7,64	77,15	11,45	76,50	15,22	75,66	18,95	74,64	22,64	73,44	26,28	72,06	29,85	78
79	78,91	3,88	78,62	7,74	78,14	11,59	77,48	15,41	76,63	19,20	75,60	22,93	74,38	26,61	72,99	30,23	79
80	79,90	3,93	79,61	7,84	79,13	11,74	78,46	15,61	77,60	19,44	76,55	23,22	75,32	26,95	73,91	30,61	80
81	80,90	3,98	80,61	7,94	80,12	11,88	79,44	15,80	78,57	19,68	77,51	23,51	76,27	27,29	74,83	31,00	81
82	81,90	4,02	81,60	8,04	81,11	12,03	80,43	16,00	79,54	19,92	78,47	23,80	77,21	27,62	75,76	31,38	82
83	82,90	4,07	82,60	8,14	82,10	12,18	81,41	16,19	80,51	20,17	79,43	24,09	78,15	27,96	76,68	31,76	83
84	83,90	4,12	83,59	8,23	83,09	12,32	82,39	16,39	81,48	20,41	80,38	24,38	79,09	28,30	77,61	32,14	84
85	84,90	4,17	84,59	8,33	84,08	12,47	83,37	16,58	82,45	20,65	81,34	24,67	80,03	28,63	78,53	32,53	85
86	85,90	4,22	85,58	8,43	85,07	12,62	84,35	16,78	83,42	20,90	82,30	24,96	80,97	28,97	79,45	32,91	86
87	86,90	4,27	86,58	8,53	86,06	12,76	85,33	16,97	84,39	21,14	83,25	25,21	81,91	29,31	80,38	33,29	87
88	87,89	4,32	87,58	8,63	87,05	12,91	86,31	17,17	85,36	21,38	84,21	25,54	82,86	29,65	81,30	33,67	88
89	88,89	4,37	88,57	8,72	88,04	13,06	87,29	17,36	86,33	21,62	85,17	25,83	83,80	29,98	82,23	34,06	89
90	89,89	4,42	89,57	8,82	89,02	13,21	88,27	17,56	87,30	21,87	86,12	26,12	84,74	30,32	83,15	34,44	90
91	90,89	4,47	90,56	8,92	90,01	13,35	89,25	17,75	88,27	22,11	87,08	26,41	85,68	30,66	84,07	34,82	91
92	91,89	4,52	91,56	9,02	91,00	13,50	90,23	17,95	89,24	22,35	88,04	26,70	86,62	30,99	85,00	35,21	92
93	92,89	4,56	92,55	9,12	91,99	13,65	91,21	18,14	90,21	22,60	89,00	27,00	87,56	31,33	85,92	35,59	93
94	93,89	4,61	93,55	9,21	92,98	13,79	92,19	18,34	91,18	22,84	89,95	27,29	88,51	31,67	86,85	35,97	94
95	94,89	4,66	94,54	9,31	93,97	13,94	93,18	18,54	92,15	23,08	90,91	27,58	89,45	32,00	87,77	36,35	95
96	95,88	4,71	95,54	9,41	94,96	14,09	94,16	18,73	93,12	23,33	91,87	27,87	90,39	32,34	88,69	36,74	96
97	96,88	4,76	96,53	9,51	95,95	14,23	95,14	18,92	94,09	23,57	92,82	28,16	91,33	32,68	89,62	37,12	97
98	97,88	4,81	97,53	9,61	96,94	14,38	96,12	19,12	95,06	23,81	93,78	28,45	92,27	33,01	90,54	37,50	98
99	98,88	4,86	98,52	9,70	97,93	14,53	97,10	19,31	96,03	24,05	94,74	28,74	93,21	33,35	91,46	37,88	99
100	99,88	4,91	99,52	9,80	98,92	14,67	98,08	19,51	97,00	24,30	95,69	29,03	94,15	33,69	92,39	38,27	100
101	100,9	4,96	100,5	9,90	99,91	14,82	99,06	19,70	97,97	24,54	96,65	29,32	95,10	34,03	93,31	38,65	101
102	101,9	5,01	101,5	10,00	100,9	14,97	100,0	19,90	98,94	24,78	97,61	29,61	96,04	34,36	94,24	39,03	102
103	102,9	5,05	102,5	10,10	101,9	15,11	101,0	20,09	99,91	25,03	98,56	29,90	96,98	34,70	95,16	39,42	03
104	103,9	5,10	103,5	10,19	102,9	15,26	102,0	20,29	100,9	25,27	99,52	30,19	97,92	35,04	96,08	39,80	104
105	104,9	5,15	104,5	10,29	103,9	15,41	103,0	20,48	101,9	25,51	100,5	30,48	98,86	35,37	97,01	40,18	105
106	105,9	5,20	105,5	10,39	104,9	15,55	104,0	20,68	102,8	25,76	101,4	30,77	99,80	35,71	97,93	40,56	106
107	106,9	5,25	106,5	10,49	105,8	15,70	104,9	20,88	103,8	26,00	102,4	31,06	100,7	36,05	98,86	40,95	107
108	107,9	5,30	107,5	10,59	106,8	15,85	105,9	21,07	104,8	26,24	103,4	31,35	101,7	36,38	99,78	41,33	108
109	108,9	5,35	108,5	10,68	107,8	15,99	106,9	21,27	105,7	26,48	104,3	31,64	102,6	36,72	100,7	41,71	109
110	109,9	5,40	109,5	10,78	108,8	16,14	107,9	21,46	106,7	26,73	105,3	31,93	103,6	37,06	101,6	42,09	110
111	110,9	5,45	110,5	10,88	109,8	16,29	108,9	21,66	107,7	26,97	106,2	32,22	104,5	37,39	102,6	42,48	111
112	111,9	5,50	111,5	10,98	110,8	16,43	109,8	21,85	108,6	27,21	107,2	32,51	105,5	37,73	103,5	42,86	112
113	112,9	5,55	112,5	11,08	111,8	16,58	110,8	22,05	109,6	27,46	108,1	32,80	106,4	38,07	104,4	43,24	113
114	113,9	5,59	113,5	11,17	112,8	16,73	111,8	22,24	110,6	27,70	109,1	33,09	107,3	38,41	105,3	43,63	114
115	114,9	5,64	114,4	11,27	113,8	16,87	112,8	22,44	111,6	27,94	110,0	33,38	108,3	38,74	106,2	44,01	115
116	115,9	5,69	115,4	11,37	114,7	17,02	113,8	22,63	112,5	28,18	111,0	33,67	109,2	39,08	107,2	44,39	116
117	116,9	5,74	116,4	11,47	115,7	17,17	114,8	22,83	113,5	28,43	112,0	33,96	110,2	39,42	108,1	44,77	117
118	117,9	5,79	117,4	11,57	116,7	17,31	115,7	23,02	114,5	28,67	112,9	34,25	111,1	39,75	109,0	45,16	118
119	118,9	5,84	118,4	11,66	117,7	17,46	116,7	23,22	115,4	28,91	113,9	34,54	112,0	40,09	109,9	45,54	119
120	119,9	5,89	119,4	11,76	118,7	17,61	117,7	23,41	116,4	29,16	114,8	34,83	113,0	40,43	110,9	45,92	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat	Distance
	¾		½		¼		0		¾		½		¼		0		
	7 Points								6 Points								

Distance	2 Points						3 Points								4 Points		Distance
	¼		½		¾		0		¼		½		¾		0		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,90	0,43	0,88	0,47	0,86	0,51	0,83	0,56	0,80	0,60	0,77	0,63	0,74	0,67	0,71	0,71	1
2	1,81	0,85	1,76	0,94	1 71	1,03	1,66	1,11	1,61	1,19	1,55	1,27	1,48	1,34	1,41	1,41	2
3	2,71	1,28	2,65	1,41	2,57	1,54	2,49	1,67	2,41	1,79	2,32	1,90	2,22	2,01	2,12	2,12	3
4	3,62	1,71	3,53	1,89	3,43	2,06	3,33	2,22	3,21	2,38	3,09	2,54	2,96	2,69	2,83	2,83	4
5	4 52	2,14	4.41	2,36	4,29	2,57	4,16	2,78	4,02	2,98	3,86	3,17	3,70	3,36	3,53	3,53	5
6	5,42	2,56	5,29	2,83	5,15	3,08	4 99	3,33	4,82	3,57	4,64	3,81	4,45	4,03	4,24	4,24	6
7	6,33	2,99	6,17	3,30	6,00	3,60	5,82	3,89	5,62	4,17	5,41	4,44	5,19	4,70	4,95	4,95	7
8	7,23	3,42	7,05	3,77	6,86	4,11	6,65	4,44	6,43	4,77	6,18	5,07	5,93	5,37	5.66	5,66	8
9	8,14	3,85	7,94	4,24	7,72	4,63	7,48	5,00	7,23	5,36	6,96	5,71	6,67	6,04	6,36	6,36	9
10	9 04	4,28	8,82	4,71	8,58	5,14	8,32	5,56	8,03	5,96	7,73	6,34	7,41	6,72	7,07	7,07	10
11	9.94	4,70	9 70	5,18	9,43	5,65	9,15	6,11	8,83	6,55	8,50	6,98	8,15	7,39	7,78	7,78	11
12	10,85	5,13	10,58	5,66	10,29	6,17	9,98	6,67	9,64	7,15	9,28	7,61	8,89	8,06	8,49	8,49	12
13	11,75	5,56	11,46	6,13	11,15	6,68	10,81	7,22	10,44	7,74	10,05	8,25	9,63	8,73	9,19	9,19	13
14	12 66	5,99	12,35	6,60	12,01	7,20	11,64	7,78	11,24	8,33	10,82	8,88	10,37	9,40	9,90	9,90	14
15	13,56	6.41	13,23	7,07	12,87	7,71	12,47	8,33	12,05	8,93	11,59	9,51	11,11	10,07	10,61	10,61	15
16	14.46	6 84	14,11	7,54	13,73	8,22	13,30	8,89	12,85	9,52	12,37	10,15	11,85	10,75	11,31	11,31	16
17	15,37	7,27	14,99	8,01	14,58	8,74	14,13	9,45	13,65	10,12	13,14	10,78	12,60	11,42	12,02	12,02	17
18	16,27	7,70	15,87	8,48	15,44	9,25	14,96	10,00	14,46	10,71	13,91	11,42	13,34	12,09	12,73	12,73	18
19	17,18	8,13	16,76	8,95	16,30	9,77	15,80	10,56	15,26	11,31	14,69	12,05	14,08	12,76	13,43	13,43	19
20	18,08	8.55	17,64	9,43	17,15	10,28	16,63	11.12	16,06	11,91	15,46	12,69	14,82	13,43	14,14	14,14	20
21	18,98	8,98	18,52	9,90	18,01	10,80	17,46	11,67	16,87	12,51	16,23	13,32	15,56	14,10	14,85	14,85	21
22	19,89	9.41	19,40	10,37	18,87	11,31	18,29	12,22	17,67	13,11	17,01	13,95	16,30	14,77	15,56	15,56	22
23	20,79	9,83	20,28	10,84	19,73	11,82	19,12	12,78	18,47	13,70	17,78	14,59	17,04	15,45	16,26	16,26	23
24	21.69	10,26	21,17	11,31	20,59	12,34	19,95	13,34	19,28	14,30	18 55	15,22	17,78	16,12	16,97	16,97	24
25	22,60	10.69	22,05	11,78	21,44	12,85	20,78	13,89	20,08	14,89	19,33	15,86	18,52	16,79	17,68	17,68	25
26	23.50	11,12	22,93	12,25	22,30	13,37	21,61	14,45	20,88	15,49	20,10	16,49	19,26	17,46	18,38	18,38	26
27	24,41	11.55	23,81	12,72	23,16	13,88	22,45	15,00	21,68	16,09	20,87	17,12	20,01	18,13	19,09	19,09	27
28	25,31	11,97	24,69	13,20	24,02	14,39	23,28	15,56	22,49	16,68	21,64	17,76	20,75	18,81	19,80	19,80	28
29	26,21	12,40	25,58	13,69	24,88	14,91	24,11	16,12	23,29	17,28	22,42	18,39	21,49	19,48	20,51	20,51	29
30	27.12	12,83	26,46	14,14	25,73	15,42	24,94	16,67	24,10	17,87	23,19	19,03	22,23	20,15	21,21	21.21	30
31	28,02	13,25	27,34	14,61	26,59	15,94	25,78	17,22	24,90	18,46	23,96	19,67	22,97	20,82	21,92	21,92	31
32	28,93	13,68	28,23	15,09	27,45	16,45	26,61	17,78	25,70	19,06	24,74	20,30	23,71	21,49	22,63	22,63	32
33	29,83	14,11	29,11	15,56	28,31	16,96	27,44	18,34	26,51	19,66	25,51	20,93	24 45	22,16	23,33	23,33	33
34	30,73	14,54	29,99	16,03	29,16	17,48	28,27	18,89	27,31	20,25	26,28	21,57	25,19	22,83	24,04	24,04	34
35	31,64	14,97	30,87	16,51	30,02	17,99	29.10	19,45	28,11	20,85	27,05	22,21	25,93	23,51	24,75	24,75	35
36	32,54	15,39	31,76	16,98	30,88	18,51	29,93	20,00	28,91	21,45	27,83	22,84	26,67	24,19	25,46	25,46	36
37	33.45	15,82	32,64	17,45	31,74	19,02	30,76	20,56	29,72	22,04	28,60	23,47	27,42	24,85	26,16	26,16	37
38	34,35	16,25	33-52	17,92	32,60	19,53	31,59	21,12	30,52	22,64	29,37	24,10	28,16	25,52	26,87	26,87	38
39	35.26	16,68	34 40	18,39	33,45	20,05	32,42	21,67	31,32	23,23	30,15	24,74	28,90	26,19	27,58	27,58	39
40	36.16	17,10	35,28	18,86	34,31	20,56	33,26	22,22	32,13	23,83	30,92	25,38	29,64	26,86	28,28	28,28	40
41	37,06	17,53	36,16	19.33	35,17	21,08	34,09	22,78	32,93	24,42	31,69	26,01	30,38	27,53	28,99	28,99	41
42	37 97	17,96	37,04	19,80	36,03	21,59	34,92	23,34	33,73	25,02	32,47	26,64	31,12	28,21	29,70	29,70	42
43	38,87	18 39	37,92	20,27	36,88	22,10	35,75	23,89	34,54	25,62	33,24	27,28	31,86	28,88	30,41	30,41	43
44	39.77	18,81	38,80	20,74	37,74	22,62	36,58	24,45	35,34	26,21	34,01	27,91	32,60	29,55	31,11	31,11	44
45	40,68	19 24	39.69	21,21	38,60	23,13	37,41	25,00	36,14	26,82	34,78	28,55	33,34	30,22	31,82	31,82	45
46	41 58	19.67	40,57	21,68	39,46	23,65	38,24	25,56	36,95	27,41	35,56	29,18	34,08	30,89	32,53	32,53	46
47	42.49	20.10	41,45	22 15	40,32	24,16	39,08	26,12	37,75	28,01	36,33	29,81	34,82	31,57	33,23	33,23	47
48	43,39	20.53	42,33	22,62	41,17	24,68	39,91	26,67	38,55	28,61	37,10	30,45	35,57	32,24	33,94	33,94	48
49	44.29	20,95	43,21	23,09	42,03	25,19	40,74	27,23	39,36	29,20	37,88	31,08	36,31	32,91	34,65	34,65	49
50	45.20	21 38	44,10	23,57	42,89	25,70	41,57	27,78	40.16	29,79	38,65	31,72	37,05	33,58	35,35	35,35	50
51	46 10	21,81	44,98	24,04	43,74	26,22	42,40	28,34	40,96	30,38	39,42	32,35	37,79	34,25	36,06	36,06	51
52	47,01	22,23	45,86	24,51	44,60	26,73	43,23	28,89	41,77	30,98	40,20	32,99	38,53	34,92	36,77	36,77	52
53	47,91	22,66	46.74	24,98	45,46	27,25	44,07	29,45	42,57	31,57	40,97	33,62	39,27	35,59	37,47	37,47	53
54	48.81	23,09	47,62	25,45	46,32	27.76	44,90	30,00	43,37	32,17	41,74	34.26	40,01	36,27	38,18	38,18	54
55	49,72	23.52	48,51	25,92	47,18	28,27	45,73	30,56	44,18	32,76	42,52	34,89	40,75	36,94	38,89	38,89	55
56	50,62	23,95	49,39	26,40	48,03	28,79	46,56	31,12	44,98	33,36	43,29	35,52	41,49	37,61	39,60	39,60	56
57	51,53	24,37	50,27	26,87	48,89	29,30	47,39	31,67	45,78	33,96	44.06	36,16	42,23	38,28	40,30	40,30	57
58	52,43	24 80	51,15	27,34	49.75	29,82	48,22	32,23	46,58	34,55	44,83	36,79	42,98	38,95	41,01	41,01	58
59	53,33	25,22	52,03	27,81	50,61	30,33	49.05	32,78	47,39	35,15	45,61	37,43	43,72	39,63	41,72	41,72	59
60	4.24	25,65	52.92	28,28	51,46	30,85	49,89	33.33	48,19	35,74	46,38	38,06	44.46	40,29	42,43	42,43	60
Distance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	¾		½		¼		0		¾		½		¼		0		
	5 Points								4 Points								

Distance	2 Points						3 Points								4 Points		Distance
	¼		½		¾		0		¼		½		¾		0		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	55,14	26,08	53,80	28,75	52,32	31,36	50,72	33,89	49,00	36,34	47,15	38,70	45,20	40,97	43,13	43,13	61
62	56,05	26,51	54,68	29,22	53,18	31,87	51,55	34,45	49,80	36,93	47,93	39,33	45,94	41,64	43,84	43,84	62
63	56,95	26,94	55,56	29,70	54,04	32,39	52,38	35,00	50,60	37,53	48,70	39,96	46,68	42,31	44,55	44,55	63
64	57,85	27,36	56,44	30,17	54,90	32,90	53,21	35,56	51,40	38,13	49,47	40,60	47,42	42,98	45,25	45,25	64
65	58,76	27,79	57,33	30,64	55,75	33,42	54,04	36,11	52,21	38,72	50,25	41,24	48,16	43,65	45,96	45,96	65
66	59,66	28,22	58,21	31,11	56,61	33,93	54,87	36,67	53,01	39,32	51,02	41,87	48,90	44,33	46,67	46,67	66
67	60,57	28,65	59,09	31,58	57,47	34,44	55,71	37,22	53,81	39,91	51,79	42,50	49,64	44,99	47,38	47,38	67
68	61,47	29,07	59,97	32,05	58,33	34,96	56,54	37,78	54,62	40,51	52,56	43,13	50,38	45,67	48,08	48,08	68
69	62,37	29,51	60,85	32,52	59,19	35,47	57,37	38,34	55,42	41,11	53,34	43,77	51,13	46,34	48,79	48,79	69
70	63,28	29,93	61,73	33,00	60,04	35,99	58,20	38,89	56,22	41,70	54,11	44,41	51,87	47,01	49,50	49,50	70
71	64,18	30,36	62,62	33,47	60,90	36,50	59,03	39,45	57,03	42,29	54,88	45,04	52,61	47,68	50,20	50,20	71
72	65,08	30,78	63,50	13,94	61,76	37,01	59,87	40,00	57,83	42,89	55,66	45,67	53,35	48,35	50,91	50,91	72
73	65,99	31,21	64,38	34,41	62,62	37,53	60,70	40,56	58,63	43,49	56,43	46,31	54,09	49,02	51,62	51,62	73
74	66,89	31,64	65,26	34,88	63,47	38,04	61,53	41,11	59,44	44,08	57,20	46,94	54,83	49,70	52,33	52,33	74
75	67,80	32,07	66,14	35,35	64,33	38,56	62,36	41,67	60,24	44,68	57,98	47,58	55,57	50,37	53,03	53,03	75
76	68,70	32,50	67,03	35,82	65,19	39,07	63,19	42,22	61,04	45,27	58,75	48,21	56,31	51,04	53,74	53,74	76
77	69,60	32,92	67,91	36,29	66,05	39,58	64,02	42,78	61,85	45,87	59,52	48,84	57,05	51,71	54,45	54,45	77
78	70,51	33,35	68,79	36,76	66,91	40,10	64,85	43,34	62,65	46,47	60,29	49,48	57,79	52,38	55,15	55,15	78
79	71,41	33,78	69,67	37,24	67,76	40,61	65,70	43,89	63,45	47,06	61,07	50,11	58,54	53,06	55,86	55,86	79
80	72,32	34,20	70,55	37,71	68,62	41,13	66,52	44,45	64,26	47,66	61,84	50,75	59,28	53,72	56,57	56,57	80
81	73,22	34,63	71,44	38,18	69,48	41,64	67,35	45,00	65,06	48,25	62,61	51,38	60,02	54,40	57,28	57,28	81
82	74,12	35,06	72,32	38,65	70,33	42,16	68,18	45,56	65,86	48,85	63,39	52,02	60,76	55,07	57,98	57,98	82
83	75,03	35,49	73,20	39,12	71,19	42,67	69,01	46,11	66,67	49,44	64,16	52,65	61,50	55,74	58,69	58,69	83
84	75,93	35,92	74,08	39,59	72,05	43,18	69,84	46,67	67,47	50,04	64,93	53,29	62,24	56,41	59,40	59,40	84
85	76,84	36,34	74,96	40,07	72,91	43,70	70,67	47,23	68,27	50,64	65,71	53,92	62,98	57,08	60,10	60,10	85
86	77,74	36,77	75,85	40,54	73,77	44,21	71,50	47,78	69,08	51,24	66,48	54,55	63,72	57,76	60,81	60,81	86
87	78,64	37,20	76,73	41,01	74,62	44,73	72,34	48,34	69,88	51,83	67,25	55,19	64,46	58,43	61,52	61,52	87
88	79,55	37,63	77,61	41,48	75,48	45,24	73,17	48,89	70,68	52,42	68,02	55,82	65,20	59,10	62,22	62,22	88
89	80,45	38,06	78,49	41,95	76,34	45,75	74,00	49,45	71,48	53,02	68,80	56,46	65,94	59,77	62,93	62,93	89
90	81,36	38,49	79,37	42,42	77,20	46,27	74,83	50,00	72,29	53,61	69,57	57,09	66,69	60,44	63,64	63,64	90
91	82,26	38,92	80,26	42,90	78,05	46,78	75,66	50,56	73,09	54,21	70,34	57,73	67,43	61,11	64,35	64,35	91
92	83,16	39,35	81,14	43,37	78,91	47,30	76,49	51,11	73,90	54,80	71,12	58,36	68,17	61,78	65,05	65,05	92
93	84,07	39,78	82,02	43,84	79,77	47,81	77,33	51,67	74,70	55,40	71,89	59,00	68,91	62,46	65,76	65,76	93
94	84,97	40,20	82,90	44,31	80,63	48,32	78,16	52,22	75,50	56,00	72,66	59,63	69,65	63,13	66,47	66,47	94
95	85,88	40,63	83,78	44,78	81,49	48,84	79,00	52,78	76,30	56,59	73,44	60,26	70,39	63,80	67,17	67,17	95
96	86,78	41,06	84,67	45,25	82,34	49,35	79,83	53,34	77,11	57,19	74,21	60,90	71,13	64,47	67,88	67,88	96
97	87,68	41,49	85,55	45,72	83,20	49,87	80,66	53,89	77,91	57,78	74,98	61,53	71,87	65,14	68,59	68,59	97
98	88,59	41,91	86,43	46,19	84,06	50,38	81,49	54,45	78,71	58,38	75,75	62,17	72,61	65,82	69,30	69,30	98
99	89,49	42,34	87,31	46,66	84,92	50,89	82,32	55,00	79,52	58,98	76,53	62,80	73,35	66,49	70,00	70,00	99
100	90,40	42,76	88,19	47,14	85,77	51,41	83,15	55,56	80,32	59,57	77,30	63,44	74,00	67,16	70,71	70,71	100
101	91,30	43,18	89,07	47,61	86,63	51,92	83,98	56,11	81,12	60,17	78,07	64,07	74,84	67,83	71,42	71,42	101
102	92,20	43,61	89,96	48,08	87,49	52,44	84,81	56,67	81,93	60,76	78,85	64,71	75,58	68,50	72,12	72,12	102
103	93,11	44,04	90,84	48,55	88,35	52,95	85,64	57,22	82,73	61,36	79,62	65,34	76,32	69,17	72,83	72,83	103
104	94,01	44,47	91,72	49,02	89,21	53,47	86,47	57,78	83,53	61,95	80,39	65,97	77,06	69,84	73,54	73,54	104
105	94,92	44,90	92,60	49,50	90,06	53,98	87,31	58,34	84,34	62,55	81,17	66,61	77,80	70,52	74,25	74,25	105
106	95,82	45,33	93,48	49,96	90,92	54,49	88,14	58,89	85,14	63,15	81,94	67,24	78,54	71,19	74,95	74,95	106
107	96,72	45,75	94,37	50,44	91,78	55,01	88,98	59,45	85,94	63,74	82,71	67,88	79,28	71,86	75,66	75,66	107
108	97,63	46,18	95,25	50,91	92,64	55,52	89,80	60,00	86,75	64,34	83,48	68,51	80,02	72,53	76,37	76,37	108
109	98,53	46,61	96,13	51,38	93,50	56,04	90,63	60,56	87,55	64,93	84,26	69,15	80,76	73,20	77,07	77,07	109
110	99,44	47,03	97,01	51,85	94,35	56,55	91,46	61,11	88,35	65,53	85,03	69,78	81,50	73,87	77,78	77,78	110
111	100,3	47,46	97,89	52,32	95,21	57,06	92,29	61,67	89,16	66,12	85,80	70,42	82,25	74,54	78,49	78,49	111
112	101,2	47,89	98,78	52,79	96,07	57,58	93,12	62,22	89,96	66,72	86,58	71,05	82,99	75,22	79,20	79,20	112
113	102,1	48,31	99,66	53,27	96,92	58,09	93,96	62,78	90,76	67,31	87,35	71,68	83,73	75,89	79,90	79,90	113
114	103,1	48,74	100,5	53,74	97,78	58,61	94,79	63,34	91,57	67,91	88,12	72,32	84,47	76,56	80,61	80,61	114
115	104,0	49,17	101,4	54,21	98,64	59,12	95,62	63,89	92,37	68,51	88,90	72,95	85,21	77,23	81,32	81,32	115
116	104,9	49,60	102,3	54,68	99,50	59,63	96,45	64,45	93,17	69,10	89,67	73,58	85,95	77,90	82,02	82,02	116
117	105,8	50,03	103,2	55,15	100,4	60,15	97,28	64,99	93,97	69,70	90,44	74,22	86,69	78,58	82,73	82,73	117
118	106,7	50,45	104,1	55,62	101,2	60,66	98,11	65,56	94,78	70,29	91,21	74,85	87,43	79,25	83,44	83,44	118
119	107,6	50,88	105,0	56,09	102,1	61,18	98,94	66,11	95,58	70,89	91,99	75,49	88,17	79,92	84,14	84,14	119
120	108,5	51,31	105,8	56,57	102,9	61,69	99,78	66,67	96,39	71,48	92,76	76,13	88,91	80,59	84,85	84,85	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	¾		½		¼		0		¾		½		¼		0		
	5 Points								4 Points								

Distance	0 Degree					,00	1 Degree.							,02	Distance
	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1,00	0,00	1,00	0,01	1,00	0,01	1,00	0,02	1,00	0,02	1,00	0,03	1,00	0,03	1
2	2,00	0,01	2,00	0,02	2,00	0,03	2,00	0,04	2,00	0,04	2,00	0,05	2,00	0,06	2
3	3,00	0,01	3,00	0,03	3,00	0,04	3,00	0,05	3,00	0,07	3,00	0,08	3,00	0,09	3
4	4,00	0,02	4,00	0,03	4,00	0,05	4,00	0,07	4,00	0,09	4,00	0,10	4,00	0,12	4
5	5,00	0,02	5,00	0,04	5,00	0,07	5,00	0,09	5,00	0,11	5,00	0,13	5,00	0,15	5
6	6,00	0,03	6,00	0,05	6,00	0,08	6,00	0,11	6,00	0,13	6,00	0,16	6,00	0,18	6
7	7,00	0,03	7,00	0,06	7,00	0,09	7,00	0,12	7,00	0,15	7,00	0,18	7,00	0,21	7
8	8,00	0,04	8,00	0,07	8,00	0,10	8,00	0,14	8,00	0,18	8,00	0,21	8,00	0,25	8
9	9,00	0,04	9,00	0,08	9,00	0,12	9,00	0,16	9,00	0,20	9,00	0,24	9,00	0,28	9
10	10,00	0,04	10,00	0,09	10,00	0,13	10,00	0,18	10,00	0,22	10,00	0,26	10,00	0,31	10
11	11,00	0,05	11,00	0,10	11,00	0,14	11,00	0,19	11,00	0,24	11,00	0,28	11,00	0,34	11
12	12,00	0,05	12,00	0,10	12,00	0,16	12,00	0,21	12,00	0,26	12,00	0,31	11,99	0,37	12
13	13,00	0,06	13,00	0,11	13,00	0,17	13,00	0,23	13,00	0,28	13,00	0,34	12,99	0,40	13
14	14,00	0,06	14,00	0,12	14,00	0,18	14,00	0,25	14,00	0,31	14,00	0,37	13,99	0,43	14
15	15,00	0,07	15,00	0,13	15,00	0,20	15,00	0,26	15,00	0,33	15,00	0,39	14,99	0,46	15
16	16,00	0,07	16,00	0,14	16,00	0,21	16,00	0,28	16,00	0,35	16,00	0,42	15,99	0,49	16
17	17,00	0,07	17,00	0,15	17,00	0,22	17,00	0,30	17,00	0,37	17,00	0,45	16,99	0,52	17
18	18,00	0,08	18,00	0,16	18,00	0,24	18,00	0,32	18,00	0,39	17,99	0,47	17,99	0,55	18
19	19,00	0,08	19,00	0,17	19,00	0,25	19,00	0,33	19,00	0,42	18,99	0,50	18,99	0,58	19
20	20,00	0,09	20,00	0,17	20,00	0,26	20,00	0,35	20,00	0,44	19,99	0,52	19,99	0,61	20
21	21,00	0,09	21,00	0,18	21,00	0,28	21,00	0,37	21,00	0,46	20,99	0,55	20,99	0,64	21
22	22,00	0,10	22,00	0,19	22,00	0,29	22,00	0,38	22,00	0,48	21,99	0,58	21,99	0,67	22
23	23,00	0,10	23,00	0,20	23,00	0,30	23,00	0,40	23,00	0,50	22,99	0,60	22,99	0,70	23
24	24,00	0,10	24,00	0,21	24,00	0,31	24,00	0,42	24,00	0,52	23,99	0,63	23,99	0,73	24
25	25,00	0,11	25,00	0,22	25,00	0,33	25,00	0,44	24,99	0,55	24,99	0,65	24,99	0,76	25
26	26,00	0,11	26,00	0,23	26,00	0,34	26,00	0,45	25,99	0,57	25,99	0,68	25,99	0,79	26
27	27,00	0,12	27,00	0,24	27,00	0,35	27,00	0,47	26,99	0,59	26,99	0,71	26,99	0,83	27
28	28,00	0,12	28,00	0,24	28,00	0,37	28,00	0,49	27,99	0,61	27,99	0,73	27,99	0,86	28
29	29,00	0,13	29,00	0,25	29,00	0,38	29,00	0,51	28,99	0,63	28,99	0,76	28,99	0,89	29
30	30,00	0,13	30,00	0,26	30,00	0,39	30,00	0,52	29,99	0,65	29,99	0,79	29,99	0,92	30
31	31,00	0,14	31,00	0,27	31,00	0,41	31,00	0,54	30,99	0,68	30,99	0,81	30,99	0,95	31
32	32,00	0,14	32,00	0,28	32,00	0,42	32,00	0,56	31,99	0,70	31,99	0,84	31,99	0,98	32
33	33,00	0,14	33,00	0,29	33,00	0,43	33,00	0,58	32,99	0,72	32,99	0,86	32,99	1,01	33
34	34,00	0,15	34,00	0,30	34,00	0,44	33,99	0,59	33,99	0,74	33,99	0,89	33,99	1,04	34
35	35,00	0,15	35,00	0,31	35,00	0,46	34,99	0,61	34,99	0,76	34,99	0,92	34,99	1,07	35
36	36,00	0,16	36,00	0,31	36,00	0,47	35,99	0,63	35,99	0,79	35,99	0,94	35,99	1,10	36
37	37,00	0,16	37,00	0,32	37,00	0,48	36,99	0,65	36,99	0,81	36,99	0,97	36,98	1,13	37
38	38,00	0,17	38,00	0,33	38,00	0,50	37,99	0,66	37,99	0,83	37,99	0,99	37,98	1,16	38
39	39,00	0,17	39,00	0,34	39,00	0,51	38,99	0,68	38,99	0,85	38,99	1,02	38,98	1,19	39
40	40,00	0,17	40,00	0,35	40,00	0,52	39,99	0,70	39,99	0,87	39,99	1,05	39,98	1,22	40
41	41,00	0,18	41,00	0,36	41,00	0,54	40,99	0,72	40,99	0,89	40,99	1,07	40,98	1,25	41
42	42,00	0,18	42,00	0,37	42,00	0,55	41,99	0,73	41,99	0,92	41,99	1,10	41,98	1,28	42
43	43,00	0,19	43,00	0,38	43,00	0,56	42,99	0,75	42,99	0,94	42,99	1,13	42,98	1,31	43
44	44,00	0,19	44,00	0,38	44,00	0,58	43,99	0,77	43,99	0,96	43,99	1,15	43,98	1,34	44
45	45,00	0,20	45,00	0,39	45,00	0,59	44,99	0,79	44,99	0,98	44,99	1,18	44,98	1,37	45
46	46,00	0,20	46,00	0,40	46,00	0,60	45,99	0,80	45,99	1,00	45,99	1,20	45,98	1,40	46
47	47,00	0,21	47,00	0,41	47,00	0,61	46,99	0,82	46,99	1,03	46,99	1,23	46,98	1,44	47
48	48,00	0,21	48,00	0,42	48,00	0,63	47,99	0,84	47,99	1,05	47,98	1,26	47,98	1,47	48
49	49,00	0,21	49,00	0,43	49,00	0,64	48,99	0,86	48,99	1,07	48,98	1,28	48,98	1,50	49
50	50,00	0,22	50,00	0,44	50,00	0,65	49,99	0,87	49,99	1,09	49,98	1,31	49,98	1,53	50
51	51,00	0,22	51,00	0,45	50,99	0,67	50,99	0,89	50,99	1,11	50,98	1,34	50,98	1,56	51
52	52,00	0,23	52,00	0,45	51,99	0,68	51,99	0,91	51,99	1,14	51,98	1,36	51,98	1,59	52
53	53,00	0,23	53,00	0,46	52,99	0,69	52,99	0,93	52,99	1,16	52,98	1,39	52,98	1,62	53
54	54,00	0,24	54,00	0,47	53,99	0,71	53,99	0,94	53,99	1,18	53,98	1,41	53,98	1,65	54
55	55,00	0,24	55,00	0,48	54,99	0,72	54,99	0,96	54,99	1,20	54,98	1,44	54,98	1,68	55
56	56,00	0,24	56,00	0,49	55,99	0,73	55,99	0,98	55,99	1,22	55,98	1,47	55,98	1,71	56
57	57,00	0,25	57,00	0,50	56,99	0,75	56,99	1,00	56,99	1,24	56,98	1,49	56,97	1,74	57
58	58,00	0,25	58,00	0,51	57,99	0,76	57,99	1,01	57,99	1,27	57,98	1,52	57,97	1,77	58
59	59,00	0,26	59,00	0,51	58,99	0,77	58,99	1,03	58,99	1,29	58,98	1,54	58,97	1,80	59
60	60,00	0,26	60,00	0,52	59,99	0,79	59,99	1,05	59,99	1,31	59,98	1,57	59,97	1,83	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	89 Degrees					57,	88 Degrees							29,	

Distance	0 Degree				,00		1 Degree						,02		Distance
	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	61,00	0,27	61,00	0,53	60,99	0,80	60,99	1,06	60,98	1,33	60,98	1,60	60,97	1,86	61
62	62,00	0,27	62,00	0,54	61,99	0,81	61,99	1,08	61,98	1,35	61,98	1,62	61,97	1,89	62
63	63,00	0,28	63,00	0,55	62,99	0,82	62,99	1,10	62,98	1,38	62,98	1,65	62,97	1,92	63
64	64,00	0,28	64,00	0,56	63,99	0,84	63,99	1,12	63,98	1,40	63,98	1,67	63,97	1,95	64
65	65,00	0,28	65,00	0,57	64,99	0,85	64,99	1,13	64,98	1,42	64,98	1,70	64,97	1,99	65
66	66,00	0,29	66,00	0,58	65,99	0,86	65,99	1,15	65,98	1,44	65,98	1,73	65,97	2,02	66
67	67,00	0,29	67,00	0,58	66,99	0,88	66,99	1,17	66,98	1,46	66,98	1,75	66,97	2,05	67
68	68,00	0,30	68,00	0,59	67,99	0,89	67,99	1,19	67,98	1,48	67,98	1,78	67,97	2,08	68
69	69,00	0,30	69,00	0,60	68,99	0,90	68,99	1,20	68,98	1,51	68,98	1,81	68,97	2,11	69
70	70,00	0,31	70,00	0,61	69,99	0,92	69,99	1,22	69,98	1,53	69,98	1,83	69,97	2,14	70
71	71,00	0,31	71,00	0,62	70,99	0,93	70,99	1,24	70,98	1,55	70,98	1,86	70,97	2,17	71
72	72,00	0,31	72,00	0,63	71,99	0,94	71,99	1,26	71,98	1,57	71,98	1,88	71,97	2,20	72
73	73,00	0,32	73,00	0,64	72,99	0,96	72,99	1,27	72,98	1,59	72,98	1,91	72,97	2,23	73
74	74,00	0,32	74,00	0,65	73,99	0,97	73,99	1,29	73,98	1,62	73,98	1,94	73,97	2,26	74
75	75,00	0,33	75,00	0,65	74,99	0,98	74,99	1,31	74,98	1,64	74,98	1,96	74,97	2,29	75
76	76,00	0,33	76,00	0,66	75,99	0,99	75,99	1,33	75,98	1,66	75,97	1,99	75,97	2,32	76
77	77,00	0,34	77,00	0,67	76,99	1,01	76,99	1,34	76,98	1,68	76,97	2,02	76,97	2,35	77
78	78,00	0,34	78,00	0,68	77,99	1,02	77,99	1,36	77,98	1,70	77,97	2,04	77,96	2,38	78
79	79,00	0,35	79,00	0,69	78,99	1,03	78,99	1,38	78,98	1,72	78,97	2,07	78,96	2,41	79
80	80,00	0,35	80,00	0,70	79,99	1,05	79,99	1,40	79,98	1,75	79,97	2,09	79,96	2,44	80
81	81,00	0,35	81,00	0,71	80,99	1,06	80,99	1,41	80,98	1,77	80,97	2,12	80,96	2,47	81
82	82,00	0,36	82,00	0,72	81,99	1,07	81,99	1,43	81,98	1,79	81,97	2,15	81,96	2,50	82
83	83,00	0,36	83,00	0,72	82,99	1,09	82,99	1,45	82,98	1,81	82,97	2,17	82,96	2,54	83
84	84,00	0,37	84,00	0,73	83,99	1,10	83,99	1,47	83,98	1,83	83,97	2,20	83,96	2,57	84
85	85,00	0,37	85,00	0,74	84,99	1,11	84,99	1,48	84,98	1,85	84,97	2,23	84,96	2,60	85
86	86,00	0,38	86,00	0,75	85,99	1,13	85,99	1,50	85,98	1,88	85,97	2,25	85,96	2,63	86
87	87,00	0,38	87,00	0,76	86,99	1,14	86,99	1,52	86,98	1,90	86,97	2,28	86,96	2,66	87
88	88,00	0,38	88,00	0,77	87,99	1,15	87,99	1,54	87,98	1,92	87,97	2,30	87,96	2,69	88
89	89,00	0,39	89,00	0,78	88,99	1,16	88,99	1,55	88,98	1,94	88,97	2,33	88,96	2,72	89
90	90,00	0,39	90,00	0,79	89,99	1,18	89,99	1,57	89,98	1,96	89,97	2,36	89,96	2,75	90
91	91,00	0,40	91,00	0,79	90,99	1,19	90,99	1,59	90,98	1,99	90,97	2,38	90,96	2,78	91
92	92,00	0,40	92,00	0,80	91,99	1,20	91,99	1,61	91,98	2,01	91,97	2,41	91,96	2,81	92
93	93,00	0,41	93,00	0,81	92,99	1,22	92,99	1,62	92,98	2,03	92,97	2,43	92,96	2,84	93
94	94,00	0,41	94,00	0,82	93,99	1,23	93,99	1,64	93,98	2,05	93,97	2,46	93,96	2,87	94
95	95,00	0,41	95,00	0,83	94,99	1,24	94,99	1,66	94,98	2,07	94,97	2,49	94,96	2,90	95
96	96,00	0,42	96,00	0,84	95,99	1,26	95,99	1,68	95,98	2,09	95,97	2,51	95,96	2,94	96
97	97,00	0,42	97,00	0,85	96,99	1,27	96,99	1,69	96,98	2,12	96,97	2,54	96,96	2,96	97
98	98,00	0,43	98,00	0,86	97,99	1,28	97,99	1,71	97,98	2,14	97,97	2,57	97,96	2,99	98
99	99,00	0,43	99,00	0,86	98,99	1,30	98,99	1,73	98,98	2,16	98,97	2,59	98,95	3,02	99
100	100,0	0,44	100,0	0,87	99,99	1,31	99,99	1,75	99,98	2,18	99,97	2,62	99,95	3,05	100
101	101,0	0,44	101,0	0,88	101,0	1,32	101,0	1,76	101,0	2,20	101,0	2,64	101,0	3,09	101
102	102,0	0,45	102,0	0,89	102,0	1,34	102,0	1,78	102,0	2,23	102,0	2,67	102,0	3,12	102
103	103,0	0,45	103,0	0,90	103,0	1,35	103,0	1,80	103,0	2,25	103,0	2,70	103,0	3,15	103
104	104,0	0,45	104,0	0,91	104,0	1,36	104,0	1,82	104,0	2,27	104,0	2,72	104,0	3,18	104
105	105,0	0,46	105,0	0,92	105,0	1,37	105,0	1,83	105,0	2,29	105,0	2,75	105,0	3,21	105
106	106,0	0,46	106,0	0,92	106,0	1,39	106,0	1,85	106,0	2,31	106,0	2,78	106,0	3,24	106
107	107,0	0,47	107,0	0,93	107,0	1,40	107,0	1,87	107,0	2,33	107,0	2,80	107,0	3,27	107
108	108,0	0,47	108,0	0,94	108,0	1,41	108,0	1,89	108,0	2,36	108,0	2,83	108,0	3,30	108
109	109,0	0,48	109,0	0,95	109,0	1,43	109,0	1,90	109,0	2,38	109,0	2,85	109,0	3,33	109
110	110,0	0,48	110,0	0,96	110,0	1,44	110,0	1,92	110,0	2,40	110,0	2,88	110,0	3,36	110
111	111,0	0,48	111,0	0,97	111,0	1,45	111,0	1,94	111,0	2,42	111,0	2,91	111,0	3,39	111
112	112,0	0,49	112,0	0,98	112,0	1,47	112,0	1,96	112,0	2,44	112,0	2,93	112,0	3,42	112
113	113,0	0,49	113,0	0,99	113,0	1,48	113,0	1,97	113,0	2,47	113,0	2,96	113,0	3,45	113
114	114,0	0,50	114,0	0,99	114,0	1,49	114,0	1,99	114,0	2,49	114,0	2,98	114,0	3,48	114
115	115,0	0,50	115,0	1,00	115,0	1,51	115,0	2,01	115,0	2,51	115,0	3,01	115,0	3,51	115
116	116,0	0,51	116,0	1,01	116,0	1,52	116,0	2,03	116,0	2,53	116,0	3,04	116,0	3,54	116
117	117,0	0,51	117,0	1,02	117,0	1,53	117,0	2,04	117,0	2,55	117,0	3,06	117,0	3,57	117
118	118,0	0,52	118,0	1,03	118,0	1,54	118,0	2,06	118,0	2,57	118,0	3,09	118,0	3,60	118
119	119,0	0,52	119,0	1,04	119,0	1,56	119,0	2,08	119,0	2,60	119,0	3,12	119,0	3,63	119
120	120,0	0,52	120,0	1,05	120,0	1,57	120,0	2,09	120,0	2,61	120,0	3,14	120,0	3,66	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	89 Degrees						57,		88 Degrees					29,	

Digitized by Google

Distance	2 Degrees							,03	3 Degrees							,05	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1,00	0,04	1,00	0,04	1,00	0,04	1,00	0,05	1,00	0,05	1,00	0,06	1,00	0,06	1,00	0,06	1
2	2,00	0,07	2,00	0,08	2,00	0,09	2,00	0,10	2,00	0,11	2,00	0,11	2,00	0,12	2,00	0,13	2
3	3,00	0,11	3,00	0,12	3,00	0,13	3,00	0,14	3,00	0,16	3,00	0,17	2,99	0,18	2,99	0,20	3
4	4,00	0,14	4,00	0,16	4,00	0,18	4,00	0,19	4,00	0,21	4,00	0,23	3,99	0,24	3,99	0,26	4
5	5,00	0,18	5,00	0,20	5,00	0,22	4,99	0,24	4,99	0,26	4,99	0,28	4,99	0,31	4,99	0,33	5
6	6,00	0,21	6,00	0,24	5,99	0,26	5,99	0,29	5,99	0,31	5,99	0,34	5,99	0,37	5,99	0,39	6
7	7,00	0,24	7,00	0,28	6,99	0,31	6,99	0,34	6,99	0,37	6,99	0,40	6,99	0,43	6,99	0,46	7
8	7,99	0,28	7,99	0,31	7,99	0,35	7,99	0,38	7,99	0,42	7,99	0,45	7,99	0,49	7,98	0,52	8
9	8,99	0,31	8,99	0,35	8,99	0,39	8,99	0,43	8,99	0,47	8,99	0,51	8,98	0,55	8,98	0,5[illegible]	9
10	9,99	0,35	9,99	0,39	9,99	0,44	9,99	0,48	9,99	0,52	9,99	0,57	9,98	0,61	9,98	0,65	10
11	10,99	0,38	10,99	0,43	10,99	0,48	10,99	0,53	10,99	0,58	10,98	0,62	10,98	0,67	10,98	0,72	11
12	11,99	0,42	11,99	0,47	11,99	0,52	11,99	0,58	11,98	0,63	11,98	0,68	11,98	0,73	11,97	0,79	12
13	12,99	0,45	12,99	0,51	12,99	0,57	12,99	0,62	12,98	0,68	12,98	0,73	12,98	0,79	12 97	0,85	13
14	13,99	0,49	13,99	0,55	13,99	0,61	13,98	0,67	13,98	0,73	13,98	0,79	13,97	0,86	13,97	0,92	14
15	14,99	0,52	14,99	0,59	14,99	0,65	14,98	0,72	14,98	0,79	14,98	0,85	14,97	0,92	14,97	0,98	15
16	15,99	0,56	15,99	0,63	15,99	0,70	15,98	0,77	15,98	0,84	15,97	0,91	15,97	0,98	15,97	1,05	16
17	16,99	0,59	16,99	0,67	16,98	0,74	16,98	0,82	16,98	0,89	16,97	0,96	16,97	1,04	16,96	1,11	17
18	17,99	0,63	17,99	0,71	17,98	0,79	17,98	0,86	17,98	0,94	17,97	1,02	17,97	1,10	17,96	1,18	18
19	18,99	0,66	18,99	0,75	18,98	0,83	18,98	0,91	18,98	0,99	18,97	1,08	18,96	1,16	18,96	1,24	19
20	19,99	0,70	19,99	0,79	19,98	0,87	19,98	0,96	19,97	1,05	19,97	1,13	19.96	1,22	19,96	1,31	20
21	20,99	0,73	20,99	0,83	20,98	0,92	20,98	1,01	20,97	1,10	20,97	1,19	20,96	1,28	20,96	1,37	21
22	21,99	0,77	21,98	0,86	21,98	0,96	21,98	1,06	21,97	1,15	21,97	1,25	21,96	1,34	21,95	1,44	22
23	22,99	0,80	22,98	0,90	22,98	1,00	22,97	1,10	22,97	1,20	22,96	1,30	22,96	1,40	22,95	1,50	23
24	23,99	0,84	23,98	0,94	23,98	1,05	23 97	1,15	23,97	1,26	23,96	1,36	23,96	1,47	23 95	1,57	24
25	24,99	0,87	24,98	0,98	24,98	1,09	24,97	1,20	24,97	1,31	24,96	1,42	24,95	1,53	24.95	1,64	25
26	25,98	0,91	25,98	1,02	25,98	1,13	25,97	1,25	25,97	1,36	25,96	1,47	25,95	1,59	25,94	1,70	26
27	26,98	0,94	26,98	1,06	26,97	1,18	26,97	1,30	26,96	1,41	26,96	1,53	26,95	1,65	26.94	1,77	27
28	27,98	0,98	27,98	1,10	27,97	1,22	27,97	1,34	27,96	1,47	27,96	1,59	27,95	1,71	27,94	1,83	28
29	28,98	1,01	28,98	1,14	28,97	1,27	28,97	1,39	28,96	1,52	28,95	1,64	28,95	1,77	28,94	1,90	29
30	29,98	1,05	29,98	1,18	29,97	1,31	29 97	1,44	29,96	1.57	29,95	1,70	29.94	1,83	29,94	1,96	30
31	30,98	1,08	30,98	1,22	30,97	1,35	30,97	1,49	30,96	1,62	30,95	1,76	30,94	1,89	30,93	2,03	31
32	31,98	1,12	31,98	1,26	31,97	1,40	31,96	1,54	31,96	1,68	31,95	1,81	31,94	1,95	31.93	2,09	32
33	32,98	1,15	32,98	1.30	32,97	1,44	32,96	1,58	32,96	1,73	32,95	1,87	32,94	2,02	32,93	2,16	33
34	33,98	1,19	33,97	1,34	33,97	1,48	33,96	1,63	33,96	1,78	33,95	1,93	33,94	2,08	33,93	2,22	34
35	34,98	1,22	34,97	1,37	34,97	1,53	34,96	1,68	34,95	1,83	34,94	1,99	34,94	2,14	34,92	2,29	35
36	35,98	1,26	35,97	1,41	35,97	1,57	35,96	1,73	35,95	1,88	35,94	2,04	35,93	2,20	35,92	2,35	36
37	36,98	1,29	36,97	1,45	36,97	1,61	36,96	1,78	36,95	1,94	36,94	2,10	36,93	2,26	36,92	2,42	37
38	37,98	1,33	37,97	1,49	37,96	1,66	37,96	1,82	37,95	1,99	37,94	2,16	37,93	2,32	37,92	2,49	38
39	38,98	1,36	38,97	1,53	38,96	1,70	38,96	1,87	38,95	2,04	38,94	2,21	38,93	2,38	38,92	2,55	39
40	39,98	1,40	39,97	1,57	39,96	1,75	39,95	1,92	39,95	2,09	39,94	2,27	39.93	2,44	39,91	2.62	40
41	40,98	1,43	40,97	1.61	40,96	1,79	40,95	1,97	40,94	2,15	40,93	2,33	40,92	2,50	40,91	2,68	41
42	41,97	1,47	41,97	1,65	41,96	1,83	41,95	2,02	41,94	2,20	41,93	2,38	41,92	2,56	41,91	2,75	42
43	42,97	1,50	42,97	1,69	42,96	1,88	42,95	2,06	42,94	2,25	42,93	2,44	42,92	2,63	42,91	2,81	43
44	43,97	1,54	43,97	1,73	43,96	1,92	43,95	2,11	43,94	2,30	43,93	2,50	43,92	2,69	43,91	2,88	44
45	44,97	1,57	44,97	1,77	44,96	1,96	44,95	2,16	44,94	2,36	44,93	2,55	44,92	2,75	44,90	2,94	45
46	45,97	1,61	45,97	1,81	45,96	2,01	45,95	2,21	45,94	2,41	45,93	2,61	45,91	2,81	45,90	3,00	46
47	46,97	1,64	46,97	1,85	46,96	2,05	46,95	2,26	46,94	2,47	46,93	2,67	46,91	2,87	46,90	3.07	47
48	47,97	1,68	47,96	1,88	47,95	2,09	47,95	2,30	47,94	2,51	47,92	2,72	47,91	2,93	47,90	3,14	48
49	48,97	1,71	48,96	1,92	48,95	2,14	48,94	2,35	48,93	2,57	48,92	2,78	48,91	2,99	48,90	3,21	49
50	49,97	1,75	49,96	1,96	49,95	2,18	49.94	2,40	49,93	2,62	49,92	2,84	49,91	3,05	49,89	3,27	50
51	50,97	1,78	50,96	2,00	50,95	2,23	50,94	2,45	50,93	2,67	50,92	2,89	50,90	3,11	50,89	3,34	51
52	51,97	1,82	51,96	2,04	51,95	2,27	51,94	2,50	51,93	2,72	51,92	2,95	51,90	3,18	51,89	3,40	52
53	52,97	1,85	52,96	2,08	52,95	2,31	52,94	2,54	52,93	2,77	52,92	3,01	52,90	3,24	52,89	3,47	53
54	53,97	1,89	53,96	2,12	53,95	2,36	53,94	2,59	53,93	2,83	53,91	3,06	53,90	3,30	53,88	3,53	54
55	54,97	1,92	54,96	2,16	54,95	2,40	54,94	2,64	54,92	2,88	54,91	3,12	54,90	3,36	54,88	3,60	55
56	55,97	1,95	55,96	2,20	55,95	2,44	55,94	2,69	55,92	2,93	55,91	3,18	55,90	3,42	55,88	3,66	56
57	56,97	1,99	56,96	2,24	56,95	2,49	56,93	2,74	56,92	2,98	56,91	3,23	56,89	3,48	56,88	3,73	57
58	57,97	2,02	57,96	2,28	57,95	2,53	57,93	2,78	57,92	3,04	57,91	3,29	57,89	3,54	57,88	3,79	58
59	58,96	2,06	58,96	2,32	58,94	2,57	58,93	2,83	58,92	3,09	58,91	3,35	58,89	3,60	58,87	3,85	59
60	59,96	2,09	59,95	2,36	59,94	2,62	59,93	2,88	59,92	3,14	59,90	3,40	59,89	3,66	59.87	3,92	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	88 Deg.		87 Degrees					,19	86 Degrees							,14	

Distance	2 Degrees							,03	3 Degrees							,05	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	
61	60,96	2,13	60,95	2,40	60,94	2,66	60,93	2,93	60,92	3,19	60,90	3,46	60,89	3,72	60,87	3,99	61
62	61,96	2,16	61,95	2,43	61,94	2,70	61,93	2,98	61,92	3,25	61,90	3,51	61,88	3,79	61,87	4,06	62
63	62,96	2,20	62,95	2,47	62,94	2,75	62,93	3,02	62,92	3,30	62,90	3,57	62,88	3,85	62,87	4,12	63
64	63,96	2,23	63,95	2,51	63,94	2,79	63,93	3,07	63,91	3,35	63,90	3,63	63,88	3,91	63,86	4,19	64
65	64,96	2,27	64,95	2,55	64,94	2,84	64,93	3,12	64,91	3,40	64,90	3,69	64,88	3,97	64,86	4,25	65
66	65,96	2,30	65,95	2,59	65,94	2,88	65,92	3,17	65,91	3,46	65,89	3,74	65,88	4,03	65,86	4,32	66
67	66,96	2,34	66,95	2,63	66,94	2,92	66,92	3,22	66,91	3,51	66,89	3,80	66,88	4,09	66,86	4,38	67
68	67,96	2,37	67,95	2,67	67,94	2,97	67,92	3,26	67,91	3,56	67,89	3,86	67,87	4,16	67,86	4,45	68
69	68,96	2,41	68,95	2,71	68,94	3,01	68,92	3,31	68,91	3,61	68,89	3,91	68,87	4,22	68,85	4,51	69
70	69,96	2,44	69,95	2,75	69,93	3,05	69,92	3,36	69,91	3,66	69,89	3,97	69,87	4,28	69,85	4,58	70
71	70,96	2,48	70,95	2,79	70,93	3,10	70,92	3,41	70,90	3,72	70,89	4,03	70,87	4,34	70,85	4,64	71
72	71,96	2,51	71,95	2,83	71,93	3,14	71,92	3,46	71,90	3,77	71,88	4,08	71,87	4,40	71,85	4,71	72
73	72,96	2,55	72,94	2,87	72,93	3,18	72,92	3,50	72,90	3,82	72,88	4,14	72,86	4,46	72,84	4,77	73
74	73,96	2,58	73,94	2,91	73,93	3,23	73,92	3,55	73,90	3,87	73,88	4,20	73,86	4,52	73,84	4,84	74
75	74,96	2,61	74,94	2,94	74,93	3,27	74,92	3,60	74,90	3,93	74,88	4,25	74,86	4,58	74,84	4,91	75
76	75,96	2,65	75,94	2,98	75,93	3,31	75,91	3,65	75,90	3,98	75,88	4,31	75,86	4,64	75,84	4,97	76
77	76,96	2,69	76,94	3,02	76,93	3,36	76,91	3,70	76,90	4,03	76,88	4,37	76,86	4,70	76,84	5,04	77
78	77,96	2,73	77,94	3,06	77,93	3,40	77,91	3,74	77,89	4,08	77,87	4,42	77,85	4,76	77,83	5,10	78
79	78,95	2,76	78,94	3,10	78,93	3,45	78,91	3,79	78,89	4,14	78,87	4,48	78,85	4,82	78,83	5,17	79
80	79,95	2,79	79,94	3,14	79,93	3,49	79,91	3,84	79,89	4,19	79,87	4,54	79,85	4,88	79,83	5,23	80
81	80,95	2,83	80,94	3,18	80,92	3,53	80,91	3,89	80,89	4,24	80,87	4,59	80,85	4,95	80,83	5,30	81
82	81,95	2,86	81,94	3,22	81,92	3,58	81,91	3,94	81,89	4,29	81,87	4,65	81,85	5,01	81,83	5,36	82
83	82,95	2,90	82,94	3,26	82,92	3,62	82,91	3,98	82,89	4,34	82,87	4,71	82,84	5,07	82,82	5,43	83
84	83,95	2,93	83,94	3,30	83,92	3,66	83,91	4,03	83,89	4,40	83,87	4,76	83,84	5,13	83,82	5,49	84
85	84,95	2,97	84,94	3,34	84,92	3,71	84,90	4,08	84,88	4,45	84,86	4,82	84,84	5,19	84,82	5,56	85
86	85,95	3,00	85,93	3,38	85,92	3,75	85,90	4,13	85,88	4,50	85,86	4,88	85,84	5,25	85,82	5,62	86
87	86,95	3,04	86,93	3,42	86,92	3,79	86,90	4,18	86,88	4,55	86,86	4,93	86,84	5,31	86,81	5,69	87
88	87,95	3,07	87,93	3,46	87,92	3,84	87,90	4,22	87,88	4,61	87,86	4,99	87,84	5,37	87,81	5,76	88
89	88,95	3,11	88,93	3,49	88,92	3,88	88,90	4,27	88,88	4,66	88,86	5,05	88,83	5,43	88,81	5,82	89
90	89,95	3,14	89,93	3,53	89,92	3,93	89,90	4,32	89,88	4,71	89,86	5,10	89,83	5,50	89,81	5,89	90
91	90,95	3,18	90,93	3,57	90,91	3,97	90,90	4,37	90,88	4,76	90,85	5,17	90,83	5,56	90,81	5,95	91
92	91,94	3,21	91,93	3,61	91,91	4,01	91,90	4,41	91,87	4,82	91,85	5,22	91,83	5,62	91,80	6,02	92
93	92,94	3,25	92,93	3,65	92,91	4,05	92,89	4,46	92,87	4,87	92,85	5,27	92,83	5,68	92,80	6,08	93
94	93,94	3,28	93,93	3,69	93,91	4,10	93,89	4,51	93,87	4,92	93,85	5,33	93,83	5,74	93,80	6,15	94
95	94,94	3,32	94,93	3,73	94,91	4,14	94,89	4,56	94,87	4,97	94,85	5,39	94,82	5,80	94,80	6,21	95
96	95,94	3,35	95,93	3,77	95,91	4,19	95,89	4,61	95,87	5,03	95,85	5,44	95,82	5,86	95,79	6,28	96
97	96,94	3,39	96,93	3,81	96,91	4,23	96,89	4,65	96,87	5,08	96,84	5,50	96,82	5,92	96,79	6,34	97
98	97,94	3,42	97,93	3,85	97,91	4,28	97,89	4,70	97,87	5,13	97,84	5,55	97,82	5,98	97,79	6,41	98
99	98,94	3,46	98,92	3,89	98,91	4,32	98,89	4,75	98,87	5,18	98,84	5,61	98,82	6,04	98,79	6,48	99
100	99,94	3,49	99,92	3,93	99,91	4,36	99,89	4,80	99,86	5,23	99,84	5,67	99,81	6,11	99,79	6,5[illegible]	100
101	100,9	3,53	100,9	3,97	100,9	4,41	100,9	4,85	100,9	5,29	100,8	5,73	100,8	6,17	100,8	6,6[illegible]	101
102	101,9	3,56	101,9	4,01	101,9	4,45	101,9	4,89	101,9	5,34	101,8	5,78	101,8	6,23	101,8	6,6[illegible]	102
103	102,9	3,60	102,9	4,04	102,9	4,49	102,9	4,94	102,9	5,39	102,8	5,84	102,8	6,29	102,8	6,74	103
104	103,9	3,63	103,9	4,08	103,9	4,54	103,9	4,99	103,9	5,44	103,8	5,90	103,8	6,35	103,8	6,80	104
105	104,9	3,67	104,9	4,12	104,9	4,58	104,9	5,04	104,9	5,50	104,8	5,95	104,8	6,41	104,8	6,87	105
106	105,9	3,70	105,9	4,16	105,9	4,62	105,9	5,09	105,9	5,55	105,8	6,01	105,8	6,47	105,8	6,93	106
107	106,9	3,73	106,9	4,20	106,9	4,67	106,9	5,13	106,9	5,60	106,8	6,07	106,8	6,53	106,8	7,00	107
108	107,9	3,77	107,9	4,24	107,9	4,71	107,9	5,18	107,9	5,65	107,8	6,12	107,8	6,59	107,8	7,06	108
109	108,9	3,80	108,9	4,28	108,9	4,76	108,9	5,23	108,9	5,71	108,8	6,18	108,8	6,66	108,8	7,13	109
110	109,9	3,84	109,9	4,32	109,9	4,80	109,9	5,28	109,9	5,76	109,8	6,24	109,8	6,72	109,8	7,19	110
111	110,9	3,87	110,9	4,36	110,9	4,84	110,9	5,33	110,8	5,81	110,8	6,29	110,8	6,78	110,8	7,26	111
112	111,9	3,91	111,9	4,40	111,9	4,89	111,9	5,37	111,8	5,86	111,8	6,35	111,8	6,84	111,8	7,33	112
113	112,9	3,94	112,9	4,44	112,9	4,93	112,9	5,42	112,8	5,92	112,8	6,41	112,8	6,90	112,8	7,39	113
114	113,9	3,98	113,9	4,48	113,9	4,97	113,9	5,47	113,8	5,97	113,8	6,48	113,8	6,96	113,8	7,46	114
115	114,9	4,01	114,9	4,51	114,9	5,02	114,9	5,52	114,8	6,02	114,8	6,52	114,8	7,02	114,8	7,52	115
116	115,9	4,05	115,9	4,55	115,9	5,06	115,9	5,57	115,8	6,07	115,8	6,58	115,8	7,08	115,8	7,59	116
117	116,9	4,08	116,9	4,59	116,9	5,10	116,9	5,62	116,8	6,12	116,8	6,63	116,8	7,14	116,8	7,65	117
118	117,9	4,12	117,9	4,63	117,9	5,15	117,9	5,66	117,8	6,18	117,8	6,69	117,8	7,20	117,7	7,72	118
119	118,9	4,15	118,9	4,67	118,9	5,19	118,9	5,71	118,8	6,23	118,8	6,75	118,8	7,27	118,7	7,78	119
120	119,9	4,19	119,9	4,71	119,9	5,23	119,9	5,76	119,8	6,28	119,8	6,80	119,8	7,33	119,7	7,85	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	88 Deg.		87 Degrees					19.	86 Degrees							14.	

Distance	4 Degrees							,07	5 Degrees							,09	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1,00	0,07	1,00	0,07	1,00	0,07	1,00	0,08	1,00	0,09	1,00	0,09	1,00	0,10	1,00	0,10	1
2	2,00	0,14	2,00	0,15	1,99	0,16	1,99	0,17	1,99	0,17	1,99	0,18	1,99	0,19	1,99	0,20	2
3	2,99	0,21	2,99	0,22	2,99	0,24	2,99	0,25	2,99	0,26	2,99	0,28	2,99	0,29	2,99	0,30	3
4	3,99	0,28	3,99	0,30	3,99	0,31	3,99	0,33	3,99	0,35	3,98	0,37	3,98	0,38	3,98	0,40	4
5	4,99	0,35	4,99	0,37	4,99	0,39	4,98	0,41	4,98	0,44	4,98	0,46	4,98	0,48	4,98	0,50	5
6	5,99	0,42	5,98	0,45	5,98	0,47	5,98	0,49	5,98	0,52	5,98	0,55	5,97	0,58	5,97	0,60	6
7	6,98	0,49	6,98	0,52	6,98	0,55	6,98	0,58	6,97	0,61	6,97	0,64	6,97	0,67	6,97	0,70	7
8	7,98	0,56	7,98	0,59	7,98	0,63	7,97	0,66	7,97	0,70	7,97	0,73	7,96	0,76	7,96	0,80	8
9	8,98	0,63	8,98	0,67	8,97	0,71	8,97	0,75	8,97	0,78	8,96	0,82	8,96	0,86	8,96	0,90	9
10	9,98	0,70	9,97	0,74	9,97	0,79	9,97	0,83	9,96	0,87	9,96	0,92	9,95	0,96	9,95	1,00	10
11	10,97	0,77	10,97	0,82	10,97	0,86	10,96	0,91	10,96	0,96	10,95	1,01	10,95	1,05	10,95	1,10	11
12	11,97	0,84	11,97	0,89	11,96	0,94	11,96	0,99	11,95	1,05	11,95	1,10	11,95	1,15	11,94	1,20	12
13	12,97	0,91	12,97	0,96	12,96	1,02	12,96	1,08	12,95	1,13	12,95	1,19	12,94	1,25	12,94	1,30	13
14	13,97	0,98	13,96	1,04	13,96	1,10	13,95	1,16	13,95	1,22	13,94	1,28	13,94	1,34	13,93	1,40	14
15	14,96	1,05	14,96	1,11	14,95	1,18	14,95	1,24	14,94	1,31	14,94	1,37	14,93	1,44	14,93	1,50	15
16	15,96	1,12	15,96	1,19	15,95	1,26	15,95	1,33	15,94	1,40	15,93	1,46	15,93	1,53	15,92	1,60	16
17	16,96	1,19	16,95	1,26	16,95	1,33	16,94	1,41	16,94	1,48	16,93	1,56	16,92	1,63	16,92	1,70	17
18	17,96	1,26	17,95	1,33	17,94	1,41	17,94	1,49	17,93	1,57	17,92	1,65	17,92	1,73	17,91	1,80	18
19	18,95	1,33	18,95	1,40	18,94	1,49	18,93	1,57	18,93	1,66	18,92	1,74	18,91	1,82	18,91	1,90	19
20	19,95	1,40	19,95	1,48	19,94	1,57	19,93	1,66	19,92	1,74	19,91	1,83	19,91	1,92	19,90	2,00	20
21	20,95	1,47	20,94	1,56	20,94	1,65	20,93	1,74	20,92	1,83	20,91	1,92	20,90	2,01	20,89	2,10	21
22	21,95	1,54	21,94	1,63	21,93	1,73	21,93	1,82	21,92	1,92	21,91	2,01	21,90	2,11	21,89	2,20	22
23	22,94	1,60	22,94	1,70	22,93	1,80	22,92	1,90	22,91	2,00	22,90	2,11	22,89	2,21	22,88	2,31	23
24	23,94	1,67	23,93	1,78	23,93	1,88	23,92	1,99	23,91	2,09	23,90	2,20	23,89	2,30	23,88	2,41	24
25	24,94	1,74	24,93	1,85	24,92	1,96	24,91	2,07	24,91	2,18	24,90	2,29	24,89	2,40	24,87	2,51	25
26	25,94	1,81	25,93	1,93	25,92	2,04	25,91	2,15	25,90	2,27	25,89	2,38	25,88	2,49	25,87	2,61	26
27	26,93	1,88	26,93	2,00	26,92	2,12	26,91	2,24	26,90	2,35	26,89	2,47	26,88	2,59	26,86	2,71	27
28	27,93	1,95	27,92	2,08	27,91	2,20	27,90	2,32	27,89	2,44	27,88	2,56	27,87	2,68	27,86	2,81	28
29	28,93	2,02	28,92	2,15	28,91	2,28	28,90	2,40	28,89	2,53	28,88	2,65	28,87	2,78	28,85	2,91	29
30	29,93	2,09	29,92	2,22	29,91	2,35	29,90	2,48	29,89	2,62	29,87	2,75	29,86	2,88	29,85	3,01	30
31	30,92	2,16	30,92	2,30	30,91	2,43	30,89	2,57	30,88	2,70	30,87	2,84	30,86	2,97	30,84	3,11	31
32	31,92	2,23	31,91	2,37	31,90	2,51	31,89	2,65	31,88	2,79	31,87	2,93	31,85	3,07	31,84	3,21	32
33	32,92	2,30	32,91	2,45	32,90	2,59	32,88	2,73	32,88	2,88	32,86	3,02	32,85	3,17	32,83	3,31	33
34	33,92	2,37	33,91	2,52	33,90	2,67	33,88	2,82	33,87	2,96	33,86	3,11	33,85	3,26	33,83	3,41	34
35	34,91	2,44	34,90	2,59	34,89	2,75	34,88	2,90	34,87	3,05	34,85	3,20	34,84	3,36	34,82	3,51	35
36	35,91	2,51	35,90	2,67	35,89	2,83	35,88	2,98	35,86	3,14	35,85	3,29	35,84	3,45	35,82	3,61	36
37	36,91	2,58	36,90	2,74	36,89	2,90	36,87	3,06	36,86	3,23	36,85	3,39	36,83	3,55	36,81	3,71	37
38	37,91	2,65	37,90	2,82	37,88	2,98	37,87	3,15	37,86	3,31	37,84	3,48	37,83	3,64	37,81	3,81	38
39	38,91	2,72	38,89	2,89	38,88	3,06	38,87	3,23	38,85	3,40	38,84	3,57	38,82	3,74	38,80	3,91	39
40	39,90	2,79	39,89	2,96	39,88	3,14	39,86	3,31	39,85	3,49	39,83	3,66	39,82	3,83	39,80	4,01	40
41	40,90	2,86	40,89	3,04	40,87	3,22	40,86	3,40	40,84	3,57	40,83	3,75	40,81	3,93	40,79	4,11	41
42	41,90	2,93	41,89	3,11	41,87	3,30	41,86	3,48	41,84	3,66	41,82	3,84	41,81	4,03	41,79	4,21	42
43	42,90	3,00	42,88	3,19	42,87	3,37	42,85	3,56	42,84	3,75	42,82	3,94	42,80	4,12	42,78	4,31	43
44	43,89	3,07	43,88	3,26	43,87	3,45	43,85	3,64	43,83	3,84	43,82	4,03	43,80	4,22	43,78	4,41	44
45	44,89	3,14	44,88	3,34	44,86	3,53	44,85	3,73	44,83	3,92	44,81	4,12	44,79	4,31	44,77	4,51	45
46	45,89	3,21	45,87	3,41	45,86	3,61	45,84	3,81	45,83	4,00	45,81	4,21	45,79	4,41	45,77	4,61	46
47	46,89	3,28	46,87	3,48	46,86	3,69	46,84	3,89	46,82	4,10	46,80	4,30	46,78	4,51	46,76	4,71	47
48	47,88	3,35	47,87	3,56	47,85	3,77	47,84	3,97	47,82	4,18	47,80	4,39	47,78	4,60	47,76	4,81	48
49	48,88	3,42	48,87	3,63	48,85	3,84	48,83	4,06	48,81	4,27	48,79	4,48	48,78	4,70	48,75	4,91	49
50	49,88	3,49	49,86	3,71	49,85	3,92	49,83	4,14	49,81	4,36	49,79	4,58	49,77	4,79	49,75	5,01	50
51	50,88	3,56	50,86	3,78	50,84	4,00	50,83	4,22	50,81	4,45	50,79	4,67	50,77	4,89	50,74	5,11	51
52	51,87	3,63	51,86	3,85	51,84	4,08	51,82	4,31	51,80	4,53	51,78	4,76	51,76	4,99	51,74	5,21	52
53	52,87	3,70	52,86	3,93	52,84	4,16	52,82	4,39	52,80	4,62	52,78	4,85	52,76	5,08	52,73	5,31	53
54	53,87	3,77	53,85	4,00	53,83	4,24	53,82	4,47	53,80	4,71	53,77	4,94	53,75	5,18	53,73	5,41	54
55	54,87	3,84	54,85	4,08	54,83	4,32	54,81	4,56	54,79	4,79	54,77	5,03	54,75	5,27	54,72	5,51	55
56	55,86	3,91	55,85	4,15	55,83	4,39	55,81	4,64	55,79	4,88	55,77	5,12	55,74	5,37	55,72	5,61	56
57	56,86	3,98	56,84	4,23	56,82	4,47	56,81	4,72	56,78	4,97	56,76	5,22	56,74	5,46	56,71	5,71	57
58	57,86	4,05	57,84	4,30	57,82	4,55	57,80	4,80	57,78	5,06	57,76	5,31	57,73	5,56	57,71	5,81	58
59	58,86	4,12	58,84	4,37	58,82	4,63	58,80	4,89	58,78	5,15	58,75	5,40	58,73	5,66	58,70	5,91	59
60	59,85	4,19	59,84	4,45	59,82	4,71	59,79	4,97	59,77	5,23	59,75	5,49	59,72	5,75	59,70	6,01	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	86 Deg.		85 Degrees						11,4		84 Degrees					9,5	

Distance	4 Degrees							,07	5 Degrees							09,	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat	Dep	
61	60,85	4,26	60,83	4,52	60,81	4,79	60,79	5,05	60,77	5,32	60,74	5,58	60,72	5,85	60,69	6,11	61
62	61,85	4,33	61,83	4,60	61,81	4,87	61,79	5,14	61,76	5,40	61,74	5,67	61,72	5,94	61,69	6,21	62
63	62,85	4,40	62,83	4,67	62,81	4,94	62,78	5,22	62,76	5,49	62,74	5,77	62,71	6,04	62,68	6,31	63
64	63,84	4,47	63,82	4,74	63,80	5,02	63,78	5,30	63,76	5,58	63,73	5,86	63,71	6,13	63,68	6,41	64
65	64,84	4,54	64,82	4,81	64,80	5,10	64,78	5,38	64,75	5,67	64,73	5,95	64,70	6,23	64,67	6,51	65
66	65,84	4,61	65,82	4,89	65,80	5,18	65,77	5,47	65,75	5,75	65,72	6,04	65,70	6,33	65,67	6,61	66
67	66,84	4,67	66,82	4,97	66,79	5,26	66,77	5,55	66,74	5,84	66,72	6,13	66,69	6,42	66,66	6,71	67
68	67,83	4,74	67,81	5,04	67,79	5,34	67,77	5,63	67,74	5,93	67,71	6,22	67,69	6,52	67,66	6,81	68
69	68,83	4,81	68,81	5,11	68,79	5,41	68,76	5,71	68,74	6,02	68,71	6,31	68,68	6,61	68,65	6,91	69
70	69,83	4,88	69,81	5,19	69,78	5,49	69,76	5,80	69,73	6,10	69,71	6,41	69,68	6,71	69,65	7,01	70
71	70,83	4,95	70,81	5,26	70,78	5,57	70,76	5,88	70,73	6,19	70,70	6,50	70,67	6,81	70,64	7,11	71
72	71,82	5,02	71,80	5,34	71,78	5,65	71,75	5,96	71,73	6,28	71,70	6,59	71,67	6,90	71,64	7,21	72
73	72,82	5,09	72,80	5,41	72,78	5,73	72,75	6,04	72,72	6,36	72,69	6,68	72,66	7,00	72,63	7,31	73
74	73,82	5,16	73,80	5,48	73,77	5,81	73,75	6,13	73,72	6,45	73,69	6,77	73,66	7,09	73,63	7,41	74
75	74,82	5,23	74,79	5,56	74,77	5,88	74,74	6,21	74,71	6,54	74,69	6,86	74,66	7,19	74,62	7,51	75
76	75,81	5,30	75,79	5,63	75,77	5,96	75,74	6,29	75,71	6,62	75,68	6,95	75,65	7,29	75,61	7,61	76
77	76,81	5,37	76,79	5,71	76,76	6,04	76,74	6,38	76,71	6,71	76,68	7,05	76,65	7,38	76,61	7,71	77
78	77,81	5,44	77,79	5,78	77,76	6,12	77,73	6,46	77,70	6,80	77,67	7,14	77,64	7,48	77,61	7,81	78
79	78,81	5,51	78,78	5,86	78,76	6,20	78,73	6,54	78,70	6,89	78,67	7,23	78,64	7,57	78,60	7,91	79
80	79,81	5,58	79,78	5,93	79,75	6,28	79,73	6,63	79,70	6,97	79,66	7,32	79,63	7,67	79,60	8,01	80
81	80,80	5,65	80,78	6,00	80,75	6,36	80,72	6,71	80,69	7,06	80,66	7,41	80,63	7,76	80,59	8,11	81
82	81,80	5,72	81,78	6,08	81,75	6,43	81,72	6,79	81,69	7,15	81,66	7,5.	81,62	7,86	81,59	8,21	82
83	82,80	5,79	82,77	6,15	82,75	6,51	82,72	6,87	82,68	7,24	82,65	7,60	82,62	7,96	82,58	8,31	83
84	83,80	5,86	83,77	6,23	83,74	6,59	83,71	6,96	83,68	7,32	83,65	7,69	83,61	8,05	83,58	8,41	84
85	84,79	5,93	84,77	6,30	84,74	6,67	84,71	7,04	84,68	7,41	84,64	7,78	84,61	8,15	84,57	8,51	85
86	85,79	6,01	85,76	6,37	85,74	6,75	85,71	7,12	85,67	7,50	85,64	7,87	85,61	8,24	85,57	8,61	86
87	86,79	6,07	86,76	6,45	86,73	6,83	86,70	7,21	86,67	7,58	86,63	7,96	86,60	8,34	86,56	8,71	87
88	87,79	6,14	87,76	6,52	87,73	6,91	87,70	7,29	87,67	7,67	87,63	8,05	87,60	8,44	87,56	8,81	88
89	88,78	6,21	88,76	6,60	88,73	6,98	88,70	7,37	88,66	7,76	88,63	8,14	88,59	8,53	88,55	8,91	89
90	89,78	6,28	89,75	6,67	89,72	7,06	89,69	7,45	89,66	7,84	89,62	8,24	89,59	8,63	89,55	9,01	90
91	90,78	6,35	90,75	6,74	90,72	7,14	90,69	7,54	90,65	7,93	90,62	8,33	90,58	8,72	90,54	9,11	91
92	91,78	6,42	91,75	6,82	91,72	7,22	91,68	7,62	91,65	8,02	91,61	8,42	91,58	8,82	91,54	9,21	92
93	92,77	6,49	92,75	6,89	92,71	7,30	92,68	7,70	92,65	8,11	92,61	8,51	92,57	8,92	92,53	9,31	93
94	93,77	6,56	93,74	6,97	93,71	7,38	93,68	7,78	93,64	8,19	93,61	8,60	93,57	9,01	93,53	9,41	94
95	94,77	6,63	94,74	7,04	94,71	7,45	94,67	7,87	94,64	8,28	94,60	8,69	94,56	9,11	94,52	9,51	95
96	95,77	6,70	95,74	7,12	95,71	2,53	95,67	7,95	95,63	8,37	95,60	8,78	95,56	9,20	95,52	9,61	96
97	96,76	6,77	96,73	7,19	96,70	7,61	96,67	8,03	96,63	8,45	96,59	8,88	96,55	9,30	96,51	9,71	97
98	97,76	6,84	97,73	7,26	97,70	7,69	97,66	8,12	97,63	8,54	97,59	8,97	97,55	9,39	97,51	9,81	98
99	98,76	6,91	98,73	7,34	98,70	7,77	98,66	8,20	98,62	8,63	98,59	9,06	98,55	9,49	98,50	9,91	99
100	99,76	6,98	99,73	7,41	99,69	7,85	99,66	8,28	99,62	8,72	99,58	9,15	99,54	9,59	99,50	10,01	100
101	100,7	7,05	100,7	7,49	100,7	7,92	100,6	8,36	100,6	8,80	100,6	9,24	100,5	9,68	100,5	10,11	101
102	101,7	7,12	101,7	7,56	101,7	8,00	101,6	8,45	101,6	8,89	101,6	9,33	101,5	9,78	101,5	10,21	102
103	102,7	7,19	102,7	7,63	102,7	8,08	102,6	8,53	102,6	8,98	102,6	9,43	102,5	9,87	102,5	10,32	103
104	103,7	7,26	103,7	7,71	103,7	8,16	103,6	8,61	103,6	9,07	103,6	9,52	103,5	9,97	103,5	10,42	104
105	104,7	7,33	104,7	7,78	104,7	8,24	104,6	8,70	104,6	9,15	104,6	9,61	104,5	10,06	104,5	10,52	105
106	105,7	7,40	105,7	7,86	105,7	8,32	105,6	8,78	105,5	9,24	105,6	9,70	105,5	10,16	105,5	10,62	106
107	106,7	7,46	106,7	7,93	106,7	8,40	106,6	8,86	106,5	9,33	106,6	9,79	106,5	10,26	106,5	10,72	107
108	107,7	7,53	107,7	8,00	107,7	8,47	107,6	8,94	107,5	9,41	107,6	9,88	107,5	10,35	107,5	10,82	108
109	108,7	7,60	108,7	8,08	108,7	8,55	108,6	9,03	108,5	9,50	108,5	9,97	108,5	10,45	108,5	10,92	109
110	109,7	7,67	109,7	8,15	109,7	8,63	109,6	9,11	109,5	9,59	109,5	10,07	109,5	10,54	109,4	11,02	110
111	110,7	7,74	110,7	8,23	110,7	8,71	110,6	9,19	110,5	9,68	110,5	10,16	110,5	10,64	110,4	11,12	111
112	111,7	7,81	111,7	8,30	111,7	8,79	111,6	9,28	111,5	9,76	111,5	10,25	111,5	10,74	111,4	11,22	112
113	112,7	7,88	112,7	8,37	112,7	8,87	112,6	9,36	112,5	9,85	112,5	0,34	112,5	10,83	112,4	11,32	113
114	113,7	7,95	113,7	8,45	113,6	8,95	113,6	9,44	113,5	9,94	113,5	10,43	113,5	10,93	113,4	11,42	114
115	114,7	8,02	114,7	8,52	114,6	9,02	114,6	9,52	114,5	10,02	114,5	10,52	114,5	11,03	114,4	11,52	115
116	115,7	8,09	115,7	8,60	115,6	9,10	115,6	9,61	115,5	10,11	115,5	10,61	115,5	11,12	115,4	11,62	116
117	116,7	8,16	116,7	8,67	116,6	9,18	116,5	9,69	116,5	10,22	116,5	10,71	116,5	11,22	116,4	11,72	117
118	117,7	8,23	117,7	8,75	117,6	9,26	117,5	9,77	117,5	10,29	117,5	10,80	117,5	11,31	117,4	11,82	118
119	118,7	8,30	118,7	8,82	118,6	9,34	118,5	9,85	118,5	10,37	118,5	10,89	118,5	11,41	118,4	11,92	119
120	119,7	8,37	119,7	8,80	119,6	9,42	119,5	9,94	119,5	10,46	119,5	10,98	119,4	11,50	119,4	12,02	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min		15 Min.		
	86 Deg.		85 Degrees					11,4	84 Degrees							9,5	

Distance	6 Degrees							,11	7 Degrees							,12	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1,00	0,11	1,00	0,11	0,99	0,11	0,99	0,12	0,99	0,12	0,99	0,13	0,99	0,13	0,99	0,14	1
2	1,99	0,21	1,99	0,22	1,99	0,23	1,99	0,24	1,99	0,24	1,98	0,25	1,98	0,26	1,98	0,27	2
3	2,99	0,32	2,98	0,33	2,98	0,34	2,98	0,35	2,98	0,37	2,98	0,38	2,98	0,39	2,97	0,41	3
4	3,98	0,41	3,98	0,44	3,97	0,45	3,97	0,47	3,97	0,49	3,97	0,51	3,97	0,52	3,96	0,54	4
5	4,97	0,52	4,97	0,54	4,97	0,57	4,97	0,59	4,97	0,61	4,96	0,63	4,96	0,65	4,95	0,67	5
6	5,97	0,63	5,96	0,65	5,96	0,68	5,96	0,71	5,96	0,73	5,95	0,76	5,95	0,78	5,95	0,81	6
7	6,96	0,73	6,96	0,76	6,96	0,79	6,95	0,82	6,95	0,85	6,94	0,88	6,94	0,91	6,94	0,94	7
8	7,96	0,84	7,95	0,87	7,95	0,91	7,95	0,94	7,94	0,98	7,94	1,01	7,94	1,04	7,93	1,08	8
9	8,95	0,94	8,95	0,98	8,94	1,02	8,94	1,06	8,93	1,10	8,93	1,14	8,93	1,18	8,92	1,21	9
10	9,95	1,05	9,94	1,09	9,94	1,13	9,93	1,18	9,93	1,22	9,92	1,26	9,92	1,31	9,91	1,35	10
11	10,94	1,15	10,94	1,20	10,93	1,25	10,92	1,29	10,92	1,34	10,91	1,39	10,91	1,44	10,90	1,48	11
12	11,93	1,25	11,93	1,31	11,92	1,36	11,92	1,41	11,91	1,46	11,90	1,51	11,90	1,57	11,89	1,62	12
13	12,93	1,36	12,92	1,42	12,92	1,47	12,91	1,53	12,90	1,58	12,90	1,64	12,90	1,70	12,88	1,75	13
14	13,92	1,46	13,92	1,52	13,91	1,59	13,90	1,65	13,90	1,71	13,89	1,77	13,89	1,83	13,87	1,89	14
15	14,92	1,57	14,91	1,63	14,90	1,70	14,90	1,76	14,89	1,83	14,88	1,89	14,88	1,96	14,86	2,02	15
16	15,91	1,67	15,91	1,74	15,90	1,81	15,89	1,88	15,88	1,95	15,87	2,02	15,87	2,09	15,85	2,16	16
17	16,91	1,78	16,90	1,85	16,89	1,92	16,88	2,00	16,87	2,07	16,86	2,15	16,86	2,22	16,84	2,29	17
18	17,90	1,88	17,89	1,96	17,88	2,04	17,88	2,12	17,87	2,19	17,86	2,27	17,86	2,35	17,83	2,43	18
19	18,90	1,98	18,89	2,07	18,88	2,15	18,87	2,23	18,86	2,32	18,85	2,40	18,85	2,48	18,83	2,56	19
20	19,89	2,09	19,88	2,18	19,87	2,26	19,86	2,35	19,85	2,44	19,84	2,52	19,84	2,61	19,82	2,70	20
21	20,89	2,20	20,88	2,29	20,86	2,38	20,85	2,47	20,84	2,56	20,83	2,65	20,83	2,74	20,81	2,83	21
22	21,88	2,30	21,87	2,39	21,86	2,49	21,85	2,59	21,84	2,68	21,82	2,77	21,82	2,87	21,80	2,97	22
23	22,87	2,41	22,86	2,50	22,85	2,60	22,84	2,70	22,83	2,80	22,82	2,90	22,82	3,00	22,79	3,10	23
24	23,87	2,51	23,86	2,61	23,85	2,72	23,83	2,82	23,82	2,93	23,81	3,03	23,81	3,13	23,78	3,24	24
25	24,86	2,61	24,85	2,72	24,84	2,83	24,83	2,94	24,82	3,05	24,80	3,16	24,80	3,27	24,77	3,37	25
26	25,86	2,72	25,85	2,83	25,83	2,94	25,82	3,06	25,81	3,17	25,79	3,28	25,79	3,40	25,76	3,51	26
27	26,85	2,82	26,84	2,94	26,83	3,06	26,81	3,17	26,80	3,29	26,78	3,41	26,78	3,53	26,75	3,64	27
28	27,85	2,93	27,83	3,05	27,82	3,17	27,81	3,29	27,79	3,41	27,78	3,53	27,78	3,66	27,74	3,78	28
29	28,84	3,03	28,83	3,16	28,81	3,28	28,80	3,41	28,79	3,53	28,77	3,66	28,77	3,79	28,73	3,91	29
30	29,84	3,14	29,82	3,27	29,81	3,40	29,79	3,53	29,78	3,66	29,76	3,79	29,76	3,92	29,73	4,05	30
31	30,83	3,24	30,82	3,38	30,80	3,51	30,79	3,64	30,77	3,78	30,75	3,91	30,75	4,05	30,72	4,18	31
32	31,83	3,35	31,81	3,48	31,79	3,62	31,78	3,76	31,76	3,90	31,74	4,04	31,74	4,18	31,71	4,32	32
33	32,82	3,45	32,80	3,59	32,79	3,74	32,78	3,88	32,76	4,02	32,74	4,17	32,74	4,31	32,70	4,45	33
34	33,81	3,56	33,80	3,70	33,78	3,85	33,77	4,00	33,75	4,14	33,73	4,29	33,73	4,44	33,69	4,59	34
35	34,81	3,66	34,79	3,81	34,78	3,96	34,76	4,11	34,74	4,27	34,72	4,42	34,72	4,57	34,68	4,72	35
36	35,80	3,76	35,79	3,92	35,77	4,08	35,75	4,23	35,73	4,39	35,71	4,54	35,71	4,70	35,67	4,86	36
37	36,80	3,87	36,78	4,03	36,76	4,19	36,75	4,35	36,73	4,51	36,70	4,67	36,70	4,83	36,66	4,99	37
38	37,79	3,97	37,77	4,14	37,76	4,30	37,74	4,47	37,72	4,63	37,70	4,80	37,70	4,96	37,65	5,13	38
39	38,79	4,08	38,77	4,24	38,75	4,42	38,73	4,58	38,71	4,75	38,69	4,92	38,69	5,99	38,64	5,26	39
40	39,78	4,18	39,76	4,36	39,74	4,53	39,72	4,70	39,70	4,88	39,68	5,05	39,68	5,22	39,64	5,39	40
41	40,78	4,29	40,76	4,46	40,74	4,64	40,72	4,82	40,70	5,00	40,67	5,17	40,67	5,35	40,63	5,53	41
42	41,77	4,39	41,75	4,57	41,73	4,76	41,71	4,94	41,69	5,12	41,66	5,30	41,66	5,48	41,62	5,66	42
43	42,77	4,40	42,74	4,68	42,72	4,87	42,70	5,06	42,68	5,24	42,66	5,43	42,66	5,61	42,61	5,80	43
44	43,76	4,60	43,74	4,79	43,72	4,98	43,70	5,17	43,67	5,36	43,65	5,55	43,65	5,74	43,60	5,93	44
45	44,75	4,70	44,73	4,90	44,71	5,10	44,69	5,29	44,67	5,48	44,64	5,68	44,64	5,87	44,59	6,07	45
46	45,75	4,81	45,73	5,01	45,71	5,21	45,68	5,41	45,66	5,61	45,63	5,81	45,63	6,00	45,58	6,20	46
47	46,74	4,91	46,72	5,12	46,70	5,32	46,68	5,52	46,65	5,73	46,62	5,93	46,62	6,14	46,57	6,34	47
48	47,74	5,02	47,71	5,23	47,69	5,43	47,67	5,64	47,64	5,85	47,62	6,06	47,62	6,27	47,56	6,47	48
49	48,73	5,12	48,71	5,34	48,69	5,55	48,66	5,76	48,64	5,97	48,61	6,18	48,61	6,40	48,55	6,61	49
50	49,73	5,23	49,70	5,44	49,68	5,66	49,65	5,88	49,63	6,09	49,60	6,31	49,60	6,53	49,54	6,74	50
51	50,72	5,33	50,70	[illegible]	50,67	5,77	50,65	6,00	50,62	6,22	50,59	6,44	50,60	6,66	50,54	6,88	51
52	51,72	5,44	51,69	5,66	51,67	5,89	51,64	6,11	51,61	6,34	51,58	6,56	51,59	6,79	51,53	7,01	52
53	52,71	5,54	52,69	5,77	52,66	6,00	52,63	6,23	52,61	6,46	52,58	6,69	52,58	6,92	52,52	7,15	53
54	53,70	5,65	53,68	5,88	53,65	6,11	53,63	6,35	53,60	6,58	53,57	6,82	53,57	7,05	53,51	7,28	54
55	54,70	5,75	54,67	5,99	54,65	6,23	54,62	6,47	54,59	6,70	54,56	6,94	54,56	7,18	54,50	7,42	55
56	55,69	5,85	55,67	6,10	55,64	6,34	55,61	6,58	55,58	6,83	55,55	7,07	55,55	7,31	55,49	7,55	56
57	56,69	5,96	56,66	6,21	56,63	6,45	56,61	6,70	56,58	6,95	56,54	7,19	56,54	7,44	56,48	7,69	57
58	57,68	6,06	57,66	6,31	57,63	6,57	57,60	6,82	57,57	7,07	57,54	7,32	57,54	7,57	57,47	7,82	58
59	58,68	6,17	58,65	6,42	58,62	6,68	58,59	6,94	58,56	7,19	58,53	7,45	58,53	7,70	58,46	7,96	59
60	59,67	6,27	59,64	6,53	59,61	6,79	59,58	7,05	59,55	7,31	59,52	7,57	59,52	7,83	59,45	8,09	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	84 Deg.		83 Degrees						81		82 Degrees					7,1	

Distance	6 Degrees							,11	7 Degrees							,12	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,67	6,38	60,64	6,64	60,61	6,91	60,58	7,17	60,55	7,43	60,51	7,70	60,48	7,96	60,44	8,23	61
62	61,66	6,48	61,63	6,78	61,60	7,02	61,57	7,29	61,54	7,56	61,50	7,82	61,47	8,09	61,43	8,36	62
63	62,66	6,59	62,63	6,86	62,60	7,13	62,56	7,41	62,53	7,68	62,50	7,95	62,46	8,22	62,42	8,50	63
64	63,65	6,69	63,62	6,97	63,59	7,24	63,56	7,52	63,52	7,80	63,49	8,08	63,45	8,35	63,42	8,63	64
65	64,64	6,80	64,61	7,08	64,58	7,36	64,55	7,64	64,52	7,92	64,48	8,20	64,44	8,48	64,41	8,77	65
66	65,64	6,90	65,61	7,19	65,58	7,47	65,55	7,76	65,51	8,04	65,47	8,33	65,44	8,62	65,40	8,90	66
67	66,63	7,01	66,60	7,29	66,57	7,58	66,54	7,88	66,50	8,17	66,46	8,45	66,43	8,75	66,39	9,04	67
68	67,63	7,11	67,60	7,40	67,56	7,70	67,53	7,99	67,49	8,29	67,46	8,58	67,42	8,88	67,38	9,17	68
69	68,62	7,21	68,59	7,51	68,56	7,81	68,52	8,11	68,49	8,41	68,45	8,71	68,41	9,01	68,37	9,31	69
70	69,62	7,32	69,58	7,62	69,55	7,92	69,52	8,23	69.48	8,53	69,44	8,83	69,40	9,14	69,36	9,44	70
71	70,61	7,42	70,58	7,73	70,54	8,04	70,51	8,35	70.47	8,65	70,43	8,96	70,39	9,27	70,35	9,58	71
72	71,61	7,53	71,57	7,84	71,54	8,15	71,50	8,46	71,46	8,77	71,42	9,09	71,38	9,40	71,34	9,71	72
73	72,60	7,63	72,57	7,95	72,53	8,26	72,49	8,58	72,46	8,90	72,42	9,21	72,37	9,53	72,33	9,84	73
74	73,59	7,74	73,56	8,06	73,52	8,38	73,49	8,70	73,45	9,02	73,41	9,34	73,37	9,66	73,32	9,98	74
75	74,59	7,84	74,56	8,17	74,52	8,49	74,48	8,82	74,44	9,14	74,40	9,46	74,36	9,79	74,32	10,11	75
76	75,58	7,94	75,55	8,27	75,51	8,60	75,47	8,93	75,44	9,26	75,39	9,59	75,35	9,92	75,31	10,25	76
77	76,58	8,05	76,54	8,38	76,51	8,72	76,47	9,05	76,43	9,38	76,38	9,72	76,34	10,05	76,30	10,38	77
78	77,57	8,15	77,54	8,49	77.50	8,83	77,46	9,17	77,42	9,51	77,38	9,84	77,33	10,18	77,29	10,52	78
79	78,57	8,26	78,53	8,61	78,49	8,94	78,45	9,29	78,41	9,63	78,37	9,97	78,32	10,31	78,28	10,65	79
80	79,56	8,36	79,53	8,71	79,49	9,06	79,45	9,40	79,40	9,75	79,36	10,09	79,32	10,44	79,27	10,79	80
81	80,56	8,47	80,52	8,82	80,48	9,17	80,44	9,52	80,39	9,87	80,35	10,22	80,31	10,57	80,26	10,92	81
82	81,55	8,57	81,51	8,93	81,47	9,28	81,43	9,64	81,38	9,99	81,34	10,35	81,30	10,70	81,25	11,06	82
83	82,55	8,68	82,51	9,04	82,47	9,40	82,43	9,76	82,38	10,12	82,34	10,48	82,29	10,83	82,24	11,19	83
84	83,54	8,78	83,50	9,15	83,46	9,51	83,42	9,87	83,37	10,24	83,33	10,60	83,28	10,96	83,23	11,33	84
85	84,53	8,88	84,50	9,25	84,45	9,62	84,41	9,99	84,37	10,36	84,32	10,73	84,27	11,10	84,22	11,46	85
86	85,53	8,99	85,49	9,36	85,45	9,73	85,40	10,11	85,36	10,48	85,31	10,85	85,26	11,23	85,22	11,60	86
87	86,52	9,09	86,48	9,47	86,44	9,85	86,40	10,23	86,35	10,60	86,30	10,98	86,26	11,36	86,21	11,73	87
88	87,52	9,20	87,48	9,58	87,43	9,96	87,39	10,34	87,34	10,73	87,30	11,11	87,25	11,49	87,20	11,87	88
89	88,51	9,30	88,47	9,69	88,43	10,07	88,38	10,46	88,34	10,85	88,29	11,23	88,24	11,62	88,19	12,00	89
90	89,51	9,41	89,47	9,80	89,42	10,19	89,38	10,58	89,33	10,97	89,28	11,36	89,23	11,75	89,18	12,14	90
91	90,50	9,51	90,46	9,91	90,41	10,30	90,37	10,70	90,32	11,09	90,27	11,49	90,22	11,88	90,17	12,27	91
92	91,50	9,62	91,45	10,02	91,41	10,41	91,36	10,81	91,31	11,21	91,26	11,61	91,21	12,01	91,16	12,41	92
93	92,49	9,72	92,45	10,13	92,40	10,53	92,36	10,93	92,31	11,33	92.26	11,74	92,20	12,14	92,15	12,54	93
94	93,49	9,83	93,44	10,23	93,40	10,64	93,35	11,05	93,30	11,46	93,25	11,86	93,20	12,27	93,14	12,68	94
95	94,48	9,93	94,41	10,34	94,39	10,75	94,34	11,17	94,29	11,58	94,24	11,99	94,19	12,40	94,13	12,81	95
96	95,47	10,04	95,43	10,45	95,38	10,87	94,34	11,28	95,29	11,70	95,23	12,12	95,18	12,53	95,12	12,95	96
97	96,47	10,14	96,42	10,56	96,38	10,98	96,33	11,40	96,28	11,82	96,22	12,24	96,17	12,66	96,11	13,08	97
98	97,46	10,24	97,42	10,67	97,37	11,09	97,32	11,52	97,27	11,94	97,22	12,37	97,16	12,79	97,11	13,22	98
99	98,46	10,35	98,41	10,78	98,36	11,21	98,31	11,64	98,26	12,07	98,21	12,49	98,15	12,92	98,10	13,35	99
100	99,45	10,45	99,41	10,89	99,36	11,32	99,31	11,75	99,26	12,19	99,20	12,62	99,14	13,05	99,09	13,49	100
101	100,4	10,56	100,4	11,00	100,4	11,43	100,3	11,87	100,2	12,31	100,2	12,75	100,1	13,18	100,1	13,62	101
102	101,4	10,66	101,4	11,11	101,3	11,55	101,3	11,99	101,2	12,43	101,2	12,87	101,1	13,31	101,1	13,75	102
103	102,4	10,77	102,4	11,21	102,3	11,66	102,3	12,11	102,2	12,55	102,2	13,00	102,1	13,45	102,1	13,89	103
104	103,4	10,87	103,4	11,32	103,3	11,77	103,3	12,22	103,2	12,68	103,2	13,13	103,1	13,58	103,1	14,02	104
105	104,4	10,98	104,4	11,43	104,3	11,89	104,3	12,34	104,2	12,80	104,2	13,26	104,1	13,71	104,0	14,16	105
106	105,4	11,08	105,4	11,54	105,3	12,00	105,3	12,46	105,2	12,92	105,2	13,38	105,1	13,84	105,0	14,30	106
107	106,4	11,18	106,4	11,65	106,3	12,11	106,3	12,58	106,2	13,04	106,1	13,50	106,1	13,97	106,0	14,43	107
108	107,4	11,29	107,4	11,76	107,3	12,23	107,3	12,69	107,2	13,16	107,1	13,63	107,1	14,10	107,0	14,56	108
109	108,4	11,39	108,3	11,87	108,3	12,34	108,2	12,81	108,2	13,28	108,1	13,76	108,1	14,23	108,0	14,70	109
110	109,4	11,50	109,3	11,98	109,3	12,45	109,2	12,93	109,2	13.41	109,1	13 88	109,0	14,36	109,0	14,83	110
111	110,4	11,60	110,3	12,08	110,3	12,57	110,2	13,05	110,2	13,53	110,1	14,01	110,0	14,49	110,0	14,97	111
112	111,4	11,71	111,3	12,19	111,3	12,68	111,2	13,16	111,2	13,65	111,1	14,14	111,0	14,62	111,0	15,10	112
113	112,4	11,81	112,3	12,30	112,3	12,79	112,2	13,28	112,2	13,77	112,1	14,26	112,0	14,75	112,0	15,24	113
114	113,4	11,92	113,3	12,41	113,3	12,90	113,2	13,40	113,1	13,89	113,1	14,39	113,0	14,88	113,0	15,37	114
115	114,4	12,02	114,3	12,52	114,3	13,02	114,2	13,52	114,1	14,01	114,1	14,51	114,0	15,01	114,0	15,51	115
116	115,4	12,13	115,3	12,63	115,3	13,13	115,2	13,63	115,1	14,14	115,1	14,64	115,0	15,14	114,9	15,64	116
117	116,4	12,23	116,3	12,74	116,2	13,24	116,2	13,75	116,1	14,26	116,1	14,76	116,0	15,27	115,9	15,78	117
118	117,4	12,33	117,3	12,8[illegible]	117,2	13,36	117,2	13,87	117,1	14,38	117,1	14,89	117,0	15,40	116,9	15,91	118
119	118,4	12,44	118,3	12,95	118,2	13,47	118,2	13,99	118,1	14,50	118,0	15,02	118,0	15,53	117,9	16,05	119
120	119,3	12,54	119,3	13,06	119,2	13,58	119,2	14,11	119,1	14,62	119,0	15,17	119,0	15,66	118,9	16,18	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	84 Deg.		83 Degrees					8,1	82 Degrees							7,1	

Distance	8 Degrees							,14	9 Degrees							,16	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,99	0,14	0,99	0,14	0,99	0,15	0,99	0,15	0,99	0,16	0,99	0,16	0,99	0,17	0,99	0,17	1
2	1,98	0,28	1,98	0,29	1,98	0,30	1,98	0,30	1,98	0,31	1,97	0,32	1,97	0,33	1.97	0,34	2
3	2,97	0,42	2,97	0,43	2,97	0,44	2,97	0,46	2,96	0,47	2,96	0,48	2,96	0,50	2,96	0,51	3
4	3,96	0,56	3,96	0,57	3,96	0,59	3,95	0,61	3,95	0,63	3,95	0,64	3,95	0,66	3,94	0,68	4
5	4,95	0,70	4,95	0,72	4,95	0,74	4,94	0,76	4,94	0,78	4,94	0,80	4,93	0,83	4,92	0,85	5
6	5,94	0,84	5,94	0,86	5,93	0,88	5,93	0,91	5,93	0,94	5,92	0,96	5,92	0,99	5,91	1,02	6
7	6,93	0,97	6,93	1,00	6,92	1,04	6,92	1,07	6,91	1,10	6,91	1,13	6,90	1,16	6,89	1,19	7
8	7,92	1,11	7,92	1,15	7,91	1,18	7,91	1,22	7,90	1,25	7,90	1,29	7,89	1,32	7,88	1,36	8
9	8,91	1,25	8,91	1,29	8,90	1,33	8,90	1,37	8,89	1,41	8,88	1,45	8,88	1,49	8,86	1,52	9
10	9,90	1,39	9,90	1,44	9,89	1,48	9,88	1,52	9,88	1,56	9,87	1,61	9,86	1,65	9,85	1,70	10
11	10,89	1,53	10,89	1,58	10,88	1,63	10,87	1,67	10,87	1,72	10,86	1,77	10,85	1,82	10,84	1,86	11
12	11,88	1,67	11,88	1,72	11,87	1,77	11,86	1,83	11,85	1,88	11,84	1,93	11,84	1,98	11,83	2,03	12
13	12,87	1,81	12,87	1,87	12,86	1,92	12,85	1,98	12,84	2,03	12,83	2,09	12,82	2,15	12,81	2,20	13
14	13,86	1,95	13,86	2,01	13,85	2,07	13,84	2,13	13,83	2,19	13,82	2,25	13,81	2,31	13,79	2,37	14
15	14,85	2,09	14,85	2,15	14,84	2,22	14,83	2,28	14,82	2,35	14,81	2,41	14,79	2,48	14,78	2,54	15
16	15,84	2,23	15,84	2,30	15,82	2,37	15,81	2,43	15,80	2,50	15,79	2,57	15,78	2,64	15,77	2,71	16
17	16,83	2,37	16,83	2,44	16,81	2,51	16,80	2,59	16,79	2,66	16,78	2,73	16,77	2,81	16,75	2,88	17
18	17,82	2,51	17,81	2,58	17,80	2,66	17,79	2,74	17,78	2,82	17,77	2,89	17,75	2,97	17,74	3,05	18
19	18,81	2,64	18,80	2,73	18,79	2,81	18,78	2,89	18,77	2,97	18,75	3,05	18,74	3,14	18,73	3,22	19
20	19,81	2,78	19,79	2,87	19,78	2,96	19,77	3,04	19,75	3,13	19,74	3,22	19,73	3,30	19,71	3,39	20
21	20,79	2,92	20,78	3,01	20,77	3,10	20,76	3,19	20,74	3,29	20,73	3,38	20,71	3,47	20,70	3,56	21
22	21,78	3,06	21,77	3,16	21,76	3,25	21,74	3,35	21,73	3,44	21,71	3,54	21,70	3,63	21,68	3,73	22
23	22,77	3,21	22,76	3,30	22,75	3,40	22,73	3,50	22,72	3,60	22,70	3,70	22,69	3,80	22,67	3,90	23
24	23,76	3,34	23,75	3,44	23,74	3,55	23,72	3,65	23,71	3,76	23,69	3,86	23,67	3,96	23,65	4,07	24
25	24,75	3,48	24,74	3,59	24,73	3,70	24,71	3,80	24,69	3,91	24,68	4,02	24,66	4,13	24,64	4,24	25
26	25,74	3,62	25,73	3,73	25,71	3,84	25,70	3,95	25,68	4,07	25,66	4,18	25,64	4,29	25,62	4,40	26
27	26,73	3,76	26,72	3,87	26,70	3,99	26,69	4,11	26,67	4,22	26,65	4,34	26,63	4,46	26,61	4,57	27
28	27,72	3,90	27,71	4,02	27,69	4,14	27,67	4,26	27,66	4,38	27,64	4,50	27,61	4,62	27,60	4,74	28
29	28,71	4,04	28,70	4,16	28,68	4,29	28,66	4,41	28,64	4,54	28,62	4,66	28,60	4,79	28,58	4,91	29
30	29,71	4,18	29,69	4,31	29,67	4,43	29,65	4,56	29,63	4,69	29,61	4,82	29,59	4,96	29,57	5,08	30
31	30,70	4,31	30,68	4,45	30,66	4,58	30,64	4,72	30,62	4,85	30,60	4,98	30,58	5,12	30,55	5,25	31
32	31,69	4,45	31,67	4,59	31,65	4,73	31,63	4,87	31,61	5,01	31,58	5,14	31,56	5,29	31,54	5,42	32
33	32,68	4,59	32,66	4,74	32,64	4,88	32,62	5,02	32,59	5,16	32,57	5,31	32,55	5,45	32,52	5,59	33
34	33,67	4,73	33,65	4,88	33,63	5,03	33,61	5,17	33,58	5,32	33,56	5,47	33,53	5,62	33,51	5,76	34
35	34,66	4,87	34,64	5,02	34,62	5,17	34,59	5,33	34,57	5,48	34,55	5,63	34,52	5,78	34,49	5,93	35
36	35,65	5,01	35,63	5,17	35,61	5,32	35,58	5,48	35,56	5,63	35,54	5,79	35,51	5,95	35,48	6,10	36
37	36,64	5,15	36,62	5,31	36,59	5,47	36,57	5,63	36,55	5,79	36,53	5,95	36,49	6,11	36,47	6,27	37
38	37,63	5,29	37,61	5,45	37,58	5,62	37,56	5,78	37,53	5,95	37,51	6,11	37,48	6,28	37,45	6,44	38
39	38,62	5,43	38,60	5,60	38,57	5,76	38,55	5,93	38,52	6,10	38,49	6,27	38,47	6,44	38,44	6,61	39
40	39,61	5,57	39,59	5,74	39,56	5,91	39,53	6,09	39,51	6,26	39,48	6,43	39,45	6,61	39,42	6,78	40
41	40,60	5,71	40,58	5,88	40,55	6,06	40,52	6,24	40,50	6,41	40,47	6,59	40,44	6,77	40,41	6,94	41
42	41,59	5,85	41,57	6,03	41,54	6,21	41,51	6,39	41,48	6,57	41,45	6,75	41,43	6,94	41,39	7,11	42
43	42,58	5,99	42,56	6,17	42,53	6,36	42,50	6,54	42,47	6,73	42,44	6,91	42,41	7,10	42,38	7,28	43
44	43,57	6,12	43,55	6,31	43,52	6,50	43,49	6,69	43,46	6,88	43,43	7,07	43,40	7,27	43,36	7,45	44
45	44,56	6,26	44,54	6,46	44,51	6,65	44,48	6,85	44,45	7,04	44,42	7,23	44,38	7,43	44,35	7,62	45
46	45,55	6,40	45,52	6,60	45,50	6,80	45,46	7,00	45,43	7,20	45,40	7,40	45,37	7,60	45,34	7,79	46
47	46,54	6,54	46,51	6,74	46,48	6,95	46,45	7,15	46,42	7,35	46,39	7,56	46,36	7,76	46,32	7,96	47
48	47,53	6,68	47,50	6,89	47,47	7,09	47,44	7,30	47,41	7,51	47,38	7,72	47,34	7,93	47,31	8,13	48
49	48,52	6,82	48,49	7,03	48,46	7,24	48,43	7,45	48,40	7,66	48,36	7,88	48,33	8,09	48,29	8,30	49
50	49,51	6,96	49,48	7,18	49,45	7,39	49,42	7,61	49,39	7,82	49,35	8,04	49,32	8,26	49,28	8,47	50
51	50,50	7,10	50,47	7,32	50,44	7,54	50,41	7,76	50,37	7,98	50,34	8,20	50,30	8,42	50,26	8,64	51
52	51,49	7,24	51,46	7,46	51,43	7,69	51,40	7,91	51,36	8,14	51,32	8,36	51,29	8,59	51,25	8,81	52
53	52,48	7,38	52,45	7,61	52,42	7,83	52,38	8,06	52,35	8,29	52,31	8,52	52,27	8,75	52,24	8,98	53
54	53,47	7,52	53,44	7,75	53,41	7,98	53,37	8,21	53,34	8,45	53,30	8,68	53,26	8,92	53,22	9,15	54
55	54,47	7,66	54,43	7,89	54,40	8,13	54,36	8,37	54,32	8,60	54,29	8,84	54,25	9,08	54,21	9,32	55
56	55,46	7,79	55,42	8,04	55,39	8,28	55,35	8,52	55,31	8,76	55,27	9,00	55,23	9,25	55,19	9,48	56
57	56,45	7,93	56,41	8,18	56,37	8,43	56,34	8,67	56,30	8,92	56,26	9,16	56,22	9,41	56,18	9,65	57
58	57,44	8,07	57,40	8,32	57,36	8,57	57,33	8,82	57,29	9,07	57,25	9,32	57,21	9,58	57,16	9,82	58
59	58,43	8,21	58,39	8,47	58,35	8,72	58,31	8,98	58,28	9,23	58,23	9,48	58,19	9,74	58,15	9,99	59
60	59,42	8,35	59,38	8,61	59,34	8,87	59,30	9,13	59,26	9,39	59,22	9,62	59,18	9,91	59,13	10,16	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	82 Deg.		81 Degrees					6,3	80 Degrees							5,7	

Distance	8 Degrees							,14	9 Degrees							,16	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,41	8,49	60,37	8,75	60,33	9,02	60,29	9,28	60,25	9,54	60,21	9,81	60,16	10,07	60,12	10,33	61
62	61,40	8,63	61,36	8,90	61,32	9,16	61,28	9,43	61,24	9,70	61,19	9,97	61,15	10,24	61,11	10,50	62
63	62,39	8,77	62,35	9,04	62,31	9,31	62,27	9,58	62,22	9,86	62,18	10,13	62,14	10,40	62,09	10,67	63
64	63,38	8,91	63,34	9,18	63,30	9,46	63,26	9,74	63,21	10,01	63,17	10,29	63,12	10,57	63,08	10,84	64
65	64,37	9,05	64,33	9,33	64,29	9,61	64,24	9,89	64,20	10,17	64,16	10,45	64,11	10,74	64,06	11,01	65
66	65,36	9,19	65,32	9,47	65,28	9,76	65,23	10,04	65,19	10,33	65,14	10,61	65,09	10,90	65,05	11,18	66
67	66,35	9,32	66,31	9,61	66,26	9,90	66,22	10,19	66,18	10,48	66,13	10,77	66,08	11,07	66,03	11,35	67
68	67,34	9,46	67,30	9,76	67,25	10,05	67,21	10,34	67,16	10,64	67,12	10,93	67,07	11,23	67,02	11,52	68
69	68,33	9,60	68,29	9,90	68,24	10,20	68,20	10,50	68,15	10,79	68,10	11,09	68,05	11,40	68,00	11,69	69
70	69,32	9,74	69,28	10,04	69,23	10,35	69,19	10,65	69,14	10,95	69,09	11,25	69,04	11,56	68,99	11,86	70
71	70,31	9,88	70,27	10,19	70,22	10,50	70,17	10,80	70,13	11,11	70,08	11,41	70,03	11,73	69,97	12,02	71
72	71,30	10,02	71,26	10,33	71,21	10,64	71,16	10,95	71,11	11,26	71,06	11,57	71,01	11,89	70,96	12,19	72
73	72,29	10,16	72,25	10,47	72,20	10,79	72,15	11,10	72,10	11,42	72,05	11,74	72,00	12,06	71,95	12,36	73
74	73,28	10,30	73,23	10,62	73,19	10,94	73,14	11,26	73,09	11,58	73,04	11,90	72,99	12,22	72,93	12,52	74
75	74,27	10,44	74,22	10,76	74,18	11,09	74,13	11,41	74,08	11,73	74,03	12,06	73,97	12,39	73,92	12,70	75
76	75,26	10,58	75,21	10,91	75,17	11,24	75,11	11,56	75,07	11,89	75,01	12,22	74,96	12,55	74,90	12,87	76
77	76,25	10,72	76,20	11,05	76,15	11,38	76,10	11,71	76,05	12,05	76,00	12,38	75,94	12,72	75,89	13,04	77
78	77,24	10,86	77,19	11,19	77,14	11,53	77,09	11,86	77,04	12,20	76,99	12,54	76,93	12,88	76,87	13,21	78
79	78,23	10,99	78,18	11,34	78,13	11,68	78,08	12,02	78,03	12,36	77,97	12,70	77,92	13,05	77,86	13,38	79
80	79,22	11,13	79,17	11,48	79,12	11,83	79,07	12,17	79,02	12,51	78,96	12,86	78,90	13,21	78,85	13,55	80
81	80,21	11,27	80,16	11,62	80,11	11,97	80,06	12,32	80,00	12,67	79,95	13,02	79,89	13,38	79,83	13,72	81
82	81,20	11,41	81,15	11,77	81,10	12,12	81,05	12,47	80,99	12,83	80,93	13,18	80,88	13,54	80,82	13,89	82
83	82,19	11,55	82,14	11,91	82,09	12,27	82,03	12,63	81,98	12,98	81,92	13,34	81,86	13,71	81,80	14,06	83
84	83,18	11,69	83,13	12,05	83,08	12,42	83,02	12,78	82,97	13,14	82,91	13,50	82,85	13,87	82,79	14,23	84
85	84,17	11,83	84,12	12,20	84,07	12,56	84,01	12,93	83,95	13,30	83,90	13,66	83,83	14,04	83,77	14,40	85
86	85,16	11,97	85,11	12,34	85,06	12,72	85,00	13,08	84,94	13,45	84,88	13,82	84,82	14,20	84,76	14,57	86
87	86,15	12,11	86,10	12,48	86,05	12,86	85,99	13,23	85,93	13,61	85,87	13,99	85,81	14,37	85,74	14,73	87
88	87,14	12,25	87,09	12,63	87,03	13,01	86,98	13,39	86,92	13,77	86,86	14,15	86,79	14,53	86,73	14,90	88
89	88,13	12,39	88,08	12,77	88,02	13,16	87,97	13,54	87,91	13,92	87,84	14,31	87,78	14,70	87,71	15,07	89
90	89,12	12,53	89,07	12,91	89,01	13,30	88,95	13,69	88,89	14,08	88,83	14,47	88,77	14,86	88,70	15,24	90
91	90,11	12,67	90,06	13,06	90,00	13,45	89,94	13,84	89,88	14,24	89,82	14,63	89,75	15,03	89,69	15,41	91
92	91,10	12,80	91,05	13,20	90,99	13,60	90,93	14,00	90,87	14,39	90,80	14,79	90,74	15,19	90,67	15,58	92
93	92,10	12,94	92,04	13,34	91,98	13,75	91,92	14,15	91,86	14,55	91,79	14,95	91,73	15,36	91,66	15,75	93
94	93,09	13,08	93,03	13,49	92,97	13,89	92,91	14,30	92,84	14,71	92,78	15,11	92,71	15,52	92,64	15,92	94
95	94,08	13,22	94,02	13,63	93,96	14,04	93,89	14,45	93,83	14,86	93,77	15,27	93,70	15,69	93,63	16,09	95
96	95,07	13,36	95,01	13,78	94,95	14,19	94,88	14,60	94,82	15,02	94,75	15,43	94,68	15,86	94,61	16,26	96
97	96,06	13,50	96,00	13,92	95,94	14,34	95,87	14,76	95,81	15,17	95,74	15,59	95,67	16,02	95,60	16,43	97
98	97,05	13,64	96,99	14,06	96,92	14,49	96,86	14,91	96,79	15,33	96,73	15,75	96,66	16,19	96,58	16,60	98
99	98,04	13,78	97,98	14,21	97,91	14,63	97,85	15,06	97,78	15,49	97,71	15,91	97,64	16,35	97,57	16,77	99
100	99,03	13,92	98,97	14,35	98,90	14,78	98,84	15,21	98,77	15,6[illegible]	98,70	16,07	98,63	16,52	98,56	16,94	100
101	100,0	14,06	99,96	14,49	99,89	14,93	99,83	15,36	99,76	15,80	99,69	16,24	99,62	16,68	99,55	17,11	101
102	101,0	14,20	100,9	14,64	100,9	15,08	100,8	15,52	100,7	15,96	100,7	16,40	100,6	16,85	100,5	17,27	102
103	102,0	14,33	101,9	14,78	101,9	15,22	101,8	15,67	101,7	16,11	101,7	16,56	101,6	17,01	101,5	17,44	103
104	103,0	14,47	102,9	14,92	102,0	15,37	102,8	15,82	102,7	16,27	102,6	16,72	102,6	17,18	102,5	17,61	104
105	104,0	14,61	103,9	15,07	103,8	15,52	103,8	15,97	103,7	16,43	103,6	16,88	103,6	17,34	103,5	17,78	105
106	105,0	14,75	104,9	15,21	104,8	15,67	104,8	16,12	104,7	16,58	104,6	17,04	104,6	17,51	104,5	17,95	106
107	106,0	14,89	105,9	15,35	105,8	15,82	105,8	16,28	105,7	16,74	105,6	17,20	105,5	17,67	105,5	18,12	107
108	106,9	15,03	106,9	15,50	106,8	15,96	106,7	16,43	106,7	16,90	106,6	17,36	106,5	17,84	106,4	18,29	108
109	107,9	15,17	107,9	15,64	107,8	16,11	107,7	16,58	107,7	17,05	107,6	17,52	107,5	18,00	107,4	18,46	109
110	108,9	15,31	108,9	15,78	108,8	16,26	108,7	16,73	108,6	17,21	108,6	17,68	108,5	18,17	108,4	18,6[illegible]	110
111	109,9	15,45	109,9	15,93	109,8	16,41	109,7	16,89	109,6	17,36	109,[illegible]	17,84	109,5	18,33	109,4	18,80	111
112	110,9	15,59	110,8	16,07	110,8	16,56	110,7	17,04	110,6	17,52	110,5	18,00	110,5	18,50	110,4	18,97	112
113	111,9	15,73	111,8	16,21	111,8	16,70	111,7	17,19	111,6	17,6[illegible]	111,5	18,16	111,5	18,66	111,4	19,14	113
114	112,9	15,87	112,8	16,36	112,7	16,85	112,7	17,34	112,6	17,83	112,5	18,32	112,4	18,83	112,4	19,31	114
115	113,9	16,01	113,8	16,50	113,7	17,00	113,7	17,49	11[illegible],6	17,99	113,5	18,49	113,4	18,99	113,3	19,48	115
116	114,9	16,14	114,8	16,65	114,7	17,15	114,7	17,65	114,6	18,[illegible]5	114,5	18,65	114,4	19,16	114,3	19,65	116
117	115,9	16,28	115,8	16,79	115,7	17,30	115,[illegible]	17,8[illegible]	115,6	18,3[illegible]	115,5	18,81	115,4	19,32	115,3	19,81	117
118	116,9	16,42	116,8	16,93	116,7	17,44	116,6	17,95	116,5	18,46	116,5	18,97	116,4	19,[illegible]	116,3	19,98	118
119	117,8	16,56	117,8	17,08	117,7	17,59	117,6	18,10	117,5	18,62	117,5	19,13	117,4	19,65	117,3	20,15	119
120	118,8	16,70	118,8	17,22	118,7	17,74	118,6	18,[illegible]5	118,5	18,7[illegible]	118,4	[illegible]	118,4	19,81	118,3	20,31	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	82 Deg.		81 Degrees					[illegible],3	80 Degrees							[illegible]7	

Distance	10 Degrees							,18	11 Degrees							,19	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,98	0,17	0,98	0,18	0,98	0,18	0,98	0,19	0,98	0,19	0,98	0,20	0,98	0,20	0,98	0,20	1
2	1,97	0,35	1,97	0,36	1,97	0,36	1,97	0,37	1,96	0,38	1,96	0,39	1,96	0,40	1,96	0,41	2
3	2,95	0,52	2,95	0,53	2,95	0,55	2,95	0,56	2,95	0,57	2,94	0,59	2,94	0,60	2,94	0,61	3
4	3,94	0,70	3,94	0,71	3,93	0,73	3,93	0,75	3,93	0,76	3,92	0,78	3,92	0,80	3,92	0,82	4
5	4,92	0,87	4,92	0,89	4,92	0,91	4,91	0,93	4,91	0,95	4,90	0,98	4,90	1,00	4,90	1,02	5
6	5,91	1,04	5,90	1,07	5,90	1,09	5,90	1,12	5,89	1,15	5,89	1,17	5,88	1,20	5,87	1,22	6
7	6,89	1,22	6,89	1,25	6,88	1,28	6,88	1,31	6,87	1,34	6,87	1,37	6,86	1,40	6,85	1,43	7
8	7,88	1,39	7,87	1,42	7,87	1,46	7,86	1,49	7,85	1,53	7,85	1,56	7,84	1,60	7,83	1,63	8
9	8,86	1,56	8,86	1,60	8,85	1,64	8,84	1,68	8,84	1,72	8,83	1,76	8,82	1,79	8,81	1,83	9
10	9,85	1,74	9,84	1,78	9,83	1,82	9,83	1,87	9,82	1,91	9,81	1,95	9,80	1,99	9,79	2,04	10
11	10,83	1,91	10,82	1,96	10,82	2,01	10,81	2,05	10,80	2,10	10,79	2,15	10,78	2,19	10,77	2,24	11
12	11,82	2,08	11,81	2,14	11,80	2,19	11,79	2,24	11,78	2,29	11,77	2,34	11,76	2,39	11,75	2,44	12
13	12,80	2,26	12,79	2,31	12,78	2,37	12,77	2,43	12,76	2,48	12,75	2,54	12,74	2,59	12,73	2,65	13
14	13,78	2,43	13,78	2,49	13,77	2,55	13,75	2,61	13,74	2,67	13,73	2,73	13,72	2,79	13,71	2,85	14
15	14,77	2,61	14,76	2,67	14,75	2,73	14,74	2,80	14,73	2,86	14,71	2,93	14,70	2,99	14,69	3,06	15
16	15,76	2,78	15,74	2,85	15,73	2,92	15,72	2,98	15,71	3,05	15,69	3,12	15,68	3,19	15,67	3,26	16
17	16,74	2,95	16,73	3,03	16,72	3,10	16,70	3,17	16,69	3,24	16,67	3,32	16,66	3,39	16,64	3,46	17
18	17,73	3,13	17,71	3,20	17,70	3,28	17,68	3,36	17,67	3,43	17,65	3,51	17,64	3,59	17,62	3,66	18
19	18,71	3,30	18,70	3,38	18,69	3,46	18,67	3,54	18,65	3,63	18,64	3,71	18,62	3,79	18,60	3,87	19
20	19,70	3,47	19,68	3,56	19,67	3,65	19,65	3,73	19,63	3,82	19,62	3,90	19,60	3,99	19,58	4,07	20
21	20,68	3,65	20,67	3,74	20,65	3,83	20,63	3,92	20,62	4,01	20,60	4,10	20,58	4,19	20,56	4,28	21
22	21,67	3,82	21,65	3,92	21,63	4,01	21,61	4,10	21,60	4,20	21,58	4,29	21,56	4,39	21,54	4,48	22
23	22,65	3,99	22,63	4,09	22,61	4,19	22,60	4,29	22,58	4,39	22,56	4,49	22,54	4,59	22,52	4,68	23
24	23,64	4,17	23,62	4,27	23,60	4,37	23,58	4,48	23,56	4,58	23,54	4,68	23,52	4,78	23,50	4,89	24
25	24,62	4,34	24,60	4,45	24,58	4,56	24,56	4,66	24,54	4,77	24,52	4,88	24,50	4,98	24,48	5,09	25
26	25,61	4,51	25,59	4,63	25,56	4,74	25,54	4,85	25,52	4,96	25,50	5,07	25,48	5,18	25,46	5,30	26
27	26,59	4,69	26,57	4,81	26,55	4,92	26,53	5,04	26,50	5,15	26,48	5,27	26,46	5,38	26,43	5,50	27
28	27,57	4,86	27,55	4,98	27,53	5,10	27,51	5,22	27,49	5,34	27,46	5,46	27,44	5,58	27,41	5,70	28
29	28,56	5,04	28,54	5,16	28,51	5,29	28,49	5,41	28,47	5,53	28,44	5,66	28,42	5,78	28,39	5,91	29
30	29,54	5,21	29,52	5,34	29,50	5,47	29,47	5,60	29,45	5,72	29,42	5,85	29,40	5,98	29,37	6,11	30
31	30,53	5,38	30,51	5,52	30,48	5,65	30,46	5,78	30,43	5,92	30,41	6,05	30,38	6,18	30,35	6,31	31
32	31,51	5,56	31,49	5,69	31,46	5,83	31,44	5,97	31,41	6,11	31,39	6,24	31,36	6,38	31,33	6,52	32
33	32,50	5,73	32,47	5,87	32,45	6,01	32,42	6,16	32,39	6,30	32,37	6,44	32,34	6,58	32,31	6,72	33
34	33,48	5,91	33,46	6,05	33,43	6,20	33,40	6,34	33,38	6,49	33,35	6,63	33,32	6,78	33,29	6,92	34
35	34,47	6,08	34,44	6,23	34,41	6,38	34,39	6,53	34,36	6,68	34,33	6,83	34,30	6,98	34,27	7,13	35
36	35,45	6,25	35,43	6,41	35,40	6,56	35,37	6,72	35,34	6,87	35,31	7,02	35,28	7,18	35,25	7,33	36
37	36,44	6,43	36,41	6,58	36,38	6,74	36,35	6,90	36,32	7,06	36,29	7,22	36,26	7,38	36,23	7,53	37
38	37,42	6,60	37,39	6,76	37,36	6,93	37,33	7,09	37,30	7,25	37,27	7,41	37,24	7,58	37,20	7,74	38
39	38,41	6,77	38,38	6,94	38,35	7,11	38,32	7,28	38,28	7,44	38,25	7,61	38,22	7,78	38,18	7,94	39
40	39,39	6,95	39,36	7,12	39,33	7,29	39,30	7,46	39,27	7,63	39,23	7,80	39,20	7,98	39,16	8,15	40
41	40,38	7,12	40,35	7,30	40,31	7,47	40,28	7,65	40,25	7,82	40,21	8,00	40,18	8,17	40,14	8,35	41
42	41,36	7,29	41,33	7,47	41,30	7,65	41,26	7,83	41,23	8,01	41,19	8,19	41,16	8,37	41,12	8,55	42
43	42,35	7,47	42,31	7,65	42,28	7,84	42,25	8,02	42,21	8,20	42,17	8,39	42,14	8,57	42,10	8,76	43
44	43,33	7,64	43,30	7,83	43,26	8,02	43,23	8,21	43,19	8,40	43,16	8,58	43,12	8,77	43,08	8,96	44
45	44,32	7,81	44,28	8,01	44,25	8,20	44,21	8,39	44,17	8,59	44,14	8,78	44,10	8,97	44,06	9,16	45
46	45,30	7,99	45,27	8,19	45,23	8,38	45,19	8,58	45,16	8,78	45,12	8,97	45,08	9,17	45,04	9,37	46
47	46,29	8,16	46,25	8,36	46,21	8,57	46,18	8,77	46,14	8,97	46,10	9,17	46,06	9,37	46,02	9,57	47
48	47,27	8,33	47,23	8,54	47,20	8,75	47,16	8,95	47,12	9,16	47,08	9,37	47,04	9,57	47,00	9,78	48
49	48,26	8,51	48,22	8,72	48,18	8,93	48,14	9,14	48,10	9,35	48,06	9,56	48,02	9,77	47,97	9,98	49
50	49,24	8,68	49,20	8,90	49,16	9,11	49,12	9,33	49,08	9,54	49,04	9,76	49,00	9,97	48,95	10,18	50
51	50,23	8,86	50,19	9,08	50,15	9,29	50,11	9,51	50,06	9,73	50,02	9,95	49,98	10,17	49,93	10,39	51
52	51,21	9,03	51,17	9,25	51,13	9,48	51,09	9,70	51,05	9,92	51,00	10,15	50,96	10,37	50,91	10,59	52
53	52,20	9,20	52,15	9,43	52,11	9,66	52,07	9,89	52,03	10,11	51,98	10,34	51,94	10,57	51,89	10,79	53
54	53,18	9,38	53,14	9,61	53,10	9,84	53,05	10,07	53,01	10,30	52,96	10,54	52,92	10,77	52,87	11,00	54
55	54,17	9,55	54,12	9,79	54,08	10,02	54,04	10,26	53,99	10,50	53,94	10,73	53,90	10,97	53,85	11,20	55
56	55,15	9,72	55,11	9,97	55,06	10,21	55,02	10,45	54,97	10,69	54,93	10,93	54,88	11,17	54,83	11,40	56
57	56,14	9,90	56,09	10,14	56,05	10,39	56,00	10,63	55,95	10,88	55,91	11,12	55,86	11,37	55,81	11,61	57
58	57,12	10,07	57,07	10,32	57,03	10,57	56,98	10,82	56,94	11,07	56,89	11,32	56,84	11,56	56,79	11,81	58
59	58,10	10,25	58,06	10,50	58,01	10,75	57,97	11,01	57,92	11,26	57,87	11,51	57,82	11,76	57,76	12,02	59
60	59,09	10,42	59,04	10,68	58,99	10,93	58,95	11,19	58,90	11,45	58,85	11,71	58,80	11,96	58,74	12,22	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	80 Deg.		79 Degrees					5,1	78 Degrees							4,7	

Distance	10 Degrees							,18	11 Degrees							,19	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,07	10,59	60,03	10,85	59,98	11,12	59,93	11,38	59,88	11,64	59,83	11,90	59,78	12,16	59,72	12,41	61
62	61,06	10,77	61,01	11,03	60,96	11,30	60,91	11,56	60,86	11,83	60,81	12,09	60,76	12,36	60,70	12,63	62
63	62,04	10,94	61,99	11,21	61,94	11,48	61,89	11,75	61,84	12,02	61,79	12,29	61,74	12,56	61,68	12,83	63
64	63,03	11,11	62,98	11,39	62,93	11,66	62,88	11,94	62,83	12,21	62,77	12,49	62,72	12,76	62,66	13,03	64
65	64,01	11,29	63,96	11,57	63,91	11,85	63,86	12,12	63,81	12,40	63,75	12,68	63,70	12,96	63,64	13,21	65
66	65,00	11,46	64,95	11,74	64,89	12,03	64,84	12,31	64,79	12,59	64,73	12,88	64,68	13,16	64,62	13,44	66
67	65,98	11,64	65,93	11,92	65,88	12,21	65,82	12,50	65,77	12,79	65,71	13,07	65,66	13,36	65,60	13,64	67
68	66,97	11,81	66,91	12,10	66,86	12,39	66,81	12,68	66,75	12,98	66,69	13,27	66,64	13,56	66,58	13,85	68
69	67,95	11,98	67,90	12,28	67,84	12,57	67,79	12,87	67,73	13,17	67,67	13,46	67,61	13,76	67,55	14,05	69
70	68,94	12,16	68,88	12,46	68,83	12,76	68,77	13,06	68,71	13,36	68,66	13,66	68,59	13,96	68,53	14,26	70
71	69,92	12,38	69,87	12,63	69,81	12,94	69,75	13,24	69,70	13,55	69,64	13,85	69,57	14,16	69,51	14,46	71
72	70,91	12,50	70,85	12,81	70,79	13,12	70,74	13,43	70,68	13,74	70,62	14,05	70,55	14,36	70,49	14,66	72
73	71,89	12,68	71,84	12,99	71,73	13,30	71,72	13,61	71,66	13,93	71,60	14,24	71,53	14,55	71,47	14,87	73
74	72,88	12,85	72,82	13,17	72,76	13,49	72,70	13,80	72,64	14,12	72,58	14,44	72,5	14,75	72,45	15,07	74
75	73,86	13,02	73,80	13,35	73,74	13,67	73,68	13,99	73,62	14,31	73,56	14,63	73,49	14,95	73,43	15,27	75
76	74,85	13,20	74,79	13,52	74,73	13,85	74,67	14,18	74,60	14,50	74,54	14,83	74,47	15,15	74,41	15,48	76
77	75,83	13,37	75,77	13,70	75,71	14,03	75,65	14,36	75,59	14,69	75,52	15,02	75,45	15,35	75,39	15,68	77
78	76,82	13,54	76,76	13,88	76,69	14,22	76,63	14,55	76,57	14,88	76,50	15,22	76,43	15,55	76,37	15,88	78
79	77,80	13,72	77,74	14,06	77,68	14,40	77,61	14,74	77,55	15,07	77,48	15,41	77,41	15,75	77,35	16,09	79
80	78,79	13,89	78,72	14,24	78,66	14,58	78,60	14,92	78,53	15,27	78,46	15,61	78,39	15,95	78,32	16,29	80
81	79,77	14,07	79,71	14,41	79,64	14,76	79,58	15,11	79,51	15,46	79,44	15,80	79,37	16,15	79,30	16,50	81
82	80,76	14,24	80,69	14,59	80,63	14,94	80,56	15,30	80,49	15,65	80,43	16,00	80,35	16,35	80,28	16,70	82
83	81,74	14,41	81,68	14,77	81,61	15,13	81,54	15,48	81,48	15,84	81,41	16,19	81,33	16,55	81,26	16,90	83
84	82,73	14,59	82,66	14,95	82,59	15,31	82,53	15,67	82,46	16,03	82,39	16,39	82,31	16,75	82,24	17,11	84
85	83,72	14,76	83,64	15,13	83,58	15,49	83,51	15,86	83,44	16,22	83,37	16,58	83,29	16,95	83,22	17,31	85
86	84,71	14,93	84,63	15,30	84,56	15,67	84,49	16,04	84,42	16,41	84,35	16,78	84,27	17,15	84,20	17,51	86
87	85,70	15,11	85,61	15,48	85,54	15,85	85,47	16,23	85,40	16,60	85,33	16,97	85,25	17,35	85,18	17,72	87
88	86,68	15,28	86,60	15,66	86,53	16,04	86,46	16,41	86,38	16,79	86,31	17,17	86,23	17,55	86,16	17,92	88
89	87,67	15,46	87,58	15,84	87,51	16,22	87,44	16,60	87,37	16,98	87,29	17,36	87,21	17,74	87,14	18,12	89
90	88,65	15,62	88,56	16,02	88,49	16,40	88,42	16,79	88,35	17,17	88,27	17,56	88,19	17,94	88,12	18,33	90
91	89,62	15,80	89,55	16,19	89,48	16,53	89,40	16,97	89,33	17,36	89,25	17,75	89,17	18,14	89,09	18,53	91
92	90,60	15,98	90,53	16,37	90,46	16,77	90,39	17,16	90,31	17,56	90,23	17,95	90,15	18,34	90,07	18,74	92
93	91,59	16,15	91,52	16,55	91,44	16,95	91,37	17,35	91,29	17,75	91,21	18,14	91,13	18,54	91,05	18,94	93
94	92,57	16,32	92,50	16,73	92,43	17,13	92,35	17,53	92,27	17,94	92,19	18,3	92,11	18,74	92,03	19,14	94
95	93,56	16,50	93,48	16,91	93,41	17,31	93,33	17,72	93,26	18,13	93,18	18,54	93,09	18,94	93,01	19,35	95
96	94,54	16,67	94,47	17,08	94,39	17,50	94,32	17,91	94,24	18,32	94,16	18,73	94,07	19,14	93,99	19,55	96
97	95,53	16,85	95,45	17,26	95,38	17,68	95,30	18,09	95,22	18,51	95,14	18,9	95,05	19,34	94,97	19,75	97
98	96,51	17,02	96,44	17,44	96,36	17,86	96,28	18,28	96,20	18,70	96,12	19,12	96,03	19,54	95,95	19,96	98
99	97,50	17,19	97,42	17,62	97,34	18,04	97,26	18,47	97,18	18,89	97,10	19,31	97,0	19,74	96,93	20,16	99
100	98,48	17,37	98,40	17,79	98,33	18,22	98,25	18,65	98,16	19,08	98,08	19,51	97,99	19,94	97,91	20,36	100
101	99,47	17,54	99,39	17,97	99,31	18,41	99,23	18,84	99,15	19,27	99,06	19,70	98,97	20,14	98,88	20,57	101
102	100,4	17,71	100,4	18,15	100,3	18,59	100,2	19,03	100,1	19,46	100,0	19,90	99,95	20,34	99,86	20,77	102
103	101,4	17,89	101,4	18,33	101,3	18,77	101,2	19,21	101,1	19,65	101,0	20,09	100,9	20,54	100,8	20,98	103
104	102,4	18,06	102,3	18,51	102,3	18,95	102,2	19,40	102,1	19,84	102,0	20,29	101,9	20,73	101,8	21,18	104
105	103,4	18,23	103,3	18,68	103,2	19,14	103,2	19,59	103,0	20,04	103,0	20,48	102,9	20,93	102,8	21,38	105
106	104,3	18,41	104,3	18,86	104,2	19,32	104,1	19,77	104,0	20,23	104,0	20,68	103,9	21,13	103,8	21,59	106
107	105,3	18,58	105,3	19,04	105,2	19,50	105,1	19,96	105,0	20,42	104,9	20,88	104,8	21,33	104,8	21,79	107
108	106,3	18,75	106,3	19,22	106,2	19,68	106,1	20,14	106,0	20,61	105,9	21,07	105,8	21,53	105,7	21,99	108
109	107,3	18,93	107,3	19,40	107,2	19,86	107,1	-0,33	107,0	20,80	106,9	21,27	106,8	21,73	106,7	22,20	109
110	108,3	19,10	108,2	19,57	108,2	20,05	108,1	20,52	108,0	21,00	107,9	21,46	107,8	21,93	107,7	22,40	110
111	109,3	19,28	109,2	19,75	109,1	20,23	109,1	20,70	108,9	21,18	108,9	21,66	108,8	22,13	108,7	22,60	111
112	110,3	19,45	110,2	19,93	110,1	20,41	110,0	20,89	109,9	21,37	109,8	21,85	109,7	22,33	109,6	22,81	112
113	111,3	19,62	111,2	20,11	111,1	20,59	111,0	21,08	110,9	21,56	110,8	22,05	110,7	22,53	110,6	23,01	113
114	112,3	19,80	112,2	20,29	112,1	20,78	112,0	21,26	111,9	21,75	111,8	22,24	111,7	22,73	111,6	23,22	114
115	113,3	19,97	113,2	20,46	113,1	20,96	113,0	21,45	112,9	21,94	112,8	22,44	112,7	22,93	112,6	23,42	115
116	114,2	20,14	114,1	20,64	114,1	21,14	114,0	21,64	113,8	22,13	113,8	22,63	113,7	23,13	113,6	23,62	116
117	115,2	20,32	115,1	20,82	115,0	21,32	114,9	21,82	114,8	22,33	114,7	22,83	114,6	23,33	114,5	23,83	117
118	116,2	20,49	116,1	21,00	116,0	21,50	115,9	22,01	115,8	22,52	115,7	23,02	115,6	23,53	115,5	24,03	118
119	117,2	20,67	117,1	21,18	117,0	21,69	116,9	22,20	116,8	22,71	116,7	23,22	116,6	23,72	116,5	24,23	119
120	118,2	20,84	118,1	21,35	118,0	21,87	117,9	22,38	117,8	22,90	117,7	23,41	117,6	23,92	117,5	24,44	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	80 Deg.		79 Degrees					5,1	78 Degrees							4,7	

Distance	12 Degrees							,21	13 Degrees							,23	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,98	0,21	0,98	0,21	0,98	0,22	0,98	0,21	0,97	0,23	0,97	0,23	0,97	0,23	0,97	0,24	1
2	1,96	0,42	1,95	0,42	1,95	0,43	1,95	0,44	1,95	0,45	1,95	0,46	1,95	0,47	1,94	0,48	2
3	2,93	0,62	2,93	0,64	2,93	0,65	2,93	0,66	2,92	0,68	2,92	0,69	2,92	0,70	2,91	0,71	3
4	3,91	0,83	3,91	0,85	3,91	0,87	3,90	0,88	3,90	0,90	3,89	0,92	3,89	0,93	3,89	0,95	4
5	4,89	1,04	4,89	1,06	4,88	1,08	4,88	1,10	4,87	1,13	4,87	1,15	4,86	1,17	4,86	1,19	5
6	5,87	1,25	5,86	1,27	5,86	1,30	5,85	1,32	5,85	1,35	5,84	1,38	5,83	1,40	5,83	1,43	6
7	6,85	1,46	6,84	1,49	6,83	1,52	6,83	1,55	6,82	1,58	6,81	1,60	6,81	1,63	6,80	1,66	7
8	7,83	1,66	7,82	1,70	7,81	1,73	7,80	1,77	7,80	1,80	7,79	1,83	7,78	1,87	7,77	1,90	8
9	8,80	1,87	8,80	1,91	8,79	1,95	8,78	1,99	8,77	2,03	8,76	2,06	8,75	2,10	8,74	2,14	9
10	9,78	2,08	9,77	2,12	9,76	2,16	9,75	2,21	9,74	2,25	9,73	2,29	9,72	2,34	9,71	2,38	10
11	10,76	2,29	10,75	2,33	10,74	2,38	10,73	2,43	10,72	2,47	10,71	2,52	10,70	2,57	10,69	2,62	11
12	11,74	2,50	11,73	2,55	11,72	2,60	11,70	2,65	11,69	2,70	11,68	2,75	11,67	2,80	11,66	2,85	12
13	12,72	2,70	12,71	2,76	12,69	2,81	12,68	2,87	12,67	2,92	12,65	2,98	12,64	3,03	12,63	3,09	13
14	13,70	2,91	13,68	2,97	13,67	3,03	13,66	3,09	13,64	3,15	13,63	3,21	13,61	3,27	13,60	3,33	14
15	14,67	3,12	14,66	3,18	14,65	3,25	14,63	3,31	14,62	3,37	14,60	3,44	14,59	3,50	14,57	3,57	15
16	15,65	3,33	15,64	3,40	15,62	3,46	15,61	3,53	15,59	3,60	15,57	3,67	15,56	3,74	15,54	3,80	16
17	16,63	3,53	16,61	3,61	16,60	3,68	16,58	3,75	16,57	3,82	16,55	3,90	16,53	3,97	16,51	4,04	17
18	17,61	3,74	17,59	3,82	17,57	3,90	17,56	3,97	17,54	4,05	17,52	4,13	17,50	4,20	17,48	4,28	18
19	18,59	3,95	18,57	4,03	18,55	4,11	18,53	4,19	18,51	4,27	18,49	4,36	18,48	4,44	18,46	4,52	19
20	19,56	4,16	19,55	4,24	19,53	4,33	19,51	4,41	19,49	4,50	19,47	4,58	19,45	4,67	19,43	4,75	20
21	20,54	4,37	20,52	4,46	20,50	4,55	20,48	4,64	20,46	4,72	20,44	4,81	20,42	4,90	20,40	4,99	21
22	21,52	4,57	21,50	4,67	21,48	4,76	21,46	4,86	21,44	4,95	21,42	5,04	21,39	5,14	21,37	5,23	22
23	22,50	4,78	22,48	4,88	22,46	4,98	22,43	5,08	22,41	5,17	22,39	5,27	22,36	5,37	22,34	5,47	23
24	23,48	4,99	23,45	5,09	23,43	5,20	23,41	5,30	23,38	5,40	23,36	5,50	23,34	5,60	23,31	5,71	24
25	24,45	5,20	24,43	5,31	24,41	5,41	24,39	5,51	24,36	5,62	24,34	5,73	24,31	5,84	24,28	5,94	25
26	25,43	5,41	25,41	5,52	25,38	5,63	25,36	5,74	25,33	5,85	25,31	5,96	25,28	6,07	25,26	6,18	26
27	26,41	5,61	26,39	5,73	26,36	5,85	26,34	5,96	26,31	6,07	26,28	6,19	26,25	6,30	26,23	6,42	27
28	27,39	5,82	27,36	5,94	27,34	6,06	27,31	6,18	27,28	6,30	27,26	6,42	27,23	6,54	27,20	6,66	28
29	28,37	6,03	28,34	6,15	28,31	6,28	28,29	6,40	28,26	6,52	28,23	6,65	28,20	6,77	28,17	6,89	29
30	29,35	6,24	29,32	6,37	29,29	6,49	29,26	6.62	29,23	6,75	29,20	6,88	29,17	7,00	29,14	7,13	30
31	30,32	6,45	30,29	6,58	30,27	6,71	30,24	6,84	30,21	6,97	30,17	7,11	30,14	7,24	30,11	7,37	31
32	31,30	6,65	31,27	6,79	31,24	6,93	31,21	7,06	31,18	7,20	31,15	7,33	31,12	7,47	31,08	7,61	32
33	32,28	6,86	32,25	7,00	32,22	7,14	32,19	7,28	32,15	7,42	32,12	7,56	32,09	7,70	32,05	7,84	33
34	33,26	7,07	33,23	7,21	33,19	7,36	33,16	7,50	33,13	7,65	33,10	7,79	33,06	7,94	33,03	8,08	34
35	34,24	7,28	34,20	7,43	34,17	7,58	34,14	7,73	34,10	7,87	34,07	8,02	34,03	8,17	34,00	8,32	35
36	35,21	7,48	35,18	7,64	35,15	7,79	35,11	7,95	35,08	8,10	35,04	8,25	35,01	8,41	34,97	8,56	36
37	36,19	7,69	36,16	7,85	36,12	8,01	36,09	8,17	36,05	8,32	36,02	8,48	35,98	8,64	35,94	8,80	37
38	37,17	7,90	37,14	8,06	37,10	8,23	37,06	8,39	37,03	8,55	36,99	8,71	36,95	8,87	36,91	9,03	38
39	38,15	8,11	38,11	8,28	38,08	8,44	38,04	8,61	38,00	8,77	37,96	8,94	37,92	9,11	37,88	9,27	39
40	39.13	8,32	39,09	8,48	39,05	8,66	39,01	8,83	38,98	9,00	38,94	9,17	38,90	9,34	38,85	9,51	40
41	40,10	8,52	40,07	8,70	40,03	8,88	39,99	9,05	39,95	9,22	39,91	9,40	39,87	9,57	39,83	9,75	41
42	41,08	8,73	41,04	8,91	41,01	9,09	40,97	9,27	40,92	9,45	40,88	9,63	40,84	9,81	40,80	9,98	42
43	42,06	8,94	42,02	9,12	41,98	9,31	41,94	9,49	41,90	9,67	41,86	9,86	41,81	10,04	41,77	10,22	43
44	43,04	9,15	43,00	9,34	42,96	9,52	42,92	9,71	42,87	9,90	42,83	10,09	42,78	10,27	42,74	10,46	44
45	44,02	9,36	43,98	9,55	43,93	9,74	43,89	9,93	43,85	10,12	43,80	10,31	43,76	10,51	43,71	10,70	45
46	45,00	9,56	44,95	9,76	44,91	9,96	44,87	10,15	44,82	10,35	44,78	10,54	44,73	10,74	44,68	10,93	46
47	45,97	9,77	45,93	9,97	45,89	10,17	45,84	10,37	45,80	10,57	45,75	10,77	45,70	10,97	45,65	11,17	47
48	46,95	9,98	46,91	10,19	46,86	10,39	46,82	10,59	46,77	10,80	46,72	11,00	46,67	11,21	46,63	11,41	48
49	47,93	10,19	47,88	10,40	47,84	10,61	47,79	10,81	47,74	11,02	47,70	11,23	47,65	11,44	47,60	11,65	49
50	48,91	10,40	48,86	10,61	48,82	10,82	48,77	11,04	48,72	11,25	48,67	11,46	48,62	11,67	48,57	11,89	50
51	49,89	10,60	49,84	10,82	49,79	11,04	49,74	11,26	49,69	11,47	49,64	11,69	49,59	11,91	49,54	12,12	51
52	50.86	10,81	50,82	11,03	50,77	11,26	50,72	11,48	50,67	11,70	50,62	11,92	50,56	12,14	50,51	12,36	52
53	51,84	11,02	51,79	11,25	51,74	11,47	51,69	11,70	51,64	11,92	51,59	12,15	51,54	12,37	51,48	12,60	53
54	52,82	11,23	52,77	11,46	52,72	11,69	52,67	11,92	52,62	12,15	52,56	12,38	52,51	12,61	52,45	12,84	54
55	53,80	11,44	53,75	11,67	53,70	11,91	53,65	12,14	53,59	12,37	53,54	12,61	53,48	12,84	53,42	13,07	55
56	54,78	11,64	54,73	11,88	54,67	12,12	54,62	12,36	54,57	12,60	54,51	12,84	54,45	13,07	54,40	13,31	56
57	55,76	11,85	55,70	12,09	55,65	12,34	55,60	12,58	55,54	12,82	55,48	13,06	55,43	13,31	55,37	13,55	57
58	56,73	12,06	56,68	12,31	56,63	12,55	56,57	12,80	56,51	13,05	56,46	13,29	56,40	13,54	56,34	13,79	58
59	57,71	12,27	57,66	12,52	57,60	12,77	57,55	13,02	57,49	13,27	57,43	13 52	57,37	13,77	57,31	14,03	59
60	58,69	12,48	58,63	12,73	58,58	12,99	58,52	13,24	58,46	13,50	58,40	13,75	58,34	14,01	58,28	14,27	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	78 Deg.		77 Degrees					4,3	76 Degrees							4,0	

Distance	12 Degrees							,21	13 Degrees							,23	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
61	59,67	12,68	59,61	12,94	59,55	13,20	59,50	13,46	59,44	13,72	59,38	13,98	59,31	14,24	59,25	14,50	61
62	60,65	12,89	60,59	13,16	60,53	13,42	60,47	13,68	60,41	13,95	60,35	14,21	60,29	14,47	60,22	14,74	62
63	61,62	13,10	61,57	13,37	61,51	13,64	61,45	13,90	61,38	14,17	61,32	14,44	61,26	14,71	61,19	14,97	63
64	62,60	13,31	62,54	13,58	62,48	13,85	62,42	14,13	62,36	14,40	62,30	14,67	62,23	14,94	62,17	15,21	64
65	63,58	13,52	63,52	13,79	63,46	14,07	63,40	14,35	63,33	14,62	63,27	14,90	63,20	15,17	63,14	15,45	65
66	64,56	13,72	64,50	14,00	64,44	14,29	64,37	14,57	64,31	14,85	64,24	15,13	64,18	15,41	64,11	15,69	66
67	65,54	13,93	65,48	14,22	65,41	14,50	65,35	14,79	65,28	15,07	65,22	15,36	65,15	15,64	65,08	15,93	67
68	66,51	14,14	66,45	14,43	66,39	14,72	66,32	15,01	66,26	15,30	66,19	15,59	66,12	15,88	66,05	16,16	68
69	67,49	14,35	67,43	14,64	67,37	14,93	67,30	15,23	67,23	15,52	67,16	15,82	67,09	16,11	67,02	16,40	69
70	68,47	14,55	68,41	14,85	68,34	15,15	68,27	15,45	68,21	15,75	68,14	16,04	68,07	16,34	67,99	16,64	70
71	69,45	14,76	69,38	15,07	69,32	15,37	69,25	15,67	69,18	15,97	69,11	16,27	69,04	16,58	68,97	16,88	71
72	70,43	14,97	70,36	15,28	70,29	15,58	70,23	15,89	70,15	16,20	70,08	16,50	70,01	16,81	69,94	17,11	72
73	71,41	15,18	71,34	15,49	71,27	15,80	71,20	16,11	71,13	16,42	71,06	16,73	70,98	17,04	70,91	17,35	73
74	72,38	15,39	72,32	15,70	72,25	16,02	72,18	16,33	72,10	16,65	72,03	16,96	71,96	17,28	71,88	17,59	74
75	73,36	15,59	73,29	15,91	73,22	16,23	73,15	16,55	73,08	16,87	73,00	17,19	72,93	17,51	72,85	17,82	75
76	74,34	15,80	74,27	16,13	74,20	16,45	74,13	16,77	74,05	17,10	73,98	17,42	73,90	17,74	73,82	18,06	76
77	75,32	16,01	75,25	16,34	75,18	16,67	75,10	16,99	75,03	17,32	74,95	17,65	74,87	17,98	74,79	18,30	77
78	76,3	16,22	76,22	16,55	76,16	16,88	76,08	17,22	76,00	17,55	75,92	17,88	75,85	18,21	75,77	18,54	78
79	77,27	16,43	77,20	16,76	77,13	17,10	77,05	17,44	76,97	17,77	76,90	18,11	76,82	18,44	76,74	18,78	79
80	78,25	16,63	78,18	16,97	78,10	17,32	78,03	17,66	77,95	18,00	77,87	18,34	77,79	18,68	77,71	19,02	80
81	79,23	16,84	79,16	17,19	79,08	17,53	79,00	17,88	78,92	18,22	78,84	18,57	78,76	18,91	78,68	19,25	81
82	80,21	17,05	80,13	17,40	80,06	17,75	79,98	18,10	79,90	18,45	79,82	18,79	79,74	19,14	79,65	19,49	82
83	81,19	17,26	81,11	17,61	81,03	17,97	80,95	18,32	80,87	18,67	80,79	19,02	80,71	19,38	80,62	19,73	83
84	82,16	17,47	82,09	17,82	82,01	18,18	81,93	18,54	81,85	18,90	81,76	19,25	81,68	19,61	81,59	19,97	84
85	83,14	17,67	83,06	18,04	82,99	18,40	82,91	18,76	82,82	19,12	82,74	19,48	82,65	19,84	82,56	20,20	85
86	84,12	17,88	84,04	18,25	83,96	18,61	83,88	18,98	83,80	19,35	83,71	19,71	83,62	20,08	83,54	20,44	86
87	85,10	18,09	85,02	18,46	84,94	18,83	84,86	19,20	84,77	19,57	84,68	19,94	84,60	20,31	84,51	20,68	87
88	86,08	18,30	86,00	18,67	85,92	19,05	85,83	19,42	85,74	19,80	85,66	20,17	85,57	20,54	85,48	20,92	88
89	87,06	18,50	86,97	18,84	86,89	19,26	86,81	19,64	86,72	20,02	86,63	20,40	86,54	20,78	86,45	21,15	89
90	88,03	18,71	87,95	19,10	87,87	19,48	87,78	19,86	87,69	20,25	87,60	20,63	87,51	21,01	87,42	21,39	90
91	89,01	18,92	88,93	19,31	88,84	19,70	88,76	20,08	88,67	20,47	88,58	20,86	88,49	21,24	88,39	21,63	91
92	89,99	19,13	89,91	19,52	89,82	19,91	89,73	20,30	89,64	20,69	89,55	21,08	89,46	21,48	89,36	21,87	92
93	90,97	19,34	90,88	19,73	90,80	20,13	90,71	20,53	90,62	20,92	90,52	21,32	90,43	21,71	90,34	22,11	93
94	91,95	19,55	91,86	19,95	91,77	20,36	91,68	20,75	91,59	21,14	91,50	21,55	91,40	21,95	91,31	22,34	94
95	92,93	19,75	92,84	20,16	92,75	20,56	92,66	20,97	92,56	21,37	92,47	21,77	92,38	22,18	92,28	22,58	95
96	93,90	19,96	93,81	20,37	93,73	20,78	93,63	21,19	93,54	21,59	93,44	22,00	93,35	22,41	93,25	22,82	96
97	94,88	20,17	94,79	20,58	94,70	21,00	94,61	21,41	94,51	21,82	94,42	22,23	94,32	22,65	94,22	23,05	97
98	95,86	20,38	95,77	20,79	95,68	21,21	95,59	21,63	95,49	22,04	95,39	22,46	95,29	22,88	95,19	23,29	98
99	96,84	20,58	96,75	21,01	96,66	21,43	96,56	21,85	96,46	22,27	96,36	22,69	96,26	23,11	96,16	23,53	99
100	97,82	20,79	97,73	21,22	97,63	21,64	97,53	22,07	97,44	22,49	97,34	22,92	97,24	23,35	97,13	23,77	100
101	98,79	21,00	98,70	21,43	98,61	21,86	98,51	22,29	98,41	22,72	98,31	23,15	98,21	23,58	98,11	24,01	101
102	99,77	21,21	99,68	21,64	99,58	22,08	99,49	22,51	99,39	22,94	99,29	23,38	99,18	23,81	99,08	24,24	102
103	100,7	21,42	100,7	21,86	100,6	22,29	100,5	22,73	100,4	23,17	100,3	23,61	100,2	24,05	100,0	24,48	103
104	101,7	21,62	101,6	22,07	101,5	22,51	101,4	22,95	101,3	23,39	101,2	23,84	101,1	24,28	101,0	24,72	104
105	102,7	21,83	102,6	22,28	102,5	22,73	102,4	23,17	102,3	23,62	102,2	24,07	102,1	24,51	102,0	24,96	105
106	103,7	22,04	103,6	22,49	103,5	22,94	103,4	23,39	103,3	23,84	103,2	24,30	103,1	24,75	103,0	25,20	106
107	104,6	22,25	104,6	22,70	104,5	23,16	104,4	23,62	104,3	24,07	104,2	24,52	104,0	24,98	103,9	25,44	107
108	105,6	22,45	105,5	22,92	105,4	23,38	105,3	23,84	105,2	24,29	105,1	24,75	105,0	25,21	104,9	25,67	108
109	106,6	22,66	106,5	23,13	106,4	23,59	106,3	24,06	106,2	24,52	106,1	24,98	106,0	25,45	105,9	25,91	109
110	107,6	22,87	107,5	23,34	107,4	23,81	107,3	24,28	107,2	24,74	107,1	25,21	107,0	25,68	106,8	26,15	110
111	108,6	23,08	108,5	23,55	108,4	24,03	108,3	24,50	108,2	24,97	108,0	25,44	107,9	25,91	107,8	26,38	111
112	109,5	23,29	109,4	23,76	109,3	24,24	109,2	24,72	109,1	25,19	109,0	25,67	108,9	26,15	108,8	26,62	112
113	110,5	23,49	110,4	23,98	110,3	24,46	110,2	24,94	110,1	25,42	110,0	25,90	109,9	26,38	109,8	26,86	113
114	111,5	23,70	111,4	24,19	111,3	24,67	111,2	25,16	111,1	25,64	111,0	26,13	110,9	26,61	110,7	27,10	114
115	112,5	23,91	112,4	24,40	112,3	24,89	112,2	25,38	112,1	25,87	111,9	26,36	111,8	26,85	111,7	27,33	115
116	113,5	24,12	113,4	24,61	113,3	25,11	113,1	25,60	113,0	26,09	112,9	26,59	112,8	27,08	112,7	27,57	116
117	114,4	24,33	114,3	24,83	114,2	25,32	114,1	25,82	114,0	26,32	113,9	26,82	113,8	27,31	113,6	27,81	117
118	115,4	24,53	115,3	25,04	115,2	25,54	115,1	26,04	115,0	26,54	114,9	27,05	114,7	27,55	114,6	28,05	118
119	116,4	24,74	116,3	25,25	116,2	25,76	116,1	26,26	116,0	26,77	115,8	27,27	115,7	27,78	115,6	28,29	119
120	117,4	24,94	117,3	25,46	117,2	25,97	117,1	26,48	117,0	26,99	116,8	27,50	116,7	28,01	116,6	28,52	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	78 Deg.		77 Degrees					4,3	76 Degrees							4,0	

Distance	14 Degrees							,25	15 Degrees							,27	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,97	0,24	0,97	0,25	0,97	0,25	0,97	0,25	0,97	0,26	0,96	0,26	0,96	0,27	0,96	0,27	1
2	1,94	0,48	1,94	0,49	1,94	0,50	1,93	0,51	1,93	0,52	1,93	0,53	1,93	0,53	1,92	0,54	2
3	2,91	0,73	2,91	0,74	2,90	0,75	2,90	0,76	2,90	0,78	2,89	0,79	2,89	0,80	2,89	0,81	3
4	3,88	0,97	3,88	0,98	3,87	1,00	3,87	1,02	3,86	1,03	3,86	1,05	3,85	1,07	3,85	1,09	4
5	4,85	1,21	4,85	1,23	4,84	1,25	4,83	1,27	4,83	1,29	4,82	1,31	4,82	1,34	4,81	1,36	5
6	5,82	1,45	5,81	1,48	5,81	1,50	5,80	1,53	5,80	1,55	5,79	1,58	5,78	1,60	5,77	1,63	6
7	6,79	1,69	6,78	1,72	6,78	1,75	6,77	1,78	6,76	1,81	6,75	1,84	6,74	1,87	6,74	1,90	7
8	7,76	1,93	7,75	1,97	7,74	2,00	7,74	2,04	7,73	2,07	7,72	2,10	7,71	2,14	7,70	2,17	8
9	8,73	2,18	8,72	2,21	8,71	2,25	8,70	2,29	8,69	2,33	8,68	2,37	8,67	2,40	8,66	2,44	9
10	9,70	2,42	9,69	2,46	9,68	2,50	9,67	2,55	9,66	2,59	9,65	2,63	9,64	2,67	9,62	2,71	10
11	10,67	2,66	10,66	2,71	10,65	2,75	10,64	2,80	10,62	2,85	10,61	2,89	10,60	2,94	10,59	2,99	11
12	11,64	2,90	11,63	2,95	11,62	3,00	11,60	3,05	11,59	3,11	11,58	3,16	11,56	3,21	11,55	3,26	12
13	12,61	3,14	12,60	3,20	12,59	3,25	12,57	3,31	12,56	3,36	12,54	3,42	12,53	3,47	12,51	3,53	13
14	13,58	3,39	13,57	3,45	13,55	3,51	13,54	3,56	13,52	3,62	13,51	3,68	13,49	3,74	13,47	3,80	14
15	14,55	3,63	14,54	3,69	14,52	3,76	14,51	3,82	14,49	3,88	14,47	3,94	14,45	4,01	14,44	4,07	15
16	15,52	3,87	15,51	3,94	15,49	4,01	15,47	4,07	15,45	4,14	15,44	4,21	15,42	4,28	15,40	4,34	16
17	16,49	4,11	16,48	4,18	16,46	4,26	16,44	4,33	16,42	4,40	16,40	4,47	16,38	4,54	16,36	4,61	17
18	17,46	4,35	17,45	4,43	17,43	4,51	17,41	4,58	17,39	4,66	17,37	4,73	17,34	4,81	17,32	4,89	18
19	18,44	4,60	18,42	4,68	18,39	4,76	18,37	4,84	18,35	4,91	18,33	5,00	18,31	5,08	18,29	5,16	19
20	19,41	4,84	19,38	4,92	19,36	5,01	19,34	5,09	19,32	5,18	19,30	5,26	19,27	5,34	19,25	5,43	20
21	20,38	5,08	20,35	5,17	20,33	5,26	20,31	5,35	20,28	5,43	20,26	5,52	20,24	5,61	20,21	5,70	21
22	21,35	5,32	21,32	5,41	21,30	5,51	21,27	5,60	21,25	5,69	21,23	5,79	21,20	5,88	21,17	5,97	22
23	22,32	5,56	22,29	5,66	22,27	5,76	22,24	5,86	22,21	5,95	22,19	6,05	22,16	6,15	22,14	6,24	23
24	23,29	5,81	23,26	5,91	23,24	6,01	23,21	6,11	23,18	6,21	23,15	6,31	23,13	6,41	23,10	6,51	24
25	24,26	6,05	24,23	6,15	24,20	6,26	24,17	6,36	24,15	6,47	24,12	6,58	24,09	6,68	24,06	6,79	25
26	25,23	6,29	25,20	6,40	25,17	6,51	25,14	6,62	25,11	6,73	25,08	6,84	25,05	6,95	25,02	7,06	26
27	26,20	6,53	26,17	6,65	26,14	6,76	26,11	6,88	26,08	6,99	26,05	7,10	26,02	7,22	25,99	7,33	27
28	27,17	6,77	27,14	6,89	27,11	7,01	27,08	7,13	27,05	7,25	27,01	7,36	26,98	7,48	26,95	7,60	28
29	28,14	7,01	28,11	7,14	28,08	7,26	28,04	7,38	28,01	7,51	27,98	7,63	27,95	7,75	27,91	7,87	29
30	29,11	7,26	29,08	7,38	29,04	7,51	29,01	7,64	28,98	7,76	28,94	7,89	28,91	8,02	28,87	8,14	30
31	30,08	7,50	30,05	7,63	30,01	7,76	29,98	7,89	29,94	8,02	29,91	8,15	29,87	8,28	29,84	8,41	31
32	31,05	7,74	31,02	7,88	30,98	8,01	30,95	8,15	30,91	8,28	30,87	8,42	30,84	8,55	30,80	8,69	32
33	32,02	7,98	31,99	8,12	31,95	8,26	31,91	8,40	31,88	8,54	31,84	8,68	31,80	8,82	31,76	8,96	33
34	32,99	8,23	32,95	8,37	32,92	8,51	32,88	8,66	32,84	8,80	32,80	8,94	32,76	9,09	32,72	9,23	34
35	33,96	8,47	33,92	8,62	33,89	8,76	33,85	8,91	33,81	9,06	33,77	9,21	33,73	9,35	33,69	9,50	35
36	34,93	8,71	34,89	8,86	34,85	9,01	34,81	9,17	34,77	9,32	34,73	9,47	34,69	9,62	34,65	9,77	36
37	35,90	8,95	35,86	9,11	35,82	9,26	35,78	9,42	35,74	9,58	35,70	9,73	35,65	9,89	35,61	10,04	37
38	36,87	9,19	36,83	9,35	36,79	9,51	36,75	9,67	36,71	9,84	36,66	9,99	36,62	10,15	36,57	10,31	38
39	37,84	9,44	37,80	9,60	37,76	9,76	37,71	9,93	37,67	10,09	37,63	10,26	37,58	10,42	37,54	10,59	39
40	38,81	9,68	38,77	9,85	38,73	10,01	38,68	10,18	38,64	10,35	38,59	10,52	38,54	10,69	38,50	10,86	40
41	39,78	9,92	39,74	10,09	39,69	10,27	39,65	10,44	39,60	10,61	39,56	10,78	39,51	10,96	39,46	11,13	41
42	40,75	10,16	40,71	10,34	40,66	10,52	40,62	10,69	40,57	10,87	40,52	11,05	40,47	11,22	40,42	11,40	42
43	41,72	10,40	41,68	10,58	41,63	10,77	41,58	10,95	41,53	11,13	41,49	11,31	41,44	11,49	41,39	11,67	43
44	42,69	10,64	42,65	10,83	42,60	11,02	42,55	11,20	42,50	11,39	42,45	11,57	42,40	11,76	42,35	11,94	44
45	43,66	10,89	43,62	11,08	43,57	11,27	43,52	11,46	43,47	11,65	43,42	11,84	43,36	12,03	43,31	12,22	45
46	44,63	11,13	44,58	11,32	44,53	11,52	44,48	11,72	44,43	11,91	44,38	12,10	44,33	12,29	44,27	12,49	46
47	45,60	11,37	45,55	11,57	45,50	11,77	45,45	11,96	45,40	12,16	45,35	12,36	45,29	12,56	45,24	12,76	47
48	46,57	11,61	46,52	11,81	46,47	12,02	46,42	12,22	46,36	12,42	46,31	12,62	46,25	12,83	46,20	13,03	48
49	47,54	11,85	47,49	12,06	47,44	12,27	47,38	12,47	47,33	12,68	47,27	12,89	47,22	13,09	47,16	13,30	49
50	48,51	12,10	48,46	12,31	48,41	12,52	48,35	12,73	48,30	12,94	48,24	13,15	48,18	13,36	48,12	13,57	50
51	49,48	12,34	49,43	12,55	49,38	12,77	49,32	12,98	49,26	13,20	49,20	13,41	49,15	13,62	49,09	13,84	51
52	50,46	12,58	50,40	12,80	50,34	13,02	50,29	13,24	50,23	13,46	50,17	13,68	50,11	13,90	50,05	14,11	52
53	51,43	12,82	51,37	13,05	51,31	13,27	51,25	13,49	51,19	13,72	51,13	13,94	51,07	14,16	51,01	14,39	53
54	52,40	13,06	52,34	13,29	52,28	13,52	52,22	13,75	52,16	13,98	52,10	14,20	52,04	14,43	51,97	14,66	54
55	53,37	13,31	53,31	13,54	53,25	13,77	53,19	14,00	53,13	14,23	53,06	14,47	53,00	14,70	52,94	14,98	55
56	54,34	13,55	54,28	13,78	54,22	14,02	54,15	14,26	54,09	14,49	54,03	14,73	53,96	14,96	53,90	15,20	56
57	55,31	13,79	55,25	14,03	55,18	14,27	55,12	14,51	55,06	14,75	54,99	14,99	54,93	15,23	54,86	15,47	57
58	56,28	14,03	56,22	14,28	56,15	14,52	56,09	14,77	56,02	15,01	55,96	15,26	55,89	15,50	55,82	15,74	58
59	57,25	14,27	57,19	14,52	57,12	14,77	57,06	15,02	56,99	15,27	56,92	15,52	56,85	15,77	56,79	16,02	59
60	58,21	14,51	58,15	14,77	58,09	15,02	58,02	15,28	57,96	15,53	57,89	15,78	57,82	16,03	57,75	16,29	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	76 Deg.		75 Degrees					3,7	74 Degrees							3,5	

James Macully's Book.

Digitized by Google

Distance	14 Degrees							,25	15 Degrees							,27	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	59,19	14,76	59,12	15,01	59,06	15,27	58,99	15,53	58,92	15,79	58,85	16,04	58,78	16,30	58,71	16,56	61
62	60,16	15,00	60,09	15,26	60,02	15,52	59,96	15,78	59,89	16,05	59,82	16,31	59,74	16,57	59,67	16,83	62
63	61,13	15,24	61,06	15,51	60,99	15,77	60,92	16,04	60,85	16,30	60,78	16,57	60,71	16,84	60,63	17,10	63
64	62,10	15,48	62,03	15,75	61,96	16,02	61,89	16,29	61,82	16,56	61,75	16,83	61,67	17,10	61,60	17,37	64
65	63,07	15,72	63,00	16,00	62,93	16,27	62,86	16,55	62,79	16,82	62,71	17,10	62,64	17,37	62,56	17,64	65
66	64,04	15,97	63,97	16,25	63,90	16,52	63,82	16,80	63,75	17,08	63,68	17,36	63,60	17,64	63,52	17,91	66
67	65,01	16,21	64,94	16,49	64,87	16,78	64,79	17,06	64,72	17,34	64,64	17,62	64,56	17,90	64,48	18,19	67
68	65,98	16,45	65,91	16,74	65,83	17,03	65,76	17,31	65,68	17,60	65,60	17,89	65,53	18,17	65,45	18,46	68
69	66,95	16,69	66,88	16,98	66,80	17,28	66,73	17,57	66,65	17,86	66,57	18,15	66,49	18,44	66,41	18,73	69
70	67,92	16,93	67,85	17,23	67,77	17,53	67,69	17,82	67,61	18,12	67,53	18,41	67,45	18,71	67,37	19,00	70
71	68,89	17,18	68,81	17,48	68,74	17,78	68,66	18,08	68,58	18,38	68,50	18,67	68,42	18,97	68,33	19,27	71
72	69,86	17,42	69,78	17,72	69,71	18,03	69,63	18,33	69,55	18,63	69,46	18,94	69,38	19,24	69,30	19,54	72
73	70,83	17,66	70,75	17,97	70,67	18,28	70,59	18,59	70,51	18,89	70,43	19,20	70,34	19,51	70,26	19,82	73
74	71,80	17,90	71,72	18,22	71,64	18,53	71,56	18,84	71,48	19,15	71,39	19,46	71,31	19,78	71,22	20,09	74
75	72,77	18,14	72,69	18,46	72,61	18,78	72,53	19,09	72,44	19,41	72,36	19,73	72,27	20,04	72,18	20,36	75
76	73,74	18,39	73,66	18,71	73,58	19,03	73,50	19,35	73,41	19,67	73,32	19,99	73,24	20,31	73,15	20,63	76
77	74,71	18,63	74,63	18,95	74,55	19,28	74,46	19,60	74,38	19,93	74,29	20,25	74,21	20,58	74,11	20,90	77
78	75,68	18,87	75,60	19,20	75,52	19,53	75,43	19,86	75,34	20,19	75,25	20,52	75,16	20,84	75,07	21,17	78
79	76,65	19,11	76,57	19,45	76,48	19,78	76,40	0,11	76,31	20,45	76,22	20,78	76,13	21,11	76,03	21,44	79
80	77,62	19,35	77,54	19,69	77,45	20,03	77,36	20,37	77,27	20,71	77,18	21,04	77,09	21,38	77,00	21,71	80
81	78,59	19,60	78,51	19,94	78,42	20,28	78,3	20,62	78,24	20,96	78,15	21,30	78,05	21,65	77,96	21,99	81
82	79,56	19,84	79,48	20,18	79,39	20,53	79,30	20,88	79,21	21,22	79,11	21,57	79,01	21,91	78,92	22,26	82
83	80,53	20,08	80,45	20,43	80,36	20,78	80,26	21,13	80,17	21,48	80,08	21,83	79,98	22,18	79,88	22,53	83
84	81,50	20,32	81,42	20,68	81,32	21,03	81,23	21,39	81,14	21,74	81,04	22,09	80,94	22,45	80,85	22,80	84
85	82,48	20,56	82,38	20,92	82,29	21,28	82,20	21,64	82,10	22,00	82,01	22,36	81,91	22,71	81,81	23,07	85
86	83,45	20,81	83,35	21,17	83,26	21,53	83,17	21,90	83,07	22,26	82,97	22,62	82,87	22,98	82,77	23,34	86
87	84,42	21,05	84,32	21,41	84,23	21,78	84,13	22,15	84,04	22,52	83,94	22,88	83,83	23,25	83,73	23,61	87
88	85,39	21,29	85,29	21,66	85,20	22,03	85,10	22,40	85,00	22,78	84,90	23,15	84,80	23,52	84,70	23,89	88
89	86,36	21,53	86,26	21,91	86,17	22,28	86,07	22,66	85,97	23,03	85,87	23,41	85,76	23,78	85,66	24,16	89
90	87,33	21,77	87,23	22,15	87,13	22,53	87,03	22,91	86,93	23,29	86,83	23,67	86,73	24,05	86,62	24,43	90
91	88,30	22,01	88,20	22,40	88,10	22,78	88,00	23,17	87,90	23,55	87,80	23,94	87,69	24,32	87,58	24,70	91
92	89,27	22,26	89,17	22,65	89,07	23,03	88,97	23,42	88,87	23,81	88,76	24,20	88,65	24,59	88,55	24,97	92
93	90,24	22,50	90,14	22,89	90,04	23,28	89,94	23,68	89,83	24,07	89,72	24,46	89,62	24,85	89,51	25,24	93
94	91,21	22,74	91,11	23,14	91,01	23,54	90,90	23,93	90,80	24,33	90,69	24,73	90,58	25,12	90,47	25,52	94
95	92,18	22,98	92,08	23,38	91,97	23,79	91,87	24,19	91,76	24,59	91,65	24,99	91,54	25,39	91,43	25,79	95
96	93,15	23,22	93,05	23,63	92,94	24,04	92,84	24,44	92,73	24,85	92,62	25,25	92,51	25,65	92,40	26,06	96
97	94,12	23,47	94,02	23,88	93,91	24,29	93,80	24,70	93,70	25,11	93,58	25,51	93,47	25,92	93,36	26,33	97
98	95,09	23,71	94,98	24,12	94,88	24,54	94,77	24,95	94,66	25,36	94,55	25,78	94,44	26,19	94,32	26,60	98
99	96,06	23,95	95,95	24,37	95,85	24,79	95,74	25,20	95,63	25,62	95,51	26,04	95,40	26,46	95,28	26,87	99
100	97,03	24,19	96,92	24,61	96,81	25,04	96,70	25,46	96,59	25,88	96,48	26,30	96,36	26,72	96,25	27,14	100
101	98,00	24,48	97,89	24,86	97,78	25,29	97,67	25,71	97,56	26,14	97,44	26,57	97,33	26,99	97,21	27,42	101
102	98,97	24,68	98,86	25,11	98,75	25,54	98,64	25,97	98,52	26,40	98,41	26,83	98,29	27,26	98,17	27,69	102
103	99,94	24,92	99,83	25,35	99,71	25,79	99,61	26,22	99,49	26,66	99,37	27,09	99,25	27,53	99,13	27,96	103
104	100,9	25,16	100,8	25,60	100,7	26,04	100,6	26,48	100,5	26,92	100,3	27,35	100,2	27,79	100,1	28,23	104
105	101,9	25,40	101,8	25,86	101,7	26,29	101,5	26,73	101,4	27,18	101,3	27,62	101,2	28,06	101,1	28,50	105
106	102,9	25,64	102,7	26,09	102,6	26,54	102,5	26,99	102,4	27,43	102,3	27,88	102,1	28,33	102,0	28,77	106
107	103,8	25,88	103,7	26,34	103,6	26,79	103,5	27,24	103,4	27,69	103,2	28,14	103,1	28,59	103,0	29,04	107
108	104,8	26,13	104,7	26,58	104,6	27,04	104,4	27,50	104,3	27,95	104,2	28,41	104,1	28,86	103,9	29,32	108
109	105,8	26,37	105,6	26,83	105,6	27,29	105,4	27,75	105,3	28,21	105,2	28,67	105,0	29,13	104,9	29,59	109
110	106,7	26,61	106,6	27,08	106,5	27,54	106,4	28,01	106,3	28,47	106,1	28,93	106,0	29,40	105,9	29,86	110
111	107,7	26,85	107,6	27,32	107,5	27,79	107,3	28,26	107,2	28,73	107,1	29,20	107,0	29,66	106,8	30,13	111
112	108,7	27,09	108,6	27,57	108,4	28,04	108,3	28,51	108,2	28,99	108,1	29,46	107,9	29,93	107,8	30,40	112
113	109,6	27,34	109,5	27,81	109,4	28,29	109,3	28,77	109,2	29,25	109,0	29,72	108,9	30,20	108,8	30,67	113
114	110,6	27,58	110,5	28,00	110,4	28,54	110,2	29,02	110,1	29,50	110,0	29,98	109,9	30,46	109,7	30,94	114
115	111,6	27,82	111,5	28,31	111,3	28,79	111,2	29,28	111,1	29,76	111,0	30,25	110,8	30,73	110,7	31,21	115
116	112,6	28,06	112,4	28,55	112,3	29,04	112,2	29,53	112,0	30,02	111,9	30,51	111,8	31,00	111,6	31,49	116
117	113,5	28,30	113,4	28,80	113,3	29,29	113,1	29,79	113,0	30,28	112,9	30,77	112,7	31,27	112,6	31,76	117
118	114,5	28,55	114,4	29,05	114,2	29,54	114,1	30,04	114,0	30,54	113,8	31,04	113,7	31,53	113,6	32,03	118
119	115,5	28,79	115,3	29,29	115,2	29,79	115,1	30,38	114,9	30,80	114,8	31,30	114,7	31,80	114,5	32,30	119
120	116,4	29,03	116,3	29,53	116,2	30,05	116,0	30,55	115,9	31,06	115,8	31,56	115,6	32,07	115,5	32,57	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min		15 Min.		
	76 Deg.		75 Degrees						3,7	74 Degrees						3,5	

Distance	16 Degrees							,29	17 Degrees							,31	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,96	0,28	0,96	0,28	0,96	0,28	0,96	0,29	0,96	0,29	0,96	0,30	0,95	0,30	0,95	0,31	1
2	1,92	0,55	1,92	0,56	1,92	0,57	1,92	0,58	1,91	0,59	1,91	0,59	1,91	0,60	1,91	0,61	2
3	2,88	0,83	2,88	0,84	2,88	0,85	2,87	0,87	2,87	0,88	2,87	0,89	2,86	0,90	2,86	0,92	3
4	3,84	1,10	3,84	1,12	3,84	1,14	3,83	1,15	3,82	1,17	3,82	1,19	3,82	1,20	3,81	1,22	4
5	4,80	1,38	4,80	1,40	4,79	1,42	4,79	1,44	4,78	1,46	4,78	1,48	4,77	1,50	4,76	1,52	5
6	5,77	1,65	5,76	1,68	5,75	1,70	5,75	1,73	5,74	1,75	5,73	1,78	5,72	1,80	5,71	1,83	6
7	6,73	1,93	6,72	1,96	6,71	1,99	6,70	2,02	6,69	2,05	6,69	2,08	6,68	2,11	6,67	2,13	7
8	7,69	2,21	7,68	2,24	7,67	2,27	7,66	2,31	7,65	2,34	7,64	2,37	7,63	2,41	7,62	2,44	8
9	8,65	2,48	8,64	2,52	8,63	2,56	8,62	2,59	8,61	2,63	8,60	2,67	8,58	2,71	8,57	2,74	9
10	9,61	2,76	9,60	2,80	9,59	2,84	9,58	2,86	9,56	2,92	9,55	2,97	9,54	3,01	9,52	3,05	10
11	10,57	3,03	10,56	3,08	10,55	3,12	10,53	3,17	10,52	3,22	10,51	3,26	10,49	3,31	10,48	3,35	11
12	11,54	3,31	11,52	3,36	11,51	3,41	11,49	3,46	11,48	3,51	11,46	3,56	11,45	3,61	11,43	3,66	12
13	12,50	3,58	12,48	3,64	12,46	3,69	12,45	3,75	12,43	3,81	12,42	3,86	12,40	3,91	12,38	3,96	13
14	13,46	3,86	13,44	3,92	13,42	3,98	13,41	4,04	13,39	4,09	13,37	4,15	13,35	4,21	13,33	4,27	14
15	14,42	4,13	14,40	4,20	14,38	4,26	14,36	4,33	14,35	4,39	14,33	4,45	14,31	4,51	14,29	4,57	15
16	15,38	4,41	15,36	4,48	15,34	4,54	15,32	4,61	15,30	4,68	15,28	4,74	15,26	4,81	15,24	4,88	16
17	16,34	4,69	16,32	4,76	16,30	4,83	16,28	4,90	16,26	4,97	16,24	5,04	16,21	5,11	16,19	5,18	17
18	17,30	4,96	17,28	5,04	17,26	5,11	17,23	5,19	17,21	5,26	17,19	5,34	17,17	5,41	17,14	5,49	18
19	18,26	5,24	18,24	5,32	18,22	5,40	18,19	5,48	18,17	5,56	18,15	5,63	18,12	5,71	18,10	5,79	19
20	19,23	5,51	19,20	5,60	19,18	5,68	19,15	5,76	19,13	5,85	19,10	5,93	19,07	6,01	19,05	6,10	20
21	20,19	5,79	20,16	5,88	20,14	5,96	20,11	6,05	20,08	6,14	20,06	6,23	20,03	6,31	20,00	6,40	21
22	21,15	6,06	21,12	6,16	21,09	6,25	21,07	6,34	21,04	6,43	21,01	6,52	20,98	6,62	20,95	6,71	22
23	22,11	6,34	22,08	6,44	22,05	6,53	22,02	6,63	22,00	6,72	21,97	6,82	21,94	6,92	21,91	7,01	23
24	23,07	6,62	23,04	6,72	23,01	6,82	22,98	6,92	22,95	7,02	22,92	7,12	22,89	7,22	22,86	7,32	24
25	24,03	6,89	24,00	7,00	23,97	7,10	23,94	7,21	23,91	7,31	23,88	7,41	23,84	7,52	23,81	7,62	25
26	24,99	7,17	24,96	7,28	24,93	7,38	24,90	7,49	24,86	7,60	24,83	7,71	24,80	7,82	24,76	7,93	26
27	25,95	7,44	25,92	7,56	25,89	7,67	25,85	7,78	25,82	7,89	25,79	8,01	25,75	8,12	25,72	8,23	27
28	26,91	7,72	26,88	7,84	26,85	7,95	26,81	8,07	26,78	8,19	26,74	8,30	26,70	8,42	26,67	8,54	28
29	27,88	7,99	27,84	8,12	27,81	8,24	27,77	8,36	27,73	8,48	27,70	8,60	27,66	8,72	27,62	8,84	29
30	28,84	8,27	28,80	8,40	28,77	8,52	28,73	8,65	28,69	8,77	28,65	8,90	28,61	9,02	28,57	9,15	30
31	29,80	8,55	29,76	8,68	29,72	8,81	29,68	8,93	29,65	9,06	29,61	9,19	29,57	9,32	29,52	9,45	31
32	30,76	8,82	30,72	8,96	30,69	9,09	30,64	9,22	30,60	9,36	30,56	9,49	30,52	9,62	30,48	9,76	32
33	31,72	9,10	31,68	9,23	31,64	9,37	31,60	9,51	31,56	9,65	31,52	9,79	31,47	9,92	31,43	10,06	33
34	32,68	9,37	32,64	9,51	32,60	9,66	32,56	9,80	32,51	9,94	32,47	10,08	32,42	10,22	32,38	10,37	34
35	33,64	9,65	33,60	9,79	33,56	9,94	33,51	10,09	33,47	10,23	33,43	10,38	33,38	10,53	33,33	10,67	35
36	34,61	9,92	34,56	10,07	34,52	10,23	34,47	10,38	34,43	10,53	34,38	10,68	34,33	10,83	34,29	10,97	36
37	35,57	10,20	35,52	10,35	35,48	10,51	35,43	10,66	35,38	10,82	35,34	10,97	35,29	11,13	35,24	11,28	37
38	36,53	10,47	36,48	10,63	36,44	10,79	36,39	10,95	36,34	11,11	36,29	11,27	36,24	11,43	36,19	11,58	38
39	37,49	10,75	37,44	10,91	37,39	11,08	37,35	11,24	37,30	11,40	37,25	11,56	37,20	11,73	37,14	11,89	39
40	38,45	11,03	38,40	11,19	38,35	11,36	38,30	11,53	38,25	11,70	38,20	11,86	38,15	12,03	38,10	12,19	40
41	39,41	11,30	39,36	11,47	39,31	11,65	39,26	11,82	39,21	11,99	39,16	12,16	39,10	12,33	39,05	12,50	41
42	40,37	11,58	40,32	11,75	40,27	11,93	40,22	12,10	40,17	12,28	40,11	12,46	40,06	12,63	40,00	12,80	42
43	41,33	11,85	41,28	12,03	41,23	12,21	41,18	12,40	41,12	12,57	41,07	12,75	41,01	12,93	40,95	13,11	43
44	42,30	12,13	42,24	12,31	42,19	12,50	42,13	12,68	42,08	12,86	42,02	13,05	41,96	13,23	41,91	13,41	44
45	43,26	12,40	43,20	12,59	43,15	12,78	43,09	12,97	43,03	13,15	42,98	13,34	42,92	13,53	42,86	13,72	45
46	44,22	12,68	44,16	12,87	44,11	13,07	44,05	13,26	43,99	13,45	43,93	13,64	43,87	13,83	43,81	14,02	46
47	45,18	12,96	45,12	13,15	45,07	13,35	45,01	13,55	44,95	13,74	44,89	13,94	44,83	14,13	44,76	14,33	47
48	46,14	13,23	46,08	13,43	46,02	13,63	45,96	13,83	45,90	14,03	45,84	14,23	45,78	14,43	45 72	14,63	48
49	47,10	13,51	47,04	13,71	46,98	13,92	46,92	14,12	46,86	14,33	46,80	14,53	46,73	14,74	4 67	14,94	49
50	48,06	13,78	48,00	13,99	47,94	14,20	47,88	14,41	47,82	14,62	47,75	14,83	47,69	15,04	47,62	15,24	50
51	49,02	14,06	48,96	14,27	48,90	14,49	48,84	14,70	48,77	14,91	48,71	15,12	48,64	15,34	48,57	15,55	51
52	49,99	14,33	49,92	14,55	49,86	14,78	49,79	14,98	49,73	15,20	49,66	15,42	49,59	15,64	49,53	15,85	52
53	50,95	14,61	50,88	14,83	50,82	15,05	50,75	15,28	50,68	15,50	50,62	15,72	50,55	15,94	50,48	16,16	53
54	51,91	14,89	51,84	15,11	51,78	15,34	51,71	15,56	51,64	15,79	51,57	16,01	51,50	16,24	51,43	16,46	54
55	52,87	15,16	52,80	15,39	52,74	15,62	52,67	15,85	52,60	16,08	52,53	16,31	52,46	16,54	52,38	16,77	55
56	53,83	15,44	53,76	15,67	53,69	15,91	53,62	16,14	53,55	16,37	53,48	16,61	53,41	16,84	53,34	17,07	56
57	54,79	15,71	54,72	15,95	54,65	16,19	54,58	16,43	54,51	16,67	54,44	16,90	54,36	17,14	54,29	17,38	57
58	55,75	15,99	55,68	16,23	55,61	16,47	55,54	16,72	55,47	16,96	55,39	17,20	55,32	17,44	55,24	17,68	58
59	56,71	16,26	56,64	16,51	56,57	16,76	56,50	17,00	56,42	17,25	56,35	17,50	56,27	17,74	56,19	17,99	59
60	57,68	16,54	57,60	16,79	57,53	17,04	57,45	17,29	57,38	17,54	57,30	17,79	57,22	18,04	57,14	18,39	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min		45 Min.		30 Min.		15 Min.		
	74 Deg.		73 Degrees					3,3	72 Degrees							3,1	

Distance	16 Degrees							,29	17 Degrees							,31	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	58,64	16,81	58,56	17,07	58,49	17,33	58,41	17,58	58,33	17,83	58,26	18,09	58,18	18,34	58,10	18,60	61
62	59,60	17,09	59,52	17,35	59,45	17,61	59,37	17,87	59,29	18,13	59,21	18,39	59,13	18,64	59,05	18,90	62
63	60,56	17,36	60,48	17,63	60,41	17,89	60,33	18,16	60,25	18,42	60,17	18,68	60,08	18,95	60,00	19,21	63
64	61,52	17,64	61,44	17,91	61,36	18,18	61,28	18,45	61,20	18,71	61,12	18,98	61,04	19,25	60,95	19,51	64
65	62,48	17,92	62,40	18,19	62,32	18,46	62,24	18,73	62,16	19,00	62,08	19,27	61,99	19,55	61,91	19,82	65
66	63,44	18,19	63,36	18,47	63,28	18,75	63,20	19,02	63,12	19,30	63,03	19,57	62,95	19,85	62,86	20,12	66
67	64,40	18,47	64,32	18,75	64,24	19,03	64,16	19,31	64,07	19,59	63,99	19,87	63,90	20,15	63,81	20,43	67
68	65,37	18,74	65,28	19,03	65,20	19,31	65,11	19,60	65,03	19,88	64,94	20,16	64,85	20,45	64,76	20,73	68
69	66,33	19,02	66,24	19,31	66,16	19,60	66,07	19,89	65,99	20,17	65,90	20,46	65,81	20,75	65,72	21,04	69
70	67,29	19,30	67,20	19,59	67,12	19,88	67,03	20,17	66,94	20,47	66,85	20,76	66,76	21,05	66,67	21,34	70
71	68,25	19,57	68,16	19,87	68,08	20,17	67,99	20,46	67,90	20,76	67,81	21,05	67,71	21,35	67,62	21,65	71
72	69,21	19,85	69,12	20,15	69,04	20,45	68,95	20,75	68,85	21,05	68,76	21,35	68,67	21,65	68,57	21,95	72
73	70,17	20,12	70,08	20,43	69,99	20,73	69,90	21,04	69,81	21,34	69,72	21,65	69,62	21,95	69,53	22,26	73
74	71,13	20,40	71,04	20,71	70,95	21,02	70,86	21,33	70,77	21,64	70,67	21,94	70,58	22,25	70,48	22,56	74
75	72,09	20,67	72,00	20,99	71,91	21,30	71,82	21,62	71,72	21,93	71,63	22,24	71,53	22,55	71,43	22,86	75
76	73,06	20,95	72,96	21,27	72,87	21,59	72,78	21,90	72,68	22,22	72,58	22,54	72,48	22,85	72,38	23,17	76
77	74,02	21,22	73,92	21,55	73,83	21,87	73,73	22,19	73,64	22,51	73,54	22,83	73,44	23,16	73,34	23,48	77
78	74,98	21,50	74,88	21,83	74,79	22,15	74,69	22,48	74,59	22,81	74,49	23,13	74,39	23,46	74,29	23,78	78
79	75,94	21,78	75,84	22,11	75,75	22,44	75,65	22,77	75,55	23,10	75,45	23,43	75,34	23,76	75,24	24,08	79
80	76,90	22,05	76,80	22,39	76,71	22,72	76,61	23,06	76,50	23,39	76 40	23,72	76,30	24,06	76,19	24,39	80
81	77,86	22,33	77,76	22,67	77,67	23,01	77,56	23,34	77,46	23,68	77,36	24,02	77,25	24,36	77,14	24,69	81
82	78,82	22,60	78,72	22,95	78,62	23,29	78,52	23,62	78,42	23,98	78,31	24,32	78,21	24,66	78,10	25,00	82
83	79,78	22,88	79,68	23,23	79,58	23,57	79,48	23,92	79,37	24,27	79,27	24,61	79,16	24,96	79,05	25,30	83
84	80,75	23,15	80,64	23,51	80,54	23,86	80,44	24,21	80,33	24,56	80,22	24,91	80,11	25,26	80,00	25,61	84
85	81,71	23,43	81,60	23,79	81,50	24,14	81,40	24,50	81,29	24,85	81,18	25,21	81,07	25,56	80,95	25,91	85
86	82,67	23,71	82,56	24,07	82,46	24,43	82,35	24,79	82,24	25,14	82,13	25,50	82,02	25,86	81,91	26,22	86
87	83,63	23,98	83,52	24,35	83,42	24,71	83,31	25,07	83,20	25,44	83,09	25,80	82,97	26,16	82,86	26,52	87
88	84,59	24,26	84,48	24,63	84,38	24,99	84,27	25,36	84,15	25,73	84,04	26,10	83,93	26,46	83,81	26,83	88
89	85,55	24,53	85,45	24,91	85,34	25,28	85,22	25,65	85,11	26,02	85,00	26,39	84,88	26,76	84,76	27,13	89
90	86,51	24,81	86,41	25,19	86,29	25,56	86,18	25,94	86,07	26,31	85,95	26,69	85,84	27,06	85,72	27,44	90
91	87,47	25,08	87,37	25,47	87,25	25,85	87,14	26,23	87,02	26,61	86,91	26,99	86,79	27,36	86,67	27,74	91
92	88,44	25,36	88,33	25,75	88,21	26,13	88,10	26,51	87,98	26,90	87,86	27,28	87,74	27,67	87,62	28,05	92
93	89,40	25,64	89,29	26,03	89,17	26,41	89,05	26,80	88,94	27,19	88.82	27,58	88,70	27,97	88,57	28,35	93
94	90,36	25,91	90,25	26,30	90,13	26,70	90,01	27,09	89,89	27,48	89,77	27,88	89,65	28,27	89,53	28,66	94
95	91,32	26,19	91,21	26,58	91,09	26,98	90,97	27,38	90,85	27,78	90,73	28,17	90,60	28,57	90,48	28,96	95
96	92,28	26,46	92,17	26,86	92,05	27,27	91,93	27,67	91,81	28,07	91,68	28,47	91,56	28,87	91,43	29,27	96
97	93,24	26,74	93,13	27,14	93,01	27,55	92,88	27,96	92,76	28,36	92,64	28,76	92,51	29,17	92,38	29,57	97
98	94,20	27,01	94,09	27,42	93,97	27,83	93,84	28,24	93,72	28,65	93,59	29,06	93,47	29,47	93,34	29,88	98
99	95,16	27,29	95,05	27,70	94,92	28,12	94,80	28,53	94,67	28,94	94,55	29,36	94,42	29,77	94,29	30,18	99
100	96,13	27,56	96,01	27,98	95,88	28,40	95,76	28,82	95,63	29,24	95,50	29,65	95,37	30,07	95,24	30,49	100
101	97,09	27,84	96,97	28,26	96,84	28,69	96,72	29,10	96,59	29,53	96,46	29,95	96,33	30,37	96,19	30,79	101
102	98,05	28,12	97,93	28,54	97,80	28,97	97,67	29,40	97,54	29,82	97,41	30,25	97,28	30,67	97,15	31,10	102
103	99,01	28,39	98,89	28,82	98,76	29,25	98,63	29,69	98,50	30,11	98,37	30,54	98,23	30,97	98,10	31,40	103
104	99,97	28,67	99,85	29,10	99,72	29,54	99,59	29,97	99,46	30,41	99,32	30,84	99,19	31,27	99,05	31,71	104
105	100,9	28,94	100,8	29,38	100,7	29,82	100,5	30,26	100,4	30,70	100,3	31,14	100,1	31,58	100,0	32,01	105
106	101,9	29,22	101,8	29,66	101,6	30,11	101,5	30,55	101,4	30,99	101,2	31,43	101,1	31,88	100,9	32,32	106
107	102,9	29,49	102,7	29,94	102,6	30,39	102,5	30,84	102,3	31,28	102,2	31,73	102,0	32,18	101,9	32,62	107
108	103,8	29,77	103,7	30,22	103,6	30,67	103,4	31,13	103,3	31,58	103,1	32,03	103,0	32,48	102,9	32,93	108
109	104,8	30,05	104,6	30,51	104,5	30,96	104,4	31,41	104,2	31,87	104,1	32,32	104,0	32,78	103,8	33,23	109
110	105,7	30,32	105,6	30,78	105,5	31,24	105,3	31,70	105,2	32,16	105,1	32,62	104,9	33,08	104,8	33,54	110
111	106,7	30,60	106,6	31,06	106,4	31,53	106,3	31,99	106,1	32,45	106,0	32,92	105,9	33,38	105,7	33,84	111
112	107,7	30,87	107,5	31,34	107,4	31,81	107,2	32,28	107,1	32,75	107,0	33,21	106,8	33,68	106,7	34,14	112
113	108,6	31,15	108,5	31,62	108,3	32,09	108,2	32,57	108,1	33,04	107,9	33,51	107,8	33,98	107,6	34,45	113
114	109,6	31,43	109,4	31,90	109,3	32,38	109,2	32,86	109,0	33,33	108,9	33,81	108,7	34,28	108,6	34,75	114
115	110,5	31,70	110,4	32,18	110,3	32,66	110,1	33,14	110,0	33,62	109,8	34,10	109,7	34,58	109,5	35,06	115
116	111,5	31,97	111,4	32,46	111,2	32,95	111,1	33,43	110,9	33,92	110,8	34,40	110,6	34,88	110,5	35,36	116
117	112,5	32,25	112,3	32,74	112,2	33,23	112,0	33,72	111,9	34,21	111,7	34,69	111,6	35,18	111,4	35,67	117
118	113,4	32,53	113,3	33,02	113,1	33,51	113,0	34,01	112,8	34,50	112,7	34,99	112,5	35,48	112,4	35,97	118
119	114,4	32,80	114,2	33,30	114,1	33,80	114,0	34,30	113,8	34,79	113,6	35,29	113,5	35,79	113,3	36,28	119
120	115,4	33,08	115,2	33,58	115,1	34,08	114,9	34,58	114,8	35,08	114,6	35,59	114,4	36,09	114,3	36,58	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	74 Deg.		73 Degrees						3,3	72 Degrees						3,1	

Digitized by Google

Distance	18 Degrees							,32	19 Degrees							,34	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,95	0,31	0 95	0,31	0,95	0,32	0,95	0,32	0,95	0,33	0,94	0,33	0,94	0,33	0,94	0,34	1
2	1,90	0,62	1 90	0,63	1,90	0,63	1,89	0,64	1,89	0,65	1,89	0,66	1,88	0,67	1,88	0,68	2
3	2,85	0,93	2,85	0,94	2,84	0,95	2,84	0,96	2,84	0,98	2,83	0,99	2,83	1,00	2,82	1,01	3
4	3,80	1,24	3,80	1,25	3,79	1,27	3,79	1,29	3,78	1,30	3,78	1,32	3,77	1,33	3,76	1,35	4
5	4,75	1,54	4,75	1,57	4,74	1,59	4,73	1,61	4,73	1,63	4,72	1,65	4,71	1,67	4,71	1,69	5
6	5,71	1,85	5,70	1,88	5,69	1,90	5,68	1,93	5,67	1,95	5,66	1,98	5,66	2,00	5,65	2,03	6
7	6,66	2,16	6,65	2,19	6,64	2,22	6,63	2,25	6,62	2,28	6,61	2,31	6,60	2,34	6,59	2,36	7
8	7,61	2,47	7,60	2,50	7,59	2,54	7,57	2,57	7,56	2,60	7,55	2,64	7,54	2,67	7,53	2,70	8
9	8,56	2,78	8,55	2,82	8,53	2,86	8,52	2,89	8,51	2,93	8,50	2,97	8,48	3,00	8,47	3,04	9
10	9,51	3,09	9,50	3,13	9,48	3 17	9,47	3,21	9,46	3,26	9,44	3,30	9,43	3,34	9,41	3,38	10
11	10,46	3,40	10,45	3,44	10,43	3,49	10,42	3,54	10,40	3,58	10,38	3,63	10,37	3,67	10,35	3,72	11
12	11,41	3,71	11,40	3,76	11,38	3,81	11,36	3,86	11,35	3,91	11,33	3,96	11,31	4,01	11,29	4,06	12
13	12,36	4,02	12,35	4,07	12,33	4,12	12,31	4,18	12,29	4,23	12,27	4,29	12,25	4,34	12,24	4,39	13
14	13,31	4,33	13,30	4,38	13,28	4,44	13,26	4 50	13,24	4,56	13,22	4,62	13,20	4,67	13,18	4,73	14
15	14,27	4,63	14,24	4,70	14,22	4,76	14,20	4,82	14,18	4,88	14,16	4,95	14,14	5,01	14,12	5,07	15
16	15,22	4,94	15,19	5,01	15,17	5,08	15,15	5,14	15,13	5,21	15,11	5,27	15,08	5,34	15,06	5,41	16
17	16,17	5,25	16,14	5,32	16,12	5,39	16,10	5,46	16,07	5,53	16,05	5,60	16,02	5,67	16,00	5,74	17
18	17,12	5,56	17,09	5,64	17,07	5,71	17,04	5,79	17,02	5,86	16,99	5,93	16,97	6,01	16,94	6,08	18
19	18,07	5,87	18,04	5,95	18,02	6,03	17,99	6,11	17,97	6,19	17,94	6,26	17,91	6,34	17,88	6,42	19
20	19,02	6,18	18,99	6,26	18,97	6,35	18,94	6,43	18,91	6,51	18,88	6,59	18,85	6,68	18,82	6,76	20
21	19,97	6,49	19,94	6,58	19,91	6,66	19,89	6,75	19,86	6,84	19,83	6,92	19,80	7,01	19,76	7,10	21
22	20,92	6,80	20,89	6,89	20,86	6,98	20,83	7,07	20,80	7,16	20,77	7,25	20,74	7,34	20,71	7,43	22
23	21,87	7,11	21,84	7,20	21,81	7,30	21,78	7,39	21,75	7,49	21,71	7,58	21,68	7,68	21,65	7,77	23
24	22,82	7.42	22,79	7,52	22,76	7,61	22,73	7,71	22,69	7,81	22,66	7,91	22,62	8,01	22,59	8,11	24
25	23,78	7,72	23,74	7,83	23,71	7,93	23,67	8,04	23,64	8,14	23,60	8,24	23,57	8,34	23,53	8,45	25
26	24,73	8,03	24,69	8,14	24,66	8,25	24,62	8,36	24,58	8,46	24,55	8,57	24,51	8,68	24,47	8,79	26
27	25,68	8,34	25,64	8,45	25,60	8.57	25,57	8,68	25,53	8,79	25,49	8,90	25,45	9,01	25,41	9,12	27
28	26,63	8,65	26,59	8,77	26,55	8,88	26,51	9,00	26,47	9,12	26,43	9,23	26,39	9,35	26,35	9,46	28
29	27,58	8,96	27,54	9,08	27,50	9,20	27,46	9,32	27,42	9,44	27,38	9,56	27,34	9,68	27,29	9,80	29
30	28 53	9,27	28,49	9,39	28,45	9,52	28,41	9,64	28,37	9,77	28,32	9,89	28,28	10,01	28,23	10,14	30
31	29,48	9,58	29,44	9,71	29,40	9,84	29,35	9,96	29,31	10,09	29,27	10,22	29,22	10,35	29,18	10,48	31
32	30,43	9,89	30,39	10 02	30,35	10,15	30,30	10,29	30,26	10,42	30,21	10,55	30,16	10,68	30,12	10,81	32
33	31,38	10,20	31,34	10,33	31,29	10,47	31,25	10,61	31,20	10,74	31,15	10,88	31,11	11,01	31,06	11,15	33
34	32,34	10,51	32,30	10,65	32,24	10,79	32,19	10,93	32,15	11,07	32,10	11,21	32,05	11,35	32,00	11,49	34
35	33,29	10,82	33,25	10,96	33,19	11,11	33,14	11,25	33,09	11,39	33,04	11,54	32,99	11,68	32,94	11,83	35
36	34,24	11,12	34,20	11,27	34,14	11,42	34,09	11,57	34,04	11,72	33,99	11,87	33,93	12,02	33,88	12,17	36
37	35,19	11,43	35,15	11 59	35,09	11,74	35,04	11,89	34,98	12,05	34,93	12,20	34,88	12,35	34,82	12,50	37
38	36,14	11,74	36,10	11,90	36,04	12,06	35,98	12,21	35,93	12,37	35,88	12,53	35,82	12,68	35,76	12,84	38
39	37,09	12,05	37,05	12,21	36,98	12,37	36,93	12,54	36,88	12,70	36,82	12,86	36,76	13,02	36,71	13,18	39
40	38,04	12,36	37,99	12,53	37,93	12,69	37,88	12,86	37,82	13,02	37,76	13,19	37,71	13,35	37,65	13,52	40
41	38,99	12,67	38,94	12,84	38,88	13,01	38,81	13,18	38,77	13,34	38,71	13,52	38,65	13,69	38,59	13,8	41
42	39,94	12,98	39,89	13,15	39,83	13,33	39,77	13,50	39,71	13,67	39,65	13,85	39,59	14,02	39,53	14,19	42
43	40,89	13,29	40,84	13,46	40,78	13,64	40,72	13,82	40,66	14,00	40,60	14,18	40,53	14,35	40,47	14,53	43
44	41,85	13,60	41,79	13,78	41,73	13,96	41,66	14,14	41,60	14,32	41,54	14,51	41,48	14,69	41,41	14,87	44
45	42,80	13,91	42,74	14,09	42,67	14,28	42,61	14,47	42,55	14,65	42,48	14,84	42,42	15,02	42,35	15,21	45
46	43,75	14,21	43,69	14,40	43,62	14,60	43,56	14,79	43,49	14,98	43,43	15,17	43,36	15,35	43,29	15,54	46
47	44,70	14,52	44,63	14,72	44,57	14,91	44,51	15,11	44,44	15,30	44,37	15,50	44,30	15,69	44,23	15,88	47
48	45,65	14,83	45,58	15,03	45,52	15,23	45,45	15,43	45,39	15,63	45,32	15,82	45;25	16,02	45,18	16,22	48
49	46,60	15,14	46,53	15,34	46,47	15,55	46,40	15,75	46,33	15,95	46,26	16,15	46,19	16,36	46,12	16,56	49
50	47,55	15,45	47,48	15,66	47,42	15,86	47,35	16,07	47,28	16,28	47,21	16,48	47,13	16,69	47,06	16,90	50
51	48,50	15,76	48,43	15,97	48,36	16,18	48,29	16,39	48,22	16,60	48,15	16,81	48,07	17,02	48,00	17,23	51
52	49,45	16,07	49,38	16,28	49,31	16,50	49,24	16,71	49,17	16,93	49,09	17,14	49,02	17,36	48,94	17,57	52
53	50,41	16,38	50,33	16,60	50,26	16,82	50,19	17,04	50,11	17,25	50,04	17,47	49,96	17,69	49,88	17,91	53
54	51,36	16,69	51,28	16,91	51,21	17,13	51,13	17,36	51,06	17,58	50,98	17,80	50,90	18,03	50,82	18,25	54
55	52,31	17,00	52,23	17,22	52,16	17,45	52,08	17,68	52,00	17,91	51,92	18,13	51,84	18,36	51,76	18,59	55
56	53,26	17,30	53,18	17,54	53,11	17,77	53,03	18,00	52,95	18,23	52,87	18,46	52,79	18,69	52,71	18,92	56
57	54,21	17,61	54,13	17,85	54,05	18,08	53,98	18,32	53,89	18,56	53,81	18,79	53,73	19,03	53,65	19,26	57
58	55,16	17,92	55,08	18,16	55,00	18,40	54,92	18,64	54,84	18,88	54,76	19,12	54,67	19,36	54,59	19,60	58
59	56,11	18,23	56,03	18,48	55,95	18,72	55,87	18,96	55,79	19,21	55,70	19,45	55,62	19,69	55,53	19,94	59
60	57,06	18,54	56,98	18,79	56,90	19,04	56,82	19,29	56,73	19,53	56,64	19,78	56,56	20,03	56,47	20,27	60
Distanc	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	72 Deg.		71 Degrees					2,9	70 Degrees							2,7	

Distance	18 Degrees							,32	19 Degrees							,34	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	58,01	18,85	57,94	19,10	57,85	19,35	57,76	19,61	57,68	19,86	57,59	20,11	57,50	20,36	57,41	20,61	61
62	58,97	19,16	58,89	19,42	58,80	19,67	58,71	19,93	58,62	20,18	58,53	20,44	58,44	20,70	58,35	20,95	62
63	59,92	19,47	59,84	19,73	59,74	19,99	59,66	20,25	59,57	20,51	59,48	20,77	59,39	21,03	59,29	21,29	63
64	60,87	19,78	60,79	20,04	60,69	20,31	60,60	20,57	60,51	20,84	60,42	21,10	60,33	21,36	60,24	21,63	64
65	61,82	20,09	61,74	20,36	61,64	20,62	61,55	20,89	61,46	21,16	61,36	21,43	61,27	21,70	61,18	21,96	65
66	62,77	20,39	62,69	20,67	62,59	20,94	62,50	21,21	62,40	21,49	62,31	21,76	62,21	22,03	62,12	22,30	66
67	63,72	20,70	63,64	20,98	63,54	21,26	63,44	21,54	63,35	21,81	63,25	22,09	63,16	22,37	63,06	22,64	67
68	64,67	21,01	64,59	21,29	64,49	21,58	64,39	21,86	64,29	22,14	64,20	22,42	64,10	22,70	64,00	22,98	68
69	65,62	21,32	65,54	21,61	65,43	21,89	65,34	22,18	65,24	22,46	65,14	22,75	65,04	23,03	64,94	23,32	69
70	66,57	21,63	66,48	21,92	66,38	22,21	66,28	22,50	66,19	22,79	66,07	23,08	65,98	23,37	65,88	23,65	70
71	67,52	21,94	67,43	22,23	67,33	22,53	67,23	22,82	67,13	23,11	67,03	23,41	66,93	23,70	66,82	23,99	71
72	68,48	22,25	68,38	22,55	68,28	22,85	68,18	23,14	68,07	23,44	67,97	23,74	67,87	24,03	67,76	24,33	72
73	69,43	22,56	69,33	22,86	69,23	23,16	69,13	23,47	69,02	23,76	68,92	24,07	68,81	24,37	68,71	24,67	73
74	70,38	22,87	70,28	23,17	70,18	23,48	70,07	23,79	69,97	24,09	69,86	24,40	69,76	24,70	69,65	25,01	74
75	71,33	23,18	71,23	23,49	71,12	23,80	71,02	24,11	70,91	24,42	70,81	24,73	70,70	25,04	70,59	25,34	75
76	72,28	23,48	72,18	23,80	72,07	24,11	71,97	24,43	71,86	24,74	71,75	25,06	71,64	25,37	71,53	25,68	76
77	73,23	23,79	73,13	24,11	73,02	24,43	72,91	24,75	72,80	25,07	72,69	25,39	72,58	25,70	72,47	26,02	77
78	74,18	24,10	74,08	24,43	73,97	24,75	73,86	25,07	73,75	25,39	73,64	25,72	73,53	26,04	73,41	26,36	78
79	75,13	24,41	75,03	24,74	74,92	25,07	74,81	25,39	74,69	25,72	74,58	26,05	74,47	26,37	74,35	26,70	79
80	76,08	24,72	75,98	25,05	75,87	25,38	75,75	25,71	75,64	26,04	75,53	26,37	75,41	26,70	75,29	27,03	80
81	77,04	25,03	76,92	25,37	76,81	25,70	76,70	26,04	76,59	26,37	76,47	26,70	76,35	27,04	76,23	27,37	81
82	77,99	25,34	77,87	25,68	77,76	26,02	77,65	26,36	77,53	26,70	77,41	27,03	77,30	27,37	77,18	27,71	82
83	78,94	25,65	78,82	25,99	78,71	26,34	78,59	26,68	78,48	27,02	78,36	27,36	78,24	27,71	78,12	28,05	83
84	79,89	25,96	79,77	26,31	79,66	26,65	79,54	27,00	79,42	27,35	79,30	27,69	79,18	28,04	79,06	28,39	84
85	80,84	26,27	80,72	26,62	80,61	26,97	80,49	27,32	80,37	27,67	80,25	28,02	80,12	28,37	80,00	28,72	85
86	81,79	26,58	81,67	26,93	81,56	27,29	81,44	27,64	81,31	28,00	81,19	28,35	81,07	28,71	80,94	29,06	86
87	82,74	26,88	82,62	27,24	82,50	27,60	82,38	27,97	82,26	28,32	82,14	28,68	82,01	29,04	81,88	29,40	87
88	83,69	27,19	83,57	27,56	83,45	27,92	83,33	28,29	83,21	28,65	83,08	29,01	82,95	29,37	82,82	29,74	88
89	84,64	27,50	84,52	27,87	84,40	28,24	84,28	28,61	84,15	28,98	84,02	29,34	83,89	29,71	83,76	30,07	89
90	85,59	27,81	85,47	28,18	85,35	28,56	85,22	28,93	85,10	29,30	84,97	29,67	84,84	30,04	84,71	30,41	90
91	86,55	28,12	86,42	28,50	86,30	28,87	86,17	29,25	86,04	29,63	85,91	30,00	85,78	30,38	85,65	30,75	91
92	87,50	28,43	87,37	28,81	87,25	29,19	87,12	29,57	86,99	29,95	86,86	30,33	86,72	30,71	86,59	31,09	92
93	88,45	28,74	88,32	29,12	88,19	29,51	88,06	29,89	87,93	30,28	87,80	30,66	87,67	31,04	87,53	31,43	93
94	89,40	29,05	89,27	29,44	89,14	29,83	89,01	30,22	88,88	30,60	88,74	30,99	88,61	31,38	88,47	31,76	94
95	90,35	29,36	90,22	29,75	90,09	30,14	89,96	30,54	89,82	30,93	89,69	31,32	89,55	31,71	89,41	32,10	95
96	91,30	29,67	91,17	30,06	91,04	30,46	90,91	30,86	90,77	31,25	90,63	31,65	90,49	32,05	90,35	32,44	96
97	92,25	29,97	92,12	30,38	91,99	30,78	91,85	31,18	91,71	31,58	91,58	31,98	91,44	32,38	91,29	32,78	97
98	93,20	30,28	93,07	30,69	92,93	31,09	92,80	31,50	92,66	31,90	92,52	32,31	92,38	32,71	92,24	33,12	98
99	94,15	30,59	94,02	31,00	93,88	31,41	93,75	31,82	93,61	32,23	93,46	32,64	93,32	33,05	93,18	33,45	99
100	95,11	30,90	94,97	31,32	94,83	31,73	94,69	32,14	94,55	32,56	94,41	32,97	94,26	33,38	94,12	33,79	100
101	96,06	31,21	95,92	31,63	95,78	32,05	95,64	32,46	95,50	32,88	95,35	33,30	95,21	33,71	95,06	34,13	101
102	97,01	31,52	96,87	31,94	96,73	32,36	96,59	32,79	96,44	33,21	96,30	33,63	96,15	34,05	96,00	34,46	102
103	97,96	31,83	97,82	32,25	97,68	32,68	97,53	33,11	97,39	33,53	97,24	33,96	97,09	34,38	96,94	34,81	103
104	98,91	32,14	98,78	32,57	98,62	33,00	98,48	33,43	98,33	33,86	98,18	34,29	98,03	34,72	97,88	35,14	104
105	99,86	32,45	99,73	32,88	99,57	33,32	99,43	33,75	99,28	34,18	99,13	34,62	98,98	35,05	98,82	35,48	105
106	100,8	32,76	100,7	33,19	100,5	33,63	100,4	34,07	100,2	34,51	100,1	34,95	99,92	35,38	99,76	35,82	106
107	101,8	33,06	101,6	33,51	101,5	33,95	101,3	34,39	101,2	34,83	101,0	35,28	100,9	35,72	100,7	36,16	107
108	102,7	33,37	102,6	33,83	102,4	34,27	102,3	34,72	102,1	35,16	102,0	35,61	101,8	36,05	101,7	36,49	108
109	103,7	33,68	103,5	34,13	103,4	34,59	103,2	35,04	103,1	35,48	102,9	35,94	102,7	36,38	102,6	36,83	109
110	104,6	33,99	104,5	34,45	104,3	34,90	104,2	35,36	104,0	35,81	103,9	36,27	103,7	36,72	103,6	37,17	110
111	105,6	34,30	105,4	34,76	105,3	35,22	105,1	35,68	105,0	36,14	104,8	36,60	104,6	37,05	104,5	37,51	111
112	106,5	34,61	106,4	35,07	106,2	35,54	106,1	36,00	105,9	36,46	105,7	36,93	105,6	37,39	105,5	37,85	112
113	107,5	34,92	107,3	35,39	107,2	35,85	107,0	36,32	106,8	36,79	106,7	37,26	106,5	37,72	106,4	38,18	113
114	108,4	35,23	108,3	35,70	108,1	36,17	108,0	36,64	107,8	37,11	107,6	37,58	107,5	38,05	107,3	38,52	114
115	109,4	35,54	109,2	36,01	109,1	36,49	108,9	36,97	108,7	37,44	108,6	37,91	108,4	38,39	108,3	38,86	115
116	110,3	35,85	110,2	36,33	110,0	36,81	109,8	37,29	109,7	37,76	109,5	38,24	109,3	38,72	109,2	39,20	116
117	111,3	36,16	111,1	36,64	111,0	37,12	110,8	37,61	110,6	38,09	110,5	38,57	110,3	39,06	110,2	39,54	117
118	112,2	36,46	112,1	36,95	111,9	37,44	111,7	37,93	111,6	38,42	111,4	38,90	111,2	39,39	111,1	39,87	118
119	113,2	36,77	113,0	37,27	112,9	37,76	112,7	38,25	112,5	38,74	112,3	39,23	112,2	39,72	112,0	40,21	119
120	114,1	37,10	114,0	37,58	113,8	38,08	113,6	38,57	113,5	39,07	113,3	39,56	113,1	40,06	113,0	40,55	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	72 Deg.		71 Degrees					2,9	70 Degrees							2,7	

Distance	20 Degrees						,36		21 Degrees						,38		Distance
	0 Min		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,94	0,34	0,94	0,35	0,94	0,35	0,94	0,35	0,93	0,36	0,93	0,36	0,93	0,37	0,93	0,37	1
2	1,88	0,68	1,88	0,69	1,87	0,70	1,87	0,71	1,87	0,72	1,86	0,73	1,86	0,73	1,86	0,74	2
3	2,82	1,03	2,82	1,04	2,81	1,05	2,81	1,06	2,80	1,08	2,80	1,09	2,79	1,10	2,79	1,11	3
4	3,76	1,37	3,75	1,38	3,75	1,40	3,74	1,42	3,73	1,43	3,73	1,45	3,72	1,47	3,72	1,49	4
5	4,70	1,71	4,69	1,73	4,68	1,75	4,68	1,77	4,67	1,79	4,66	1,81	4,65	1,83	4,64	1,85	5
6	5,64	2,05	5,63	2,08	5,62	2,10	5,61	2,13	5,60	2,15	5,59	2,18	5,58	2,20	5,57	2,22	6
7	6,58	2,39	6,57	2,42	6,56	2,45	6,55	2,48	6,54	2,51	6,52	2,54	6,51	2,57	6,50	2,59	7
8	7,52	2,74	7,51	2,77	7,49	2,80	7,48	2,83	7,47	2,87	7,46	2,90	7,44	2,93	7,43	2,96	8
9	8,46	3,08	8,44	3,12	8,43	3,15	8,42	3,19	8,40	3,23	8,39	3,26	8,37	3,30	8,36	3,34	9
10	9,40	3,42	9,38	3,46	9.37	3,50	9,35	3,54	9,34	3,58	9,32	3,62	9,30	3,67	9,29	3,71	10
11	10,34	3,76	10,32	3,81	10,30	3,85	10,29	3,90	10,27	3,94	10,25	3,99	10,23	4,03	10,22	4,08	11
12	11,28	4,10	11,26	4,15	11,24	4,20	11,22	4,25	11,20	4,30	11,18	4,35	11,17	4,40	11,15	4,45	12
13	12,22	4,45	12,20	4,50	12,18	4,55	12,16	4,61	12,14	4,66	12,12	4,71	12,10	4,77	12,07	4,82	13
14	13,16	4,79	13,14	4,85	13,11	4,90	13,09	4,96	13,07	5,02	13,05	5,07	13,03	5,13	13,00	5,19	14
15	14,10	5,13	14,07	5,19	14,05	5,25	14,03	5,31	14,00	5,38	13,98	5,44	13,96	5,50	13,93	5,56	15
16	15,04	5,47	15,01	5,54	14,99	5,60	14,96	5,67	14,94	5,73	14,91	5,80	14,89	5,86	14,86	5,93	16
17	15,98	5,81	15,95	5,88	15,92	5,95	15,90	6,02	15,87	6,09	15,84	6,16	15,82	6,23	15,79	6,30	17
18	16,92	6,16	16,89	6,23	16,86	6,30	16,83	6,38	16,80	6,45	16,78	6,52	16,75	6,60	16,72	6,67	18
19	17.85	6,50	17,83	6,58	17,80	6,65	17,77	6,73	17,74	6,81	17,71	6,89	17,68	6,96	17,65	7,04	19
20	18,79	6,84	18,76	6,92	18,73	7,00	18,70	7,09	18,67	7,17	18,64	7,25	18,61	7,33	18,58	7,41	20
21	19,73	7,18	19,71	7,27	19,67	7,35	19,64	7,44	19,61	7,53	19,57	7,61	19,54	7,70	19,51	7,78	21
22	20,67	7,52	20,64	7,61	20,61	7,71	20,57	7,80	20,54	7,88	20,50	7,97	20,47	8,06	20,43	8,15	22
23	21,61	7,87	21,58	7,96	21,54	8,06	21,51	8,15	21,47	8,24	21,44	8,34	21,40	8,43	21,36	8,52	23
24	22,55	8,21	22,52	8,31	22,48	8,41	22,45	8,50	22,41	8,60	22,37	8,70	22,33	8,80	22,29	8,89	24
25	23,49	8,55	23,46	8,65	23,42	8,76	23,38	8,86	23,34	8,96	23,30	9,06	23,26	9,16	23,22	9,26	25
26	24,43	8,89	24,39	9,00	24,35	9,11	24,31	9,21	24.27	9.32	24,23	9,42	24,19	9,53	24,15	9,63	26
27	25,37	9,23	25,33	9,35	25,29	9,46	25,25	9,57	25,21	9,68	25,16	9,79	25,12	9,90	25,08	10,00	27
28	26,31	9,58	26,27	9,69	26,23	9,81	26,18	9,92	26,14	10,03	26,10	10,15	26,05	10,26	26,01	10,38	28
29	27,25	9,92	27,21	10,04	27,16	10,16	27,12	10,27	27,07	10,39	27,03	10,51	26,98	10,63	26,94	10,75	29
30	28,19	10,26	28,15	10,38	28,10	10,51	28,05	10,63	28,01	10,75	27,96	10,87	27,91	11,00	27,86	11,12	30
31	29,13	10,60	29,08	10,73	29,04	10,86	28,99	10,98	28,94	11,11	28,89	11,24	28,84	11,36	28,79	11,49	31
32	30,07	10,95	30,02	11,08	29,97	11,21	29,93	11,34	29,87	11,47	29,82	11,60	29,77	11,73	29,72	11,86	32
33	31,01	11,29	30,96	11,42	30,91	11,56	30,86	11,69	30,81	11,83	30,76	11,96	30,70	12,10	30,65	12,23	33
34	31,95	11,63	31,90	11,77	31,85	11,91	31,80	12,05	31,74	12,18	31,69	12,32	31,64	12,46	31,58	12,60	34
35	32,89	11,97	32,84	12,12	32,78	12,26	32,73	12,40	32,68	12,54	32,62	12,69	32,57	12,83	32,51	12,97	35
36	33,83	12,31	33,78	12,46	33,72	12,61	33,67	12,76	33,61	12,90	33,55	13,05	33,50	13,19	33,44	13,34	36
37	34,77	12,66	34,71	12,81	34,66	12,96	34,60	13,11	34,54	13,26	34,48	13,41	34,43	13,56	34,37	13,71	37
38	35,71	13,00	35,62	13,15	35,59	13,31	35,54	13,46	35,48	13,62	35,41	13,77	35,36	13,93	35,29	14,08	38
39	36,65	13,34	36,59	13,50	36,53	13,66	36,47	13,82	36,41	13,98	36,35	14,14	36,29	14,29	36,22	14,45	39
40	37,59	13,68	37,53	13,85	37,47	14,01	37,41	14,17	37,34	14,34	37,28	14,50	37,22	14,66	37,15	14,82	40
41	38,53	14,02	38,47	14,19	38,40	14,36	38,34	14,53	38,28	14,69	38,21	14,86	38,15	15,03	38,08	15,19	41
42	39,47	14,37	39,40	14,54	39,34	14,71	39,28	14,88	39,21	15,05	39,14	15,22	39,08	15,39	39,01	15,56	42
43	40,41	14,71	40,34	14,88	40,28	15,06	40,21	15,23	40,14	15,41	40,08	15,59	40,01	15,76	39,94	15,93	43
44	41,35	15,05	41,28	15,23	41,21	15,41	41,15	15,59	41,08	15,77	41,01	15,95	40,94	16,13	40,87	16,30	44
45	42,29	15,39	42,22	15,58	42,15	15,76	42,08	15,94	42,01	16,13	41,94	16,31	41,87	16,49	41,80	16,67	45
46	43,23	15,73	43,16	15,92	43,09	16,11	43,02	16,30	42,94	16,49	42,87	16,67	42,80	16,86	42,73	17,05	46
47	44,17	16,08	44,10	16,27	44,02	16,46	43,95	16,65	43,88	16,84	43,80	17,04	43,73	17,23	43,65	17,42	47
48	45,11	16,42	45,03	16,62	44,96	16,81	44,89	17,01	44,81	17,20	44,74	17,40	44,66	17,59	44,58	17,79	48
49	46,05	16,76	45,97	16,96	45,90	17,16	45,82	17,36	45,75	17,56	45,67	17,76	45,59	17,96	45,51	18,16	49
50	46,99	17,10	46,91	17,31	46,83	17,51	46,76	17,72	46,68	17,92	46,60	18,12	46,52	18,33	46,44	18,53	50
51	47,93	17,44	47,85	17,65	47,77	17,86	47,69	18,07	47,61	18,28	47,53	18,49	47,45	18,69	47,37	18,90	51
52	48,86	17,79	48,79	18,00	48,71	18,21	48,61	18,42	48,54	18,64	48,47	18,85	48,38	19,06	48,30	19,27	52
53	49,80	18,13	49,73	18,34	49,64	18,56	49,56	18,78	49,48	18,99	49,40	19,21	49,31	19,43	49,23	19,64	53
54	50,74	18,47	50,66	18,69	50,58	18,91	50,50	19,13	50,41	19,35	50,33	19,57	50,24	19,79	50,16	20,01	54
55	51,68	18,81	51,60	19,04	51,52	19,26	51,43	19,49	51,35	19,71	51,26	19,94	51,17	20,16	51,09	20,38	55
56	52,62	19,15	52,54	19,38	52,45	19,61	52,37	19,84	52,28	20,07	52,19	20,30	52,10	20,52	52,01	20,75	56
57	53,56	19,50	53,48	19,73	53,39	19,96	53,30	20,20	53,21	20,43	53,13	20,66	53,03	20,89	52,94	21,12	57
58	54,50	19,84	54,42	20,08	54,33	20,31	54,24	20,55	54,15	20,79	54,06	21,02	53,96	21,26	53,87	21,49	58
59	55,44	20,18	55,35	20,42	55,26	20,66	55,17	20,90	55,08	21,14	54,99	21,38	54,90	21,62	54,80	21,86	59
60	56,38	20,53	56,29	20,77	56,20	21,01	56,11	21,26	56,02	21,50	55,92	21,75	55,83	21,99	55,73	22,23	60
Distance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	70 Deg.		69 Degrees					2,6	68 Degrees							2,5	

Distance	20 Degrees							,36	21 Degrees							,38	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	57,32	20,86	57,23	21,11	57,14	21,36	57,04	21,61	56,95	21,86	56,85	22,11	56,76	22,36	56,66	22,60	61
62	58,26	21,21	58,17	21,46	58,07	21,71	57,98	21,97	57,88	22,22	57,79	22,47	57,69	22,73	57,59	22,98	62
63	59,20	21,55	59,11	21,81	59,01	22,06	58,91	22,32	58,82	22,58	58,72	22,83	58,62	23,09	58,52	23,35	63
64	60,14	21,89	60,04	22,15	59,95	22,41	59,85	22,67	59,75	22,94	59,65	23,20	59,55	23,46	59,44	23,72	64
65	61,08	22,23	60,98	22,50	60,88	22,76	60,79	23,03	60,68	23,29	60,58	23,56	60,48	23,82	60,37	24,09	65
66	62,02	22,57	61,92	22,84	61,82	23,11	61,72	23,38	61,62	23,65	61,51	23,92	61,41	24,19	61,30	24,46	66
67	62,96	22,92	62,86	23,19	62,76	23,46	62,66	23,74	62,55	24,01	62,45	24,28	62,34	24,56	62,23	24,83	67
68	63,90	23,26	63,80	23,54	63,69	23,82	63,59	24,09	63,48	24,37	63,38	24,65	63,27	24,92	63,16	25,20	68
69	64,84	23,60	64,74	23,88	64,63	24,17	64,53	24,45	64,42	24,73	64,31	25,01	64,20	25,29	64,09	25,57	69
70	65,78	23,94	65,67	24,23	65,57	24,52	65,46	24,80	65,35	25,09	65,24	25,37	65,13	25,66	65,02	25,94	70
71	66,72	24,28	66,61	24,57	66,50	24,87	66,40	25,15	66,28	25,44	66,17	25,73	66,06	26,02	65,95	26,31	71
72	67,66	24,63	67,55	24,92	67,44	25,22	67,33	25,51	67,22	25,80	67,11	26,10	66,99	26,39	66,88	26,68	72
73	68,60	24,97	68,49	25,27	68,38	25,57	68,27	25,86	68,15	26,16	68,04	26,46	67,92	26,76	67,80	27,05	73
74	69,54	25,31	69,43	25,61	69,31	25,92	69,20	26,22	69,09	26,52	68,97	26,82	68,85	27,12	68,73	27,42	74
75	70,48	25,65	70,36	25,96	70,25	26,27	70,14	26,57	70,02	26,88	69,90	27,18	69,78	27,49	69,66	27,79	75
76	71,42	25,99	71,30	26,31	71,19	26,62	71,07	26,93	70,95	27,24	70,83	27,55	70,71	27,85	70,59	28,16	76
77	72,36	26,34	72,24	26,65	72,12	26,97	72,01	27,28	71,89	27,59	71,77	27,91	71,64	28,22	71,52	28,52	77
78	73,30	26,68	73,18	27,00	73,06	27,31	72,94	27,63	72,82	27,95	72,70	28,27	72,57	28,59	72,45	28,90	78
79	74,24	27,02	74,12	27,34	74,00	27,67	73,88	27,99	73,75	28,31	73,63	28,63	73,50	28,95	73,38	29,27	79
80	75,18	27,36	75,06	27,69	74,93	28,02	74,81	28,34	74,69	28,67	74,56	29,00	74,43	29,32	74,31	29,65	80
81	76,12	27,70	75,99	28,04	75,87	28,37	75,75	28,70	75,62	29,03	75,49	29,36	75,37	29,69	75,23	30,02	81
82	77,05	28,05	76,93	28,38	76,81	28,72	76,68	29,05	76,55	29,39	76,43	29,72	76,30	30,05	76,16	30,39	82
83	77,99	28,39	77,87	28,73	77,74	29,07	77,62	29,41	77,49	29,75	77,36	30,08	77,23	30,42	77,09	30,76	83
84	78,93	28,73	78,81	29,07	78,68	29,42	78,55	29,76	78,42	30,10	78,29	30,45	78,16	30,79	78,02	31,13	84
85	79,87	29,07	79,75	29,42	79,62	29,77	79,49	30,11	79,35	30,46	79,22	30,81	79,09	31,15	78,95	31,50	85
86	80,81	29,41	80,68	29,77	80,55	30,12	80,42	30,47	80,29	30,82	80,15	31,17	80,02	31,52	79,88	31,87	86
87	81,75	29,76	81,62	30,11	81,49	30,47	81,36	30,82	81,22	31,16	81,09	31,53	80,95	31,89	80,81	32,24	87
88	82,69	30,10	82,56	30,46	82,43	30,82	82,29	31,18	82,15	31,54	82,02	31,89	81,88	32,25	81,74	32,61	88
89	83,63	30,44	83,50	30,81	83,36	31,17	83,23	31,53	83,09	31,90	82,95	32,26	82,81	32,62	82,66	32,98	89
90	84,57	30,78	84,44	31,15	84,30	31,52	84,16	31,89	84,02	32,25	83,88	32,62	83,74	32,99	83,59	33,35	90
91	85,51	31,12	85,38	31,50	85,24	31,87	85,10	32,24	84,96	32,61	84,81	32,98	84,67	33,35	84,52	33,72	91
92	86,45	31,47	86,31	31,84	86,17	32,22	86,03	32,60	85,89	32,97	85,75	33,34	85,60	33,72	85,45	34,09	92
93	87,39	31,81	87,25	32,19	87,11	32,57	86,97	32,95	86,82	33,33	86,68	33,71	86,53	34,09	86,38	34,46	93
94	88,33	32,15	88,19	32,54	88,05	32,92	87,90	33,30	87,76	33,69	87,61	34,07	87,46	34,45	87,31	34,83	94
95	89,27	32,49	89,13	32,88	88,98	33,27	88,84	33,66	88,69	34,04	88,54	34,43	88,39	34,82	88,24	35,20	95
96	90,21	32,83	90,07	33,23	89,92	33,62	89,77	34,01	89,62	34,40	89,47	34,80	89,32	35,18	89,17	35,57	96
97	91,15	33,18	91,00	33,57	90,86	33,97	90,71	34,37	90,56	34,76	90,41	35,16	90,25	35,55	90,10	35,94	97
98	92,09	33,52	91,94	33,92	91,79	34,32	91,64	34,72	91,49	35,11	91,34	35,52	91,18	35,92	91,02	36,31	98
99	93,03	33,86	92,88	34,27	92,73	34,67	92,58	35,07	92,42	35,48	92,27	35,88	92,11	36,28	91,95	36,69	99
100	93,97	34,20	93,82	34,61	93,67	35,02	93,51	35,43	93,36	35,84	93,20	36,24	93,04	36,65	92,88	37,06	100
101	94,91	34,54	94,76	34,96	94,60	35,37	94,45	35,78	94,29	36,20	94,13	36,61	93,97	37,02	93,8[illegible]	37,43	101
102	95,85	34,89	95,70	35,30	95,54	35,72	95,39	36,14	95,23	36,55	95,06	36,97	94,90	37,38	94,74	37,80	102
103	96,79	35,23	96,63	35,65	96,48	36,07	96,32	36,49	96,16	36,92	96,00	37,33	95,83	37,75	95,67	38,17	103
104	97,73	35,57	97,57	36,00	97,41	36,42	97,26	36,85	97,09	37,27	96,93	37,70	96,76	38,12	96,60	38,54	104
105	98,67	35,91	98,51	36,34	98,35	36,77	98,19	37,20	98,03	37,63	97,86	38,06	97,69	38,48	97,53	38,91	105
106	99,61	36,25	99,45	36,69	99,29	37,12	99,12	37,56	98,96	37,99	98,79	38,42	98,63	38,85	98,45	39,28	106
107	100,5	36,60	100,4	37,04	100,2	37,47	100,1	37,91	99,89	38,35	99,73	38,78	99,56	39,22	99,38	39,65	107
108	101,5	36,94	101,3	37,38	101,2	37,82	101,0	38,26	100,8	38,70	100,7	39,14	100,5	39,58	100,3	40,02	108
109	102,4	37,28	102,3	37,73	102,1	38,17	101,9	38,62	101,8	39,06	101,6	39,51	101,4	39,94	101,2	40,39	109
110	103,4	37,62	103,2	38,07	103,0	38,52	102,9	38,97	102,7	39,42	102,5	39,87	102,3	40,32	102,2	40,76	110
111	104,3	37,96	104,1	38,42	104,0	38,87	103,8	39,33	103,6	39,78	103,5	40,23	103,3	40,68	103,1	41,13	111
112	105,2	38,31	105,1	38,77	104,9	39,22	104,7	39,68	104,6	40,14	104,4	40,59	104,2	41,05	104,0	41,50	112
113	106,2	38,65	106,0	39,11	105,8	39,57	105,7	40,04	105,5	40,50	105,3	40,96	105,1	41,42	105,0	41,87	113
114	107,1	38,99	107,0	39,46	106,8	39,92	106,6	40,39	106,4	40,85	106,2	41,32	106,1	41,78	105,9	42,24	114
115	108,1	39,33	107,9	39,80	107,7	40,27	107,5	40,74	107,4	41,21	107,2	41,68	107,0	42,15	106,8	42,61	115
116	109,0	39,67	108,8	40,15	108,7	40,62	108,5	41,10	108,3	41,57	108,1	42,04	107,9	42,51	107,7	42,99	116
117	109,9	40,02	109,8	40,50	109,6	40,97	109,4	41,45	109,2	41,93	109,0	42,41	108,9	42,88	108,7	43,36	117
118	110,9	40,36	110,7	40,84	110,5	41,32	110,3	41,81	110,2	42,29	110,0	42,77	109,8	43,25	109,6	43,73	118
119	111,8	40,70	111,6	41,19	111,5	41,67	111,3	42,16	111,1	42,65	110,9	43,13	110,7	43,61	110,5	44,10	119
120	112,8	41,04	112,6	41,53	112,4	42,03	112,2	42,92	112,0	43,00	111,8	43,49	111,7	43,98	111,5	44,47	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	70 Deg.		69 Degrees						2,6		68 Degrees					2,5	

Distance	22 Degrees							,40	23 Degrees							,42	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,93	0,38	0,93	0,38	0,92	0,38	0,92	0,39	0,92	0,39	0,92	0,40	0,92	0,40	0,92	0,40	1
2	1,85	0,75	1,85	0,76	1,85	0,77	1,84	0,77	1,84	0,78	1,84	0,79	1,83	0,80	1,83	0,81	2
3	2,78	1,12	2,78	1,14	2,77	1,15	2,77	1,16	2,76	1,17	2,76	1,18	2,75	1,20	2,75	1,21	3
4	3,71	1,50	3,70	1,52	3,70	1,53	3,69	1,55	3,68	1,56	3,68	1,58	3,67	1,60	3,66	1,61	4
5	4,64	1,87	4,63	1,89	4,62	1,91	4,61	1,93	4,60	1,95	4,59	1,97	4,59	1,99	4,58	2,01	5
6	5,56	2,25	5,55	2,27	5,54	2,30	5,53	2,32	5,52	2,34	5,51	2,37	5,50	2,39	5,49	2,42	6
7	6,49	2,62	6,48	2,65	6,47	2,68	6,46	2,71	6,44	2,74	6,43	2,76	6,42	2,79	6,41	2,82	7
8	7,42	3,00	7,40	3,03	7,39	3,06	7,38	3,09	7,36	3,13	7,35	3,16	7,34	3,19	7,32	3,22	8
9	8,35	3,37	8,33	3,41	8,32	3,44	8,30	3,48	8,29	3,52	8,27	3,55	8,25	3,59	8,24	3,63	9
10	9,27	3,75	9,26	3,79	9,24	3,83	9,22	3,87	9,21	3,91	9,19	3,95	9,17	3,99	9,15	4,03	10
11	10,20	4,12	10,18	4,17	10,16	4,21	10,14	4,25	10,13	4,30	10,11	4,34	10,09	4,39	10,07	4,43	11
12	11,13	4,50	11,11	4,54	11,09	4,59	11,07	4 64	11,05	4,69	11,03	4,74	11,01	4,79	10,98	4,83	12
13	12,05	4,87	12,03	4,92	12,01	4,97	11,99	5,03	11,97	5,08	11,94	5,13	11,92	5,18	11,90	5,24	13
14	12,98	5,24	12,96	5,30	12,94	5,36	12,91	5,11	12,89	5,47	12,86	5,53	12,84	5,58	12,81	5,64	14
15	13,91	5,62	13,88	5,68	13,86	5,74	13,83	5,80	13,81	5,86	13,78	5,92	13,76	5,98	13,73	6,04	15
16	14,84	5,99	14,81	6,06	14,78	6,12	14,76	6,19	14,73	6,25	14,70	6,32	14,67	6,38	14,65	6,44	16
17	15,76	6,37	15,73	6,44	15,71	6,51	15,68	6,57	15,65	6,64	15,62	6,71	15,59	6,78	15,56	6,85	17
18	16,69	6,74	16,66	6,82	16,63	6,89	16,60	6,96	16,57	7,03	16,54	7,11	16,51	7,18	16,48	7,25	18
19	17,62	7,12	17,59	7,19	17,55	7,27	17,52	7,35	17,49	7,42	17,46	7,50	17,42	7,58	17,39	7,65	19
20	18,54	7,49	18,51	7,57	18,48	7,65	18,44	7,73	18,41	7,82	18,38	7,90	18,34	7,98	18,31	8,06	20
21	19,47	7,87	19,44	7,95	19,40	8,04	19,37	8,12	19,33	8,21	19,30	8,29	19,26	8,37	19,22	8,46	21
22	20,40	8,24	20,36	8,33	20,33	8,42	20,29	8,51	20,25	8,60	20,21	8,69	20,18	8,77	20,14	8,86	22
23	21,33	8,62	21,29	8,71	21,25	8,80	21,21	8,89	21,17	8,99	21,13	9,08	21,09	9,17	21,05	9,26	23
24	22,25	8,99	22,21	9,09	22,17	9,18	22,13	9,28	22,09	9,38	22,05	9,47	22,01	9,57	21,97	9,66	24
25	23,18	9,37	23,14	9,47	23,10	9,57	23,06	9,67	23,01	9,77	22,97	9,87	22,93	9,97	22,88	10,07	25
26	24,11	9,74	24,06	9,84	24,02	9,95	23,98	10,05	23,93	10,16	23,89	10,26	23,84	10,37	23,80	10,47	26
27	25,03	10,11	24,99	10,22	24,95	10,33	24,90	10,44	24,85	10,55	24,81	10,66	24,76	10,77	24,71	10,87	27
28	25,96	10,49	25,92	10,60	25,87	10,72	25,82	10,83	25,77	10,94	25,73	11,05	25,68	11,16	25,63	11,28	28
29	26,89	10,86	26,84	10,98	26,79	11,10	26,74	11,21	26,70	11,33	26,65	11,45	26,60	11,56	26,54	11,68	29
30	27,82	11,24	27,77	11,36	27,72	11,48	27,67	11,60	27,62	11,72	27,56	11,84	27,51	11,96	27,46	12,08	30
31	28,74	11,61	28,69	11,74	28,64	11,86	28,59	11,99	28,54	12,11	28,48	12,24	28,43	12,36	28,37	12,49	31
32	29,67	11,99	29,62	12,12	29,56	12,25	29,51	12,38	29,46	12,50	29,40	12,63	29,35	12,76	29,29	12,89	32
33	30,60	12,36	30,54	12,50	30,49	12,63	30,43	12,76	30,38	12,89	30,32	13,03	30,26	13,16	30,21	13,29	33
34	31,52	12,74	31,47	12,87	31,41	13,01	31,36	13,15	31,30	13,28	31,24	13,42	31,18	13,56	31,12	13,69	34
35	32,45	13,11	32,39	13,25	32,34	13,39	32,28	13,54	32,22	13,68	32,16	13,82	32,10	13,96	32,04	14,10	35
36	33,38	13,49	33,32	13,63	33,26	13,78	33,20	13,92	33,14	14,07	33,08	14,21	33,01	14,36	32,95	14,50	36
37	34,31	13,86	34,25	14,01	34,18	14,16	34,12	14,31	34,06	14,46	34,00	14,61	33,93	14,75	33,87	14,90	37
38	35,23	14,24	35,17	14,39	35,11	14,54	35,04	14,69	34,98	14,85	34,91	15,00	34,85	15,15	34,78	15,30	38
39	36,16	14,61	36,10	14,77	36,03	14,92	35,97	15,08	35,90	15,24	35,83	15,40	35,77	15,55	35,70	15,71	39
40	37,09	14,98	37,02	15,15	36,96	15,30	36,89	15,47	36,82	15,63	36,75	15,79	36,68	15,95	36,61	16,11	40
41	38,01	15,36	37,95	15,52	37,88	15,69	37,81	15,86	37,74	16,02	37,67	16,19	37,60	16,35	37,53	16,51	41
42	38,94	15,73	38,87	15,90	38,80	16,07	38,73	16,24	38,66	16,41	38,59	16,59	38,52	16,75	38,44	16,92	42
43	39,87	16,10	39,80	16,28	39,73	16,45	39,66	16,63	39,58	16,80	39,51	16,97	39,43	17,15	39,36	17,32	43
44	40,80	16,48	40,72	16,66	40,65	16,84	40,58	17,02	40,50	17,19	40,43	17,37	40,35	17,54	40,27	17,72	44
45	41,72	16,86	41,65	17,04	41,57	17,22	41,50	17,40	41,42	17,58	41,35	17,76	41,27	17,94	41,19	18,12	45
46	42,65	17,23	42,58	17,42	42,50	17,60	42,42	17,79	42,34	17,97	42,27	18,16	42,18	18,34	42,10	18,53	46
47	43,58	17,61	43,50	17,80	43,42	17,99	43,34	18,18	43,26	18,37	43,18	18,55	43,10	18,74	43,02	18,93	47
48	44,51	17,98	44,43	18,18	44,35	18,37	44,27	18,56	44,18	18,76	44,10	18,95	44,02	19,14	43,93	19,33	48
49	45,43	18,36	45,35	18,55	45,27	18,75	45,19	18,95	45,11	19,15	45,02	19,34	44,94	19,54	44,85	19,73	49
50	46,36	18,73	46,28	18,93	46,19	19,13	46,11	19,34	46,03	19,54	45,94	19,74	45,85	19,94	45,77	20,14	50
51	47,29	19,11	47,20	19,31	47,12	19,52	47,03	19,72	46,95	19,93	46,86	20,13	46,77	20,34	46,68	20,54	51
52	48,21	19,48	48,13	19,69	48,04	19,90	47,95	20,11	47,87	20,32	47,78	20,53	47,69	20,74	47,60	20,94	52
53	49,14	19,86	49,05	20,07	48,97	20,18	48,88	20,50	48,79	20,71	48,70	20,92	48,60	21,13	48,51	21,35	53
54	50,07	20,23	49,98	20,45	49,89	20,66	49,80	20,88	49,71	21,10	49,62	21,32	49,52	21,53	49,43	21,75	54
55	51,00	20,60	50,90	20,83	50,81	21,05	50,72	21,27	50,63	21,49	50,53	21,71	50,44	21,93	50,34	22,15	55
56	51,92	20,98	51,83	21,20	51,74	21,43	51,64	21,66	51,55	21,88	51,45	22,11	51,36	22,33	51,26	22,55	56
57	52,85	21,35	52,76	21,58	52,67	21,81	52,57	22,04	52,47	22,27	52,37	22,50	52,27	22,73	52,17	22,96	57
58	53,78	21,73	53,68	21,96	53,59	22,20	53,49	22,43	53,39	22,66	53,29	22,90	53,19	23,13	53,09	23,36	58
59	54,70	22,10	54,61	22,34	54,51	22,58	54,41	22,82	54,31	23,05	54,21	23,29	54,11	23,53	54,00	23,76	59
60	55,63	22,48	55,53	22,72	55,43	22,96	55,33	23,20	55,23	23,44	55,13	23,68	55,02	23,93	54,92	24,17	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	68 Deg.		67 Degrees					2,4	66 Degrees							2,2	

Diſtance	22 Degrees							,40	23 Degrees							,42	Diſtance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	56,56	22,85	56,46	23,10	56,36	23,34	56,25	23,59	56,15	23,83	56,05	24,08	55,95	24,32	55,83	24,57	61
62	57,49	23,23	57,38	23,48	57,28	23,73	57,18	23,98	57,07	24,22	56,97	24,47	56,86	24,72	56,75	24,97	62
63	58,41	23,60	58,31	23,86	58,21	24,11	58,10	24,37	57,99	24,62	57,88	24,87	57,78	25,12	57,66	25,37	63
64	59,34	23,98	59,23	24,23	59,13	24,49	59,02	24,75	58,91	25,01	58,80	25,26	58,69	25,52	58,58	25,78	64
65	60,27	24,35	60,16	24,61	60,05	24,87	59,94	25,14	59,83	25,40	59,72	25,66	59,61	25,92	59,49	26,18	65
66	61,19	24,72	61,08	24,99	60,98	25,26	60,87	25,52	60,75	25,79	60,64	26,05	60,53	26,32	60,41	26,58	66
67	62,12	25,10	62,01	25,37	61,90	25,63	61,79	25,91	61,67	26,18	61,56	26,45	61,44	26, 2	61,32	26,99	67
68	63,05	25,47	62,94	25,75	62,82	26,02	62,71	26,30	62,59	26,57	62,48	26,84	62,36	27,12	62,24	27,39	68
69	63,98	25,85	63,86	26,13	63,75	26,41	63,63	26,68	63,52	26,96	63,40	27,23	63,28	27,52	63,15	27,79	69
70	64,90	26,22	64,79	26,51	64,67	26,79	64,55	27,07	64,44	27,35	64,32	27,63	64,19	27,91	64,07	28,19	70
71	65,83	26,60	65,71	26,89	65,60	27,17	65,48	27,46	65,36	27,74	65,23	28,03	65,11	28,31	64,99	28,60	71
72	66,76	26,97	66,64	27,26	66,52	27,55	66,40	27,84	66,28	28,13	66,15	28,42	66,03	28,71	65,90	29,00	72
73	67,69	27,35	67,57	27,64	67,44	27,94	67,32	28,22	67,20	28,52	67,07	28,82	66,95	29,11	66,82	29,40	73
74	68,61	27,72	68,49	28,02	68,37	28,32	68,24	28,62	68,12	28,91	67,99	29,21	67,86	29,51	67,73	29,81	74
75	69,54	28,10	69,42	28,40	69,29	28,70	69,17	29,00	69,04	29,30	68,91	29,61	68,78	29,91	68,65	30,21	75
76	70,47	28,47	70,34	28,78	70,21	29,08	70,09	29,39	69,96	29,69	69,83	30,00	69,70	30,31	69,56	30,61	76
77	71,39	28,85	71,27	29,16	71,14	29,47	71,01	29,78	70,88	30,09	70,75	30,40	70,61	30,71	70,48	31,01	77
78	72,32	29,22	72,19	29,54	72,06	29,85	71,93	30,16	71,80	30,48	71,67	30,79	71,53	31,1	71,39	31,42	78
79	73,25	29,59	73,12	29,91	72,99	30,23	72,85	30,55	72,72	30,87	72,59	31,19	72,4	31,50	72,31	31,82	79
80	74,17	29,97	74,04	30,29	73,91	30,61	73,78	30,94	73,64	31,26	73,50	31,58	73,37	31,90	73,23	32,22	80
81	75,10	30,34	74,97	30,67	74,83	31,00	74,70	31,32	74,56	31,65	74,42	31,97	74,28	32,30	74,14	32,62	81
82	76,03	30,72	75,89	31,05	75,76	31,38	75,62	31,71	75,48	32,04	75,34	32,37	75,20	32,70	75,06	33,03	82
83	76,96	31,09	76,82	31,43	76,68	31,76	76,54	32,09	76,40	32,43	76,26	32,76	76,12	33,10	75,97	33,43	83
84	77,88	31,47	77,75	31,81	77,61	32,15	77,47	32,48	77,32	32,82	77,18	33,15	77,03	33,50	76 89	33,83	84
85	78,81	31,84	78,67	32,19	78,53	32,53	78,39	32,87	78,24	33,21	78,10	33,55	77,95	33,90	77,80	34,24	85
86	79,74	32,22	79,60	32,56	79,45	32,91	79,31	33,26	79,16	33,60	79,02	33,95	78,87	34,29	78,71	34,64	86
87	80,66	32,59	80,52	32,94	80,38	33,29	80,23	33,64	80,08	34,00	79,94	34,34	79,78	34,69	79,63	35,04	87
88	81,59	32,97	81,45	33,32	81,30	33,68	81,16	34,03	81,00	34,39	80,86	34,73	80,71	35,09	80,55	35,44	88
89	82,52	33,34	82,37	33,70	82,23	34,06	82,08	34,42	81,93	34,78	81,77	35,13	81,62	35,49	81,40	35,85	89
90	83,45	33,72	83,30	34,08	83,15	34,44	83,00	34,81	82,85	35,17	82,69	35,53	82,54	35,89	82,3	36,25	90
91	84,37	34,09	84,22	34,46	84,07	34,82	83,92	35,19	83,77	35,56	83,61	35,92	83,46	36,29	83,29	36,65	91
92	85,30	34,46	85,15	34,84	85,00	35,21	84,84	35,57	84,69	35,95	84,53	36,32	84,37	36,69	84,21	37,05	92
93	86,23	34,84	86,08	35,22	85,92	35,59	85,77	35,97	85,61	36,34	85,45	36,71	85,29	37,09	85,12	37,46	93
94	87,16	35,21	87,00	35,59	86,85	35,97	86,69	36,35	86,53	36,73	86,37	37,11	86,20	37,48	86,04	37,86	94
95	88,08	35,59	87,92	35,97	87,77	36,35	87,61	36,74	87,45	37,12	87,29	37,50	87,12	37,88	86,95	38,26	95
96	89,01	35,96	88,85	36,35	88,69	36,74	88,53	37,12	88,37	37,51	88,21	37,90	88,04	38,28	87,87	38,67	96
97	89,94	36,34	89,78	36,73	89,62	37,12	89,45	37,51	89,29	37,90	89,12	38,29	88,95	38,68	88,78	39,07	97
98	90,86	36,71	90,70	37,11	90,54	37,50	90,38	37,90	90,21	38,29	90,04	38,69	89,87	39,08	89,70	39,47	98
99	91,79	37,09	91,63	37,49	91,46	37,89	91,30	38,28	91,13	38,69	90,96	39,08	90,79	39,48	90,61	39,88	99
100	92,72	37,46	92,55	37,87	92,39	38,27	92,22	38,67	92,05	39,07	91,88	39,47	91,71	39,88	91,5	40,28	100
101	93,65	37,84	93,48	38,24	93,31	38,65	93,14	39,06	92,97	39,46	92,80	39,87	92,63	40,28	92,45	40,68	101
102	94,57	38,21	94,41	38,62	94,24	39,03	94,06	39,45	93,89	39,86	93,72	40,26	93,54	40,67	93,36	41,08	102
103	95,50	38,59	95,3	39,00	95,16	39,42	94,98	39,83	94,81	40,25	94,63	40,66	94,46	41,07	94,28	41,48	103
104	96,43	38,96	96,26	39,38	96,08	39,80	95,91	40,22	95,73	40,64	95,56	41,05	95,37	41,47	95,19	41,89	104
105	97,35	39,33	97,18	39,76	97,01	40,18	96,83	40,61	96,65	41,03	96,47	41,45	96,29	41,87	96,11	42,29	105
106	98,28	39,71	98,11	40,14	97,93	40,56	97,75	40,99	97,57	41,42	97,39	41,84	97,21	42,27	97,02	42,69	106
107	99,21	40,08	99,03	40,52	98,86	40,95	98,68	41,38	98,49	41,81	98,31	42,24	98,13	42,67	97,94	43,10	107
108	100,1	40,46	99,96	40,89	99,78	41,33	99,60	41,76	99,41	42,20	99,23	42,63	99,04	43,07	98,85	43,50	108
109	101,1	40,83	100,9	41,27	100,7	41,71	100,5	42,15	100,3	42,59	100,2	43,03	99,96	43,47	99,77	43,90	109
110	102,0	41,21	101,8	41,65	101,6	42,10	101,4	42,54	101,3	42,98	101,1	43,42	100,9	43,86	100,7	44,30	110
111	102,9	41,58	102,7	42,03	102,6	42,48	102,4	42,93	102,2	43,37	102,0	43,82	101,8	44,26	101,6	44,71	111
112	103,8	41,96	103,7	42,41	103,5	42,86	103,3	43,31	103,1	43,76	102,9	44,21	102,7	44,66	102,5	45,11	112
113	104,8	42,33	104,6	42,79	104,4	43,24	104,2	43,70	104,0	44,15	103,8	44,61	103,6	45,06	103,4	45,51	113
114	105,7	42,71	105,5	43,17	105,3	43,63	105,1	44,09	104,9	44,54	104,7	45,00	104,5	45,46	104,3	45,92	114
115	106,6	43,08	106,4	43,55	106,2	44,01	106,1	44,47	105,9	44,94	105,7	45,40	105,5	45,86	105,3	46,32	115
116	107,6	43,45	107,4	43,92	107,2	44,39	107,0	44,86	106,8	45,33	106,6	45,79	106,4	46,26	106,2	46,72	116
117	108,5	43,83	108,3	44,30	108,1	44,77	107,9	45,25	107,7	45,72	107,5	46,19	107,3	46,66	107,1	47,12	117
118	109,4	44,21	109,2	44,68	109,0	45,16	108,8	45,63	108,6	46,11	108,4	46,58	108,2	47,06	108,0	47,53	118
119	110,3	44,58	110,1	45,06	109,9	45,54	109,7	46,02	109,5	46,50	109,3	46,98	109,1	47,45	108,9	47,93	119
120	111,3	44,95	111,1	45,44	110,9	45,92	110,7	46,41	110,5	46,89	110,3	47,37	110,0	47,85	109,8	48,33	120
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	68 Deg.		67 Degrees					2,4	66 Degrees							2,2	

Distance	24 Degrees							,45	25 Degrees							,47	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
1	0,91	0,41	0,91	0,41	0,91	0,42	0,91	0,42	0,91	0,42	0,90	0,43	0,90	0,43	0,90	0,43	1
2	1,83	0,81	1,82	0,82	1,82	0,83	1,82	0,84	1,81	0,85	1,81	0,85	1,81	0,86	1,80	0,87	2
3	2,74	1,22	2,74	1,23	2,73	1,24	2,72	1,26	2,72	1,27	2,71	1,28	2,71	1,29	2,70	1,30	3
4	3,65	1,63	3,65	1,64	3,64	1,66	3,63	1,68	3,63	1,69	3,62	1,71	3,61	1,72	3,60	1,74	4
5	4,57	2,03	4,56	2,05	4,55	2,07	4,54	2,09	4,58	2,11	4,52	2,13	4,51	2,15	4,50	2,17	5
6	5,48	2,44	5,47	2,46	5,46	2,49	5,45	2,51	5,44	2,54	5,43	2,56	5,42	2,58	5,40	2,64	6
7	6,40	2,85	6,38	2,88	6,37	2,90	6,36	2,93	6,34	2,96	6,33	2,99	6,32	3,01	6,31	3,04	7
8	7,31	3,25	7,29	3,29	7,28	3,32	7,27	3,35	7,25	3,38	7,24	3,41	7,22	3,44	7,21	3,48	8
9	8,22	3,66	8,21	3,70	8,19	3,73	8,17	3,77	8,16	3,80	8,14	3,84	8,12	3,88	8,11	3,91	9
10	9,14	4,07	9,12	4,11	9,10	4,15	9,08	4,19	9,06	4,23	9,05	4,27	9,03	4,31	9,01	4,35	10
11	10,05	4,47	10,03	4,52	10,01	4,56	9,99	4,61	9,97	4,65	9,95	4,69	9,93	4,74	9,91	4,78	11
12	10,96	4,88	10,94	4,93	10,92	4,98	10,90	5,02	10,88	5,07	10,85	5,12	10,83	5,17	10,81	5,21	12
13	11,88	5,29	11,85	5,34	11,83	5,39	11,81	5,44	11,78	5,49	11,76	5,55	11,73	5,60	11,71	5,65	13
14	12,79	5,69	12,76	5,75	12,74	5,81	12,71	5,86	12,69	5,92	12,66	5,97	12,64	6,03	12,61	6,08	14
15	13,70	6,10	13,68	6,16	13,65	6,22	13,62	6,28	13,59	6,34	13,57	6,40	13,54	6,46	13,51	6,52	15
16	14,62	6,51	14,59	6,57	14,56	6,64	14,53	6,70	14,50	6,76	14,47	6,83	14,44	6,89	14,41	6,95	16
17	15,53	6,91	15,50	6,98	15,47	7,05	15,44	7,12	15,41	7,19	15,37	7,25	15,35	7,32	15,31	7,39	17
18	16,44	7,32	16,41	7,39	16,38	7,47	16,35	7,54	16,31	7,61	16,28	7,68	16,25	7,75	16,21	7,82	18
19	17,36	7,73	17,32	7,80	17,29	7,88	17,25	7,96	17,22	8,03	17,18	8,11	17,15	8,18	17,11	8,26	19
20	18,27	8,14	18,24	8,21	18,20	8,29	18,16	8,37	18,13	8,45	18,09	8,53	18,05	8,61	18,01	8,69	20
21	19,18	8,54	19,15	8,63	19,11	8,71	19,07	8,79	19,03	8,88	18,99	8,96	18,96	9,04	18,92	9,12	21
22	20,10	8,95	20,06	9,04	20,02	9,12	19,98	9,21	19,94	9,30	19,90	9,39	19,86	9,47	19,82	9,56	22
23	21,01	9,36	20,97	9,45	20,94	9,55	20,89	9,63	20,84	9,72	20,80	9,81	20,76	9,90	20,72	9,99	23
24	21,93	9,76	21,88	9,86	21,85	9,96	21,80	10,05	21,75	10,14	21,71	10,24	21,66	10,33	21,62	10,43	24
25	22,84	10,17	22,79	10,27	22,75	10,38	22,70	10,47	22,66	10,57	22,61	10,67	22,57	10,77	22,52	10,86	25
26	23,75	10,58	23,71	10,68	23,66	10,79	23,61	10,89	23,56	10,99	23,51	11,09	23,47	11,20	23,42	11,30	26
27	24,67	10,98	24,62	11,09	24,57	11,21	24,52	11,31	24,47	11,41	24,41	11,52	24,37	11,63	24,32	11,73	27
28	25,58	11,39	25,53	11,50	25,48	11,62	25,43	11,73	25,37	11,84	25,32	11,95	25,28	12,06	25,22	12,17	28
29	26,49	11,80	26,44	11,91	26,39	12,04	26,34	12,14	26,28	12,26	26,23	12,37	26,18	12,49	26,12	12,60	29
30	27,41	12,20	27,35	12,32	27,30	12,44	27,24	12,56	27,19	12,68	27,13	12,80	27,08	12,92	27,02	13,03	30
31	28,32	12,61	28,26	12,73	28,21	12,86	28,15	12,98	28,10	13,10	28,04	13,22	27,98	13,35	27,92	13,47	31
32	29,23	13,02	29,18	13,14	29,12	13,27	29,06	13,40	29,00	13,53	28,94	13,65	28,88	13,78	28,82	13,90	32
33	30,15	13,42	30,09	13,55	30,03	13,69	29,97	13,82	29,91	13,95	29,85	14,08	29,79	14,21	29,72	14,34	33
34	31,06	13,83	31,00	13,97	30,94	14,10	30,88	14,24	30,81	14,37	30,75	14,51	30,69	14,64	30,62	14,77	34
35	31,97	14,24	31,91	14,38	31,85	14,51	31,78	14,66	31,72	14,79	31,65	14,93	31,59	15,07	31,53	15,21	35
36	32,89	14,64	32,82	14,79	32,76	14,93	32,69	15,07	32,63	15,22	32,56	15,36	32,50	15,50	32,43	15,64	36
37	33,80	15,05	33,73	15,20	33,67	15,35	33,60	15,49	33,53	15,64	33,46	15,79	33,40	15,93	33,33	16,08	37
38	34,72	15,46	34,65	15,61	34,58	15,76	34,51	15,91	34,44	16,06	34,37	16,21	34,30	16,36	34,23	16,51	38
39	35,63	15,86	35,56	16,02	35,49	16,18	35,42	16,33	35,34	16,49	35,28	16,64	35,21	16,79	35,13	16,94	39
40	36,54	16,27	36,47	16,43	36,40	16,59	36,33	16,75	36,25	16,91	36,18	17,07	36,10	17,22	36,03	17,38	40
41	37,46	16,68	37,38	16,84	37,31	17,00	37,23	17,17	37,16	17,33	37,08	17,49	37,01	17,65	36,93	17,81	41
42	38,37	17,08	38,29	17,25	38,22	17,42	38,14	17,58	38,06	17,75	37,99	17,92	37,92	18,08	37,83	18,25	42
43	39,28	17,49	39,20	17,66	39,13	17,83	39,05	18,00	38,97	18,18	38,89	18,34	38,82	18,51	38,73	18,68	43
44	40,20	17,90	40,12	18,07	40,04	18,25	39,96	18,42	39,88	18,60	39,79	18,77	39,72	18,94	39,63	19,12	44
45	41,11	18,30	41,03	18,48	40,95	18,66	40,87	18,84	40,78	19,02	40,70	19,20	40,62	19,38	40,53	19,55	45
46	42,02	18,71	41,94	18,89	41,86	19,08	41,77	19,26	41,69	19,45	41,60	19,63	41,52	19,81	41,43	19,99	46
47	42,94	19,12	42,85	19,30	42,77	19,49	42,68	19,68	42,59	19,87	42,51	20,05	42,42	20,24	42,33	20,42	47
48	43,85	19,52	43,76	19,72	43,68	19,91	43,59	20,10	43,50	20,29	43,41	20,48	43,32	20,67	43,23	20,85	48
49	44,76	19,93	44,68	20,13	44,59	20,32	44,50	20,52	44,41	20,71	44,31	20,91	44,23	21,10	44,13	21,29	49
50	45,68	20 34	45,59	20,54	45,50	20,74	45,41	20,93	45 32	21,13	45,22	21,33	45,14	21,53	45,04	21,72	50
51	46,59	20,74	46,50	20,95	46,41	21,15	46,32	21,35	46,22	21,55	46,13	21,76	46,03	21,96	45,94	22,16	51
52	47,51	21,15	47,41	21,36	47,32	21,57	47,22	21,77	47,13	21,98	47,03	22,18	46,94	22,39	46,84	22,59	52
53	48,42	21,56	48,32	21,77	48,23	21,98	48,13	22,19	48,03	22,40	47,94	22,61	47,84	22,82	47,74	23,03	53
54	49,33	21,96	49,23	22,18	49,14	22,40	49,04	22,61	48,95	22,82	48,84	23,04	48,74	23,25	48,64	23,46	54
55	50,25	22,37	50,15	22,59	50,05	22,81	49,95	23,03	49,85	23 24	49,74	23,46	49,65	23,68	49,54	23,90	55
56	51,16	22,78	51,06	23,00	50,96	23,23	50,86	23,45	50,75	23,67	50,65	23,89	50,55	24,11	50,44	24,33	56
57	52,07	23,18	51,97	23,41	51,87	23,64	51,76	23,87	51,66	24,09	51,55	24,32	51,45	24,54	51,34	24,77	57
58	52,98	23,59	52,88	23,82	52,78	24,06	52,68	24,29	52,56	24,52	52,45	24,75	52,35	24,97	52,24	25,20	58
59	53,90	24,00	53,79	24,23	53,69	24,47	53,58	24,70	53,47	24,94	53,36	25,17	53,26	25,41	53,14	25,63	59
60	54,81	24,40	54,71	24,64	54,60	24,88	54,49	25,12	54,38	25,36	54,27	25,59	54,16	25,83	54,04	26,07	60
Distance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	66 Deg.		65 Degrees					2,14	64 Degrees							2,05	

Digitized by Google

Distance	24 Degrees							,45	25 Degrees							,47	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	
61	55,73	24,81	55,62	25,06	55,51	25,30	55,40	25,54	55,29	25,78	55,17	26,02	55,06	26,26	54,94	26,51	61
62	56,64	25,22	56,53	25,47	56,42	25,71	56,30	25,96	56,19	26,20	56,08	26,45	55,96	26,69	55,84	26,94	62
63	57,56	25,63	57,44	25,88	57,33	26,13	57,21	26,38	57,10	26,63	56,98	26,88	56,86	27,12	56,75	27,37	63
64	58,47	26,03	58,35	26,29	58,24	26,54	58,12	26,80	58,00	27,05	57,88	27,30	57,77	27,56	57,65	27,80	64
65	59,38	26,44	59,27	26,70	59,15	26,96	59,03	27,22	58,91	27,47	58,79	27,73	58,67	27,99	58,55	28,24	65
66	60,30	26,85	60,18	27,11	60,06	27,37	59,94	27,63	59,82	27,90	59,69	28,16	59,57	28,42	59,45	28,67	66
67	61,21	27,26	61,09	27,52	60,97	27,79	60,84	28,05	60,72	28,32	60,60	28,58	60,48	28,85	60,35	29,11	67
68	62,13	27,66	62,00	27,93	61,88	28,20	61,75	28,47	61,63	28,74	61,50	29,01	61,38	29,38	61,25	29,54	68
69	63,04	28,07	62,91	28,34	62,79	28,62	62,66	28,89	62,53	29,16	62,40	29,44	62,28	29,71	62,15	29,97	69
70	63,95	28,47	63,82	28,75	63,70	29,03	63,57	29,31	63,44	29,58	63,31	29,86	63,18	30,14	63,05	30,41	70
71	64,86	28,88	64,74	29,16	64,61	29,44	64,48	29,73	64,35	30,01	64,22	30,29	64,08	30,57	63,95	30,85	71
72	65,78	29,29	65,65	29,57	65,52	29,86	65,39	30,14	65,25	30,43	65,12	30,72	64,99	30,99	64,85	31,28	72
73	66,69	29,69	66,56	29,98	66,43	30,27	66,29	30,56	66,16	30,85	66,02	31,15	65,89	31,43	65,75	31,71	73
74	67,61	30,10	67,47	30,39	67,34	30,69	67,20	30,98	67,07	31,28	66,94	31,58	66,79	31,86	66,65	32,15	74
75	68,52	30,51	68,39	30,81	68,25	31,10	68,11	31,40	67,97	31,70	67,84	32,00	67,70	32,29	67,55	32,58	75
76	69,43	30,91	69,30	31,22	69,16	31,52	69,02	31,82	68,88	32,12	68,75	32,42	68,60	32,72	68,46	33,02	76
77	70,35	31,32	70,21	31,63	70,07	31,93	69,93	32,24	69,78	32,54	69,65	32,85	69,50	33,15	69,36	33,45	77
78	71,26	31,73	71,12	32,04	70,98	32,35	70,83	32,66	70,69	32,97	70,55	33,28	70,41	33,58	70,26	33,88	78
79	72,18	32,14	72,03	32,45	71,89	32,76	71,74	33,08	71,60	33,39	71,46	33,70	71,31	34,01	71,16	34,32	79
80	73,08	32,54	72,94	32,86	72,80	33,18	72,65	33,50	72,51	33,81	72,36	34,13	72,21	34,44	72,06	34,76	80
81	74,00	32,95	73,85	33,27	73,71	33,59	73,56	33,91	73,41	34,23	73,26	34,55	73,11	34,87	72,96	35,19	81
82	74,91	33,35	74,77	33,68	74,62	34,00	74,47	34,33	74,32	34,66	74,17	34,98	74,01	35,30	73,86	35,62	82
83	75,83	33,76	75,68	34,09	75,53	34,42	75,38	34,75	75,22	35,08	75,07	35,41	74,92	35,73	74,76	36,06	83
84	76,74	34,17	76,59	34,50	76,44	34,84	76,28	35,17	76,13	35,50	75,97	35,83	75,82	36,17	75,66	36,49	84
85	77,65	34,57	77,50	34,91	77,35	35,25	77,19	35,59	77,04	35,93	76,88	36,26	76,72	36,60	76,56	36,93	85
86	78,57	34,98	78,41	35,32	78,26	35,67	78,10	36,01	77,94	36,35	77,78	36,69	77,63	37,03	77,46	37,36	86
87	79,48	35,39	79,33	35,74	79,17	36,08	79,01	36,43	78,85	36,77	78,69	37,12	78,53	37,46	78,36	37,79	87
88	80,40	35,80	80,24	36,15	80,08	36,50	79,92	36,85	79,75	37,19	79,59	37,54	79,43	37,89	79,26	38,23	88
89	81,31	36,20	81,15	36,56	80,99	36,91	80,83	37,26	80,66	37,62	80,49	37,97	80,33	38,33	80,16	38,66	89
90	82,22	36,61	82,06	36,97	81,90	37,32	81,73	37,68	81,57	38,04	81,40	38,39	81,23	38,75	81,06	39,10	90
91	83,13	37,01	82,97	37,38	82,81	37,74	82,64	38,10	82,47	38,46	82,31	38,82	82,14	39,18	81,96	39,54	91
92	84,05	37,42	83,88	37,79	83,72	38,15	83,55	38,52	83,38	38,88	83,21	39,25	83,04	39,61	82,87	39,97	92
93	84,96	37,83	84,79	38,20	84,63	38,57	84,46	38,94	84,29	39,31	84,11	39,67	83,94	40,04	83,77	40,40	93
94	85,84	38,24	85,71	38,61	85,54	38,98	85,37	39,36	85,19	39,73	85,02	40,10	84,85	40,47	84,67	40,84	94
95	86,79	38,61	86,62	39,02	86,45	39,40	86,27	39,76	86,10	40,15	85,92	40,53	85,75	40,90	85,57	41,27	95
96	87,70	39,02	87,52	39,43	87,36	39,81	87,18	40,18	87,00	40,57	86,83	40,95	86,65	41,33	86,47	41,71	96
97	88,62	39,43	88,44	39,84	88,27	40,23	88,09	40,60	87,91	41,00	87,73	41,38	87,55	41,76	87,37	42,14	97
98	89,53	39,83	89,35	40,25	89,18	40,64	89,00	41,02	88,82	41,42	88,63	41,81	88,46	42,19	88,27	42,57	98
99	90,42	40,24	90,26	40,66	90,09	41,06	89,91	41,44	89,73	41,84	89,54	42,23	89,36	42,62	89,17	43,01	99
100	91,36	40,67	91,18	41,07	91,00	41,47	90,81	41,87	90,63	42,26	90,45	42,66	90,26	43,05	90,07	43,45	100
101	92,27	41,08	92,09	41,48	91,91	41,88	91,72	42,29	91,54	42,69	91,35	43,08	91,16	43,48	90,97	43,88	101
102	93,18	41,49	93,00	41,89	92,82	42,30	92,63	42,70	92,44	43,11	92,25	43,51	92,07	43,91	91,87	44,31	102
103	94,10	41,90	93,91	42,31	93,73	42,71	93,54	43,12	93,35	43,53	93,16	43,94	92,97	44,34	92,77	44,75	103
104	95,01	42,30	94,82	42,72	94,64	43,13	94,45	43,54	94,26	43,95	94,06	44,37	93,87	44,78	93,67	45,18	104
105	95,93	42,71	95,74	43,13	95,55	43,54	95,35	43,96	95,16	44,38	94,97	44,79	94,77	45,21	94,58	45,62	105
106	96,83	43,12	96,65	43,54	96,46	43,96	96,26	44,38	96,07	44,80	95,87	45,22	95,68	45,64	95,48	46,05	106
107	97,75	43,52	97,56	43,95	97,37	44,37	97,17	44,80	96,97	45,22	96,77	45,65	96,59	46,07	96,38	46,48	107
108	98,67	43,93	98,47	44,36	98,28	44,79	98,08	45,22	97,88	45,65	97,68	46,07	97,49	46,50	97,28	46,92	108
109	99,58	44,34	99,38	44,77	99,18	45,20	98,99	45,64	98,79	46,07	98,58	46,50	98,39	46,93	98,18	47,35	109
110	100,5	44,74	100,3	45,18	100,1	45,62	99,90	46,05	99,69	46,49	99,49	46,92	99,29	47,36	99,08	47,78	110
111	101,4	45,15	101,2	45,59	101,0	46,03	100,8	46,47	100,6	46,91	100,4	47,35	100,2	47,79	99,98	48,22	111
112	102,3	45,56	102,1	46,00	101,9	46,45	101,7	46,89	101,5	47,33	101,3	47,78	101,1	48,22	100,9	48,66	112
113	103,2	45,96	103,0	46,41	102,8	46,86	102,6	47,31	102,4	47,76	102,2	48,20	102,0	48,65	101,8	49,09	113
114	104,1	46,37	103,9	46,83	103,7	47,28	103,5	47,73	103,3	48,18	103,1	48,63	102,9	49,08	102,7	49,52	114
115	105,1	46,78	104,9	47,23	104,6	47,69	104,4	48,15	104,2	48,60	104,0	49,06	103,8	49,52	103,6	49,96	115
116	106,0	47,18	105,8	47,65	105,6	48,11	105,3	48,57	105,1	49,02	104,9	49,49	104,7	49,95	104,5	50,39	116
117	106,9	47,59	106,7	48,06	106,5	48,52	106,3	48,99	106,0	49,45	105,8	49,91	105,6	50,38	105,4	50,83	117
118	107,8	48,00	107,6	48,47	107,4	48,94	107,2	49,41	106,9	49,87	106,7	50,34	106,5	50,81	106,3	51,26	118
119	108,7	48,40	108,5	48,97	108,3	49,35	108,1	49,82	107,8	50,30	107,6	50,77	107,4	51,23	107,2	51,70	119
120	109,6	48,81	109,4	49,29	109,2	49,76	109,0	50,24	108,8	50,71	108,5	51,19	108,3	51,67	108,1	52,13	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	66 Deg.		65 Degrees					2,14	64 Degrees							2,05	

Distance	26 Degrees ,49								27 Degrees ,51								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,90	0,44	0,90	0,44	0,90	0,45	0,89	0,45	0,89	0,45	0,89	0,46	0,89	0,46	0,89	0,47	1
2	1,80	0,88	1,79	0,89	1,79	0,89	1,79	0,90	1,78	0,91	1,78	0,92	1,77	0,92	1,77	0,93	2
3	2,70	1,32	2,69	1,33	2,69	1,34	2,68	1,35	2,67	1,36	2,67	1,37	2,66	1,39	2,66	1,40	3
4	3,60	1,75	3,59	1,77	3,58	1,79	3,57	1,80	3,56	1,82	3,56	1,83	3,55	1,85	3,54	1,86	4
5	4,49	2,19	4,48	2,21	4,48	2,23	4,47	2,25	4,46	2,27	4,45	2,29	4,44	2,31	4,43	2,23	5
6	5,39	2,63	5,38	2,65	5,37	2,68	5,36	2,70	5,35	2,72	5,33	2,75	5,32	2,77	5,31	2,79	6
7	6,29	3,07	6,28	3,10	6,27	3,12	6,25	3,15	6,24	3,18	6,22	3,21	6,21	3,23	6,20	3,26	7
8	7,19	3,51	7,18	3,54	7,16	3,57	7,14	3,60	7,13	3,63	7,11	3,66	7,10	3,69	7,08	3,73	8
9	8,09	3,95	8,07	3,98	8,05	4,02	8,04	4,05	8,02	4,09	8,00	4,12	7,98	4,16	7,97	4,19	9
10	8,99	4,38	8,97	4,42	8,95	4,46	8,93	4,50	8,91	4,54	8,89	4,58	8,87	4,62	8,85	4,66	10
11	9,89	4,82	9,87	4,87	9,84	4,91	9,82	4,95	9,80	4,99	9,78	5,04	9,76	5,08	9,73	5,12	11
12	10,79	5,26	10,76	5,31	10,74	5,35	10,72	5,40	10,69	5,45	10,67	5,49	10,64	5,54	10,62	5,59	12
13	11,68	5,70	11,66	5,75	11,63	5,80	11,61	5,85	11,58	5,90	11,56	5,95	11,53	6,00	11,51	6,05	13
14	12,58	6,14	12,56	6,19	12,53	6,25	12,50	6,30	12,47	6,36	12,45	6,41	12,42	6,47	12,40	6,52	14
15	13,48	6,58	13,45	6,63	13,42	6,69	13,40	6,75	13,37	6,81	13,34	6,87	13,31	6,93	13,28	6,99	15
16	14,38	7,01	14,35	7,08	14,32	7,14	14,29	7,20	14,26	7,26	14,22	7,33	14,19	7,39	14,16	7,45	16
17	15,28	7,45	15,25	7,52	15,21	7,59	15,18	7,65	15,15	7,72	15,11	7,78	15,08	7,85	15,05	7,92	17
18	16,18	7,89	16,14	7,96	16,11	8,03	16,07	8,10	16,04	8,17	16,00	8,24	15,97	8,31	15,93	8,38	18
19	17,08	8,33	17,04	8,40	17,00	8,48	16,97	8,55	16,93	8,63	16,89	8,70	16,85	8,76	16,82	8,85	19
20	17,98	8,77	17,94	8,85	17,90	8,92	17,86	9,00	17,82	9,08	17,78	9,16	17,74	9,24	17,70	9,31	20
21	18,88	9,21	18,83	9,29	18,79	9,37	18,75	9,45	18,71	9,53	18,67	9,62	18,63	9,70	18,59	9,78	21
22	19,77	9,64	19,73	9,73	19,69	9,82	19,65	9,90	19,60	9,99	19,56	10,07	19,51	10,16	19,47	10,24	22
23	26,67	10,08	20,63	10,17	20,58	10,26	20,54	10,35	20,49	10,44	20,45	10,58	20,40	10,62	20,36	10,71	23
24	21,57	10,52	21,52	10,62	21,48	10,71	21,43	10,80	21,38	10,90	21,34	10,99	21,29	11,08	21,24	11,18	24
25	22,47	10,96	22,42	11,06	22,37	11,16	22,33	11,25	22,28	11,35	22,23	11,45	22,18	11,55	22,13	11,64	25
26	23,37	11,40	23,32	11,50	23,27	11,60	23,22	11,70	23,17	11,80	23,12	11,91	23,06	12,01	23,01	12,11	26
27	24,27	11,84	24,22	11,94	24,16	12,05	24,11	12,15	24,06	12,26	24,00	12,36	23,95	12,47	23,89	12,57	27
28	25,17	12,27	25,11	12,39	25,06	12,49	25,00	12,60	24,95	12,71	24,89	12,82	24,84	12,93	24,78	13,04	28
29	26,07	12,71	26,01	12,83	25,95	12,94	25,90	13,05	25,84	13,17	25,78	13,28	25,72	13,39	25,67	13,60	29
30	26,96	13,15	26,91	13,27	26,85	13,39	26,79	13,50	26,73	13,62	26,67	13,74	26,61	13,85	26,55	13,97	30
31	27,86	13,59	27,80	13,71	27,74	13,83	27,68	13,95	27,62	14,07	27,56	14,19	27,50	14,32	27,44	14,43	31
32	28,76	14,03	28,70	14,15	28,64	14,28	28,58	14,40	28,51	14,53	28,45	14,65	28,38	14,78	28,32	14,90	32
33	29,66	14,47	29,60	14,60	29,53	14,73	29,47	14,85	29,40	14,98	29,34	15,11	29,27	15,24	29,21	15,37	33
34	30,56	14,90	30,49	15,04	30,43	15,17	30,36	15,30	30,29	15,44	30,23	15,57	30,16	15,70	30,09	15,83	34
35	31,46	15,34	31,39	15,48	31,32	15,62	31,25	15,75	31,19	15,89	31,12	16,03	31,05	16,16	30,98	16,30	35
36	32,36	15,78	32,29	15,92	32,22	16,06	32,15	16,20	32,08	16,34	32,01	16,48	31,93	16,62	31,86	16,76	36
37	33,26	16,22	33,18	16,37	33,11	16,51	33,04	16,65	32,97	16,80	32,89	16,94	32,82	17,09	32,75	17,23	37
38	34,15	16,66	34,08	16,81	34,01	16,96	33,93	17,10	33,86	17,25	33,78	17,40	33,71	17,55	33,63	17,70	38
39	35,05	17,10	34,98	17,25	34,90	17,40	34,83	17,55	34,75	17,71	34,67	17,85	34,59	18,00	34,52	18,16	39
40	35,95	17,54	35,88	17,69	35,80	17,85	35,72	18,00	35,64	18,16	35,56	18,31	35,49	18,47	35,40	18,62	40
41	36,85	17,97	36,77	18,13	36,69	18,29	36,61	18,45	36,53	18,61	36,45	18,77	36,37	18,93	36,29	19,09	41
42	37,75	18,41	37,67	18,58	37,59	18,74	37,51	18,90	37,42	19,07	37,34	19,23	37,25	19,39	37,17	19,56	42
43	38,65	18,85	38,57	19,02	38,48	19,19	38,40	19,35	38,31	19,52	38,23	19,69	38,14	19,86	38,06	20,02	43
44	39,55	19,29	39,46	19,46	39,38	19,63	39,29	19,80	39,20	19,98	39,12	20,15	39,03	20,32	38,94	20,49	44
45	40,45	19,73	40,36	19,90	40,27	20,08	40,18	20,26	40,10	20,43	40,01	20,61	39,92	20,78	39,83	20,95	45
46	41,35	20,17	41,26	20,35	41,17	20,53	41,08	20,71	40,99	20,88	40,90	21,06	40,80	21,24	40,71	21,42	46
47	42,24	20,60	42,15	20,79	42,06	20,97	41,97	21,16	41,88	21,34	41,78	21,52	41,69	21,70	41,60	21,89	47
48	43,14	21,04	43,05	21,23	42,96	21,42	42,86	21,61	42,77	21,79	42,67	21,98	42,58	22,16	42,48	22,35	48
49	44,04	21,48	43,95	21,67	43,85	21,86	43,76	22,06	43,66	22,25	43,56	22,44	43,46	22,63	43,37	22,82	49
50	44,94	21,92	44,84	22,12	44,75	22,31	44,65	22,51	44,55	22,70	44,45	22,89	44,35	23,09	44,25	23,28	50
51	45,84	22,36	45,74	22,56	45,64	22,76	45,54	22,96	45,44	23,15	45,35	23,35	45,25	23,55	45,14	23,75	51
52	46,74	22,80	46,64	23,00	46,54	23,20	46,44	23,41	46,33	23,61	46,23	23,81	46,14	24,01	46,02	24,21	52
53	47,64	23,23	47,53	23,44	47,43	23,65	47,32	23,86	47,22	24,06	47,12	24,27	47,03	24,47	46,91	24,68	53
54	48,54	23,67	48,43	23,88	48,33	24,10	48,21	24,31	48,12	24,52	48,01	24,73	47,91	24,94	47,79	25,15	54
55	49,43	24,11	49,33	24,33	49,22	24,54	49,11	24,76	49,01	24,97	48,90	25,19	48,79	25,40	48,68	25,61	55
56	50,33	24,55	50,23	24,77	50,12	24,99	50,00	25,21	49,90	25,42	49,78	25,64	49,68	25,86	49,56	26,08	56
57	51,23	24,99	51,12	25,21	51,01	25,43	50,89	25,66	50,79	25,88	50,67	26,10	50,57	26,32	50,45	26,54	57
58	52,13	25,43	52,02	25,65	51,91	25,88	51,78	26,11	51,68	26,33	51,59	26,56	51,45	26,78	51,33	27,01	58
59	53,03	25,86	52,92	26,10	52,80	26,33	52,68	26,56	52,57	26,79	52,45	27,02	52,33	27,25	52,22	27,48	59
60	53,93	26,30	53,81	26,54	53,70	26,77	53,57	27,01	53,46	27,24	53,34	27,47	53,22	27,71	53,10	27,95	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	64 Deg.		63 Degrees 1,96								62 Degrees 1,88						

Distance	26 Degrees							,49	27 Degrees							,51	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	54,83	26,74	54,71	26,98	54,59	27,22	54,47	27,46	54,35	27,69	54,23	27,93	54,11	28,17	53,98	28,40	61
62	55,73	27,18	55,61	27,42	55,49	27,66	55,37	27,91	55,24	28,15	55,12	28,39	55,00	28,63	54,87	28,87	62
63	56,62	27,62	56,50	27,8[illegible]	56,38	28,11	56,25	28,36	56,13	28,60	56,02	28,85	55,88	29,[illegible]	55,75	29,34	63
64	57,52	28,05	57,40	28,31	57,28	28,56	57,15	28,81	57,03	29,06	56,90	29,30	56,77	29,55	56,64	29,80	64
65	58,42	28,49	58,30	28,75	58,17	29,00	58,04	29,26	57,92	29,51	57,79	29,76	57,66	30,02	57,52	30,27	65
66	59,32	28,93	59,19	29,19	59 07	29,45	58,94	29,71	58,81	29,96	58,68	30,22	58,5[illegible]	30,48	58,41	30,73	66
67	60,22	29,37	60,09	29,63	59,96	29,89	59,83	30,76	59,70	30,42	59,56	30,68	59,43	30,94	59,29	31,20	67
68	61,12	29,81	60,99	30,07	60,86	30,34	60,72	30,61	60,59	30,87	60,45	31,14	60,32	31,40	60,18	31,67	68
69	62,02	30,24	61,89	30,52	61,75	30,79	61,62	31,06	61,48	31,33	61,34	31,59	61,20	31,86	61,06	32,13	69
70	62,92	30,69	62,78	30,96	62,65	31,23	62,51	31,51	62,37	31,78	62,23	32,06	62,09	32,32	61,95	32,59	70
71	63,81	31,12	63,68	31,40	63,54	31,68	63,40	31,96	63,26	32,23	63,12	32,51	62,98	32,79	62,83	33,06	71
72	64,71	31,56	64,58	31,84	64,44	32,13	64,30	32,41	64,15	32,69	64,01	32,97	63,87	33,25	63,72	33,53	72
73	65,61	32,00	65,47	32,29	65,33	32,57	65,19	32,86	65,04	33,14	64,90	33,43	64,75	33,71	64,60	33,99	73
74	66,51	32,44	66,37	32,73	66,23	33,02	66,08	33,31	65,94	33,60	65,79	33,88	65,64	34,17	65,49	34,46	74
75	67,41	32,88	67,27	33,17	67,12	33,46	66,97	33,76	66,83	34,05	66,68	34,34	66,53	34,63	66,37	34,92	75
76	68,31	33,31	68,17	33,61	68,02	33,91	67,87	34,21	67,72	34,50	67,57	34,80	67,41	35,10	67,26	35,39	76
77	69,21	33,75	69,06	34,05	68,91	34,36	68,77	34,66	68,61	34,96	68,45	35,26	68,30	35,56	68,14	35,86	77
78	70,11	34,19	69,96	34,50	69,81	34,80	69,65	35,11	69,50	35,41	69,34	35,72	69,19	36,02	69,03	36,32	78
79	71,01	34,63	70,86	34,9[illegible]	70,70	35,25	70,55	35,56	70,39	35,87	70,23	36,17	70,07	36,48	69,91	36,79	79
80	71,90	35,07	71,75	35,38	71,59	35,70	71,44	36,01	71,28	36,32	71,12	36,63	70,96	36,94	70,80	37,25	80
81	72,80	35,51	72,65	35,8[illegible]	72,49	36,14	72,33	36,46	72,17	36,77	72,01	37,09	71,85	37,40	71,68	37,72	81
82	73,70	35,95	73,54	36,27	73,38	36,59	73,22	36,91	73,06	37,23	72,90	37,55	72,74	37,86	72,57	38,18	82
83	74,60	36,38	74,44	36,71	74,28	37,03	74,12	37,36	73,95	37,68	73,79	38,00	73,62	38,33	73,46	38,65	83
84	75,50	36,82	75,34	37,15	75,17	37,48	75,01	37,81	74,85	38,14	74,68	38,46	74,51	38,79	74,34	39,11	84
85	76,40	37,26	76,24	37,59	76,07	37,93	75,9[illegible]	38,26	75,74	38,59	75,57	38,92	75,40	39,25	75,23	39,58	85
86	77,30	37,70	77,13	38,04	76,96	38,37	76,80	38,71	76,63	39,04	76,46	39,38	76,28	39,71	76,11	40,05	86
87	78,20	38,14	78,03	38,48	77,86	38,82	77,69	39,16	77,52	39,50	77,35	39,84	77,17	40,17	77,00	40,51	87
88	79,10	38,57	78,93	38,92	78,75	39,26	78,58	39,61	78,41	39,95	78,23	40,29	78,06	40,64	77,88	40,98	88
89	79,99	39,01	79,82	39,36	79,65	39,71	79,48	40,06	79,30	40,41	79,13	40,75	78,94	41,10	78,77	41,44	89
90	80,89	39.45	80.72	39.81	80,54	40,16	80,37	40,51	80,19	40,86	80,01	41,21	79,83	41,56	79.65	41,91	90
91	81,79	39,89	81,62	40,25	81,44	40,60	81,26	40,96	81,03	41,31	80,90	41,67	80,72	42,02	80,53	42,37	91
92	82,69	40,33	82,51	40,70	82,33	41,05	82,15	41,41	81,97	41,77	81,79	42,12	81,61	42,48	81,42	42,84	92
93	83,59	40,77	83,41	41,13	83,23	41,50	83,05	41,86	82,86	42,22	82,68	42,58	82,49	42,94	82,30	43,30	93
94	84,49	41,21	84,31	41,57	84,12	41,94	83,94	42,31	83,75	42,68	83,57	43,04	83,38	43,41	83,19	43,77	94
95	85,39	41,64	85,20	42,02	85,02	42,39	84,85	42,76	84,64	43,13	84,46	43,50	84,27	43,87	84,07	44,24	95
96	86,29	42,08	86,10	42,46	85,91	42,83	85,73	43,21	85 5[illegible]	43,59	85,35	43,96	85,15	44,33	84,96	44,70	96
97	87,19	42,52	87,00	42,90	86,81	43,28	86,62	43,66	86,43	44,04	86,24	44,41	86,04	44,79	85,84	45,17	97
98	88,08	42,96	87,89	43,34	87,70	43,73	87,52	44,11	87,32	44,49	87,12	44,87	86,93	45,25	86,73	45,63	98
99	88,98	43,40	88,79	43,78	88,60	44,17	88,41	44,56	88,21	44,95	88,01	45,33	87,81	45,72	87,61	46,10	99
100	89,88	43,84	89,69	44,23	89,49	44,62	89,30	45,01	89,10	45,40	88,90	45,79	88,70	46,18	88,50	46,56	100
101	90,78	44,28	90,58	44,67	90,39	45,07	90,19	45,46	89,99	45,85	89,79	46,25	89,59	46,64	89,38	47,03	101
102	91,68	44,71	91,48	45,11	91,28	45,51	91,08	45,91	90,88	46,31	90,68	46,70	90,48	47,10	90,27	47,49	102
103	92,58	45,15	92,38	45,56	92,18	45,96	91,98	46,36	91,77	46,76	91,57	47,16	91,36	47,56	91,15	47,96	103
104	93,48	45,59	93,28	46,00	93,07	46,40	92,87	46,81	92,67	47,22	92,46	47,60	92,25	48,02	92,04	48.43	104
105	94,37	46,03	94,17	46,44	93.97	46,85	93,76	47,26	93,56	47.68	93,35	48,06	93,14	48,49	92,9[illegible]	48,89	105
106	95,27	46,47	95,07	46,88	94,86	47,30	94,66	47,71	94,45	48,12	94,24	48,54	94,02	48,95	93,81	49,36	106
107	96,17	46,90	95,97	47,32	95,76	47,74	95,55	48,16	95,34	48,59	95,13	48,99	94,91	49,41	94,69	49,82	107
108	97,07	47,34	96,86	47,77	96,65	48,19	96,44	48,61	96,2[illegible]	49,04	96,01	49,45	95,80	49,87	95,58	50,29	108
109	97,97	47,78	97,76	48,21	97,55	48,63	97,34	49,06	97,12	49,49	96,90	49,91	96,68	50,33	96,46	50,76	109
110	98,87	48,22	98,66	48,65	98,44	40,08	98,2[illegible]	49,51	98,0[illegible]	49.94	97,79	50,37	97,57	50,79	97,35	51,22	110
111	99,77	48,65	99,55	49,09	99,34	49,53	99,12	49,96	98,91	50,39	98,68	50,82	98,46	51,26	98,23	51,68	111
112	100,7	49,10	100,5	49,54	100,2	49,97	100,0	50,41	99,80	50,85	99,57	51,28	99,35	51,72	99,12	52,15	112
113	101,6	49,54	101,3	49,98	101,0	50,42	100,9	50,86	100,7	51,30	100,4	51,74	100,2	52,18	100,0	52,62	113
114	102,5	49,97	102,2	50,42	101,9	50,87	101,8	51,31	101,6	51,76	101,3	52,20	101,1	52,64	100,9	53,08	114
115	103,4	50,41	103,1	50,86	102,8	51,31	102,7	51,76	102,5	52,21	102,2	52,66	102,0	53,10	101,8	53,5[illegible]	115
116	104,3	50,85	104,0	51,30	103,7	51,76	103,6	52,21	103,4	52,66	103,1	53,11	102,9	53,57	102,7	54,0[illegible]	116
117	105,2	51,28	104,9	51,75	104,6	52,20	104,5	52,66	104,2	53,12	104,0	53,57	103,8	54,03	103,5	54,45	117
118	106,1	51,72	105,8	52,19	105,5	52,65	105,4	53,11	105,0	53,57	104,9	54,03	104,7	54,49	104,4	54,95	118
119	107,0	52,16	106,7	52,63	106,4	53,10	106,3	53,56	105,9	54,63	105,8	54,49	105,6	54,95	105,3	55,41	119
120	107,9	52,60	107,6	53,08	107,4	53,54	107,2	54,01	106,9	54,48	106,7	54,94	106,4	55,41	106,1	55,87	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	64 Deg.		63 Degrees							1,96	62 Degrees					1,88	

Distance	28 Degrees							,53	29 Degrees							,55	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
1	0,88	0,47	0,88	0,47	0,88	0,48	0,88	0,48	0,88	0,49	0,87	0,49	0,87	0,49	0,87	0,50	1
2	1,77	0,94	1,76	0,95	1,76	0,95	1,75	0,96	1,75	0,97	1,75	1,00	1,74	0,99	1,74	0,99	2
3	2,65	1,41	2,64	1,42	2,64	1,43	2,63	1,44	2,62	1,46	2,62	1,47	2,61	1,48	2,61	1,49	3
4	3,53	1,88	3,52	1,89	3,52	1,91	3,51	1,92	3,50	1,94	3,49	1,96	3,48	1,97	3,47	1,99	4
5	4,42	2,35	4,40	2,37	4,39	2,39	4,38	2,41	4,37	2,43	4,36	2,45	4,35	2,46	4,34	2,48	5
6	5,30	2,82	5,29	2,84	5,27	2,86	5,26	2,89	5,25	2,91	5,25	2,93	5,22	2,96	5,21	2,98	6
7	6,18	3,29	6,17	3,31	6,15	3,34	6,14	3,37	6,12	3,40	6,11	3,42	6,09	3,45	6,08	3,47	7
8	7,06	3,76	7,05	3,79	7,03	3,82	7,01	3,85	6,99	3,88	6,98	3,91	6,96	3,94	6,95	3,97	8
9	7,95	4,23	7,93	4,27	7,91	4,29	7,89	4,33	7,87	4,37	7,85	4,40	7,83	4,43	7,81	4,47	9
10	8,83	4,70	8,81	4,73	8,79	4,77	8,77	4,81	8,75	4,85	8,73	4,89	8,70	4,92	8,68	4,96	10
11	9,71	5,16	9,69	5,21	9,67	5,25	9,64	5,29	9,62	5,33	9,60	5,38	9,57	5,42	9,55	5,46	11
12	10,60	5,63	10,57	5,68	10,55	5,73	10,52	5,77	10,50	5,82	10,47	5,86	10,44	5,91	10,42	5,96	12
13	11,48	6,10	11,45	6,15	11,42	6,20	11,40	6,25	11,37	6,30	11,34	6,35	11,31	6,40	11,29	6,45	13
14	12,36	6,57	12,33	6,63	12,30	6,68	12,28	6,73	12,25	6,79	12,22	6,84	12,18	6,89	12,15	6,95	14
15	13,24	7,04	13,21	7,10	13,18	7,16	13,15	7,22	13,12	7,27	13,09	7,33	13,05	7,39	13,02	7,44	15
16	14,13	7,51	14,10	7,57	14,06	7,63	14,03	7,70	14,00	7,76	13,96	7,82	13,92	7,88	13,99	7,94	16
17	15,01	7,98	14,98	8,05	14,94	8,11	14,91	8,18	14,87	8,24	14,84	8,31	14,79	8,37	14,86	8,44	17
18	15,89	8,45	15,86	8,52	15,82	8,59	15,79	8,66	15,75	8,73	15,71	8,80	15,66	8,86	15,63	8,93	18
19	16,78	8,92	16,74	8,99	16,70	9,07	16,66	9,14	16,62	9,21	16,58	9,29	16,53	9,35	16,49	9,43	19
20	17,66	9,39	17,62	9,46	17,58	9,54	17,54	9,62	17,49	9,70	17,45	9,77	17,41	9,85	17,36	9,92	20
21	18,54	9,86	18,50	9,94	18,46	10,02	18,41	10,10	18,37	10,18	18,32	10,26	18,28	10,34	18,23	10,42	21
22	19,43	10,33	19,38	10,41	19,33	10,50	19,29	10,58	19,24	10,67	19,20	10,75	19,15	10,83	19,10	10,92	22
23	20,31	10,80	20,26	10,89	20,21	10,97	20,17	11,06	20,12	11,15	20,07	11,24	20,02	11,32	19,97	11,41	23
24	21,19	11,27	21,14	11,36	21,09	11,45	21,04	11,54	20,99	11,64	20,94	11,73	20,89	11,82	20,84	11,91	24
25	22,07	11,74	22,02	11,83	21,97	11,93	21,92	12,03	21,87	12,12	21,81	12,22	21,76	12,31	21,70	12,40	25
26	22,96	12,20	22,90	12,30	22,85	12,41	22,79	12,51	22,74	12,61	22,69	12,71	22,63	12,81	22,57	12,90	26
27	23,84	12,67	23,79	12,78	23,73	12,88	23,67	12,99	23,62	13,09	23,57	13,20	23,50	13,29	23,44	13,40	27
28	24,72	13,14	24,67	13,25	24,61	13,36	24,55	13,47	24,49	13,58	24,43	13,68	24,37	13,78	24,31	13,89	28
29	25,61	13,61	25,55	13,72	25,49	13,83	25,43	13,95	25,37	14,06	25,31	14,17	25,24	14,28	25,18	14,39	29
30	26,49	14,08	26,43	14,20	26,37	14,32	26,30	14,43	26,24	14,54	26,18	14,66	26,11	14,77	26,05	14,89	30
31	27,37	14,55	27,31	14,67	27,14	14,79	27,18	14,91	27,11	15,03	27,05	15,15	26,98	15,27	26,91	15,38	31
32	28,26	15,02	28,19	15,14	28,02	15,27	28,06	15,29	27,99	15,51	27,92	15,64	27,85	15,76	27,78	15,88	32
33	29,14	15,49	29,07	15,62	28,90	15,75	28,93	15,87	28,86	16,00	28,80	16,13	28,72	16,25	28,65	16,38	33
34	30,02	15,96	29,95	16,09	29,78	16,22	29,81	16,35	29,74	16,48	29,67	16,61	29,59	16,74	29,52	16,87	34
35	30,90	16,43	30,83	16,57	30,65	16,70	30,69	16,84	30,61	16,96	30,54	17,10	30,46	17,23	30,39	17,37	35
36	31,79	16,90	31,71	17,04	31,54	17,18	31,56	17,32	31,49	17,45	31,42	17,59	31,33	17,73	31,25	17,86	36
37	32,67	17,37	32,59	17,51	32,42	17,65	32,44	17,80	32,36	17,94	32,29	18,08	32,20	18,22	32,12	18,36	37
38	33,55	17,84	33,48	17,98	33,30	18,13	33,32	18,28	33,24	18,42	33,16	18,57	33,07	18,71	32,99	18,86	38
39	34,44	18,31	34,36	18,46	34,18	18,61	34,20	18,76	34,11	18,90	34,03	19,06	33,94	19,20	33,86	19,35	39
40	35,32	18,78	35,24	18,93	35,15	19,09	35,07	19,24	35,00	19,39	34,90	19,54	34,81	19,70	34,73	19,85	40
41	36,20	19,25	36,12	19,41	36,03	19,56	35,95	19,72	35,86	19,88	35,77	20,03	35,68	20,19	35,60	20,35	41
42	37,08	19,72	37,00	19,88	36,91	20,04	36,82	20,20	36,73	20,36	36,65	20,52	36,55	20,68	36,46	20,85	42
43	37,97	20,19	37,88	20,35	37,79	20,52	37,70	20,68	37,60	20,85	37,52	21,01	37,42	21,17	37,33	21,34	43
44	38,85	20,66	38,76	20,83	38,67	20,99	38,58	21,16	38,48	21,33	38,39	21,50	38,29	21,67	38,20	21,83	44
45	39,73	21,12	39,64	21,30	39,55	21,47	39,45	21,65	39,35	21,82	39,27	21,99	39,16	22,16	39,07	22,33	45
46	40,62	21,59	40,52	21,77	40,43	21,95	40,33	22,13	40,23	22,30	40,14	22,48	40,03	22,65	39,94	22,83	46
47	41,50	22,07	41,40	22,24	41,31	22,43	41,21	22,61	41,11	22,80	41,01	22,97	40,90	23,14	40,80	23,32	47
48	42,38	22,54	42,28	22,72	42,19	22,90	42,09	23,09	41,98	23,28	41,88	23,46	41,77	23,64	41,67	23,82	48
49	43,26	23,00	43,17	23,19	43,06	23,38	42,96	23,57	42,85	23,77	42,76	23,95	42,64	24,13	42,54	24,31	49
50	44,15	23,47	44,05	23,67	43,94	23,86	43,84	24,05	43,73	24,24	43,63	24,43	43,52	24,62	43,41	24,81	50
51	45,03	23,94	44,93	24,14	44,82	24,34	44,71	24,53	44,61	24,73	44,50	24,93	44,39	25,11	44,28	25,31	51
52	45,91	24,41	45,81	24,61	45,70	24,81	45,59	25,01	45,48	25,61	45,37	25,42	45,26	25,61	45,15	25,80	52
53	46,80	24,88	46,69	25,09	46,58	25,29	46,47	25,49	46,36	25,70	46,24	25,91	46,13	26,10	46,01	26,30	53
54	47,68	25,35	47,57	25,56	47,46	25,77	47,35	25,97	47,23	26,18	47,12	26,40	47,00	26,59	46,88	26,80	54
55	48,56	25,82	48,45	26,03	48,34	26,24	48,22	26,46	48,11	26,67	47,99	26,89	47,87	27,08	47,75	27,29	55
56	49,45	26,29	49,33	26,50	49,22	26,72	49,10	26,94	48,98	27,15	48,86	27,37	48,74	27,57	48,62	27,79	56
57	50,33	26,76	50,21	26,97	50,09	27,20	49,98	27,42	49,85	27,64	49,74	27,86	49,61	28,07	49,49	28,28	57
58	51,21	27,23	51,09	27,46	50,97	27,67	50,85	27,90	50,73	28,12	50,61	28,35	50,48	28,56	50,35	28,78	58
59	52,10	27,70	51,97	27,92	51,85	28,15	51,73	28,38	51,60	28,61	51,48	28,84	51,35	29,05	51,22	29,28	59
60	52,98	28,17	52,85	28,40	52,73	28,63	52,60	28,86	52,48	29,09	52,35	29,32	52,22	29,55	52,09	29,77	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	62 Deg.		61 Degrees						1,80		60 Degrees					1,73	

Distance	28 Degrees ,53								29 Degrees ,55								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	53,86	28,64	53,73	28,87	53,61	29,11	53,48	29,34	53,35	29,57	53,22	29,81	53,09	30,04	52,96	30,27	61
62	54,74	29,11	54,62	29,35	54,49	29,58	54,36	29,82	54,23	30,06	54,10	30,29	53,96	30,53	53,83	30,77	62
63	55,63	29,58	55,50	29,82	55,37	30,06	55,24	30,30	55,10	30,54	54,97	30,78	54,83	31,02	54,70	31,26	63
64	56,51	30,04	56,38	30,29	56,25	30,54	56,11	30,78	55,98	31,03	55,84	31,27	55,70	31,51	55,56	31,76	64
65	57,39	30,51	57,26	30,76	57,12	31,02	56,99	31,26	56,85	31,51	56,72	31,76	56,57	32,01	56,43	32,25	65
66	58,28	30,98	58,14	31,24	57,99	31,49	57,87	31,75	57,73	32,00	57,59	32,25	57,44	32,50	57,30	32,75	66
67	59,16	31,45	59,04	31,70	58,87	31,97	58,74	32,23	58,60	32,48	58,46	32,74	58,31	32,99	58,17	33,25	67
68	60,04	31,92	59,90	32,18	59,75	32,45	59,62	32,71	59,48	32,97	59,33	33,23	59,18	33,48	59,04	33,74	68
69	60,92	32,39	60,78	32,66	60,63	32,92	60,50	33,19	60,35	33,45	60,21	33,72	60,05	33,97	59,90	34,24	69
70	61,81	32,86	61,66	33,13	61,52	33,40	61,37	33,67	61,22	33,94	61,08	34,20	60,03	34,41	60,77	34,74	70
71	62,69	33,33	62,54	33,61	62,40	33,88	62,25	34,15	62,09	34,42	61,95	34,69	61,80	34,96	61,64	35,23	71
72	63,57	33,80	63,42	34,08	63,28	34,36	63,13	34,63	62,97	34,91	62,82	35,18	62,67	35,45	62,51	35,73	72
73	64,46	34,27	64,31	34,55	64,15	34,83	64,00	35,11	63,84	35,30	63,69	35,67	63,54	35,95	63,38	36,22	73
74	65,34	34,74	65,19	35,02	65,03	35,31	64,88	35,59	64,72	35,88	64,57	36,16	64,41	36,44	64,25	36,72	74
75	66,22	35,21	66,07	35,50	65,91	35,79	65,76	36,03	65,59	36,35	65,44	36,65	65,28	36,93	65,11	37,22	75
76	67,11	35,68	66,95	35,97	66,79	36,26	66,63	36,56	66,47	36,85	66,31	37,14	66,15	37,42	65,98	37,71	76
77	67,99	36,15	67,83	36,44	67,67	36,74	67,51	37,04	67,35	37,33	67,19	37,63	67,02	37,91	66,85	38,21	77
78	68,87	36,62	68,71	36,92	68,55	37,22	68,39	37,52	68,22	37,82	68,06	38,11	67,89	38,41	67,72	38,70	78
79	69,75	37,08	69,59	37,39	69,42	37,69	69,26	38,00	69,09	38,30	68,93	38,60	68,76	38,90	68,59	9,20	79
80	70,64	37,56	70,47	37,87	70,31	38,17	70,14	38,48	69,97	38,78	69,80	9,09	69,63	39,39	69,46	39,70	80
81	71,52	38,03	71,35	38,34	71,19	38,65	71,02	38,96	70,85	39,27	70,67	39,58	70,50	39,89	70,32	[illegible]	81
82	72,40	38,50	72,23	38,81	72,06	39,13	71,89	39,44	71,71	39,75	71,55	40,07	71,37	40,38	71,19	40,69	82
83	73,29	38,97	73,11	39,29	72,94	39,61	72,77	39,02	72,59	40,24	72,42	40,56	72,24	40,87	72,06	41,19	83
84	74,17	39,43	74,00	39,76	73,82	40,08	73,65	40,40	73,40	40,72	73,39	41,04	73,11	41,36	72,93	41,68	84
85	75,05	39,90	74,88	40,23	74,70	40,56	74,52	40,88	74,34	41,21	74,17	41,53	73,98	41,85	73,80	42,18	85
86	75,93	40,37	75,76	40,70	75,58	41,04	75,40	41,37	75,21	41,70	75,04	42,02	74,85	42,35	74,66	42,67	86
87	76,82	40,84	76,64	41,18	76,46	41,51	76,28	41,85	76,09	42,18	75,91	42,51	75,72	42,84	75,53	43,17	87
88	77,70	41,31	77,52	41,65	77,34	41,99	77,17	42,33	76,96	42,67	76,78	43,00	76,59	43,33	76,40	43,67	88
89	78,58	41,78	78,40	42,12	78,22	42,47	78,03	4 ,81	77,84	43,15	77,65	43,49	77,46	43,82	77,27	44,16	89
90	79,47	42,25	79,28	42,60	79,09	42,94	78,91	43,29	78,72	43,63	78,53	43,97	78,33	44,32	78,14	44,66	90
91	80,35	42,72	80,16	43,07	79,97	43,42	79,78	43,77	79,59	44,12	79,40	44,46	79,20	44,81	79,01	45,16	91
92	81,23	43,19	81,04	43,55	80,85	43,90	80,66	44,25	80,47	44,60	80,27	44,95	80,07	45,30	79,87	45,65	92
93	82,12	43,66	81,92	44,02	81,73	44,38	81,54	44,73	81,34	45,09	81,14	45,44	80,94	45,79	80,74	46,15	93
94	83,00	44,13	82,80	44,49	82,61	44,85	82,41	45,21	82,22	45,57	82,02	45,93	81,81	46,29	81,61	46,64	94
95	83,88	44,60	83,69	44,96	83,49	45,33	83,29	45,69	83,09	46,06	82,89	46,42	82,68	46,78	82,48	47,14	95
96	84,76	45,07	84,57	45,44	84,37	45,81	84,17	46,18	83,97	46,54	83,76	46,91	83,55	47,27	83,33	47,63	96
97	85,65	45,54	85,45	45,91	85,25	46,28	85,05	46,66	84,84	47,03	84,64	47,40	84,42	47,76	84,21	48,13	97
98	86,53	46,00	86,33	46,38	86,13	46,76	85,92	47,14	85,72	47,51	85,51	47,89	85,29	48,25	85,08	48,63	98
99	87,41	46,47	87,21	46,86	87,01	47,24	86,80	47,62	86,59	48,00	86,38	48,38	86,16	48,75	85,95	49,12	99
100	88,30	46,95	88,09	47,33	87,88	47,72	87,67	48,10	87,46	48,48	87,25	48,86	87,04	49,24	86,82	49,62	100
101	89,18	47,42	88,97	47,81	88,76	48,19	88,55	48,58	88,34	48,97	88,12	49,35	87,91	49,73	87,69	50,12	101
102	90,06	47,89	89,85	48,28	89,65	48,67	89,43	49,06	89,21	49,45	89,00	49,84	88,78	50,23	88,56	50,61	102
103	90,94	48,35	90,73	48,75	90,52	49,15	90,30	49,54	90,09	49,94	89,87	50,33	89,65	50,72	89,42	51,11	103
104	91,83	48,82	91,61	49,22	91,40	49,62	91,18	50,02	90,96	50,42	90,74	50,82	90,52	51,2	90,29	51,61	104
105	92,71	49,29	92,49	49,70	92,28	50,10	92,06	50,50	91,84	50,91	91,61	51,31	91,39	51,70	91,16	52,10	105
106	93,59	49,76	93,38	50,17	93,16	50,58	92,94	50,99	92,71	51,39	92,49	51,80	92,26	52,19	92,03	52,60	106
107	94,48	50,23	94,26	50,64	94,04	51,06	93,81	51,47	93,59	51,88	93,36	52,28	93,13	52,69	92,90	53,09	107
108	95,36	50,70	95,14	51,12	94,91	51,53	94,69	51,95	94,46	52,36	94,24	52,77	94,02	53,18	93,76	53,59	108
109	96,24	51,17	96,02	51,59	95,79	52,01	95,57	52,43	95,34	52,85	95,11	53,26	94,87	53,67	94,65	54,09	109
110	97,13	51,64	96,90	52,07	96,67	52,49	96,44	52,91	96,21	53,33	95,98	53,75	95,74	54,17	95,50	54,58	110
111	98,01	52,11	97,78	52,54	97,55	52,97	97,32	53,39	97,08	53,81	96,85	54,24	96,61	54,66	96,37	55,08	111
112	98,89	52,58	98,66	53,01	98,43	53,44	98,10	53,87	97,96	54,30	97,72	54,73	97,48	55,15	97,24	55,58	112
113	99,77	53,05	99,54	53,48	99,31	53,92	99,07	54,35	98,83	54,78	98,59	55,21	98,35	55,64	98,11	56,07	113
114	100,7	53,52	100,4	53,96	100,2	54,40	99,95	54,83	99,71	55,27	99,47	55,70	99,22	56,13	98,97	56,57	114
115	101,5	53,99	101,3	54,43	101,1	54,47	100,8	55,31	100,6	55,75	100,3	56,19	100,1	56,63	99,84	57,06	115
116	102,4	54,46	102,2	54,90	101,0	55,35	101,7	55,80	101,5	56,24	101,2	56,68	101,0	57,12	100,7	57,56	116
117	103,3	54,93	103,1	55,38	102,8	55,83	102,6	6,28	102,3	56,72	102,1	57,17	101,8	57,61	101,6	58,06	117
118	104,2	55,09	103,9	55,85	103,7	56,30	103,5	56,76	103,2	57,21	103,0	57,66	102,7	58,10	102,4	58,55	118
119	105,1	55,56	104,8	56,32	104,6	56,78	104,3	57,24	104,1	57,69	103,8	58,15	103,6	58,59	103,3	59,05	119
120	106,0	56,34	105,7	56,80	105,5	57,26	105,2	57,72	105,0	58,18	104,7	58,64	104,4	59,09	104,2	59,55	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Distance
	0 Min.		45 Min		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	62 Deg.		61 Degrees 1,80								60 Degrees 1,73						

Digitized by Google

Distance	30 Degrees ,58								31 Degrees ,60								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,87	0,50	0,86	0,50	0,86	0,51	0,86	0,51	0,86	0,51	0,85	0,52	0,85	0,52	0,85	0,53	1
2	1,73	1,00	1,73	1,00	1,72	1,01	1,72	1,02	1,71	1,03	1,71	1,04	1,70	1,04	1,70	1,05	2
3	2,60	1,50	2,59	1,51	2,58	1,52	2,58	1,53	2,57	1,54	2,56	1,56	2,56	1,57	2,55	1,58	3
4	3,46	2,00	3,45	2,01	3,45	2,03	3,44	2,04	3,43	2,06	3,42	2,07	3,41	2,09	3,40	2,10	4
5	4,33	2,50	4,32	2,52	4,31	2,54	4,28	2,56	4,29	2,57	4,27	2,59	4,26	2,61	4,25	2,63	5
6	5,20	3,00	5,18	3,02	5,17	3,04	5,16	3,07	5,14	3,09	5,13	3,11	5,12	3,13	5,10	3,16	6
7	6,06	3,50	6,05	3,53	6,03	3,55	6,02	3,58	6,00	3,60	5,98	3,63	5,97	3,66	5,95	3,68	7
8	6,93	4,00	6,91	4,03	6,89	4,06	6,88	4,09	6,86	4,12	6,84	4,15	6,82	4,18	6,80	4,21	8
9	7,79	4,50	7,77	4,53	7,75	4,57	7,73	4,60	7,71	4,63	7,69	4,67	7,67	4,70	7,65	4,74	9
10	8,66	5,00	8,64	5,04	8,62	5,07	8,59	5,11	8,57	5,15	8,55	5,19	8,53	5,22	8,50	5,26	10
11	9,53	5,50	9,50	5,54	9,48	5,58	9,45	5,62	9,43	5,66	9,40	5,71	9,38	5,75	9,35	5,79	11
12	10,39	6,00	10,35	6,04	10,34	6,09	10,31	6,13	10,29	6,18	10,26	6,22	10,23	6,27	10,20	6,31	12
13	11,26	6,50	11,23	6,55	11,20	6,60	11,17	6,65	11,14	6,6	11,11	6,74	11,08	6,79	11,05	6,84	13
14	12,12	7,00	12,09	7,05	12,06	7,10	12,03	7,16	12,00	7,21	11,97	7,26	11,94	7,32	11,90	7,37	14
15	12,99	7,50	12,96	7,56	12,93	7,61	12,89	7,67	12,86	7,72	12,82	7,78	12,79	7,84	12,75	7,89	15
16	13,86	8,00	13,82	8,06	13,79	8,12	13,75	8,18	13,71	8,24	13,68	8,30	13,64	8,36	13,60	8,42	16
17	14,72	8,50	14,69	8,56	14,68	8,63	14,61	8,69	14,57	8,75	14,53	8,82	14,50	8,88	14,45	8,94	17
18	15,59	9,00	15,55	9,07	15,51	9,14	15,47	9,20	15,43	9,27	15,39	9,34	15,35	9,40	15,30	9,47	18
19	16,45	9,50	16,41	9,57	16,37	9,65	16,33	9,71	16,28	9,78	16,24	9,86	16,20	9,93	16,15	10,00	19
20	17,32	10,00	17,28	10,07	17,23	10,15	17,19	10,23	17,14	10,30	17,10	10,37	17,05	10,45	17,01	10,52	20
21	18,19	10,50	18,14	10,58	18,09	10,66	18,05	10,74	18,0	10,82	17,95	10,89	17,91	10,97	17,86	11,05	21
22	19,05	11,00	19,00	11,08	18,96	11,17	18,91	11,25	18,86	11,33	18,81	11,41	18,76	11,50	18,71	11,58	22
23	19,92	11,50	19,87	11,59	19,82	11,67	19.76	11,76	19,71	11,85	19,66	11,93	19,61	12,02	19,56	12,10	23
24	20,78	12,00	20,73	12,09	20,68	12,18	20,62	12,27	20,57	12,36	20,52	12,45	20,46	12,54	20,41	12,63	24
25	21,65	12,50	21,60	12,59	21,54	12,69	21,48	12,78	21,43	12,88	21,37	12,97	21,32	13,06	21,26	13,15	25
26	22,52	13,00	22,46	13,10	22,40	13,20	22,34	13,29	22,28	13,39	22,23	13,49	22,17	13,59	22,11	13,68	26
27	23,38	13,50	23,32	13,60	23,27	13,71	23,20	13,80	23,14	13,91	23,08	14,01	23,02	14,11	22,96	14,21	27
28	24,25	14,00	24,19	14,11	24,13	14,21	24,06	14,31	24,00	14,42	23,94	14,53	23,88	14,63	23,81	14,73	28
29	25,11	14,50	25,05	14,61	24,99	14,72	24,92	14,82	24,86	14,94	24,79	15,05	24,73	15,16	24,66	15,26	29
30	25,98	15,00	25,91	15,11	25,85	15,22	25,78	15,34	25,71	15,45	25,65	15,56	25,58	15,67	25,51	15,79	30
31	26,85	15,50	26,78	15,62	26,71	15,73	26,64	15,85	26,57	15,97	26,50	16,08	26,43	16,20	26,36	16,31	31
32	27,71	16,00	27,64	16,12	27,57	16,24	27,50	16,36	27,43	16,48	27,36	16,60	27,28	16,72	27,21	16,84	32
33	28,58	16,50	28,51	16,62	28,43	16,75	28,36	16,87	28,29	17,00	28,21	17,12	28,14	17,24	28,06	17,36	33
34	29,44	17,00	29,37	17,13	29,30	17,26	29,22	17,38	29,14	17,51	29,07	17,64	28,99	17,77	28,91	17,89	34
35	30,31	17,50	30,23	17,63	30,16	17,77	30,08	17,89	30,00	18,03	29,92	18,16	29,84	18,29	29,76	18,41	35
36	31,18	18,00	31,10	18,14	31,02	18,27	30,94	18,40	30,86	18,54	30,78	18,68	30,70	18,81	30,61	18,94	36
37	32,04	18,50	31,96	18,64	31,88	18,78	31,79	18,92	31,71	19,06	31,63	19 20	31,55	19,34	31,46	19,47	37
38	32,91	19,00	32,83	19,14	32,74	19,29	32,65	19,43	32,57	19,57	32,49	19,71	32,40	19,86	32,31	19,99	38
39	33,77	19,50	33,69	19,65	33,60	19,80	33,51	19,94	33,43	20,09	33,44	20,23	33,26	20,38	33 16	20,52	39
40	34,64	20,00	34,55	20,15	34,46	20,30	34,38	20 45	34,29	20,60	34,20	20,75	34,11	20,90	34,01	21,05	40
41	35,51	20,50	35,42	20,65	35,33	20,81	35,23	20,96	35,14	21,12	35,05	21,27	34,96	21,42	34,86	21,57	41
42	36,37	21,00	36,28	21,16	36,19	21,32	36,09	21,47	36,00	21,63	35,92	21,79	35,81	21,95	35,71	22,10	42
43	37,24	21,50	37,15	21,66	37,05	21,83	36,95	21,98	36,86	22,15	36,76	22,31	36,66	22,47	36,56	22,63	43
44	38,10	22,00	38,01	22,17	37,91	22,33	37,81	22,48	37,71	22,66	37,62	22,83	37,52	22,99	37,41	23,15	44
45	38,97	22,50	38,87	22,67	38,77	22,84	38,67	22,99	38,57	23,18	38,47	23,35	38,37	23,51	38,26	23,68	45
46	39,84	23,00	39,74	23,17	39,64	23,35	39,53	23,50	39,43	23,69	39,33	23,86	39,22	24,04	39,11	24,20	46
47	40,70	23,50	40,60	23,68	40,50	23,86	40,39	24,01	40,29	24,21	40,18	24,38	40,08	24,56	39,96	24,73	47
48	41,57	24,00	41,47	24,18	41,36	24,36	41,25	24,52	41,14	24,72	41,04	24,90	40,93	25,08	40,81	25,26	48
49	42,43	24,50	42,33	24,69	42,22	24,86	42,11	25,03	42,00	25,24	41,89	25,42	41,78	25,61	41,66	25,78	49
50	43,30	25 00	43,16	25,19	43,08	25,36	42 97	25,56	42,86	25,75	42,75	25,9	42,64	26,12	42,52	26,31	50
51	44,16	25,50	44,06	25,69	43, 4	25,88	43,83	26,08	43,72	26,27	43,60	26,46	43,48	26,65	43,37	26,84	51
52	45,03	26,00	44,92	26,20	44,81	26,39	44,69	26,59	44,57	26,77	44,46	26,98	44,34	27,17	44,22	27,36	52
53	45,90	26,50	45,78	26,70	45,67	26 90	45,55	27,10	45,45	27,29	45,31	27,50	45,19	27,69	45,07	27,89	53
54	46,76	27,00	46,65	27,20	46,53	27·41	46,41	27,61	46,29	27,80	46,17	28,01	46,04	28,22	45,92	28,41	54
55	47,63	27,50	47,51	27,71	47,39	27,92	47,27	28,12	47,14	28,32	47,02	28,53	46,90	28,74	46,77	28,94	55
56	48,50	28,00	48,38	28,21	48,25	28,42	48,12	28,63	48,00	28,85	47,88	29,05	47,75	29,26	47,62	29,47	56
57	49,36	28,50	49,24	28,72	49,12	28,93	48,98	29,14	48,86	29,35	48,73	29,57	48,60	29,79	48,47	30,00	57
58	50,23	29,00	50,10	29,22	49,98	29,44	49,84	29,65	49,71	29,86	49,59	30,09	49,46	30,31	49,32	30,52	58
59	51,10	29,50	50,97	29,72	50,84	29,95	50,70	30,16	50,57	30,38	50,44	30,61	50,31	30,83	50,17	31,04	59
60	51,96	30,00	51,83	30,23	51,70	30,45	51,56	30,68	51,43	30,92	51,29	31,13	51,16	31,35	51,02	31,57	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	60 Deg.		59 Degrees 1,66								58 Degree 1,60						

Distance	30 Degrees ,58								31 Degrees ,60								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	52,83	30,50	52,69	30,73	52,56	30,96	52,42	31,19	52,29	31,42	52,15	31,64	52,01	31,87	51,87	32,10	61
62	53,69	31,00	53,56	31,23	53,42	31,47	53,28	31,70	53,14	31,93	53,00	32,16	52,80	32,40	52,72	32,62	62
63	54,56	31,50	54,42	31,74	54,28	31,98	54,14	32,21	54,00	32,45	53,86	32,68	53,72	32,92	53,57	33,15	63
64	55,43	32,00	55,29	32,24	55,15	32,48	55,00	32,72	54,86	32,96	54,71	33,20	54,57	33,44	54,42	33,68	64
65	56,29	32,50	56,15	32,75	56,01	32,99	55,86	33,23	55,71	33,48	55,57	33,72	55,42	33,96	55,27	34,20	65
66	57,16	33,00	57,01	33,25	56,87	33,50	56,72	33,74	56,57	33,99	56,42	34,24	56,28	34,49	56,12	34,73	66
67	58,02	33,50	57,88	33,75	57,73	34,01	57,58	34,25	57,43	34,51	57,28	34,76	57,13	35,01	56,97	35,25	67
68	58,89	34,00	58,74	34,26	58,59	34,52	58,44	34,76	58,29	35,02	58,13	35,28	57,98	35,53	57,82	35,78	68
69	59,76	34,50	59,61	34,76	59,46	35,02	59,30	35,28	59,14	35,54	58,99	35,80	58,83	36,06	58,67	36,31	69
70	60,62	35,00	60,47	35,26	60,31	35,53	60,16	35,79	60,00	36,05	59,84	36,31	59,68	36,57	59,52	36,83	70
71	61,49	35,50	61,33	35,77	61,18	36,04	61,02	36,30	60,86	36,57	60,70	36,83	60,54	37,09	60,37	37,36	71
72	62,35	36,00	62,20	36,27	62,04	36,54	61,88	36,81	61,72	37,08	61,55	37,35	61,39	37,62	61,22	37,89	72
73	63,22	36,50	63,06	36,78	62,90	37,05	62,74	37,32	62,57	37,60	62,41	37,87	62,24	38,14	62,07	38,41	73
74	64,09	37,00	63,92	37,28	63,76	37,56	63,59	37,83	63 42	38,11	63,26	38,39	63,10	38,67	62,92	38,94	74
75	64,95	37,50	64,79	37,78	64,62	38,07	64,45	38,34	64,28	38,63	64,12	38,91	63,95	39,19	63,77	39,46	75
76	65,82	38,00	65,65	38,29	65,49	38,58	65,31	38,86	65,13	39,14	64,97	39,43	64,82	39,71	64,62	39,99	76
77	66,68	38,50	66,52	38,79	66,35	39,08	66,17	39,37	65,99	39,66	65,83	39,95	65,66	40,23	65,47	40,52	77
78	67,55	39,00	67,38	39,30	67,21	39,59	67,03	39,88	66,86	40,17	66,68	40,47	66,51	40,76	66,32	41,04	78
79	68,42	39,50	68,24	39,80	68,07	40,10	67,89	40,39	67,70	40,69	67,54	40,98	67,36	41,28	67,17	41,57	79
80	69,28	40,00	69,11	40,30	68,93	40,60	68,75	40,90	68,57	41,20	68,39	41,50	68,21	41,80	68,03	42,10	80
81	70,15	40,50	69,97	40,81	69,79	41,11	69,61	41,41	69,43	41,72	69,25	42,02	69,06	42,32	68,88	42,62	81
82	71,01	41,00	70,83	41,31	70,65	41,62	70,47	41,92	70,29	42,23	70,10	42,54	69,92	42,85	69,73	43,15	82
83	71,88	41,50	71,70	41,81	71,52	42,13	71,33	42,44	71,14	42,75	70,96	43,06	70,77	43,37	70,58	43,67	83
84	72,75	42,00	72,56	42,32	72,38	42,63	72,19	42,95	72,00	43,26	71,81	43,58	71,62	43,89	71,43	44,20	84
85	73,61	42,50	73,43	42,82	73,24	43,14	73,05	43,46	72,86	43,78	72,67	44,10	72,48	44,41	72,28	44,73	85
86	74,48	43,00	74,29	43,32	74,10	43,65	73,91	43,97	73,72	44,29	73,52	44,62	73,33	44,94	73,13	45,25	86
87	75,34	43,50	75,15	43,83	74,96	44,16	74,77	44,48	74,57	44,81	74,38	45,13	74,18	45 46	73,98	45,78	87
88	76,21	44,00	76,02	44,33	75,83	44,67	75,62	44,99	75,43	45,32	75,23	45,65	75,03	45,98	74,83	46,30	88
89	77,08	44,50	76,88	44,84	76,69	45,17	76,48	45,50	76,29	45,84	76,09	46,17	75,89	46,51	75,68	46,83	89
90	77,94	45,00	77,75	45,34	77,55	45,68	77,35	46,02	77,14	46,35	76,94	46,69	76,74	47,02	76,53	47,36	90
91	78,81	45,50	78,61	45,84	78,41	46,19	78,21	46,53	78,00	46,87	77,80	47,21	77,59	47,55	77,38	47,88	91
92	79,67	46,00	79,47	46,35	79,27	46,69	79,06	47,04	78,86	47,38	78,65	47,73	78,44	48,07	78,23	48,41	92
93	80,54	46,50	80,34	46,85	80,13	47,20	79,92	47,55	79,72	47,90	79,51	48,24	79,30	48,59	79,08	48,94	93
94	81,41	47,00	81,20	47,35	80,99	47,71	80,78	48,06	80,57	48,41	80,36	48,76	80,15	49,12	79,93	49,46	94
95	82,27	47,50	82,07	47,86	81,86	48,22	81,64	48,57	81,43	48,92	81,22	49,28	81,01	49,64	80,78	49,99	95
96	83,14	48,00	82,93	48,36	82,73	48,73	82,50	49,08	82,29	49,44	82,07	49,80	81,86	50,16	81,63	50,52	96
97	84,00	48,50	83,79	48,87	83,58	49,23	83,36	49,59	83,14	49,96	82,93	50,32	82,71	50,69	82,48	51,04	97
98	84,87	49,00	84,66	49,37	84,44	49,74	84,22	50,10	84,00	50,47	83,78	50,84	83,57	51,21	83,33	51,57	98
99	85,74	49,50	85,52	49,87	85,29	50,25	85,08	50,61	84,86	50,99	84,64	51,36	84,42	51,73	84,18	52,09	99
100	86,60	50,00	86,38	50,38	86,16	50,75	85,94	51,13	85,72	51,50	85,49	51,88	85,26	52,25	85,03	52,62	100
101	87,47	50,50	87,25	50,88	87,02	51,26	86,80	51,64	86,57	52,02	86,35	52,40	86,12	52,77	85,88	53,15	101
102	88,33	51,00	88,11	51,38	87,89	51,77	87,66	52,15	87,43	52,53	87,20	52,91	86,97	53,30	86,73	53,67	102
103	89,20	51,50	88,98	51,89	88,75	52,28	88,52	52,66	88,29	53,05	88,06	53,43	87,82	53,82	87,58	54,20	103
104	90,07	52,00	89,84	52,39	89,61	52,79	89,38	53,17	89,14	53,56	88,91	53,95	88,68	54,34	88,43	54,72	104
105	90,93	52,50	90,70	52,90	90,47	53,29	90,24	53,68	90,00	54,08	89,77	54,47	89,53	54,87	89,28	55,25	.05
106	91,80	53,00	91,57	53,40	91,33	53,80	91,09	54,19	90,86	54,59	90,62	54,99	90,38	55,39	90,13	55,78	106
107	92,66	53,50	92,43	53,90	92,20	54,31	91,95	54,71	91,72	55,11	91,48	55,51	91,23	55,91	90,98	56,30	107
108	93,53	54,00	93,30	54,41	93,06	54,82	92,81	55,22	92,57	55,62	92,33	56,03	92,09	56,43	91,83	56,83	108
109	94,40	54,50	94,16	54,91	93,92	55,33	93,67	55,73	93,43	56,14	93 19	56,55	92,94	56,96	92,68	57,35	109
110	95,26	55,00	95,02	55,41	94,78	55,83	94,53	56,24	94,29	56,65	94,04	57,06	93,79	57,47	93,54	57,88	110
111	96,13	55,50	95,89	55,92	95,64	56,34	95,39	56,75	95,15	57,18	94,89	57,58	94,64	58,00	94,39	58,41	111
112	96,99	56,00	96,75	56,42	96,50	56,84	96,25	57,26	96,00	57,68	95,75	58,10	95,50	58,52	95,24	58,93	112
113	97,86	56,50	97,61	56,93	97,36	57,35	97,11	57,77	96,86	58,20	96,60	58,62	96,35	59,04	96,09	59,46	113
114	98,73	57,00	98,48	57,43	98,23	57,86	97,97	58,29	97,72	58,71	97,46	59,14	97,20	59,57	96,94	59,99	114
115	99,59	57,50	99,34	57,93	99,09	58,37	98,83	58,80	98,57	59,23	98,31	59,66	98,05	60,09	97,79	60,51	115
116	100,5	58,00	100,2	58,44	99,95	58,88	99,69	59,31	99,43	59,74	99,17	60,18	98,91	60,61	98,64	61,04	116
117	101,3	58,50	101,1	58,94	100,8	59,38	100,5	59,82	100,3	60,26	100,0	60,70	99,76	61,14	99,49	61,56	117
118	102,2	59,00	101,9	59,45	101,7	59,89	101,4	60,33	101,1	60,77	100,8	61,22	100,6	61,66	100,3	62,09	118
119	103,1	59,50	102,8	59,95	102,5	60,40	102,3	60,84	102,0	61,29	101,7	61,74	101,5	62,18	101,2	62,62	119
120	104,0	60,00	103,7	60,45	103,4	60,90	103,1	61,35	102,9	61,89	102,6	62,25	102,3	62,70	102,0	63,14	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	60 Deg.		59 Degrees				1,66				58 Degrees				1,60		

Digitized by Google

Distance	32 Degrees ,62								33 Degrees ,65								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
1	0,85	0,53	0,85	0,53	0,84	0,54	0,84	0,54	0,84	0,54	0,84	0,55	0,83	0,55	0,83	0,56	1
2	1,70	1,06	1,69	1,07	1,69	1,07	1,68	1,08	1,68	1,09	1,67	1,10	1,67	1,10	1,66	1,11	2
3	2,54	1,59	2,54	1,60	2,53	1,61	2,52	1,62	2,52	1,63	2,51	1,64	2,50	1,66	2,49	1,67	3
4	3,39	2,12	3,38	2,13	3,37	2,15	3,36	2,16	3,35	2,18	3,34	2,19	3,34	2,21	3,33	2,22	4
5	4,24	2,65	4,23	2,67	4,22	2,69	4,20	2,79	4,19	2,72	4,18	2,74	4,17	2,76	4,16	2,78	5
6	5,09	3,18	5,07	3,20	5,06	3,22	5,05	3,25	5,03	3,27	5,02	3,29	5,00	3,31	4,99	3,33	6
7	5,94	3,71	5,92	3,73	5,90	3,76	5,89	3,78	5,87	3,81	5,85	3,84	5,84	3,86	5,82	3,89	7
8	6,78	4,24	6,77	4,27	6,75	4,30	6,73	4,33	6,71	4,36	6,69	4,39	6,67	4,42	6,65	4,45	8
9	7,63	4,77	7,61	4,80	7,59	4,84	7,57	4,87	7,55	4,90	7,53	4,93	7,50	4,97	7,48	5,00	9
10	8,48	5,30	8,46	5,34	8,43	5,37	8,41	5,41	8,39	5,45	8,36	5,48	8,34	5,52	8,32	5,56	10
11	9,33	5,83	9,30	5,87	9,27	5,91	9,25	5,95	9,22	5,99	9,20	6,03	9,17	6,07	9,15	6,11	11
12	10,18	6,36	10,15	6,40	10,12	6,45	10,09	6,49	10,06	6,54	10,03	6,58	10,01	6,62	9,98	6,67	12
13	11,02	6,89	10,99	6,94	10,96	6,98	10,93	7,03	10,90	7,08	10,87	7,13	10,84	7,17	10,[illegible]	7,22	13
14	11,87	7,42	11,84	7,47	11,81	7,52	11,77	7,57	11,74	7,63	11,71	7,67	11,67	7,73	11,64	7,78	14
15	12,72	7,95	12,69	8,00	12,65	8,06	12,61	8,11	12,58	8,17	12,54	8,22	12,51	8,28	12,47	8,31	15
16	13,57	8,48	13,53	8,54	13,49	8,60	13,45	8,65	13,42	8,72	13,38	8,77	13,34	8,83	13,30	8,89	16
17	14,42	9,01	14,38	9,07	14,34	9,13	14,29	9,19	14,26	9,26	14,21	9,32	14,18	9,38	14,13	9,45	17
18	15,26	9,54	15,22	9,60	15,18	9,67	15,14	9,73	15,10	9,81	15,05	9,87	15,01	9,93	14,96	9,99	18
19	16,11	10,07	16,07	10,14	16,02	10,21	16,98	10,27	15,94	10,35	15,89	10,41	15,84	10,49	15,80	10,56	19
20	16,96	10,60	16,91	10,67	16,87	10,75	16,82	10,82	16,77	10,89	16,73	10,97	16,68	11,04	16,63	11,12	20
21	17,81	11,13	17,76	11,21	17,71	11,28	17,56	11,36	17,61	11,44	17,56	11,51	17,51	11,59	17,46	11,67	21
22	18,65	11,66	18,61	11,74	18,55	11,82	18,50	11,90	18,45	11,98	18,40	12,06	18,35	12,14	18,29	12,22	22
23	19,50	12,19	19,45	12,27	19,40	12,36	19,34	12,44	19,29	12,53	19,23	12,61	19,18	12,69	19,12	12,78	23
24	20,35	12,72	20,30	12,81	20,24	12,90	20,18	12,98	20,13	13,07	20,07	13,16	20,01	13,25	19,95	13,34	24
25	21,20	13,25	21,14	13,34	21,08	13,44	21,03	13,52	20,97	13,62	20,91	13,71	20,85	13,80	20,78	13,89	25
26	22,05	13,78	21,99	13,88	21,93	13,97	21,87	14,06	21,81	14,16	21,74	14,25	21,68	14,35	21,62	14,45	26
27	22,90	14,31	22,84	14,41	22,77	14,51	42,61	14,61	22,65	14,71	22,58	14,80	22,52	14,90	22,45	15,00	27
28	23,74	14,84	23,68	14,94	23,62	15,05	23,45	15,15	23,48	15,25	23,41	15,35	23,35	15,45	23,28	15,56	28
29	24,59	15,37	24,53	15,48	24,45	15,58	24,39	15,69	24,32	15,80	24,25	15,90	24,18	16,01	24,11	16,12	29
30	25,44	15,90	25,37	16,01	25,30	16,12	25,23	16,23	25,16	16,34	25,09	16,45	25,02	16,56	24,94	16,67	30
31	26,29	16,43	26,22	16,54	26,14	16,66	26,07	16,77	26,00	16,88	25,92	17,00	25,85	17,11	25,78	17,22	31
32	27,14	16,96	27,06	17,08	26,99	17,19	26,91	17,31	26,84	17,43	26,76	17,54	26,68	17,66	26,61	17,78	32
33	27,99	17,49	27,91	17,61	27,83	17,73	27,75	17,85	27,68	17,97	27,60	18,09	27,52	18,21	27,44	18,34	33
34	28,83	18,02	28,76	18,14	28,67	18,27	28,59	18,39	28,52	18,52	28,43	18,64	28,35	18,77	28,27	18,89	34
35	29,68	18,55	29,60	18,68	29,52	18,80	29,44	18,93	29,35	19,06	29,27	19,19	29,19	19,32	29,10	19,4[illegible]	35
36	30,53	19,08	30,45	19,21	30,36	19,34	30,28	19,47	30,19	19,61	30,10	19,74	30,02	19,87	29,93	20,00	36
37	31,38	19,61	31,29	19,75	31,20	19,88	31,12	20,02	31,03	20,15	30,94	20,28	30,85	20,42	30,76	20,56	37
38	32,23	20,14	32,14	20,28	32,05	20,41	31,96	20,56	31,87	20,70	31,78	20,83	31,69	20,97	31,59	21,12	38
39	33,07	20,67	32,99	20,81	32,89	20,95	32,80	21,10	32,71	21,24	32,61	21,38	32,52	21,53	32,42	21,67	39
40	33,92	21,20	33,83	21,34	33,70	21,49	33,64	21,64	33,55	21,79	33,45	21,93	33,36	22,08	33,26	22,22	40
41	34,77	21,73	34,67	21,88	34,58	22,03	34,48	22,18	34,39	22,33	34,29	22,48	34,19	22,63	34,09	22,78	41
42	35,62	22,26	35,52	22,41	35,42	22,57	35,32	22,72	35,22	22,88	35,12	23,03	35,02	23,18	34,92	23,34	42
43	36,47	22,79	36,37	22,95	36,26	23,10	36,16	23,26	36,06	23,42	35,96	23,58	35,86	23,73	35,75	23,89	43
44	37,31	23,32	37,21	23,48	37,11	23,64	37,01	23,80	36,90	23,97	36,80	24,12	36,69	24,29	36,58	24,45	44
45	38,16	23,85	38,06	24,01	37,95	24,18	37,85	24,34	37,74	24,51	37,63	24,67	37,53	24,84	37,41	25,00	45
46	39,01	24,38	38,90	24,55	38,79	24,71	38,69	24,88	38,58	25,06	38,47	25,22	38,36	25,39	38,25	25,56	46
47	39,86	24,91	39,75	25,08	39,64	25,25	39,53	25,43	39,42	25,90	39,30	25,77	39,19	25,94	39,08	26,12	47
48	40,71	25,44	40,60	25,62	40,48	25,79	40,37	25,97	40,26	26,15	40,14	26,32	40,03	26,49	39,91	26,67	48
49	41,55	25,97	41,44	26,15	41,32	26,32	41,21	26,51	41,10	26,69	40,98	26,86	40,86	27,05	40,74	27,23	49
50	42,40	26,50	42,29	26,68	42,17	26,86	42,05	27,05	41,93	27,23	41,81	27,41	41,69	27,60	41,57	27,78	50
51	43,25	27,03	43,13	27,21	43,01	27,40	42,89	27,59	42,77	27,80	42,65	27,96	42,53	28,15	42,41	28,34	51
52	44,10	27,56	43,98	27,75	43,86	27,94	43,73	28,13	43,61	28,34	43,49	28,51	43,36	28,70	43,24	28,89	52
53	44,95	28,09	44,82	28,28	44,70	28,48	44,57	28,67	44,45	28,89	44,32	29,06	44,20	29,25	44,07	29,45	53
54	45,79	28,62	45,67	28,82	45,54	29,01	45,42	29,21	45,29	29,43	45,16	29,61	45,03	29,80	44,90	30,00	54
55	46,64	29,15	46,52	29,35	46,38	29,55	46,26	29,75	46,13	29,98	45,99	30,15	45,86	30,36	45,73	30,56	55
56	47,49	29,68	47,36	29,88	47,23	30,09	47,10	30,29	46,97	30,52	46,83	30,70	46,70	30,91	46,56	31,12	56
57	48,34	30,21	48,21	30,42	48,07	30,62	47,94	30,84	47,81	31,07	47,67	31,25	47,53	31,46	47,39	31,67	57
58	49,19	30,74	49,05	30,95	48,91	31,16	48,78	31,38	48,65	31,61	48,50	31,80	48,37	32,01	48,22	32,23	58
59	50,03	31,27	49,90	31,49	49,76	31,70	49,62	31,92	49,48	32,16	49,34	32,35	49,20	32,56	49,05	32,78	59
60	50,88	31,79	50,74	32,02	50,60	32,24	50,46	32,46	50,32	32,68	50,18	32,90	50,03	33,12	49,89	33,33	60
Distance	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	58 Deg.		57 Degrees 1,54								56 Degrees 1,48						

Digitized by Google

Distance	32 Degrees							,62	33 Degrees							,65	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	51,73	32,32	51,59	32,55	51,45	32,77	51,30	33,00	51,16	33,22	51,01	33,44	50,87	33,67	50,72	33,89	61
62	52,58	32,85	52,44	33,08	52,29	33,31	52,14	33,54	52,00	33,77	51,85	33,98	51,70	34,22	51,55	34,45	62
63	53,42	33,38	53,28	33,62	53,13	33,85	52,98	34,08	52,84	34,31	52,68	34,53	52,53	34,77	52,38	35,00	63
64	54,27	33,91	54,13	34,15	53,97	34,39	53,83	34,62	53,68	34,86	53,52	35,08	53,37	35,32	53,21	35,56	64
65	55,12	34,44	54,97	34,69	54,82	34,92	54,67	35,16	54,51	35,40	54,36	35,63	54,20	35,88	54,04	36,11	65
66	55,97	34,97	55,82	35,22	55,66	35,46	55,51	35,71	55,35	35,95	55,19	36,17	55,04	36,43	54,87	36,67	66
67	56,81	35,50	56,67	35,75	56,50	35,99	56,35	36,25	56,19	36,50	56,03	36,72	55,87	36,98	55,71	37,23	67
68	57,66	36,03	57,51	36,29	57,35	36,53	57,19	36,79	57,03	37,04	56,86	37,27	56,70	37,53	56,54	37,78	68
69	58,51	36,56	58,36	36,82	58,19	37,07	58,03	37,33	57,87	37,58	57,70	37,82	57,54	38,08	57,37	38,34	69
70	59,36	37,09	59,20	37,35	59,04	37,61	58,87	37,87	58,71	38,12	58,54	38,38	58,37	38,64	58,20	38,89	70
71	60,21	37,62	60,05	37,89	59,88	38,15	59,71	38,41	59,55	38,67	59,38	38,93	59,21	39,19	59,03	39,45	71
72	61,06	38,15	60,89	38,42	60,72	38,68	60,55	38,95	60,38	39,21	60,21	39,48	60,04	39,74	59,87	40,00	72
73	61,91	38,68	61,74	38,95	61,57	39,22	61,40	39,49	61,22	39,76	61,05	40,02	60,87	40,29	60,70	40,56	73
74	62,76	39,21	62,58	39,49	62,41	39,76	62,24	40,03	62,06	40,30	61,88	40,57	61,71	40,84	61,53	41,11	74
75	63,60	39,74	63,43	40,02	63,25	40,30	63,08	40,57	62,90	40,85	62,72	41,12	62,54	41,40	62,36	41,67	75
76	64,45	40,27	64,28	40,56	64,09	40,83	63,92	41,11	63,74	41,40	63,56	41,67	63,38	41,95	63,19	42,23	76
77	65,30	40,80	65,12	41,09	64,94	41,37	64,76	41,65	64,58	41,94	64,39	42,22	64,21	42,50	64,02	42,78	77
78	66,15	41,33	65,97	41,62	65,78	41,91	65,60	42,20	65,42	42,48	65,23	42,76	65,04	43,05	64,85	43,34	78
79	67,00	41,86	66,81	42,16	66,62	42,44	66,44	42,74	66,26	43,03	66,06	43,33	65,88	43,60	65,69	43,89	79
80	67,84	42,39	67,66	42,69	67,47	42,98	67,28	43,28	67,09	43,57	66,90	43,86	66,71	44,15	66,52	44,45	80
81	68,69	42,92	68,50	43,22	68,31	43,52	68,12	43,82	67,93	44,12	67,74	44,41	67,54	44,71	67,35	45,00	81
82	69,54	43,45	69,35	43,76	69,16	44,06	68,96	44,36	68,77	44,66	68,57	44,96	68,38	45,26	68,18	45,56	82
83	70,39	43,98	70,20	44,29	70,00	44,59	69,81	44,90	69,61	45,21	69,41	45,51	69,21	45,81	69,01	46,11	83
84	71,24	44,51	71,04	44,82	70,84	45,13	70,65	45,44	70,45	45,75	70,25	46,05	70,05	46,36	69,84	46,67	84
85	72,08	45,04	71,89	45,36	71,69	45,67	71,49	45,98	71,29	46,30	71,08	46,60	70,88	46,91	70,67	47,23	85
86	72,93	45,57	72,74	45,89	72,53	46,21	72,33	46,52	72,12	46,84	71,92	47,15	71,71	47,47	71,50	47,78	86
87	73,78	46,10	73,58	46,43	73,37	46,74	73,18	47,06	72,96	47,39	72,75	47,70	72,55	48,02	72,34	48,34	87
88	74,63	46,63	74,43	46,96	74,21	47,28	74,02	47,61	73,80	47,93	73,59	48,25	73,38	48,57	73,17	48,89	88
89	75,48	47,16	75,27	47,49	75,06	47,82	74,86	48,15	74,64	48,48	74,43	48,79	74,22	49,12	73,99	49,45	89
90	76,32	47,69	76,12	48,02	75,90	48,36	75,69	48,69	75,48	49,02	75,27	49,35	75,05	49,67	74,83	50,00	90
91	77,17	48,22	76,95	48,56	76,75	48,89	76,53	49,23	76,32	49,56	76,10	49,89	75,88	50,22	75,66	50,56	91
92	78,02	48,75	77,86	49,09	77,59	49,43	77,38	49,77	77,16	50,11	76,94	50,44	76,72	50,78	76,49	51,11	92
93	78,87	49,28	78,65	49,63	78,43	49,97	78,22	50,31	78,00	50,65	77,77	50,99	77,55	51,33	77,33	51,67	93
94	79,72	49,81	79,40	50,16	79,28	50,50	79,06	50,85	78,84	51,20	78,61	51,54	78,39	51,88	78,18	52,22	94
95	80,56	50,34	80,35	50,69	80,12	51,04	79,90	51,39	79,67	51,74	79,45	52,09	79,22	52,43	79,01	52,78	95
96	81,41	50,87	81,19	51,23	80,96	51,58	80,74	51,93	80,51	52,29	80,28	52,63	80,05	52,99	79,84	53,34	96
97	82,26	51,40	82,04	51,76	81,81	52,12	81,58	52,47	81,35	52,83	81,12	53,18	80,89	53,54	80,67	53,89	97
98	83,11	51,93	82,88	52,30	82,65	52,65	82,42	53,01	82,19	53,38	81,95	53,73	81,72	54,09	81,50	54,45	98
99	83,96	52,46	83,73	52,83	83,49	53,19	83,26	53,56	83,03	53,92	82,79	54,28	82,56	54,64	82,33	55,00	99
100	84,80	52,99	84,57	53,36	84,34	53,72	84,10	54,09	83,87	54,46	83,63	54,83	83,39	55,19	83,15	55,56	100
101	85,65	53,52	85,42	53,89	85,18	54,27	84,94	54,64	84,71	55,01	84,46	55,38	84,22	55,75	84,00	56,11	101
102	86,50	54,05	86,26	54,43	86,02	54,80	85,79	55,18	85,54	55,55	85,30	55,92	85,06	56,30	84,83	56,67	102
103	87,35	54,58	87,11	54,96	86,87	55,34	86,63	55,72	86,38	56,10	86,14	56,47	85,89	56,85	85,66	57,22	103
104	88,20	55,11	87,96	55,49	87,70	55,88	87,47	56,26	87,22	56,64	86,97	57,02	86,72	57,40	86,49	57,78	104
105	89,04	55,64	88,80	56,03	88,55	56,42	88,31	56,80	88,06	57,19	87,86	57,57	87,56	57,95	87,34	58,34	105
106	89,89	56,17	89,65	56,56	89,40	56,95	89,15	57,34	88,90	57,73	88,64	58,12	88,39	58,51	88,17	58,89	106
107	90,74	56,70	90,49	57,10	90,24	57,49	89,99	57,88	89,74	58,28	89,48	58,66	89,23	59,06	89,00	59,45	107
108	91,59	57,23	91,34	57,63	91,08	58,03	90,83	58,42	90,58	58,82	90,32	59,21	90,06	59,61	89,84	60,00	108
109	92,44	57,76	92,19	58,16	91,93	58,56	91,67	58,97	91,42	59,37	91,15	59,76	90,89	60,16	90,69	60,56	109
110	93,29	58,29	93,03	58,69	92,77	59,10	92,51	59,51	92,25	59,91	91,99	60,31	91,73	60,71	91,46	61,11	110
111	94,13	58,82	93,88	59,23	93,62	59,64	93,35	60,05	93,09	60,45	92,83	60,86	92,56	61,26	92,29	61,67	111
112	94,98	59,35	94,72	59,76	94,46	60,18	94,20	60,59	93,93	61,00	93,66	61,41	93,40	61,82	93,12	62,22	112
113	95,83	59,88	95,56	60,30	95,30	60,71	95,04	61,13	94,77	61,54	94,50	61,96	94,23	62,37	93,96	62,78	113
114	96,68	60,41	96,41	60,83	96,14	61,25	95,88	61,67	95,63	62,09	95,34	62,50	95,06	62,92	94,79	63,34	114
115	97,53	60,94	97,25	61,37	96,99	61,79	96,72	62,21	96,45	62,63	96,17	63,05	95,90	63,47	95,62	63,87	115
116	98,37	61,47	98,10	61,90	97,83	62,32	97,56	62,75	97,29	63,18	97,01	63,60	96,73	64,02	96,45	64,45	116
117	99,22	62,00	98,95	62,43	98,67	62,86	98,40	63,29	98,13	63,72	97,84	64,15	97,57	64,58	97,28	64,99	117
118	100,1	62,53	99,79	62,97	99,52	63,40	99,24	63,83	98,97	64,27	98,68	64,70	98,40	65,13	98,11	65,54	118
119	101,0	63,06	100,6	63,50	100,4	63,94	100,1	64,38	99,71	64,81	99,52	65,24	99,23	65,68	98,95	66,10	119
120	101,8	63,59	101,5	64,03	101,2	64,48	100,9	64,91	100,6	65,36	100,4	65,79	100,1	66,23	99,78	66,67	120
Distance	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	58 Deg.		57 Degrees						1,54		56 Degrees					1,48	

Distance	34 Degrees							,67	35 Degrees							,70	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,83	0,56	0,83	0,56	0,82	0,57	0,82	0,57	0,82	0,57	0,82	0,58	0,81	0,58	0,81	0,58	1
2	1,66	1,12	1,65	1,13	1,65	1,13	1,64	1,14	1,64	1,15	1,63	1,15	1,63	1,16	1,62	1,17	2
3	2,49	1,69	2,47	1,69	2,47	1,70	2,46	1,71	2,46	1,72	2,45	1,73	2,44	1,74	2,43	1,75	3
4	3,32	2,25	3,30	2,25	3,30	2,27	3,29	2,28	3,28	2,29	3,27	2,30	3,26	2,32	3,25	2,34	4
5	4,15	2,81	4,13	2,81	4,12	2,83	4,11	2,85	4,10	2,87	4,08	2,89	4,07	2,90	4,06	2,92	5
6	4,97	3,36	4,96	3,38	4,94	3,40	4,93	3,42	4,91	3,44	4,90	3,46	4,88	3,48	4,87	3,51	6
7	5,80	3,91	5,79	3,94	5,77	3,96	5,75	3,99	5,73	4,01	5,72	4,04	5,69	4,06	5,68	4,09	7
8	6,63	4,47	6,61	4,50	6,59	4,53	6,57	4,56	6,55	4,59	6,53	4,62	6,51	4,65	6,49	4,67	8
9	7,46	5,03	7,44	5,06	7,42	5,10	7,39	5,13	7,37	5,16	7,35	5,19	7,33	5,23	7,30	5,26	9
10	8,29	5,59	8,27	5,63	8,24	5,66	8,22	5,70	8,19	5,74	8,17	5,77	8,14	5,81	8,12	5,84	10
11	9,12	6,15	9,09	6,19	9,06	6,23	9,04	6,27	9,01	6,31	8,98	6,34	8,95	6,39	8,93	6,43	11
12	9,95	6,71	9,92	6,75	9,89	6,80	9,86	6,84	9,83	6,88	9,80	6,93	9,77	6,97	9,74	7,01	12
13	10,78	7,27	10,75	7,32	10,71	7,36	10,68	7,41	10,65	7,46	10,62	7,50	10,58	7,55	10,55	7,59	13
14	11,61	7,83	11,57	7,88	11,54	7,93	11,50	7,98	11,47	8,03	11,43	8,08	11,40	8,13	11,36	8,18	14
15	12,44	8,39	12,40	8,44	12,36	8,49	12,33	8,55	12,29	8,60	12,25	8,66	12,21	8,71	12,17	8,76	15
16	13,26	8,95	13,23	9,01	13,19	9,06	13,15	9,12	13,11	9,18	13,07	9,23	13,02	9,21	12,99	9,35	16
17	14,09	9,51	14,05	9,57	14,01	9,63	13,98	9,69	13,92	9,75	13,88	9,81	13,84	9,87	13,80	9,93	17
18	14,92	10,06	14,88	10,13	14,83	10,19	14,79	10,26	14,74	10,33	14,70	10,39	14,65	10,45	14,61	10,51	18
19	15,75	10,62	15,71	10,69	15,66	10,76	15,61	10,83	15,56	10,90	15,52	10,94	15,47	11,03	15,42	11,10	19
20	16,58	11,18	16,53	11,26	16,48	11,33	16,43	11,40	16,38	11,47	16,33	11,54	16,28	11,61	16,23	11,68	20
21	17,41	11,74	17,36	11,82	17,31	11,89	17,25	11,97	17,20	12,05	17,15	12,12	17,10	12,19	17,04	12,27	21
22	18,24	12,30	18,19	12,38	18,13	12,46	18,08	12,54	18,02	12,62	17,98	12,70	17,91	12,78	17,85	12,85	22
23	19,07	12,86	19,01	12,95	18,95	13,03	18,90	13,11	18,84	13,19	18,78	13,27	18,52	13,36	18,67	13,44	23
24	19,90	13,42	19,84	13,51	19,78	13,59	19,72	13,68	19,66	13,77	19,60	13,85	19,34	13,94	19,48	14,02	24
25	20,73	13,98	20,67	14,08	20,60	14,16	20,54	14,25	20,48	14,34	20,41	14,43	20,15	14,52	20,29	14,60	25
26	21,56	14,54	21,49	14,64	21,43	14,72	21,36	14,82	21,30	14,92	21,23	15,00	20,97	15,10	21,10	15,19	26
27	22,38	15,10	22,32	15,20	22,25	15,29	22,19	15,39	22,12	15,49	22,05	15,58	21,78	15,68	21,91	15,77	27
28	23,21	15,66	23,15	15,77	23,07	15,86	23,01	15,96	22,93	16,06	22,87	16,17	22,59	16,26	22,73	16,36	28
29	24,04	16,22	23,97	16,33	23,90	16,42	23,83	16,53	23,75	16,64	23,69	16,75	23,41	16,84	23,54	16,94	29
30	24,87	16,78	24,80	16,88	24.72	16,99	24,65	17,10	24,57	17,21	24,50	17,31	24,42	17,42	24,35	17,53	30
31	25,70	17,33	25,62	17,45	25,55	17,56	25,47	17,67	25,39	17,78	25,32	17,89	25,24	18,00	25,16	18,11	31
32	26,53	17,89	26,45	18,01	26,37	18,12	26,29	18,24	26,21	18,35	26,13	18,47	26,05	18,58	25,97	18,70	32
33	27,36	18,45	27,28	18,57	27,20	18,69	27,12	18,81	27,03	18,93	26,95	19,05	26,87	19,16	26,78	19,28	33
34	28,19	19,01	28,11	19,14	28,02	19,26	27,94	19,38	27,85	19,50	27,77	19,62	27,68	19,74	27,59	19,86	34
35	29,02	19,57	28,93	19,70	28,84	19,82	28,76	19,95	28,67	20,08	28,58	20,20	28,49	20,33	28,41	20,45	35
36	29,84	20,13	29,76	20,26	29,67	20,39	29,58	20,52	29,49	20,65	29,40	20,78	29,31	20,91	29,22	21,03	36
37	30,67	20,69	30,59	20,82	30,49	20,95	30,40	21,09	30,31	21,22	30,22	21,35	30,12	21,49	30,03	21,62	37
38	31,50	21,25	31,41	21,39	31,32	21,52	31,23	21,66	31,13	21,80	31,03	21,93	30,94	22,07	30,84	22,20	38
39	32,33	21,81	32,24	21,95	32,14	22,09	32,05	22,23	31,95	22,51	31,85	22,51	31,75	22,65	31,65	22,78	39
40	33,16	22,37	33,06	22,51	32,96	22.66	32,87	22,80	32,77	22,94	32,67	23,09	32,56	23,23	32,46	23,37	40
41	33,99	22,93	33,89	23,07	33,79	23,22	33,69	23,37	33,58	23,52	33,48	23,66	33,38	23,81	33,27	23,95	41
42	34,82	23,49	34,72	23,64	34,61	23,79	34,51	23,94	34,40	24,09	34,30	24,24	34,19	24,39	34,09	24,54	42
43	35,65	24,04	35,54	24,20	35,44	24,35	35,33	24,51	35,22	24,66	35,12	24,82	35,01	24,97	34,90	25,12	43
44	36,48	24,60	36,37	24,76	36,26	24,92	36,15	25,08	36,04	25,24	35,93	25,35	35,82	25,55	35,71	25,71	44
45	37,31	25,16	37,20	25,33	37,08	25,49	36,98	25,65	36,86	25,81	36,75	25,97	36,63	26,13	36,52	26,29	45
46	38,14	25,72	38,03	25,89	37,91	26,05	37,80	26,22	37,68	26,39	37,57	26,55	37,45	26,71	37,33	26,87	46
47	38,96	26,28	38,85	26,45	38,73	26,62	38,62	26,79	38,50	26,96	38,38	27,12	38,26	27,29	38,15	27,46	47
48	39,79	26,84	39,68	27,0[illegible]	39,56	27,18	39,44	27,36	39,32	27,53	39,20	27,70	39,07	27,88	38,96	28,04	48
49	40,62	27,40	40,51	27,58	40,39	27,75	40,26	27,93	40,14	28,11	40,02	28,28	39,89	28,46	39,77	28,63	49
50	41,45	27,96	41,33	28,14	41,21	[illegible]	41,08	[illegible]	40,96	28,68	40,83	28,86	40,71	29,03	40,58	29,21	50
51	42,28	28,52	42,16	28,70	42,03	28,89	41,90	29,07	41,78	29,25	41,65	29,93	41,52	29,62	41,39	29,80	51
52	43,11	29,08	42,98	29,27	42,85	29,45	42,73	29,64	42,60	29,83	42,47	30,01	42,33	30,20	42,20	30,38	52
53	43,94	29,64	43,81	29,83	43,68	30,02	43,55	30,21	43,41	30,40	43,28	30,59	43,15	30,78	43,01	30,96	53
54	44,77	30,20	44,64	30,39	44,50	30,58	44,37	30,73	44,23	30,97	44,10	31,17	43,96	31,36	43,83	31,55	54
55	45,60	30,75	45,26	30,95	45,33	31,15	45,19	31,35	45,05	31,55	44,92	31,74	44,78	31,94	44,64	32,13	55
56	46,43	31,31	46,29	31,52	46,15	31,72	46,01	31,92	45,87	32,12	45,73	32,32	45,59	32,52	45,45	32,72	56
57	47,25	31,87	47,12	32,08	46,97	32,28	46,84	32,49	46,69	32,70	46,55	32,90	46,40	33,10	46,26	33,30	57
58	48,08	32,43	47,95	32,64	47,80	32,85	47,66	33,06	47,51	33,27	47,37	33,47	47,22	33,68	47,07	33,88	58
59	48,91	32,99	48,77	33,20	48,62	33,41	48,48	33,63	48,33	33,84	48,18	34,05	48.03	34,26	47,89	34,47	59
60	49,74	33,55	49,59	33,77	49,45	33,98	49,30	34,20	49,15	34,41	49,00	34,63	48,85	34,84	48,69	35,05	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	56 Deg.		55 Degrees					1,43	54 Degrees							1,38	

Distance	34 Degrees							,67	35 Degrees							,70	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	50,57	34,11	50,42	34,33	50,27	34,55	50,12	34,77	49,97	34,99	49,81	35,21	49,66	35,42	49,51	35,64	61
62	51,40	34,67	51,25	34,89	51,10	35,12	50,94	35,34	50,79	35,56	50,63	35,78	50,47	36,00	50,32	36,22	62
63	52,23	35,23	52,08	35,46	51,92	35,68	51,76	35,91	51,61	36,14	51,45	36,37	51,29	36,58	51,13	36,81	63
64	53,06	35,79	52,90	36,02	52,74	36,25	52,59	36,48	52,42	36,71	52,27	36,94	52,10	37,17	51,94	37,39	64
65	53,89	36,35	53,73	36,58	53,51	36,81	53,41	37,05	53,24	37,28	53,07	37,51	52,92	37,75	52,75	37,98	65
66	54,72	36,90	54,56	37,15	54,39	37,38	54,23	37,62	54,06	37,86	53,90	38,09	53,73	38,33	53,56	38,56	66
67	55,54	37,46	55,38	37,71	55,22	37,95	55,05	38,19	54,88	38,43	54,72	38,67	54,54	38,91	54,38	39,14	67
68	56,37	38,02	56,21	38,27	56,04	38,51	55,87	38,76	55,70	39,0	55,53	39,24	55,36	39,49	55,19	39,73	68
69	57,20	38,58	57,04	38,83	56,86	39,08	56,70	39,33	56,52	39,58	56,35	39,82	56,17	40,07	56,00	40,31	69
70	58,03	39,14	57,86	39,40	57,69	39,65	57,52	39,90	57,34	40,15	57,16	40,40	56,99	40,65	56,81	40,89	70
71	58,80	39,70	58,69	39,96	58,51	40,21	58,34	40,47	58,16	40,72	57,98	40,98	57,80	41,23	57,62	41,48	71
72	59,69	40,26	59,51	40,52	59,34	40,78	59,16	41,04	58,98	41,30	58,80	41,55	58,62	41,81	58,43	42,07	72
73	60,52	40,82	60,34	41,08	60,16	41,35	59,98	41,61	59,80	41,87	59,61	42,13	59,43	42,39	59,25	42,65	73
74	61,35	41,38	61,17	41,65	60,98	41,91	60,80	42,18	60,62	42,45	60,43	42,71	60,24	42,97	60,06	43,23	74
75	62,18	41,94	62,00	42,21	61,81	42,48	61,63	42,75	61,44	43,02	61,25	43,29	61,06	43,55	60,87	43,82	75
76	63,01	42,50	62,80	42,77	62,63	43,04	62,45	43,32	61,25	43,59	62,07	43,86	61,87	44,13	61,68	44,40	76
77	63,84	43,06	63,65	43,34	63,46	43,61	63,27	43,89	63,07	44,17	62,88	44,44	62,69	44,72	62,49	44,99	77
78	64,66	43,61	64,48	43,90	64,28	44,18	4,09	44,46	63,89	44,74	63,70	45,02	63,50	45,30	63,31	45,57	78
79	65,49	44,17	65,30	44,46	65,10	44,74	64,91	45,03	64,71	45,32	64,52	45,5[illegible]	64,31	45,88	64,12	46,15	79
80	66,32	44,73	66,13	45,02	65,93	45,31	65,73	45,60	65,53	45,89	65,33	46,17	65,13	46,46	64,93	46,74	80
81	67,15	45,29	66,95	45,59	66,75	45,88	66,54	46,17	66,35	46,40	66,15	46,74	65,94	47,04	65,74	47,32	81
82	67,98	45,85	67,78	46,15	67,58	46,44	67,38	46,74	67,17	47,03	66,96	47,32	66,76	47,62	66,55	47,91	82
83	68,81	46,41	68,61	46,71	68,40	47,01	68,20	47,31	67,99	47,61	67,78	47,90	67,57	48,20	67,36	48,49	83
84	69,64	46,97	69,43	47,28	69,23	47,58	69,09	47,88	68,81	48,18	68,60	48,47	68,39	48,78	68,17	49,08	84
85	70,47	47,53	70,26	47,84	70,05	48,14	69,84	48,45	69,63	48,76	69,42	49,05	69,20	49,36	68,99	49,66	85
86	71,30	48,09	71,09	48,40	70,87	48,71	70,66	49,02	70,45	49,33	70,23	49,63	70,01	49,94	69,80	50,24	86
87	72,13	48,65	71,92	48,96	71,70	49,27	71,49	49,59	71,26	49,90	71,05	50,20	70,83	50,52	70,61	50,83	87
88	72,95	49,21	72,74	49,53	72,52	49,84	72,31	50,16	72,08	50,48	71,87	50,78	71,64	51,10	71,42	51,41	88
89	73,78	49,77	73,57	50,09	73,35	50,41	73,13	50,73	72,90	51,05	72,68	51,36	72,46	51,68	72,23	52,00	89
90	74,61	50,33	74,39	50,65	74,17	50,98	73,95	51,30	73,72	51,62	73,50	51,94	73,27	52,26	73,04	52,58	90
91	75,44	50,89	75,22	51,21	75,00	51,54	74,77	51,87	74,54	52,20	74,31	52,52	74,08	52,84	73,85	53,17	91
92	76,27	51,44	76,05	51,78	75,82	52,11	75,59	52,44	75,36	52,77	75,13	53,10	74,90	53,42	74,67	53,75	92
93	77,10	52,00	76,87	52,34	76,64	52,67	76,41	53,01	76,18	53,34	75,95	53,67	75,71	54,01	75,48	54,34	93
94	77,93	52,56	77,70	52,90	77,47	53,24	77,24	53,58	77,00	53,94	76,77	54,25	76,53	54,59	76,29	54,92	94
95	78,76	53,12	78,53	53,47	78,29	53,81	78,06	54,15	77,82	54,49	77,58	54,83	77,34	55,17	77,10	55,50	95
96	79,59	53,68	79,35	54,03	79,12	54,37	78,88	54,72	78,64	55,07	78,40	55,41	78,15	55,75	77,91	56,09	96
97	80,42	54,24	80,18	54,59	79,94	54 94	79,70	55,29	79,46	55,64	79,22	55,98	78,97	56,33	78,72	56,67	97
98	81,25	54,80	81,01	55,16	80,76	55,56	80,50	55,86	80,28	56,21	80,03	56,56	79,78	56,91	79,53	57,26	98
99	82,07	55,36	81,84	55,72	81,59	56,07	81,35	56,43	81,10	56,79	80,85	57,14	80,60	57,49	80,35	57,84	99
100	82,90	55,92	82,66	56,28	82,41	56,64	82,16	57,00	81,91	57,36	81,66	57,71	81,41	58,07	81,16	58,43	100
101	83,73	56,48	83,49	56,84	83,24	57,21	82,99	57,57	82,73	57,93	82,48	58,29	82,23	58,65	81,97	59,01	101
102	84,56	57,03	84,31	57,41	84,06	57,77	83,81	58,14	83,55	58,49	83,30	58,87	83,04	59,23	82,78	59,59	102
103	85,39	57,59	85,14	57,97	84,88	58,34	84,63	58,71	84,37	59,06	84,11	59,45	83,85	59,81	83,59	60,18	103
104	86,22	58,14	85,97	58,53	85,71	58,91	85,45	59,28	85,19	59,63	84,93	60,02	84,67	60,39	84,41	60,76	104
105	87,05	58,70	86,79	59,09	86,5[illegible]	59,47	86,27	59,85	86,01	60,21	85,75	60,60	85,48	60,97	85,22	61,35	105
106	87,88	59,26	87,62	59,66	87,36	60,04	87,10	60,42	86,83	60,78	86,57	61,18	86,30	61,56	86,03	61,93	106
107	88,73	59,82	88,45	60,22	88,18	60,60	87,92	60,99	87,65	61,36	87,38	61,75	87,11	62,14	86,84	62,51	107
108	89,56	60,38	89,27	60,78	89,00	61,17	88,74	61,56	88,47	61,93	88,20	62,33	87,92	62,72	87,65	63,10	108
109	90,38	60,94	90,10	61,35	89,83	61,74	89,56	62,13	89,29	62,50	89,[illegible]2	62,91	88,74	63,30	88,46	63,68	109
110	91,19	61,51	90,92	61,91	90,65	62,30	90,38	62,70	90,11	63,0[illegible]	[illegible]9,83	63,49	89,55	63,88	89,27	64,27	110
111	92,02	62,07	91,75	62,47	91,48	62,87	91,20	63,27	90,93	63,67	90,65	64,06	90,37	64,46	90,08	64,8[illegible]	111
112	92,85	62,63	92,58	63,03	92,30	63,44	92,03	63,84	91,74	64,24	91,42	64,64	91,18	65,04	90,90	65,44	112
113	93,68	63,19	93,41	63,60	93,13	64,00	92,85	64,45	92,56	64,82	92,28	65,22	91,99	65,62	91,71	66,02	113
114	94,51	63,75	94,23	64,16	93,95	64,57	93,67	64,98	93,38	65,39	93,10	65 79	92,81	66,20	92,52	66,60	114
115	95,34	64,31	95,06	64,72	94,77	65,15	94,49	65,55	94,20	65,96	93,91	66,37	93,62	66,78	93,33	67,19	115
116	96,17	64,86	95,89	65,29	95,60	65,71	95,3	66,12	95,02	66,54	94,73	66,95	94,44	67,36	94,14	67,77	116
117	96,99	65,4[illegible]	90,71	65,85	96,42	66,28	96,14	66,69	95,84	67,11	95,55	67,53	95,25	67,94	94 96	68,36	117
118	97,83	65,98	97,54	66,41	97,25	66,84	96,96	67,26	96,66	67,69	96,37	68,10	96,06	68,52	95,77	68,94	118
119	98,65	66,54	98,37	66,97	98,07	67,41	97,78	67,83	97,48	68,26	97,18	68,68	96,88	69,11	96,58	69,52	119
120	99,48	67,10	99,19	67,54	98,90	67,97	98,60	68,40	98,30	68,85	98,00	69,26	97,69	69,68	97,39	70,11	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	56 Deg.		55 Degrees					1,43	54 Degrees							1,38	

Distance	36 Degrees ,73								37 Degrees ,75								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
1	0,81	0,59	0,81	0,59	0,81	0,59	0,81	0,60	0,80	0,60	0,80	0,60	0,79	0,61	0,79	0,61	1
2	1,62	1,18	1,61	1,18	1,61	1,19	1,60	1,20	1,60	1,20	1,59	1,21	1,59	1,22	1,58	1,22	2
3	2,43	1,76	2,42	1,77	2,41	1,78	2,40	1,79	2,40	1,80	2,39	1,82	2,38	1,83	2,37	1,84	3
4	3,24	2,35	3,23	2,36	3,21	2,38	3,20	2,39	3,20	2,41	3,18	2,42	3,17	2,43	3,16	2,45	4
5	4,04	2,9	4,03	2,96	4,02	2,97	4,01	2,99	3,99	3,01	3,98	3,03	3,97	3,04	3,95	3,06	5
6	4,85	3,53	4,84	3,55	4,82	3,57	4,81	3,59	4,79	3,61	4,78	3,63	4,76	3,65	4,74	3,67	6
7	5,66	4,11	5,64	4,14	5,63	4,16	5,61	4,19	5,59	4,21	5,57	4,24	5,55	4,26	5,53	4,29	7
8	6,4	4,70	6,45	4,73	6,43	4,76	6,41	4,79	6,39	4,81	6,37	4,84	6,35	4,87	6,33	4,90	8
9	7,28	5,29	7,20	5,32	7,23	5,35	7,21	5,38	7,19	5,42	7,16	5,45	7,14	5,48	7,12	5,51	9
10	8,09	5,88	8,06	5,91	8,04	5,95	8,01	5,98	7,99	6,02	7,96	6,05	7,93	6,09	7,91	6,12	10
11	8,90	6,46	8,87	6,50	8,84	6,54	8,81	6,58	8,78	6,62	8,76	6,66	8,73	6,70	8,70	6,73	11
12	9,71	7,05	9,68	7,10	9,65	7,14	9,61	7,18	9,58	7,22	9,55	7,26	9,52	7,30	9,49	7,35	12
13	10,52	7,64	10,48	7,69	10,45	7,73	10,41	7,78	10,38	7,82	10,35	7,87	10,31	7,91	10,28	7,96	13
14	11,33	8,23	11,29	8,28	11,25	8,33	11,21	8,37	11,18	8,43	11,14	8,47	11,11	8,52	11,07	8,57	14
15	12,13	8,82	12,09	8,87	12,06	8,93	12,01	8,96	11,98	9,03	11,94	9,08	11,90	9,13	11,86	9,18	15
16	12,94	9,4	12,90	9,46	12,86	9,52	12,82	9,56	12,77	9,63	12,74	9,68	12,69	9,74	12,65	9,79	16
17	13,75	9,99	13,71	10,06	13,67	10,1	13,62	10,16	13,57	10,23	13,53	10,29	13,48	10,35	13,44	10,41	17
18	14,56	10,58	14,51	10,64	14,47	10,71	14,42	10,76	14,37	10,83	14,33	10,89	14,28	10,96	14,23	11,02	18
19	15,37	11,17	15,32	11,23	15,27	11,30	15,22	11,36	15,17	11,44	15,12	11,50	15,07	11,57	15,02	11,63	19
20	16,18	11,76	16,13	11,83	16,08	11,90	16,02	11,96	15,97	12,04	15,92	12,11	15,87	12,17	15,81	12,24	20
21	16,99	12,34	16,93	12,4	16,88	12,49	16,83	12,56	16,77	12,64	16,72	12,71	16,66	12,78	16,60	12,86	21
22	17,80	12,93	17,74	13,01	17,68	13,09	17,63	13,16	17,57	13,24	17,51	13,31	17,45	13,39	17,40	13,47	22
23	18,61	13,52	18,55	13,60	18,49	13,68	18,43	13,76	18,37	13,84	18,31	13,92	18,25	14,00	18,19	14,08	23
24	19,42	14,11	19,35	14,19	19,29	14,28	19,23	14,36	19,17	14,44	19,10	14,53	19,04	14,61	18,98	14,69	24
25	20,22	14,70	20,16	14,78	20,10	14,87	20,03	14,96	19,97	15,05	19,90	15,13	19,83	15,22	19,77	15,30	25
26	21,03	15,28	20,9	15,37	20,89	15,47	20,83	15,55	20,77	15,65	20,70	15,74	20,62	15,83	20,56	15,92	26
27	21,84	15,87	21,77	15,96	21,69	16,06	21,63	16,15	21,57	16,25	21,49	16,34	21,42	16,44	21,35	16,53	27
28	22,65	16,4	22,58	16,55	22,50	16,66	22,43	16,75	22,26	16,85	22,29	16,95	22,21	17,05	22,14	17,14	28
29	23,46	17,05	23,38	17,14	23,31	17,25	23,33	17,35	23,16	17,45	23,08	17,55	23,00	17,66	22,93	17,75	29
30	24,27	17,63	24,19	17,74	24,12	17,84	24,04	17,95	23,96	18,05	23,88	18,16	23,79	18,26	23,72	18,37	30
31	25,08	18,22	25,00	18,33	24,92	18,44	24,84	18,55	24,76	18,66	24,68	18,76	24,59	18,87	24,51	18,98	31
32	25,89	18,81	25,80	18,92	25,72	19,03	25,64	19,15	25,56	19,26	25,47	19,37	25,39	19,48	25,30	19,59	32
33	26,70	19,40	26,61	19,51	26,53	19,63	26,44	19,74	26,36	19,86	26,27	19,97	26,18	20,09	26,09	20,20	33
34	27,51	19,99	27,42	20,10	27,33	20,22	27,24	20,34	27,15	20,46	27,06	20,58	26,97	20,70	26,88	20,81	34
35	28,32	20,57	28,22	20,69	28,14	20,82	28,04	20,94	27,95	21,06	27,86	21,18	27,77	21,31	27,68	21,43	35
36	29,12	21,16	29,03	21,28	28,94	21,41	28,84	21,54	28,75	21,67	28,66	21,79	28,56	21,92	28,47	22,04	36
37	29,93	21,75	29,83	21,88	29,74	22,01	29,64	22,14	29,55	22,27	29,45	22,39	29,35	22,53	29,26	22,65	37
38	30,74	22,34	30,64	22,47	30,55	22,60	30,45	22,73	30,35	22,87	30,25	23,00	30,14	23,14	30,05	23,26	38
39	31,55	22,93	31,45	23,06	31,35	23,20	31,25	23,33	31,15	23,47	31,05	23,60	30,94	23,75	30,84	23,87	39
40	32,36	23,51	32,26	23,65	32,15	23,79	32,05	23,93	31,95	24,27	31,84	24,21	31,73	24,35	31,63	24,49	40
41	33,17	24,10	33,06	24,24	32,96	24,39	32,85	24,53	32,74	24,67	32,64	24,82	32,53	24,96	32,42	25,10	41
42	33,98	24,89	33,87	24,83	33,76	24,98	33,65	25,13	33,54	25,28	33,43	25,42	33,32	25,57	33,21	25,71	42
43	34,79	25,48	34,68	25,42	34,57	25,58	34,45	25,73	34,34	25,88	34,23	26,03	34,11	26,18	34,00	26,32	43
44	35,60	26,06	35,48	26,02	35,37	26,17	35,25	26,32	35,14	26,48	35,02	26,63	34,91	26,79	34,79	26,94	44
45	36,41	26,65	36,29	26,61	36,17	26,77	36,05	26,92	35,94	27,08	35,82	27,24	35,70	27,39	35,58	27,55	45
46	37,21	27,24	37,09	27,20	36,98	27,36	36,86	27,52	36,74	27,68	36,62	27,84	36,49	28,00	36,37	28,16	46
47	38,02	27,83	37,90	27,79	37,78	27,96	37,66	28,12	37,54	28,29	37,41	28,45	37,28	28,61	37,16	28,77	47
48	38,83	28,42	38,71	28,38	38,59	28,55	38,46	28,72	38,34	28,89	38,21	29,05	38,08	29,22	37,96	29,38	48
49	39,64	29,00	39,51	28,97	39,39	29,15	39,26	29,31	39,14	29,49	39,00	29,66	38,87	29,83	38,75	30,00	49
50	40,45	29,59	40,32	29,57	40,19	29,74	40,06	29,91	39,93	30,09	39,80	30,26	39,67	30,44	39,53	30,61	50
51	41,26	30,18	41,13	30,16	41,00	30,34	40,86	30,51	40,73	30,69	40,60	30,87	40,46	31,0	40,33	31,2	51
52	42,07	30,77	41,93	30,75	41,80	30,93	41,66	31,11	41,52	31,29	41,39	31,47	41,25	31,66	41,12	31,83	52
53	42,87	31,35	42,74	31,34	42,60	31,53	42,47	31,71	42,32	31,90	42,19	32,08	42,05	32,26	41,91	32,45	53
54	43,68	31,94	43,55	31,93	43,41	32,12	43,27	32,31	43,12	32,50	42,98	32,68	42,84	32,87	42,70	33,06	54
55	44,49	32,53	44,35	32,52	44,21	32,72	44,07	32,91	43,92	33,10	43,78	33,29	43,63	33,48	43,49	33,67	55
56	45,30	33,14	45,16	33,11	45,02	33,31	44,87	33,51	44,72	33,70	44,58	33,89	44,43	34,09	44,28	34,28	56
57	46,11	33,69	45,96	33,70	45,82	33,91	45,67	34,11	45,51	34,30	45,37	34,50	45,22	34,70	45,07	34,89	57
58	46,92	34,28	46,77	34,29	46,62	34,50	46,47	34,70	46,31	34,91	46,17	35,10	46,01	35,31	45,86	35,51	58
59	47,73	34,87	47,58	34,88	47,43	35,10	47,27	35,30	47,11	35,51	46,96	35,71	46,8	35,82	46,65	36,1	59
60	48,54	35,46	48,30	35,48	48,23	35,60	48,07	35,90	47,91	36,11	47,76	36,32	47,60	36,53	47,44	36,73	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	54 Deg.		53 Degrees					1,33	52 Degrees							1,28	

Distance	36 Degrees ,73								37 Degrees ,75								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	49,35	35,85	49,19	36,07	49,04	36,28	48,88	36,50	48,72	36,71	48,56	36,92	48,39	37,13	48,23	37,34	61
62	50,16	36,44	49,99	36,66	49,84	36,88	49,68	37,09	49,52	37,31	49,35	37,53	49,19	37,74	49,02	37,96	62
63	50,97	37,03	50,80	37,25	50,64	37,47	50,48	37,69	50,31	37,91	50,15	38,13	49,98	38,35	49,81	38,57	63
64	51,78	37,62	51,61	37,84	51,45	38,07	51,28	38,29	51,11	38,52	50,94	38,74	50,77	38,96	50,60	39,18	64
65	52,59	38,21	52,42	38,43	52,25	38,66	52,08	38,89	51,91	39,12	51,74	39,34	51,57	39,57	51,40	39,79	65
66	53,39	38,79	53,22	39,02	53,06	39,26	52,88	39,49	52,71	39,72	52,54	39,95	52,36	40,18	52,19	40,40	66
67	54,20	39,38	54,03	39,62	53,86	39,85	53,68	40,08	53,51	40,32	53,33	40,55	53,15	40,79	52,98	41,02	67
68	55,01	39,97	54,83	40,21	54,66	40,45	54,48	40,68	54,31	40,92	54,13	41,16	53,94	41,40	53,77	41,63	68
69	55,82	40,56	55,65	40,80	55,47	41,04	55,28	41,28	55,11	41,53	54,92	41,76	54,74	42,00	54,56	42,24	69
70	56,63	41,14	56,45	41,39	56,27	41,64	56,09	41,88	55,90	42,13	55,72	42,37	55,54	42,61	55,35	42,85	70
71	57,44	41,73	57,26	41,98	57,07	42,23	56,89	4[illegible],48	56,70	42,73	56,52	42,97	56,34	43,22	56,14	43,47	71
72	58,25	42,32	58,06	42,57	57,88	42,83	57,69	43,08	57,50	43,33	57,31	43,58	57,14	43,83	56,93	44,08	72
73	59,06	42,91	58,87	43,16	58,68	43,42	58,49	43,68	58,30	43,93	58,11	44,18	57,93	44,44	57,72	44,69	73
74	59,87	43,50	59,67	43,76	59,49	44,02	59,29	44,27	59,10	44,53	58,90	44,79	58,73	45,05	58,51	45,30	74
75	60,68	44,08	60,48	44,35	60,29	44,61	60,09	44,87	59,90	45,14	59,70	45,39	59,52	45,66	59,30	45,91	75
76	61,48	44,67	61,29	44,93	61,09	45,21	60,89	45,47	60,70	45,74	60,49	46,00	60,31	46,27	60,09	46,53	76
77	62,29	45,26	62,09	45,53	61,90	45,80	61,69	46,07	61,50	46,34	61,29	46,60	61,11	46,88	60,88	47,14	77
78	63,10	45,85	62,90	46,12	62,70	46,40	62,50	46,67	62,30	46,94	62,09	47,21	61,90	47,48	61,68	47,75	78
79	63,91	46,44	63,70	46,71	63,50	46,99	63,30	47,27	63,10	47,54	62,88	47,81	62,69	48,09	62,47	48,36	79
80	64,78	47,02	64,51	47,30	64,31	47,59	64,10	47,87	63,89	48,15	63,68	48,42	63,47	48,70	63,25	48,98	80
81	65,53	47,61	65,32	47,90	65,11	48,18	64,90	48,46	64,69	48,75	64,48	49,03	64,26	49,31	64,05	49,59	81
82	66,34	48,20	66,13	48,49	65,92	48,78	65,70	49,06	65,49	49,35	65,27	49,63	65,05	49,92	64,84	50,20	82
83	67,15	48,79	66,93	49,08	66,72	49,37	66,50	49,66	66,29	49,95	66,07	50,24	65,85	50,53	65,63	50,81	83
84	67,96	49,37	67,74	49,67	67,52	49,97	67,30	50,26	67,09	50,55	66,86	50,84	66,64	51,14	66,42	51,43	84
85	68,77	49,96	68,54	50,26	68,33	50,56	68,10	50,86	67,89	51,16	67,66	51,45	67,43	51,75	67,2[illegible]	52,04	85
86	69,57	50,55	69,35	50,85	69,13	51,16	68,91	51,45	68,68	51,76	68,46	52,05	68,23	52,35	68,00	52,65	86
87	70,38	51,14	70,1[illegible]	51,44	69,94	51,75	69,71	52,05	69,48	52,36	69,25	52,66	69,02	52,96	68,79	53,26	87
88	71,19	51,73	70,96	52,03	70,74	52,35	70,51	52,65	70,28	52,96	70,05	53,26	69,81	53,57	69,58	53,87	88
89	72,00	52,31	71,77	52,62	71,54	52,94	71,31	53,25	71,08	53,56	70,84	53,87	70,60	54,18	70,37	54,49	89
90	72,81	52,90	72,58	53,22	72,35	53,53	72,11	53,85	71,88	54,16	71,64	54,48	71,40	54,79	71,16	55,10	90
91	73,61	53,49	73,39	53,81	73,15	54,13	72,91	54,45	72,68	54,77	72,44	55,08	72,19	55,40	71,95	55,71	91
92	74,42	54,08	74,19	54,40	73,95	54,72	73,71	55,04	73,48	55,37	73,23	55,69	72,99	56,01	72,74	56,32	92
93	75,23	54,66	74,99	54,99	74,76	55,32	74,52	55,64	74,27	55,97	74,03	56,29	73,78	56,61	73,53	56,94	93
94	76,04	55,25	75,80	55,58	75,56	55,91	75,32	56,24	75,07	56,57	74,82	56,90	74,57	57,22	74,33	57,55	94
95	76,85	55,84	76,61	56,17	76,37	56,51	76,12	56,84	75,87	57,17	75,62	57,50	75,37	57,83	75,12	58,16	95
96	77,66	56,43	77,42	56,76	77,17	57,10	76,92	57,44	76,67	57,78	76,42	58,11	76,16	58,44	75,91	58,77	96
97	78,47	57,02	78,22	57,35	77,97	57,70	77,72	58,03	77,47	58,38	77,21	58,71	76,95	59,05	76,70	59,38	97
98	79,27	57,60	79,03	57,95	78,7[illegible]	58,29	78,52	58,63	78,27	58,98	78,01	59,32	77,75	59,66	77,49	60,00	98
99	80,08	58,19	79,83	58,54	79,50	58,89	79,32	59,23	79,0[illegible]	59,58	78,80	59,92	78,54	60,27	78,28	60,61	99
100	80,90	58,78	80,64	59,13	80,[illegible]9	59,48	80,12	59,83	79,86	60,18	79,60	60,53	79,33	60,[illegible]8	79,07	61,23	100
101	81,71	59,37	81,55	59,72	81,19	60,08	80,93	60,43	80,66	60,78	80,40	61,13	80,1[illegible]	61,48	79,86	61,83	101
102	82,52	59,95	82,36	60,31	81,99	60,67	81,73	61,03	81,46	61,39	81,19	61,73	80,92	62,09	80,65	62,45	102
103	83,33	60,54	83,16	60,90	82,80	61,27	82,53	61,63	82,26	61,99	81,99	62,34	81,72	62,70	81,44	63,06	103
104	84,14	61,13	83,97	61,49	83,60	61,86	83,33	62,22	83,06	62,59	82,78	62,95	82,51	63,31	82,23	63,67	104
105	84,95	61,72	84,77	62,09	84,41	62,46	84,13	62,82	83,86	63,19	83,58	63,55	83,30	63,92	83,02	64,28	105
106	85,76	62,31	85,58	62,68	85,21	63,05	84,93	63,42	84,66	63,79	84,38	64,16	84,00	64,53	83,81	64,89	106
107	86,56	62,90	86,39	63,27	86,01	63,65	85,73	64,02	85,46	64,40	85,17	64,76	84,89	65,14	84,61	65,51	107
108	87,37	63,48	87,19	63,86	86,82	64,24	86,53	64,62	86,26	65,00	85,97	65,37	85,68	65,75	85,40	66,12	108
109	88,18	64,07	87,99	64,45	87,62	64,84	87,33	65,21	87,05	65,60	86,76	65,97	86,47	66,36	86,19	66,73	109
110	88,99	64,66	88,71	65,04	88,42	65,43	88,14	65,81	87,85	66,20	87,56	66,58	87,27	66,06	86,98	67,34	110
111	89,80	65,24	89,51	65,63	89,23	66,02	88,94	66,41	88,65	66,80	88,36	67,19	88,06	67,57	87,77	67,96	111
112	90,61	65,83	90,32	66,23	90,03	66,62	89,74	67,2[illegible]	89,45	67,40	89,15	67,79	88,85	68,18	88,56	68,57	112
113	91,42	66,42	91,13	66,82	90,84	67,21	90,54	67,61	90,25	68,01	89,95	68,40	89,65	68,79	89,35	69,18	113
114	92,23	67,01	91,93	67,41	91,64	67,81	91,34	68,21	91,05	68,61	90,74	69,00	90,44	69,40	90,14	69,79	114
115	93,04	67,60	92,74	68,00	92,45	68,4[illegible]	92,14	68,80	91,84	69,21	91,54	69,61	91,23	70,01	90,93	70,40	115
116	93,85	68,18	93,54	68,59	93,25	69,00	92,94	69,40	92,64	69,81	92,34	70,21	92,03	70,62	91,72	71,02	116
117	94,65	68,77	94,35	69,18	94,05	69,59	93,74	70,00	93,44	70,41	93,13	70,82	92,8[illegible]	71,23	92,51	71,63	117
118	95,46	69,36	95,16	69,77	94,86	70,19	94,55	70,60	94,24	71,02	93,93	71,42	93,61	71,84	93,30	72,24	118
119	96,27	69,95	95,96	70,36	95,65	70,78	95,35	71,20	95,04	71,62	94,72	72,03	94,41	72,44	94,09	72,85	119
120	97,08	70,54	96,77	70,96	96,46	71,38	96,15	71,80	95,84	72,22	95,52	72,63	95,20	73,05	94,88	73,47	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 M[illegible]		30 Min		15 Min.		
	54 Deg.		53 Degrees 1,33								52 Degrees 1,28						

Digitized by Google

Distance	38 Degrees						,78		39 Degrees						,81		Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,79	0,62	0,79	0,62	0,78	0,63	0,78	0,63	0,78	0,63	0,77	0,63	0,77	0,64	0,77	0,64	1
2	1,58	1,23	1,57	1,24	1,57	1,25	1,56	1,25	1,55	1,26	1,55	1,27	1,54	1,27	1,54	1,28	2
3	2,36	1,85	2,36	1,86	2,35	1,87	2,34	1,88	2,33	1,89	2,32	1,90	2,32	1,91	2,31	1,92	3
4	3,15	2,46	3,14	2,48	3,13	2,49	3,12	2,50	3,11	2,52	3,10	2,53	3,09	2,54	3,08	2,56	4
5	3,94	3,08	3,93	3,10	3,91	3,11	3,90	3,13	3,89	3,15	3,87	3,16	3,86	3,18	3,84	3,20	5
6	4,73	3,69	4,71	3,72	4,70	3,74	4,68	3,76	4,66	3,78	4,65	3,80	4,63	3,82	4,61	3,84	6
7	5,52	4,31	5,50	4,33	5,48	4,36	5,46	4,38	5,44	4,41	5,42	4,43	5,40	4,45	5,38	4,48	7
8	6,30	4,93	6,28	4,95	6,26	4,98	6,24	5,01	6,22	5,04	6,20	5,07	6,17	5,09	6,15	5,12	8
9	7,09	5,54	7,07	5,57	7,04	5,60	7,02	5,63	6,99	5,66	6,97	5,69	6,95	5,73	6,92	5,76	9
10	7,88	6,16	7,85	6,19	7,83	6,23	7,80	6,26	7,77	6,29	7,74	6,33	7,72	6,36	7,69	6,39	10
11	8,67	6,77	8,64	6,81	8,61	6,85	8,58	6,89	8,55	6,92	8,52	6,97	8,49	6,99	8,46	7,03	11
12	9,46	7,39	9,42	7,43	9,39	7,47	9,35	7,51	9,33	7,55	9,29	7,59	9,26	7,63	9,23	7,67	12
13	10,25	8,00	10,21	8,05	10,17	8,09	10,14	8,14	10,10	8,18	10,07	8,23	10,03	8,27	10,00	8,31	13
14	11,04	8,62	10,99	8,67	10,96	8,72	10,92	8,76	10,88	8,81	10,84	8,86	10,80	8,91	10,76	8,95	14
15	11,82	9,24	11,78	9,29	11,74	9,33	11,70	9,39	11,65	9,44	11,62	9,49	11,58	9,54	11,53	9,59	15
16	12,61	9,85	12,56	9,91	12,52	9,96	12,48	10,02	12,43	10,07	12,39	10,13	12,35	10,18	12,30	10,23	16
17	13,40	10,47	13,35	10,52	13,31	10,59	13,26	10,64	13,21	10,70	13,16	10,76	13,12	10,81	13,07	10,87	17
18	14,18	11,08	14,13	11,14	14,09	11,21	14,04	11,27	13,99	11,33	13,94	11,39	13,89	11,45	13,84	11,51	18
19	14,97	11,70	14,92	11,76	14,87	11,83	14,82	11,89	14,77	11,96	14,71	12,02	14,66	12,09	14,61	12,15	19
20	15,76	12,31	15,71	12,38	15,05	12,45	15,60	12,52	15,54	12,50	15,49	12,65	15,43	12,72	15,38	12,79	20
21	16,55	12,93	16,49	13,00	16,44	13,07	16,38	13,14	16,32	13,22	16,26	13,29	16,20	13,36	16,15	13,43	21
22	17,34	13,55	17,27	13,62	17,22	13,70	17,16	13,77	17,10	13,85	17,04	13,92	16,98	13,99	16,92	14,07	22
23	18,12	14,15	18,06	14,24	18,00	14,32	17,94	14,40	17,87	14,47	17,81	14,55	17,75	14,63	17,68	14,71	23
24	18,91	14,78	18,85	14,86	18,78	14,94	18,72	15,02	18,65	15,10	18,58	15,18	18,52	15,26	18,45	15,35	24
25	19,70	15,39	19,63	15,46	19,57	15,57	19,50	15,65	19,43	15,73	19,36	15,82	19,29	15,90	19,22	15,98	25
26	20,40	16,01	20,41	16,08	20,35	16,19	20,28	16,27	20,21	16,36	20,13	16,45	20,06	16,53	19,99	16,62	26
27	21,28	16,63	21,20	16,70	21,13	16,81	21,05	16,90	20,98	16,99	20,91	17,08	20,84	17,17	20,76	17,26	27
28	22,06	17,24	21,99	17,31	21,92	17,43	21,84	17,53	21,76	17,62	21,69	17,72	21,61	17,81	21,53	17,90	28
29	22,85	17,86	22,77	17,93	22,70	18,06	22,62	18,15	22,54	18,25	22,46	18,35	22,38	18,44	22,29	18,54	29
30	23,64	18,47	23,56	18,57	23,48	18,68	23,40	18,78	23,32	18,88	23,23	18,98	23,15	19,08	23,07	19,18	30
31	24,43	19,09	24,35	19,19	24,26	19,30	24,18	19,40	24,09	19,51	24,01	19,61	23,93	19,72	23,83	19,82	31
32	25,22	19,70	25,13	19,81	25,04	19,92	24,96	20,03	24,87	20,14	24,78	20,25	24,69	20,35	24,60	20,46	32
33	26,00	20,32	25,92	20,43	25,83	20,54	25,74	20,66	25,65	20,77	25,55	20,88	25,47	20,99	25,37	21,10	33
34	26,79	20,93	26,70	21,05	26,61	21,17	26,52	21,28	26,43	21,40	26,33	21,51	26,24	21,63	26,14	21,74	34
35	27,58	21,55	27,49	21,67	27,39	21,79	27,30	21,91	27,20	22,03	27,10	22,15	27,01	22,26	26,91	22,38	35
36	28,37	22,17	28,27	22,29	28,18	22,41	28,08	22,53	27,98	22,65	27,88	22,78	27,78	22,90	27,68	23,02	36
37	29,16	22,78	29,06	22,91	28,96	23,04	28,86	23,16	28,75	23,28	28,65	23,41	28,55	23,53	28,45	23,66	37
38	29,94	23,40	29,84	23,53	29,74	23,66	29,64	23,79	29,53	23,91	29,42	24,05	29,33	24,17	29,22	24,30	38
39	30,73	24,01	30,63	24,14	30,53	24,28	30,42	24,41	30,31	24,54	30,20	24,68	30,09	24,81	29,99	24,93	39
40	31,52	24,63	31,41	24,76	31,30	24,90	31,20	25,04	31,09	25,17	30,98	25,31	30,87	25,44	30,75	25,58	40
41	32,31	25,24	32,20	25,38	32,09	25,52	31,98	25,66	31,87	25,80	31,75	25,94	31,62	26,08	31,52	26,22	41
42	33,10	25,86	32,98	26,00	32,87	26,15	32,76	26,29	32,64	26,43	32,52	26,57	32,41	26,72	32,29	26,81	42
43	33,88	26,47	33,77	26,62	33,65	26,77	33,54	26,92	33,42	27,06	33,30	27,21	33,18	27,35	33,06	27,50	43
44	34,67	27,09	34,55	27,24	34,44	27,39	34,32	27,54	34,20	27,70	34,07	27,84	33,95	27,99	33,83	28,13	44
45	35,46	27,71	35,34	27,86	35,22	28,02	35,10	28,17	34,97	28,32	34,85	28,47	34,73	28,62	34,60	28,77	45
46	36,25	28,32	36,12	28,48	36,00	28,64	35,88	28,79	35,75	28,95	35,62	29,11	35,50	29,26	35,37	29,41	46
47	37,04	28,94	36,91	29,10	36,78	29,26	36,66	29,42	36,53	29,58	36,39	29,74	36,27	29,90	36,14	30,05	47
48	37,82	29,55	37,69	29,72	37,57	29,88	37,44	30,05	37,30	30,21	37,17	30,37	37,04	30,53	36,91	30,69	48
49	38,61	30,17	38,48	30,34	38,35	30,50	38,22	30,67	38,08	30,84	37,94	31,01	37,81	31,17	37,68	31,33	49
50	39,40	30,78	39,27	30,96	39,13	31,13	38,99	31,30	38,80	31,47	38,72	31,64	38,58	31,80	38,44	31,97	50
51	40,19	31,40	40,05	31,57	39,91	31,75	39,77	31,92	39,64	32,10	39,49	32,27	39,35	32,44	39,21	32,61	51
52	40,98	32,02	40,83	32,19	40,70	32,37	40,55	32,55	40,41	32,72	40,27	32,90	40,13	33,08	39,98	33,25	52
53	41,77	32,63	41,62	32,81	41,48	33,00	41,33	33,17	41,19	33,35	41,04	33,54	40,90	33,71	40,75	33,89	53
54	42,55	33,25	42,41	33,43	42,26	33,62	42,11	33,80	41,97	33,98	41,82	34,17	41,67	34,34	41,52	34,53	54
55	43,34	33,86	43,19	34,05	43,05	34,24	42,89	34,43	42,75	34,61	42,59	34,80	42,44	34,98	42,29	35,17	55
56	44,13	34,48	43,98	34,67	43,83	34,86	43,67	35,05	43,52	35,24	43,36	35,43	43,21	35,62	43,06	35,81	56
57	44,92	35,10	44,76	35,29	44,61	35,49	44,45	35,68	44,30	35,87	44,15	36,07	43,99	36,26	43,83	36,45	57
58	45,71	35,71	45,55	35,91	45,39	36,11	45,23	36,30	45,07	36,50	44,93	36,70	44,76	36,89	44,59	37,08	58
59	46,49	36,33	46,33	36,53	46,18	36,73	46,01	36,93	45,85	37,13	45,70	37,33	45,53	37,53	45,36	37,72	59
60	47,28	36,04	47,12	37,15	46,96	37,35	46,79	37,56	46,63	37,76	46,46	37,96	46,30	38,17	46,13	38,37	60
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		Distance
	52 Deg.		51 Degrees						1,23		50 Degrees					1,19	

Digitized by Google

	38 Degrees							,78	39 Degrees							,81	
Distance	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	
61	48,07	37,56	47,90	37,76	47,74	37,97	47,57	38,18	47,41	38,39	47,24	38,60	47,07	38,80	46,90	39,01	61
62	48,86	38,17	48,69	38,38	48,52	38,60	48,35	38,81	48,18	39,02	48,01	39,23	47,84	39,43	47,67	39,64	62
63	49,65	38,79	49,47	39,00	49,31	39,22	49,13	39,43	48,96	39,65	48,79	39,86	48,61	40,07	48,44	40,28	63
64	50,43	39,40	50,26	39,62	50,09	39,84	49,91	40,06	49,74	40,28	49,56	40,50	49,39	40,70	49,21	40,92	64
65	51,22	40,02	51,04	40,24	50,87	40,47	50,69	40,69	50,51	40,90	50,34	41,13	50,16	41,35	49,98	41,56	65
66	52,01	40,64	51,83	40,86	51,66	41,09	51,47	41,31	51,29	41,53	51,11	41,76	50,93	41,98	50,74	42,20	66
67	52,80	41,25	52,61	41,48	52,44	41,71	52,25	41,94	52,07	42,16	51,88	42,39	51,70	42,62	51,51	42,84	67
68	53,59	41,87	53,40	42,10	53,22	42,34	53,03	42,56	52,85	42,79	52,66	43,03	52,47	43,25	52,28	43,48	68
69	54,37	42,48	54,18	42,72	54,00	42,96	53,81	43,19	53,62	43,42	53,43	43,66	53,24	43,89	53,05	43,12	69
70	55,16	43,10	54,97	43,34	54,78	43,58	54,59	43,81	54,40	44,05	54,21	44,29	54,01	44,53	53,82	44,76	70
71	55,95	43,71	55,76	43,95	55,57	44,20	55,37	44,44	55,18	44,68	54,98	44,92	54,79	45,16	54,59	45,40	71
72	56,74	44,33	56,54	44,57	56,35	44,82	56,15	45,06	55,96	45,31	55,76	45,56	55,56	45,80	55,36	46,04	72
73	57,53	44,94	57,33	45,19	57,13	45,45	56,93	45,69	56,73	45,94	56,53	46,19	56,33	46,43	56,13	46,68	73
74	58,31	45,56	58,11	45,81	57,92	46,07	57,71	46,32	57,51	46,57	57,30	46,82	57,10	47,07	56,90	47,32	74
75	59,10	46,18	58,90	46,43	58,7	46,69	58,49	46,94	58,29	47,20	58,08	47,46	57,87	47,71	57,60	47,96	75
76	59,89	46,79	59,68	47,04	59,48	47,31	59,27	47,57	59,06	47,83	58,85	48,03	58,65	48,34	58,43	48,60	76
77	60,68	47,41	60,47	47,66	60,27	47,94	60,05	48,20	59,84	48,46	59,63	48,72	59,42	48,98	59,20	49,23	77
78	61,46	48,02	61,25	48,28	61,05	48,56	60,83	48,82	60,62	49,08	60,4	49,3	60,19	49,61	59,97	49,87	78
79	62,25	48,64	62,04	48,90	61,83	49,18	61,61	49,45	61,39	49,71	61,17	49,99	60,96	50,25	60,94	50,51	79
80	63,04	49,25	62,83	49,53	62,61	49,80	62,39	50,07	62,17	50,35	61,95	50,62	61,73	50,89	61,51	51,16	80
81	63,83	49,87	63,61	50,15	63,39	50,42	63,17	50,70	62,95	50,98	62,73	51,25	62,50	51,52	62,28	51,79	81
82	64,62	50,49	64,40	50,77	64,18	51,05	63,96	51,33	63,73	51,60	63,50	51,88	63,27	52,16	63,05	52.43	82
83	65,41	51,10	65,18	51,38	64,96	51,67	64,74	51,95	64,50	52,23	64,27	52,52	64,05	52,79	63,81	53,07	83
84	66,19	51,72	65,97	52,00	65,74	52,29	65,52	52,58	65,28	52,86	65,05	53,15	64,82	53,43	64,58	53,71	84
85	66,98	52,33	66,75	52,62	66,52	52,92	66,30	53,20	66,06	53,49	65,82	53,78	65,59	54,07	65,35	54,35	85
86	67,77	52,95	67,54	53,24	67,31	53,54	67,08	53,83	66,83	54,12	66,60	54,42	66,36	54,70	66,12	54,99	86
87	68,56	53,57	68,32	53,86	68,10	54,16	67,86	54,46	67,61	54,75	67,37	55,05	67,13	55,34	66,89	55,63	87
88	69,35	54,18	69,11	54,48	68.89	54,79	68,64	55,08	68,39	55,38	68,14	55,68	67,91	55,97	67,66	56,27	88
89	70,13	54,80	69,89	55,10	69,67	55,41	69,42	55,71	69,17	56,01	68,92	56,32	68,68	56,61	68,43	56,90	89
90	70,92	55,41	70,68	55,72	70,44	56.03	70,19	56,33	69,94	56,64	69,70	56,94	69,45	57,25	69,20	57,55	90
91	71,71	56,03	71,46	56,34	71,22	56,6	70,97	56,96	70,72	57,27	70,47	57,58	70,22	57,88	69,97	58,19	91
92	72,50	56,64	72,25	56,96	72,00	57,27	71,75	57,59	71,50	57,90	71,24	58,21	70,99	58,52	70,73	58,83	92
93	73,29	57,26	73,03	57,58	72,78	57,90	72,53	58,21	72,28	58,53	72,02	58,84	71,76	59,16	71,50	59,47	93
94	74,07	57,87	73,82	58,19	73,57	58,52	73,31	58,84	73,05	59,16	72,79	59,48	72,53	59,79	72,27	60,11	94
95	74,86	58,49	74,60	58,81	74,35	59,14	74,09	59,46	73,83	59,78	73,57	60,11	73,31	60,43	73,04	60,76	95
96	75,65	59,11	75,39	59,43	75,13	59,76	74,87	60,09	74,61	60,41	74,34	60,74	74,08	61,06	73,81	61,38	96
97	76,44	59,72	76,17	60,05	75,92	60,39	75,65	60,72	75,38	61,04	75,11	61,38	74,85	61,70	74,58	62,02	97
98	77,23	69,34	76,96	60,67	76,70	61,01	76,42	61,34	76,16	61,67	75,89	62,01	75,62	62,34	75,35	62,66	98
99	78,01	60,95	77,74	61,29	77,48	61,63	77,21	61,97	76,94	62,30	76,66	62,63	76,39	62,97	76,12	63,30	99
100	78,80	61,57	78,53	61,91	78,26	62,25	77,99	62,59	77,72	62,93	77,44	63,2	77,16	63,61	76,88	63,94	100
101	79,59	62,18	79,32	62,53	79,04	62,87	78,77	63,22	78,49	63,56	78,21	63,90	77,93	64,25	77,65	64,58	101
102	80,38	62,80	80,10	63,15	79,83	63,50	79,55	63,84	79,27	64,19	78,99	64,54	78,71	64,88	78,42	65,22	102
103	81,17	63,41	80,89	63,77	80,61	64,12	80,33	64,47	80,05	64,82	79,76	65,17	79,48	65,52	79,19	65,86	103
104	81,95	64,03	81,67	64,39	81,39	64,74	81,11	65,10	80,82	65,45	80,54	65,80	80,25	66,15	79,96	66,50	104
105	82,74	64,65	82,46	65,00	82,18	65,37	81,89	65,72	81,60	66,08	81,31	66,44	81,02	66,79	80,73	67,14	105
106	83,53	65,26	83,24	65,62	82,96	65,99	82,67	66,35	82,38	66,71	82,08	67,07	81,79	67,42	81,70	67,78	106
107	84,32	65,88	84,03	66,2	83,74	66,61	83,45	66,97	83,16	67,34	82,86	67,70	82,57	68,06	82,27	68,42	107
108	85,11	66,49	84,81	66,86	84,53	67,24	84,23	67,60	83,93	67,96	83,63	68,34	83,34	68,70	83,04	69,06	108
109	85,89	67,11	85,60	67,48	85,31	67,86	85,01	68,23	84,71	68,59	84,41	68,97	84,11	69,33	83,81	69,70	109
110	86,68	67,72	86,39	68,10	86,09	68,48	85,79	68,85	85,49	69,23	85,18	69,60	84,88	69,97	84,57	70,34	110
111	87,47	68,34	87,17	68,72	86,87	69,1	86,57	69,48	86,26	69,85	85,96	70,23	85,65	70,61	85,34	70,98	111
112	88,26	68,96	87,96	69,33	87,65	69,72	87,35	70,10	87,04	70,48	86,73	70,87	86,42	71,24	86,11	71,62	112
113	89,05	69,57	88,74	69,96	88,44	70,35	88,13	70,73	87,82	71,11	87,51	71,50	87,19	71,88	86,88	72,26	113
114	89,83	70,19	89,53	70,58	89,22	70,97	88,91	71,36	88,60	71,74	88,28	72,13	87,97	72,51	87,65	72,89	114
115	90,62	70,80	90,31	71,19	90,00	71,59	89,69	71,98	89,37	72,37	89,05	72,76	88,74	73,15	88,42	73,53	115
116	91,41	71,42	91,10	71,81	90,79	72,21	90,47	72,61	90,15	73,00	89,83	73,40	89,51	73,79	89,1	74,17	116
117	92,20	72,04	91,88	72,43	91,57	72,84	91,25	73,23	90,93	73,63	90,60	74,03	90,28	74,42	89,95	74,81	117
118	92,99	72,65	92,67	73,05	92,35	73,46	92,03	73,86	91,70	74,26	91,38	74,66	91,05	75,06	90,72	75,45	118
119	93,77	73,27	93,45	73,67	93,13	74,08	92,81	74,49	92,48	74,88	92,15	75,29	91,83	75,69	91,49	76,09	119
120	94,56	73,88	94,24	74,29	93,91	74,70	93,59	75,11	93,26	75,52	92.93	75,93	92,59	76,33	92,26	76,73	120
	Dep.	Lat.	Dep.	Lat	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
Distance	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min		Distance
	52 Deg.		51 Degrees						1,23	50 Degrees						1,19	

Distance	40 Degrees ,84								41 Degrees ,87								Distance
	0 Min.		15 Min		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,77	0,64	0,76	0,65	0,76	0,65	0,76	0,65	0,76	0,66	0,75	0,66	0,75	0,66	0,75	0,67	1
2	1,53	1,29	1,53	1,29	1,52	1,30	1,52	1,31	1,51	1,31	1,50	1,32	1,50	1,33	1,49	1,33	2
3	2,30	1,93	2,29	1,94	2,28	1,95	2,27	1,96	2,26	1,97	2,26	1,98	2,25	1,99	2,24	2,00	3
4	3,06	2,57	3,05	2,58	3,05	2,60	3,03	2,61	3,02	2,62	3,01	2,63	3,00	2,65	2,98	2,66	4
5	3,83	3,21	3,82	3,23	3,80	3,25	3,78	3,26	3,77	3,28	3,76	3,30	3,75	3,31	3,73	3,33	5
6	4,60	3,86	4,58	3,88	4,56	3,90	4,55	3,92	4,53	3,94	4,51	3,96	4,49	3,98	4,48	4,00	6
7	5,36	4,50	5,34	4,52	5,32	4,55	5,30	4,57	5,28	4,59	5,26	4,62	5,24	4,64	5,22	4,66	7
8	6,13	5,14	6,11	5,17	6,08	5,20	6,06	5,22	6,04	5,25	6,02	5,28	5,99	5,30	5,97	5,33	8
9	6,89	5,79	6,87	5,82	6,84	5,85	6,82	5,88	6,79	5,91	6,77	5,93	6,74	5,96	6,72	5,99	9
10	7,66	6,43	7,63	6,46	7,60	6,50	7,58	6,53	7,55	6,56	7,52	6,59	7,49	6,63	7,46	6,66	10
11	8,43	7,07	8,40	7,11	8,37	7,14	8,33	7,18	8,30	7,22	8,27	7,25	8,24	7,29	8,21	7,33	11
12	9,19	7,71	9,16	7,75	9,13	7,79	9,09	7,85	9,06	7,87	9,02	7,92	8,99	7,95	8,95	7,99	12
13	9,96	8,36	9,92	8,40	9,89	8,44	9,85	8,49	9,81	8,53	9,77	8,57	9,74	8,61	9,70	8,66	13
14	10,72	9,00	10,69	9,05	10,65	9,09	10,61	9,14	10,57	9,18	10,53	9,23	10,49	9,28	10,45	9,32	14
15	11,49	9,64	11,45	9,69	11,41	9,74	11,37	9,79	11,32	9,84	11,28	9,89	11,24	9,94	11,19	9,99	15
16	12,26	10,29	12,21	10,34	12,17	10,39	12,12	10,45	12,08	10,50	12,03	10,55	11,98	10,60	11,94	10,66	16
17	13,02	10,93	12,98	10,98	12,93	11,04	12,88	11,09	12,83	11,15	12,78	11,21	12,73	11,27	12,68	11,32	17
18	13,79	11,57	13,74	11,63	13,69	11,69	13,64	11,75	13,59	11,81	13,53	11,87	13,48	11,93	13,43	11,99	18
19	14,55	12,21	14,50	12,28	14,46	12,34	14,40	12,40	14,34	12,46	14,29	12,53	14,23	12,59	14,18	12,65	19
20	15,32	12,86	15,27	12,92	15,21	12,99	15,15	13,06	15,09	13,12	15,04	13,19	14,98	13,25	14,92	13,32	20
21	16,09	13,50	16,03	13,57	15,97	13,64	15,91	13,71	15,85	13,78	15,79	13,85	15,73	13,92	15,67	13,98	21
22	16,85	14,14	16,79	14,21	16,73	14,29	16,67	14,36	16,60	14,43	16,54	14,51	16,48	14,58	16,41	14,65	22
23	17,62	14,79	17,55	14,86	17,49	14,94	17,43	15,01	17,36	15,09	17,30	15,16	17,23	15,24	17,16	15,32	23
24	18,39	15,43	18,32	15,51	18,25	15,59	18,18	15,67	18,11	15,75	18,05	15,82	17,98	15,90	17,91	15,98	24
25	19,15	16,07	19,08	16,15	19,01	16,23	18,94	16,32	18,87	16,39	18,80	16,48	18,73	16,57	18,65	16,65	25
26	19,92	16,71	19,84	16,80	19,77	16,88	19,70	16,97	19,62	17,05	19,55	17,14	19,47	17,23	19,40	17,31	26
27	20,68	17,36	20,61	17,44	20,53	17,53	20,46	17,63	20,38	17,70	20,30	17,80	20,22	17,89	20,14	17,98	27
28	21,45	18,00	21,37	18,09	21,29	18,18	21,22	18,28	21,13	18,36	21,05	18,46	20,97	18,56	20,89	18,65	28
29	22,22	18,64	22,13	18,74	22,05	18,83	21,97	18,93	21,89	19,02	21,81	19,12	21,72	19,22	21,64	19,31	29
30	22,98	19,28	22,90	19,38	22,81	19,48	22,73	19,58	22,64	19,68	22,56	19,78	22,47	19,88	22,38	19,98	30
31	23,75	19,93	23,66	20,03	23,57	20,13	23,49	20,24	23,39	20,34	23,31	20,44	23,22	20,54	23,13	20,64	31
32	24,51	20,57	24,42	20,68	24,33	20,78	24,24	20,89	24,15	20,99	24,06	21,10	23,97	21,21	23,87	21,31	32
33	25,28	21,21	25,19	21,32	25,09	21,43	25,00	21,54	24,91	21,65	24,81	21,76	24,72	21,86	24,62	21,97	33
34	26,05	21,86	25,95	21,97	25,85	22,08	25,76	22,20	25,66	22,31	25,56	22,42	25,47	22,53	25,37	22,64	34
35	26,81	22,50	26,71	22,61	26,61	22,73	26,52	22,85	26,42	22,96	26,32	23,08	26,21	23,19	26,11	23,31	35
36	27,58	23,14	27,48	23,26	27,37	23,38	27,28	23,50	27,17	23,62	27,07	23,74	26,96	23,86	26,86	23,97	36
37	28,34	23,79	28,24	23,91	28,13	24,03	28,03	24,15	27,93	24,37	27,82	24,39	27,71	24,52	27,60	24,64	37
38	29,11	24,43	29,00	24,55	28,89	24,68	28,79	24,81	28,68	25,03	28,57	25,05	28,46	25,18	28,35	25,31	38
39	29,88	25,07	29,76	25,20	29,65	25,33	29,55	25,46	29,44	25,69	29,32	25,71	29,21	25,85	29,10	25,97	39
40	30,64	25,71	30,53	25,85	30,42	25,98	30,30	26,11	30,19	26,24	30,07	26,37	29,96	26,51	29,84	26,64	40
41	31,41	26,36	31,29	26,49	31,18	26,63	31,06	26,76	30,94	26,90	30,83	27,03	30,71	27,17	30,59	27,30	41
42	32,17	26,99	32,06	27,14	31,94	27,28	31,82	27,42	31,60	27,55	31,58	27,69	31,46	27,83	31,33	27,97	42
43	32,94	27,64	32,82	27,78	32,70	27,93	32,58	28,07	32,35	28,21	32,33	28,35	32,20	28,49	32,08	28,63	43
44	33,71	28,28	33,58	28,43	33,46	28,57	33,34	28,72	33,11	28,87	33,08	29,01	32,94	29,16	32,83	29,30	44
45	34,47	28,93	34,34	29,08	34,22	29,22	34,09	29,38	33,86	29,52	33,83	29,67	33,69	29,82	33,57	29,97	45
46	35,24	29,57	35,11	29,72	34,98	29,87	34,85	30,03	34,62	30,18	34,59	30,33	34,44	30,48	34,32	30,63	46
47	36,00	30,21	35,87	30,37	35,74	30,52	35,61	30,68	35,37	30,83	35,34	30,99	35,19	31,15	35,06	31,30	47
48	36,77	30,86	36,63	31,01	36,50	31,17	36,37	31,33	36,13	31,49	36,09	31,65	35,94	31,81	35,81	31,96	48
49	37,54	31,50	37,40	31,66	37,26	31,82	37,13	31,99	36,88	32,15	36,84	32,31	36,69	32,47	36,56	32,63	49
50	38,30	32,14	38,16	32,31	38,02	32,47	37,88	32,64	37,74	32,80	37,59	32,97	37,45	33,13	37,30	33,29	50
51	39,07	32,78	38,93	32,95	38,78	33,12	38,64	33,29	38,49	33,46	38,24	33,63	38,20	33,79	38,05	33,96	51
52	39,83	33,43	39,69	33,60	39,54	33,77	39,40	33,94	39,25	34,12	39,00	34,29	38,95	34,46	38,80	34,63	52
53	40,60	34,07	40,45	34,24	40,30	34,42	40,15	34,60	40,00	34,77	39,75	34,95	39,70	35,12	39,54	35,29	53
54	41,37	34,71	41,21	34,89	41,06	35,07	40,91	35,25	40,76	35,43	40,50	35,60	40,44	35,78	40,29	35,96	54
55	42,13	35,36	41,98	35,54	41,82	35,72	41,67	35,90	41,51	36,08	41,25	36,26	41,19	36,45	41,03	36,62	55
56	42,90	36,00	42,74	36,18	42,58	36,37	42,43	36,56	42,27	36,74	42,00	36,92	41,94	37,11	41,78	37,29	56
57	43,66	36,64	43,50	36,83	43,34	37,02	43,19	37,21	43,02	37,40	42,76	37,58	42,69	37,77	42,53	37,96	57
58	44,43	37,28	44,27	37,47	44,10	37,67	43,95	37,86	43,77	38,05	43,51	38,24	43,44	38,44	43,27	38,62	58
59	45,20	37,93	45,03	38,12	44,86	38,31	44,70	38,52	44,53	38,71	44,26	38,90	44,19	39,10	44,02	39,29	59
60	45,96	38,57	45,79	38,77	45,63	38,97	45,45	39,17	45,28	39,36	45,01	39,56	44,94	39,76	44,76	39,95	60
Distance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min		45 Min.		30 Min.		15 Min.		
	50 Deg.		49 Degrees 1,15								48 Degrees 1,11						

Distance	40 Degrees							,84	41 Degrees							,87	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	46,73	39,21	46,56	39,41	46,39	39,62	46,21	39,82	46,04	40,02	45,86	40,16	45,69	40,42	45,51	40,62	61
62	47,49	39,85	47,32	40,06	47,15	40,27	46,97	40,47	46,79	40,68	46,61	40,82	46,44	41,08	46,26	41,29	62
63	48,26	40,50	48,08	40,71	47,91	40,91	47,73	41,13	47,55	41,33	47,37	41,48	47,19	41,75	47,00	41,95	63
64	49,03	41,14	48,85	41,35	48,67	41,56	48,49	41,78	48,31	41,99	48,12	42,14	47,93	42,41	47,75	42,62	64
65	49,79	41,78	49,61	42,00	49,43	42,21	49,24	42,43	49,06	42,64	48,88	42,80	48,68	43,07	48,49	43,28	65
66	50,56	42,43	50,37	42,64	50,19	42,86	50,00	43,08	49,81	43,30	49,62	43,46	49,43	43,74	49,24	43,95	66
67	51,32	43,07	51,14	43,29	50,95	43,51	50,76	43,74	50,57	43,96	50,37	44,11	50,18	44,40	49,99	44,62	67
68	52,09	43,71	51,90	43,94	51,71	44,16	51,52	44,39	51,32	44,61	51,13	44,77	50,93	45,06	50,73	45,28	68
69	52,86	44,35	52,66	44,58	52,47	44,81	52,28	45,04	52,08	44,27	51,88	45,43	51,68	45,72	51,48	45,96	69
70	53,62	45,00	53,43	45,23	53,23	45,46	53,04	45,69	52,83	45,93	52,63	46,16	52,43	46,38	52,22	46,61	70
71	54,39	45,64	54,19	45,87	53,99	46,11	53,79	46,35	53,59	46,58	53,38	46,81	53,18	47,05	52,97	47,28	71
72	55,16	46,28	54,95	46,52	54,75	46,76	54,55	47,00	54,34	47,24	54,13	47,47	53,93	47,71	53,72	47,94	72
73	55,92	46,92	55,72	47,17	55,51	47,41	55,30	47,65	55,10	47,89	54,89	48,13	54,67	48,37	54,46	48,6[illegible]	73
74	56,69	47,57	56,48	47,81	56,27	48,06	56,06	48,31	55,85	48,55	55,64	48,79	55,42	49,04	55,21	49,28	74
75	57,46	48,21	57,24	48,46	57,03	48,69	56,82	48,96	56,61	49,20	56,39	49,45	56,17	49,70	55,95	49,94	75
76	58,22	48,85	58,00	49,10	57,79	49,34	57,58	49,61	57,36	49,86	57,14	50,11	56,92	50,36	56,70	50,51	76
77	58,99	49,50	58,77	49,75	58,55	49,99	58,34	50,26	58,12	50,52	57,89	50,77	57,67	51,02	57,45	51,17	77
78	59,75	50,14	59,53	50,40	59,31	50,64	59,09	50,92	58,87	51,17	58,64	51,43	58,42	51,69	58,19	51,84	78
79	60,52	50,77	60,29	51,04	60,07	51,29	59,85	51,57	59,63	51,83	59,40	52,09	59,17	52,35	58,94	52,51	79
80	61,28	51,42	61,06	51,69	60,83	51,95	60,61	52,22	60,38	52,49	60,15	52,75	59,91	53,01	59,69	53,27	80
81	62,05	52,07	61,82	52,34	61,59	52,6[illegible]	61,36	52,87	61,13	53,14	60,90	53,41	60,67	53,67	60,43	53,94	81
82	62,82	52,71	62,58	52,98	62,35	53,25	62,12	53,53	61,89	53,80	61,65	54,07	61,42	54,34	61,18	54,60	82
83	63,58	53,35	63,35	53,63	63,11	53,90	62,88	54,18	62,64	54,45	62,40	54,73	62,16	55,00	61,92	55,27	83
84	64,35	54,00	64,11	54,27	63,87	54,55	63,64	54,83	63,40	55,11	63,16	55,38	62,91	55,66	62,67	55,93	84
85	65,11	54,64	64,87	54,92	64,63	55,20	64,40	55,49	64,15	55,77	63,91	56,04	63,66	56,33	63,42	56,60	85
86	65,88	55,28	65,64	55,57	65,39	55,85	65,15	56,14	64,91	56,42	64,66	56,70	64,41	56,99	64,16	57,27	86
87	66,65	56,92	66,40	56,21	66,15	56,50	65,91	56,79	65,66	57,08	65,41	57,36	65,16	57,65	64,91	57,93	87
88	67,41	56,57	67,16	56,86	66,91	57,15	66,67	57,45	66,42	57,73	66,16	58,02	65,91	58,31	65,65	58,60	88
89	68,18	57,21	67,93	57,50	67,67	57,80	67,43	58,10	67,17	58,39	66,92	58,68	66,66	58,98	66,40	59,26	89
90	68,94	57,85	68,69	58,15	68,44	58,45	68,18	58,76	67,92	59,05	67,67	59,34	67,41	59,64	67,15	59,93	90
91	69,71	58,49	69,45	58,80	69,19	59,10	68,94	59,40	68,68	59,70	68,42	60,00	68,16	60,30	67,89	60,60	91
92	70,48	59,14	70,22	59,44	69,96	59,75	69,70	60,05	69,43	60,36	69,17	60,66	68,90	60,96	68,64	61,26	92
93	71,24	59,78	70,98	60,09	70,72	60,40	70,46	60,71	70,19	61,01	69,92	61,32	69,65	61,63	69,38	61,93	93
94	72,01	60,42	71,74	60,74	71,48	61,05	71,20	61,36	70,94	61,67	70,67	61,98	70,40	62,29	70,13	62,59	94
95	72,77	61,07	72,51	61,38	72,24	61,70	71,96	62,01	71,78	62,33	71,43	62,64	71,15	62,95	70,88	63,26	95
96	73,54	61,71	73,27	62,02	73,00	62,35	72,72	62,67	72,45	62,98	72,18	63,30	71,90	63,61	71,62	63,93	96
97	74,31	62,35	74,03	62,67	73,76	63,00	73,48	63,32	73,2[illegible]	63,64	72,93	63,96	72,65	64,28	72,37	64,59	97
98	75,07	63,00	74,80	63,32	74,52	63,65	74,24	63,97	73,96	64,29	73,68	64,61	73,40	64,94	73,11	65,25	98
99	75,84	63,64	75,56	63,97	75,28	64,29	74,99	64,63	74,72	64,95	74,43	65,27	74,15	65,60	73,85	65,92	99
100	76,60	64,28	76,32	64,61	76,04	64,95	75,76	65,28	75,47	65,61	75,18	65,94	74,90	66,26	74,61	66,59	100
101	77,37	64,92	77,09	65,26	76,80	65,59	76,52	65,93	76,23	66,26	75,94	66,59	75,65	66,93	75,35	67,25	101
102	78,14	65,57	77,85	65,90	77,56	66,24	77,27	66,58	76,98	66,92	76,69	67,25	76,39	67,59	76,10	67,92	102
103	78,90	66,21	78,61	66,55	78,32	66,89	78,03	67,24	77,74	67,57	77,44	67,91	77,14	68,25	76,84	68,59	103
104	79,67	66,85	79,38	67,20	79,09	67,54	78,79	67,89	78,49	68,23	78,19	68,57	77,89	68,92	77,59	69,25	104
105	80,43	67,49	80,14	67,84	79,85	68,19	79,55	68,54	79,25	68,88	78,94	69,23	78,64	69,58	78,33	69,92	105
106	81,20	68,14	80,90	68,49	80,61	68,84	80,31	69,19	80,00	69,54	79,70	69,89	79,39	70,24	79,08	70,58	106
107	81,97	68,78	81,66	69,13	81,37	69,49	81,06	69,85	80,76	70,20	80,45	70,55	80,14	70,91	79,83	71,25	107
108	82,73	69,42	82,43	69,78	82,13	70,14	81,82	70,50	81,51	70,85	81,20	71,21	80,89	71,57	80,57	71,92	108
109	83,50	70,07	83,19	70,43	82,89	70,79	82,58	71,15	82,26	71,51	81,95	71,87	81,64	72,23	81,32	72,58	109
110	84,26	70,71	83,96	71,07	83,65	71,44	83,33	71,80	83,02	72,17	82,70	72,53	82,39	72,89	82,07	73,25	110
111	85,03	71,36	84,72	71,72	84,41	72,09	84,09	72,46	83,77	72,82	83,45	73,19	83,14	73,55	82,81	73,91	111
112	85,80	71,99	85,48	72,37	85,17	72,74	84,85	73,11	84,53	73,48	84,21	73,85	83,88	74,21	83,56	74,58	112
113	86,56	72,64	86,24	73,01	85,93	73,39	85,61	73,76	85,28	74,14	84,96	74,51	84,64	74,88	84,31	75,25	113
114	87,33	73,28	87,01	73,66	86,69	74,04	86,37	74,42	86,04	74,79	85,71	75,17	85,39	75,54	85,05	75,91	114
115	88,09	73,92	87,78	74,30	87,45	74,68	87,12	75,07	86,79	75,45	86,46	75,82	86,14	76,20	85,80	76,58	115
116	88,86	74,57	88,5[illegible]	74,94	88,21	75,33	87,88	75,72	87,55	76,10	87,21	76,48	86,88	76,87	86,54	77,25	116
117	89,63	75,21	89,30	75,60	88,97	75,98	88,64	76,38	88,30	76,76	87,97	77,14	87,63	77,53	87,29	77,91	117
118	90,39	75,85	90,06	76,23	89,73	76,63	89,39	77,03	89,06	77,42	88,72	77,80	88,38	78,19	88,04	78,58	118
119	91,16	76,49	90,82	76,88	99,49	77,28	90,15	77,68	89,81	78,07	89,47	78,46	89,13	78,86	88,78	79,24	119
120	91,93	77,14	91,59	77,53	91,25	77,93	90,91	78,33	90,56	78,73	90,22	79,12	89,88	79,51	89,53	79,91	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	50 Deg.		49 Degrees					1,15			48 Degrees					1,11	

Distance	42 Degrees							,90	43 Degrees							,93	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Lat.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,74	0,67	0,74	0,67	0,74	0,68	0,73	0,68	0,73	0,68	0,73	0,68	0,72	0,69	0,72	0,69	1
2	1,49	1,34	1,48	1,34	1,47	1,35	1,47	1,36	1,46	1,36	1,46	1,37	1,45	1,38	1,44	1,38	2
3	2,23	2,07	2,22	2,02	2,21	2,03	2,20	2,04	2,19	2,05	2,18	2,06	2,18	2,06	2,17	2,07	3
4	2,97	2,68	2,96	2,69	2,95	2,70	2,94	2,71	2,92	2,72	2,91	2,74	2,90	2,75	2,89	2,77	4
5	3,72	3,35	3,70	3,36	3,69	3,38	3,67	3,39	3,66	3,41	3,64	3,43	3,63	3,44	3,61	3,46	5
6	4,46	4,01	4,44	4,03	4,42	4,05	4,41	4,07	4,39	4,09	4,37	4,11	4,35	4,13	4,33	4,15	6
7	5,20	4,68	5,18	4,71	5,16	4,73	5,14	4,75	5,12	4,77	5,10	4,80	5,08	4,82	5,06	4,84	7
8	5,94	5,35	5,92	5,38	5,90	5,40	5,87	5,43	5,85	5,46	5.83	5,48	5,80	5,51	5,78	5,53	8
9	6,69	6,02	6,66	6,05	6,64	6,08	6,61	6,11	6.58	6,14	6,55	6,17	6,53	6,19	6,50	6,22	9
10	7,43	6,69	7,40	6,72	7,37	6,76	7,34	6,79	7,31	6,82	7,28	6,85	7,25	6,88	7,22	6,91	10
11	8,17	7,36	8,14	7,40	8,11	7,43	8,08	7,47	8,04	7,50	8,01	7,54	7,98	7,57	7,95	7,61	11
12	8,92	8,03	8,88	8,07	8,85	8,11	8,81	8,15	8,78	8,18	8,74	8,22	8,70	8,26	8,67	8,30	12
13	9,66	8,70	9,62	8,74	9,58	8,78	9,55	8,82	9,51	8,87	9,47	8,91	9,43	8,95	9,39	8,99	13
14	10,40	9,37	10,36	9,41	10,32	9,46	10,28	9,50	10,24	9,55	10,20	9,59	10,15	9,64	10,11	9,68	14
15	11,15	10,04	11,10	10,08	11,06	10,13	11,01	10,18	10,97	10,23	10,92	10,28	10,88	10,32	10,83	10,37	15
16	11,89	10,71	11,84	10,70	11,79	10,81	11,75	10,86	11,70	10,91	11,65	10,96	11,60	11,01	11,56	11,07	16
17	12,63	11,37	12,58	11,43	12,53	11,49	12,48	11,54	12,43	11,59	12,38	11,65	12,33	11,70	12,28	11,76	17
18	13,38	12,04	13,32	12,10	13,27	12,16	13,22	12,22	13,16	12,28	13,11	12,33	13,05	12,39	13,00	12,45	18
19	14,12	12,71	14,06	12,77	14,01	12,84	13,96	12,90	13,89	12,96	13,84	13,02	13,78	13,08	13,72	13,14	19
20	14,86	13,38	14,80	13,45	14,75	13,51	14,69	13,58	14,63	13,64	14,57	13,70	14,51	13,77	14,45	13,83	20
21	15,61	14,05	15,54	14,12	15,48	14,19	15,42	14,25	15,36	14,32	15,29	14,39	15,23	14,45	15,17	14,52	21
22	16,35	14,72	16,28	14,79	16,22	14,86	16,15	14,93	16,09	15,00	16,02	15,07	15,96	15,14	15,89	15,21	22
23	17,09	15,39	17,02	15,46	16,96	15,54	16,89	15,61	16,82	15,69	16,75	15,76	16,68	15,83	16,61	15,91	23
24	17,83	16,06	17,76	16,13	17,79	16,22	17,62	16,29	17,55	16,37	17,48	16,44	17,41	16,52	17,33	16,60	24
25	18,58	16,73	18,50	16,80	18,43	16,89	18,36	16,97	18,28	17,05	18,21	17,13	18,13	17,21	18,06	17,29	25
26	19,32	17,40	19,24	17,47	19,17	17,57	19,09	17,65	19,01	17,73	18,94	17,81	18,86	17,89	18,77	17,98	26
27	20,06	18,07	19,98	18,15	19,91	18,24	19,82	18,33	19,74	18,41	19,66	18,50	19,58	18,58	19,50	18,67	27
28	20,81	18,73	20,72	18,82	20,64	18,92	20,56	19,01	20,47	19,10	20,39	19,18	20,31	19,27	20,22	19,37	28
29	21,55	19,40	21,46	19,49	21,38	19,60	21,29	19,69	21,21	19,78	21,12	19,87	21,03	19,96	20,94	20,06	29
30	22,29	20,07	22,21	20,17	22,12	20,27	22,03	20,36	21,94	20,46	21,85	20,55	21,76	20,65	21,67	20,74	30
31	23,04	20,74	22,95	20,84	22,85	20,94	22,76	21,04	22,67	21,14	22,58	21,24	22,49	21,34	22,39	21,44	31
32	23,78	21,41	23,69	21,51	23,59	21,62	23,50	21,72	23,40	21,82	23,30	21,92	23,21	22,03	23,11	22,13	32
33	24,52	22,08	24,43	22,19	24,33	22,30	24,23	22,40	24,13	22,51	24,02	22,61	23,94	22,71	23,84	22,82	33
34	25,27	22,75	25,17	22,86	25,07	22,96	24,97	23,08	24,86	23,19	24,75	23,29	24,66	23,40	24,56	23,51	34
35	26,01	23,42	25,91	23,53	25,80	23,64	25,70	23,76	25,60	23,87	25,48	23,98	25,39	24,09	25,28	24,20	35
36	26,75	24,09	26,65	24,20	26,54	24,31	26,43	24,44	26,32	24,55	26,21	24,66	26,11	24,78	26,00	24,90	36
37	27,49	24,76	27,39	24,87	27,28	24,99	27,17	25,12	27,06	25,23	26,94	25,35	26,84	25,47	26,73	25,59	37
38	28,24	25,43	28,13	25,55	28,01	25,67	27,90	25,79	27,79	25,91	27,66	26,03	27,56	26,16	27,45	26,28	38
39	28,98	26,09	28,87	26,22	28,75	26,34	28,64	26,47	28,52	26,60	28,39	26,72	28,29	26,84	28,18	26,97	39
40	29,73	26,76	29,61	26,89	29,49	27,02	29,37	27,15	29,25	27,28	29,13	27,41	29.01	27,53	28,89	27,66	40
41	30,47	27,43	30,35	27,57	30,23	27,70	30,11	27,83	29,98	27,96	29,86	28,09	29,74	28,22	29,62	28,35	41
42	31,21	28,10	31,09	28,24	30,96	28,38	30,84	28,51	30,72	28,64	30,59	28,78	30,46	28,91	30,34	29,04	42
43	31,95	28,77	31,83	28,91	31,69	29,05	31,57	29,19	31,45	29,33	31,32	29,46	31,19	29,60	31,06	29,74	43
44	32,70	29,44	32,57	29,58	32,43	29,73	32,31	29,87	32,18	30,01	32,05	30,15	31,91	30,29	31,78	30,43	44
45	33,44	30,10	33,31	30,25	33,17	30,40	33,04	30,55	32,91	30,69	32,77	30,83	32,64	30,97	32,50	31,12	45
46	34,18	30,77	34,05	30,93	33,90	31,08	33,78	31,23	33,64	31,37	33,50	31,52	33,36	31,66	33,23	31,82	46
47	34,93	31,44	34,79	31,60	34,64	31,76	34,51	31,90	34,37	32,05	34,23	32,20	34,09	32,35	33,95	32,51	47
48	35,67	32,11	35,53	32,27	35,38	32,43	35,24	32,59	35,10	32,74	34,96	32,89	34,82	33,04	34,67	33,20	48
49	36,41	32,78	36,27	32,94	36,11	33,11	35,98	33,26	35,83	33,42	35,69	33,57	35,54	33,73	35,39	33,90	49
50	37,16	33,46	37,01	33,62	36,86	33,78	36,72	33,94	36,57	34,10	36,42	34,26	36,27	34,42	36,12	34,58	50
51	37,90	34,13	37,75	34,29	37,60	34,46	37,45	34,62	37,30	34,78	37,15	34,94	36,99	35,11	36,84	35,27	51
52	38,64	34,79	38,49	34,96	38,34	35,13	38,18	35,30	38,03	35,46	37,87	35,63	37,72	35,79	37,56	35,96	52
53	39,39	35,46	39,23	35,63	39,07	35,81	38,92	35,98	38,76	36,15	38,60	36,31	38,44	36,48	38,28	36,65	53
54	40,13	36,13	39,97	36,31	39,81	36,48	39,65	36,66	39,49	36,83	39,33	37,00	39,17	37,17	39,01	37,34	54
55	40,87	36,80	40,71	36,98	40,55	37,16	40,39	37,33	40,22	37,51	40,06	37,68	39,89	37,86	39,73	38,04	55
56	41,61	37,47	41,45	37,65	41,29	37,84	41,12	38,01	40,95	38,19	40,79	38,37	40,62	38,55	40,45	38,73	56
57	42,36	38,14	42,19	38,32	42,02	38,51	41,85	38,69	41,68	38,87	41,51	39,05	41,34	39,23	41,16	39,43	57
58	43,10	38,81	42,93	38,99	42,76	39,19	42,59	39,37	42,42	39,56	42,24	39,74	42,07	39,92	41,89	40,11	58
59	43,84	39,48	43,67	39,67	43,50	39,86	43,32	40,05	43,15	40,24	42,97	40,42	42,78	40,61	42,62	40,80	59
60	44,59	40,15	44,41	40,34	4.24	40,53	44,06	40,73	43,88	40,92	43,70	41,11	43,52	41,30	43,34	41,49	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	48 Deg.		47 Degrees					1,07	46 Degrees							1,04	

Distance	42 Degrees							,90	43 Degrees							,93	Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	
61	45,33	40,82	45,15	41,01	44,97	41,21	44,79	41,44	44,61	41,60	44,43	41,80	44,25	41,99	44,06	42,18	61
62	46,07	41,49	45,89	41,69	45,71	41,89	45,53	42,09	45,34	42,28	45,16	42,48	44,97	42,68	44,79	42,87	62
63	46,82	42,15	46,63	42,36	46,45	42,56	46,26	42,76	46,07	42,97	45,89	43,17	45,70	43,36	45,51	43,57	63
64	47,56	42,82	47,37	43,03	47,18	43,23	46,99	43,44	46,80	43,65	46,61	43,85	46,42	44,05	46,23	44,26	64
65	48,30	43,49	48,11	43,70	47,92	43,91	47,73	44,12	47,54	44,33	47,34	44,54	47,15	44,74	46,95	44,95	65
66	49,05	44,16	48,85	44,37	48,66	44,58	48,46	44,80	48,27	45,01	48,07	45,22	47,87	45,43	47,67	45,64	66
67	49,79	44,83	49,59	45,05	49,40	45,26	49,20	45,48	49,00	45,69	48,80	45,91	48,60	46,12	48,40	46,33	67
68	50,53	45,50	50,83	45,72	50,13	45,93	49,93	46,16	49,73	46,38	49,53	46,59	49,32	46,80	49,12	47,03	68
69	51,27	46,17	51,07	46,40	50,87	46,61	50,66	46,84	50,46	47,06	50,25	47,28	50,05	47,49	49,84	47,72	69
70	52,02	46,84	51,81	47,07	51,61	47,29	51,40	47,52	51,19	47,74	50,99	47,96	50,78	48,1[illegible]	50,56	48,41	70
71	52,76	47,51	52,55	47,74	52,34	47,97	52,14	48,19	51,93	48,42	51,71	48,65	51,50	48,87	51,29	49,10	71
72	53,51	48,18	53,29	48,41	53,08	48,64	52,87	48,87	52,66	49,10	52,44	49,33	52,23	49,56	52,01	49,79	72
73	54,25	48,85	54,03	49,08	53,82	49,32	53,60	49,55	53,39	49,79	53,17	50,02	52,95	50,25	52,73	50,48	73
74	54,99	49,51	54,77	49,75	54,56	49,99	54,34	50,23	54,42	50,47	53,90	50,70	53,68	50,94	53,45	51,17	74
75	55,73	50,18	55,51	50,43	55,29	50,67	55,07	50,91	54,85	51,15	54,63	51,39	54,40	51,62	54,17	51,87	75
76	56,48	50,85	56,25	51,10	56,03	51,35	55,81	51,59	55,58	51,83	55,35	52,07	55,13	52,31	54,90	52,56	76
77	57,22	51,52	56,99	51,77	56,77	52,02	56,54	52,27	56,31	52,51	56,08	52,76	55,85	53,00	55,62	53,25	77
78	57,96	52,19	57,73	52,44	57,51	52,70	57,27	52,95	57,04	53,20	56,81	53,44	56,58	53,69	56,34	53,94	78
79	58,71	52,86	58,47	53,11	58,24	53,37	58,01	53,63	57,77	53,88	57,54	54,13	57,30	54,38	57,06	54,63	79
80	59,45	53,53	59,22	53,79	58,98	54,05	58,75	54,30	58,51	54,56	58,27	54,81	58,03	55,07	57,79	55,32	80
81	60,19	54,20	59,96	54,46	59,72	54,72	59,48	54,98	59,24	55,24	59,00	55,50	58,75	55,76	58,51	56,01	81
82	60,94	54,87	60,70	55,13	60,46	55,40	60,21	55,66	59,97	55,92	59,73	56,18	59,48	56,44	59,23	56,70	82
83	61,68	55,54	61,44	55,81	61,19	56,07	60,95	56,34	60,70	56,61	60,45	56,87	60,20	57,13	59,95	57,40	83
84	62,42	56,21	62,18	56,48	61,93	56,75	61,68	57,02	61,43	57,29	61,18	57,55	60,92	57,82	60,68	58,08	84
85	63,17	56,87	62,92	57,15	62,67	57,43	62,42	57,70	62,16	57,97	61,91	58,23	61,65	58,51	61,40	58,78	85
86	63,91	57,54	63,66	57,82	63,40	58,10	63,15	58,38	62,89	58,65	62,64	58,92	62,38	59,20	62,12	59,47	86
87	64,65	58,21	64,40	58,49	64,14	58,78	63,88	59,06	63,62	59,33	63,37	59,61	63,10	59,88	62,84	60,16	87
88	65,39	58,88	65,14	59,17	64,88	59,46	64,62	59,74	64,36	60,02	64,09	60,29	63,83	60,57	63,56	60,86	88
89	66,14	59,55	65,88	59,84	65,61	60,13	65,35	60,41	65,09	60,70	64,82	60,98	64,55	61,2	64,29	61,55	89
90	66,88	60,22	66,62	60,51	66,35	60,80	66,09	61,09	65,82	61,38	65,55	61,67	65,28	61,95	65,01	62,24	90
91	67,63	60,89	67,36	61,18	67,09	61,48	66,82	61,77	66,55	62,06	66,28	62,35	66,01	62,64	65,73	62,9	91
92	68,37	61,56	68,10	61,86	67,83	62,15	67,56	62,45	67,28	62,74	67,01	63,04	66,73	63,33	66,46	63,62	92
93	69,11	62,23	68,84	62,53	68,57	62,83	68,29	63,13	68,01	63,43	67,74	63,72	67,46	64,02	67,18	64,31	93
94	69,85	62,90	69,58	63,20	69,30	63,51	69,02	63,81	68,75	64,11	68,46	64,41	68,18	64,70	67,90	65,00	94
95	70,60	63,57	70,32	63,87	70,04	64,18	69,76	64,49	69,48	64,79	69,19	65,09	68,91	65,39	68,62	65,70	95
96	71,34	64,24	71,06	64,54	70,78	64,86	70,49	65,17	70,21	65,47	69,92	65,78	69,6[illegible]	66,[illegible]8	69,34	66,39	96
97	72,08	64,90	71,80	65,22	71,51	65,53	71,23	65,84	70,94	66,15	70,65	66,46	70,36	66,77	70,07	67,08	97
98	72,83	65,57	72,54	65,89	72,25	66,21	71,96	66,52	71,67	66,84	71,38	67,15	71,08	67,46	70,79	67,77	98
99	73,57	66,24	73,28	66,56	72,99	66,89	72,69	67,20	72,40	67,52	72,10	67,83	71,81	68,14	71,51	68,46	99
100	74,31	66,91	74,02	67,24	73,73	67,56	73,43	67,88	73,13	68,20	72,84	68,5	72,54	68,83	72,2	69,15	100
101	75,06	67,58	74,76	67,91	74,46	68,23	74,17	68,56	73,87	68,88	73,56	69,20	73,26	69,52	72,96	69,84	101
102	75,80	68,25	75,50	68,58	75,20	68,90	74,90	69,24	74,60	69,56	74,29	69,89	73,99	70,21	73,68	70,53	102
103	76,54	68,92	76,24	69,25	75,94	69,58	75,63	69,92	75,33	70,25	75,02	70,57	74,71	70,90	74,40	71,23	103
104	77,29	69,59	76,98	69,92	76,68	70,25	76,37	70,60	76,06	70,93	75,75	71,26	75,44	71,57	75,12	71,92	104
105	78,03	70,26	77,72	70,60	77,41	70,93	77,10	71,27	76,79	71,61	76,48	71,94	76,16	72,25	75,84	72,61	05
106	78,77	70,93	78,46	71,27	78,15	71,60	77,84	71,95	77,52	72,39	77,20	72,63	76,89	72,94	76,57	73,30	06
107	79,51	71,59	79,20	71,94	78,89	72,28	78,57	72,63	78,25	73,07	77,93	73,31	77,61	73,63	77,29	73,99	107
108	80,26	72,26	79,94	72,62	79,63	72,96	79,30	73,31	78,98	73,76	78,68	74,00	78,34	74,32	78,01	74,6	108
109	81,00	72,93	80,68	73,29	80,36	73,63	80,04	73,99	79,71	74,44	79,41	74,68	79,06	75,01	78,73	75,38	09
110	81,74	73,60	81,42	73,96	81,10	74,31	80,77	74,67	80,45	75,02	80,12	75,37	79,79	75,71	79,46	76,0	110
111	82,49	74,27	82,16	74,63	81,84	74,99	81,51	75,35	81,18	75,70	80,85	76,05	80,82	76,41	80,18	76,75	111
112	83,23	74,94	82,90	75,30	82,57	75,67	82,24	76,03	81,91	76,38	81,58	76,74	81,24	77,09	80,90	77,46	112
113	83,97	75,61	83,64	75,98	83,31	76,34	82,98	76,70	82,64	77,07	82,30	77,42	81,97	77,78	81,63	78,14	113
114	84,72	76,28	84,38	76,65	84,05	77,02	83,71	77,38	83,37	77,75	83,03	78,11	82,69	78,47	82,35	78,8	114
115	85,46	76,95	85,12	77,32	84,79	77,69	84,44	78,06	84,10	78,43	83,76	78,79	83,42	79,16	83,07	79,53	15
116	86,20	77,62	85,86	77,99	85,52	78,37	85,18	78,74	84,83	79,11	84,49	79,48	84,13	79,85	83,79	80,22	16
117	86,95	78,28	86,60	78,66	86,26	79,05	85,91	79,42	85,57	79,79	85,22	80,17	84,86	80,54	84,51	80,9	17
118	87,69	78,95	87,34	79,34	86,99	79,72	86,65	80,10	86,30	80,48	85,95	80,85	85,58	81,22	85,24	81,60	18
119	88,43	79,63	88,08	80,01	87,73	80,40	87,38	80,78	87,03	81,16	86,67	81,54	86,31	81,91	85,96	82,2	19
120	89,18	80,30	88,83	80,68	88,47	81,07	88,12	81,46	87,76	81,84	87,40	82,22	87,04	82,60	86,68	82,9	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep	Lat.	Dep	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min		45 Min.		30 Min.		15 Min.		
	48 Deg.		47 Degrees						1,07		46 Degrees					1,04	

Distance	44 Degrees ,97						45 Deg.		44 Degrees ,97						45 Deg.		Distance
	0 Min.		20 Min.		40 Min.		0 Min.		0 Min.		20 Min.		40 Min.		0 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,72	0,69	0,72	0,70	0,71	0,70	0,71	0,71	43,88	42,37	43,63	42,63	43,38	42,88	43,13	43,13	61
2	1,44	1,39	1,43	1,40	1,42	1,41	1,41	1,41	44,60	43,07	44,35	43,33	44,09	43,58	43,84	43,84	62
3	2,16	2,08	2,15	2,10	2,13	2,11	2,12	2,12	45,32	43,76	45,06	44,03	44,81	44,29	44,55	44,55	63
4	2,83	2,78	2,86	2,79	2,84	2,81	2,83	2,83	46,04	44,46	45,78	44,73	45,52	44,99	45,25	45,25	64
5	3,60	3,47	3,58	3,49	3,56	3,51	3,53	3,53	46,75	45,15	46,49	45,42	46,23	45,69	45,96	45,96	65
6	4,32	4,17	4,29	4,19	4,27	4,22	4,24	4,24	47,47	45,85	47,21	46,12	46,94	46,40	46,67	46,67	66
7	5,03	4,86	5,01	4,89	4,98	4,92	4,95	4,95	48,19	46,54	47,92	46,82	47,55	47,10	47,38	47,38	67
8	5,75	5,56	5,72	5,59	5,69	5,62	5,66	5,66	48,91	47,24	48,64	47,52	48,36	47,80	48,08	48,08	68
9	6,47	6,25	6,44	6,29	6,40	6,33	6,36	6,36	49,63	48,93	49,35	48,22	49,08	48,50	48,79	48,79	69
10	7,19	6,95	7,15	6,99	7,11	7,03	7,07	7,07	50,35	48,63	50,07	48,91	49,78	49,21	49,50	49,50	70
11	7,91	7,64	7,87	7,69	7,82	7,73	7,78	7,78	51,07	49,32	50,78	49,62	50,43	49,91	50,20	50,20	71
12	8,63	8,34	8,58	8,39	8,53	8,44	8,49	8,49	51,79	50,02	51,50	50,32	51,21	50,61	50,91	50,91	72
13	9,35	9,03	9,30	9,08	9,25	9,14	9,19	9,19	52,81	50,71	52,21	51,01	51,91	51,32	51,62	51,62	73
14	10,07	9,73	10,01	9,78	9,96	9,84	9,90	9,90	53,53	51,41	52,93	51,71	52,63	52,02	52,33	52,33	74
15	10,79	10,42	10,73	10,48	10,67	10,54	10,61	10,61	54,25	52,10	53,64	52,41	53,34	52,72	53,03	53,03	75
16	11,51	11,12	11,44	11,18	11,38	11,25	11,31	11,31	54,97	52,80	54,36	53,11	54,05	53,42	53,74	53,74	76
17	12,23	11,81	12,16	12,88	12,09	11,95	12,02	12,02	55,69	53,49	55,07	53,81	54,76	54,13	54,45	54,45	77
18	12,94	12,51	12,87	12,57	12,80	12,65	12,73	12,73	56,41	54,19	55,79	54,51	55,47	54,83	55,15	55,15	78
19	13,66	13,20	13,59	13,27	13,51	13,36	13,43	13,43	57,12	54,88	56,50	55,21	56,18	55,53	55,86	55,86	79
20	14,39	13,89	14,31	13,98	14,22	14,06	14,14	14,14	57,55	55,57	57,22	55,91	56,90	56,24	56,57	56,57	80
21	15,11	14,59	15,02	14,68	14,93	14,76	14,85	14,85	58,27	56,27	57,94	56,60	57,61	56,94	57,28	57,28	81
22	15,82	15,28	15,74	15,37	15,65	15,46	15,56	15,56	58,98	56,96	58,65	57,30	58,32	57,64	57,98	57,98	82
23	16,54	15,98	16,45	16,07	16,36	16,17	16,26	16,26	59,70	57,66	59,37	58,00	59,03	58,35	58,69	58,69	83
24	17,26	16,67	17,17	16,77	17,07	16,87	16,97	16,97	60,42	58,35	60,08	58,70	59,74	59,05	59,40	59,40	84
25	17,98	17,37	17,88	17,47	17,78	17,57	17,68	17,68	61,14	59,05	60,80	59,40	60,45	59,75	60,10	60,10	85
26	18,70	18,06	18,60	18,17	18,49	18,28	18,38	18,38	61,86	59,74	61,51	60,10	61,16	60,45	60,81	60,81	86
27	19,42	18,76	19,31	18,87	19,20	18,98	19,09	19,09	62,58	60,44	62,23	60,80	61,87	61,16	61,52	61,52	87
28	20,14	19,45	20,03	19,57	19,91	19,68	19,80	19,80	63,30	61,13	62,94	61,50	62,58	61,86	62,22	62,22	88
29	20,86	20,15	20,74	20,27	20,62	20,39	20,51	20,51	64,02	61,83	63,66	62,20	63,30	62,56	62,93	62,93	89
30	21,58	20,84	21,46	20,98	21,34	21,09	21,21	21,21	64,74	62,52	64,38	62,89	64,01	63,27	63,64	63,64	90
31	22,30	21,53	22,17	21,66	22,05	21,79	21,92	21,92	65,46	63,21	65,09	63,59	64,72	63,97	64,35	64,35	91
32	23,02	22,23	22,89	22,36	22,76	22,49	22,63	22,63	66,18	64,01	65,81	64,29	65,43	64,67	65,05	65,05	92
33	23,74	22,92	23,60	23,06	23,47	23,20	23,33	23,33	66,90	64,70	66,52	64,99	66,14	65,37	65,76	65,76	93
34	24,46	23,62	24,32	23,76	24,18	23,90	24,04	24,04	67,62	65,40	67,24	65,68	66,85	66,08	66,47	66,47	94
35	25,17	24,31	25,03	24,46	24,89	24,60	24,75	24,75	68,34	66,09	67,95	66,39	67,56	66,79	67,17	67,17	95
36	25,89	25,01	25,75	25,16	25,62	25,31	25,46	25,46	69,05	66,79	68,67	67,09	68,27	67,49	67,88	67,88	96
37	26,61	25,71	26,46	25,86	26,31	26,01	26,16	26,16	69,77	67,48	69,38	67,79	68,99	68,19	68,59	68,59	97
38	27,33	26,41	27,18	26,56	27,02	26,71	26,87	26,87	70,49	68,18	70,10	68,49	69,70	68,89	69,30	69,30	98
39	28,05	27,10	27,89	27,25	27,73	27,42	27,58	27,58	71,21	68,87	70,81	69,19	70,41	69,59	70,00	70,00	99
40	28,77	27,79	28,61	27,95	28,45	28,12	28,28	28,28	71,93	69,47	71,53	69,88	71,12	70,30	70,71	70,71	100
41	29,49	28,48	29,33	28,65	29,10	28,82	28,99	28,99	72,65	70,16	72,24	70,58	71,83	71,00	71,42	71,42	101
42	30,21	29,18	30,04	29,35	29,87	29,52	29,70	29,70	73,37	70,86	72,96	71,28	72,54	71,70	72,12	72,12	102
43	30,93	29,87	30,76	30,05	30,58	30,23	30,41	30,41	74,09	71,55	73,67	71,98	73,25	72,40	72,83	72,83	103
44	31,65	30,57	31,47	30,75	31,29	30,93	31,11	31,11	74,81	72,25	74,39	72,68	73,96	73,11	73,54	73,54	104
45	32,37	31,26	32,19	31,45	32,00	31,63	31,82	31,82	75,53	72,94	75,10	73,38	74,68	73,81	74,25	74,25	105
46	33,09	31,96	32,90	32,14	32,71	32,34	32,53	32,53	76,25	73,64	75,82	74,08	75,39	74,51	74,95	74,95	106
47	33,81	32,65	33,62	32,84	33,43	33,04	33,23	33,23	76,97	74,33	76,53	74,78	76,10	75,22	75,66	75,66	107
48	34,53	33,35	34,33	33,54	34,14	33,74	33,94	33,94	77,69	75,03	77,25	75,47	76,81	75,92	76,37	76,37	108
49	35,24	34,04	35,05	34,24	34,85	34,44	34,65	34,65	78,40	75,72	77,96	76,17	77,52	76,62	77,07	77,07	109
50	35,97	34,73	35,76	34,94	35,56	35,15	35,35	35,35	79,13	76,41	78,68	76,87	78,23	77,33	77,78	77,78	110
51	36,69	35,43	36,48	35,64	36,27	35,85	36,06	36,06	79,85	77,11	79,40	77,57	78,95	78,04	78,49	78,49	111
52	37,40	36,12	37,19	36,34	30,98	36,55	36,77	36,77	80,56	77,80	80,11	78,27	79,65	78,74	79,20	79,20	112
53	38,12	36,82	37,91	37,04	37,69	37,26	37,47	37,47	81,28	78,50	80,83	78,97	80,37	79,45	79,90	79,90	113
54	38,84	37,51	38,62	37,74	38,40	37,96	38,18	38,18	82,00	79,19	81,54	79,67	81,08	80,15	80,61	80,61	114
55	39,56	38,21	39,34	38,44	39,12	38,66	38,89	38,89	82,72	79,89	82,26	80,37	81,79	80,85	81,32	81,32	115
56	40,28	38,90	40,05	39,14	39,82	39,37	39,59	39,59	83,44	80,58	82,97	81,06	82,50	81,55	82,02	82,02	116
57	41,01	39,60	40,77	39,84	40,54	40,07	40,30	40,30	84,16	81,28	83,69	81,76	83,21	82,26	82,73	82,73	117
58	41,72	40,29	41,48	40,53	41,25	40,77	41,01	41,01	84,88	81,97	84,40	82,46	83,92	82,96	83,44	83,44	118
59	42,44	40,99	42,20	41,23	41,90	41,48	41,72	41,72	85,60	82,67	85,12	83,16	84,64	83,66	84,14	84,14	119
60	43,16	41,68	42,92	41,93	42,67	42,18	42,43	42,43	86,32	83,36	85,83	83,86	85,34	84,35	84,85	84,85	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		40 Min.		20 Min.		0 Min.		0 Min.		40 Min.		20 Min.		0 Min.		
	46 Deg.		45 Degrees 1,00						46 Deg.		45 Degrees 1,00						

END OF BOOK VII.

Digitized by Google

Distance	44 Degrees					,97	45 Deg.	
	0 Min.		20 Min.		40 Min.		0 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0,72	0,69	0,72	0,70	0,71	0,70	0,71	0,71
2	1,44	1,39	1,43	1,40	1,42	1,41	1,41	1,41
3	2,16	2,08	2,15	2,10	2,13	2,11	2,12	2,12
4	2,88	2,78	2,86	2,79	2,84	2,81	2,83	2,83
5	3,60	3,47	3,58	3,49	3,56	3,51	3,53	3,53
6	4,32	4,17	4,29	4,19	4,27	4,22	4,24	4,24
7	5,03	4,86	5,01	4,89	4,98	4,92	4,95	4,95
8	5,75	5,56	5,72	5,59	5,69	5,62	5,66	5,66
9	6,47	6,25	6,44	6,29	6,40	6,33	6,36	6,36
10	7,19	6,95	7,15	6,99	7,11	7,03	7,07	7,07
11	7,91	7,64	7,87	7,69	7,82	7,73	7,78	7,78
12	8,63	8,34	8,58	8,39	8,53	8,44	8,49	8,49
13	9,35	9,03	9,30	9,08	9,25	9,14	9,19	9,19
14	10,07	9,73	10,01	9,78	9,96	9,84	9,90	9,90
15	10,79	10,42	10,73	10,48	10,67	10,54	10,61	10,61
16	11,51	11,12	11,44	11,18	11,38	11,25	11,31	11,31
17	12,23	11,81	12,16	12,58	12,09	11,95	12,02	12,02
18	12,94	12,51	12,87	12,57	12,80	12,65	12,73	12,73
19	13,65	13,20	13,59	13,27	13,51	13,36	13,43	13,43
20	14,39	13,89	14,31	13,98	14,22	14,06	14,14	14,14
21	15,11	14,59	15,02	14,68	14,93	14,76	14,85	14,85
22	15,82	15,28	15,74	15,37	15,65	15,46	15,56	15,56
23	16,54	15,98	16,45	16,07	16,36	16,17	16,26	16,26
24	17,26	16,67	17,17	16,77	17,07	16,87	16,97	16,97
25	17,98	17,37	17,88	17,47	17,78	17,57	17,68	17,68
26	18,70	18,06	18,60	18,17	18,49	18,28	18,38	18,38
27	19,42	18,76	19,31	18,87	19,20	18,98	19,09	19,09
28	20,14	19,45	20,03	19,57	19,91	19,68	19,80	19,80
29	20,86	20,15	20,74	20,27	20,62	20,39	20,51	20,51
30	21,58	20,84	21,46	20,96	21,34	21,09	21,21	21,21
31	22,30	21,53	22,17	21,66	22,05	21,79	21,92	21,92
32	23,02	22,23	22,89	22,36	22,76	22,49	22,63	22,63
33	23,74	22,92	23,60	23,06	23,47	23,20	23,33	23,33
34	24,46	23,62	24,32	23,76	24,18	23,90	24,04	24,04
35	25,17	24,31	25,03	24,46	24,89	24,60	24,75	24,75
36	25,89	25,01	25,75	25,16	25,60	25,31	25,46	25,46
37	26,61	25,71	26,46	25,86	26,31	26,01	26,16	26,16
38	27,33	26,41	27,18	26,56	27,02	26,71	26,87	26,87
39	28,05	27,10	27,89	27,25	27,73	27,42	27,58	27,58
40	28,77	27,79	28,61	27,95	28,45	28,12	28,28	28,28
41	29,49	28,48	29,33	28,65	29,16	28,82	28,99	28,99
42	30,21	29,18	30,04	29,35	29,87	29,52	29,70	29,70
43	30,93	29,87	30,76	30,05	30,58	30,23	30,41	30,41
44	31,65	30,57	31,47	30,75	31,29	30,93	31,11	31,11
45	32,37	31,26	32,19	31,45	32,00	31,63	31,82	31,82
46	33,09	31,96	32,90	32,14	32,71	32,34	32,53	32,53
47	33,81	32,65	33,62	32,84	33,43	33,04	33,23	33,23
48	34,53	33,35	34,33	33,54	34,14	33,74	33,94	33,94
49	35,24	34,04	35,05	34,24	34,85	34,44	34,65	34,65
50	35,97	34,73	35,79	34,94	35,50	35,15	35,35	35,35
51	36,69	35,43	36,48	35,64	36,27	35,85	36,06	36,06
52	37,40	36,12	37,19	36,34	30,98	36,55	36,77	36,77
53	38,12	36,82	37,91	37,04	37,69	37,26	37,47	37,47
54	38,84	37,51	38,62	37,74	38,40	37,96	38,18	38,18
55	39,56	38,21	39,34	38,44	39,12	38,66	38,89	38,89
56	40,28	38,90	40,05	39,14	39,82	39,37	39,50	39,59
57	41,01	39,60	40,77	39,84	40,54	40,07	40,30	40,30
58	41,72	40,29	41,48	40,53	41,25	40,77	41,01	41,01
59	42,44	40,99	42,20	41,23	41,90	41,48	41,72	41,72
60	43,16	41,68	42,92	41,93	42,67	42,18	42,43	42,43
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0 Min.		40 Min.		20 Min.		0 Min.	
	46 Deg.		45 Degrees			1,00		

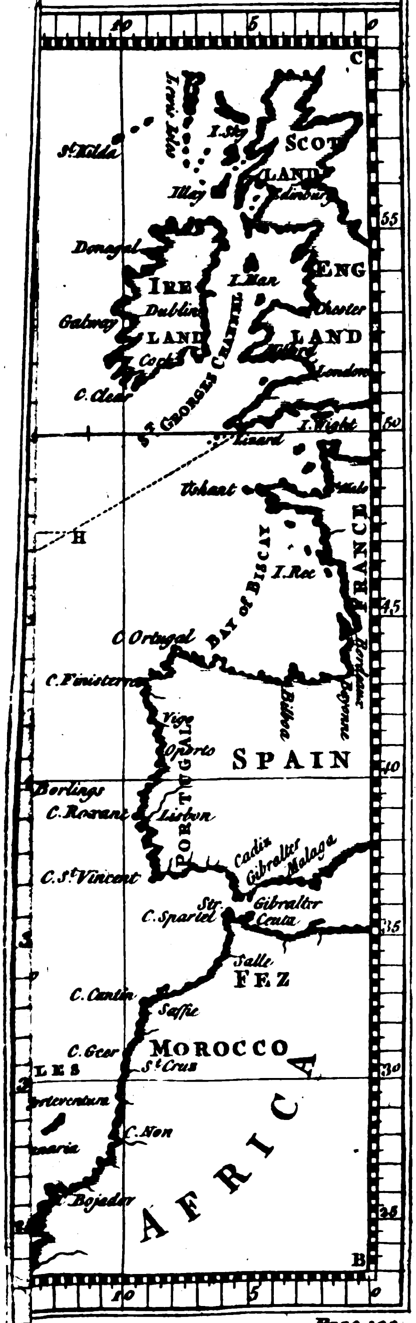
44 Degrees					,97	45 Deg.		Distance
0 Min.		20 Min.		40 Min.		0 Min.		
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
43,88	42,37	43,63	42,63	43,38	42,88	43,13	43,13	61
44,60	43,07	44,35	43,33	44,09	43,58	43,84	43,84	62
45,32	43,76	45,06	44,03	44,81	44,29	44,55	44,55	63
46,04	44,46	45,78	44,73	45,52	44,99	45,25	45,25	64
46,75	45,15	46,49	45,42	46,23	45,69	45,96	45,96	65
47,47	45,85	47,21	46,12	46,94	46,40	46,67	46,67	66
48,19	46,54	47,92	46,82	47,55	47,10	47,38	47,38	67
48,91	47,24	48,64	47,52	48,36	47,80	48,08	48,08	68
49,63	48,93	49,35	48,22	49,08	48,50	48,79	48,79	69
50,35	48,63	50,07	48,91	49,78	49,21	49,50	49,50	70
51,07	49,32	50,78	49,62	50,43	49,91	50,20	50,20	71
51,79	50,02	51,50	50,32	51,21	50,61	50,91	50,91	72
52,81	50,71	52,21	51,01	51,91	51,32	51,62	51,62	73
53,53	51,41	52,93	51,71	52,63	52,02	52,33	52,33	74
54,25	52,10	53,64	52,41	53,34	52,72	53,03	53,03	75
54,97	52,80	54,36	53,11	54,05	53,42	53,74	53,74	76
55,69	53,49	55,07	53,81	54,70	54,13	54,45	54,45	77
56,41	54,19	55,79	54,51	55,47	54,83	55,15	55,15	78
57,12	54,88	56,50	55,21	56,18	55,53	55,86	55,86	79
57,55	55,57	57,22	55,91	56,90	56,24	56,57	56,57	80
58,27	56,27	57,94	56,60	57,61	56,94	57,28	57,28	81
58,98	56,96	58,65	57,30	58,32	57,64	57,98	57,98	82
59,70	57,66	59,37	58,00	59,03	58,35	58,69	58,69	83
60,42	58,35	60,08	58,70	59,74	59,05	59,40	59,40	84
61,14	59,05	60,80	59,40	60,45	59,75	60,10	60,10	85
61,86	59,74	61,51	60,10	61,16	60,45	60,81	60,81	86
62,58	60,44	62,23	60,80	61,87	61,16	61,52	61,52	87
63,30	61,13	62,94	61,50	62,58	61,86	62,22	62,22	88
64,02	61,83	63,66	62,20	63,30	62,56	62,93	62,93	89
64,74	62,52	64,38	62,89	64,01	63,27	63,64	63,64	90
65,46	63,21	65,09	63,59	64,72	63,97	64,35	64,35	91
66,18	64,01	65,81	64,29	65,43	64,67	65,05	65,05	92
66,90	64,70	66,52	64,99	66,14	65,37	65,76	65,76	93
67,62	65,40	67,24	65,68	66,85	56,08	66,47	66,47	94
68,34	66,09	67,95	66,39	67,56	56,79	67,17	67,17	95
69,05	66,79	68,67	67,09	68,27	67,49	67,88	67,88	96
69,77	67,48	69,38	67,79	68,99	68,19	68,59	68,59	97
70,49	68,18	70,10	68,49	69,70	68,89	69,30	69,30	98
71,21	68,87	70,81	69,19	70,41	59,59	70,00	70,00	99
71,93	69,47	71,53	69,88	71,12	70,30	70,71	70,71	100
72,65	70,16	72,24	70,58	71,83	71,00	71,42	71,42	101
73,37	70,86	72,96	71,28	72,54	71,70	72,12	72,12	102
74,09	71,55	73,67	71,98	73,25	72,40	72,83	72,83	103
74,81	72,25	74,39	72,68	73,96	73,11	73,54	73,54	104
75,53	72,94	75,10	73,38	74,68	73,81	74,25	74,25	105
76,25	73,64	75,82	74,08	75,39	74,51	74,95	74,95	106
76,97	74,33	76,53	74,78	76,10	75,22	75,66	75,66	107
77,69	75,03	77,25	75,47	76,81	75,92	76,37	76,37	108
78,40	75,72	77,96	76,17	77,52	76,62	77,07	77,07	109
79,13	76,41	78,68	76,87	78,23	77,33	77,78	77,78	110
79,85	77,11	79,40	77,57	78,95	78,04	78,49	78,49	111
80,56	77,80	80,11	78,27	79,65	78,74	79,20	79,20	112
81,28	78,50	80,83	78,97	80,37	79,43	79,90	79,90	113
82,00	79,19	81,54	79,67	81,08	80,14	80,61	80,61	114
82,72	79,89	82,26	80,37	81,79	80,84	81,32	81,32	115
83,44	80,58	82,97	81,06	82,50	81,55	82,02	82,02	116
84,16	81,28	83,69	81,76	83,21	82,26	82,73	82,73	117
84,88	81,97	84,40	82,46	83,92	82,96	83,44	83,44	118
85,60	82,67	85,12	83,16	84,64	83,66	84,14	84,14	119
86,32	83,36	85,83	83,86	85,34	84,36	84,85	84,85	120
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
0 Min.		40 Min.		20 Min.		0 Min.		
46 Deg.		45 Degrees					1,00	

END OF BOOK VII.

Digitized by Google

Digitized by Google

Pl. XII.



Digitized by Google

THE

ELEMENTS

OF

NAVIGATION.

BOOK VIII.

OF GLOBULAR SAILING.

SECTION I.

Definitions and Principles.

1. BY Globular Sailing is meant the manner of eſtimating either the difference of latitude, difference of longitude, departure, courſe, or diſtance, from any two of them being known, upon principles deduced from the ſpherical figure of the Earth.

In the preceding parts of ſailing, the operations were performed as if the courſes and diſtances of ſhips had been run on a plane or flat ſurface. But this cannot be true, as appears from Book VI. Art. 2. To which, as farther proofs, it may be added, 1ſt. That mariners, as they ſail from northern or ſouthern latitudes towards the equator, obſerve the ſtars about the poles conſtantly to diminiſh their altitude or height above the apparent horizon. 2d. It is alſo well known, that in eclipſes of the moon, the darkened part is bounded by a circular curve; and conſequently the body which caſts the ſhade, or obſtructs the light, muſt be bounded by a like curve. But as this obſcuration is cauſed by the Earth, conſequently its ſurface muſt be limited by a circular figure, that is, it muſt be globular.

2. As meridians are circles on the terraqueous globe, meeting in the poles, it is obvious that any two of these circles must recede more from one another at greater distances from the poles; and at equal distances from both poles, or at the equator, the distance between the meridians is the greatest.

The true place of a ship at sea depends upon its distance from the equator, and from some noted meridian; and because the meridional distance, that is, the distance between two meridians, varies in every latitude; it is therefore convenient, that this distance should be reckoned in a fixed latitude, and where the degrees are of the same magnitude with those of the meridian; which can be only at the equator, where 60 nautical miles make a degree.

3. Now a ship sailing from any latitude upon an oblique rhumb, until she has made a known departure, by the rules of plane sailing, will reckon herself under the same meridian, whether she sails to the northward or southward. But from what has been said, this cannot be true; for the same meridional distance, which in this case is taken as departure, will not serve two different latitudes on the same side of the equator; therefore the common methods of plane sailing alone are not sufficient to shew the ship's true place, a necessary correction being wanted with respect to her longitude.

The incorrect method of plane sailing was probably founded on the manner in which the sea-charts were at first constructed. For it being most convenient to represent the meridians, parallels of latitude, and rhumb lines in such charts by right lines, where the meridians would be parallel, and the east and west lines cut them at right angles; of consequence the distances of the meridian in every parallel were equal to the distances at the equator; and a degree on any parallel of latitude, was of the same size as a degree on the equator: hence each degree of longitude in those parallels was increased beyond its just size, in proportion as the equator, or its radius, is greater than the parallel, or its radius.

4. These material objections against the sea-charts could be removed only by adopting a different method of constructing them; and it had been hinted, some hundred years since, by several persons, that the degrees of latitude in such charts ought to be lengthened as they approach the poles. Accordingly Mr. *Gerrard Mercator*, a Fleming, published the first chart of this kind in the year 1556, in which the degrees of latitude were gradually lengthened from the equator toward the poles; but in what manner, or how the chart was constructed, he did not shew; neither were those degrees increased in the true proportion.

5. About the year 1590, Mr. *Edward Wright*, an Englishman, discovered the true principles upon which such a chart should be constructed; which is to increase the degrees of latitude as they approach the poles, in the same proportion as the degrees of longitude decrease on the globes. But it was not until the year 1599, when he published his errors in Navigation,

Digitized by Google

vigation, that he shewed publicly the principles of the true sea-chart, and the method of constructing it: but notwithstanding Mr. Wright was the real inventor, the charts made on this construction are called Mercator charts. However, as a true method of computing a ship's place at sea does not appear to have been known till Mr. Wright published the said book; therefore, although the chart may not improperly be called *Mercator*'s, from his being the first publisher of a chart of this kind, yet the method of sailing, called Mercator's, should, in justice, be named from Mr. *Wright*.

6. The difficulty of constructing a true sea-chart seems to have consisted in finding a proper manner of applying the surface of a globe to a plane, which Mr. *Wright* happily accomplished by a most ingenious conception; the substance of which follows.

1st. Suppose a rectangular plane were rolled about the globe, until the edges of the plane met, and formed a kind of concave cylinder inclosing the globe, and touching its equator.

2d. Conceive the surface of this globe to swell (like a bladder while it is blowing up) from the equator towards the poles, proportionally in latitude as it does in longitude, until every part of its surface meet that of the concave cylinder, and impress on it the lines that were drawn on the globular surface.

3d. Then the cylinder, or rectangular plane, being unrolled, will represent a sea-chart, the parts of which bear the same proportion to one another, as the corresponding parts on the globe do; and in which all the lines will be right lines.

For in this formation of the nautical chart, every parallel of latitude on the globe will be increased till it is equal to the equator; and so the distance of the meridians in those parallels will become equal to their distance at the equator; consequently the meridians on the chart are expressed by parallel right lines.

Also, the meridians being lengthened as the parallels are increased, every degree of latitude is lengthened in the same proportion as the degrees of longitude are increased; therefore the distances of the parallels of latitude become wider and wider as they approach the poles.

Again. As the rhumb lines on the globe cut the meridians at equal angles, they will also cut the meridians at equal angles on the chart, and consequently be expressed by right lines; since none but right lines can cut several parallel right lines at equal angles.

The construction of such a chart Mr. Wright deduced from the following principles.

Digitized by Google

SECTION II.

Of the Reckoning of Longitude.

7. PROPOSITION I.

The distance between any two meridians at the equator,
Is in proportion to their distance in any parallel of latitude;
As the radius,
To the co-sine of that latitude.

DEMONSTRATION. See Fig. 1. Pl. XIII.

Let PDFE represent the fourth part of a sphere; E being the center, P the pole, ED the radius of the equator, AB the radius of a parallel of latitude. Then the arcs PBD, PC*d*, will each represent a quadrant of a meridian; D*d* is an arc of the equator, and BC an arc of a parallel of latitude; also the arc DB expresses the latitude, and PB the complement of the latitude, the right sine of which is BA. (III. 3)

Now (II. 197) the circumference of a circle, the radius of which is ED, is to the circumference of a circle, the radius of which is AB, as ED is to AB; that is, as the radius of the equator, to the radius of the parallel; or, as radius to the co-sine of the latitude.

But like arcs, have the same ratio which their circumferences have. (II. 150, 197)

And like arcs D *d*, BC, are intercepted between the same two meridians; therefore

An arc of the equator is to a like arc in any parallel of latitude,
As the radius, to the co-sine of that latitude.

8. COROL. Hence it is easy to construct a table shewing the approach of two meridians in any latitude from the equator to the poles; or in what proportion the degrees of longitude diminish in every latitude.

9. PROPOSITION II.

Any part of a parallel of latitude is to a like part of a meridian, as radius is to the secant of the latitude of that parallel.

DEMONSTRATION. See Fig. 2. Pl. XIII.

Let PDE represent a quadrant of a meridian, where P is the pole, and DE the radius of the equator; AB is the radius of a parallel of latitude, or is the co-sine of the latitude, the sine of which is BF, and secant EC.

Then EF : EB : : ED : EC. (III. 34)
Or cos. lat. : rad. : : rad. : secant of the lat. in that parallel.
But cos. lat. : rad. : : part of a parallel : like part of the equator. (7)
Therefore, part of a parallel of latitude, is to a like part of the equator;
As the radius is to the secant of the lat. to that parallel.
Now like parts of the meridian and equator are equal, as great circles.
Therefore any part of a parallel of lat. is to a like part of a meridian; as radius, to the secant of the lat. to that parallel.

10. PRO-

Digitized by Google

10. PROPOSITION III.

The distance of any parallel of latitude (A) *from the equator is expressed by the sum of the secants of all the arcs between the equator and that parallel.*

DEMONSTRATION.

Now (9) As radius, to the secant of the latitude A;

So is a diminished deg. of long. in lat. A, or a degree of that parallel, to a degree of the meridian.

But the degrees of latitude, or of the meridian, are to be lengthened in proportion as the degrees of longitude diminish. (5)

Therefore, As radius, to the secant of the latitude A;

So is a natural deg. of the meridian, to a lengthened deg. in lat. A.

Here radius being as unity, and one natural deg. as unity also,

The length of a degree in any latitude is as the secant of that latitude, or may be expressed by that secant.

Now the distance of any parallel from the equator is the sum of all the successive arcs between the equator and that parallel.

Consequently the distance of that parallel is expressed by the sum of the secants of all these arcs between the equator and that parallel of latitude.

11. COR. Hence it appears that by the addition of the secants of small arcs the distances of the parallels of latitude from the equator are obtained.

And these several distances, which are called *meridional parts*, being disposed in a table corresponding to the degrees and minutes in a quadrant, form a table of meridional parts.

This was the excellent discovery of the celebrated Mr. *Wright*, by which the art of Navigation received greater improvements than by any thing that had been done before, the discovery of the mariner's compass excepted; and indeed, in this and other things, he so far perfected the art, that little else was wanted beside an accurate method to find the longitude at sea. There have been since his time many eminent men, who have done much towards rendering Navigation more perfect; yet if the real use of their improvements be strictly considered, it will perhaps be found, that they amount to no more than other methods of performing the same operations: the improvements made by Mr. *Richard Norwood* and Dr. *Halley* only excepted.

12. Mr. Wright made his table for the division of the nautical meridian, or the table of meridional parts, as follows.

The meridional parts for 1 min. he made equal to the secant of 1 min.

The mer. parts to 2 min. equal to the sum of the sec. of 1 and 2 min.

The mer. parts to 3 min. equal to the sum of the sec. of 1, 2, and 3 m.

The mer. parts to 4 m. equal to the sum of the mer. parts of 3 min. and the sec. of 4 min.

And so on by a constant addition of the secants.

Digitized by Google

Now although a table thus made is abundantly ſufficient for all nautical uſes; yet, had the ſecants of ſmaller parts than minutes been taken, the table would have been more correct. And therefore Mr. *Oughtred*, Sir *Jonas Moore*, Dr. *Wallis*, Dr. *Halley*, and others, have been induced to ſeek methods of conſtructing theſe tables with more accuracy than by the addition of the ſecants to every minute.

But a table of meridional parts conſtructed by the moſt accurate method, has only ſhewed, that Mr. *Wright*'s table does no where exceed the true meridian parts by half a minute, and this only near the pole; for in latitudes, as far as navigation is practicable, the difference is ſcarce ſenſible.

A table of meridional parts being obtained (ſee the table at the end of this book) the meridians and parallels of latitude for a ſea chart, in which the ſituation of places will bear the ſame proportion to one another as on the globe, may be conſtructed by the following propoſition.

13. PROPOSITION IV.

To conſtruct a ſea-chart, which ſhall contain a given number of degrees of latitude and longitude.

Suppoſe from the latitude of 23 degrees N. to the lat. of 59 degrees N. with 80 degrees of weſt longitude from the meridian of London.

SOLUTION.

1ſt, Write the ſeveral degrees of latitude, included between the propoſed limits, orderly under one another in a column, the greateſt being uppermoſt.

2d. Then beginning at the lower one, write in another column, againſt each degree, the difference * between the meridional parts of the leſſer latitude, and of that degree of latitude.

3d. Divide each of theſe meridional differences by 60, ſetting the quotients againſt their reſpective dividends, in another column; and theſe will be the meridional parts reduced to degrees of longitude, and will expreſs the meaſures of the diviſions for the meridional degrees.

If the meridional differences to parts of degrees, or minutes, be wanted, they are to be taken from the table of meridional parts in the ſame manner.

Theſe three articles are exemplified in the following table; which, although made to ſerve from the equator to 72 degrees of latitude, yet will ſerve for any intermediate limits, by ſubtracting the meridional degrees belonging to the latitude where the chart is to begin from thoſe of all the latitudes the chart is to contain: from the ſeveral remainders make a table, and theſe will be the numbers to be transferred to the chart, as is ſhewn in what follows.

---

* This is beſt done by writing the merid. parts of the leſſer lat. cloſe to the upper edge of a bit of paper, of the ſame ſize with the tabular figures; then this number being applied to the mer. parts of the other degrees, the differences may be readily taken.

A TABLE

Digitized by Google

A TABLE *for constructing a Mercator's Chart.*

Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.
72	6335	105,6	54	3865	64,4	36	2318	38,6	18	1098	18,3
71	6146	102,4	53	3764	62,7	35	2244	37,4	17	1035	17,2
70	5966	99,4	52	3665	61,1	34	2171	36,2	16	0973	16,2
69	5795	96,6	51	3569	59,5	33	2100	35,0	15	0910	15,2
68	5631	93,8	50	3475	57,9	32	2028	33,8	14	0848	14,1
67	5474	91,2	49	3382	56,4	31	1958	32,6	13	0787	13,1
66	5324	88,7	48	3292	54,9	30	1888	31,5	12	0725	12,1
65	5179	86,3	47	3203	53,4	29	1819	30,3	11	0664	11,1
64	5039	84,0	46	3116	51,9	28	1751	29,2	10	0603	10,1
63	4905	81,7	45	3030	50,5	27	1684	28,1	9	0542	9,0
62	4775	79,6	44	2946	49,1	26	1616	26,9	8	0482	8,0
61	4649	77,5	43	2863	47,7	25	1550	25,8	7	0421	7,0
60	4527	75,5	42	2782	46,4	24	1484	24,7	6	0361	6,0
59	4409	73,5	41	2702	45,0	23	1419	23,6	5	0300	5,0
58	4294	71,6	40	2623	43,7	22	1354	22,6	4	0240	4,0
57	4183	69,7	39	2545	42,4	21	1289	21,5	3	0180	3,0
56	4074	67,9	38	2468	41,1	20	1225	20,4	2	0120	2,0
55	3968	66,1	37	2393	39,9	19	1161	19,3	1	0060	1,0

4th. Draw a line AB (see Plate XII.) to represent a part of the parallel of latitude where the chart is to begin (which in this example is the parallel of 23°); and on this line, by the help of a scale of equal parts, lay a number of successive divisions to express the proposed number of degrees of longitude.

Thus 80 degrees of longitude being proposed, from some scale take one of the primary divisions, and this distance being repeated eight successive times in the line AB, will give divisions to every tenth degree of longitude, and then let the intermediate degrees be inserted, and AB will be divided into 80 equal parts of that scale; which, in this example, is the scale where eight subdivisions or degrees make an inch: in like manner the parts of degrees may be inserted.

5th. From the ends A, B, draw lines AD, BC, perpendicular to AB; and on these lines lay the divisions expressed by the meridional degrees in the foregoing table, beginning at the line AB.

Thus, if the chart began at the equator, and extended to 70 degrees of latitude; for 70 deg. take 99,4; for 69 deg. take 96,6; for 68 deg. take 93,8, &c.; and these divisions taken from the same scale, and laid severally on AD, BC, will give the divisions for the degrees of latitude increased in their true proportion; and the like for the intermediate parts of degrees.

But

Digitized by Google

But the chart beginning at 23 deg. of lat. its meridional degrees 23,6 are to be ſubtracted from thoſe belonging to all the latitudes to be introduced in the chart. The reſpective remainders are ſhewn in the following table:

Deg. Lat.	Mer. Deg.	Deg. Lat.	Mer. Deg.	Deg. Lat.	Mer. Deg.	Deg. Lat.	Mer. Deg.	Deg. Lat.	Mer. Deg.	Deg. Lat.	Mer. Deg.
59	49,9	53	39,1	47	29,8	41	21,4	35	13,8	29	6,7
58	48,0	52	37,5	46	28,3	40	20,1	34	12,6	28	5,6
57	46,1	51	35,9	45	26,9	39	18,8	33	11,4	27	4,5
56	44,3	50	34,3	44	25,5	38	17,5	32	10,2	26	3,3
55	42,5	49	32,8	43	24,1	37	16,3	31	9,0	25	2,2
54	40,8	48	31,2	42	22,8	36	15,0	30	7,0	24	1,1

Then theſe meridional degrees, taken from the ſame ſcale uſed for the degrees of longitude, are to be applied to the meridians BC, AD; ſo that the meridian extent of the chart will be 49,9 ſuch diviſions, as the parallel extent eaſtward contains 80.

6th. Draw lines through the ſeveral correſponding diviſions of latitude, and they will repreſent the parallels of latitude; lines drawn through the diviſions of longitude, will expreſs the meridians or parallels of longitude. In this example, the meridians and parallels are drawn only to every 10 degrees.

7th. From ſome point of the chart, as a center, let the rhumb lines be drawn.

14. Note, The difference between the meridional parts to two given latitudes, is called the MERIDIONAL DIFFERENCE OF LATITUDE, to diſtinguiſh it from the difference of latitude of thoſe two places reckoned in miles of the equator, which is called the *proper difference of latitude.*

In a chart thus conſtructed, every place may be laid down in its true poſition, with regard to other places, by its latitude and longitude, with as much accuracy as on the globe itſelf, the diſtances of the meridians and parallels of latitude having the ſame proportion to one another in both. Thus, on the globe, the diſtance of two meridians in the parallel of 60 degrees is half their diſtance at the equator, becauſe the co-ſine of 60 degrees is half the radius (III. 24); ſo in the chart, at the latitude of 60 degrees, the meridional difference of latitude to one minute is double to the meridional difference of latitude of one minute from the equator, the ſecant of 60 degrees being double to the radius (III. 24, 34); and the like analogy holds in other correſponding latitudes.

Now as the meridians are parallel right lines, and are cut at right angles by the parallels of latitude, and the rhumbs alſo being right lines; ſuch a chart is of more ſervice to the mariner for moſt purpoſes, than the globe is.

The properties of the ſeveral lines and angles uſed in ſailing by this chart will be ſhewn in the following propoſitions.

Digitized by Google

15. PROPOSITION V.

If a ship sails on any oblique rhumb, the proper difference of latitude to the departure, the meridional difference of latitude to the difference of longitude, and the radius to the tangent of the course, are all in the same ratio. See Fig. 1. Pl. XII.

Demonstration.

Suppose a ship from P in the latitude of 30 deg. N. sails on the rhumb PS, to S in the latitude of 40 degrees north.

Now because she has made 10 deg. of diff. lat.; make PO, in the meridian, equal to 10 degrees of the equator; and draw O R parallel to Q S, meeting the rhumb P S in R.

Then PO expresses the proper difference of latitude.
OR the departure.
PR the distance sailed in equatorial measure.
∠OPR is the angle of the course.

And R is the apparent place of the ship.

But having made 10 deg. diff. lat. she should be in the parallel of 40 degrees; her place therefore, when corrected by longitude, will be in S.

Then QS will be the difference of longitude.

And PQ the meridional difference of latitude.

Now the triangles POR, PQS, are similar.

Therefore PO : OR : : PQ : QS. (II. 167)
Also PO : OR : : rad. : t. ∠OPR. (III. 46)

Consequently. As the proper diff. lat., to the departure;
So the merid. diff. lat., to the diff. longitude.
And So is the radius , to the tang. of the course.

16. PROPOSITION VI.

The tangents of the angles which different rhumbs make with the meridians, are directly proportional to the differences of longitude made on those rhumbs to equal meridional differences of latitude: Or, are reciprocally proportional to unequal meridional differences of latitude on those rhumbs, when the differences of longitude are equal. See Fig. 1. Plate XII.

Demonstration.

Let QS, QV, be the differences of longitude made on the rhumbs PS, PV, to the common merid. diff. lat. PQ; also PW, PQ, be the meridional differences of latitude, on the same rhumbs, to the equal differences of longitude WX, QV.

Now PQ : QV : : R : t. ∠QPV } (III. 46)
And PQ : QS : : R : t. ∠QPS. }
Consequently QV : QS : : t, ∠QPV : t, ∠QPS. (II. 155)
Again. Since R : t, ∠QPV : : PQ : QV } (III. 46)
And R : t, ∠WPX : : PW : QV (=WX) }
Then R × QV = PQ × t. ∠QPV = PW × t, ∠WPX (II. 162)
Consequently PW : PQ : : t, ∠QPV : t, ∠WPX. (II. 46, 163)

17. PROP.

Digitized by Google

17. PROPOSITION VII.

If a ship sails on several different rhumbs, the whole meridional diff. lat. is equal to the sum, or difference of all the successive meridional differences of lat.: And the whole diff. long. is also equal to the sum, or differences of all the successive differences of longitude; the sums being taken when they are of the same name; and the differences when of contrary names. See Fig. 2. Plate XII.

DEMONSTRATION.

1st. Suppose a ship sails from E in the lat. of 23° N. to G in the parallel of 26 deg. N. Then E g=mer. diff. lat. and G g=diff. long.

2d. To sail from G to H in the parallel of 28 deg. Then G h=diff. lat. and h H=diff. long.

Now E m=E g+G h, is the whole diff. latitude.

And m H=mh—H h, is the whole diff. longitude.

3d. She sails west from H to I: here she only alters her longitude by HI; so that her present diff. long. is m I.

4th. In sailing from I to K, she increases her diff. long. by k K, from m I to g K; and decreases her diff. lat. by I k, from E m to E g.

5th. In sailing north from K to P, the diff. long. p P continues the same; but the diff. lat. is increased by K P, from E g to E p.

6th. In running east from P to M, the diff. lat. E p does not alter; but the diff. longitude is diminished from p P to p M.

7th. By going from M to N, the diff. lat. is increased by M l, from E p to E q; and the diff. long. is changed from p M, or q l, to q N.

Consequently the whole diff. lat, E q is equal to the sums, or differences of all the differences of lat.; and the same of q N, the whole difference of longitude.

18. PROPOSITION VIII.

If the course between any two places, outward and homeward, be on the opposite rhumbs; then in each case the differences of latitude, departures, and differences of longitude, will always be the same. See Fig. 3. Plate XII.

DEMONSTRATION.

Suppose a ship at a in lat. 25 deg. N. sails on one rhumb to the latitude 40 deg. N. so that at the end of every third day she alters her diff. lat. five deg. or 300 miles; and returns, on the opposite rhumb, in the same manner.

Through the intersections a of this rhumb, with the parallel of every five degrees, draw meridians; make a d, a f, each equal to five common degrees of the equator; and draw d b, f e, parallel to the parallels of latitude.

Then are the lines a d the proper differences of latitudes outward to each third day's account, which must be every where equal; and also, the equal lines a f are the differences of latitude homeward to the like accounts.

The

Digitized by Google

The lines $d\,b$ outward, and $f\,e$ homeward, are the departures to each third day's account.

The lines $a\,b$ outward, and $a\,e$ homeward, are the distances run to each third day's account.

The meridian lines $a\,c$ outward, and $a\,n$ homeward, are the meridional differences of latitude; and the west and east lines $c\,a$ outward, and $n\,a$ homeward, taken on the parallels of latitude, are the differences of longitude.

Now it is evident from the construction that the triangles $a\,d\,b$, $a\,f\,e$, in each account, are equal to one another.

Also, that the meridional differences of latitude, and the differences of longitude, to the accounts between the same parallels of latitude outward and homeward, are respectively equal to one another.

Consequently the truth of the proposition is manifest.

19. PROPOSITION IX.

The divisions of the meridian line on the Mercator's chart form a table of the differences of longitude answering to each minute of latitude on the rhumb line making an angle of 45 *degrees with the meridian.* See Fig. 1. Pl. XII.

DEMONSTRATION.

Let PV be a rhumb of 45 degrees.

Then, since PQ is at right angles to QV.

The angle QPV $=\angle$ QVP, each being half a right angle.

Consequently QV $=$ QP. (II. 104)

Now PQ is the sum of all the meridional differences of latitude between the parallels through P and Q. (11)

And QV is the sum of all the differences of longitude between the meridians through Q and V.

Therefore on a rhumb of 45 degrees, the sum of all the differences of longitude is equal to the sum of all the meridional differences of latitude.

But the sum of all the meridional differences of latitude is the same as the nautical meridian. (12)

Consequently, on a rhumb of 45 degrees the difference of longitude, or the sum of all the intermediate differences of longitude to every minute of latitude, is equal to the corresponding parts of the nautical meridian line.

20. In the Philosophical Transactions, N° 219, Dr. Halley has given a very curious paper relating to the division of the nautical meridian, by a method quite different from Mr. Wright's; and because it contains a method of performing the problems of sailing according to the true chart, by the help of Briggs's, or the common table of logarithmic tangents, without a table of meridional parts; the substance of that paper is here annexed.

The

Digitized by Google

The Doctor says: "It was first discovered by chance, and, as far as I "can learn, first published by Mr. *Henry Bond*, as an addition to Nor-"wood's Epitomy of Navigation, about the year 1645, that *the meridian "line was analogous to a scale of logarithmic tangents of half the comple-"ments of the latitude*. The difficulty to prove the truth of this propo-"sition seemed such to Mr. *Mercator*" (an ingenious mathematician then living, and) "the author of the Logarithmotechnia, that he pro-"posed to wager a good sum of money, against whoso would fairly un-"dertake it, that he should not demonstrate either that it was true or "false: And about that time Mr. *John Collins* holding a correspondence "with most of the eminent mathematicians of the age, did excite them "to this enquiry.

"The first that demonstrated the said analogy was the excellent Mr. "*James Gregory*, in his *Exercitationes Geometricæ*, published *anno* 1668, "which he did, not without a long train of consequences and compli-"cation of proportions, whereby the evidence of the demonstration is in "a great measure lost, and the reader wearied before he attains it." The Doctor proceeds, "Nor hath any one, that I know of, yet discovered the "rule for computing independently the interval of the meridional parts "answering to any two given latitudes."

The Doctor then gives the demonstration of the said analogy in a very elegant manner; and draws several useful conclusions. But, as he confesses himself, he is too concise for learners; and the writers on this subject have been no less so. In order therefore to set this affair in a clear light, and to keep to the Doctor's principles, it was thought convenient to dispose of the subject in the following manner; but the proposition may be proved from principles very different from those which were used by the Doctor.

21. PROPOSITION X.

On the globe, the rhumb lines oblique to the meridians are spirals, which continually approach the poles.

DEMONSTRATION.

In any place on the surface of the globe the rhumb running north and south, coincides with the meridian of that place; the east and west rhumbs are perpendicular to the meridian, and the other rhumbs are oblique to it; but this obliquity is the same under every meridian; therefore all the rhumbs, except the north and south, cut the meridians at equal angles.

When right lines are parallel to each other, a right line will cut them at equal angles (II. 95): But not so, when the lines are inclined to one another; therefore several inclining lines cannot be cut at equal angles, except by a curve line bending toward the place where those lines would meet.

Now the meridians on the globe, meeting in the poles, are inclined to one another; therefore the oblique rhumbs cutting them at equal angles, are curve lines continually approaching the poles.

22. PRO-

Digitized by Google

22. PROPOSITION XI.

The ſpiral rhumbs on the globe become proportional ſpirals in the ſtereographic projection on the plane of the equator. See Fig. 3. Plate XIII.

DEMONSTRATION.

Let CAEB repreſent part of a ſtereographic projection of the ſphere on the plane of the equator, where AEB is part of the equator, C the pole, CA, CD, CE, &c. are meridians, and the ſpiral A *d e f* one of the rhumbs.

Now in every ſtereographic projection the lines interſecting each other form angles equal to the angles on the ſphere which they repreſent. (IV. 52)

Therefore the projection of the rhumb line A *d e f* cuts the radii or meridians AD, AE, &c. at equal angles.

But this is a property alſo of the proportional ſpiral. (II. 225)

Therefore the ſpiral rhumbs on the globe become proportional ſpirals in this projection.

23. COR. Hence the differences of longitude AD, AE, AF, &c. are logarithms of the ratios of the intercepted parts C *d*, C *e*, C *f*, &c. of the meridians to the radius CA.

24. PROPOSITION XII.

The meridian line is a ſcale of logarithmic tangents of half the complement of the latitudes beginning from the radius.

DEMONSTRATION.

Let the figure CADEB be part of the ſtereographic projection of the ſphere on the plane of the equator, as in the laſt propoſition: and on any rhumb let the points A, *d*, *e*, *f*, &c. repreſent certain places on the globe, of which A is a point in the equator; then will D *d*, E *e*, F *f*, &c. expreſs their reſpective latitudes, and the arcs AD, AE, AF, &c. their differences of longitude from the longitude of A; alſo C being the pole, the lines C *d*, C *e*, C *f*, &c. are the projections of the complements of their latitudes.

Now in this projection the lines C *d*, C *e*, C *f*, &c. are equal to the tangents of half the complements of thoſe latitudes. (IV. 48)

And the differences of longitude AD, AE, AF, &c. are logarithms of the ratio of thoſe tangents, or of the lines C *d*, C *e*, C *f*, &c. to the radius CA.

Alſo the lengthened degrees of the nautical meridian line are the longitudes of thoſe degrees made on the rhumb of 45 degrees, whether expreſſed in minutes, according to the uſual tables, or in degrees, as ſome writers have done.

25. PRO-

25. PROPOSITION XIII.

The logarithmic tangent of half the complement of any latitude in Napier's original system, divided by 0,0002908882, &c. first multiplied by the radius of the tables, exhibits in minutes the change in longitude, which will be made on the rhumb of 45 degrees from the equator to that latitude; or the lengthened degrees in the meridian line from the equator to that latitude.

DEMONSTRATION.

The differences of longitude AD, AE, AF, &c. being on the rhumb of 45°, logarithms to C *d*, C *e*, C *f*, &c. which begin from the radius, and proceed from thence, in like manner as Napier's logarithmic tangents do from his radius: (II. 229)

Therefore his logarithmic tangent of half the complement of any latitude bears to his radius the ratio of the arc of longitude accompanying the change of latitude to the radius of that arc, consequently it is the ratio of the number of minutes contained in that arc to the measure of the radius in minutes.

Hence the logarithm will also be to the radius of the table multiplied by 0,0002908882, &c. (the arc of one minute, when the radius is unity) as the number of minutes in this arc is to the measure of the radius in minutes multiplied by 0,0002908882, &c. that is, to one minute; for the measure of the radius in minutes is to one minute, as unity to 0,0002908882, &c.

Therefore the number of minutes contained in the longitude, or the lengthened degrees in the meridian line, is equal to the logarithm named, divided by 0,0002908882, &c. first multiplied by the radius of the table.

26. COR. Napier's radius being 10000000, the logarithmic tangent will be divided by 2908,882, &c.

If the difference between the logarithmic tangents of half the complements of any two latitudes, when on the same side of the equator, or their sum, if one latitude be north and the other south, be divided in the same manner, the quotient shall give the meridional parts for the interval between the two latitudes.

27. PROPOSITION XIV.

If in Briggs's logarithms the index, or characteristic alone be considered as an integer, and all the rest as an appendage of decimals, the difference between the logarithm of the radius, and the logarithmic tangent of half the complement of the latitude of any place divided by 0,000126331 14, &c. gives the minutes of the change of longitude in passing on the rhumb of 45° to the latitude of that place, or the meridional parts corresponding to that latitude.

DEMONSTRATION.

Briggs's logarithms thus interpreted are to Napier's original logarithms, as 1 to Napier's logarithm of 10 (or rather to his logarithm of the ratio between 10 and 1) which is nearly 2302585 1 *, and the difference

* The number usually set down, as Napier's logarithm of 10, is more properly his logarithm divided by the radius of his trigonometrical table, which is the radix from which he raised his logarithms.

named are logarithms of the respective tangents to the radius. Therefore these divided by $\frac{2908,882}{23025851}$ (=0,00012633114, &c.) will produce the same quotient, as Napier's logarithms assigned to the same tangents (which are the logarithms of the ratio of those tangents to the radius in his system) divided by 2908,882: this quotient therefore will be the minutes of the change of longitude on a rhumb of 45°, that is, the length of the meridian line.

28. Cor. If the difference from the radius of the logarithmic tangent, taken from any table of logarithms of Briggs's form, be considered as consisting wholly of integers, and divided by 12633114, &c. in which so many figures shall be esteemed integers, as are four short in number of the logarithmic tangent taken, the index included, the quotient shall give the meridional parts appertaining to that latitude *.

Also here, if in any logarithmic table of the common form, the difference between the logarithmic tangents of half the complements of any two latitudes on the same side of the equator, or their sum if one latitude be north and the other south, be considered, as an integer number, and divided in like manner, the quotient shall be the meridional parts for the interval between the two latitudes.

Scholium.

29. The numbers in Napier's table divided by 2908,882, &c. exhibiting the change of longitude on a rhumb of 45°, the tangent of which is equal to the radius, the numbers themselves will express the change in longitude on a rhumb, the tangent of which is 2908,882, &c. times the radius, and the angle 89° 58′ 49″; and if the logarithm be divided by 10, 100, or 1000, the angle of the rhumb will respectively be 89° 48′ 11″, 88° 1′ 52″, or 71° 1′ 42″, which is the angle Dr. Halley has chosen.

After the same manner in Briggs's system, the difference of the tangent of half the complement of any latitude from the radius divided by 0,00012633114, &c. exhibiting the corresponding length of the meridian line, should the index of the logarithm be alone considered as an integer number, those differences will be the change of longitude on a rhumb, the tangent of which is equal to the radius of any trigonometrical canon of Briggs's form multiplied by 0,00012633114 38, &c. and the angle 0° 0′ 26″. But if one figure besides the index be taken as integer, the tangent of the rhumb will be the radius multiplied by 0,0012633, &c. the angle being 0° 4′ 20½″; if two, the angle will be 43′ 25½″; if three, the angle will be 7° 12′ 0″; and if four, as Dr. Halley proposes, the angle will be 51° 38′ 9″.

From the preceding propositions all the problems relating to the true method of sailing may be accurately resolved; and although they are here all contained under the general title of globular sailing, yet as the

* Thus when the tables of logarithms have eight places with the index, the divisor will be 1263,3, &c. but when the tables consist of 7 or 6 places, the divisor will be 126,33, &c. or 12,633, &c.; and so on.

Digitized by Google

common cuſtom has been to diſtinguiſh different kinds, in which the longitude is conſidered; ſo here, in compliance with ſuch cuſtom, it was thought proper to retain the uſual forms, *viz. parallel ſailing*, *middle latitude ſailing*, and *Mercator's ſailing*, or more properly *Wright's ſailing*; which are diſtinctly treated of in the following ſections.

SECTION III.

Of Parallel Sailing.

30. PARALLEL SAILING *is the art of finding what diſtance a ſhip ſhould run due eaſt or weſt, in ſailing from the meridian of one place to that of another place, in any parallel of latitude.*

This kind of piloting is generally uſed in conducting a ſhip to an iſland, which lies at a conſiderable diſtance from the main land, or other iſlands; and alſo on ſome other occaſions.

The method of performing which is to ſail to the parallel of latitude the place is in, keeping a good account, ſo as to be certain whether the place is then to the eaſtward, or weſtward; and alſo, if poſſible, to know the longitude arrived at; and then to run due weſt, or eaſt, until the ſhip comes near the longitude of the given place, where ſhe is ſure to make the port required.

The computations in parallel ſailing depend on the following

RULE.

31. *As radius,* = R.
To the co-ſine of the latitude of any parallel; = S.
So is the miles of longitude between any two meridians, = L.
To the diſtance of thoſe meridians in that parallel. = D.

For the demonſtration, ſee Art. 7.

From the ſame propoſition is eaſily deduced the following

RULE.

32. *As the co-ſine of one latitude,* = S.
Is to the co-ſine of another latitude; = *s*.
So is a given meridional diſtance in the firſt parallel, = D.
To the correſponding meridional diſtance in the ſecond parallel. = *d*.

33. And hence ariſe the following proportions.

R	:	S	::	L	:	D.
S	:	R	::	D	:	L.
L	:	D	::	R	:	S.
S	:	*s*	::	D	:	*d*
D	:	*d*	::	S	:	*s*.

By which all the caſes that can happen in this kind of ſailing are readily reſolved by the logarithms, and alſo by the following table, calculated for a difference of longitude of 1 degree, or 60 nautical miles of the equator, by the firſt rule. Thus,

As radius, to the co-ſine of any latitude; ſuppoſe 30°;
So 60 *miles of longitude, to the meridional diſtance* 51,96.

And the like to the other latitudes.

4 34. A

Digitized by Google

34. *A* TABLE *shewing how many miles answer to a degree of longitude, at every degree of latitude.*

Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles
1	59,99	16	57,67	31	51,43	46	41,68	61	29,09	76	14 51
2	59,96	17	57,38	32	50,88	47	40,92	62	28,17	77	13,50
3	59,92	18	57,06	33	50,32	48	40,15	63	27,24	78	12 48
4	59,85	19	56,73	34	49,74	49	39,36	64	26,30	79	11,45
5	59,77	20	56,38	35	49,15	50	38,57	65	25,36	80	10,42
6	59,67	21	56,01	36	48,54	51	37,76	66	24,41	81	9,38
7	59,56	22	55,63	37	47,92	52	36,94	67	23,44	82	8,35
8	59,42	23	55,23	38	47,28	53	36,11	68	22.48	83	7,32
9	59,26	24	54,81	39	46,63	54	35,27	69	21,50	84	6,28
10	59,09	25	54,38	40	45,96	55	34,41	70	20,52	85	5,23
11	58,89	26	53,93	41	45,28	56	33,55	71	19,53	86	4,18
12	58,69	27	53,46	42	44,59	57	32,68	72	18,54	87	3,14
13	58,46	28	52,97	43	43,88	58	31,79	73	17,54	88	2,09
14	58,22	29	52,47	44	43,16	59	30,90	74	16,54	89	1,05
15	57,95	30	51,96	45	42,43	60	30,00	75	15,53	90	0,00

The use of this table will be evident from what follows:

35. *If the meridional distance is wanted to degrees and minutes, proceed thus:*

Take the difference of the meridional distances to the given degrees, and those which are next greater; multiply this difference by the given minutes, and divide the product by 60; then the quotient subtracted from the miles against the given degrees in the table, will leave the meridional distance required.

36. *But if a meridional distance, intermediate to those in the table, was given to find the corresponding degrees and minutes.*

Subtract the given meridional distance from the next greater, found in the table; multiply the remainder by 60; divide the product by the difference of the meridional distances next greater and less than the given one; then the quotient being annexed as minutes to the degrees of the next greater meridional distance, will give the degrees and minutes sought.

EXAM. to the first Rule.

How many miles answer to a degree of long. in the lat. of 48° 26′ *?*
Lat. 48° 40,15 miles.
Lat. 49 39,36 miles.

The diff. is 0,79, which multiplied by 26 gives 20,55; this divided by 60 gives 0,38; which taken from 40,15 leaves 39,77, the miles required.

EXAM. to the second Rule.

In what. lat. do 46,08 *miles nafwer to one deg. of longitude?*
From 46,63, the miles to 39°.
Take 46,08, the given miles.

Leaves 0,55; which multip. by 60 gives 33,00; this divided by 0,67, the diff between 39° and 40°, gives 49′. So 39° 49′ is the lat. sought.

Digitized by Google

37. CASE I. Given the latitude and difference of longitude; required the distance.

EXAM. *A ship in the latitude of 32° N. sails due east till her difference of longitude is 384 miles: Required the distance she has run.*

By CONSTRUCTION*. Fig. 4. Pl. XIII.

From any point P, with the radius of 90°, taken from the scale of natural sines, describe the arc EQ; draw the chord EQ equal to 384 miles taken from a scale of equal parts; and draw the radii PE, PQ.

From the same point P, with a radius equal to the sine of 58° (the comp. lat.) taken from the nat. sines describe the arc AB; and draw the chord AB, the measure of which is the distance sought.

Here P represents the north pole; the arc EQ the equator; the arc AB a parallel of latitude; the chord EQ is the difference of longitude; the chord AB is the meridional distance sought; A is the place sailed from, B the place arrived at; and the radii PE, PQ, express the meridians of the places so sailed from, and arrived at.

By COMPUTATION.

As radius	=	90° 00′	10,00000
To co-s. lat.	=	32 00	9,92842
So miles long.	=	384	2,58433
To miles dist.	=	325,6	2,51275

So that she has run 325,6 miles.

By the TABLE. (34)

Seek the miles to the given latitude; multiply them by the given diff. longitude; the quotient divided by 60 will give the meridional distance sought.

Thus. To lat. 32° answers 50,88 miles.
Multiply 384 the given diff. longitude.

20352
40704
15264

60)19537,92(325,632 = merid. dist. sought.

* This and the construction of the following cases depend on the Orthographic projection † of the circles of the sphere on the plane of the equator, that circle being the primitive, and its center or pole representing the point into which the pole of the Earth is projected; consequently the distance from the pole of any parallel of latitude, must be expressed by the complement of that latitude.

† This projection is formed by supposing that any point on the surface of a sphere is projected on a plane passing through its center, by a line drawn through that point perpendicular to the plane; which amounts to the same, as if the visual ray came from an eye at an infinite distance.

Thus in Fig. 1. Pl. XIII. perpend. lines through B, b, project those points in r, z, on the plane [illegible]: Therefore small circles on that plane are described with the radii E r, E z = the sines of the arcs P B, P b.

38. CASE

38. CASE II. Given the latitude and meridional distance; required the difference of longitude.

EXAM. *A ship from the latitude 53° 36′ N. longitude 10° 18′ E. sails due west 236 miles: Required her present longitude.*

By CONSTRUCTION. Fig. 4. Pl. XIII.

From the point P, with the sine of 90°, and the co-sine of 53° 36′, describe the arcs EQ, CD. Draw the chord CD=236; through C and D draw the radii PE, PQ; then the chord EQ being drawn, will be the difference of longitude.

By COMPUTATION.

As PC, the co-s. lat.	=	53° 36′	0,22664		6,0)39,8(6°	38′.
To PE, radius	=	90 00	10,00000	Long. from	10	18E.
So CD, merid. dist.	=	236 m.	2,37291	Diff. long.	6	38W.
To EQ, diff. long.	=	397,7	2,59955	Long. in	3	40E.

By the TABLE.

Find the meridional distance to a deg. of long. in lat. 53° 36′ (35), and make it a divisor to the product of the given meridional distance by 60; then will the quotient be the diff. long. sought.

Thus. The diff. merid. dist. to 53° and 54°, is 0,85; which multiplied by 36′, and divided by 60′, gives 0,51; this taken from 36,11, the merid. dist. to 53°, leaves 35,6 for the merid. dist. to 53° 36′: Then 236 multiplied by 60, and the quotient divided by 35,6, gives 397,7 for the diff. long. sought.

39. CASE III. Given the difference of longitude, and its corresponding meridional distance; required the parallel of latitude.

EXAM. *In what latitude do 384 miles of meridional distance answer to 500 miles of diff. longitude?*

By CONSTRUCTION. Fig. 5. Pl. XIII.

From the point P, with the sign of 90°, describe the arc EQ; draw the chord EQ=500, and draw the radii PE, PQ; make EC=384, draw CB parallel to EP; then the arc AB being described with the radius PB, is the parallel of lat. sought.

By COMPUTATION.

As EQ, the diff. long.	=	500	7,30103	So in the lat. 39° 49′ 384 miles of merid. dist. answer to 500 miles of longitude.
To AB, merid. dist.	=	384	2,58433	
So PE, radius	=	90° 00′	10,00000	
To PA, the co-s. lat.	=	39 40	9,88536	

By the TABLE.

The given merid. dist. 384 being multiplied by 60, and the product divided by the given diff. long. 500, gives 46,08, the merid. dist. to one deg. of long. in the lat. sought: and by article 36, the latitude will be found to be 39° 49′.

Digitized by Google

40. CASE IV. Given the diſtance of two places in a given parallel of latitude; required the diſtance of two other places, under the ſame meridians with the former, in another given parallel of latitude.

EXAM. *From two ports in the lat. 32° 20′ N. diſtant 256 miles, two ſhips ſail directly north: How far are they diſtant from one another, when they come to the lat. 44° 30 N.?*

By CONSTRUCTION. Fig. 6, Pl. XIII.

From the point P, with radii equal to the co-ſines of 32° 20′, and 44° 30′, deſcribe the arcs AB, DE; draw the chord AB=256, and draw PA, PB; then will the chord DE be the diſt. ſought.

By COMPUTATION.

As PA, the co-ſ. of lat. from	=	22° 20′	0,07317
To PD, the co-ſ. of lat. in	=	44 30	9,85324
So AB, the firſt diſt.	=	256	2,40824
To DE, the preſent diſt.	=	216,1	2,33465

By the TABLE.

The merid. diſtances to 32° 20′, and 44° 30′ (found by 35) are 50,7 and 42,8: then the given merid. diſtance 256 multiplied by 42,8, and the product 1095,68 divided by 50,7, the quotient 216,1 is the meridional diſtance ſought.

41. CASE V. Given the diſtances between the ſame two meridians in different parallels, and alſo the latitude of one parallel, to find the latitude of the other.

EXAM. *If two ſhips in the lat. 44° 30′ N. diſtant from one another 216 miles, ſhould both ſail directly ſouth, until their diſtance is 256 miles; what latitude are they come to?*

By CONSTRUCTION. Fig. 7. Pl. XIII.

From P, with a radius of the co-ſine of 44° 30′, the lat. ſailed from, deſcribe the arc DE; draw the chord DE=216; and through D and E draw PA, PB; continue DE till DF=256; through F draw FB parallel to PA, meeting FB in B; then an arc deſcribed from P, through B and A, will be the parallel of latitude come to.

By COMPUTATION.

As DE, the firſt diſt.	=	216	7,66554
To AB, the ſecond diſt.	=	256	2,40824
So PD, the co-ſ. lat. from	=	44° 30′	9,85324
To PA, the co-ſ. lat. in	=	32 17	9,92702

By the TABLE.

To lat. 44° 30′ find (35) the mer. diſt. 42,8; this multiplied by 256, and the product divided by 216, gives 50,72; which (by 36) will be found to be the merid. diſt. to 32° 17′, the latitude ſought.

42. *Other*

James Macnally's Book.

Digitized by Google

42. *Other examples to exercise the foregoing cases.*

Ex. I. *What is the distance between St. Mary's in lat. 37° 00′ N. long. 25° 00′ W. and Cape Henry in lat. 37° 00′ N. long. 76° 23′ W.?*

As rad. : co-s. lat. 37° 00′ : : diff. long. 3083 : dist. 2462.

Ex. II. *A ship from Cape Clear sails west 265 miles; what long. is she come to?*

As co-s. lat. 51° 18′ : radius : : merid. dist. 265 : diff. long. 423,8.
Answer. The present longitude is 16° 54′ W.

Ex. III. *A ship having run due east for 3 days, at the rate of 5 knots an hour, finds she has altered her longitude 8° 16′; what parallel of latitude did she sail in?*

As diff. long. 496 : merid. dist. 360 : : rad. : co-s. lat. 43° 28′.

Ex. IV. *Suppose two ships in the parallel of 47° 54′ N. their difference of long. being 9 35′, should both sail directly south 836 miles; how far were they from each other when they set out, and also after they had run that distance?*

As rad. : co-s. lat. 47° 54′ : : diff. long. 575 : first merid. dist. 385,5m.
Now 836 miles = 13° 56′; therefore the lat. come to is 33° 58′.
As rad. : co-s. lat. 33° 58′ : : diff. long. 575 : last merid. dist. 476,9 m.

Ex. V. *What is the diff. lat. between two parallels on diff. sides of the equator, when, between the same two meridians, the meridional distance in the northern parallel is* AB=238 *miles, in the southern parallel is* CD=195 *miles, and at the equator is* EQ=352 *miles?*

As diff. long. 352 : north. mer. dist. 238 : : rad. : co-s. lat. 47° 27′ N.
As diff. long. 352 : south. mer. dist. 195 : : rad. : co-s. lat. 56° 22′ S.
Then the sum of these two latitudes, *viz* 103° 49′, is the diff. lat. sought.

In this figure 8, Pl. XIII. P is the north pole, and S is the south pole; but the construction on one side of the equator is sufficient, as is evident by drawing *e d* parallel to PE, and *dc* parallel to EQ.

The difference of longitude and meridional distances may be considered as tangents to their respective arcs, as well as chords. (II. 185)

Among the natural scales on the Gunter, are two, which used jointly, answer the end of the foregoing table: these are a scale of chords marked *CH*, and a scale of longitude marked *ML*, standing close to one another; they are thus used:

Find the given latitude on the scale of chords, and right against it, in the scale of longitude, is the division expressing the miles of merid. distance in that lat. to one degree of longitude.

Thus against the chord 60° stands 30 miles; the chord 50° stands between 38 and 39 miles; and so of the rest.

Digitized by Google

SECTION IV.

Of Middle Latitude, and Mercator's failings.

Of Middle Latitude failing.

43. MIDDLE LATITUDE SAILING *is a manner of folving the feveral cafes of globular failing, by the principles of plane and parallel failing jointly.*

This method, which is not quite accurate, is founded on the following fuppofition.

44. *The departure is reckoned as a meridional diftance in that latitude, which is a middle parallel between the latitude failed from, and the latitude arrived at.*

Now although the arithmetical mean of the co-fines of two diftant latitudes is not the co-fine of the arithmetical mean of thofe latitudes; neither is the departure between two places on an oblique rhumb equal to the diftance between their meridians in a mean latitude; yet when the parallels of thofe places are near the equator, or not far diftant from one another, in any latitude, the error becomes fo fmall, as not materially to affect the nautical conclufions drawn from the foregoing fuppofition.

This artifice feems to have been invented on account of the eafy manner in which the feveral cafes may be refolved by the Traverfe Table, and where a table of meridional parts is wanting. The computations depend on the following rules,

RULE I.

45. If the places are on the fame fide of the equator, add the latitude failed from to the latitude arrived at, and take half the fum for the middle latitude; but if they are on different fides, half their difference is the middle latitude,

RULE II.

46. As the co-fine of the middle latitude, = C.
Is to the radius; = R.
So is the departure, = D.
To the difference of longitude. = L.

RULE III.

47. As the co-fine of the middle latitude, = C.
Is to the tangent of the courfe; = T.
So is the difference of latitude, = P.
To the difference of longitude. = L.

The fecond rule is the fame as the firft rule in parallel failing, which is demonftrated at art. 7.

Demonftration

Digitized by Google

Demonstration of the third rule.

Now co-s. mid. lat. : rad. : : departure : diff. long. (7)
Therefore rad. × dep. = co-s. mid. lat. × diff. long. (II. 162)
Also diff. lat. : depart. : : rad. : tang. course. (VII. 26)
Therefore rad. × dep. = diff. lat. × tang. course. (II. 162)
Consequently co-s. mid. lat. × diff. long. = diff. lat. × t. course. (II. 46)
Therefore co-s. mid. lat. : tang. course : : diff. lat. : diff. long. (II. 163)

From rules II. and III. arise the following proportions.

C : R : : D : L.
L : D : : R : C.
R : C : : L : D.

C : T : : P : L.
P : L : : C : T.

Where the letters signify the names they stand against in the rules.

Of Mercator's sailing.

48. MERCATOR'S SAILING *is the art of resolving the several cases of Globular sailing by Plane Trigonometry, with the assistance of a table of meridional parts, or of logarithmic tangents.*

The computations herein are performed by the following rules. (15)

49. RULE I.

		Therefore
As merid. diff. lat.	= M.	M : L : : R : T.
To diff. longitude;	= L.	R : T : : M : L.
So is the radius,	= R.	T : R : : L : M.
To tang. course.	= T.	

50. RULE II.

		Therefore
As the prop. diff. lat.	= P.	
To the departure;	= D.	P : D : : M : L.
So mer. diff lat.	= M.	M : L : : P : D.
To diff. longitude	= L.	

These rules are demonstrated at Prop. IV.

51. RULE III.

		Therefore
As diff. log. tang. ½ co-lats.	= G.	G : N : : L : T.
To tang of 51° 38′ 09″;	= N.*	N : G : : T : L.
So is a given diff. long.	= L.	T : L : : N : G.
To tang. course.	= T	

For the demonstration of this analogy, see Prop. XIII. (29)

* The log. tang. of 51° 38′ 09″ is 10,10151; its ar. co. is 9,89849. (I. 88) The decimal part of this log. tang. answers also to 85° 28′ 37″; and to 89° 32′ 47″; and to 89° 57′ 17″; their indices being 11, 12, 13: So that at either of these angles, the diff of longitude will be shewn by the diff. of the log. tang. of the half co-lats. sailed from and come unto; observing that the number of integer places in G becomes one more, for each unit that the index is increased.

Digitized by Google

PROBLEM I.

52. *Given the latitudes of two places:*
Required the meridional difference of latitude between those places.

CASE I. When both places are on one side of the equator.

RULE I. The difference of the meridional parts answering to each latitude will give the meridional difference of latitude required.

RULE II. The difference of the log. tangents of the half co-latitudes divided by 12,63, will give the meridional difference of latitude required.

EXAM. I. *What is the meridional difference of latitude between the island of St. Thomas and Gibraltar?*

By the meridional parts.				By the log. tangents.
Gibraltar lat.	36°	05′ N.		Co-lat.=53° 55′; ½ co-lat.=26° 57½′
St. Thomas's lat.	00	00		Co-lat.=90 00; ½ co-lat.=45 00
Merid. parts to	36	05	2324	Log. tang. 10,00000 to 45 00
Merid. parts to	00	00	0000	Log. tang. 9,70638 to 26 57½
Merid. diff. lat.	=		2324	12,63) 29362(2325
				4102
				3130
				6040

EXAM. II. *What is the meridional difference of latitude between the Lizard and Cape Verd?*

By the meridional parts.				By the log. tangents.
C. Verd's lat.	14°	47′ N.		Co-lat.=75° 13′; ½ co-lat.=37° 36½′
Lizard's lat.	49	57 N.		Co-lat.=40 03; ½ co-lat.=20 01½
Merid. parts to	49	57	3470	Log. tang. 9,88668 to 37 36½
Merid. parts to	14	47	897	Log. tang. 9,56166 to 20 01½
Merid. diff. lat.	=		2573	12,63) 32502(2573=m.p.

53. CASE II. When the given places are on different sides of the equator.

RULE I. The sum of the meridional parts answering to each latitude will be the meridional difference of latitude required.

RULE II. The sum of the log. co-tangents, abating the index, of the half co-latitudes, divided by 12,63, will be the meridional difference of latitude required.

EXAM *What is the meridional difference of latitude between Cape Verd, and the Island of St. Helena?*

By the meridional parts.				By the log. tangents.
C. Verd's lat.	14°	47′ N.		Co-lat.=75° 13′; ½ co-lat.=37° 36½′
St. Helena	15	55 S.		Co-lat.=74 05; ½ co-lat.=37 02½
Merid. parts to	15	55	968	Log. co-t. 0,11332 to 37 36½
Merid. parts to	14	47	897	Log. co-t. 0,12223 to 37 02½
Merid. diff. lat. to	=		1865	12,63) 23555(1865=m.p.

PRO-

PROBLEM II.

54. *Given the lat. of one place, and the merid. diff. lat. between that and another place:*
Required the latitude of the other place.

CASE I. When the given lat. and mer. diff. lat. have like names.

RULE I. To the merid. parts of the given lat. add the given meridional diff. lat.; seek the sum in the table of meridional parts, and the corresponding degrees and minutes give the latitude sought.

RULE II. Multiply the given merid. diff. lat. by 12,63; subtract the product, rejecting all to the right of the 5th decimal place *, from the log. tang. of the given half-co lat.; seek the degrees to the remainder among the log. tang. and these deg. doubled give the co-lat. required.

EXAM. *A ship from the lat. 14° 43′ N. sails northward till she finds her merid. diff lat. is 2578; what latitude is she come to?*

By meridional parts.	By log. tangent.
To the lat. 14° 43′ N.	The co-lat. is 75° 17′; ½ co-lat. 37° 38′.
The mer. parts = 893 N.	And 2578 multiplied by 12,63, gives 32560, 14.
Add mer. diff. lat. = 2578 N.	From 9,88707 = log. tang. 37° 38′
The sum is = 3471	Take 0,32560
Which answers to 49° 58′ N. The latitude sought.	Leaves 9,56147 = log. tang. 20° 01′.
	Which doubled is 40° 02′.
	Whose comp. is 49 58 = lat. sought.

55. CASE II. When the given lat. and meridional diff. lat. have unlike names.

RULE I. Take the difference between the meridional parts of the given latitude and the meridional diff. lat. the remainder found in the table of meridional parts will give the latitude sought.

RULE II. Multiply the given meridional diff. lat. by 12,63; add the product to the log tan. of the given half co latitude, the degrees answering to the sum, considered as a tangent, being doubled, gives the co-latitude required.

EXAM. *A ship from the latitude 49° 57′ N. sails southward till her meridional diff. lat. is 2578; what latitude is she come to?*

By meridional parts.	By log. tangents.
To the lat. 49° 57′ N.	Co-lat. 40° 03′; ½ co-lat. 20° 01′.
The merid. parts = 3470 N.	And 2578 × 12,63 = 32560,14.
Subt. merid. diff. lat. = 2578 S.	To 9,56146 = log. tang. 20° 01.
Remain merid. parts 892	Add 0,32560
Which answers to 14° 42′ N. The latitude come to.	Sum 9,88706 = log. tang. 37° 01′.
	Which doubled is 75° 16′.
	Whose comp. is 14 44 = lat.

* That is, rejecting all below the number of places in the tables used.

PRO-

PROBLEM III.

56. Given the latitudes and longitudes of two places: Required their bearing and distance.

EXAM. *What is the course and distance from Cape Clear in Ireland, to the island of St. Mary, one of the Azores?*

By MIDDLE LATITUDE SAILING.

C. Clear's lat.	51° 18′ N.	Long.	9° 50′ W.
St. Mary's lat.	37 00 N.	Long.	25 00 W.
Diff. lat.	14 18=858 m.	Diff. long.	15 10=910 m.

Sum of the lat. 88 18; Midd. lat. 44° 09′; Co-mid. lat. 45° 51′.

By CONSTRUCTION. Fig. 9. Plate XIII.

Draw the meridian AD; describe the quadrant A *m p* with the sine of 90°, and the arc EF with the co-sine of the middle latitude. Make the chord *m*B equal to 910, the diff. longitude; draw AB cutting the arc EF in F, and draw the chord EF. Made AD equal to 858, the diff. lat. draw DC parallel to A *p* and equal to EF: and draw AC.

Then AC is the distance, and the angle DAC is the course.

By COMPUTATION.

For the Course.			*For the Distance.*		
D : L :: C : T.		(47)	sin. ∠C : AD :: R : AC.		
As diff. lat.	= 858	7,06651	As co-s. cour.	= 37° 16′	0,09918
To diff. long.	= 910	2,95904	To diff. lat.	= 858	2,93349
So co-s. m. lat.	= 44° 09′	9,85583	So rad.	= 90° 00′	10,00000
To tang. cour.	= 37 16	9,88138	To dist.	= 1078	3,03267

By the TRAVERSE TABLE.

1st. With the co-mid. lat. found among the degrees, and the diff. longitude, or some part of it (if the whole is too large), taken among the distances, find the departure, or some part of it, in its column:

Observing to multiply this depart. by the same number the diff. longitude was divided by.

2d. With the diff. lat. and dep. together, or their like parts, find the course among the degrees, and the distance in its column.

Let the diff. long. 910 be broken into parts; *viz.* into 100 taken nine times, and into 10: And as the co-mid. lat. is 45° 51′, or $45^\circ\frac{5}{6}$; proceed thus:

The departures to 100, in the columns of 45° and 46°, are 70,7 and 71,9; the diff. is 1,2; $\frac{5}{6}$ parts thereof is, 1,0; which added to 70,7 makes 71,7; for the dep. to 100; and for 900 it will be 645,3. Also, the departures to 10 in the columns of 45° and 46°, are 7,07 and 7,19; $\frac{5}{6}$ of their diff. 1,0, and this with 7,07 makes 7,17 the dep. to 10; and the whole dep.=652,5.

Now take $\frac{1}{20}$ of the diff. lat. 858, and of the dep. 65,25, *viz.* 42,9 and 32,62, these will be found together under 37° 15′ for the course; and between

Digitized by Google

between 53 and 54 dist.; suppose 53,9; which taken 20 times gives 1078 for the distance.

57. By MERCATOR's SAILING.

C. Clear long.	9° 50′ W.	Lat.	51° 18′	Mer. parts	3597
St. Mary's long.	25 00 W.	Lat.	37 00	Mer. parts	2393
Diff. long.	15 10	Diff. lat.	14 18	Mer. diff. lat.	1204
Or 910 miles.		Or 858 miles.			

By CONSTRUCTION. Fig. 17. Plate XIII.

Draw the meridian AB, and describe the quadrant A *m p*; make AD =858, the proper diff. lat. and AB=1204, the meridional diff. lat.; draw DC, BE, parallel to A *p*; make BE equal to 910, the diff. long. and draw AE.

Then A is the place of Cape Clear, C that of St. Mary's; AC is the distance, CD the departure, and the angle DAC is the course.

COMPUTATION *by Meridional Parts.*

For the Course.			*For the Distance.*		
M : L :: R : T.		(49)	sin.∠C : AD :: R : AC.		
As mer. d. lat.	= 1204	6,91937	As co-s. cour.	= 37° 05′	0,09813
To diff. long.	= 910	2,95904	To prop. d. lat.	= 858	2,93349
So rad.	= 45° 00′	10,00000	So rad.	= 90° 00′	10,00000
To tan. cour.	= 37 05	9,87841	To dist.	= 1076	3,03162

COMPUTATION *by Logarithmic Tangents.*

C. Clear's lat.	51° 18′	Co-lat.	38° 42′.	½ co-lat.	19° 21′.
St. Mary's lat.	37 00	Co-lat.	53 00.	½ co-lat.	26 30.

To ½ co-lat. 26° 30′, its log. tang.	=	9,69774
To ½ co-lat. 19 21, its log. tang.	=	9,54552
Difference	=	1522,2=G.

For the Course.

G : N :: L : T.		(51)
As G	1522	6,81759
To N		10,10151
So diff. long.	910	2,95904
To tang. cour.	37° 04′	9,87814

For the Distance.

The distance will be the same as in the former computation; for the diff. of a min. in the course will not cause a diff. of a mile in the distance of the two places.

By the TRAVERSE TABLE.

Seek the meridional diff. lat. and diff. long. together, as if they were diff. lat. and departure, and the course is given among the degrees.

Then with the course and proper diff. lat. find the distance.

Thus taking $\frac{1}{20}$th of 1204 and 910, *viz.* 60,2 and 45,5; they will be found together under 37° 00′ for the course.

And taking $\frac{1}{20}$th of the diff. lat. 858, *viz.* 42,9, and the course 37° 0′, gives about 53,8 for the dist. which taken 20 times gives 1076 dist.

PRO-

Digitized by Google

PROBLEM IV.

58. Given the bearing and latitudes of two places.
Required the diftance and difference of longitude.

EXAM. *A fhip which had taken her departure from a place in latitude 37° 00′ N. longitude 22° 56′ W. fteers N. 33° 19′ E.; and cloudy weather coming on, fhe got no obfervation till eight days after, and then found herfelf in latitude 51° 18′ N.: Required her true diftance and prefent longitude.*

By MIDDLE LATITUDE SAILING.

Depart. lat.	37° 00′ N.	Sum of the latitudes	88° 18′
Prefent lat.	51 18 N.	Mid. lat.	44 09
Diff. lat.	14 18=858 m.	Co-mid. lat.	45 51

By CONSTRUCTION. Fig. 10. Plate XIII.

Draw the meridian AD=858, the diff. lat. defcribe the quadrant A *m p*; make *m c* equal to 33° 19′, the courfe: draw DC parallel to A *p* meeting the rhumb AC, drawn through *c*, in *m* C: with the fine of the co-mid. lat. 45° 51′, defcribe the arc EF, in which apply the departure DC, from E to F: draw AB through F, and draw the chord *m* B.

Then is AC the diftance run, and *m* B the diff. longitude.

By COMPUTATION.

For the diftance.

fin.∠C : AD :: R : AC.		
As co-f. cour.	= 33° 19′	0,07798
To diff. lat.	= 858	2,93349
So rad.	= 90° 00′	10,00000
To dift.	= 1027	3,01147

For the diff. longitude.

C : T :: P : L.		(47)
As co-f. m. lat.	= 44° 09′	0,14417
To tang. cour.	= 33 19	9,81776
So diff. lat.	= 858	2,93349
To diff. long.	= 786	2,89542

Now 22° 56′ W. = Dep. long.
60)786(13 06 E. = Diff. long.

9 50 W. = Pref. long.

By the TRAVERSE TABLE.

1ft. With the courfe among the degrees, and the diff. lat. in its proper column, find the departure and diftance, in their columns.

2d. With the co-mid. lat. among the degrees, and the departure in its column, find the diff. long. among the diftances.

Thus taking the $\frac{1}{20}$ of diff. lat. 858, *viz.* 42,9; with it, and the courfe $33\frac{1}{3}$°, the departure will be found 28,1, and the dift. 51,3; each being multiplied by 20, gives 562 for the departure, and 1026 for the diftance.

The co-mid. lat. 45° 51′, or $45\frac{7}{8}$ degrees, and 28,1 = $\frac{1}{20}$ of the departure, will give 39,5 in the column of diftances; which being multiplied by 20, gives 790 for the difference of longitude.

59. By

Digitized by Google

59. By MERCATOR's SAILING.

Departed lat.	37° 00′ N.	Mer. parts	2393
Present lat.	51 18 N.	Mer. parts	3597
Diff. lat.	14 18 = 858 m.	Mer. diff. lat.	1204

CONSTRUCTION, Fig. 18. Plate XIII.

Draw a meridian AB, in which take AB=1204, the mer. diff. lat. and AD=858, the proper diff. lat. Describe the quadrant A *m p*, and take *mc*=33° 19′, the course: through B and D, draw BE, DC, parallel to A *p*, meeting the rhumb drawn through A and *c*, in the points E, C.

Then is AC the distance, and BE the diff. longitude.

COMPUTATION *by Meridional Parts:*

For the distance.			*For the diff. longitude.*		
sin.∠DCA : AB : : R : AC.			R : T : : M : L.		(49)
As co-s. cour.	= 33° 19′	0,07798	As rad.	= 90° 00′	10,00000
To diff. lat.	= 858	2,93349	To tang. cour.	= 33 19	9,81776
So radius	= 90° 00′	10,00000	So m. diff. lat.	= 1204	3,08063
To dist.	= 1027	3,01147	To diff. long.	= 791,4	2,89839

Now if from	22° 56′ W. =	Dep. long.
There be taken 60)791	(13 11 E. =	Diff. long.
Then	9 45 W. =	Pres. long.

COMPUTATION *by Logarithmic Tangents.*

Departed lat.	37° 00′ N.	Co-lat.	53° 00′	½ co-lat.	26° 30′.
Present lat.	51 18 N.	Co-lat.	38 42	½ co-lat.	19 21.

To ½ co-lat. 26° 30′, its log. tang.	=	9,69774
To ½ co-lat. 19 21, its log. tang.	=	9,54552
Difference	=	1522,2=G.

For the distance.	*For the diff. longitude.*		
sin.∠DCA : AB : : R : AC.	N : G : : T : L.		(51)
	As N	=	9,89849
	To G	= 1522	3,18241
The distance is found as above.	So tang. cour.	= 33° 19′	9.81776
	To diff. long.	= 791,8	2,89866

By the TRAVERSE TABLE.

With the course among the degrees, and the diff. lat. found in the column of lat. find the distance in its column.

With the course among the degrees, and the mer. diff. lat. in the column of lat. find the corresponding dep. and take it for the diff. long.

Now $\frac{1}{20}$th of 858, the diff. lat. and of 1204, the mer. diff. lat. are 42,9 and 60,2. Then, under 33° 15′, the diff. lat. 42,9 falls between 51 and 52 in the distances, take it 51,5; which multiplied by 20 gives 1030 for the distance.

And under 33° 15′, the mer. diff. lat. falls against 39,48 of departure, which multiplied by 20 gives 789,6 for the diff. longitude.

PRO-

Digitized by Google

PROBLEM V.

60. Given one latitude, course and distance:
Required the other latitude and diff. longitude.

EXAM. *A ship takes her departure from a place in lat. 51° 18′ N. long. 9° 50′ W.; and steers S. 33° 08′ W. till she has run 1024 miles: Required her present latitude and longitude.*

By MIDDLE LATITUDE SAILING.

By CONSTRUCTION. Fig. 11. Plate XIII.

Draw a meridian AD, and describe the quadrant A *m p*; make the arc *mc* = 30° 08′, the course: in the rhumb drawn through C, take AC = 1024, the distance: draw CD parallel to A *p*, meeting AD in D.

By COMPUTATION.

For the diff. latitude.

R : AC : : sin. ∠C : AD.

As rad.	= 90° 00′	10,00000
To dist.	= 1024	3,01030
So co-s. cour.	= 33° 8′	9,92293
To diff. lat.	= 857,5	2,93323

For the diff. longitude.

As C : T : : P : L.

As co-s. m. lat.	= 44° 09′	0,14417
To tang. cour.	= 33 08	9,81473
So diff. lat.	= 857,5	2,93323
To diff. long.	= 780,1	2,89213

Now	9°	50′ W.	= Dep. long.
60) 780	(13	00 W.	= Diff. long.
	22	50 W.	= Pres. long.

Now	51°	18′ N.	= Dep. lat.
60)857	(14	17 S.	= Diff. lat.
	37	01 N.	= Pres. lat.
	88	19	= Sum of the lats.
	44	09	= Mid. lat.
	45	51	= Co-m. lat.

Then in the arc EF, described with the sin. co-mid. lat. 45° 51′. apply CD from E to F: through F draw AB, cutting the arc *m c p* in B; then, *m* B being drawn, will be the diff. long. sought.

By the TRAVERSE TABLE.

With the course found among the degrees, and the distance in its column, find the dep. and diff. lat.; and hence find the other lat.

Seek the co-mid. lat. among the degrees, and the dep. in its column, then the corresponding dist. is the diff. long. sought.

Thus. Under the course 33° 15′, and against the dist. 51,2, which is the 20th part of 1024, stands lat. 42,7; dep. 28.

Then 42,7 × 20 = 854 m. = 14° 14′, the diff. lat.

Hence the pres. lat. is 37° 04′ N.; and the co-mid. lat. 45° 49′.

Again. Over the degrees 45° 40′, the nearest dep. to 28 stands against 39 in the distances.

Then 39 × 20 = 780 m, the diff. longitude.

61. By

Digitized by Google

By Mercator's Sailing.

61. **Construction.** Fig. 19. Plate XIII.

Draw the meridian AB, describe the quadrant A *m p*; make the arc *m c*=33° 08′, the course. In the rhumb AC drawn through *c*, take AC=1024 miles, the dist.; and draw CD parallel to A *p*.

Computation *by Meridional Parts.*

For the diff. latitude.

As rad. : AC : : sin. ∠C : AD.

As rad.	=	90° 00′	10,00000
To dist.	=	1024	3,01030
So co-s. cour.	=	33° 08′	9,92293
To pro. diff. lat.	=	857,5	2,93323

Now	51° 18′ N.	=	Dep. lat.
60) 857	(14 17 S.	=	Diff. lat.
	37 01 N.	=	Pres. lat.

To 51° 18′ merid. parts	=	3597
To 37 01 merid. parts	=	2394
Merid. diff. lat.	=	1203

For the diff. longitude.

As R : T : : M : L.

As rad.	=	90° 00′	10,00000
To tang. cour.	=	33 08	9,81473
So mer. d. lat.	=	1203	3,08026
To diff. long.	=	785,2	2,89499

Now	9° 50′ W.	=	Dep. long.
60)785	(13 05 W.	=	Diff. long.
	22 55 W.	=	Pres. long.

Make AB=1203; through B draw BE parallel to A *p*, meeting AC continued in E; then BE is the diff. longitude.

Computation *by Logarithmic Tangents.*

The diff. lat. and present lat. being found as above.

Dep. lat.	51° 18′.	Co-lat.	38° 42′.	½ co-lat.	19° 21′.
Pres. lat.	37 01.	Co-lat.	52 59.	½ co-lat.	26 29½.

To ½ co-lat.	26° 29½′, its log. tang.	=	9,69758
To ½ co-lat.	19 21, its log. tang.	=	9,54552
	Difference	=	1520.6=G.

As N : G : : T : L.

As N	=		9,89849
To G	=	1521	3,18213
So tan. cour.	=	33° 08′	9,81473
To diff. long.	=	785,9	2,89535

Now	9° 50′ W.	=	Dep. long.
60)786	(13 06 W.	=	Diff. long.
	22 56 W.	=	Pres. long.

By the Traverse Table.

With the course and distance, find the diff. latitude.

From thence find the present lat. and the mer. diff. latitude.

With the course, and the mer. diff. lat. taken in the column of lat. find the corresponding dep. which will be the diff. longitude.

Thus $\frac{1}{20}$th of the dist. 1024 is 51,2. Then under the course 33° 15′, against 51,2 among the distances, stands 42,7 in col. of lat. And 42,7 × 20 gives 854; so the diff. lat. is 14° 14′; the present lat. is 37° 04′ N. and the mer. diff. lat. is 1200; $\frac{1}{20}$th of which is 60,0.

To the course 33° 15′, against lat. 60,0, or its nearest 60,21, stands 39,48, which multiplied by 20 gives 789,6 for the diff. long. required.

Digitized by Google

PROBLEM VI.

62. Given the latitudes of two places, and their diſtance: Required their bearing, and difference of longitude.

EXAM. *A ſhip in lat. 51° 18′ N. long. 22° 06′ W., is bound to a place in the SE. quarter, diſtant 1024 miles, and in lat. 37° 00′ N.: what is her direct courſe, and how much muſt ſhe alter her long. to arrive at the deſired port?*

By MIDDLE LATITUDE SAILING.

Lat. from 51° 18′ N.	Sum of the latitudes	88° 18′
Lat. to 37 00 N.		
	Middle latitude	44 09
Diff. lat. 14 18 = 858 miles.		
	Co-middle latitude	45 51

By CONSTRUCTION. Fig. 12. Plate XIII.

Draw the meridian AD = 858 miles; deſcribe the quadrant A *m p*: from A, with 1024 miles, the given diſtance, cut DC, drawn parallel to A*p*, in C; draw AC. In the arc EF, deſcribed with the ſine of 45° 51′, the co-middle lat., apply the departure DC from E to F; through F draw AB, and draw the chord B*m*.

Then the courſe is meaſured by the arc *mc*; and the diff. long. by the line *m* B.

By COMPUTATION.

For the courſe.			*For the diff. longitude.*		
AC : rad. : : AD : ſin. ∠C.			C : T : : P : L.		
As diſt.	= 1024	6,98970	As co-ſ. m. lat.	= 44° 09′	0,14417
To rad.	= 90° 00′	10,00000	To tan. cour.	= 33 05	9,81390
So diff. lat.	= 858	2,93349	So diff. lat.	= 858	2,93349
To co-ſ. cour.	= 33° 05′	9,92319	To diff. long.	= 779	2,89156

Courſe SE. b. S. nearly.

Now 22° 06′ W. = Long. from.
60)779(12 59 E. = Diff. long.
9 07 W. = Preſ. long.

By the TRAVERSE TABLE.

With the diſtance and diff. lat. in their columns, find the courſe among the degrees, and the dep. in its column.

With the co-middle lat. among the degrees, and the dep. in its column, find the diff. long. among the diſtances.

Thus. To the diſt. 64 $\left(=\frac{1024}{16}\right)$, and the lat. 53,62 $\left(=\frac{858}{16}\right)$ the courſe is 33° 00′; and the dep. 34,86.

The co-mid. lat. 46° (the neareſt to 45° 51′), the dep. 34,86 (falling between 34,53 and 35,24, belonging to the diſtance 48 and 49), gives 48,5 in the col. of diſtances; which mult. by 16 gives 776 for the diff. long.

Note. $\frac{1}{16}$th of the numbers was taken rather than $\frac{1}{10}$th, becauſe 16 divides 1024 without a fraction; and it is more convenient to ſeek a diſt. in whole numbers, than with a fraction annexed.

63. By

Digitized by Google

63. By MERCATOR'S SAILING.

Lat. from	51° 18′ N.	Mer. parts	=	3597
Lat. to	37 00 N.	Mer. parts	=	2393
Diff. lat.	14 18 = 858 m.	Mer. diff. lat.	=	1204

By CONSTRUCTION. Fig. 20. Plate XIII.

In the meridian AB, take AB = 1204, the meridional diff. lat. and AD = 858, the proper diff. lat.; describe the quadrant A *m p*; from A, with the distance 1024, cut DC, drawn parallel to A*p*, in C; draw AC, and continue it until it meets BE, drawn parallel to A *p* in E.

Then BE = diff. long. and arc *m c* measures the course.

COMPUTATION *by Meridional Parts.*

For the course.

AC : rad. : : AD : s. ∠ACD.

As dist.	= 1024		6,98970
To rad.	= 90° 00′		10,00000
So p. diff. lat.	= 858		2,93349
To co-s. cour.	= 33° 05′		9,92319

Course SE. by S. nearly.

For the diff. longitude.

Rad. : T : : M : L.

As rad.	= 90° 00′	10,00000
To tang. cour.	= 33 05	9,81390
So m. diff. lat.	= 1204	3,08063
To diff. long.	= 784,4	2,89453

Now 22° 06′ W. = Long. from.
60)784(13 04 E. = Diff. long.
9 02 W. = Long. to.

COMPUTATION *by Logarithmic Tangents.*

Depart. lat.	51° 18′.	Co-lat.	38° 42′.	½ co-lat.	19° 21′.
Lat. bound to	37 00.	Co-lat.	53 00.	½ co-lat.	26 30.

To ½ co-lat.	26° 30′,	its log. tang.	=	9,69774
To ½ co-lat.	19 21,	its log. tang.	=	9,54552
		Difference	=	1522,2 = G.

For the course.

AC : rad. : : AD : s. ∠ACD.

Course is S. 33° 05′ E. as above.

For the diff. longitude.

N : G : : T : L.

As N	=	9,89849
To G	= 1522	3,18241
So tan. cour.	= 33° 05′	9,81390
To diff. long.	= 784,9	2,89480

By the TRAVERSE TABLE.

With the distance and diff. lat. in their columns, find the course among the degrees.

With the course among the degrees, and the meridional diff. lat. in the column of latitude, find the diff. long. in the column of departure.

The course, found as before, is 33° 00′.

And $\frac{1}{20}$th of the meridional diff. lat. *viz.* 60,2 found under 33°, in the column of latitude, the nearest corresponding departure is 39,21; which multiplied by 20 gives 784,2 for the diff. longitude.

PROBLEM VII.

64. Given the latitudes of two places, and the departure:
Required the course, distance, and difference of longitude.

EXAM. *A ship from the latitude 37° 00′ N., longitude 48° 20′ W., sails between the N. and E., and being come to the latitude 51° 18′ N., finds she has made 564 miles of departure: what was her direct course, distance run, and present longitude?*

By MIDDLE LATITUDE SAILING.

Present lat.	51° 18′ N.	Sum of the latitudes	88° 18′
Departed lat.	37 00 N.	Mid. lat.	44 09
Diff. lat.	14 18 = 858 m.	Co-mid. lat.	45 51

By CONSTRUCTION. Fig. 13. Plate XIII.

In a meridian line, take AD = 858 m., the diff. lat. Describe the quadrant A *m p*, and parallel to A *p* draw DC = 564 m. the departure; also draw the distance AC; in the arc EF, described with the sine of the co-mid. lat. 45° 51′, apply the chord EF equal to DC; through F draw AB; then the chord *m* B will be the diff. long., and the arc *m c* measures the course.

By COMPUTATION.

To find the course.

AD : DC : : rad. : t. ∠DAC.		
As diff. lat.	= 858	7,06651
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To tang. cour.	= 33 19	9,81779

To find the distance.

Sin. ∠DAC : DC : : rad. : AC.		
As sin. cour.	= 33° 19′	0,26022
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To dist.	= 1027	3,01150

To find the diff. longitude.

C : R : : D : L.		
As co-s. m. lat.	= 44° 09′	0,14417
To rad.	= 90 00	10,00000
So depart.	= 564	2,75128
To diff. long.	= 786	2,89545

Or C : T : : P : L.

Now 48° 20′ W.	=	Dep. long.
60)785(13 06 E.	=	Diff. long.
35 14 W.	=	Pres. long.

Course NE. b. N. nearly.

By the TRAVERSE TABLE.

The diff. lat. and departure being found together, will give the course among the degrees, and the distance in its column.

With the co-mid. lat. among the degrees, and the departure in its column, find the diff. longitude among the distances.

Now $\frac{1}{20}$th of 858, the diff. lat., and of 564, the dep., are 42,9 and 28,2. The nearest numbers to these are found together under the course 33° 30′, and to the distance 51,2; which, multiplied by 20, gives 1024.

Also the departure 28,2 being found to the co-mid. latitude 46°, gives 39,2; which multiplied by 20 gives 784 for the diff. longitude.

65. By

Digitized by Google

65. By MERCATOR'S SAILING.

Present lat.	51° 18′ N.	Mer. parts	3597
Departed lat.	37 00 N.	Mer. parts	2393
Diff. lat.	14 18=858 m.	Mer. diff. lat.	1204

By CONSTRUCTION. Fig. 21. Plate XIII.

In a meridian line take AB=1204 m., the meridional diff. lat.; and AD=858 m., the prop. diff. lat. Describe the quadrant A *m p*; through D draw DC parallel to A *p*, and make DC=564 m., the dep. Through C, draw AE meeting BE, drawn parallel to A *p*.

Then is AC the distance, BE the diff. longitude; and the arc *m c* measures the course.

COMPUTATION *by Meridional Parts*.

For the course. AD : DC : : rad. : t. ∠DAC.

As diff. lat.	= 858	7,06651
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To tang. cour.	= 33 19	9,81779

For the distance. Sin. ∠DAC : DC : : rad. : AC.

As sin. cour.	= 33° 19′	0,26022
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To dist.	= 1027	3,01150

For the diff. long. P : D : : M : L.

As prop. diff. lat.	= 858	7,06651
To depart.	= 564	2,75128
So mer. diff. lat.	= 1204	3,08063
To diff. long.	= 791,5	2,89842

Or R : T : : M : L.

Now 48° 20′ W.	= Dep. long.
60)791(13 11 E.	= Diff. long.
35 09 W. =	Pres. long.

Course NE. b. N. nearly.

COMPUTATION *by Logarithmic Tangents*.

Departed lat.	37° 00′ N.	Co-lat.	53° 00′.	½ co-lat.	26° 30′.
Present lat.	51 18 N.	Co-lat.	38 42.	½ co-lat.	19 21.

To ½ co-lat. 26° 30′, its log. tang.	=	9,69774
To ½ co-lat. 19 21, its log. tang.	=	9,54552
Difference	=	1522,2 = G.

The course and distance are found as above.

For the diff. longitude. N : G : : T : L.

As N	=	9,89849
To G.	= 1522	3,18241
So tang. cour.	= 33° 19′	9,81776
To diff. long.	= 791,9	2,89866

By the TRAVERSE TABLE.

The course, found as before, is 33° 30′; under which, against 60,2 (=$\frac{1}{20}$th of the mer. diff. lat.) in the column of latitude, stands 39,74 in the column of departure. Then 39,74 × 20=794,8, the diff. longitude.

PROBLEM VIII.

66. Given one latitude, the course, and departure: Required the other latitude, distance, and diff. longitude.

EXAM. *A ship from the latitude 51° 18′ N., longitude 9° 50′ W., sails S. 33° 19′ W., until her departure is 564 miles; required her present latitude, longitude, and distance.*

By MIDDLE LATITUDE SAILING.

CONSTRUCTION. Fig. 14. Plate XIII.

Draw a meridian line AD; describe the quadrant A *m p*; make A*a*= 564, the departure, and the arc *m c*=33° 19′, the course; through *c* draw the rhumb AC meeting *a* C, drawn parallel to AD, in C; and draw CD parallel to A*p*.

By COMPUTATION.

For the diff. latitude.		
Sin.∠DAC : CD : : sin. ∠ACD : AD.		
As sin. cour.	= 33° 19′	0,26022
To depart.	= 564	2,75128
So cos. cour.	= 33° 19′	9,92202
To diff. lat.	= 858	2,93352

Now	51° 18′ N.	= Dep. lat.
60)858(	14 18 S.	= Diff. lat.
	37 00 N.	= Present lat.
	88 18	= Sum of the lat.
	44 09	= Middle lat.
	45 51	= Co-m. lat.

Then in the arc EF, described with the sine of 45° 51′, apply CD from E to F; through F draw AB; and draw the diff. longitude B *m*.

To find the distance.		
Sin.∠DAC : CD : : rad. : AC.		
As sin. course	= 33° 19′	0,26022
To departure	= 564	2,75128
So rad.	= 90° 00′	10,00000
To distance	= 1027	3,01150

To find the diff. longitude.		
As C : rad. : : D : L.		
As cos. mid. lat.	= 44° 09′	0,14417
To rad.	= 90 00	10,00000
So departure	= 564	2,75128
To diff. long.	= 786	2,89545

Now	9° 50′ W.	= Dep. long.
60)786(	13 06 W.	= Diff. long.
	22 56 W.	= Present long.

By the TRAVERSE TABLE.

With the course 33° 15′ (the nearest to 33° 19′) and the departure 28,2 (=$\frac{1}{20}$th of 564) in its column, find the diff. of lat. (42,53) in the column of latitude, and in the column of distance find the distance 51,2.

Then 42,53×20=850,6; and 51,2×20=1024.

Hence the present lat. is 37° 07′ N., and the co-mid. lat. 45° 48′.

The co-mid. lat. 45° 40′ and departure 28,2 gives 30,2 in the column of distances, which multiplied by 20 gives 784, for the diff. of longitude.

67. By

67. By MERCATOR'S SAILING.

By CONSTRUCTION. Fig. 22. Plate XIII.

Draw a meridian line AB; describe the quadrant A *m p*; make A *a* =564, and the arc *m c*=33° 19′; draw *a c* parallel to AB meeting the rhumb AC, drawn through *c*, in C; and draw the departure CD parallel to A *p*.

COMPUTATION *by Meridional Parts.*

For the diff. latitude.			Now 51° 18′N.	=	Dep. lat.
Sin ∠DAC : CD :: sin. ∠DCA : AD.			60)858(14 18 S.	=	Diff. lat.
As sin. cour.	= 33° 19′	0,26022	37 00 N.	=	Pres. lat.
To depart.	= 564	2,75128	To 51° 18′ merid. parts	=	3598
So co-s. cour.	= 33° 19′	9,92202	To 37 00 merid. parts	=	2394
To diff. lat.	= 858	2,93352	Merid. diff. lat.	=	1204

Then make AB=1204; draw BE parallel to A *p*, meeting AC continued, in E; and BE is the diff. of longitude.

To find the distance.			*To find the diff. longitude.*		
As sin. ∠DAC : DC :: rad. : AC.			P : D :: M : L.		
As sin. cour.	= 33° 19′	0,26022	As p. diff. lat.	= 858	7,06651
To depart.	= 564	2,75128	To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000	So mer. diff. lat.	= 1204	3,08063
To distance	= 1027	3,01150	To diff. long.	= 791,4	2,89842

Now 9° 50′ W. = Dep. long.
60)791(13 11 W. = Diff. long.

23 01 W. = Pres. long.

COMPUTATION *by Logarithmic Tangents.*

Find the diff. latitude and present latitude as above.

Then,	Dep. lat. 51° 18′.	Co-lat. 38° 42′.	½ co-lat. 19° 21′.
	Pres. lat. 37 00.	Co-lat. 53 00.	½ co-lat. 26 30.

To ½ co-lat. 26° 30′, its log. tang. is = 9,69774
To ½ co-lat. 19 21, its log. tang. is = 9,54552

Difference = 1522,2 = G.

To find the diff. longitude.			N : G :: T : L.
As N	=	9,89849	
To G	= 1522	3,18241	The distance and present longitude may be found as above.
So tang. cour.	= 33° 19′	9,81776	
To diff. long.	= 791,8	2,89866	

By the TRAVERSE TABLE.

Find, as before, the diff. lat.=851; and the distance=1024.

Then the present lat. is 37° 07′N.; and the mer. diff. lat. is 1197, $\frac{1}{20}$th of which is 59,85.

Now under the course 33° 15′, and against 60,21, the nearest to 59,85 in the column of latitude, stands in the column of dep. 39,48; which, multiplied by 20, gives 789,6 for the diff. longitude.

 PROBLEM

PROBLEM IX.

68. Given one latitude, the diſtance, and departure: Required the other latitude, courſe, and diff. longitude.

EXAM. *A ſhip from the latitude 37° 00′ N., longitude 9° 02′ W., having ſailed between the N. and W. 1027 miles, reckons ſhe has made 564 miles of departure; what was her direct courſe, and the preſent latitude and longitude?*

By MIDDLE LATITUDE SAILING.

By CONSTRUCTION. Fig. 15. Plate XIII.

Draw the meridian line AD; deſcribe the quadrant A *m p*; make A *a* = 564 m.; from A, with 1027, the diſtance, cut *a* C, drawn parallel to AD, in C; draw AC, and draw the departure CD parallel to A *p*.

By COMPUTATION.

To find the courſe. AC : rad. : : CD : ſin. ∠DAC.			*To find the diff. latitude.* Rad. : AC : : ſin. ∠DCA : AD.		
As diſt.	= 1027	6,98843	As rad.	= 90° 00′	10,00000
To rad.	= 90° 00′	10,00000	To diſt.	= 1027	3,01157
So depart.	= 564	2,75128	So co-ſ. cour.	= 33° 19′	9.92202
To ſin. cour.	= 33° 19′	9.73971	To diff. lat.	= 858,2	2,93359

Now 37° 00′ N. = Dep. lat.
60)858(14 18 N. = Diff. lat.

51 18 N. = Preſ. lat.

Sum of the latitudes 88° 18′

Mid. lat. 44 09

Co-mid. lat. 45 51

Then deſcribe the arc EF with the ſine of 45° 51′, and therein apply CD from E to F; through F draw AB; and draw the diff. long. B *m*.

To find the diff. longitude.			C : T : : P : L.		
As coſ. m. lat.	= 44° 09′	0,14417	Now 9° 02′ W.	=	Dep long.
To tang. cour.	= 33 19	9,81776	60)786(13 06 W.	=	Diff. long.
So diff. lat.	= 858,2	2,93359			
			22 08 W.	=	Preſ. long.
To diff. long.	= 786,2	2,89552	Courſe is NW. b. N. nearly.		

By the TRAVERSE TABLE.

Now 1/20th of the diſtance is 51,35, and of the departure 28,2.

Find under what courſe, among the degrees, 28,2 ſtands in the departure column againſt 51,35 in the column of diſtances; which will be under 33° 30′ and againſt 42,8 in the diff. of lat. column.

Then 42,8 × 20 = 856: hence the preſent latitude is 51° 16′ N.; and the co-middle latitude is 45° 52′.

With the neareſt co-middle latitude (46°) and the departure 28,2 find 39,2, the diff. longitude, among the diſtances.

Then 39,2 × 20 = 784, for the diff. longitude.

69. By

Digitized by Google

69. By MERCATOR's SAILING.

By CONSTRUCTION. Fig. 23. Plate XIII.

Drawn a meridian AB; describe a quadrant A m p; make A a=564; draw a C parallel to AB; from A with 1027, the distance, cut a C in C; draw the departure CD parallel to A p, and draw the distance AC.

COMPUTATION by Meridional Parts.

To find the course.

AC : rad. : : CD : sin. ∠DAC.

As dist.	= 1027		6,98843
To rad.	= 90° 00′		10,00000
So depart.	= 564		2,75128
To sin. cour.	= 33° 19′		9,73971

To find the diff. latitude.

Rad. : AC : : sin. ∠DCA : AD.

As Rad.	= 90° 00′		10,00000
To dist.	= 1027		3,01157
So cos. cour.	= 33° 16′		9,92202
To diff. lat.	= 858,2		2,93359

Now 37° 00′N.	=	Dep. lat
60)858(14 18 N.	=	Diff. lat
51 18 N.	=	Pres. lat

To 51° 18′, the mer. parts = 3598
To 37 00, the mer. parts = 2394

Mer. diff. lat. = 1204

Then make AB=1204; continue AC till it meets BE, drawn parallel to A p; and BE is the diff. longitude.

To find the diff. longitude.

As rad.	= 90° 00′		10,00000
To tang. cour.	= 33 19		9,81776
So m. diff. lat.	= 1204		3,08063
To diff. long.	= 791,4		2,89839

Rad. : T : : M : L.

Now 9° 02′ W.	=	Long. from.
60)791(13 11 W.	=	Diff. long.
22 13 W.	=	Pres. long.

Course NW. b. N. nearly.

COMPUTATION by Logarithmic Tangents.

Find the course and present latitude as above.

Then, Dep. lat.	37° 00′N.	Co lat.	53° 00′.	½ co-lat.	26° 30′.
Pres. lat.	51 18 N.	Co-lat.	38 42.	½ co-lat.	19 21.

To ½ co-lat. 26° 30′, its log. tang.	=	9,69774
To ½ co-lat. 19 21, its log. tang.	=	9.54552
Difference	=	1522,2=G.

To find the diff. longitude.

N : G : : T : L.

As N	=	9,89849
To G	= 1522	3,18241
So tang. cour.	= 33° 19′	9,81776
To diff. long.	= 791,8	2,89866

The present longitude may be found as above.

By the TRAVERSE TABLE.

Find, as before, by proportioning for the parts, the diff. lat.=856, and the course N. 33° 30′W.

Hence the present lat. is 51° 16′N.; and the mer. diff. lat.=1200, $\frac{1}{20}$th of which is 60.

Then in the column of latitudes, under 33° 30′, find 60,04, the nearest to 60; against which, in the departure, stands 39,74; which, multiplied by 20, gives 794,8 for the diff. of longitude.

70. PROBLEM X.

Given one latitude, departure, and diff. longitude:
Required the other latitude, course, and distance.

EXAM. *A ship from the latitude 51° 18′ N., longitude 22° 06′ W., having sailed between the S. and E. for several days, reckons she has made 564 miles of departure, and 786 miles of longitude: what is the lat. and long. of the place arrived at, and also her direct course and distance?*

This Problem cannot be resolved by Mercator's sailing.

By MIDDLE LATITUDE SAILING.

By CONSTRUCTION. Fig. 16. Plate XIII.

Draw a meridian AD; describe the quadrant A *m* *p*; in the arc *m* *p* apply the chord *m* B=786, the diff. long.; draw AB; make *m* *a*=564; draw *a* F parallel to A *m*, and with the radius AF describe the arc FE, and draw the chord EF.

Then is EF the departure, and AE the sine of the co-mid. lat.

By COMPUTATION.

To find the co-mid. latitude.

L : D :: rad. : C.

As diff. long.	= 786	7,10458
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To co-s. m. lat.	= 44° 09′	9,85586

Now Co-mid. lat.	= 45° 51′
Middle lat.	44 09
Sum of the lats.	88 18
Depart. lat.	51 18
Pres. lat.	37 00
Diff. lat.	14 18=858 m.

Make AD=858; draw DC parallel to A *p*, and equal to EF; then AC being drawn, will be the distance; and ∠DAC the course.

To find the course.

P : L :: C : T.

As diff. lat.	= 858	7,06651
To diff. long.	= 786	2,89542
So co-s. m. lat.	= 45° 51′	9,85583
To tang. cour.	= 33 19	9,81776

Now 22° 06′ W. = Dep. long.
60)786(13 06 E. = Diff. long.
9 00 W. = Pres. long.

To find the distance.

Sin. ∠DAC : DC :: rad. : AC.

As sin. cour.	= 33° 19′	0,26022
To depart.	= 564	2,75128
So rad.	= 90° 00′	10,00000
To dist.	= 1027	3,01150

The course is SE. b. S. nearly.
Distance 1027 miles.
Present lat. 37° 00′ N.

By the TRAVERSE TABLE.

Now $\frac{1}{20}$th of the diff. long. and dep. are 39,3 and 28,2.

Seek in the table, until the given depart. 28,2 is found in its column against the given diff. long. 39,3 in the column of distance; and it gives the co-mid. lat. among the degrees at the top or bottom of the table.

Here 28,2 falls between 28,27 (over 46°) and 28,11 (over 45° 40′) the depart. answering to the dist. 39,3; therefore, taking the co-mid. lat. =45° 50′, the present lat. is 37° 02′ N.; the diff. lat. is 856; and its $\frac{1}{20}$th is 42,8.

Then 42,8 and 28,2 will be found together under 33° 30′, the course, and between 51 and 52 in the distances; suppose 51,2, which, multiplied by 20, gives 1024 for the distance.

PROBLEM

Digitized by Google

PROBLEM XI.

71. Given one latitude, course, and difference of longitude:
Required the other latitude and distance.

EXAM. *A ship from the lat. 37° 00′ N., longitude 22° 56′ W., runs on a course N., 33° 19′ E., until she finds her difference of longitude is 786 miles: what is her present latitude and distance sailed?*

This problem cannot be resolved by middle latitude sailing.

By MERCATOR'S SAILING.

By CONSTRUCTION. Fig. 24. Plate XIII.

Draw the meridian AB; describe the quadrant A *m p*; continue A *p* till A *a*=786 miles, the diff. longitude, and draw AE parallel to AB. Make the arc *m c*=33° 19′; draw the rhumb A *c* till it meets AE in E, and draw EB parallel to A *p*.

COMPUTATION *by Meridional Parts.*

To find the mer. diff. latitude.			
T : R : : L : M.			Dep. lat. 37° 00′N. Mer. pts. 2393
As tang. cour.	= 33° 19′	0,18224	Mer. d. lat. 1196
To rad.	= 90 00	10,00000	
So diff. long.	= 786	2,89542	Pres. lat. 51 12½N. M. pts. 3589
To m. diff. lat.	= 1196	3,07766	Diff. lat. 14 12½=852½ miles.

Make AD=852½; draw DC parallel to A *p*; then AC is the distance.

To find the distance	Sin. ∠DCA	: AD : : rad. : AC.
As cos. cour.	= 33° 19′	0,07798
To diff. lat.	= 852,5	2,93069
So rad.	= 90° 00′	10,00000
To distance	= 1020	3,00867

COMPUTATION *by Logarithmic Tangents.*

To find the present latitude.			
T : L : : N : G.			Dep. lat. 37° 00′. Co-lat. 53° 00′.
			½co-lat. 26 30. L. tang. 9,69774
As tang. cour.	= 33° 19′	0,18224	G = 1511
To diff. long.	= 786	2,89542	
So N	=	10,10151	½co-lat. 19 24. L. tang. 9,54664
To G	= 1511	3,17917	Co-lat. 38 48

Therefore the pres. lat. is 51° 12′ N.

By the TRAVERSE TABLE.

Seek the diff. long. in the column of departure to the given course, and it gives in the column of latitude the meridional diff. lat.

Thus under 33° 15′, against 39,3 (=1/20th of 786) in the departure stands 59,38; or by proportioning 59,96, which, multiplied by 20, gives 1199 for the mer. diff. lat. Hence the present lat. is 51° 14′ N.; and the diff. lat. 854; its 1/20th is 42,7.

Then under 33° 15′, in the col. of lat. 42,7 stands against 51 in the col. of distances; which multiplied by 20, gives 1020 for the distance.

PROBLEM

PROBLEM XII.

72. Given the courſe, departure, and difference of longitude:
Required the latitudes, departed from and arrived at.

EXAM. *From a place in north latitude, a ſhip ſails S. 33° 15′ E. until ſhe has made 564 miles of departure, and 786 miles of difference of longitude: what were the latitudes ſailed from and arrived in?*

SOLUTION.

As the ſine of the courſe is to the departure
So is the co-ſine of the courſe to the difference of the latitude = 860
And as the diff. longitude is to the departure
So is the radius to the co-ſine of the middle latitude = 44, 09.

Now $\frac{860}{60} = 14° 20′$ the diff. lat. the half is 7° 10′.

Then 44° 09′ + 7° 10′ = 51° 19′, the latitude ſailed from;
And 44 09 — 7 10 = 36 59, the latitude arrived in.

Hence any two of theſe four particulars being given, viz.
Courſe, diſtance, departure, difference of latitude,
together with the difference of longitude:
The two latitudes may thence be found.

PROBLEM XIII.

73. Given one latitude, diſtance, and difference of longitude:
Required the courſe, and the preſent latitude.

SOLUTION.

1. Find the meridional diſtance (37) to uſe as a firſt departure.
When the courſe is toward the equator, augment this mer. diſt. for a ſecond departure; if toward the pole, diminiſh it for a ſecond departure. Let the 1ſt dep. be altered about a 5th or 6th of itſelf for a ſecond departure.
2. With the given diſtance and theſe departures, taken ſeparately in order; Find the reſpective courſes, and differences of latitudes. (VII. 32)
And hence, the preſent latitudes and mer. differences of lat. (52)
3. To each courſe and reſpective mer. diff. lat. find a diff. long. (48)
4. Between each of theſe differences of longitude, taken in order, and that given, take the two differences; which call the 1ſt and 2d errors.
Take the product of the 1ſt departure by the 2d error, and the product of the 2d departure by the firſt error.

5. If

5. If the two differences of longitude found by the 3d art. were both too great, or both too small; let the difference of the said two products be divided by the difference of the errors, and the quotient may be taken for the true departure.
   But if the two differences found were one too great, and one too small; let the sum of the said products be divided by the sum of the said errors, and the quotient may be taken for the true departure.
6. With the true dep. and dist. find the true course and diff. latitude. (VII. 32)

Exam. *A ship from the latitude of 37° N., having sailed for some days on a direct course in the NW. quarter, finds that she has run 1027 miles, and has made 790 miles of difference of longitude: on what course did she steer, and what latitude has she come to?*

With radius and the diff. long. 790, find a mer. dist. (631) which being diminished by about its $\frac{1}{6}$th, or by 100, gives 531.

Then 631 and 531 may be taken for the 1st and 2d departures.

The distance 1027, and these departures, give the courses 37° 45′ and 31°, and also the differences of latitude 814 and 883; or 13° 34′ and 14° 43′.

Hence the supposed latitudes are 50° 34′ and 51° 43′; and the meridional differences of latitude will be 1135 and 1245.

With 1135 and 1245, taken with the courses 37° 45′ and 31°, the differences of long. are 879 and 748.

And 879—790=89, the 1st error, too great:

Also 790—748=42, the 2d error, too small.

The sum of these errors is 131, the divisor.

Now 631 × 42=26502; and 531 × 89=47259; the sum of these products is 73761.

Then 73761 ÷ 131 gives 563 for the true departure.

With the dist. 1027 and dep. 563, the course is N. 33° 15′ W.

The diff. lat. is 860 m.=14° 20′ N.

And the present latitude is 51° 20′ N.

SECTION

SECTION V.

Of compound Courses corrected by Longitude.

How to solve compound courses or traverses, on the principles of plane sailing, has been already shewn; but it is necessary also to shew how the proper allowances for longitude are to be introduced into such accounts; which is easily done by any of the following methods.

74. RULE I.

1st. Complete the traverse table to each course and distance, and find the whole diff. latitude, departure, and present latitude. (VII. 36)

2d. With the diff. latitude and departure find the direct course and distance. (VII. 33)

3d. If you work by middle latitude, with the departed latitude and present latitude find the co-mid. lat.; with which, and the departure, find the difference of longitude. (64)

Or 4th. If by Mercator, with the departed latitude and present latitude find the meridional difference of latitude; with which, and the direct course, find the difference of longitude. (59)

75. RULE II. *By Middle Latitude.*

1st. To the traverse table (completed as above) annex seven other cols.; intitle them dep. lats., pres. lats., sum. lats., mid. lats., co-mid. lats., diff. longit.
E. | W.

2d. By the several differences of latitude found in the traverse table, fill up the first and second columns; and hence the corresponding sum. lats., mid. lats., and co-mid. lats., will be obtained.

3d. With each co-mid. lat., and corresponding departure, find the diff. of longitude to each course (64), and set them in the columns marked E. W., according to the name of the departure used.

4th. Add up both the east and west columns of longitude, and the difference of their sums will be the whole difference of longitude.

76. RULE III. *By Mercator.*

1st. To the traverse table (completed as above) annex five other columns: intitle them successive latitudes, meridional parts, mer. diff. lat., diff. long.
E. | W.

2d. By the several differences of latitude, found in the traverse table, fill up the column of successive latitudes; set their meridional parts in its column; and the meridional differences in its column.

3d. To each course, and its corresponding meridional diff. lat., find (59) the diff. longitude; which set in its proper column.

4th. The difference of the sums of the east and west columns of longitude will be the whole difference of longitude.

The first of these rules is most commonly practised at sea; but either of the latter gives the result more accurately.

The operations, by these rules, may be all performed by the traverse table at the end of Book VII.

77. EXAM-

Digitized by Google

77. Example I. *Yesterday noon we were in latitude 38° 14′ N., longitude 25° 56′ W., and have since run the following courses and distances.*
1st. NE. b. N. ¾ E. 56 m.; 2d. NNW. 38 m.; 3d. NW. b. W. 46 m.; 4th. SSE. 30 m. 5th. S. b. W. 20 m.; 6th. NE. b. N. 60 m.
Required the ship's place with her direct course and distance.

By the First Rule.

The Traverse Table.

Courses.	D.	N.	S.	E.	W.
NE. b. N. ¾ E.	56	45,0		33,4	
NNW.	38	35,1			14,5
NW. b. W.	46	25,6			38,2
SSE.	30		27,7	11,5	
S. b. W.	20		19,6		3,9
NE. b. N.	60	50,0		33,3	
		155,7	47,3	78,2	56,6
Diff. lat.		108,4	Dep.	21,6	

Hence (VII. 33) the course is N. b. E., distance 111 miles.

By Middle Latitude.

Dep. lat. = 38° 14′ N.	Mid. lat.	= 39° 8′	
Diff. lat. = 1 48 N.	Co-mid. lat.	= 50 52	
Present lat. = 40 2 N.	Dep. long.	= 25 56 W.	
Sum. lats. = 78 16	Diff. long.	= 0 28 E.	(64)
	Long. from	= 25 56 W.	
	Present long.	= 25 28 W.	

By Mercator.

Dep. lat. 38° 14′ N. M. pts. = 2486,1	Depart. long.	= 25 56 W.	
Pref. lat. 49 2 N. M. pts. = 2625,3	Diff. long.	= 0 28 E.	(59)
Mer. diff. lat. = 139,2	Present long.	= 25 28 W.	

Explanation.

The diff. lat. 108,4 and the dep. 21,6 being sought for, standing together in the traverse table (VII. 67) will be found under one point, or 11° 15′ for the course, and against 111 miles for the distance.

The co-mid. lat. 50° 52′, or its nearest 50° 45′, being found in the traverse table (VII. 67), and the departure 21,6 in the dep. column; then right against it in the col. of dist. stands 28 for the diff. long.

The course 11° 15′ being found among the deg. at top in the traverse table (VII. 67), and the mer. diff. lat. 139,2 (or its ½, viz. 69,6) found in the col. of lat., gives a corresponding dep. 28, (=13,85 × 2) for the difference of longitude.

By

By the SECOND RULE.

Traverse Table.						Longitude Table.						
Courses.	D.	N.	S.	E.	W.	Dep. lats.	Pres. lats.	Sum. lats.	Mid. lats.	C. M. lats.	Diff. l. E.	W.
NE.b.N.¼E.	56	45,0		33,4		38° 14′	38° 59′	77° 13′	38° 36′	51° 24′	43	
NNW.	38	35,1			14,5	38 59	39 34	78 33	39 16	50 44		19
NW. b. W.	46	25,6			38,2	39 34	40 0	79 34	39 47	50 13		50
SSE.	30		27,7	11,5		40 0	39 32	79 32	39 46	50 14	15	
S. b. W.	20		19,6		3,9	39 32	39 12	78 44	39 22	50 38		5
NE. b. N.	60	50,0		33,3		39 12	40 2	79 14	39 37	50 23	43	
		155,7	47,3	78,2	56,6						101	74
Diff. lat. =		108,4	Dep.	21,6						Diff. longitude. =	27	

EXPLANATION.

Dep. lat. 38° 14′N., and diff. lat. 45′N., gives pref. lat. 38° 59′N.
Dep. lat. 38 59 N., and diff. lat. 35 N., gives pref. lat. 39 34 N.
Dep. lat. 39 24 N., and diff. lat. 26 N., gives pref. lat. 40 0 N.
Dep. lat. 40 0 N., and diff. lat. 28 S., gives pref. lat. 39 32 N.
And so on, to make the first two columns in the longitude table.
The sum of each opposite two gives the sum of lats. in 3d column.
From these arise the columns of mid. lat. and co-mid. lat.

Then (by art. 64) with each co-mid. lat., and corresponding departure, the column of longitude is filled up; and the sums of the columns of longitude being taken, their diff. will be the whole diff. of longitude.

By the THIRD RULE.

Traverse Table.						Longitude Table.				
Courses.	D.	Diff. lat. N.	S.	Depart. E.	W.	Success. latits.	Mer. parts.	M. Diff. lat.	Diff. long. .	W.
						38° 14′	2486,1			
NE.b.N.¼E.	56	45,0		33,4		38 59	2543,7	57,6	43,8	
NNW.	38	35,1			14,5	39 34	2588,9	45,2		18,7
NW. b. W.	46	25,6			38,2	40 0	2622,7	33,8		50,5
SSE.	30		27,7	11,5		39 32	2586,3	36,4	15,0	
S. b. W.	20		19,6		3,9	39 12	2560,4	25,9		5,1
NE. b. N.	60	50,0		33,3		40 2	2625,3	65,9	43,3	
		155,7	47,3	78,2	56,6				102,1	74,3
Diff. lat. =		108,4	Dep.	21,6			Diff. longit. =		27,8	

EXPLANATION.

The column of successive lats. is filled up from the differences of lat. found in the traverse table: to these lats. the meridional parts and the differences are to be found: then by the courses and meridional diff. of latitudes, the diff. of longitudes are found, as shewn in art. 59 of this book. The diff. of long. made good, found by all the methods, is nearly the same.

78. Ex-

78. EXAMPLE II. *Suppose a ship from the latitude 52° 20′ N., and longitude 14° 38′ W., has sailed the following courses, viz.*
1st. ESE. 43m. 2d. SW. 32m. 3d. SE. b. S. 58 m.
4th. SSW. 60m.
Required her present latitude and longitude, also her direct course and distance.

By the FIRST RULE.

The TRAVERSE TABLE.

Courses.	D.	N.	S.	E.	W.
ESE.	43		16,5	39,7	
SW.	32		22,6		22,6
SE. b. S.	58		48,2	32,2	
SSW.	60		55,4		23,0
Diff. lat. =			142,7	71,9	45,6
Departure =				26,3	

Hence (VII. 33) the course is S. 10° 30′ E. distance 146 miles.

To find the difference of Longitude.

By MIDDLE LATITUDE.

Dep. lat.	= 52° 20′ N.	Mid. lat.	= 51° 8′
Diff. lat.	= 2 23 S.	Co-mid. lat.	= 38 52
Present lat.	= 49 57 N.	Dep. long.	= 14 38 W.
		Diff. long.	= 0 42 E. (64)
Sum. lats.	= 102 17		
		Present long.	= 13 56 W. (VI. 53)

By MERCATOR.

Dep. lat. 52° 20′ N. Mer. parts	3698	Depart. long.	= 14 38 W.
Pres. lat. 49 57 N. Mer. parts	3470	Diff. long.	= 0 42 E. (59)
Mer. diff. lat.	228	Present long.	= 13 56 W. (VI. 53)

EXPLANATION.

The halves of the diff. lat. and dep., *viz.* 71, 35, and 13,15, being sought for, standing together, in the traverse table (VII. 67), their nearest numbers, *viz.* 71,73 and 13,30, stand under 10° 30′ for the course; and against 73 in the column of dist.; which doubled, as the table was entered with halves, gives 146 for the direct distance made good.

The co-mid. lat. 38° 52′, or its nearest 38° 45′, being sought in the traverse table (VII. 67); then in the column signed Dep. the number nearest to 26,3 (the dep. by this question) stands against 42 in the col. of dist.; which is to be taken for the difference of longitude.

Or thus, Seek under the direct course 10° 30′, and in the column signed Lat. for the nearest number to the mer. diff. lat. (=228, or to some part thereof, *viz.* its ¼=) 57; then the corresponding departure is 10,57; which, taken four times, gives 42,28 for the difference of longitude.

By the Second Rule.

Traverse Table.						Longitude Table.						
Courses.	D.	N.	S.	E.	W.	Dep. lats.	Pref. lats.	Sum lats.	Mid. lats.	Co-m. lats.	D. lon. E.	D. lon. W.
ESE.	43		16,5	39,7		52° 20′	52° 04′	104° 24′	52° 12′	37° 48′	65	
SW.	32		22,6		22,6	52 04	51 41	103 45	51 52	38 08		37
SE. b. S.	58		48,2	32,2		51 41	50 53	102 34	51 17	38 43	51	
SSW.	60		55,4		23,0	50 53	49 58	100 51	50 26	39 34		36
Diff. lat. =			142,7	71,9	45,6						116	73
Depart. =				26,3						Diff. lon. =	43	

Explanation.

Dep. lat. 52° 20′ N., and diff. lat. 16 S., give pref. lat. 52° 04′ N.
Dep. lat. 52 04 N., and diff. lat. 23 S., give pref. lat. 51 41 N.
Dep. lat. 51 41 N., and diff. lat. 48 S., give pref. lat. 50 53 N.
Dep. lat. 50 53 N., and diff. lat. 55 S., give pref. lat. 49 58 N.
Which completes the first two columns of the longitude table.
The sums of the opposite dep. lat. and pref. lat. make the 3d column.
The halves of these sums make the mid. lats. in the 4th column.
And their complements make the 5th column.

Then with these co-mid. lats. and their corresponding departures, the differences of longitude being found (64), and set in their proper columns; the difference of the sums of the columns of longitude gives the whole difference of longitude.

By the Third Rule.

Traverse Table.						Longitude Table.				
Courses.	D.	N.	S.	E.	W.	Success. lats.	Merid. parts.	Mid. lat.	Diff. long. E.	Diff. long. W.
						52° 20′	3697,8			
ESE.	43		16,5	39,7		52 04	3671,7	26,1	62,8	
SW.	32		22,6		22,6	51 41	3634,4	37,3		37,3
SE b. S.	58		48,2	32,2		50 53	3557,7	76,7	51,2	
SSW.	60		55,4		23,0	49 58	3471,4	86,3		35,7
Diff. lat. =			142,7	71,9	45,6				114,0	73,0
Depart. =				26,3				Diff. long. =	41,0	

Explanation.

By the differences of latitude, first found, the column of successive latitudes is filled up; to these the meridional parts and their differences are then taken; the courses and corresponding meridional diff. lat. give (59) the differences of longitude.

In this example, the difference in the result by the three methods is very inconsiderable.

Digitized by Google

79. Example III. *Suppose a ship from the latitude 67° 30′ N., longitude 8° 46′ W., has sailed the following courses, viz.*

NE. 64 m. NNE. 50 m. NW. b. N. 58 m. WNW. 72 m.
West, 48 m. SSW. 38 m. S. b. E. 45 m. ESE. 40 m.

Required her present latitude and longitude.

By Middle Latitude, according to the second Rule.

Courses.	D.	Diff. lats. N.	Diff. lats. S.	Depart. E.	Depart. W.	Successi. lats.	Sum lats.	Mid. lats.	Co-m. lats.	D.long. E.	D.long. W.
						67° 30′	° ′	° ′	° ′		
NE.	64	45,3		45,3		68 15	135 45	67 52	22 08	120	
NNE.	50	46,2		19,1		69 01	137 16	68 38	21 22	53	
NW.b.N.	58	48,2			32,2	69 49	138 50	69 25	20 35		92
WNW.	72	27,6			66,5	70 17	140 06	70 03	19 57		195
West	48				48,0	70 17	140 34	70 17	19 43		142
SSW.	38		35,1		14,5	69 42	139 59	69 59	20 01		42
S. b. E.	45		44,1	8,8		68 58	138 40	69 25	20 40	25	
ESE.	40		15,3	36,9		68 43	137 41	68 50	21 10	102	
		167,3	94,5	110,1	161,2					300	471
		Diff. lat. = 72,8		Depart. = 51,1						Diff. long. = 171	

By Mercator, according to the third Rule.

Courses.	D.	Diff. lat. N.	Diff. lat. S.	Depart. E.	Depart. W.	Successi. lats.	Mer. parts.	Mer. d. lat.	Diff. long. E.	Diff. long. W.
						67° 30′	5551,6			
NE.	64	45,3		45,3		68 15	5671,1	119,5	119,5	
NNE.	50	46,2		19,1		69 01	5797,3	126,2	52,4	
NW.b.N.	58	48,2			32,2	69 49	5933,9	136,6		91,1
WNW.	72	27,6			66,5	70 17	6016,0	82,1		198,6
West	48				48,0	70 17	6016,0	00,0		142,*
SSW.	38		35,1		14,5	69 42	5913,7	102,3		42,4
S. b. E.	45		44,1	8,8		68 58	5789,0	124,7	24,8	
ESE.	40		15,3	36,0		68 43	5747,4	41,6	100,7	
		167,3	94,5	110,1	161,2				297,4	474,1
		Diff. lat. = 72,8		Depart. = 51,1					Diff. longit. = 176,7	

Hence the present latitude is 68° 43′ N.; and present long. 11° 42′ W.

According to the first Rule.

The co-mid. lat. between the first and last lats. is 21° 54′, with which, and the departure 51,1, the diff. long. will be 137 miles.

Also the mer. diff. lat. between the first and last lats. is 195,8; with which, and the diff. lat. 72,8, and the dep. 51,1, gives a diff. long. 137,1.

* This diff. long. is found by Art. 38 of this Book.

80. Example IV. *Suppose a ship from the latitude* 68° 38′ *N. longitude* 8° 40′ *E. has sailed the following courses, viz.*

NE. b. N.	63m.	NE.	38m.	NNE.	56m.
North	30m.	NW. b. N.	25m.	NNW. ½ W.	36m.
N. by E.	40m.	NE. b. E. ½ E.	72m.	SE.	50m.
ENE.	65m.				

Required her present latitude and longitude, with her direct course and distance to the North Cape, in lat. 71° 27′ *N., longitude* 26° 30′ *E.*

By Middle Latitude, according to the second Rule.

Courses.	D.	Diff. lats. N.	Diff. lats. S.	Depart. E.	Depart. W.	Successf. lats.	Sum lats.	Mid. lats.	Co-m. lats.	D. lon. E.	D. lon. W.
						68° 38′	° ′	° ′	° ′		
NE. b. N.	63	52,4		35,0		69 30	138 8	69 4	20 56	98	
NE.	38	26,9		26,9		69 57	139 27	69 43	20 17	78	
NNE.	56	51,7		21,4		70 49	140 46	70 23	19 37	64	
North.	30	30,0				71 19	142 8	71 4	18 56	00	00
NW. b. N.	25	20,7			13,9	71 40	142 59	71 30	18 30		44
NNW.½W.	36	31,7			17,0	72 12	143 52	71 56	18 4		55
N. b. E.	40	39,2		7,8		72 51	145 3	72 31	17 29	26	
NE.b.E.½E.	72	33,9		63,5		73 25	146 16	73 8	16 52	220	
SE.	50		35,3	35,3		72 50	146 15	73 7	16 53	121	
ENE.	65	24,9		60,0		73 15	146 5	73 3	16 57	205	
		311,4	35,3	249,9	30,9					812	99
Diff. lat. =		276,1		219,0	Dep.			Diff. long. =		713	

By Mercator, according to the third Rule.

Courses.	D.	Diff. lats. N.	Diff. lats. S.	Depart. E.	Depart. W.	Successf. lats.	Mer. parts.	Mer. d. lat.	Diff. long. E.	Diff. long. W.
						68° 38′	5733,7			
NE. b. N.	63	52,4		35,0		69 30	5879,2	145,5	97,2	
NE.	38	26,9		26,9		69 57	5957,2	78,0	78,0	
NNE.	56	51,7		21,4		70 49	6112,1	154,9	64,0	
North	30	30,0				71 19	6204,5	92,4		
NW. b. N.	25	20,7			13,9	71 40	6270,7	66,2		44,0
NNW. ½ W.	36	31,7			17,0	72 12	6373,9	103,2		55,0
N. b. E.	40	39,2		7,8		72 51	6503,8	129,9	26,0	
NE.b.E.½E.	72	33,9		63,5		73 25	6621,0	117,2	219,4	
SE.	50		35,3	35,3		72 50	6500,4	120,6	120,6	
ENE.	65	24,9		60,0		73 15	6586,1	85,7	207,0	
		311,4	35 3	249,9	30,9				812,2	99,0
		35,3		30,9					99,0	
Dep. lat. =		276,1		219,0	Dep.		Diff. long. =		713,2	

By

By the First Rule.

With $\frac{1}{10}$th of the diff. lat. and departure, *viz.* 27,61 and 21,9, the direct course is N. 38° 30′ E., and distance 353.

The co-mid. lat. is 19° 04′; with which, and the departure 219, the difference of longitude is 673.

The meridional diff. lat. 852,4; with which, and the direct course 38° 30′, the difference of longitude is 676.

To find the direct course and distance from the ship's place to the North Cape.

Depart. lat.	= 68° 38′ N.			Dep. long.	= 8° 40′ E.
Diff. lat.	= 4 36 N.			Diff. long.	= 11 53 E.
Present lat.	= 73 14 N.	Mer. parts	= 6582,6	Present long.	= 20 33 E.
N. Cape's lat.	= 71 27 N.	Mer. parts	= 6229,6	N. C.'s long.	= 26 30 E.
Diff. lat.	= 1 47 N	M. d. lat.	= 353,0	Diff. long.	= 5 57 E.
Or	= 107 miles.			Or	= 357 miles.

By Middle Latitude.

Sum of the lats. 144° 41′; mid. lat. 72° 21′; co-mid. lat. 17° 39′.
To the co-mid. lat. 17° 39′, and the diff. longitude 357 (= 119 × 3) taken as a distance, the corresponding depart. is (36,28 × 3 =) 108,84. As the diff. lat. 107, and depart. 108,8, are so nearly equal, therefore The course to the North Cape is SE., and the distance 152 miles.

By Mercator.

The meridional diff. lat. 353, and diff. long. 357, taken as a diff. lat. and depart. gives the course S. 45° 20′ E. and the distance 152 miles.

81. ### Remark.

The three methods of operation are sufficiently illustrated in the preceding examples. From whence it may be inferred, that in latitudes not exceeding 45°, the *first method*, or that usually practised at sea, is correct enough for any runs that can be made in one or two days; and one day's run may be safely worked by the same method in latitudes as high as 50° or 52°: but in latitudes nearer the pole, it will be proper to find the difference of longitude to compound courses by either of the second or third methods, as may be seen by comparing the results to the third and fourth examples; the first method giving the difference of longitude too small, by a quantity considerable enough to produce fatal consequences.

Digitized by Google

SECTION VI.

The Construction and Use of a Mercator's Chart.

The linear and numeral solutions of such questions as may be proposed concerning sailing, by the principles on which Mercator's charts are founded, having been sufficiently exemplified; it follows next to shew how such questions may be solved by the chart itself.

82. PROBLEM I.

To make a true sea-chart, which shall shew the known sea coasts, islands, rocks, shoals, &c. that are contained within any proposed limits.

SOLUTION.

1st. Construct the boundaries or limits of the chart, within the proposed latitudes and longitudes (13), and let the degrees of latitude and longitude be marked on these limits.

2d. On a piece of stiff paper, parchment, &c. make a scale of equal parts, like the degrees of longitude that are in the graduated parallel of latitude, and let the divisions on this scale be numbered in the same manner.

3d. From a table of the latitudes and longitudes of places (VI. 137) extract those places, with their latitudes and longitudes, that lie within the proposed limits.

4th. Then by sliding the outside divisions of the scale of the graduated parallel along the graduated meridians, so that both ends of the scale, at the same time, always cut like divisions of latitude; the points corresponding to the latitudes and longitudes of the places contained within the proposed limits may be readily marked in the chart.

5th. Lines being properly drawn from point to point, will form the outlines of the sea coasts, islands, &c.; to which may be annexed the *depths of water*, *setting of currents*, and whatever else may be judged convenient for the chart to contain.

In this manner the sea-coasts, &c. were laid down in the chart, Plate XII.; containing part of the sea coasts of Europe, Africa, and America, with the intermediate islands, extending from the latitude of 23 degrees to 59 degrees north; and from the longitude of London, or 0 degrees, to 80 degrees of west longitude.

83. The Gunter's scales have two lines drawn on them; one marked *M. R.*, signifying the *nautical meridian*; and the other, which is placed directly under it, is marked *E. P.*, signifying *equal parts*.

These equal parts are degrees of longitude, to which the divisions of the nautical meridian are fitted, by increasing them in their true proportion; which is readily done by the table in Art. 13, taking the meridional degrees from the scale of equal parts, or degrees of longitude. These two lines, or scales, are used either to construct a Mercator's chart, or to shew nearly the meridional diff. lat. between any two parallels of latitude.

The

Digitized by Google

The construction of a Mercator's chart (or rather the limits or borders of it) is easily performed by these lines, by transferring the divisions, corresponding to the degrees to be used, from these scales to the paper the chart is to be drawn on. See Plate XII. Thus:

On an east and west line (AB) apply the extent, taken from the scale of longitude (EP), between the degrees of longitude where the chart is to begin and end (suppose between the longitudes 0° and 80°).

Through these two extremities (A, B,) draw two meridians (AD, BC,) each of a length equal to the extent, taken from the line of latitudes (Mer.), between the two latitudes where the chart is to begin and end (suppose between the latitudes 23° and 59°).

Then the several degrees both of longitude and latitude, taken from those scales, and separately applied in their respective places, will form the borders of the chart as required.

The meridional difference of latitude is found by taking the extent, on the meridian scale, between the two proposed latitudes, in a pair of compasses, and applying it to the line of longitude; then the number of equatorial degrees, and parts of degrees, being reduced to miles, will shew the meridional diff. latitude between those parallels.

The scale of longitude, which was put perhaps on all the two-feet Gunter's scales made before the year 1746 for common sale, had each degree of longitude rather less than $\frac{1}{4}$th of an inch, and the meridian scale fitted to that size; so that about 85 meridian degrees came within the length of the scale: and consequently the charts constructed from them had their degrees rather too small to be of much use to seamen, whose instruments and hands are not, usually, so nice as to work with tolerable accuracy on such small charts; and such scales continue still to be made by some workmen. But since that time certain alterations, conceived to be useful, have been made in Gunter's scales by some of the instrument-makers, to whom they were communicated*; and now a degree of longitude is made nearly half an inch, and is divided into five parts of 12 minutes each; and the meridional degrees, fitted thereto, are in two lengths, or scales; the first containing 40 degrees: and the other, beginning at 40°, extends to 68°; most navigations being performed within those limits.

The scale of logarithmic tangents, put on the Gunter's scale, is also a scale of meridional parts, or a scale of the differences of longitude to a course on the fourth rhumb, or to the rhumb making angles of 45 degrees, with the meridians, on a Mercator's chart.

For to the latitudes 0°, 5°, 10°, 15°, 20°, 25°, 30°, &c.; the half complements are 45°, $42\frac{1}{2}$°, 40°, $37\frac{1}{2}$°, 35°, $32\frac{1}{2}$°, 30°, &c. Therefore, if on the scale of log. tang. be set the numbers 5, 10, 15, &c. against the divisions represented by 45°, $42\frac{1}{2}$°, 40°, &c., and the intermediate divisions be estimated accordingly; then will those divisions, taken as latitudes, be the log. tang. of their half polar distances, or half co-latitudes; which (23) are analogous to the lengthened degrees on the meridian; and consequently (19) represent the differences of longitude on the rhumb of 45°.

* By the author of these Elements.

Digitized by Google

A ſcale of equal parts, or a ſcale of longitude proper to this ſcale of meridional parts, may be found by the table, art. 13, p. 137. Thus, take from the ſcale of log. tang. marked as the ſcale of mer. parts, as above ſaid, the mer. parts to any propoſed latitude; then that diſtance, being divided into as many equal parts as there are mer. deg. ſtanding againſt that latitude in the table, will be the ſcale of equal parts required.

Thus. The firſt 20° of lat. which is the diſtance from the tangent of 45° to the tangent of 35°, being divided into 20,4 equal parts, will be the ſcale of longitude required.

Alſo, the firſt 30° of lat. which is the ſpace between 45° and 30° on the log. tangents, gives 31,5 equatorial parts.

And (which is the moſt accurate among them) the diſtance between the tangents of 45° and $22\frac{1}{2}$°, anſwering to the firſt 45° of latitude, gives 50,5 equal parts, or degrees of the equator.

84. PROBLEM II.

A latitude and longitude being given, to find the correſponding place on the chart. Example. Lat. 32° 25′ N. long. 17° 21′ W, Plate XII.

SOLUTION.

1ſt. In the graduated meridian * take the diſtance between the propoſed latitude and the neareſt parallel of latitude drawn acroſs the chart with a pair of compaſſes, as between the lat. 32° 25′, and the parallel of 30°.

2d. With other compaſſes, take the diſtance in the graduated parallel † between the propoſed longitude and the neareſt meridian drawn acroſs the chart, as between the long. 17° 21′ W. and the meridian paſſing through 20° of longitude.

3d. Slide the point of one compaſs along the meridian of 20°, and a point of the other compaſs along the parallel of 30°, keeping the points of each pair of compaſſes perpendicular to the line they ſlide along; then will the meeting of the other points of the compaſſes ſhew the place correſponding to the given latitude and longitude; which in this example is the [illegible] end of the iſland of Madeira.

This problem is moſt readily ſolved by the means of ſuch a moveable ſcale of longitude, as is deſcribed and uſed in the foregoing problem.

Or thus. A meridian drawn through the degrees of longitude given, and a parallel of latitude drawn through the given degrees of latitude, their interſection will be the place required.

* The graduated meridian is the ſcale of latitudes on the right or left hand borders of the chart.

† The graduated parallel is the ſcale of longitudes on the top or bottom borders of the chart.

85. PRO-

Digitized by Google

85. PROBLEM III.

A place being given on the chart, to find its latitude and longitude.

Suppose Palma, one of the Canary Isles. Plate XII.

SOLUTION.

1st. With the compasses take the shortest distance between the given place and the nearest parallel of latitude; this distance, applied to the graduated meridian from the said parallel, the same way the place lies, will give the latitude sought. Thus the distance from Palma to the parallel of 30°, applied from 30° southward, gives 28° 35′ N. for the latitude sought.

2d. In like manner, the shortest distance taken between the given place and the nearest meridian, being applied to the graduated parallel from that meridian, will give the longitude: thus the distance from Palma to the meridian through 20°, applied from 20° eastward, will give 17° 21′ W. longitude.

86. PROBLEM IV.

Two places being given on a Mercator's chart, to find their difference of latitude and difference of longitude.

Suppose Cape Finisterre and the island of Porto Sancto. Plate XII.

SOLUTION.

Find the latitude and longitude of each place; then the required differences are readily known.

By Prob. III.	C. Finisterre's lat.	= 43° 15′ N.	Long. =	9° 30′ W.	
	Isl. Porto Sancto lat.	= 33 15 N.	Long. =	15 55 W.	
	Diff. lat.	= 10 00	D. long. =	6 25 W.	

87. PROBLEM V.

To find the bearing, or course, between two given places on a Mercator's chart.

Suppose between Cape Clear and the island St. Michael. Plate XII.

SOLUTION.

Lay the edge of a ruler upon Cape Clear and the middle of the island of St. Michael; and, holding the ruler in this position, take the shortest distance between the edge of the ruler and the center of the nearest compass, or fly in a pair of compasses; slide one point of the compasses along the edge of the ruler, till the other point cuts the border of the fly; and the course will be found to be SW. b. S. $\frac{1}{4}$ W. nearly.

And the like for other places.

PRO-

Digitized by Google

PROBLEM VI.

Two places being given on a Mercator's Chart, to find their distance.

88. Case I. *When the given places are both under the same meridian, or under the equator.*

Solution.

Find the latitude of each place when under the same meridian, or their longitudes if under the equator.

Then the difference of the latitudes is the distance sought; or, the difference of longitudes is the distance sought.

89. Case II. *When the given places are both under the same parallel of latitude.*

Suppose between Cape Roxant and the island of St. George. Pl. XII.

Solution.

Lay the edge of a ruler over the given places; take half the distance of those places with the compasses; set one point on the division cut by the ruler in the graduated meridian, and apply the other point upward and downward on the same meridian, noting the degrees of latitude the said point falls on: Then the difference of those latitudes will be the distance sought nearly.

Thus, half the distance between Cape Roxant and the island of St. George, will reach from 38° 40′, the division cut by the edge of a ruler laid over those places, to 45° 00′ northward, and to 32° 20′ southward; the difference between these two latitudes is 12° 40′, or 760 miles nearly, for the distance required.

But if the proposed places lie in a parallel of latitude greater than 30 degrees, it will come nearer the truth to work as follows:

Take that meridional degree in which the parallel falls in the compasses; and as many times as this distance is contained in a straight line between the two places, of so many degrees is their distance to be estimated; which is reduced to miles as before.

Thus the distance between the latitudes of 38° 00′ N. and 39° 00′ N. will be contained about $12\frac{2}{3}$ times between Cape Roxant and the island of St. George, or the distance will be 12° 40′, as before.*

A third method, better than either, is as follows: Consider what number of points and parts of a point is contained in the co-latitude of the given places. Extend the compasses from one place to the other, and set this extent from the center of any one of the compasses, or flies, that is drawn on the chart along the rhumb which expresses the number of points and parts contained in the co-latitude. Keeping one foot of the compasses in the point where it falls, shut in the other until it will just

* These operations depend on the following proportion:
As mer. diff. lat. : proper diff. lat. :: diff. long. : departure; which will differ but very little from the meridional distance, unless the places are very far asunder.

touch

touch the meridian that passes through the center of the fly; and this extent being applied to the graduated parallel will give the distance between the two places in degrees, as is plain from the principles of parallel sailing.

90. CASE III. *When the given places differ both in latitude and longitude.*

Suppose the Lizard and the island of Corvo. Plate XII. Fig. 4.

SOLUTION.

Find the latitudes of the two places, and their diff. latitude. Take the diff. lat. in degrees and parts from the equator.

Lay the edge of a ruler over the two places; and slide one point of the compasses along the edge of it, until the other point touches a parallel (without cutting it); then, the other point resting here, take the distance from thence to where the edge of the ruler cuts this parallel, which being measured on the graduated parallel, will give the distance sought in degrees.

Thus the difference of latitude between Corvo and the Lizard is 10° 09′; then 10° 09′ taken from the graduated parallel, and one point of the compasses applied to the edge of a ruler, laid in the direction CL, slide that point along CL till the other point touches the parallel of 50 degrees in E; then the distance DL, measured on the graduated parallel, gives about 20° 25′ = 1225 miles, for the distance required.

For, if the difference of latitude DE be taken on a meridian through C, from C to F; and the parallel of latitude FH be drawn, cutting the rhumb line CL in H; then are the triangles LDE, HCF, congruous; and CH = DL. (II. 95, 102)

Now it is evident, that the parts of the triangle CFH, CGL, bear the same proportion to one another, as have been shewn in Art. 25 of this, where CF is the proper diff. lat. CG the mer. diff. lat., GL the diff. long. FH the departure, and CH the distance: Consequently the distance DL, found as above, is the true distance sought.

91. PROBLEM VII.

Given the latitude and longitude of the departed place, the course, and the latitude of the present place: Required that place on the chart.

EXAMPLE.

A ship from the island of Flores runs SE. b. S. ¼E. till she finds herself in the latitude 27° 29′ N.; required her present place. Plate XII. Fig. 5.

SOLUTION.

Through the departed place, Flores, draw the given rhumb, *viz.* SE. b. S. ¼E. and its intersection with the parallel of latitude drawn through the latitude of the present place, *viz.* 27° 29′, will give the ship's place on the chart; which will be near the island Ferro, or in lat. 27° 48′ N. long. 17° 26′ W.

92. PRO-

Digitized by Google

92. PROBLEM VIII.

Given the departed place, and also the course and distance, to find the present place on the chart.

EXAMPLE.

A ship from the island Ferro runs NW. b. N. ¼W. 951 miles; what is the latitude and longitude of the present place? Plate XII. Fig. 5.

SOLUTION.

Lay the edge of a ruler over Ferro in the position of the given course NW. b. N. ¼W.; take the degrees, 15° 51′, in the given distance, 951 miles, from the graduated parallel, and apply this extent from Ferro along the ruler's edge to R; take the nearest distance between R, and a parallel PZ drawn through Ferro, and see how many degrees this extent makes on the graduated parallel, which will be 11° 35′; those degrees counted northward from Ferro will give 39° 23′ N. for the ship's latitude; then the point Q, where a parallel through this latitude intersects the edge of the ruler, still lying in the first position, will be the ship's present place.

93. *If the course is due east or west.*

EXAMPLE.

A ship from Cape Roxant sails due west 760 miles: required her present place. Plate XII.

SOLUTION.

Take half the degrees (*viz.* 6° 20′) in the given distance 760 miles; add them to, and subtract them from, the given lat. 38° 42′, noting the sum 45° 02′, and the remainder 32° 22′: then the extent between those degrees, taken in the graduated meridian, and applied from the given place westward in the parallel, will give the ship's present place; which will be near the island of St. George.

Or thus, if the latitude be above 30 degrees:

Take the length of a degree in the latitude of the given parallel, as much above the parallel as below it; and turn this distance over in that parallel, the same way the course is, as many times as there are degrees in the given distance, and this will give the ship's place.

Thus the length of a degree taken in the latitude 38° 42′, and turned over from Cape Roxant to the west 12⅔ times, the compasses will fall on the island of St. George.

Or lay the edge of a ruler over the center of a fly, in the direction of that rhumb which makes an angle with the meridian, equal to the colatitude of the given place. Take the number of degrees in the given distance from the graduated parallel, and slide one foot of the compasses along the edge of the ruler, until the other touches the meridian passing through the fly. Keeping one foot fixed, in this position, by the edge of the ruler, open the other to the center of the fly; then set this extent from the given place along its parallel of latitude, and it will give the present place of the ship.

94. PRO-

94. PROBLEM IX.

Given the departed place with the difference of latitude and distance: Required the ship's place on the chart.

EXAMPLE.

A ship from Q sails in the SE. quarter 951 miles, and then finds herself in lat. 27° 48′ N., having altered her latitude 11° 35′: required her present place. Plate XII. Fig. 5.

SOLUTION.

Take the difference of latitude, 11° 35′, from the graduated parallel; lay this extent from Q along the edge of a ruler, lying north and south, to X; turn the edge of the ruler about X, till it lies in an east and west position: from the graduated parallel take 15° 51′, the degrees in 951 miles, the given distance; apply this extent from Q, to cut the edge of the ruler in V: let the points of the compasses rest in Q and V, and apply the edge of the ruler close to those points; then the point P, where the parallel of 27° 48′ is cut by the ruler's edge, is the ship's place required.

95. PROBLEM X.

Given the departed place with the course and difference of longitude: Required the ship's place on the chart.

EXAMPLE.

A ship from P sails NW. b. N. ¾ W.: required her place when she has altered her longitude 12° 53′. Plate XII. Fig. 5.

SOLUTION.

Take the given difference of longitude 12° 53′ from the graduated parallel; slide one foot of the compasses along the edge of a ruler laid on P, in the position PQ of the given course, until the other foot just touches a meridian PT drawn through P in T; then will the point Q, where the foot rests against the ruler's edge, be the place required.

96. *If the course had been due east or west.*

EXAMPLE.

A ship from Cape Roxant sails due west until she has altered her longitude 16° 40′: required her place on the chart.

SOLUTION.

Take the difference of longitude 16° 40′ from the graduated parallel: then this extent, applied from the given place, Cape Roxant, due west, will give the place required, which is near the island of St. George.

97. PROBLEM XI.

Given the departed place, with the difference of latitude and departure: Required the ship's place on the chart.

EXAMPLE.

A ship from Q, in lat. 39° 23′ N., sails between the south and east till she comes into the lat. 27° 48′ N., having made by account 649 miles of departure: required the ship's present place. Plate XII. Fig. 5.

SOLUTION.

Take the given difference of latitude 11° 35′ from the graduated parallel, and apply this extent from Q, along the edge of a ruler laid in the meridian of Q to X; take 10° 49′ = 649 miles, the given departure, from

Digitized by Google

from the graduated parallel; set one foot on x, and lay this extent eastward to v. so that xv be in a perpendicular position to the ruler's edge: lay the edge of the ruler on the points Q and v, and where it cuts ZP, the parallel of the ship's present latitude in P, is the ship's place.

Then the longitude, course, and distance may be found as before. See Articles 85, 87, 90.

98. PROBLEM XII.

Given the departed place, with the course and departure: Required the ship's place on the chart.

Example.

A ship from P, in latitude 27° 48′ N., sails NW.b. N. ¼ W., until she has made 649 miles of departure: required her present place; Plate XII. Fig. 5.

Solution.

Lay the edge of a ruler over the given place P, in the position of the given course NW. b. N ¼ W.; take from the graduated parallel 10° 49′=649, the given departure, and slide one foot along the ruler's edge, until the other foot just touches a meridian PT, drawn through P in S; the distance SP, applied to the graduated parallel, gives the diff. latitude; and consequently the present latitude is known: then where the ruler's edge, lying in the same position, cuts the present parallelel of lat. TQ, as in Q, is the place sought.

99. PROBLEM XIII.

Given the departed place with the distance, and departure: To find the ship's present place on the chart.

Example.

A ship from Q, in lat. 39° 23′N., in sailing between the south and east 951 miles, found she has made 649 miles of departure: Where is the present place of the ship? Plate XII. Fig. 5.

Solution.

From the graduated parallel take 10° 49′=649 miles, the given departure, and lay this extent from Q to O directly east; with the extent 15° 51′ =951 miles, the given distance, taken from the graduated parallel, one foot being set in Q; with the other foot cut the edge of a ruler laid on O, as a meridian, in V; then OV, measured on the graduated parallel, gives the diff. latitude, and consequently the present latitude 27° 48′ will be found: lay a ruler's edge over Q and V, and where it cuts the parallel of 27° 48′, as in P, is the ship's place required.

SECTION

Digitized by Google

SECTION VII.

Of sailing on a Great Circle of the Sphere.

100. GREAT CIRCLE SAILING is the art of finding what places a ship must go through, and what courses she must steer, that her track may be in the arc of a great circle (or nearly so) passing through the place sailed from and that bound to.

Although Mercator's sailing resolves truly all the cases incident to a ship's course along the rhumb passing through two places; yet there is no case in which the course performed on the direct rhumb line is the shortest distance between those two places, except when they both lie under the same meridian, or on the equator.

For, on the sphere, the shortest distance between two places is the arc of a great circle intercepted between them (IV. 23); consequently the spiral, or rhumb, passing through those places, is not the shortest distance, except when that rhumb coincides with a great circle, which can only be on a meridian, or on the equator.

It is chiefly on account of the shortest distance that this method of sailing has been proposed; and, for the most part, it is advantageous for a ship to reach her port by the shortest way she can.

As the solutions of the cases in Mercator's sailing were performed by plane triangles; so the cases in great circle sailing, are resolved by the solution of spheric triangles.

A great variety of cases may be proposed in this kind of sailing; but as they serve rather for exercises in the solution of spheric triangles, than for any real use toward the navigating a ship, those which appertain to one Problem only will be here more particularly considered, as they are the most useful cases that usually occur.

101. The angle of position, is an angle which a great circle, passing over two places, makes with the meridian of one of them; and shews the angular position of one place from the other.

PROBLEM.

Given the latitudes and longitudes of two places on the Earth: Required their nearest distance on the surface, together with the angles of position from either place to the other.

This Problem may be branched into six Cases.

102. CASE I. *When the two places lie under the same meridian.*

SOLUTION. Their difference of latitude will give their distance; and the position of one from the other will be directly north or south.

103. CASE

103. CASE II. *When the two places lie under the equator.*

SOLUTION. Their distance is equal to their difference of longitude, and the angle of position is a right angle, or the course from one to the other is due east or west.

104. CASE III. *When both places are in the same parallel of latitude.*

EXAMPLE. *What is the least distance between St. Mary's, in latitude* 37° 00′ *N., longitude* 25° 0′ *W., and Cape Henry, in latitude* 37° 00′, *longitude* 76° 23′ *W.?*

GENERAL CONSTRUCTION. Plate XIII. Fig. 25.

1st. Describe a circle PESQ, representing the meridian of one of the places, suppose of the eastern one, as St. Mary's; draw the line EQ, representing the equator, and at right angles to it draw the line PS, for the axis of the earth, the extremity of which, P, is the north pole, and S is the south pole; and on this circle lay off from P to A the complement of the latitude of (St. Mary's) the eastern place.

2d. On the equator, lay off from Q to C (IV. 70) the difference of longitude between the two places (51° 23′); and through P, C, S, (II. 72) describe the circle P C S, which will be the meridian of the other place (Cape Henry); on which lay from P to B the co-latitude of this place; which is done by describing the arc A *a* about the pole P (IV. 68) at the distance of the co-latitude.

3d. Through the points A, B, D, describe a great circle ABD. (II. 72)

Then A represents one place (St. Mary's), B the other (Cape Henry); PA and PB are their co-latitudes; the angle APB, which is measured by the arc QC (IV. 9), is the diff. long.; the arc AB is the nearest distance of those places; the angle PAB is the angle of position from A to B; and the angle PBA is the angle of position from B to A.

The arc AB may be measured as directed in Art. 70. Book IV.

And the angle PAB, or PBA, as shewn in Art. 72. Book IV.

Now the places having the same latitude, PA is equal to PB, and ∠PAB=∠PBA (IV. 90). Therefore, if the arc PI be described (IV. 75) making the angle API=25° 41½′, the half of the difference of longitude; PI will be perpendicular to AB, and bisect it.]

And in the triangle AIP, right-angled at I, there will be given the hypothenuse AP=53° 00′; the ∠API=25° 41½′: to find the leg AI=half the distance sought, and the ∠PAI=the angle of position.

The solution falls under Art. 130, 132. Book IV.

To

To find the distance.

As radius,	Or, As rad.	=	90° 00′	10,00000
To sin. hyp. PA;	To co-s. lat.	=	37 00	9,90235
So sin. giv. ∠ API,	So sin. ½ diff. long.	=	25 41½	9,63702
To sin. leg AI.	To sin. ½ distance	=	20 15½	9,53937

Which doubled, gives 40 31 for the dist. AB.

And this 40° 31′ reduced to nautical miles, is 2431, which is 31 miles less than 2462, the distance given by parallel sailing. See Art. 42 of this.

To find the angle of position.

As radius,	Or, As rad.	=	90° 00′	10,000000
To co-s. hypoth. PA;	To sin. lat. *	=	37 00	9,77946
So tang. giv. ∠ API,	So tang. ½ diff. long.	=	25 41½	9,68222
To co-t. ∠ A.	To co-t. ∠ posit.	=	73 51	9,46168

It appears by this, that to sail from A to B, or from B to A, the ship must first steer N. 73° 51′ W. or E.; and then gradually increase her course till she comes to I, where it will be due W. or E.; and from thence the course is to be gradually diminished again till she comes to the other port, where it will be 73° 51′, the same as she set out with: But how these courses are to be thus altered will be shewn hereafter.

105. CASE IV. *When one place has latitude, and the other has none, or is under the equator.*

EXAMPLE. *What is the nearest distance between the Island of St. Thomas in lat.* 0° 00′, *and long.* 1° 00′ *E., and Port St. Julian, in lat.* 48° 51′ *S. and longitude* 65° 10′ *W.?*

Port St. Julian, in lat.	48° 51′ S.	Long.	65° 10′ W.
Isl. St. Thomas, in lat.	0 00	Long.	1 00 E.
Julian's co-lat.	41 09	Diff. long.	66 10

By CONSTRUCTION. Plate XIII. Fig. 26.

Let the point A be St. Thomas under the equator, the poles of which are P and S.

Make AC, the measure of the angle ASC, equal to 66° 10′=diff. long. (IV. 74)

Then as Port St. Julian is in south lat., about S the south pole, at the distance of Julian's co-lat., describe the arc *aa*, cutting SCP, the meridian of Julian, in B. (IV. 66.)

Through the points A, B, E, a great circle being described the arc AB is the distance sought.

The distance AB may be measured by Art. 70. Book IV.

And the angles of position at A and B are to be measured as directed in Art. 72. Book IV.

* For the complement of a complement is the arc itself: Thus QA, or the distance from the equator, shews the lat. But QA is the comp. of AP; and AP of AQ.

COMPUTATION. In the quadrantal triangle ASB, there is

Given the co-lat. of St. Thomas, or	AS=90° 00′	The rest are found as in Art. 162, Book IV.
the co-lat. of Julian,	SB=41 09	
the diff. longitude,	∠ASB=66 10	

Or, in the supplemental triangle ACB, right-angled at C, there is
Given the lat. of St. Julian's, or the leg CB=48° 51′.
the diff. longitude, or the leg CA=66 10.
The solution falls under Article 140. Book IV.

To find the distance AB.

As radius,	Or, As radius		= 90° 00′	10,00000
To co-s. either leg;	To co-s. diff. long.	AC	= 66 10	9,60646
So co-s. other leg,	So co-s. diff. lat.	CB	= 48 51	9,81825
To co-s. hyp.	To co-s. dist.	AB	= 74 35	9,42471

So that the dist. AB=74° 35′ is 4475 miles; which is less by 57 miles than the distance found by Mercator's sailing.

To find the angle of position at A. (IV. 139.)

As radius,	Or, As radius		= 90° 00′	10,00000
To sin. leg AC;	To sin. diff. long.	AC	= 66 10	9,96129
So co-t. leg CB,	So co-t. diff. lat,	CB	= 48 51	9,94146
To co-t. op. ∠ A.	To co-t. ∠posit. at	A	= 51 22	9,90275

To find the angle of position at B.

As radius,	Or, As radius		= 90° 00′	10,00000
To sin. leg CB;	To sin. diff. lat.	CB	= 48 51	9,87679
So co-t. leg AC,	So co-t. diff. long.	AC	= 66 10	9,64517
To co-t. op. ∠B.	To co-t. ∠ posit. at	B	= 71 36	9,52196

So that a ship sailing from the Island of St. Thomas must first shape her course S. 51° 22′ W.; and then by constantly altering her course towards the west, so as to arrive at Port St. Julian on a course S. 71° 36′ W. she will have sailed the shortest distance between those places.

106. CASE V. *When the latitudes of the given places are both north, or both south.*

EXAMPLE. *What is the nearest distance between the Lizard and the Island of Bermudas; and also the angles of position at each place?*

The lizard in lat. 49° 57′ N. and long. 5° 21′ W.
Isl. Bermudas in lat. 32 35 N. and long. 63 32 W.

Diff. long. 58 11

By CONSTRUCTION. Plate XIII. Fig. 27.

Make PA=57° 25′, the co-lat. of Bermudas; Pa=40° 03′, the co-lat. of the Lizard; and (IV. 68) with the tang. of Pa describe the arc *a a*. With

Digitized by Google

With the ſecant, of 58° 11′, the diff. long. (IV. 76), deſcribe arcs from P and S, which give the center of the circle PCS, the meridian of the Lizard; its interſection with *a a* gives B the place of the Lizard.

Deſcribe a great circle through A, B, D, (II. 72), and the intercepted arc AB is the diſtance ſought; and the angles PAB, PBA, are the poſitions required.

The diſtance AB may be meaſured by (IV. 70); and the poſitions by (IV. 72.)

Had the eaſtern place, the Lizard, been put on the primitive circle, the great circle AB would have been difficult to deſcribe; and therefore the weſtern place was put on the primitive circle, it being a matter of indifference which of the places is ſo taken.

COMPUTATION. In the oblique ſpheric triangle APB.

Given			
Given Bermudas's co-lat.,	PA = 57° 25′	}	Required the reſt.
Lizard's co-lat.,	PB = 40 03		
Diff. longitude	∠APB = 58 11		

The ſolution falls under Art. 151. Book IV.

To find the diſtance AB.

As radius,	Or, As radius	= 90° 00′	10,00000
To co-ſ. giv. ∠;	To co-ſ. diff. long. ∠APB	= 58 11	9,72198
So tang. eith. ſide,	So tang. Berm. co-lat. PA	= 57 25	10,19442
To tang. M.	To tang. fourth arc	= 39 31	9,91640
	Which take from Lizard's co-lat.	= 40 03	
	Leaves a fifth arc	= 0 32 = N.	

As co-ſ. M,	As co-ſ. fourth arc	= 39 31	0,11270
To co-ſ. N;	To co-ſ. fifth arc	= 0 32	9,99998
So co-ſ. ſide 1ſt uſed,	So ſin. Bermudas lat.	= 32 35	9,73121
To co-ſ. ſide required.	To co-ſ. diſtance AB	= 45 44	9,84389

To find the angle of poſition PBA. (IV. 150).

As this angle is oppoſite to the ſide uſed in the firſt proportion, therefore the fourth and fifth arcs here uſed, are the ſame as above.

As ſin. N,	As ſin. fifth arc	= 0° 32′	2,03113
To ſin. M;	To ſin. fourth arc	= 39 31	9,80366
So tang, given ∠,	So tang. diff. long. ∠ APB	= 58 11	10,20731
To tang. req. ∠.	To tang. ∠ poſit. ∠PBA	= 89 29	12,04210

To find the angle of poſition PAB.

The other parts being found, this angle may be found by the proportion between oppoſite ſides and angles. Thus:

As ſin. PA,	Or, As ſin. Bermudas's co-lat.	= 57° 25′	0,07437
To ſin. ∠ PBA;	To ſin. ∠poſ. at Lizard	= 89 29	9,99998
So ſin. BP,	So ſin. Lizard's co-lat.	= 40 03	9,80852
To ſin. ∠ PAB.	To ſin. ∠poſ. at Bermudas	= 49 47	9,88287

Digitized by Google

Or, working by Art. 150. Book IV. the ſame angles would be obtained.

Had the two firſt proportions been worked with the Lizard's latitude inſtead of Bermudas's, the ſame diſtance would have been found.

So the ſhorteſt diſtance between the Lizard and Bermudas is 45° 44′, or 2744 ſea miles; which is 56 miles leſs than the diſtance found by Mercator's ſailing.

And a ſhip to run this ſhorteſt tract muſt ſail from the Lizard S. 89° 29′ W., and gradually leſſen the courſe, ſo as to arrive at Bermudas on the rhumb bearing S. 49° 47′ W.: whereas the direct courſe from one place to the other, as found by Mercator's ſailing, is S. 68° 09′ W.

107. CASE VI. *When one of the given places has north latitude, and the other has ſouth latitude.*

EXAMPLE. *What is the neareſt diſtance from the Iſland of St. Helena to the Iſland of Bermudas; and alſo the angles of poſition at each place?*

Iſland of Bermudas in lat.	32° 35′ N.	and long.	63° 32′ W.
Iſland of St. Helena in lat.	15 55 S.	and long.	5 49 W.
		Diff. long.	57° 43′

By CONSTRUCTION. Pl. XIII. Fig 28.

Make QA = 15° 55′, the lat. of St. Helena; deſcribe the arc *aa* about P (IV. 68) with the tangent of P*a* = 57° 25′, the co-lat. of Bermudas.

Arcs deſcribed from P, S, with the ſecant of 57° 43′, the diff. long., will give the centre of the circle PCS, the meridian of Bermudas; and its interſection B with *aa*, is the place of Bermudas.

Deſcribe a great circle through A, B, D; the intercepted arc AB is the diſtance ſought, which may be meaſured by IV. 70; and the angles PAD, ABS, are the poſitions required, which are to be meaſured as directed in Art. 72. Book IV.

COMPUTATION. In the oblique ſpheric triangle ABP.

Given PA = 105° 55′, St. Helena's lat., added to 90°; or its N. pol. diſt.
PB = 57 25, Bermudas's co-lat.
∠APB = 57 43, their difference of longitude.

To find the reſt. The ſolution falls under Art. 150, 151. Book IV.

To find the diſtance AB.

As radius,	Or, As radius	= 90° 00′		10,00000
To co-ſ. ∠P;	To co-ſ. diff. long.	= 57 43		9,72763
So tang. PB,	So tang. Berm. co-lat.	= 57 25		10,19442
To tang. M.	To tang. fourth arc	= 39 53		9,92205
	Which taken from	= 105 55	= St. Helen's N. [polar diſt.	
	Leaves a fifth arc	= 66 02	= N.	

As co-ſ. M,	Or, As co-ſ. fourth arc	= 39 53	0,11501
To co-ſ. N;	To co-ſ. fifth arc	= 66 02	9,60874
So co-ſ. PB,	So ſin. Bermudas lat.	= 32 35	9,73121
To co-ſ. AB.	To co-ſ. diſtance	= 73 26	9,45496

To

To find the angle of position PAB.

The fourth and fifth arcs being found as before.

As fin. N,	Or, As fin. fifth arc	= 66° 02′	0,03916
To fin. M;	To fin. fourth arc	= 39 53	9,80701
So tang. $\angle$P,	So tang. diff. long.	= 57 43	10,19944
To tang. $\angle$A.	To tang. $\angle$position PAB	= 48 00	10,04561

To find the angle of position ABP.

As fin. BA,	Or, As fin. of dift.	= 73° 26′	0,01841
To fin. $\angle$P;	To fin. diff. long.	= 57 43	9,92707
So fin. PA,	So fin. St. Helena's N. P. dift.	= 105 55	9,98302
To fin. $\angle$ABP.	To fin. $\angle$position ABP	= 58° 01′	9,92850

But becaufe the given difference of latitude is lefs than 90°, and the fide PA greater, the angle ABP muft be greater than 90°; and is, therefore, 121° 59′, which is the fupplement of 58° 01′.

So that were a fhip to fail from St. Helena to Bermudas on the arc of a great circle, fhe muft firft fhape her courfe N. 48° 00′ W., and gradually alter it from the north towards the weft, fo as to arrive at Bermudas on a courfe N. 58° 01′ W., after having run 73° 26′, or 4406 fea miles.

The courfe found by Mercator's failing is N. 48° 45′ W., and the diftance is 4414 miles.

By this it appears, that when the places are one in N. latitude, and the other in S. latitude, and neither of them far from the equator, there is but a fmall difference between the refults found by Mercator's and great circle failing: for near the equator the rhumb lines do not differ greatly from great circles.

From the folution of the foregoing cafes it is plain, that to fail on the arc of a great circle, the fhip muft continually alter her courfe. But as this is a difficulty too great to be admitted into the practice of Navigation, it has been thought fufficiently exact to effect this bufinefs by a kind of approximation; that is, by a method which nearly approaches to failing on a great circle.

108. The principle upon which this approximation is founded, is *that in fmall arcs, the difference between the arc and its chord, or tangent, is fo fmall, that they may be taken one for the other in any nautical operations.*

 Upon

Upon this principle, the great circles on the earth are ſuppoſed to be made up of ſhort right lines, each of which is a ſegment of a rhumb line.

And on this ſuppoſition the ſolution to the following Problem is founded.

PROBLEM II.

109. *Having given the latitudes and longitudes of the places ſailed from and bound to, to find the ſucceſſive latitudes on the arc of a great circle in thoſe places where the alteration in longitude ſhall be a given quantity; together with the courſes and diſtances between thoſe places.*

SOLUTION.

I. Find the angle of poſition at each place, and their diſtance by one of the preceding ſix caſes.

II. Find the greateſt latitude the great circle runs through; that is, find the perpendicular from the pole to that circle; and alſo find the ſeveral angles at the pole, made by the given alterations of longitude between this perpendicular and the ſucceſſive meridians come to.

III. With this perpendicular, and the polar angles, ſeverally, find as many correſponding latitudes, by ſaying (IV. 148):

As rad. : tang. greateſt lat. : : coſ. 1ſt. polar ∠ : tang. 1ſt. lat.
: : coſ. 2d. polar ∠ : tang. 2d. lat.
&c. &c.

IV. Having the ſeveral latitudes paſſed through, and the difference of longitude between each, find, by Mercator's ſailing (57), the courſes and diſtances between thoſe latitudes, and theſe are the ſeveral courſes and diſtances the ſhip muſt run to keep nearly on the arc of a great circle.

The ſmaller the alterations in longitude are taken, the nearer will this method approach the truth; but it is ſufficient to compute to every five degrees of difference of longitude: the length of an arc of five degrees differing from its chord or tangent only by 0,0002; as may be found from the Articles 25, 31, 33. Book III.

110. QUESTION I. *A ſhip being bound from a place in lat.* 37° 00′ *N. long.* 22° 56′ *W., to a place in the ſame lat., and in long.* 76° 23′ *W., it is propoſed ſhe ſhall ſail as near the arc of a great circle as ſhe can, by altering her courſe at every five degrees difference of longitude; required the latitude at each time of altering the courſe, and alſo the courſes, and diſtances between theſe ſeveral latitudes.*

Lat.

Digitized by Google

Lat. of the place failed from is 37° 00′ N.	the long.	22° 56′ W.	
Lat. of the place bound to is 37 00 N.	the long.	76 23 W.	
	The diff. of long.	53 27	

The figure being defcribed, and the computation made as in Art. 104. the diftance BA is found to be 42° 06′, and the ∠A or ∠B = 73° 09′, the angle of pofition. Plate XIII. Fig. 29.

Now the triangle APB, being ifofceles, the perpendicular PI falls in the middle of AB; and the latitudes, courfes, and diftances, being known in running the half BI, thofe in the half IA will alfo be known.

Let the points *a*, *b*, *c*, *d*, &c. be the p'aces arrived at on each alteration of five degrees of longitude: then will the arcs P*a*, P*b*, P*c*, P*d*, &c. be the refpective co-latitudes of thofe places, and are the hypothenufes of the right-angled fpheric triangles PI*a*, PI*b*, PI*c*, PI*d*, &c.

In the triangle PIB.		As rad.	=	90° 00′	10,00000
Given PB	= 53° 00′	To fin. PB	=	53 00	9,90235
∠PBI	= 73 09	So fin. ∠B	=	73 09	9,98004
To find PI.		To fin. PI	=	49 51	9,88329

Now $\angle \text{IPB} = \left(\frac{53° 27'}{2}\right)$ 26° 43½′; ∠IP*a* = 21° 43½′; ∠IP*b* = 16° 43½′; ∠IP*c* = 11° 43½′; ∠IP*d* = 6° 43½′, are the feveral polar angles.

		21° 43½′	16° 43½′	11° 43½′	6° 43½′
Then rad.	= 90° 00′	10,00000	10,00000	10,00000	10,00000
To co-t. PI	= 49 51	9,92612	9,92612	9,92612	9,92612
So co-f. polar angle		9,96800	9,98123	9,99084	9,99700
To tang. lat.		9,89412	9,90735	9,91696	9,92312
Which are		38° 05′	38° 56′	39° 33′	39° 57′

The degrees and min. fet over each column, are the polar angles ufed in that propórtion, and the correfponding latitudes ftand at the bottom.

111. The firft term of thefe proportions being radius, and the fecond term conftant, the operations may be very expeditioufly performed thus:

On a flip of paper let the log. of the fecond or conftant term be written of the fame fize with the printed figures; apply this log. cot. fucceffively to the log. co-fines of the polar angles: Then the fum of the two logs. being written down each time, will give the log. tangents of the feveral latitudes arrived at.

By this method, each proportion will be worked by writing down only one line.

Hence it appears, the fhip muft firft fail from the lat. 37° 00′ N. to lat. 38° 05′ N.; thence to lat. 38° 56′ N.; thence to lat. 39° 33′ N.; thence to lat. 39° 57′ N.; thence to lat. 40° 09′ N., which is the greateft latitude fhe muft go to; and from thence fhe muft proceed through the latitudes 39° 57′, 39° 33′, 38° 56′, 38° 05′, and fo to 37° 00′, the parallel fhe fet out from, and in which fhe is to find the place fhe is bound to.

Digitized by Google

Now between these several latitudes, with the respective differences of longitude, find, by Mercator's failing, Art. 57, the courses and distances.

If the results of the several operations, in the questions of great circle sailing, be entered in such a table as the following, it will be found of some convenience to the operator.

Polar angles.	Succeff. longs.	Succeff. lats.	Diff. long.	Diff. lat.	Merid. parts.	Merid. d. lat.	Cour.	Dist.
∠IPB 26° 43½′	22° 56′	37° 00′			2392,6			
∠IPa 21 43½	27 56	38 05	300	65	2474,6	82,0	74 43	246,6
∠IPb 16 43½	32 56	38 56	300	51	2539,8	65,2	77.44	240,0
∠IPc 11 43½	37 56	39 33	300	37	2587,6	47,8	80,57	235,2
∠IPd 6 43½	42 56	39 57	300	24	2618,8	31,2	84,04	232,2
	49 39½	40 09	403,5	12	2634,5	15,7	87,46	307,9
								1261,9

In the first column are the angles at the pole contained between the perpendicular and the several meridians differing by 5° of longitude.

In the second column, the departed longitude 22° 56′ being increased by the differences of longitude, make the successive longitudes come to.

In the third column are the successive latitudes passed through in sailing from the place set out from to the greatest latitude.

In the fourth and fifth columns are the differences between the longitudes and latitudes in the second and third columns.

In the sixth column are the meridional parts to the successive latitudes; and in the seventh column are the meridional diff. of latitudes.

The eighth and ninth columns contain the courses and distances between the places answering to the second and third columns.

The numbers in the third, eighth, and ninth columns, are found by working the logarithmic proportions on a waste paper; but the work is here omitted, as it is so easily supplied.

Now the column of distances being summed up amounts to 1261,9; which being doubled gives 2523,8 miles for the distance between the two places.

And the courses the ship must steer are, 1st. N. 74° 43′ W.; 2d. N. 77° 44′ W.; 3d. N. 80° 57′ W.; 4th. N. 84° 04′ W.; 5th. N. 87° 46′ W.; 6th. S. 87° 46′ W.; 7th. S. 84° 04′ W.; 8th. S. 80° 57′ W.; 9th. S. 77° 44′ W.; 10th. S. 74° 43′ W.: and on these courses she must run the respective distances standing against them.

112. QUESTION II. *It is proposed that a ship, bound from the Lizard to a place in lat. 32° 25′ N. and long. 66° 45′ W. shall sail on a great circle, and alter her course at every five degrees of longitude; required the latitudes through which the ship is to pass, and also the course and distance between each.*

The Lizard's lat. is 49° 57′ N. Long. 5° 21′ W. } Diff. long. 61° 24′.
Lat. place bound to is 32 25 N. Long. 66 45 W. }

Having described the figure, Plate XIII. Fig. 30, and found the ∠PAB = 49° 35′, the ∠PBA = 87° 15′, and the side AB = 47° 54′, as in Art. 106.

Draw

James Macully's Book

Digitized by Google

Draw PI at right angles to ABD. (IV. 73)

In the equator, lay off from the center the tangents of 5, 10, 15, 20, &c. to 55 degrees; and those points give the centers to the arcs of co-lat. to every 5° diff. longitude. (IV. 75)

To find the perpend. PI.			*To find the polar angle* API.		
As rad.	= 90° 00′	10,00000	As rad.	= 90° 00′	10,00000
To sin. PA	= 57 35	9,92643	To tang. ∠A	= 49 35	10,06978
So sin. ∠A	= 49 35	9,88158	So cos. AP.	= 32 25	9,72922
To sin. PI	= 40 00	9,80801	To cot, ∠API	= 57 48	9,79900

Now the polar angle API, or the diff. long. between the perpend. PI and the meridian of the place bound to, 57° 48′, being taken from 61° 24′, the whole diff. long. leaves 3° 36′ for the diff. long. between the Lizard and the point I. Also 5°, the proposed alteration of longitude, being subtracted as often as can be from 57° 48′, leaves the several polar angles; with which, and the perpendicular PI the several latitudes arrived at are found by Art. 111.

Then having those latitudes, and the differences of longitude between them, find the successive courses and distances by Art. 57.

Let the several results be placed as in the following table; the logarithmic work being performed on a waste paper is here omitted.

Also, suppose the small letters in the figure supplied.

Polar angles.	Successf. longs.	Successf. lats.	Diff. long.	Diff. lats.	Merid. parts.	Merid. d. lat.	Courses	Dists.
	5° 14′	49° 57′	216	3	3469,8	4,7	88° 45′	137,5
∠IPB 3° 36′	8 50	50 00	168	2	3474,5	3,1	88 56	107,4
∠IP*a* 2 48	11 38	49 58	300	14	3471,4	21,7	85 52	194,2
∠IP*b* 7 48	16 38	49 44	300	27	3449,7	41,6	82 06	196,4
∠IP*c* 12 48	21 38	49 17	300	40	3408,1	60,9	78 31	200,6
∠IP*d* 17 48	26 38	48 37	300	55	3347,2	82,5	74 37	207,3
∠IP*e* 22 48	31 38	47 42	300	71	3264,7	104,3	70 50	216,3
∠IP*f* 27 48	6 38	46 31	300	88	3160,4	126,8	67 10	226,8
∠IP*g* 32 48	41 38	45 03	300	106	3034,2	147,8	63 46	239,8
∠IP*h* 37 48	46 38	43 17	300	127	2886,4	171,5	60 15	255,9
∠IP*i* 42 48	51 38	41 10	300	149	2714,9	194,4	57 03	273,9
∠IP*k* 47 48	56 38	38 41	300	175	2520,5	219,8	53 46	296,1
∠IP*l* 52 48	61 38	35 46	300	201	2300,7	242,7	51 02	319,6
	66 38	32 25			2058,0			2871,8

Now the sum of the several distances make 2871,8 miles.

But the distance in the arc of a great circle is 2874 miles.

The difference of the two methods is therefore 2,2 miles.

In this example it was judged necessary to keep the fractional place in the meridional parts, in order to have the distances more accurate.

113. QUESTION III. *A ship being bound from a place in lat.* 16° 00′ *S. long.* 6° 15′ *W. to a place in lat.* 32° 25′ *N. long.* 66° 38′ *W. it is proposed she shall sail near the arc of a great circle passing through those places, and*

and alter her course at every 5° of longitude: required the latitudes where those courses are to be altered, and also the course and distance between each place of alteration.

Lat. of place sailed from 16° 00′ S. Long. 6° 15′ W. } Diff. long = 60° 23′.
Lat. of place bound to 32 25 N. Long. 66 38 W. }

Having described the figure, Plate XIII. Fig. 31. and found the ∠PBA = 120°. 15′; ∠PAB = 49° 20′; and the distance AB = 75° 19′; as in Art. 107.

In the equator QF, lay off from F the tangents of 5° 10° 15°, &c. to 55°; and those points will give the centers to the meridians passing through every five deg. of long. between the two places.

To find the perpendicular.				*To find the polar ∠BPI.*			
As rad.	= 90°	00′	10,00000	As rad.	= 90° 00′		10,00000
To sin.	PB = 57	35	9,92643	To co-s.	BP = 57 35		9,72922
So sin. ∠PBI	= 59	45	9,93643	So tang. ∠PBI	= 59 45		10,23419
To sin.	PI = 46	49	9,86286	To cot. ∠BPI	= 47 25		9,96341

Now the several polar angles, longitudes, latitudes, diff. of longs., diff. of lats., mer. parts, mer. diff. of lats., courses and distances, being computed on a waste paper, their results are to be entered in a table as follows:

Polar angles.	Successi. longs.	Successi. lat.	Diff. long.	Diff. lats.	Mer. parts.	Mer. d. lat.	Courses.	Dist.
	6° 15′	16°00′S			973			
∠IPl = 102° 48′	11 15	11 45	300	255	709	264	48° 39′	386,0
∠IPk = 97 48	16 15	7 16	300	269	437	272	47 48	400,5
∠IPi = 92 48	21 15	2 38	300	278	158	279	47 05	408,3
∠IPh = 87 48	26 15	2 04N	300	282	124	282	46 46	411,7
∠IPg = 82 48	31 15	6 43	300	279	404	280	46 58	408,8
∠IPf = 77 48	36 15	11 13	300	270	677	273	47 42	402,1
∠IPe = 72 48	41 15	15 31	300	258	943	266	48 26	388.8
∠IPd = 67 48	46 15	9 32	300	241	1195	252	49 51	374,7
∠IPc = 62 48	51 15	23 13	300	221	1433	238	51 34	355,5
∠IPb = 57 48	56 15	26 34	300	201	1654	221	53 37	338,9
∠IPa = 52 48	61 15	29 34	300	180	1858	204	55 47	320,1
	66 38	32 25	323	171	2058	200	58 14	324,8
								4519,3

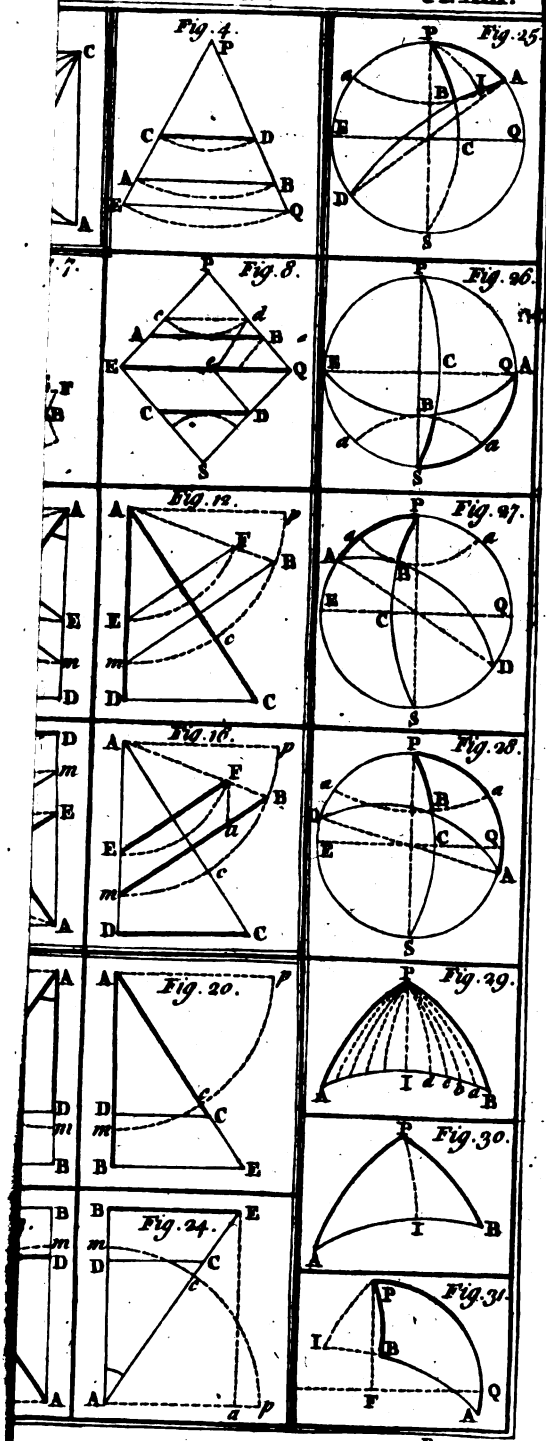
114. The track of a ship when directed nearly in the arc of a great circle, as in the preceding articles, may be delineated on the Mercator's chart, by marking on it, by the help of the latitudes and longitudes, the successive places where the ship is to alter her course; then those places or points being joined by right lines will shew the path, along which the ship is to sail under the proposed circumstances.

Thus in Plate XII. the route proposed in question II. Art. 110, is drawn from the Lizard to Bermudas, the situations of those two places, as they are laid down in that chart, being those proposed in this example. And notwithstanding this track on the chart appears much longer than the rhumb passing through those two places, yet it must be remembered, that these rhumb lines are only the representations of curves on the sphere, the absolute lengths of which are not hereby expressed.

6 SECTION

Digitized by Google

SAILING. Pl. XIII.



Page 202

Digitized by Google

SECTION VIII.

Of the errors arising in the cases of Sailing, upon the supposition that the Earth is not a Sphere.

115. The reasoning and conclusions in the preceding Sections of this Book, have been delivered in the opinion that the Earth is a sphere; but it has appeared from many observations made since the Year 1672, that its figure is not that of a perfect sphere; its axis, or polar diameter, being shorter than the equatorial diameter.

This notion first arose from observation made on pendulum clocks; which being fitted to beat seconds in the latitudes of Paris and London, were found to move slower as they approached the equator; and the pendulums were obliged to be shortened about $\frac{2}{5}$ parts of an inch, to agree with the times of the stars passing the meridian (V. 264). This difference in the lengths of the pendulum appearing to those great men, *Huygens* and *Newton*, to be a much greater quantity than could arise from the alteration by heat only, they, separately, discovered that the Earth was flatted at the poles*; and Sir Isaac Newton has shewn in his *Principles of Natural Philosophy*, that this flatness is about 17 $\frac{1}{10}$ miles, and that *the polar diameter is to the equatorial diameter*, as 229 is to 230.

---

* To give the learner a notion how this conclusion was drawn, it has been thought proper to add what follows, collected chiefly from Newton's Princip. Book III. Prop. 18, 19, 20.

CENTRIPETAL FORCE is, like *Gravitation*, that power by which heavy bodies tend towards a center.

CENTRIFUGAL FORCE is that by which bodies recede from a center; in the manner that the particles of water and thrumbs fly from a whirled mop.

The swifter the mop is whirled, the greater is the centrifugal force, and the particles fly off with greater velocity.

The diurnal rotation of the Earth gives to all its parts a centrifugal force, by which the parts receding from the axis endeavour to ascend about the equator; for if it was not higher there, the seas, from the centrifugal force, subsiding about the poles and rising towards the equator, would lay all things there under water.

Bodies acted on at the same time by a centripetal and a centrifugal force, have their power of gravitation lessened.

A falling body moves swifter as it approaches the Earth.

Gravitating bodies move swifter as their gravity increases; and the contrary.

A plummet at the end of a string, or a pendulum, when made to swing, returns to its lowest point by its weight or gravity.

And the slower the vibration of the pendulum is, the less its gravitation.

Consequently, the same pendulum vibrating slower than would arise from its lengthening by heat, shews a decrease of gravity in that pendulum; and as this decrease of gravity became gradually greater in approaching the equator, the Earth must be more prominent there than at the poles; that is, the Earth is a little flatted at the poles.

116. But,

Digitized by Google

116. But, notwithstanding the scientific deductions of this most accurate mathematician, many of the philosophers in France embraced the strange notion of the Earth's being of an oblong figure, the polar diameter being the longer. And as these different notions were supposed to retard the general progress of science in France, their KING resolved that the affair should be determined by actual mensuration at his own expence. Accordingly, about the year 1735, two companies of the most able mathematicians of that nation were appointed; the one to measure a degree of a meridian as near the equator as they could; and the other company to perform a like operation as near the north pole as could be conveniently attempted.

117. For, the Earth being supposed a spheroid, and consequently every meridian an ellipsis, it was known, as a mathematical problem, that the respective measures of a degree of a meridian in each of two known distant latitudes being had, the relation of the diameters could be found: and, that if the measured lengths of those degrees increased towards the pole, the figure would be that of an oblate spheroid, such as *Newton* assigned; otherwise, its figure would be an oblong spheroid, such as was insisted on by *Cassini*. Now the length of a degree of the meridian between Paris and Amiens, or which had its middle point in latitude 49° 22′ N, was understood to be 57060 toises;* having been measured by *Picart*, in 1670, and being re-examined by *Cassini* in 1701. And this length was to be compared with the length of a degree measured at the polar circle and the equator.

118. The gentlemen appointed for the northern expedition were Messieurs *Maupertuis*, *Clairaut*, *Camus*, *le Monnier*, and *Outhier* of France; who were joined by M. *Celsus*, an eminent astronomer in Sweden. The company proceeded to Swedish Lapland, and began their operations in July 1736, which they finished in the following May; and among many other curious and useful particulars they obtained the measure of a degree, the middle point of which was in the latitude of 66° 20′ N., and found it to be 57438,9 toises, when reduced to the level of the sea; and discovered that *the Earth is flatted at the Poles*, the proportion of the equatorial diameter to the polar diameter being as 1 to 0,9891.

119. The other company of gentlemen, who were ordered to the south, consisted of Messieurs *Godin*, *Bouguer*, and *la Condamine*, of France; to whom were joined Don *Jorge Juan*, and Don *Antoine de Ulloa*, of Spain. These mathematicians departed from Europe about the middle of the year 1735, and began their operations, in the province of Quito in Peru, about October, 1736, and finished them in eight Years, after many interruptions. Among the valuable pieces of knowledge resulting from their observations, it appears that *the Earth is flatted at the poles*.

120. The Spanish gentlemen, who published their account separately, assign 56767,8 toises for the measure of a degree of the meridian at the equator, and 266 to 265; or 1 to 0,99624 for the ratio of the equatorial to the polar diameters of the earth.

* A measure containing 6 French feet, or 6 feet $4\frac{8}{10}$ inches English, nearly: the French foot being to the English foot as 1,068 to 1.

Digitized by Google

M. Bouguer gives for the measured length of a degree of the meridian at the equator 56753 toises, when reduced to the level of the sea, and makes the diameter of the equator to that at the poles, as 179 to 178; or as 1 to 0,99441.

M. de la Condamine gives for the measure of a degree under the equator, a length of 56749 toises.

M. De la Caille, being at the *Cape of Good Hope* in 1752, found the length of a degree of the meridian latitude 33° 18½′ S. to be 57037 toises.

In 1755, Father *Boscowich* found the length of a degree in latitude 43° N. to be 56972 toises, as measured between Rome and Rimini in Italy. In the year 1740, Messieurs Cassini, the younger, and De la Caille again examined the former measures in France; and, after making all the necessary corrections, they found the measure of a degree, the middle of which is in 49° 22′ N., to be 57074 toises; and the length of a degree of the meridian in latitude 45° to be 57050 toises.

121. M *de Maupertuis* has added to his narrative of the observations made by himself and his associates in the north, a method of computing the proportion between the polar and equatorial diameters, from the measurements taken in any two different latitudes; but he solves the problem by an approximation only. Among the curious problems communicated by Mr. *Jones* to Mr. *Gardiner*, and published by him in his quarto edition of logarithmic tables, there is the result of a true solution of this problem, but without either analysis or demonstration. While I was intent on an investigation of the solution, Dr. *Pemberton* was pleased to put into my hands a very elegant one of it by his friend Dr. *Letherland*, with leave to communicate it to the public; and I shall accompany it with such other problems, as are requisite for applying this solution to the purposes of navigation, the whole composing the series of problems following.

122. PROBLEM I.

Supposing the Earth to be a spheroid, having its axis less than the equatorial diameter, to find the proportion between the axis and that diameter from measures of a degree of the meridian taken in two different latitudes.

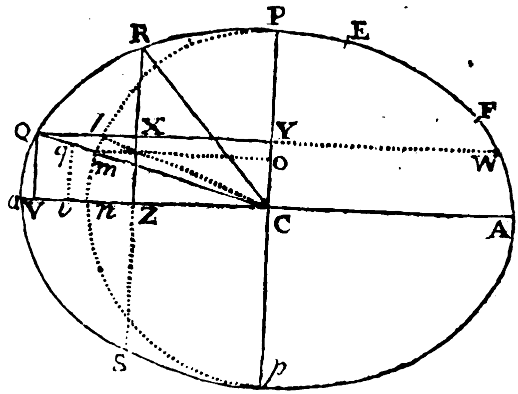
ANALYSIS.

Let aPAp be an ellipsis representing a section of the Earth through its axis Pp; the equatorial diameter, or the greater axis of the ellipsis, being aA; let E and F be two places, where the measure of a degree has been taken: these measures are proportional to the radii of curvature in the ellipsis at those places; and if CQ, CR are conjugates to the diameters, the vertices of which are E and F, CQ will be to CR in the subtriplicate ratio of the radius of curvature in E to the radius of curvature in F *, and therefore in a given ratio one to the other. Then QV

* See Milne's Conic Sect. Cor. I. Prop. IV. Part VI.

and

and RZS being drawn parallel to Pp, and QXYW parallel to aA at the angles QCP, RCP, are the latitudes at E and F; so that these angles, and the ratio of CQ to CR being given, the rectilinear figure CVQXRY is given in species: and the ratio of $VC^q - ZC^q (= QX \times XW)$ to $RZ^q - QV^q (= RX \times XS)$ is given, which is the ratio of CA^q to CP^q. Therefore the ratio of CA to CP is given.



Hence, if the sine and co-sine of the greater latitude be each augmented in the subtriplicate ratio of the measure of the degree in the greater latitude to that in the lesser, then the difference of the squares of the augmented sine, and the sine of the lesser latitude, will be to the difference of the squares of the co-sine of the lesser latitude and the augmented co-sine, in the duplicate ratio of the equatorial to the polar diameter.

For C*q* being taken in CQ equal to CR, and *qv* drawn parallel to QV; C*v* and *vq*, CZ and ZR will be the sines and co-sines of the respective latitudes to the same radius; and CV, VQ will be the augmentations of C*v* and C*q* in the ratio named.

123. Corollary I.

If one of the degrees measured is at the equator, the co-sine of the latitude of the other being augmented in the subtriplicate ratio of the degrees, the tangent of the latitude will be to the tangent answering to the augmented co-sine in the ratio of the greater axis to the lesser.

For supposing the place out of the equator to be E; if the semicircle P *l m n p* be described, and *l*C joined, and *mo* drawn parallel to *a*C; C*o* is the co-sine of the latitude to the radius CP; and CY that co-sine augmented in the ratio named; YQ being to Y*l*, that is, C*a* to C*n* or CP, as the tangent of the angle YCQ; the latitude of the point E, to the tangent of the angle YC*l*, appertaining to the augmented co-sine.

124. Corollary II.

In this case, half the *latus rectum* of the greater axis *a*A, being the radius of curvature in A, is given in magnitude from the degree measured there; and thence the axes themselves will be given in magnitude.

125. Corollary III.

Hence also the proportion of the axes being given from any two measurements, the *latus rectum* of the greater axis, and the axes themselves, will be given in magnitude. For if an angle be taken, the tangent of which

Digitized by Google

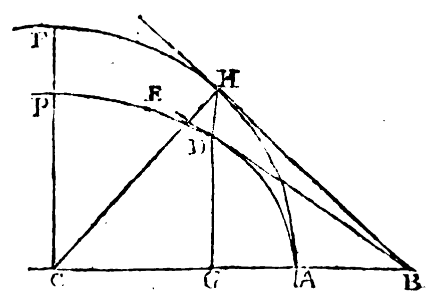
which shall be to the tangent of either latitude, as the lesser axis to the greater, the measure of a degree in that latitude, will be to the measure of a degree at the equator, in the triplicate ratio of the co-sine of this angle to the co-sine of the latitude.

Thus E being one of the places measured, the tangent of the angle YC*l*, will be to the tangent of YCQ, the latitude of the point E, as Y*l* to YQ, that is, as the lesser axis to the greater; and CQ : C*l* : : s, C*l*Y : s, CQY : : *cos.* *l*CY : *cos.* QCY, Q^c being to Cl^c (CP^c) as the radius of curvature in E to the radius of curvature in A, that is, as the measure of a degree in E to the measure of a degree in A.

And thus both the figure and magnitude of the Earth may be deduced from any two measurements given.

126 PROBLEM II.

The Earth being supposed a spheroid, to find the semi-diameter of a parallel to the equator in any given latitude.



Let PDA be one fourth part of an elliptical meridian, where CA, the greater semi-axis, is the radius of the Earth's equator; and let BE be drawn to touch the ellipsis in D, and make with CA an angle CBD equal to the complement of the latitude given; then is D the place on the Earth having the given latitude; and the circular quadrant AF being described with the radius CA, let GDH be drawn parallel to the lesser semi-axis CP of the ellipsis; then BH, CH being joined, BH touches the arch AF in H, and is perpendicular to CH.

Now as GD : GH (that is, CP : CA) : : tang. ∠ GBD : tang. ∠ GBH
: : co-t. latitude : co-t. ∠ GCH.

Hence the angle GCH is given; and radius is to the co-sine of the ∠ GCH, as CH to CG. Whence CG is given, which is equal to the semidiameter of the circle passing through D, parallel to the equator.

127. PROBLEM III.

The spheroidal figure of the Earth being supposed, to measure the elliptic arch corresponding to any given latitude.

M. *Clairaut*, one of the gentlemen engaged in the northern expedition, obliged me, when he was in London, in the year 1753, with the following series for measuring an elliptic arch.

" If in the preceding figure AC be denoted by *a*, CP by *b*, and *aa*—
" *bb* by *cc*; then, S denoting an arch in a circle the radius of which is
" unity,

Digitized by Google

" unity, which will measure the angle GDB, the latitude of the point D,
" AD will be equal to

" $\overline{\frac{b}{a}+\frac{3\,bbcc}{4a^3}+\frac{45\,bbc^4}{64a^5}\,\&c.} \times S - \overline{\frac{3\,bbcc}{8a^3}+\frac{15\,bbc^4}{32a^5}} \times \text{fin. } 2\,S + \frac{15\,bbc^4}{256a^5}$
" $\times$ fin. 4 S &c.

" But in regard to the earth, all the powers of c above cc may be neglected, and the arch AD confidered as equal

" to $\frac{bb\times\overline{4aa+3cc}}{4a^3}\times S - \frac{3b\,bcc}{8a^3}\times \text{fin. } 2S.$

" Or to $\frac{bb\times\overline{4aa+3cc}}{4a^3}\times S - \frac{3bbcc}{8a^3}\times\frac{\text{tabular fine of twice the lat.}}{\text{radius}}$

Whence if a circle be conftituted, the radius of which is $\frac{bb\times\overline{4aa+2cc}}{4a^3}$, then in this circle, the arch which meafures the latitude, will exceed AD by $\frac{3bbcc}{8a^3}\times\frac{\text{tab. fine of twice the lat.}}{\text{radius}}$, that is, this excefs will be to $\frac{3b\,bcc}{8a^3}$, as the fine of twice the latitude to radius.

COROLLARY.

When AD becomes the elliptical quadrant AP, the fine of twice the arch correfponding to the angle GDB vanifhing, AP will be equal to the quadrantal arch of the faid circle, the radius of which is $\frac{bb\times\overline{4aa+3cc}}{4a^3}$.

128. PROBLEM IV.

To find the meridional parts in the chart of Mercator's form for any given latitude, the earth being a fpheroid.

The late Mr. Maclaurin, in his Treatife on Fluxions *, has given this rule for reducing the meridional parts of the fphere to the fpheroid; take an arch the fine of which is to the fine of the latitude, in the proportion of the diftance of the foci in the generating ellipfis, to the greater axis; and diminifh the meridional parts in the fphere by a number, which fhall be to the fpherical meridional parts appertaining to this arch in the fame proportion.

But in the Earth this arch will be fo fmall, that its fine, the arch itfelf, and the fpherical meridional parts, will not differ fenfibly from each other: whence the number to be deducted from the fpherical meridional parts appertaining to the latitude fhall be to the number of minutes contained in the fine of the latitude in the duplicate ratio of the diftance of the foci to the greater axis. Therefore in the preceding propofition c being half the diftance between the foci, the reduction of the meridional parts in the fphere to the fpheroid, will be $\frac{cc}{aa}\times\frac{3437\frac{1}{4}\text{ fin. lat.}}{\text{radius}}$.

* Article 898. See alfo Phil. Tranfact. Vol. 41. page 808.

Or

Or in the figure to Proposition II. $\frac{\overline{CA}^2 - \overline{CP}^2}{\overline{CA}^2} \times \frac{3437\frac{1}{4}\ \text{sin. lat.}}{\text{radius}}$.

Application of these problems to the several measurements above-mentioned.

127. For finding the ratio between the two axes of the Earth by Prob. I. Let E denote the greater, and F the lesser of the two latitudes, M and N. the respective measures taken in each: and let O denote $\sqrt[3]{\frac{M}{N}}$.

Then $\sqrt{\frac{s's',F - O^2 \times s's',E.}{O^2 \times ss,E - ss,F}}$ is $= \frac{\text{lesser axis.}}{\text{greater axis}}$.

Also if M represent the measure in a latitude denoted by E, and N the measure at the equator; let A denote an angle, the measure of which is $\sqrt[3]{\frac{M.}{N}} \times s',E$.

Then $\frac{s,A}{s,E}$ is $= \frac{\text{lesser axis}}{\text{greater axis}}$.

129. The lengths of a degree of a meridian, obtained by actual mensuration in different latitudes, are the following.

Maupertuis and associates in lat.	66° 20′ found	M=57438	toises.
Cassini and De la Caille	49 22	M=57074	
	45 0	M=57050	
Boscowich	43 0	M=56972	
De la Caille	33 18	M=57037	
Juan and Ulloa	at the equator	M=56768	
Bouguer	at the equator	M=56753	
De la Condamine	at the equator	M=56749	

Now by comparing the 1st with each of the following; the 2d with each of the following; and in like manner the 3d, 4th, and 5th, with each of the following, there will arise 25 results, each shewing the relation of those axes or diameters; which results are here annexed to be compared.

I. Comparing the 1st with each of the following.

Putting E for 66° 20′, and F for each of the following. Then log. of O will be=0,0009203; or 0,0009812; or 0,0011793; or 0,0010142; or 0,0016986; or 0,0017368; or 0,0017470. Also $ss,E \times O^2 - ss,F$ =0,2665109; or 0,3426650; or 0,3783127; or 0,5413670. $s's',F - s's',E \times O^2$ =0,2622636; or 0,3381362; or 0,3728667; or 0,5366855.

Also, at the equator, log. s,A=10,3562514; or 10,3561943; or 10,3561372.

And the ratio of the greater axis to the lesser will be found to be as 1 to 0,9919994; or to 0,99337; or to 0,9927763; or to 0,9945213; or to 0,99540025; or to 0,9952717; or to 0,9951407.

II. Putting E for 49° 22′, and F for each of the following. Then log. O will be=0,0000609; or 0,0002589; or 0,0000939; or 0,0007782; or 0,0008165; or 0,0008267.

And the ratio of the greater axis to the leſſer will be found to be as 1 to 0,9981542; or to 0,9946330; or to 0,9992120; or to 0,9968662; or to 0,9967689; or to 0,9966710.

III. Putting E for 45°, and F for each of the following. Then log. of O will be=0,0001980; or 0,0000330; or 0,0007173; or 0,0007556; or 0,0007658.

And the ratio of the greater axis to the leſſer will be found to be as 1 to 0,9870030; or to 0,9996164; or to 0,9967087; or to 0,9965152; or to 0,996467.

IV. Putting E for 43°, and comparing it with the equatorial meaſures (for I do not compare it with that of 33° 18′, becauſe this compariſon would require the Earth to be oblong, contrary to the tenor of the other obſervations,) and it will be found, that the ratio of the greater axis to the leſſer is as 1 to 0,9974272; or 1 to 0,9972334; or 1 to 0,9971849.

V. Putting E for 33° 18′, and comparing it with the equatorial meaſures, it will be found, that the ratio of the greater axis to the leſſer is as 1 to 0,9949364; or 1 to 0,9946205; or 1 to 0,9945677.

The arithmetical means of the ſeveral compariſons are 0,9940688; 0,9946736; 0,9952621; 0,9972818; 0,9947082.

And the mean of all of them is 0,9951989.

130. REMARK.

The latitudes of 49° 22′ and of 45° fall within the meridian line drawn through France, the meaſures of which formerly taken have been re-examined, and corrected, ſince the northern and ſouthern expeditions. If we compare theſe only with thoſe two different meaſurements, that by Mr. Maupertuis and his aſſociates in the north, and that by Bouguer at the equator, the ratio of the greater axis to the leſſer will be reduced to theſe ſix, viz. as 1 to 0,9919994; or 1 to 0,99337; or 1 to 0,9952717; or 1 to 0,9981542; or 1 to 0,9967698; or 1 to 0,9965152.

The arithmetical mean of theſe ratios, viz. of 1 to 0,9953467, may be taken for the ratio of the greater axis to the leſſer; which is as 230 to 228,92974, or very near the ratio aſſigned by Newton.

131. *The proportion of the axes being given, to find their magnitude from a meaſurement at the equator.*

The circular arch equal to the radius is 57,29578 degrees; therefore this number multiplying the meaſure at the equator, gives the radius of curvature there; which is half the *latus rectum* appertaining to the greater axis; and this is to half the leſſer axis in the ratio of the leſſer axis to the greater: hence firſt the leſſer axis, and then the greater will be made known.

Thus, if the greater axis is to the leſſer as 1 to 0,9953467, and the meaſure at the equator 56753 toiſes, as Bouguer has ſtated it, then the leſſer ſemi-axis will be 3266910 toiſes, and the greater 3282183.

132. To

Digitized by Google

132. To find the ſame from a meaſurement taken in any latitude.

If M repreſents the meaſure in a latitude denoted by E, and N the meaſure at the equator, N may be found as follows.

By Corollary III. Problem I. If an angle A be found, ſuch that its tangent may be $= \frac{\text{leſſer axis}}{\text{greater axis}} \times t, E$; N, the meaſure at the equator will be $= M \times \text{cube} \frac{s, E}{s, A}$.

And hence the axes may be known as above.

From the meaſures in the latitudes 66° 20′; 49° 22′; 45°; and at the equator, ſix ratios between the axes were found (130); now each ratio being compared with both of its reſpective latitudes and meaſures, will give nine values of the axes. Thus

The greater ſemi-axis = 3277500, or 3277484, or 3279655, or 3279702, or 3271718, or 3271779, or 3282937, or 3273007, or 3274479.

The leſſer ſemi-axis = 3251278, or 3251263, or 3257911, or 3257958, or 3265678, or 3265704, or 3267414, or 3262430, or 3263053:

The reſpective means will be $\begin{cases} \text{the greater ſemi-axis } 3276473. \\ \text{the leſſer ſemi-axis } 3260299. \end{cases}$

And between theſe and thoſe found at article 130, the means will be for the greater ſemi-axis, 3279328, and for the leſſer 3263604.

And theſe proportioned by the mean ratio of the axis, found art. 130, will give finally, for $\left\{ \begin{array}{ll} \text{the greater ſemi-axis} & 3279328 \\ \text{the leſſer ſemi-axis} & 3264068 \end{array} \right\}$ French toiſes.

133. Hence the Engliſh foot being to the French, as 107 to 114; the greater ſemi-axis will be 3493863 Engliſh fathoms; and the leſſer 3477606 Engliſh fathoms.

And an Engliſh mile conſiſting of 880 fathoms; the greater ſemi-axis will be 3970,298 miles, and the leſſer 3951,824 miles.

134. Since in problem III. the exceſs of the arch of latitude, to the radius $\frac{bb \times \overline{4aa + 3cc}}{4a^3}$, above the correſponding elliptic arch, is to $\frac{3bbcc}{8a^3}$ as the ſine of twice the latitude to radius; and the number of minutes in any arch is equal to the length of that arch multiplied by 3437¾ (the number of minutes in an arch equal to the radius) and divided by the radius of that arch, the number of minutes of the circle, the radius of which is $\frac{bb \times \overline{4aa + 3cc}}{4a^3}$, contained in this exceſs, will be $\frac{3bbcc}{8a^3} \times 3437\frac{3}{4}$ divided by this radius, that is, to $\frac{\frac{3}{2}cc}{4aa + 3cc} \times 3437\frac{3}{4}$, as the ſine of twice the latitude to radius. But a being equal to 230, and $b = 228{,}92974$, $\frac{\frac{3}{2}cc}{4aa + 3cc} \times 3437\frac{3}{4}$ will be equal to 11,887 (nearly 12.)

Therefore the exceſs of the minutes of latitude above the minutes contained in the arch equal to AD of the circle, the ſemi-diameter of which is $\frac{bb \times \overline{4aa + 3cc}}{4a^3}$, will be to 11,887, as the ſine of twice the latitude to radius.

And thus will the arch AD be aſſigned, as meaſured by a log-line adjuſted to the diviſions of the elliptical quadrant into 60 times 90 parts, according to the length aſſigned to this quadrant in the corollary annexed to Problem III.

135. This number to be deducted may alſo be found nearly enough by the traverſe tables, thus: (VII. 66, 67.)

Among the courſes ſeek the double of the given latitude, when under 45°, or the double of the complement of the latitude, when above 45°, and againſt 12 in the column of diſtances take the correſponding departure for the number to be deducted.

In an oblique courſe, the diſtance run between any two latitudes will be to the arch of the meridian contained within thoſe latitudes, as radius to the co-ſine of the courſe.

136. In the next place, in regard to the ſhip's change in longitude on an oblique courſe, the difference between the meridional parts for the ſphere and ſpheroid (by Problem IV.) is to $\frac{\overline{AC}^2 - \overline{CP}^2}{\overline{AC}^2} \times 3437\frac{3}{4}$, as the ſine of the latitude the ſhip arrives at from the equator, to radius.

Therefore, when the equatorial diameter of the earth is to the polar diameter, as 230 to 228,92974, the difference of the ſpheroidal meridional parts from thoſe of the ſphere will be to 31,919, as the ſine of the latitude to radius. But by the conſtitution of the meridian line, the meridional parts expreſs the change of longitude made by a ſhip, whether on the ſphere or ſpheroid, on the rhumb of 45.

And the change of longitude on this rhumb is to the change of longitude on any other rhumb, as the tangent of 45°, that is, the radius, to the tangent of that other rhumb.

137. Moreover, this reduction of the meridional parts from the ſphere to the ſpheroid may be taken nearly from the traverſe tables, thus:

With the given latitude among the courſes, and againſt 32 in the column of diſtances, take the correſponding departure for the reduction.

138. In a courſe due eaſt or weſt at any latitude, the ratio of the radius of that parallel run upon in the ſpheroid, to the ſemi-diameter of the Earth's equator, is found by Problem II. And any diſtance run upon that parallel, meaſured by the log, being reduced to minutes of the Earth's equator; thoſe minutes will be to the change of longitude in minutes, as the radius of that parallel to the ſemi-diameter of the equator.

The preceding precepts will be ſufficiently illuſtrated by the following examples.

139. EXAM. I. *Let it be propoſed to find the diſtance a ſhip ſhall run upon the ſuppoſed elliptical meridian, in increaſing her latitude from 42 to 68 degrees.*

According to article 134, the log-line being adjuſted to a ſphere, the ſemi-diameter of which is $\frac{bb \times 4aa + 3cc}{4a^3}$, the reduction from this ſphere to the ſpheroidal earth will be to 11,887, as the ſine of twice the latitude to radius, and the calculation will proceed thus:

For

For the lat. 42°.

As rad.		10,00000
To *s*,84° (2×42°)		9.99761
So	11,887	1,07507
To the reduction	11,822	1,07268
Minutes in 42°		= 2520,000
reduction		= 11,822
The elliptic arc for 42°		= 2508,178

For the lat. 68°.

As rad.		10,00000
To *s*,136° (2×68°)		9,84177
So	11,887	1,07507
To the reduction	8,257	0,91684
Minutes in 68°		= 4080,000
reduction		= 8,257
The elliptic arc for 68°		= 4071,743

The lesser number deducted from the greater gives 1563,564 for the divisions of the log-line adjusted to the measurement of the elliptic meridian, which are contained between the latitudes of 42° and 68° on the same side of the equator.

Moreover, in the traverse table, under twice 42°, over-against the number 12 in the column of distance, stands in the column of departure, the number 12 for the first correction; and under twice 90°—68°, that is, 44°, stands the number 8 for the second.

140. Exam. II. *Let it be proposed to find the course and distance from the Lizard, in the latitude of* 49° 57′ *N. to Barbadoes, in the latitude of* 13° *N., the difference of longitude being* 54° 36′=3276′.

For the arch of the meridian, the reduction for the greater latitude is 11,71, and for the lesser 5,22. Therefore the latitudes reduced are 2985,29, and 774,78, the difference is 2210,51, which is the measure of the elliptic arch between the two latitudes in the measures of the log-line, adjusted as above.

In the next place the meridional parts are thus calculated.

For the latitude 49° 57′.

As rad.		10,00000
To *s*, lat.	=49 57′	9.88393
So	31,919	1,50405
To the reduction	24,43	1,38798
For the latitude of 49° 57		
The spheric[l]. mer. parts		= 3469,80
reduction		= 24,43
The spheroid[l]. mer. parts		= 3445,37

For the latitude 13° 0′.

As rad.		10,00000
To *s*, lat.	13° 0′	9.35209
So	31,919	1,50405
To the reduction	7,18	0,85614
For the latitude of 13°		
The spheric[l]. mer. parts		= 786,80
reduction		= 7,18
The spheroid[l]. mer. parts		= 779,62

Also under each of the latitudes, in the traverse table the same reductions will be found nearly in the columns of departure over-against the number 32 in the column of distance.

The difference of the numbers 3445,37 and 779,62, being 2665,75, is the meridional parts in the spheroid for the difference of the latitudes. And the meridional diff. lat. in the sphere is 2683,0.

Hence for the course and distance.

In the spheroid.			*But in the sphere*		
Diff. long.	= 3276,0	3,51534	Diff. long.	= 3276,0	3,51534
Mer. parts	= 2665,75	3,42582	Mer. diff. lat.	= 2683,0	3,42862
Tan. course	= 50° 51′ 50″	10,08952	Tang. course	= 50° 41′ 0″	10,08672

For the distance.

In the spheroid.			*In the sphere.*		
Arch of the mer. in min. or miles of the log. line.	2210,51	3,34449	49° 57′ − 13° 0′ = 36° 57′ = 2217 min.		
			Proper diff. lat.	= 2217	3,34577
Co-s. of the course	50° 51′ 50″	9,80014	Co-s. of the course	= 50° 41′	9,80182
Distance in the measures of the log.	3502	3,54435	Dist. in min. of the sphere	= 3499	3,54395

141 Exam. III. *To find the distance of Cape Henry in lat. 37° N. and long. 76° 23′ W. from St. Mary's, nearly in the same latitude, with longitude 22° 56′ W.*

The difference of longitude 53° 27′ = 3207 m.

In the spheroid.				*In the sphere.*	
$\frac{CA}{CP}$ (fig. Prob. II.)	0,00203	Co-s.	9,90307	Co-s. 37°	9,90235
Co-t. latitude	10,12289	Diff. long.	3,50610	Diff. long.	3,50610
Co-t. A.	10,12492	2564½	3,40917	2561¼	3,40845

Thus in the spheroid the parallel in the latitude of 37° contains for 3207 minutes of longitude 2564½ minutes of the equator; and if the logarithm of $\frac{AF}{AP}$ in the figure of Prob. II. (= 0,00101) had been farther added to the logarithm of 2564½, the sum of these logarithms would have been 3,41018, and the arch of the parallel would be found to contain 2571½ minutes, as measured by the log-line; whereas, in the sphere, this portion of the parallel contains 2561¼ minutes of the equator.

142. Remark.

It appears from the preceding reductions, that the course of a ship on the earth, considered as a spheroid, is so near to what it would be on a sphere, the circumference of which is equal to that of one of the elliptical meridians, that with a log-line adjusted to such a sphere, an artist may safely trust to the single rules of globular sailing in his days works, even though his account of course and distance were much more certain than it is possible for them to be. It is therefore unnecessary here to enter into the question, whether the figure of the earth is a genuine spheroid, formed by the revolution of a real ellipsis about its axis, or of some more compounded figure, as Mr. Bouguer, who has discussed this point at large, contends, presuming on the precise accuracy of the several measurements.

143. A

143. A TABLE

OF

MERIDIONAL PARTS

To every Degree and Minute

OF THE

QUADRANT.

Calculated on a Supposition that the Earth is a perfect Sphere.

Where D. l. stands for degree of lat. and M. P. for meridional parts, seek the degrees of latitude at the top or bottom, and the minutes in the right or left hand columns; and the corresponding meridional parts will stand right against the minutes, and in the column signed with the degree proposed.

S 4

Digitized by Google

D. l.	0	1	2	3	4	5	6	7	8	9	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	0,0	60,0	120,0	180,1	240,2	300,4	360,7	421,1	481,6	542,2	0
1	1,0	61,0	121,0	181,1	241,2	301,4	361,7	422,1	482,6	543,3	1
2	2,0	62,0	122,0	182,1	242,2	302,4	362,7	423,1	483,6	544,3	2
3	3,0	63,0	123,0	183,1	243,2	303,4	363,7	424,1	484,6	545,3	3
4	4,0	64,0	124,0	184,1	244,2	304,4	364,7	425,1	485,6	546,3	4
5	5,0	65,0	125,0	185,1	245,2	305,4	365,7	426,1	486,6	547,3	5
6	6,0	66,0	126,0	186,1	246,2	306,4	366,7	427,1	487,6	548,3	6
7	7,0	67,0	127,0	187,1	247,2	307,4	367,7	428,1	488,6	549,3	7
8	8,0	68,0	128,0	188,1	248,2	308,4	368,7	429,1	489,6	550,3	8
9	9,0	69,0	129,0	189,1	249,2	309,4	369,7	430,1	490,7	551,4	9
10	10,0	70,0	130,0	190,1	250,2	310,4	370,7	431,1	491,7	552,4	10
11	11,0	71,0	131,0	191,1	251,2	311,4	371,7	432,1	492,7	553,4	11
12	12,0	72,0	132,0	192,1	252,2	312,4	372,7	433,1	493,7	554,4	12
13	13,0	73,0	133,0	193,1	253,2	313,4	373,7	434,2	494,7	555,4	13
14	14,0	74,0	134,0	194,1	254,2	314,4	374,7	435,2	495,7	556,4	14
15	15,0	75,0	135,0	195,1	255,2	315,4	375,7	436,2	496,7	557,4	15
16	16,0	76,0	136,0	196,1	256,2	316,4	376,8	437,2	497,7	558,4	16
17	17,0	77,0	137,0	197,1	257,2	317,5	377,8	438,2	498,7	559,4	17
18	18,0	78,0	138,0	198,1	258,2	318,5	378,8	439,2	499,8	560,5	18
19	19,0	79,0	139,0	199,1	259,2	319,5	379,8	440,2	500,8	561,5	19
20	20,0	80,0	140,0	200,1	260,2	320,5	380,8	441,2	501,8	562,5	20
21	21,0	81,0	141,0	201,1	261,3	321,5	381,8	442,2	502,8	563,5	21
22	22,0	82,0	142,0	202,1	262,3	322,5	382,8	443,2	503,8	564,5	22
23	23,0	83,0	143,0	203,1	263,3	323,5	383,8	444,2	504,8	565,5	23
24	24,0	84,0	144,0	204,1	264,3	324,5	384,8	445,2	505,8	566,6	24
25	25,0	85,0	145,0	205,1	265,3	325,5	385,8	446,3	506,8	567,6	25
26	26,0	86,0	146,0	206,1	266,3	326,5	386,8	447,3	507,8	568,6	26
27	27,0	87,0	147,0	207,1	267,3	327,5	387,8	448,3	508,9	569,6	27
28	28,0	88,0	148,0	208,1	268,3	328,5	388,8	449,3	509,9	570,6	28
29	29,0	89,0	149,0	209,1	269,3	329,5	389,8	450,3	510,9	571,6	29
30	30,0	90,0	150,0	210,1	270,3	330,5	390,8	451,3	511,9	572,6	30
31	31,0	91,0	151,0	211,1	271,3	331,5	391,8	452,3	512,9	573,7	31
32	32,0	92,0	152,0	212,1	272,3	332,5	392,9	453,3	513,9	574,7	32
33	33,0	93,0	153,1	213,1	273,3	333,5	393,9	454,3	514,9	575,7	33
34	34,0	94,0	154,1	214,1	274,3	334,5	394,9	455,3	515,9	576,7	34
35	35,0	95,0	155,1	215,1	275,3	335,5	395,9	456,3	516,9	577,7	35
36	36,0	96,0	156,1	216,1	276,3	336,5	396,9	457,3	518,0	578,7	36
37	37,0	97,0	157,1	217,1	277,3	337,5	397,9	458,4	519,0	579,7	37
38	38,0	98,0	158,1	218,1	278,3	338,5	398,9	459,4	520,0	580,8	38
39	39,0	99,0	159,1	219,1	279,3	339,6	399,9	460,4	521,0	581,8	39
40	40,0	100,0	160,1	220,2	280,3	340,6	400,9	461,4	522,0	582,8	40
41	41,0	101,0	161,1	221,2	281,3	341,6	401,9	462,4	523,0	583,8	41
42	42,0	102,0	162,1	222,2	282,3	342,6	402,9	463,4	524,0	584,8	42
43	43,0	103,0	163,1	223,2	283,3	343,6	403,9	464,4	525,0	585,8	43
44	44,0	104,0	164,1	224,2	284,3	344,6	404,9	465,4	526,0	586,8	44
45	45,0	105,0	165,1	225,2	285,3	345,6	405,9	466,4	527,1	587,9	45
46	46,0	106,0	166,1	226,2	286,3	346,6	407,0	467,4	528,1	588,9	46
47	47,0	107,0	167,1	227,2	287,3	347,6	408,0	468,4	529,1	589,9	47
48	48,0	108,0	168,1	228,2	288,3	348,6	409,0	469,5	530,1	590,9	48
49	49,0	109,0	169,1	229,2	289,3	349,6	410,0	470,5	531,1	591,9	49
50	50,0	110,0	170,1	230,2	290,3	350,6	411,0	471,5	532,1	592,9	50
51	51,0	111,0	171,1	231,2	291,3	351,6	412,0	472,5	533,1	593,9	51
52	52,0	112,0	172,1	232,2	292,4	352,6	413,0	473,5	534,1	595,0	52
53	53,0	113,0	173,1	233,2	293,4	353,6	414,0	474,5	535,1	596,0	53
54	54,0	114,0	174,1	234,2	294,4	354,6	415,0	475,5	536,2	597,0	54
55	55,0	115,0	175,1	235,2	295,4	355,6	416,0	476,5	537,2	598,0	55
56	56,0	116,0	176,1	236,2	296,4	356,6	417,0	477,5	538,2	599,0	56
57	57,0	117,0	177,1	237,2	297,4	357,6	418,0	478,5	539,2	600,0	57
58	58,0	118,0	178,1	238,2	298,4	358,6	419,0	479,5	540,2	601,0	58
59	59,0	119,0	170,1	239,2	299,4	359,6	420,0	480,5	541,2	602,1	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	0	1	2	3	4	5	6	7	8	9	D. l.

Digitized by Google

D. l.	10	11	12	13	14	15	16	17	18	19	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	603,1	664,1	725,3	786,8	848,5	910,5	972,8	1035,3	1098,2	1161,5	0
1	604,1	665,1	726,4	787,8	849,5	911,5	973,8	1036,3	1099,3	1162,5	1
2	605,1	666,1	727,4	788,8	850,5	912,6	974,8	1037,4	1100,3	1163,6	2
3	606,1	667,1	728,4	789,9	851,6	913,6	975,9	1038,4	1101,4	1164,7	3
4	607,1	668,1	729,4	790,9	852,6	914,6	976,9	1039,5	1102,4	1165,7	4
5	608,2	669,2	730,5	791,9	853,6	915,7	978,0	1040,5	1103,5	1166,8	5
6	609,2	670,2	731,5	792,9	854,7	916,7	979,0	1041,6	1104,5	1167,8	6
7	610,2	671,2	732,5	794,0	855,7	917,7	980,0	1042,6	1105,6	1168,9	7
8	611,2	672,2	733,5	795,0	856,7	918,8	981,1	1043,7	1106,6	1170,0	8
9	612,2	673,2	734,5	796,0	857,8	919,8	982,1	1044,7	1107,7	1171,0	9
10	613,2	674,3	735,6	797,0	858,8	920,8	983,2	1045,8	1108,7	1172,1	10
11	614,2	675,3	736,6	798,1	859,8	921,9	984,2	1046,8	1109,8	1173,1	11
12	615,3	676,3	737,6	799,1	860,9	922,9	985,2	1047,9	1110,8	1174,2	12
13	616,3	677,3	738,6	800,2	861,9	923,9	986,3	1048,9	1111,9	1175,2	13
14	617,3	678,4	739,6	801,2	862,9	925,0	987,3	1049,9	1112,9	1176,3	14
15	618,3	679,4	740,7	802,2	864,0	926,0	988,4	1051,0	1114,0	1177,4	15
16	619,3	680,4	741,7	803,2	865,0	927,0	989,4	1052,0	1115,0	1178,4	16
17	620,3	681,4	742,7	804,2	866,0	928,1	990,4	1053,1	1116,1	1179,5	17
18	621,3	682,4	743,7	805,3	867,1	929,1	991,5	1054,1	1117,1	1180,5	18
19	622,4	683,4	744,8	806,3	868,1	930,1	992,5	1055,2	1118,2	1181,6	19
20	623,4	684,5	745,8	807,3	869,1	931,2	993,6	1056,2	1119,2	1182,7	20
21	624,4	685,5	746,8	808,4	870,1	932,2	994,6	1057,3	1120,3	1183,7	21
22	625,4	686,5	747,8	809,4	871,2	933,2	995,6	1058,3	1121,3	1184,8	22
23	626,4	687,5	748,9	810,4	872,2	934,3	996,7	1059,4	1122,4	1185,8	23
24	627,4	688,5	749,9	811,4	873,2	935,3	997,7	1060,4	1123,4	1186,9	24
25	628,5	689,6	750,9	812,5	874,3	936,3	998,8	1061,4	1124,5	1188,0	25
26	629,5	690,6	751,9	813,5	875,3	937,4	999,8	1062,5	1125,5	1189,0	26
27	630,5	691,6	753,0	814,5	876,3	938,4	1000,8	1063,5	1126,6	1190,1	27
28	631,5	692,6	754,0	815,5	877,4	939,4	1001,9	1064,6	1127,6	1191,1	28
29	632,5	693,6	755,0	816,6	878,4	940,5	1002,9	1065,6	1128,7	1192,2	29
30	633,5	694,7	756,0	817,6	879,4	941,5	1004,0	1066,7	1129,7	1193,2	30
31	634,6	695,7	757,1	818,6	880,5	942,5	1005,0	1067,7	1130,8	1194,3	31
32	635,6	696,7	758,1	819,6	881,5	943,6	1006,1	1068,8	1131,8	1195,4	32
33	636,6	697,7	759,1	820,7	882,5	944,6	1007,1	1069,8	1132,9	1196,4	33
34	637,6	698,7	760,1	821,7	883,6	945,6	1008,1	1070,9	1134,0	1197,5	34
35	638,6	699,8	761,1	822,7	884,6	946,7	1009,2	1072,0	1135,1	1198,5	35
36	639,6	700,8	762,2	823,8	885,6	947,7	1010,2	1073,0	1136,1	1199,6	36
37	640,7	701,8	763,2	824,8	886,7	948,7	1011,3	1074,1	1137,2	1200,7	37
38	641,7	702,8	764,2	825,8	887,7	949,8	1012,3	1075,1	1138,2	1201,7	38
39	642,7	703,8	765,2	826,8	888,7	950,8	1013,4	1076,2	1139,3	1202,8	39
40	643,7	704,9	766,3	827,9	889,8	951,9	1014,4	1077,2	1140,3	1203,9	40
41	644,7	705,9	767,3	828,9	890,8	952,9	1015,4	1078,3	1141,4	1204,9	41
42	645,8	706,9	768,3	829,9	891,8	953,9	1016,5	1079,3	1142,4	1206,0	42
43	646,8	707,9	769,3	831,0	892,9	955,0	1017,5	1080,4	1143,5	1207,1	43
44	647,8	709,0	770,4	832,0	893,9	956,0	1018,6	1081,4	1144,6	1208,1	44
45	648,8	710,0	771,4	833,0	894,9	957,1	1019,6	1082,5	1145,6	1209,2	45
46	649,8	711,0	772,4	834,1	896,0	958,1	1020,6	1083,5	1146,7	1210,2	46
47	650,8	712,0	773,4	835,1	897,0	959,2	1021,7	1084,6	1147,7	1211,3	47
48	651,9	713,0	774,5	836,1	898,0	960,2	1022,7	1085,6	1148,8	1212,4	48
49	652,9	714,1	775,5	837,2	899,1	961,3	1023,8	1086,7	1149,8	1213,4	49
50	653,9	715,1	776,5	838,2	900,1	962,3	1024,8	1087,7	1150,9	1214,5	50
51	654,9	716,1	777,5	839,2	901,1	963,4	1025,9	1088,8	1152,0	1215,5	51
52	655,9	717,1	778,6	840,2	902,2	964,4	1026,9	1089,8	1153,0	1216,6	52
53	657,0	718,2	779,6	841,3	903,2	965,5	1028,0	1090,9	1154,1	1217,7	53
54	658,0	719,2	780,6	842,3	904,3	966,5	1029,0	1091,9	1155,1	1218,7	54
55	659,0	720,2	781,7	843,4	905,3	967,6	1030,1	1093,0	1156,2	1219,8	55
56	660,0	721,2	782,7	844,4	906,3	968,6	1031,1	1094,0	1157,2	1220,9	56
57	661,0	722,3	783,7	845,4	907,4	969,6	1032,2	1095,1	1158,3	1221,9	57
58	662,1	723,3	784,7	846,5	908,4	970,7	1033,2	1096,1	1159,4	1223,0	58
59	663,1	724,3	785,8	847,5	909,4	971,7	1034,3	1097,2	1160,4	1224,1	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	10	11	12	13	14	15	16	17	18	19	D. l.

Digitized by Google

D. l.	20	21	22	23	24	25	26	27	28	29	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min
0	1225,1	1289,2	1353,7	1418,6	1484,1	1550,0	1616,5	1683,5	1751,2	1819,5	0
1	1226,2	1290,3	1354,8	1419,7	1485,2	1551,1	1617,6	1684,6	1752,3	1820,6	1
2	1227,3	1291,3	1355,8	1420,8	1486,3	1552,2	1618,7	1685,8	1753,4	1821,7	2
3	1228,3	1292,4	1356,9	1421,9	1487,3	1553,3	1619,8	1686,9	1754,6	1822,9	3
4	1229,4	1293,5	1358,0	1423,0	1488,4	1554,4	1620,9	1688,0	1755,7	1824,0	4
5	1230,4	1294,5	1359,0	1424,1	1489,5	1555,5	1622,0	1689,1	1756,8	1825,2	5
6	1231,5	1295,6	1360,2	1425,1	1490,6	1556,6	1623,2	1690,3	1758,0	1826,3	6
7	1232,6	1296,7	1361,2	1426,2	1491,7	1557,7	1624,3	1691,4	1759,1	1827,5	7
8	1233,6	1297,8	1362,3	1427,3	1492,8	1558,8	1625,4	1692,5	1760,2	1828,6	8
9	1234,7	1298,8	1363,4	1428,4	1493,9	1559,9	1626,5	1693,6	1761,4	1829,7	9
10	1235,8	1299,9	1364,5	1429,5	1495,0	1561,0	1627,6	1694,8	1762,5	1830,9	10
11	1236,8	1301,0	1365,6	1430,6	1496,1	1562,1	1628,7	1695,9	1763,6	1832,0	11
12	1237,9	1302,0	1366,6	1431,7	1497,2	1563,2	1629,8	1697,0	1764,8	1833,2	12
13	1239,0	1303,1	1367,7	1432,8	1498,3	1564,3	1631,0	1698,1	1765,9	1834,3	13
14	1240,0	1304,2	1368,8	1433,9	1499,4	1565,4	1632,1	1699,3	1767,0	1835,5	14
15	1241,1	1305,3	1369,9	1434,9	1500,5	1566,5	1633,2	1700,4	1768,2	1836,6	15
16	1242,2	1306,3	1370,9	1436,0	1501,6	1567,6	1634,3	1701,5	1769,3	1837,8	16
17	1243,2	1307,4	1372,0	1437,1	1502,7	1568,7	1635,4	1702,6	1770,5	1838,9	17
18	1244,3	1308,5	1373,1	1438,2	1503,8	1569,8	1636,5	1703,8	1771,6	1840,1	18
19	1245 4	1309,6	1374,2	1439,3	1504,9	1571,0	1637,7	1704,9	1772,7	1841,2	19
20	1246,4	1310,6	1375,3	1440,4	1506,0	1572,1	1638,8	1706,0	1773,9	1842,4	20
21	1247,5	1311,7	1376,4	1441,5	1507,1	1573,2	1639,9	1707,1	1775,0	1843,5	21
22	1248,6	1312,8	1377,4	1442,6	1508,2	1574,3	1641,0	1708,3	1776,1	1844,6	22
23	1249,6	1313,8	1378,5	1443,7	1509,3	1575,4	1642,1	1709,4	1777,2	1845,8	23
24	1250,7	1314,9	1379,6	1444,8	1510,4	1576,5	1643,2	1710,5	1778,4	1846,9	24
25	1251,8	1316,0	1380,7	1445,8	1511,5	1577,6	1644,3	1711,6	1779,5	1848,1	25
26	1252,8	1317,1	1381,8	1446,9	1512,6	1578,7	1645,5	1712,8	1780,6	1849,2	26
27	1253,9	1318,1	1382,8	1448,0	1513,7	1579,8	1646,6	1713,9	1781,8	1850,4	27
28	1255,0	1319,2	1383,9	1449,1	1514,8	1580,9	1647,7	1715,0	1783,0	1851,5	28
29	1256,0	1320,3	1385,0	1450,2	1515,9	1582,0	1648,8	1716,1	1784,1	1852,7	29
30	1257,1	1321,4	1386,1	1451,3	1517,0	1583,2	1649,9	1717,3	1785,2	1853,8	30
31	1258,2	1322,5	1387,2	1452,4	1518,1	1584,3	1651,0	1718,4	1786,4	1855,0	31
32	1259,2	1323,5	1388,3	1453,5	1519,2	1585,4	1652,2	1719,5	1787,5	1856,1	32
33	1260,3	1324,6	1389,4	1454,6	1520,3	1586,5	1653,3	1720,7	1788,6	1857,2	33
34	1261,4	1325,7	1390,4	1455,6	1521,4	1587,6	1654,4	1721,8	1789,8	1858,4	34
35	1262,4	1326,7	1391,5	1456,7	1522,5	1588,7	1655,5	1722,9	1790,9	1859,6	35
36	1263,5	1327,8	1392,6	1457,8	1523,6	1589,8	1656,6	1724,0	1792,1	1860,7	36
37	1264,6	1328,9	1393,7	1458,9	1524,7	1590,9	1657,8	1725,2	1793,2	1861,9	37
38	1265,6	1330,0	1394,8	1460,0	1525,8	1592,0	1658,9	1726,3	1794,3	1863,0	38
39	1266,7	1331,0	1395,8	1461,1	1526,9	1593,2	1600,0	1727,4	1795,5	1864,2	39
40	1267,8	1332,1	1396,9	1462,2	1528,0	1594,3	1661,1	1728,6	1796,6	1865,3	40
41	1268,8	1333,2	1398,0	1463,3	1529,1	1595,4	1662,2	1729,7	1797,8	1866,5	41
42	1269,9	1334,3	1399,1	1464,4	1530,2	1596,5	1663,4	1730,8	1798,9	1867,6	42
43	1271,0	1335,3	1400,2	1465,5	1531,3	1597,6	1664,5	1731,9	1800,0	1868,8	43
44	1272,1	1336,4	1401,3	1466,6	1532,4	1598,7	1665,6	1733,1	1801,2	1869,9	44
45	1273,1	1337,5	1402,4	1467,7	1533,5	1599,8	1666,7	1734,2	1802,3	1871,1	45
46	1274,2	1338,6	1403,4	1468,8	1534,6	1600,9	1667,8	1735,3	1803,5	1872,2	46
47	1275,3	1339,7	1404,5	1469,8	1535,7	1602,0	1669,0	1736,5	1804,6	1873,4	47
48	1276,3	1340,7	1405,6	1470,9	1536,8	1603,1	1670,1	1737,6	1805,7	1874,5	48
49	1277,4	1341,8	1406,7	1472,0	1537,9	1604,3	1671,2	1738,7	1806,9	1875,7	49
50	1278,5	1342,9	1407,8	1473,1	1539,0	1605,4	1672,3	1739,9	1808,0	1876,8	50
51	1279,5	1344,0	1408,8	1474,2	1540,1	1606,5	1673,4	1741,0	1809,2	1878,0	51
52	1280,6	1345,1	1409,9	1475,3	1541,2	1607,6	1674,5	1742,1	1810,3	1879,2	52
53	1281,7	1346,1	1411,0	1476,4	1542,3	1608,7	1675,7	1743,2	1811,4	1880,3	53
54	1282,8	1347,2	1412,1	1477,5	1543,4	1609,8	1676,8	1744,4	1812,6	1881,5	54
55	1283,8	1348,3	1413,2	1478,6	1544,5	1610,9	1678,0	1745,5	1813,7	1882,6	55
56	1284,9	1349,4	1414,3	1479,7	1545,6	1612,0	1679,1	1746,6	1814,9	1883,8	56
57	1286,0	1350,4	1415,4	1480,8	1546,7	1613,1	1680,2	1747,8	1816,0	1884,9	57
58	1287,0	1351,5	1416,5	1481,9	1547,8	1614,2	1681,3	1748,9	1817,2	1886,1	58
59	1288,1	1352,6	1417,6	1483,0	1548,9	1615,4	1682,4	1750,0	1818,3	1887,2	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	20	21	22	23	24	25	26	27	28	29	D. l.

Digitized by Google

D. l.	30	31	32	33	34	35	36	37	38	39	D. l.
min.	M. P	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P	M. P.	min.
0	1888,4	1958,0	2028,4	2099,6	2171,5	2244,3	2318,0	2392,7	2468,3	2545,0	0
1	1889,5	1959,2	2029,6	2100,7	2172,7	2245,5	2319,3	2393,9	2469,6	2546,2	1
2	1890,7	1960,4	2030,7	2101,9	2173,9	2246,8	2320,5	2395,2	2470,8	2547,5	2
3	1891,9	1961,6	2031,9	2103,1	2175,1	2248,0	2321,7	2396,4	2472,1	2548,8	3
4	1893,0	1962,7	2033,1	2104,3	2176,3	2249,2	2323,0	2397,7	2473,4	2550,1	4
5	1894,1	1963,9	2034,3	2105,5	2177,5	2250,4	2324,2	2398,9	2474,6	2551,4	5
6	1895,3	1965,0	2035,5	2106,7	2178,7	2251,6	2325,4	2400,2	2475,9	2552,7	6
7	1896,5	1966,2	2036,7	2107,9	2180,0	2252,9	2326,7	2401,4	2477,1	2554,0	7
8	1897,6	1967,4	2037,8	2109,1	2181,2	2254,1	2327,9	2402,7	2478,5	2555,3	8
9	1898,8	1968,5	2039,0	2110,3	2182,4	2255,3	2329,2	2403,9	2479,7	2556,6	9
10	1899,9	1969,7	2040,2	2111,5	2183,6	2256,5	2330,4	2405,2	2481,0	2557,8	10
11	1901,1	1970,9	2041,4	2112,7	2184,8	2257,8	2331,6	2406,4	2482,3	2559,1	11
12	1902,3	1972,0	2042,6	2113,9	2186,0	2259,0	2332,9	2407,7	2483,5	2560,4	12
13	1903,4	1973,2	2043,8	2115,1	2187,2	2260,2	2334,1	2409,0	2484,8	2561,7	13
14	1904,6	1974,4	2044,9	2116,3	2188,4	2261,4	2335,3	2410,2	2486,1	2563,0	14
15	1905,7	1975,6	2046,1	2117,5	2189,6	2262,7	2336,6	2411,5	2487,4	2564,3	15
16	1906,9	1976,8	2047,3	2118,7	2190,8	2263,9	2337,8	2412,7	2488,6	2565,6	16
17	1908,1	1977,9	2048,5	2119,8	2192,0	2265,1	2339,0	2414,0	2489,9	2566,9	17
18	1909,2	1979,1	2049,7	2121,0	2193,3	2266,3	2340,3	2415,2	2491,2	2568,2	18
19	1910,4	1980,3	2050,8	2122,2	2194,5	2267,6	2341,5	2416,5	2492,5	2569,5	19
20	1911,5	1981,4	2052,0	2123,4	2195,7	2268,8	2342,8	2417,8	2493,7	2570,7	20
21	1912,7	1982,6	2053,2	2124,6	2196,9	2270,0	2344,0	2419,0	2495,0	2572,0	21
22	1913,8	1983,7	2054,4	2125,8	2198,1	2271,2	2345,3	2420,3	2496,3	2573,3	22
23	1915,0	1984,9	2055,6	2127,0	2199,3	2272,5	2346,5	2421,5	2497,6	2574,6	23
24	1916,2	1986,1	2056,8	2128,2	2200,5	2273,7	2347,8	2422,8	2498,8	2575,9	24
25	1917,3	1987,3	2058,0	2129,4	2201,7	2274,9	2349,0	2424,0	2500,1	2577,2	25
26	1918,5	1988,4	2059,1	2130,6	2203,0	2276,1	2350,2	2425,3	2501,4	2578,5	26
27	1919,6	1989,6	2060,3	2131,8	2204,2	2277,4	2351,5	2426,5	2502,7	2579,7	27
28	1920,8	1990,8	2061,5	2133,0	2205,4	2278,6	2352,7	2427,8	2503,9	2581,1	28
29	1921,9	1992,0	2062,7	2134,2	2206,6	2279,8	2354,0	2429,1	2505,2	2582,4	29
30	1923,1	1993,1	2063,9	2135,4	2207,8	2281,0	2355,2	2430,3	2506,5	2583,7	30
31	1924,3	1994,3	2065,1	2136,6	2209,0	2282,3	2356,5	2431,6	2507,8	2585,0	31
32	1925,4	1995,5	2066,2	2137,8	2210,2	2283,5	2357,7	2432,9	2509,0	2586,3	32
33	1926,6	1996,6	2067,4	2139,0	2211,4	2284,7	2358,9	2434,1	2510,3	2587,6	33
34	1927,8	1997,8	2068,6	2140,2	2212,7	2286,0	2360,2	2435,4	2511,6	2588,9	34
35	1928,9	1999,0	2069,8	2141,4	2213,9	2287,2	2361,4	2436,7	2512,9	2590,2	35
36	1930,1	2000,2	2071,0	2142,6	2215,1	2288,4	2362,7	2437,9	2514,2	2591,5	36
37	1931,3	2001,3	2072,2	2143,8	2216,3	2289,7	2363,9	2439,2	2515,4	2592,8	37
38	1932,4	2002,5	2073,4	2145,0	2217,5	2290,9	2365,2	2440,4	2516,7	2594,1	38
39	1933,6	2003,7	2074,6	2146,2	2218,7	2292,1	2366,4	2441,7	2518,0	2595,4	39
40	1934,7	2004,9	2075,7	2147,4	2219,9	2293,3	2367,7	2443,0	2519,3	2596,7	40
41	1935,9	2006,0	2076,9	2148,6	2221,2	2294,6	2368,9	2444,2	2520,6	2598,0	41
42	1937,1	2007,2	2078,1	2149,8	2222,4	2295,8	2370,2	2445,5	2521,8	2599,3	42
43	1938,2	2008,4	2079,3	2151,0	2223,6	2297,0	2371,4	2446,8	2523,1	2600,6	43
44	1939,4	2009,6	2080,5	2152,2	2224,8	2298,3	2372,7	2448,0	2524,4	2601,9	44
45	1940,5	2010,7	2081,7	2153,4	2226,0	2299,5	2373,9	2449,3	2525,7	2603,2	45
46	1941,7	2011,9	2082,9	2154,6	2227,2	2300,7	2375,2	2450,6	2527,0	2604,5	46
47	1942,9	2013,1	2084,1	2155,8	2228,5	2302,0	2376,4	2451,8	2528,3	2605,8	47
48	1944,0	2014,3	2085,3	2157,0	2229,7	2303,2	2377,7	2453,1	2529,5	2607,1	48
49	1945,2	2015,4	2086,5	2158,2	2230,9	2304,4	2378,9	2454,3	2530,8	2608,4	49
50	1946,4	2016,6	2087,7	2159,4	2232,1	2305,7	2380,1	2455,6	2532,1	2609,7	50
51	1947,5	2017,8	2088,9	2160,7	2233,3	2306,9	2381,4	2456,9	2533,4	2611,0	51
52	1948,7	2019,0	2090,1	2161,9	2234,6	2308,1	2382,6	2458,1	2534,7	2612,3	52
53	1940,9	2020,2	2091,3	2163,1	2235,8	2309,4	2383,9	2459,4	2536,0	2613,6	53
54	1951,0	2021,3	2092,5	2164,3	2237,0	2310,6	2385,1	2460,7	2537,2	2614,9	54
55	1952,2	2022,5	2093,7	2165,5	2238,2	2311,8	2386,4	2461,9	2538,5	2616,2	55
56	1953,4	2023,7	2094,9	2166,7	2239,4	2313,1	2387,6	2463,2	2539,8	2617,5	56
57	1954,5	2024,9	2096,1	2167,9	2240,7	2314,3	2388,9	2464,5	2541,1	2618,8	57
58	1955,7	2026,0	2097,3	2169,1	2241,9	2315,5	2390,2	2465,8	2542,4	2620,1	58
59	1956,9	2027,2	2098,5	2170,3	2243,1	2316,7	2391,4	2467,0	2543,7	2621,4	59
min.	M. P.	M. P.	M. P.	M. P	M. P	M. P.	M. P.	M. P	M. P	M. P.	min.
D. l.	30	31	32	33	34	35	36	37	38	39	D. l.

Digitized by Google

D. l.	40	41	42	43	44	45	46	47	48	49	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	2622,7	2701,6	2781,7	2863,1	2945,7	3030,0	3115,6	3202,8	3291,6	3382,1	0
1	2624,0	2702,9	2783,1	2864,5	2947,2	3031,4	3117,0	3204,2	3293,1	3383,6	1
2	2625,3	2704,3	2784,4	2865,8	2948,6	3032,8	3118,5	3205,7	3294,6	3385,2	2
3	2626,6	2705,6	2785,8	2867,2	2950,0	3034,2	3119,9	3207,2	3296,1	3386,7	3
4	2627,9	2706,9	2787,1	2868,5	2951,4	3035,6	3121,4	3208,6	3297,5	3388,2	4
5	2629,2	2708,3	2788,5	2870,0	2952,8	3037,0	3122,8	3210,1	3299,0	3389,7	5
6	2630,5	2709,6	2789,8	2871,3	2954,2	3038,4	3124,2	3211,6	3300,5	3391,3	6
7	2631,9	2710,9	2791,2	2872,7	2955,6	3039,8	3125,7	3213,0	3302,0	3392,8	7
8	2633,2	2712,2	2792,5	2874,1	2957,0	3041,3	3127,1	3214,5	3303,5	3394,3	8
9	2634,5	2713,6	2793,8	2875,4	2958,4	3042,7	3128,6	3216,0	3305,0	3395,9	9
10	2635,8	2714,9	2795,1	2876,8	2959,8	3044,1	3130,0	3217,4	3306,5	3397,4	10
11	2637,1	2716,2	2796,5	2878,2	2961,1	3045,5	3131,5	3218,9	3308,0	3398,9	11
12	2638,4	2717,5	2797,9	2879,5	2962,5	3047,0	3132,9	3220,4	3309,5	3400,4	12
13	2639,7	2718,9	2799,3	2880,9	2963,9	3048,4	3134,3	3221,9	3311,0	3402,0	13
14	2641,0	2720,2	2800,6	2882,3	2965,3	3049,8	3135,8	3223,3	3312,5	3403,5	14
15	2642,3	2721,5	2802,0	2883,7	2966,7	3051,2	3137,2	3224,8	3314,0	3405,0	15
16	2643,6	2722,9	2803,3	2885,0	2968,1	3052,6	3138,7	3226,3	3315,5	3406,6	16
17	2644,9	2724,2	2804,7	2886,4	2969,5	3054,1	3140,1	3227,7	3317,0	3408,1	17
18	2646,3	2725,5	2806,0	2887,8	2970,9	3055,5	3141,6	3229,2	3318,5	3409,6	18
19	2647,6	2726,9	2807,4	2889,2	2972,3	3056,9	3143,0	3230,7	3320,0	3411,2	19
20	2648,9	2728,2	2808,8	2890,5	2973,7	3058,3	3144,5	3232,2	3321,5	3412,7	20
21	2650,2	2729,5	2810,1	2891,9	2975,1	3059,7	3145,9	3233,6	3323,1	3414,2	21
22	2651,5	2730,8	2811,4	2893,3	2976,5	3061,2	3147,4	3235,1	3324,6	3415,8	22
23	2652,8	2732,2	2812,8	2894,7	2977,9	3062,6	3148,8	3236,6	3326,1	3417,3	23
24	2654,1	2733,5	2814,1	2896,0	2979,3	3064,0	3150,3	3238,1	3327,6	3418,8	24
25	2655,5	2734,8	2815,5	2897,4	2980,7	3065,4	3151,7	3239,5	3329,1	3420,4	25
26	2656,8	2736,2	2816,8	2898,8	2982,1	3066,9	3153,2	3241,0	3330,6	3421,9	26
27	2658,1	2737,5	2818,2	2900,2	2983,5	3068,3	3154,6	3242,5	3332,1	3423,5	27
28	2659,4	2738,8	2819,5	2901,5	2984,9	3069,7	3156,1	3244,0	3333,6	3425,0	28
29	2660,7	2740,2	2820,9	2902,9	2986,3	3071,1	3157,5	3245,5	3335,1	3426,5	29
30	2662,0	2741,5	2822,3	2904,3	2987,7	3072,6	3159,0	3246,9	3336,6	3428,1	30
31	2663,3	2742,9	2823,6	2905,7	2989,1	3074,0	3160,4	3248,4	3338,1	3429,6	31
32	2664,6	2744,2	2825,0	2907,1	2990,5	3075,4	3161,9	3249,9	3339,6	3431,2	32
33	2666,0	2745,5	2826,3	2908,4	2991,9	3076,9	3163,3	3251,4	3341,1	3432,7	33
34	2667,3	2746,9	2827,7	2909,7	2993,3	3078,3	3164,8	3252,9	3342,7	3434,2	34
35	2668,6	2748,2	2829,0	2911,2	2994,7	3079,7	3166,2	3254,4	3344,2	3435,8	35
36	2669,9	2749,5	2830,4	2912,6	2996,1	3081,1	3167,7	3255,8	3345,7	3437,3	36
37	2671,2	2750,9	2831,8	2914,0	2997,5	3082,6	3169,1	3257,3	3347,2	3438,9	37
38	2672,5	2752,2	2833,1	2915,3	2998,9	3084,0	3170,6	3258,8	3348,7	3440,4	38
39	2673,9	2753,5	2834,5	2916,7	3000,3	3085,4	3172,1	3260,3	3350,1	3442,0	39
40	2675,1	2754,9	2835,8	2918,1	3001,8	3086,9	3173,5	3261,8	3351,7	3443,5	40
41	2676,5	2756,2	2837,2	2919,5	3003,2	3088,3	3175,0	3263,3	3353,2	3445,0	41
42	2677,8	2757,6	2838,6	2920,9	3004,6	3089,7	3176,4	3264,7	3354,8	3446,6	42
43	2679,1	2758,9	2839,9	2922,3	3006,0	3091,2	3177,9	3266,2	3356,3	3448,1	43
44	2680,5	2760,2	2841,3	2923,6	3007,4	3092,6	3179,3	3267,7	3357,8	3449,7	44
45	2681,8	2761,5	2842,6	2925,0	3008,8	3094,0	3180,8	3269,2	3359,3	3451,2	45
46	2683,1	2762,9	2844,0	2926,4	3010,2	3095,5	3182,3	3270,7	3360,8	3452,8	46
47	2684,4	2764,3	2845,4	2927,8	3011,6	3096,9	3183,7	3272,2	3362,3	3454,3	47
48	2685,7	2765,6	2846,7	2929,2	3013,0	3098,3	3185,2	3273,7	3363,9	3455,9	48
49	2687,1	2766,9	2848,1	2930,6	3014,4	3099,8	3186,6	3275,2	3365,4	3457,4	49
50	2688,4	2768,3	2849,5	2932,0	3015,8	3101,2	3188,1	3276,6	3366,9	3459,0	50
51	2689,7	2769,6	2850,8	2933,3	3017,2	3102,6	3189,6	3278,1	3368,4	3460,5	51
52	2691,0	2771,0	2852,2	2934,7	3018,7	3104,1	3191,0	3279,6	3369,9	3462,1	52
53	2692,3	2772,3	2853,6	2936,1	3020,1	3105,6	3192,5	3281,1	3371,5	3463,6	53
54	2693,7	2773,7	2854,9	2937,5	3021,5	3107,0	3194,0	3282,6	3373,0	3465,2	54
55	2695,0	2775,0	2856,3	2938,9	3022,9	3108,4	3195,4	3284,1	3374,5	3466,7	55
56	2696,3	2776,4	2857,7	2940,3	3024,3	3109,8	3196,9	3285,6	3376,0	3468,3	56
57	2697,6	2777,7	2859,1	2941,7	3025,7	3111,2	3198,4	3287,1	3377,6	3469,8	57
58	2699,0	2779,0	2860,5	2943,1	3027,1	3112,7	3199,8	3288,6	3379,1	3471,4	58
59	2700,3	2780,4	2861,8	2944,4	3028,5	3114,1	3201,3	3290,1	3380,6	3473,0	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P	min.
D. l.	40	41	42	43	44	45	46	47	48	49	D. l.

Digitized by Google

D. l.	50	51	52	53	54	55	56	57	58	59	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	3474,5	3568,8	3665,2	3763,8	3864,7	3968,0	4073,9	4182,6	4294,3	4409,2	0
1	3476,1	3570,4	3666,9	3765,5	3866,4	3969,7	4075,7	4184,5	4296,2	4411,1	1
2	3477,6	3572,0	3668,5	3767,1	3868,1	3971,5	4077,5	4186,3	4298,1	4413,1	2
3	3479,2	3573,6	3670,1	3768,8	3869,8	3973,2	4079,3	4188,2	4300,0	4415,0	3
4	3480,7	3575,2	3671,7	3770,4	3871,5	3975,0	4081,1	4190,0	4301,9	4417,0	4
5	3482,3	3576,8	3673,4	3772,1	3873,2	3976,7	4082,9	4191,8	4303,8	4418,9	5
6	3483,9	3578,4	3675,0	3773,8	3874,9	3978,4	4084,7	4193,7	4305,7	4420,8	6
7	3485,4	3580,0	3676,6	3775,4	3876,6	3980,2	4086,5	4195,5	4307,6	4422,8	7
8	3487,0	3581,6	3678,2	3777,1	3878,3	3982,0	4088,3	4197,4	4309,5	4424,7	8
9	3488,5	3583,2	3679,9	3778,8	3880,0	3983,7	4090,1	4199,2	4311,4	4426,7	9
10	3490,1	3584,8	3681,5	3780,4	3881,7	3985,5	4091,9	4201,1	4313,2	4428,6	10
11	3491,7	3586,4	3683,1	3782,1	3883,4	3987,2	4093,7	4202,9	4315,1	4430,6	11
12	3493,2	3588,0	3684,8	3783,8	3885,1	3989,0	4095,5	4204,7	4317,0	4432,5	12
13	3494,8	3589,5	3686,4	3785,5	3886,8	3990,7	4097,3	4206,6	4318,9	4434,5	13
14	3496,3	3591,1	3688,0	3787,1	3888,6	3992,5	4099,1	4208,4	4320,8	4436,4	14
15	3497,9	3592,7	3689,7	3788,8	3890,3	3994,2	4100,9	4210,3	4322,7	4438,4	15
16	3599,5	3594,3	3691,3	3790,5	3892,0	3996,0	4102,7	4212,1	4324,6	4440,4	16
17	3501,0	3595,9	3692,9	3792,1	3893,7	3997,7	4104,5	4214,0	4326,5	4442,3	17
18	3502,6	3597,5	3694,6	3793,8	3895,4	3999,5	4106,3	4215,8	4328,4	4444,3	18
19	3504,2	3599,1	3696,2	3795,5	3897,1	4001,3	4108,1	4217,7	4330,3	4446,2	19
20	3505,7	3600,7	3697,8	3797,2	3898,8	4003,0	4109,9	4219,5	4332,2	4448,2	20
21	3507,3	3602,3	3699,5	3798,8	3900,5	4004,8	4111,7	4221,4	4334,2	4450,2	21
22	3508,9	3603,9	3701,1	3800,5	3902,3	4006,5	4113,5	4223,2	4336,1	4452,1	22
23	3510,5	3605,5	3702,7	3802,2	3904,0	4008,3	4115,3	4225,1	4338,0	4454,1	23
24	3512,0	3607,1	3704,4	3803,9	3905,7	4010,0	4117,1	4227,0	4339,9	4456,0	24
25	3513,6	3608,7	3706,0	3805,5	3907,4	4011,8	4118,9	4228,8	4341,8	4458,0	25
26	3515,1	3610,3	3707,7	3807,2	3909,1	4013,6	4120,7	4230,7	4343,7	4460,0	26
27	3516,7	3611,9	3709,3	3808,9	3910,9	4015,3	4122,5	4232,5	4345,6	4461,9	27
28	3518,3	3613,6	3710,9	3810,6	3912,6	4017,1	4124,3	4234,4	4347,5	4463,9	28
29	3519,8	3615,2	3712,6	3812,3	3914,3	4018,9	4126,1	4236,2	4349,4	4465,9	29
30	3521,4	3616,8	3714,2	3813,9	3916,0	4020,6	4127,9	4238,1	4351,3	4467,8	30
31	3523,0	3618,4	3715,9	3815,6	3917,7	4022,4	4129,7	4240,0	4353,2	4469,8	31
32	3524,6	3620,0	3717,5	3817,3	3919,5	4024,2	4131,6	4241,8	4355,2	4471,8	32
33	3526,1	3621,6	3719,2	3819,0	3921,2	4025,9	4133,4	4243,7	4357,1	4473,8	33
34	3527,7	3623,2	3720,8	3820,7	3922,9	4027,7	4135,2	4245,6	4359,0	4475,7	34
35	3529,3	3624,8	3722,4	3822,3	3924,6	4029,5	4137,0	4247,4	4360,9	4477,7	35
36	3530,9	3626,4	3724,1	3824,0	3926,4	4031,2	4138,8	4249,3	4362,8	4479,7	36
37	3532,4	3628,0	3725,7	3825,7	3928,1	4033,0	4140,6	4251,2	4364,8	4481,7	37
38	3534,0	3629,6	3727,4	3827,4	3929,8	4034,8	4142,5	4253,0	4366,7	4483,6	38
39	3535,6	3631,3	3729,0	3829,1	3931,5	4036,6	4144,3	4254,9	4368,6	4485,6	39
40	3537,2	3632,9	3730,7	3830,8	3933,3	4038,3	4146,1	4256,8	4370,5	4487,6	40
41	3538,8	3634,5	3732,3	3832,5	3935,0	4040,1	4147,9	4258,6	4372,5	4489,6	41
42	3540,3	3636,1	3734,0	3834,2	3936,7	4041,9	4149,7	4260,5	4374,4	4491,6	42
43	3541,9	3637,7	3735,6	3835,8	3938,5	4043,6	4151,6	4262,4	4376,3	4493,5	43
44	3543,5	3639,3	3737,3	3837,5	3940,2	4045,4	4153,4	4264,3	4378,2	4495,5	44
45	3545,1	3640,9	3738,9	3839,2	3941,9	4047,2	4155,2	4266,1	4380,1	4497,5	45
46	3546,7	3642,5	3740,6	3840,9	3943,7	4049,0	4157,0	4268,0	4382,1	4499,5	46
47	3548,2	3644,2	3742,2	3842,6	3945,4	4050,8	4158,8	4269,9	4384,0	4501,5	47
48	3549,8	3645,8	3743,9	3844,3	3947,1	4052,5	4160,7	4271,8	4385,9	4503,5	48
49	3551,4	3647,4	3745,6	3846,0	3948,9	4054,3	4162,5	4273,6	4387,9	4505,5	49
50	3553,0	3649,0	3747,2	3847,7	3950,6	4056,1	4164,3	4275,5	4389,8	4507,5	50
51	3554,6	3650,6	3748,9	3849,4	3952,3	4057,9	4166,2	4277,4	4391,7	4509,4	51
52	3556,1	3652,3	3750,5	3851,1	3954,1	4059,7	4168,0	4279,3	4393,7	4511,4	52
53	3557,7	3653,9	3752,2	3852,8	3955,8	4061,4	4169,8	4281,1	4395,6	4513,4	53
54	3559,3	3655,5	3753,8	3854,5	3957,6	4063,2	4171,7	4283,0	4397,5	4515,4	54
55	3560,9	3657,1	3755,5	3856,2	3959,3	4065,0	4173,5	4284,9	4399,5	4517,4	55
56	3562,5	3658,7	3757,2	3857,9	3961,0	4066,8	4175,3	4286,8	4401,4	4519,4	56
57	3564,1	3660,4	3758,8	3859,6	3962,8	4068,6	4177,2	4288,7	4403,4	4521,4	57
58	3565,7	3662,0	3760,5	3861,3	3964,5	4070,4	4179,0	4290,6	4405,3	4523,4	58
59	3567,3	3663,6	3762,2	3863,0	3966,3	4072,1	4180,8	4292,5	4407,2	4525,4	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	50	51	52	53	54	55	56	57	58	59	D. l.

Digitized by Google

D. l.	60	61	62	63	64	65	66	67	68	69	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	4527,4	4649,2	4775,0	4905,0	5039,4	5178,8	5323,6	5474,0	5630,9	5794,6	0
1	4529,4	4651,3	4777,1	4907,2	5041,7	5181,2	5326,0	5476,6	5633,5	5797,4	1
2	4531,4	4653,4	4779,3	4909,4	5044,0	5183,6	5328,5	5479,2	5636,2	5800,2	2
3	4533,4	4655,5	4781,4	4911,6	5046,3	5186,0	5330,9	5481,7	5638,9	5803,0	3
4	4535,4	4657,5	4783,5	4913,8	5048,6	5188,3	5333,4	5484,3	5641,5	5805,8	4
5	4537,4	4659,6	4785,7	4916,0	5050,8	5190,7	5335,9	5486,9	5644,2	5808,6	5
6	4539,4	4661,7	4787,8	4918,2	5053,2	5193,1	5338,3	5489,4	5646,9	5811,4	6
7	4541,4	4663,7	4790,0	4920,4	5055,5	5195,4	5340,8	5492,0	5649,6	5814,2	7
8	4543,4	4665,8	4792,1	4922,6	5057,7	5197,8	5343,3	5494,6	5652,3	5817,0	8
9	4545,4	4667,9	4794,2	4924,8	5060,0	5200,2	5345,7	5497,1	5655,0	5819,8	9
10	4547,5	4669,9	4796,4	4927,1	5062,3	5202,6	5348,2	5499,7	5657,6	5822,6	10
11	4549,5	4672,0	4798,5	4929,3	5064,6	5205,0	5350,7	5502,3	5660,3	5825,4	11
12	4551,5	4674,1	4800,7	4931,5	5066,9	5207,3	5353,2	5504,9	5663,0	5828,2	12
13	4553,5	4676,2	4802,8	4933,7	5069,2	5209,7	5355,6	5507,4	5665,7	5831,0	13
14	4555,5	4678,2	4804,9	4935,9	5071,5	5212,1	5358,1	5510,0	5668,4	5833,9	14
15	4557,5	4680,3	4807,1	4938,1	5073,8	5214,5	5360,6	5512,6	5671,1	5836,7	15
16	4559,5	4682,4	4809,2	4940,4	5076,1	5216,9	5363,1	5515,2	5673,8	5839,5	16
17	4561,5	4684,5	4811,4	4942,6	5078,4	5219,3	5365,6	5517,8	5676,5	5842,3	17
18	4563,6	4686,6	4813,5	4944,8	5080,7	5221,7	5368,1	5520,4	5679,2	5845,2	18
19	4565,6	4688,6	4815,7	4947,0	5083,0	5224,1	5370,5	5523,0	5681,9	5848,0	19
20	4567,6	4690,7	4817,8	4949,3	5085,3	5226,5	5373,0	5525,6	5684,6	5850,8	20
21	4569,6	4692,8	4820,0	4951,5	5087,7	5228,9	5375,5	5528,2	5687,3	5853,7	21
22	4571,6	4694,9	4822,2	4953,7	5090,0	5231,3	5378,0	5530,8	5690,0	5856,5	22
23	4573,7	4697,0	4824,3	4956,0	5092,3	5233,7	5380,5	5533,4	5692,8	5859,3	23
24	4575,7	4699,1	4826,5	4958,2	5094,6	5236,1	5383,0	5536,0	5695,5	5862,2	24
25	4577,7	4701,2	4828,6	4960,4	5096,9	5238,5	5385,5	5538,6	5698,2	5865,0	25
26	4579,7	4703,2	4830,8	4962,7	5099,2	5240,9	5388,0	5541,2	5700,9	5867,9	26
27	4581,8	4705,3	4832,9	4964,9	5101,5	5243,3	5390,5	5543,8	5703,6	5870,7	27
28	4583,8	4707,4	4835,1	4967,1	5103,9	5245,7	5393,0	5546,4	5706,3	5873,5	28
29	4585,8	4709,5	4837,3	4969,4	5106,2	5248,1	5395,5	5549,0	5709,1	5876,4	29
30	4587,8	4711,6	4839,4	4971,6	5108,5	5250,5	5398,0	5551,6	5711,8	5879,3	30
31	4589,9	4713,7	4841,6	4973,9	5110,8	5252,9	5400,5	5554,2	5714,5	5882,1	31
32	4591,9	4715,8	4843,8	4976,1	5113,1	5255,3	5403,0	5556,8	5717,3	5885,0	32
33	4593,9	4717,9	4845,9	4978,3	5115,5	5257,7	5405,6	5559,5	5720,0	5887,8	33
34	4596,0	4720,0	4848,1	4980,6	5117,8	5260,1	5408,1	5562,1	5722,7	5890,7	34
35	4598,0	4722,1	4850,3	4982,8	5120,1	5262,6	5410,6	5564,7	5725,5	5893,6	35
36	4600,1	4724,2	4852,5	4985,1	5122,5	5265,0	5413,1	5567,3	5728,2	5896,4	36
37	4602,1	4726,3	4854,6	4987,3	5124,8	5267,4	5415,6	5569,9	5731,0	5899,3	37
38	4604,1	4728,4	4856,8	4989,6	5127,1	5269,8	5418,1	5572,6	5733,7	5902,2	38
39	4606,2	4730,5	4859,0	4991,8	5129,5	5272,3	5420,7	5575,2	5736,4	5905,1	39
40	4608,2	4732,6	4861,2	4994,1	5131,8	5274,7	5423,2	5577,8	5739,2	5907,9	40
41	4610,3	4734,7	4863,3	4996,3	5134,1	5277,1	5425,7	5580,5	5741,9	5910,8	41
42	4612,3	4736,9	4865,5	4998,6	5136,5	5279,5	5428,2	5583,1	5744,7	5913,7	42
43	4614,3	4739,0	4867,7	5000,9	5138,8	5282,0	5430,8	5585,7	5747,5	5916,6	43
44	4616,4	4741,1	4869,9	5003,1	5141,2	5284,4	5433,3	5588,4	5750,2	5919,5	44
45	4618,4	4743,2	4872,1	5005,4	5143,5	5286,8	5435,8	5591,0	5753,0	5922,4	45
46	4620,5	4745,3	4874,3	5007,6	5145,9	5289,3	5438,4	5593,7	5755,7	5925,2	46
47	4622,5	4747,4	4876,4	5009,9	5148,2	5291,7	5440,9	5596,3	5758,5	5928,1	47
48	4624,6	4749,5	4878,6	5012,2	5150,6	5294,2	5443,5	5599,0	5761,3	5931,0	48
49	4626,6	4751,7	4880,8	5014,4	5152,9	5296,6	5446,0	5601,6	5764,0	5933,9	49
50	4628,7	4753,8	4882,0	5016,7	5155,3	5299,0	5448,5	5604,3	5766,8	5936,8	50
51	4630,7	4755,9	4885,2	5019,0	5157,6	5301,5	5451,1	5606,9	5769,6	5939,7	51
52	4632,8	4758,0	4887,4	5021,2	5160,0	5303,9	5453,6	5609,6	5772,3	5942,6	52
53	4634,8	4760,1	4889,6	5023,5	5162,3	5306,3	5456,2	5612,2	5775,1	5945,5	53
54	4636,9	4762,3	4891,8	5025,8	5164,7	5308,8	5458,7	5614,9	5777,9	5948,5	54
55	4639,0	4764,4	4894,0	5028,1	5167,0	5311,3	5461,3	5617,5	5780,7	5951,4	55
56	4641,0	4766,5	4896,2	5030,3	5169,4	5313,7	5463,8	5620,2	5783,5	5954,3	56
57	4643,1	4768,6	4898,4	5032,6	5171,8	5316,2	5466,4	5622,9	5786,2	5957,2	57
58	4645,1	4770,8	4900,6	5034,9	5174,1	5318,6	5468,9	5625,5	5789,0	5960,1	58
59	4647,2	4772,9	4902,8	5037,2	5176,5	5321,1	5471,5	5628,2	5791,8	5963,0	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	60	61	62	63	64	65	66	67	68	69	D. l.

Digitized by Google

D. L.	70	71	72	73	74	75	76	77	78	79	D. L.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	5966,0	6145,7	6334,9	6534,5	6745,7	6970,3	7210,1	7467,2	7744,6	8045,7	0
1	5968,9	6148,8	6338,1	6537,9	6749,4	6974,2	7214,2	7471,7	7749,4	8051,0	1
2	5971,8	6151,9	6341,4	6541,3	6753,0	6978,1	7218,3	7476,1	7754,2	8056,2	2
3	5974,7	6155,0	6344,6	6544,7	6756,6	6981,9	7222,5	7480,6	7759,0	8061,5	3
4	5977,7	6158,0	6347,8	6548,2	6760,3	6985,8	7226,6	7485,0	7763,9	8066,8	4
5	5980,6	6161,1	6351,1	6551,6	6763,9	6989,7	7230,8	7489,5	7768,7	8072,0	5
6	5983,5	6164,2	6354,3	6555,0	6767,6	6993,6	7234,9	7494,0	7773,5	8077,3	6
7	5986,5	6167,3	6357,6	6558,5	6771,2	6997,5	7239,1	7498,5	7778,4	8082,6	7
8	5989,4	6170,4	6360,9	6561,9	6774,9	7001,4	7243,3	7502,9	7783,2	8087,9	8
9	5992,4	6173,5	6364,1	6565,4	6778,5	7005,3	7247,5	7507,4	7788,1	8093,2	9
10	5995,3	6176,6	6367,4	6568,8	6782,2	7009,2	7251,6	7511,9	7793,0	8098,5	10
11	5998,3	6179,7	6370,6	6572,3	6785,8	7013,1	7255,8	7516,4	7797,8	8103,8	11
12	6001,2	6182,8	6373,9	6575,7	6789,5	7017,0	7260,0	7520,9	7802,7	8109,2	12
13	6004,2	6185,9	6377,2	6579,2	6793,2	7020,9	7264,2	7525,4	7807,6	8114,5	13
14	6007,1	6189,0	6380,5	6582,6	6796,9	7024,8	7268,4	7530,0	7812,5	8119,8	14
15	6010,1	6192,1	6383,7	6586,1	6800,5	7028,7	7272,6	7534,5	7817,4	8125,2	15
16	6013,0	6195,2	6387,0	6589,5	6804,2	7032,7	7276,8	7539,0	7822,3	8130,6	16
17	6016,0	6198,3	6390,3	6593,0	6807,9	7036,6	7281,0	7543,6	7827,2	8135,9	17
18	6019,0	6201,4	6393,6	6596,5	6811,6	7040,5	7285,2	7548,1	7832,2	8141,3	18
19	6021,9	6204,6	6396,9	6600,0	6815,3	7044,5	7289,4	7552,7	7837,1	8146,7	19
20	6024,9	6207,7	6400,2	6603,4	6819,0	7048,4	7293,7	7557,2	7842,0	8152,1	20
21	6027,9	6210,8	6403,5	6606,9	6822,7	7052,4	7297,9	7561,8	7847,0	8157,5	21
22	6030,8	6213,9	6406,8	6610,4	6826,4	7056,3	7302,1	7566,3	7851,9	8162,9	22
23	6033,8	6217,1	6410,1	6613,9	6830,1	7060,3	7306,4	7570,9	7856,9	8168,3	23
24	6036,8	6220,2	6413,4	6617,4	6833,8	7064,2	7310,6	7575,5	7861,9	8173,7	24
25	6039,8	6223,3	6416,7	6620,9	6837,6	7068,2	7314,9	7580,1	7866,8	8179,2	25
26	6042,7	6226,5	6420,0	6624,4	6841,3	7072,2	7319,1	7584,7	7871,8	8184,6	26
27	6045,7	6229,6	6423,3	6627,9	6845,0	7076,2	7323,4	7589,3	7876,8	8190,1	27
28	6048,7	6232,7	6426,6	6631,4	6848,7	7080,1	7327,7	7593,9	7881,8	8195,5	28
29	6051,7	6235,9	6429,9	6635,0	6852,5	7084,1	7332,0	7598,5	7886,8	8201,0	29
30	6054,7	6239,0	6433,2	6638,5	6856,2	7088,1	7336,2	7603,1	7891,8	8206,5	30
31	6057,7	6242,2	6436,6	6642,0	6860,0	7092,1	7340,4	7607,7	7896,8	8212,0	31
32	6060,7	6245,3	6439,9	6645,5	6863,7	7096,1	7344,8	7612,3	7901,9	8217,5	32
33	6063,7	6248,5	6443,2	6649,1	6867,5	7100,1	7349,1	7617,0	7906,9	8223,0	33
34	6066,7	6251,7	6446,6	6652,6	6871,2	7104,1	7353,4	7621,6	7911,9	8228,5	34
35	6069,7	6254,8	6449,9	6656,1	6875,0	7108,2	7357,7	7626,3	7917,0	8234,1	35
36	6072,7	6258,0	6453,3	6659,7	6878,7	7112,2	7362,0	7630,9	7922,1	8239,6	36
37	6075,7	6261,2	6456,6	6663,2	6882,5	7116,2	7366,4	7635,6	7927,1	8245,1	37
38	6078,8	6264,4	6460,0	6666,8	6886,3	7120,2	7370,7	7640,2	7932,2	8250,7	38
39	6081,8	6267,5	6463,3	6670,3	6890,1	7124,3	7375,0	7644,9	7937,[illegible]	8256,3	39
40	6084,8	6270,7	6466,7	6673,9	6893,8	7128,3	7379,4	7649,6	7942,4	8261,8	40
41	6087,8	6273,9	6470,0	6677,4	6897,6	7132,5	7383,7	7654,3	7947,5	8267,4	41
42	6090,8	6277,1	6473,4	6681,0	6901,4	7136,4	7388,0	7659,0	7952,6	8273,0	42
43	6093,9	6280,3	6476,8	6684,6	6905,2	7140,4	7392,4	7663,7	7957,7	8278,6	43
44	6096,9	6283,5	6480,1	6688,1	6909,0	7144,5	7396,8	7668,4	7962,8	8284,2	44
45	6099,9	6286,6	6483,5	6691,7	6912,8	7148,6	7401,1	7673,1	7968,0	8289,9	45
46	6103,0	6289,8	6486,9	6695,3	6916,6	7152,6	7405,5	7677,8	7973,1	8295,5	46
47	6106,0	6293,0	6490,3	6698,9	6920,4	7156,7	7409,9	7682,6	7978,2	8301,1	47
48	6109,1	6296,2	6493,6	6702,4	6924,2	7160,8	7414,2	7687,3	7983,4	8306,8	48
49	6112,1	6299,4	6497,0	6706,0	6928,1	7164,9	7418,6	7692,0	7988,5	8312,4	49
50	6115,1	6302,7	6500,4	6709,6	6931,9	7169,0	7423,0	7696,8	7993,7	8318,1	50
51	6118,2	6305,9	6503,8	6713,2	6935,7	7173,0	7427,4	7701,5	7998,9	8323,8	51
52	6121,2	6309,1	6507,2	6716,8	6939,5	7177,1	7431,8	7706,3	8004,0	8329,4	52
53	6124,3	6312,3	6510,6	6720,4	6943,4	7181,2	7436,2	7711,0	8009,2	8335,1	53
54	6127,4	6315,5	6514,0	6724,0	6947,2	7185,3	7440,6	7715,8	8014,4	8340,8	54
55	6130,4	6318,7	6517,4	6727,6	6951,1	7189,5	7445,0	7720,6	8019,6	8346,6	55
56	6133,5	6322,0	6520,8	6731,2	6954,9	7193,6	7449,5	7725,4	8024,8	8352,3	56
57	6136,5	6325,2	6524,2	6734,9	6958,8	7197,7	7453,9	7730,2	8030,0	8358,0	57
58	6139,6	6328,4	6527,6	6738,5	6962,6	7201,8	7458,3	7735,0	8035,3	8363,7	58
59	6142,7	6331,7	6531,0	6742,1	6966,5	7205,9	7462,8	7739,8	8040,5	8369,5	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. L.	70	71	72	73	74	75	76	77	78	79	D. L.

Digitized by Google

D. l.	80	81	82	83	84	85	86	87	88	89	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	8375,3	8739,1	9145,5	9605,9	10137,0	10764,7	11532,6	12522,3	13916,6	16299,8	0
1	8381,0	8745,5	9152,7	9614,1	10146,6	10776,2	11547,0	12541,4	13945,4	16357,5	1
2	8386,8	8751,9	9159,9	9622,4	10156,2	10787,7	11561,4	12560,7	13974,4	16416,3	2
3	8392,6	8758,3	9167,2	9630,6	10165,8	10799,3	11575,9	12580,0	14003,7	16476,1	3
4	8398,3	8764,8	9174,4	9638,9	10175,4	10810,8	11590,5	12599,5	14033,2	16537,0	4
5	8404,1	8771,2	9181,6	9647,2	10185,1	10822,6	11605,0	12619,1	14063,0	16598,9	5
6	8409,9	8777,7	9188,9	9655,5	10194,8	10834,2	11619,7	12638,8	14093,0	16662,0	6
7	8415,8	8784,1	9196,2	9663,8	10204,6	10845,9	11634,5	12658,6	14123,3	16726,2	7
8	8421,6	8790,6	9203,5	9672,2	10214,4	10857,7	11649,3	12678,6	14153,9	16791,7	8
9	8427,4	8797,1	9210,8	9680,6	10224,2	10869,6	11664,1	12698,6	14184,7	16858,5	9
10	8433,3	8803,6	9218,1	9689,0	10234,0	10881,4	11679,1	12718,8	14215,8	16926,5	10
11	8439,1	8810,1	9225,4	9697,4	10243,8	10893,3	11694,0	12739,1	14247,2	16995,6	11
12	8445,0	8816,6	9232,7	9705,8	10253,7	10905,2	11709,1	12759,5	14278,9	17066,9	12
13	8450,9	8823,2	9240,2	9714,2	10263,6	10917,2	11724,2	12780,0	14310,9	17140,3	13
14	8456,8	8829,7	9247,6	9722,7	10273,5	10929,1	11739,4	12800,7	14343,2	17213,2	14
15	8462,6	8836,3	9255,0	9731,2	10283,5	10941,2	11754,7	12821,5	14375,8	17288,7	15
16	8468,6	8842,8	9262,4	9739,7	10293,5	10953,3	11770,0	12842,5	14408,7	17366,0	16
17	8474,5	8849,4	9269,9	9748,3	10303,5	10965,5	11785,4	12863,5	14441,9	17444,0	17
18	8480,4	8856,0	9277,3	9756,8	10313,6	10977,7	11800,9	12884,7	14475,4	17525,9	18
19	8486,3	8862,6	9284,8	9765,4	10323,7	10989,9	11816,4	12906,0	14509,3	17608,7	19
20	8492,3	8869,3	9292,3	9774,0	10333,8	11002,2	11832,0	12927,4	14543,5	17694,6	20
21	8498,2	8875,9	9299,8	9782,7	10344,0	11014,5	11847,6	12948,9	14578,1	17780,5	21
22	8504,2	8882,6	9307,3	9791,3	10354,1	11026,9	11863,4	12970,6	14613,0	17869,9	22
23	8510,2	8889,2	9314,8	9800,0	10364,3	11039,3	11879,2	12992,5	14648,3	17961,6	23
24	8516,2	8895,9	9322,4	9808,6	10374,5	11051,7	11895,1	13014,4	14683,9	18055,8	24
25	8522,2	8902,6	9330,0	9817,3	10384,8	11064,2	11911,0	13036,6	14719,9	18152,6	25
26	8528,2	8909,3	9337,6	9826,1	10395,0	11076,8	11927,1	13058,8	14756,3	18252,3	26
27	8534,2	8916,0	9345,[illegible]	9834,8	10405,3	11089,3	11943,1	13081,2	14793,0	18354,9	27
28	8540,2	8922,7	9352,8	9843,6	10415,7	11102,0	11959,3	13103,8	14830,2	18460,7	28
29	8546,2	8929,5	9360,4	9852,4	10426,2	11114,6	11975,6	13126,5	14867,8	18569,8	29
30	8552,3	8936,2	9368,1	9861,3	10436,6	11127,4	11991,9	13149,3	14905,8	18682,5	30
31	8558,4	8943,0	9375,8	9870,1	10447,1	11140,1	12008,4	13172,3	14944,2	18799,1	31
32	8564,4	8949,8	9383,5	9879,0	10457,5	11152,9	12024,9	13195,5	14983,0	18919,7	32
33	8570,5	8956,6	9391,2	9887,8	10468,0	11165,8	12041,5	13218,8	15022,3	19044,7	33
34	8576,6	8963,4	9398,9	9896,7	10478,5	11178,7	12058,2	13242,3	15062,1	19174,4	34
35	8582,7	8970,2	9406,6	9905,7	10489,1	11191,7	12074,9	13265,9	15102,3	19309,2	35
36	8588,9	8977,1	9414,4	9914,6	10499,7	11204,7	12091,7	13289,7	15143,0	19449,5	36
37	8595,0	8983,9	9422,1	9923,6	10510,4	11217,7	12108,6	13313,7	15184,2	19595,8	37
38	8601,1	8990,8	9429,9	9932,7	10521,1	11230,8	12125,6	13337,8	15225,8	19748,6	38
39	8607,3	8997,7	9437,8	9941,7	10531,8	11244,0	12142,7	13362,1	15268,0	19908,5	39
40	8613,5	9004,6	9445,6	9950,8	10542,6	11257,2	12159,9	13386,6	15310,7	20076,4	40
41	8619,6	9011,5	9453,4	9959,8	10553,3	11270,5	12177,1	13411,2	15353,8	20252,5	41
42	8625,8	9018,4	9461,3	9968,9	10564,1	11283,8	12194,4	13436,1	15397,8	20483,3	42
43	8632,0	9025,4	9469,1	9978,0	10574,9	11297,1	12211,8	13461,1	15442,1	20635,1	43
44	8638,2	9032,3	9477,0	9987,2	10585,8	11310,5	12229,3	13486,3	15486,9	20843,5	44
45	8644,5	9039,3	9484,9	9996,3	10596,7	11324,0	12246,9	13511,6	15532,6	21065,4	45
46	8650,7	9046,3	9492,9	10005,5	10607,6	11337,6	12264,6	13537,0	15578,7	21302,5	46
47	8656,9	9053,3	9500,8	10014,8	10618,6	11351,1	12282,4	13562,8	15625,5	21557,3	47
48	8663,2	9060,3	9508,8	10024,0	10629,7	11364,8	12300,2	13588,9	15672,7	21832,5	48
49	8669,5	9067,3	9516,8	10033,3	10640,8	11378,4	12318,1	13615,1	15721,0	22131,6	49
50	8675,7	9074,4	9524,8	10042,6	10651,9	11392,2	12336,3	13641,4	15769,8	22459,3	50
51	8682,0	9081,4	9532,9	10051,9	10663,0	11406,0	12354,4	13667,8	15819,3	22821,5	51
52	8688,3	9088,5	9540,9	10061,3	10674,1	11419,8	12372,7	13694,5	15869,4	23226,4	52
53	8694,6	9095,6	9548,9	10070,6	10685,3	11433,7	12391,0	13721,5	15920,4	23685,4	53
54	8701,0	9102,7	9557,0	10080,0	10696,5	11447,7	12409,5	13748,9	15972,1	24215,3	54
55	8707,3	9109,8	9565,1	10089,4	10707,7	11461,7	12428,0	13776,1	16024,6	24842,1	55
56	8713,6	9116,9	9573,2	10098,9	10719,1	11475,8	12446,5	13803,7	16077,9	25609,2	56
57	8720,0	9124,0	9581,4	10108,4	10730,4	11489,9	12465,3	13831,5	16132,0	26598,2	57
58	8726,4	9131,2	9589,5	10117,9	10741,8	11504,1	12484,2	13859,6	16187,0	27992,1	58
59	8732,7	9138,4	9597,7	10127,4	10753,3	11518,3	12503,1	13887,8	16242,9	30375,0	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	80	81	82	83	84	85	86	87	88	89	D. l.

END of BOOK VIII.

Digitized by Google

THE

ELEMENTS

OF

NAVIGATION.

BOOK IX.

OF DAYS WORKS.

1. BY DAYS WORKS are here meant the practical methods of finding a ſhip's place every day at noon, and ſettling the courſe and diſtance ſhe has then to ſail.

The navigator requires for this purpoſe the following elements, or neceſſary things, to be known:

I. The means of meaſuring and correcting the run of the ſhip.
II. The nature and uſe of the ſea and azimuth compaſſes.
III. How to find the Sun's amplitude and azimuth.
IV. How to find the variation of the compaſs, and to correct the courſes the ſhip has ſailed on that account.
V. How to find the ſhip's lee-way, and thence to correct the courſes.
VI. The nature and uſe of inſtruments proper for obſerving the altitudes and diſtances of celeſtial objects.
VII. How to find the latitude and longitude by celeſtial obſervations.
VIII. How to correct the daily account of latitude and longitude.

Digitized by Google

SECTION I.

2. *Of the measuring a Ship's run.*

A great variety of methods has been proposed to measure the rate at which a ship sails, but that mostly in use at this time, especially among the English, is by the *log* and *half minute glass*.

The Log is a piece of thin board, of a sectoral or quadrantal form, loaded in the circular side with lead sufficient to make it swim upright in the water: to this is fastened a line about 150 fathoms long, called the Log-line, which is divided into certain spaces, called knots; and the log-line is wound on a reel, which turns very easily.

The Half Minute Glass is of the form of an *hour-glass*, and contains such a quantity of fine sand, as will run through the hole in its neck in half a minute of time.

The making of the experiment to find the velocity of the ship is called Heaving the Log, which is thus performed:

One man holds the reel, and another the half minute glass; an officer of the watch throws the log over the ship's stern, on the lee side, and when he observes the stray line is run off the reel (which is about 10 fathoms, this distance being usually allowed to carry the log out of the eddy of the ship's wake) and the first mark is going off, he cries *turn!* the glass-holder answers *done!* who watching the glass, the moment it is run out says *stop!* the reel being immediately stopt, the last mark run off shews the number of knots, and the distance of that mark from the reel is estimated in fathoms. Then the knots and fathoms, together, shew the distance the ship has run the preceding hour, if the wind has been constant.

In the King's ships, India ships, and some others, it is usual to heave the log every hour: but coasters, and those which make short voyages, heave the log once in two hours only.

3. This practice of measuring a ship's rate of sailing is founded upon the following principle.

That *the length of each knot ought to be the same part of a sea mile; as half a minute is of an hour.*

Therefore the length of each knot should be either

$(\frac{1}{2} \times \frac{1}{60} =) \quad \frac{1}{120}$ of a nautical mile.

Or $(\frac{1}{2} \times \frac{1}{60} \times \frac{1}{60} =) \quad \frac{1}{7200}$ of a degree.

Or $(\frac{1}{2} \times \frac{1}{60} \times \frac{1}{60} \times \frac{1}{360} =) \quad \frac{1}{2592000}$ of a great circle.

By Mr. Richard Norwood's experiment (see V. 73) it appears, that a degree of a great circle on the Earth contains 367200 English feet, and $\frac{1}{60}$ thereof, or 6120 feet, is the length of one nautical mile.

Hence $\frac{1}{120}$th of 6120, or 51 feet, should be the length of each knot.

But because it is safer to have the reckoning rather before the ship than after it, therefore 50 feet may be taken as the proper length of each knot; and each knot is now usually divided into 8 fathoms.

The

Digitized by Google

The length of the knots in the log-line, used formerly, was only 42 feet; and it is much to be wished that no line so divided was now in use, but custom in many things prevails over reason. This way of dividing the log-line was founded on the supposition that 60 miles, each of 5000 English feet, made a degree; for $\frac{1}{120}$ of 5000 is $41\frac{2}{3}$, or in round numbers 42 feet. And although many mariners find by experience that this length of the knot is too short, yet rather than quit the *old way*, they use glasses for half minute ones that run but 24 or 25 seconds.

The method usually recommended to try if the glasses are accurate, is this: On a round nail or peg hang a small thread that has a musket-ball fixed to one end, $39\frac{1}{8}$ inches being carefully measured from the center of the ball to the loop which goes over the peg. Then make it swing, and count one for every time it passes under the peg, beginning at the second time it passes, and the number of swings which it makes during the time the glass is running out, shews the seconds which that glass runs.

For experience shews, that the length of a second pendulum is about $39\frac{1}{8}$ inches.

The distance given by the log may be wrong on three accounts; namely, by an error either in the glass, or the log-line, or in both.

4. CASE I. *When the log-line is truly divided, and the glass is faulty.*

RULE. As the seconds run by the glass, are to 30 seconds;
So is the distance run by the log, to the true distance.

EXAM. *Suppose a ship sails at the rate of* $6\frac{1}{2}$ *knots while a glass runs out, which runs only* 25 *seconds: What is the true rate of sailing?*

As 25 : 30 : : 6,5 : 7,8 miles, the true distance sailed in an hour.

5. CASE II. *When the glass is true, and the log-line is faulty.*

RULE. As 50 feet, is to the distance measured between knot and knot;
So is the distance run by the log, to the true distance.

EXAM. *Suppose a ship sails at the rate of* $6\frac{1}{2}$ *knots an hour, by a log-line which has only* 44 *feet to a knot: What is the true rate of sailing?*

As 50 : 44 : : 6,5 : 5,72 miles, the true distance sailed in an hour.

6. CASE. III. *When both log-line and glass are faulty.*

RULE. Multiply thrice the measured length of a knot by the distance run per log; the product, divided by five times the measured time of the glass, will give the true distance run.

EXAM. *Suppose a ship runs* 5 *knots an hour, by a log-line of* 45 *feet to a knot, and a glass of* 25 *seconds: What is the true rate of sailing?*

Then $3 \times 45 \times 5$, and divided by 5×25, gives 5,4 miles = true dist.

For suppose K = meas. length of a knot; G = seconds per glass; D = run per log.

Then G : 30 : : D : $30 \times D \div$ *G = dist. run by a correct glass. (4)

And 50 : K : : $30 \times D \div G$: $30 \times D \times K \div G \times 50 = 3 \times D \times K \div 5 \times G$.

* The mark $\div$ signifies divided by.

 The

The log is subject to drive with the motion which the water may have at its surface, and thereby give an erroneous rate of sailing (for the experiment supposes the *log* fixed in the place where it is, when the first knot goes off the *reel)*; therefore many methods have been proposed to remove, or at least to lessen this error; and among them, that seems most worthy of notice, which was proposed by the late M. *Bouguer* *, in his Treatise on Navigation, published at Paris in the year 1753, and which was composed by the order of the Minister of State; and again reprinted there in the year 1760, with some alterations, by the late Abbé de la Caille; both those gentlemen had been separately engaged in very long voyages, and consequently had much marine experience: the substance of this method will be here given, though somewhat differently drawn up.

7. Take for the Log a conical piece of wood, through, or along the axis of which the log-line must be passed, and made fast to it, about 40, 50, 60, or more feet from one end; and to this end fix the Diver, which is a body formed of two equal square pieces of tin, or of thin iron plate, fixed at right angles to one another along their diagonals. The size of this diver must be so fitted to that of the cone, that the cone may just float.

A cone of three inches diameter in the base, and of six inches in the slant height, is proposed by M. Bouguer, to suit a diver made of plates about 9½ inches square. The float is fixed to the log-line at the intersection of the diagonals; and the *loop* and *peg* used as in the common log.

When this compound log is hove overboard, the diver will sink too deep to be much affected by the current, or motion of the water at the surface; and the log will keep more steadily in the place where it first fell; and consequently, the knots run off the reel will shew more accurately the ship's rate of sailing.

As the common log is affected by the whole motion of the current, so this compound log will feel only a part of it; *viz.* such a part nearly, as the resistance of the *cone* is of the resistance of the *diver*: thus the resistances of the above cone and diver are about as 1 to 5; and consequently this log will drive but ⅕ part of what the common log would; and so the ship's true run will be affected by ⅕ part only of the motion of the waters.

8. *To obtain the true rate of sailing*, it will be proper to heave alternately, hour and hour, the common log and this compound log. Then the difference of their knots run off, augmented by its ¼th part, is the correction; which applied to the knots of the common log will give the ship's true rate of sailing, at the middle time between the hours when those logs were hove. The correction is added when the run by the compound log is greatest; otherwise it is subtracted.

9. *To find the course made good.* Increase the observed angle between the log-lines by one fourth part; and this gives the correction to be applied to the apparent course, or the opposite of that shewn by the common log.

* The French Academician concerned in measuring a degree of a meridian in Peru.

The

Digitized by Google

The correction is to be applied to the { right / left } of the apparent course.

When the bearing of the common log is to the { left / right } of the comp. log.

10. Or thus: The length run off both logs, together with their bearings, being known, on a card or compass apply the knots run off (taken from a scale of equal parts) along their respective bearings, from the center; join the ends, and in this line produced, on the side next the compound log's length, take ¼ of the interval; then a line drawn from the end, thus produced, to the center of the card, will shew the true course and distance made good.

Or, the true course and distance may be found by computation; by working in the two triangles formed by the above construction.

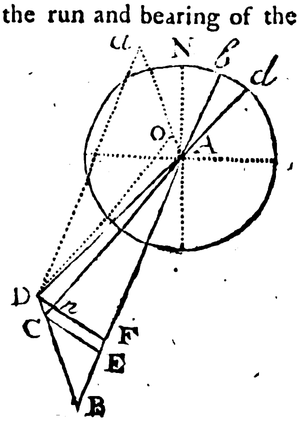
Ex. I. *The common log having run 6,7 knots, bore N. 42° E. at 9 h. 30 m. A. M. and at 11 h. 30 m. A. M. the compound log having run off 8,3 knots, it bore N. 37° E.: Required the correct course and rate of sailing at 10 h. A. M.*

Common. log.	Run 6,7k.	bear. N. 42° E.
Comp. log.	8,3k.	N. 37 E.
Diff.	1,6	5
¼ part	0,4	1¼
Correction	2,0	6¼
True run	8,7	Bear. S. 35¼° W.

Ex. II. *At 5 h. P. M. the common log having run off 7,6 knots, it bore S. 18° W.; and at 7 h. P. M. the compound log having run off 5,2 knots, it bore S. 26° W.: Required the true course and rate at 6 h. P. M.*

Common. log.	Run 7,6k.	Bear. S. 18° W.
Comp. log.	5,2	S. 26 W.
Diff.	2,4	8
¼ part	0,6	2
Correction	3,0	10
True run	4,6	Bear. N. 28° E.

11. The following explanation of Ex. II. will shew the reason of these corrections. Suppose the line AB to represent the run and bearing of the ship by the common log; and AC the run and bearing by the compound log; and let the ship be supposed at D when the logs were hove. Then her apparent run by the wind, with the common log, is the line D*a*, or its parallel BA, while the log is driven by the current along the line DB; so that the ship's real run is along the line DA (VII. 48). Also, by the compound log, the ship's apparent run by the wind is the line D*o*, or its parallel CA; while the log drives from D to C, which is only ⅕th part of DB; so the real run is DA. Take EB = AB ∽ AC; draw CE and its parallel DF; then is EF = ¼EB (II. 165), AF is nearly equal to AD, and ∠DAC is very nearly equal to ¼∠BAC.



 For

Digitized by Google

For $An = AF$ (II. 165): and An in the time of making the experiment cannot differ much from AD; neither can Dn differ much from $\frac{1}{4}$ of Fn; consequently the $\angle DAn$ is very nearly equal to $\frac{1}{4}$ $\angle FAn$.

Therefore AF being known gives the run DA. Also the bearing AB being known by observation, or its opposite Ab; and the $\angle ABD$ found by correction, the bearing DAd, or the real course, becomes known.

Or: Computing in the triangle BAC, with the two sides, and the included angle, find $\angle BCA$ and BC: then in the triangle ACD, knowing AC, CD ($= \frac{1}{4}BC$), and $\angle ACD$; find $\angle CAD$ and AD.

12. REMARK.

I. There seems to be a mistake in the dimensions of the cone, and diver, proposed by M. Bouguer, and followed by M. de la Caille; for no kind of wood used in British dock-yards, when formed into a cone of those dimensions, will float a diver made of stout tin plates, one side of the square being 9¼ inches. Such a diver, weighing 1 $\frac{7}{8}$ lb. avoirdupois, required to float it a cone of 5 inches diameter, and 12 inches on the slant side, so that the point of the cone, which was made of light fir, should just appear above the water. Now supposing one side of such a square tin diver to be about 10 inches, and made of plate only $\frac{2}{3}$ of the thickness of the former (for it is suspected there is no tin of half its thickness), such a diver would weigh, with its solder, about 20 ounces, and can be floated by a light fir cone of 4 inches diameter in the base, and 10 inches in the slant height, or length; and such a compound log might, perhaps, be found on trial to be affected by about as much again as that proposed by M. Bouguer, and consequently *the difference between the numbers given by the common log and compound logs, must be augmented by $\frac{2}{3}$ of itself to produce the necessary correction.*

13. II. When a current, such as a tide, runs to any depth, the velocity of that current may be much better ascertained by the compound log, than by the common one, provided the diver does not descend lower than the run of the current; for as those ships which are deepest immerged, drive fastest with the tide, so the diver being acted on below, as well as the log on the surface, their joint motion will give the total effort of the current's motion, better than what could be derived from the motion at the surface only. Also, by such a compound log, the depth to which any current runs, may be easily tried.

SECTION

Digitized by Google

SECTION II.

Of the Mariner's Compass.

14. The MARINER'S COMPASS is an instrument used at sea to point out the way a ship does, or is to go; and consists of three parts, namely, the box, the card or fly, and the needle.

The Box, which contains the card and needle, is a circular brass box hung within a square wooden one, by two concentric rings, called *jimbals*, so fixed by cross centers to the two boxes, that the inner one, or compass box, shall retain an horizontal position in all motions of the ship.

The CARD, or FLY, is a circle of stiff paper representing the horizon; and is divided into points and quarter points of the compass.

The NEEDLE is a strait piece of steel made magnetical; which has the property of pointing with one of its ends towards the north pole of the world.

The needle is fixed to the under side of the card, and in the center is placed a conical socket, which is put on an upright pointed pin, fixed in the bottom of the box; so that the card, hanging on the pin, turns freely round its center; and one of the points, by the property of the needle, will always be directed towards the north pole *.

The top of the box is covered with a glass pane, that the motion of the card may not be disturbed by the wind. This apparatus is called the *Compass*. The compass box is to be so placed in the ship, that the middle section of the box, parallel to its sides, may be parallel to the middle section of the ship, along its keel.

15. Before the invention of the compass, which happened towards the latter end of the 13th century, the navigating of ships was a very tedious and precarious operation, and seldom made out of sight of land. But the compass enables the mariner to hold his course over the seas in as direct and true a track, as the land carrier directs his carriage in a well-beaten road. Hence it might be reasonably imagined, that no necessary expence or care should ever be wanting in the construction of this most useful instrument. But it has so happened, that some years ago scarce one sea compass in ten was fit for the use for which it was made; they were fabricated by unskilful and ignorant workmen for the wholesale dealers in the shipping way: and such dealers generally pay no more regard to the construction of this instrument, on which the success of the voyage, and the lives of the men, in a great measure depend, than they do to any indifferent thing of the same price.

---

* If a magnet, or a piece of iron made magnetical, be suspended by a thread, or floated on a piece of light wood or cork in a vessel of water; let the body be turned round either eastward or westward, one and the same point will always be turned towards the north when the body becomes at rest.

Digitized by Google

There are however compaſſes uſed in the Royal Navy, India ſhips, and ſome few trading ſhips, which are conſtructed with more care, and on better principles; and are therefore vaſtly preferable to thoſe commonly uſed in the merchant's ſervice, which, from their conſtruction, ſeem to have been contrived purpoſely to vary from what was to be expected of them; as by joining the outſide box together with iron nails; making the needle of ſoft wire; and diſpoſing it in the form of a rhombus, in expectation that the magnetical forces of the ſides would conſpire to act in the diagonal; making the pin and ſocket ſo badly, as to prevent the card from traverſing, &c. &c.

It is only within a few years, that ſea-compaſſes have been made free from that multitude of inconveniences which formerly attended the beſt of them: Such inconveniences were, firſt, needles having ſeveral poles, occaſioned by their irregular ſhape; for the beſt kind are ſtraight bars with flat ends. 2d. The needles being made of ſuch a temper as was capable neither of receiving, nor of retaining half the virtue it is poſſible to give them; and conſequently, they were not directed to the poles with that ſtrength and perſeverance they might have been. 3d. The want of proper means to reſtore their magnetiſm during the courſe of a voyage, when it has been impaired. 4th. The troubleſome and inaccurate methods of repairing the pin on which the card turned when it has been damaged, and alſo the expence attending the uſe of agate caps, or ſockets, which are the moſt proper. 5th. The want of proper contrivances to hinder the card from being greatly affected by the various motions of the ſhip. Theſe, and ſeveral other imperfections, have been happily removed by the labours of the truly celebrated Dr. *Gowen Knight*, F. R. S. whoſe admirable invention of giving magnetiſm to ſteel bars, greatly ſuperior to any power they could derive from the natural loadſtones, joined to a multitude of experiments which he has made for the marine ſervice, has produced the means of conſtructing ſea-compaſſes ſo perfect, that there ſeems nothing farther to be wiſhed for, as neceſſary to this inſtrument. It may be reaſonably expected, that ſuch correct compaſſes will readily be brought into general uſe, as well in merchant's ſhips as in ſhips of war; for Knight's compaſſes are now univerſally uſed in the royal navy.

16. After the diſcovery of that moſt uſeful property of the magnet, or loadſtone, namely, its giving a polarity to hardened iron or ſteel, the compaſs was for many years uſed, without knowing that its direction in any wiſe deviated from the poles of the world: about the middle of the 16th century, ſo certain were ſome of its inflexibly pointing to the north, that they treated with contempt the notion of the variation, which about that time began to be ſuſpected. However, careful obſervations ſoon diſcovered that in England, and its neighbourhood, the needle pointed to the eaſtward of the true north: and the quantity of this deviation being known, mariners became as well ſatisfied as if the compaſs had none; becauſe the true courſe could be obtained by making allowance for the true variation.

From ſucceſſive obſervations made afterwards, it was found that the deviation of the needle from the north was not a conſtant quantity; but

that

Digitized by Google

that it gradually diminished, and at last, namely, about the year 1657, it was found at London, that the needle pointed due north, and has ever since been getting to the westward, and now the variation is near 22 degrees to the westward of the north: So that in any one place it may be suspected the variation has a kind of libratory motion, traversing through the north to unknown limits eastward and westward. But the settling of this point must be left to time.

About the same time it was also discovered, that the variation of the needle was different in different parts of the world, it being west in some places when it was east in others; and in places where the variation was of the same name, yet the quantity of it differed greatly. It was therefore found necessary that mariners should, every day, or as often as they had opportunity, make proper observations of the sun's amplitude or azimuth, by which they might be enabled to find the variation of the compass in the place they were then, and thence correct their courses properly.

17. Besides the common sea-compass, there is another, called the AZIMUTH COMPASS, the use of which is to take the bearing of any celestial object, when it is in, or above the horizon. This compass differs in no respect from the other, only that the circumference of the card or box is divided into degrees; and there is fitted to the box an index with two sights, which are upright pieces of brass, placed diametrically opposite to each other, having slits down their middles, through which the sun or star is to be viewed at the time of observation.

18. *To make Artificial Magnets.*

As there are many accidents at sea, which make it very convenient, and even necessary, for mariners to know how to restore the magnetic virtue to their damaged needles, it was judged proper to shew how, independent of a loadstone, magnetism might be given to steel bars; and with these bars to touch the needles of their compasses.

The following method is extracted from a paper given by Mr. John Canton, F. R. S. in the Philosophical Transactions for the year 1750.

Procure six bars of soft steel, about 3 inches long, $\frac{1}{4}$ inch broad, and $\frac{1}{20}$ thick; and other six of the hardest steel, each of double those dimensions; and let each of the 12 bars be marked with a line round them at one end, which call the north end; and the other, the south end. Procure also four bars of soft iron, called conductors; two of the same thickness and breadth, but only half the length of the soft bars; the other two, alike proportioned to the hard bars; have ready also an iron poker and tongs that have been long in use.

Let the poker be held nearly upright, with its point downwards; and let one of the soft steel bars be held tightly against the middle of the poker by a thread with its N. end downwards; then with the lower end of the tongs, held also nearly upright, stroke the steel bar from the N. end upwards, about 10 times, on both sides: and in this manner serve four of the soft steel bars; and each will be made able to suspend a small key by its N. end.

Lay

Lay the other two soft steel bars in a parallel position, at the distance of ¼ inch, with a N. and S. end to touch each of their proper conductors. Then placing two of the touched steel bars together, breadth to breadth, the N. end of one to the S. end of the other; and the other two put in like manner against these, one on each side, so as to have two north ends together, and also two south ends; separate with a large pin the two north points from the two south points, at one end; and to the middle of one of the two soft bars apply the open end of the compound bar, held upright, with the two norths towards the south end of the lying bar, and in this position slide the compound bar backwards and forwards four times the whole length of the lying bar, ending at the middle; from whence remove the compound bar to the middle of the other lying one, which rub in like manner: then turn both bars the other side upwards, and repeat the operation on each. Let the two lying bars make the inner two of the compound one, and place those which were before the two outside ones between the conductors, on which the operation of rubbing is to be performed with the end of the compounded bar. Repeat this operation until each pair of bars has been rubbed four times, and their magnetic power will be greatly increased.

Now putting three contiguous N. ends to three S. ends, with this compound bar, the lower ends being opened with a pin, as before, touch two pairs of the hard bars, placed at half an inch distance, between their proper conductors, in the manner above described; and with these four touched bars make a compound one to touch the other pair; observing that the lower ends be parted near a quarter of an inch after they are set on the middle of the lying bar, and that they are closed before they are taken off: touch each pair of hard bars three times over, and these bars will be strongly magnetical. To make them more so, let each pair, lying between their conductors, be touched twice over by two others, held as nearly horizontal as can be, one in each hand, by drawing at the same time the N. end of one from the middle of the lying bar over its S. end; and the S. end of the other from the middle over the N. end, and bringing them every time to the middle of the lying bar without touching it. Four of these horizontal strokes along each side will give as much magnetic strength to the hard bars as they seem capable of receiving; and each bar, if well hardened, will lift near two pounds weight avoirdupois.

19. *To preserve these Artificial Magnets.*

The six hard bars, with their two conductors put end to end as one bar, should be kept in a case; the bars being put face to face, having a N. and S. end together alternately; thus they will retain their virtue a long time, and be ready for any experiments: and should their power be found to fail, it may be restored, by the latter part of the operation, in a few minutes.

20. To

Digitized by Google

20. *To give Magnetism to Compass Needles.*

Lay the two needles of equal length, about an inch asunder, with the N. end of one and S. end of the other pointing the same way, and apply two conductors in contact with their ends. Then with two magnetic hard bars, one in each hand, and held as nearly horizontal as can be with the upper ends of contrary names turned outwards to the right and left, let a needle be stroked or rubbed from the middle to both ends at the same time, for 10 or 12 times, a N. end of a bar going over the S. end of the needle, and the S. end of a bar going over the N. end of a needle. Then without moving from the place, change hands with the bars, or, in the same hands, turn the other ends downwards, and stroke the other needle in like manner, and they will both be magnetical. But to make them still stronger, repeat the operation three or four times from needle to needle; and at last turn the lower side of each needle upwards, and repeat the operations of rubbing them, as on the other sides.

In the rubbings or touchings to procure magnetism, the hand should not return directly back the way it came, but should return in a kind of oval figure, carrying the hand about six or eight inches beyond the point of the bar or needle where the touch ended; but not beyond the point on the side where the touch begins.

It may be proper to observe, that the needle, which before it was made magnetical, hung level on its pivot, does afterwards incline to the horizon; which inclination is called its *Dip:* The horizontality is to be restored by putting a small counterpoise, or ring of brass wire, on to that end of the needle which appears to be the lightest.

PROBLEM.

To make an observation with the Azimuth Compass.

21. I. FOR AN AMPLITUDE *.

When the center of the sun is about one of his diameters above the horizon, turn the compass round in the box, until the center of the sun may be seen through the narrow slit which is in one of the sight vanes, exactly on the thread which bisects the slit in the other, at that instant push the stop which is in the side of the box against the edge of the card, and the degree, and parts of a degree, which stand against the middle line on the stop, is the amplitude of the sun for that time.

22. II. FOR AN AZIMUTH †.

Turn the compass round in the box until the center of the sun may be seen through the narrow slit, which is in one of the sight vanes, exactly on the thread which bisects the slit in the other; or, until the shadow of

---

* Amplitudes are from observations made on objects in the horizon. See Book V. 112, 147 to 152.

† Azimuths are from observations made on objects above the horizon. See Book V. 111, 152.

Digitized by Google

that thread falls directly along the line of the index: when either of these is effected, push in the stop against the edge of the card, and that degree and parts of a degree which stand against the middle line on the stop is the azimuth of the sun at that time.

What is here said of the sun, is in like manner to be applied to the stars.

23. When there is a rough sea, and the ship rolls much, the observation is best performed by two persons, thus:

Let one look through the sights, and turn them till the thread cuts the center of the sun, and be sure to keep a constant sight of it, notwithstanding the motion of the ship, which being signified to the assistant by any word, let him that instant observe what degree of the card is against the middle line of the stop, and the arc intercepted between that point and the meridian will shew the quantity of the magnetic amplitude or azimuth. If the card should vibrate very much, let him take the middle degree between the limits to which the vibrations extend.

When the magnetic azimuth of any object is observed, its altitude must also be taken at the same time.

This instrument is also useful in setting the ship's wake, in order to find the lee-way; and also to find the bearings of headlands and other objects.

SECTION III.

24. *To work an Amplitude.*

The true amplitude of a celestial object is its distance from one of the cardinal points of the horizon, at the rising or setting of that object.

The amplitude is reckoned eastward in the morning; but it is named westward in the evening.

The customary way of accounting the amplitude is, to reckon it so much to the southward or northward of the east in the morning; and in the evening so much to the southward or northward of the west: but as bearings are generally taken from the meridian, in the following pages the amplitudes will be estimated chiefly from the north point of the horizon.

The finding of the true amplitude at sea is of considerable importance in navigation; for the true course which the ship has steered is partly ascertained thereby.

25. PRO-

Digitized by Google

25. PROBLEM.

Given the latitude of the place, and the declination of a celestial object: Required the true amplitude of that object.

SOLUTION.

Say: As the co-sine of the latitude is to radius.
So is the sine of the given decl. to the co-sine of the amplitude.

Or, Add 10 to the index of the log. sine of the declin. and subtract the log. co-sine of the latitude from the sum, the remainder is the log. co-sine of the true amplitude.

The amplitude, thus found, is to be reckoned from that point of the horizon or compass, which is of the same name with the declination of that object.

If the amplitude be wanted from the east or west points of the horizon, the last term of the proportion will be a sine instead of a co-sine; and the amplitude is to be taken to the northward of those points, when the declination is north; or to the southward, when the declination is south.

26. SOLUTION BY THE TRAVERSE TABLE.

With the declination among the courses, find the departure to the distance 100.

With the given latitude among the courses, and said departure in the column of latitude, find the distance.

Look for a column of departure, where this distance stands against 100 in the column of distance, and the degrees in the corresponding course will give the amplitude from the east or west.

This rule will always give the degrees as truly as by logarithms: and as the magnetic amplitude cannot be observed more exactly, the true amplitude will be had sufficiently correct by this rule.

EXAM. I. *In the latitude of 38° 25′ N. what is the Sun's true amplitude when his declination is 18° 59′ N.?*

By Logarithms.

As cos. lat.	=	38°	25′	0,10595
To radius	=	R		10,00000
So sin. decl.	=	18	59	9,51227
To sin. hor. arc	=	24	32	9,61822
Subtract from		90	00	for N. dec.
Rem. true amp.	=	65	28	from N.

By the Traverse Table.

To decl. 19° 00′, and dist. 100, the dep. is 32,56.
To lat. 38° 25′, and diff. lat. 32, the dist. is 41.
To dist. 100, and dep. 41, the course is 24° 45′. Therefore the horizontal arc is 24° 45′.

In this and the following examples the nearest degree and minute to the declination, that can be found in the Traverse Table, is taken for the declination.

EXAM.

Digitized by Google

EXAM. II. *Required the Sun's true amplitude in the lat. of 51° 32′ N. when the Sun's declination is 20° 56′ S.*

By Logarithms.

As cos. lat.	= 51°	32′	0,20617	
To radius	= R		10,00000	
So sin. decl.	= 20	56	9,55301	
To sin. hor. arc	= 35	03	9,75918	
Add to	90	00	for S. decl.	
Gives true amp.	= 125	03	fr. the N.	

By the Traverse Table.

To decl. 21° 00′, and dist. 100, the dep. is 35,8.
To lat. 51° 30′, and diff. lat. 35,8, the dist. is 57.
To dist. 100, and dep. 57, the course is 34° 45′. Therefore 35° may be taken for the horizontal arc sought.

EXAM. III. *When the Sun's declination was 20° 10′ S. what was his amplitude at the Cape of Good Hope, in lat. 34° 15′ S.?*

By Logarithms.

As cos. lat.	= 34°	15′	0,08271	
To radius	= R		10,00000	
So sin. decl.	= 20	10	9,53751	
To sin. hor. arc	= 24	39	9,62022	
Which add to	90	00	for S. decl.	
Gives true amp.	= 114	39	fr. the N.	

By the Traverse Table.

To decl. 20° 15′, and dist. 100, the dep. is 34,6.
To lat. 34° 15′, and diff. lat. 34,6, the dist. is 42.
To dist. 100, and dep. 42, the course is 24° 45′. Therefore 25° may be taken for the horizontal arc sought.

EXAM. IV. *On what point of the horizon does the star Arcturus rise and set at Buenos Ayres, in lat. 34° 35′ S.?*

By Logarithms.

As cos. lat.	= 34°	35′	0,08444	
To radius	= R		10,00000	
So sin. decl.	= 20	29	9,54399	
To sin. hor. arc	= 25	09	9,62843	
Which add to	90	00	for S. dec.	
Gives true amp.	= 115	09	fr. the N.	

By the Traverse Table.

To decl. 20° 30′, and dist. 100, the dep. is 35,0.
To lat. 34° 30′, and diff. lat. 35,0, the dist. is 42,5.
To dist. 100, and dep. 42,5, the course is 25° 15′. Therefore the horizontal arc may be taken as 25 degrees.

SECTION

SECTION IV.

27. *To work an Azimuth.*

The true azimuth of a celestial object is its bearing from the north or south points of the horizon, when above it.

In the forenoon the azimuth is reckoned eastward, and in the afternoon westward.

The azimuth is usually estimated from the south, when to the southward of the east or west points of the horizon; and from the north when to the northward of those points.

The use of the azimuth is to find the variation of the compass, in order to correct the courses which the ship has steered.

28. PROBLEM.

The latitude of the place, the declination of the object, and its altitude being known; required the true azimuth of that object.

SOLUTION.

When the latitude and declination are of the same name, let the codeclination be called A.

But when of contrary names, add the declination to 90 degrees, and call the sum A.

Let the difference between the co-lat. and co-alt. be called D.

Also, find the half sum and half difference of A and D.

Then write these four logarithms under one another.

Namely: The arith. comp. of the log. sine of the co-latitude.
The arith. comp. of the log. sine of the co-altitude.
The logarithmic sine of the foresaid half sum of A and D.
The logarithmic sine of the foresaid half diff of A and D.

Add these four logarithms together, and take half their sum, which seek among the sines for the corresponding degrees and minutes, and these being doubled will give the true azimuth required: from the north, in north latitudes, and from the south in south latitudes.

The working of an azimuth by logarithms, although as short as any numeral solution of this problem can be expected to be, has been thought one of the most tedious elements that enter into a common day's work: but by Gunter's scale, it may be readily done as follows, and sufficiently correct.

29. *To work an Azimuth by the Gunter's Scale.*

Find the co-lat., co-alt., the half sum, and half difference, as above.

Then, On the scale of log. sines, set one point of the compasses on the half sum, extend the other point to the co-lat., observing whether the second point falls to the right or left of the first, and take the compasses off without altering their extent.

Set one point on the co-alt., and let the second point fall where it will (the same way it did before); there hold it, and open the compasses till the other point falls on the half difference, then take them off without altering their extent.

Now

Digitized by Google

Now ſet one point of the compaſſes on the braſs pin at the beginning, or right hand end of the ſcale of verſed ſines (marked V. S.), turn the other point to the left, and obſerve what degrees and minutes in the verſed ſines it falls on; thoſe degrees and minutes will be the azimuth, if the latitude is ſouth: but if north, take them from 180°, and the remainder is the azimuth ſought, reckoned in both caſes from the north.

If the extent, when applied from the co-alt. to a fourth, ſhould reach beyond the right-hand end of the ſcale, as will ſometimes happen, then lay the Gunter flat on a board or table, and let the point reſt on it in a line with the ſines, and take the extent from thence to the half difference, and work as before.

Theſe directions, with thoſe in Book III. 84, 85, will remove all the ſeeming difficulties, that beginners may meet with, in working an azimuth by the Gunter's ſcale.

EXAM. I. *At ſea, in latitude 40° 38′ N. in the afternoon, the Sun's altitude was obſerved to be 20° 46′, when his declination was 17° 10′ S.: Required the Sun's true azimuth at that time.*

By LOGARITHMS.

The co-alt. is 69° 14′
The co-lat. is 49 22

The diff. D=19 52

Now 107° 10′=A=90° & decl.
And 19 52=D.

127 02	63° 31′=½ ſum.
2) 87 18	43 39=½ diff.

Ar. co-log. ſin. co-lat.=	49° 22′	0,11982
Ar. co-log. ſin. co-lat.=	69 14	0,02917
Log. ſin. ½ ſum =	63 31	9,95185
Log. ſin. ½ diff. =	43 39	9,83901
The ſum of the four logs		19,93985
Their ½ ſum gives	38° 55′	9,96992

The double is, 137 50, which is the Sun's true azim. from the N. point of the horizon.

By GUNTER'S SCALE.

On the ſines, the extent from 63° 31′ to 49° 22′ will reach from 69° 14′ to a little more than 52°. Let the point reſt there, and extend the other to 43° 39′; this extent will reach from the beginning of the verſed ſines to about 42°, which taken from 180, leaves 138° for the azimuth from the N. point of the horizon, and is very near what was found by the logarithms.

EXAM. II. *What is the Sun's true azimuth in the latitude of 26° 30′ N. when his altitude in the forenoon is 24° 28′, and his decl. is 22° 40′ N.?*

By LOGARITHMS.

The co-alt. is 65° 32′
The co-lat. is 63 30

The diff. D= 2 02

Now 67° 20′=A, is 90° leſs decl.
And 2 02=D.

69 22	34° 41′=½ ſum.
2) 65 18	32 39=½ diff.

Ar. co-log. ſin. co-lat. =	63° 30′	0,04821
Ar. co-log. ſin. co-alt. =	65 32	0,04086
Log. ſine ½ ſum =	34 41	9,75514
Log. ſine ½ diff. =	32 39	0,73200
The ſum of the four logs		19,57621
Their ½ ſum gives	37° 52′	9,78810

The double is, 75 44, which is the Sun's true azim. from the N. point of the compaſs.

By Gunter's Scale.

On the log. sines, the extent from 34° 41′ to 63° 30′, will reach from 65° 32′ to some point beyond the right-hand end of the scale; let the point of the compasses rest there, and extend the other point to the sine of 32° 39′, and this extent will reach on the versed sines, from the beginning, or 0 deg. to 104° 20′, the azimuth from the south, nearly as found by logarithms.

Exam. III. *At the island of St. Helena, in lat. 16° 00′ S. the Sun's altitude was observed in the forenoon to be 30° 22′, when his declination was 22° 58′ S.: What was the Sun's azimuth at that time?*

The co-lat. is 74° 00′	Ar. co-log. sine co-lat. = 74° 00′ 0,01716
The co-alt. is 59 38	Ar. co-log. sine co-alt. = 59 38 0,06409
	Log. sine ½ sum = 40 42 9,81431
The diff. D = 14 22	Log. sine ½ diff. = 26 20 9,64698
Now 67° 02′ = A, is 90° less decl.	The sum of the four logs. 19,54254
And 14 22 = D.	
	Their ½ sum, gives 36° 12′ 9,77127
81 24 | 40° 42′ = ½ sum.	
2)	Which doubled, is 72 24, for the Sun's true
52 40 | 26 20 = ½ diff.	azim. from the south, or 107° 36′ from the N.

Or thus: The extent from 40° 42′ to 74° 00′ on the sines, will reach from the sine of 59° 38′ to a point beyond the limits of the scale; then the extent from that point to the sine of 26° 20′, will reach on the versed sines from 0 deg. to about 107° 40′, the azimuth from the north.

Exam. IV. *On what point of the horizon, at the Cape of Good Hope, does the star Aldebaran bear, when its altitude is 22° 25′?*

The co-alt. is 67° 35′	Ar. co-log. sin. co-lat. = 55° 45′ 0,08271
The co-alt. is 55 45	Ar. co-log. sin. co-alt. = 67 35 0,03412
	Log. sin. ½ sum = 58 54 9,93261
The diff. D = 11 50	Log. sin. ½ diff. = 47 05 9,86472
Now 105° 59′ = A, is 90, and decl.	The sum of the four logs. 19,91416
And 11 50 = D.	
	Their ½ sum gives 64° 57′ 9,95708
117 49 | 58° 54′ = ½ sum.	
2)	Which doubled, is 129 54, for the Sun's true
94 09 | 47 05 = ½ diff.	azim. from the S. or 50° 06′ from the N.

Or thus: The extent from about 59° to about 67½° on the sines reaches from about 55¾° to about 63°: then the extent from about 63° to about 47°, reaches from the beginning of the versed sines, to about 50° for the azimuth from the north.

These examples sufficiently shew, that an azimuth may be worked by the Gunter's scale, not only with great readiness, but also as accurately as the magnetic azimuth can be taken by the compass.

The manner of working amplitudes and azimuths has been pretty largely insisted on, in order to render them familiar to mariners; who, for the generality, esteem these operations very troublesome; and it is on this account that many writers have contrived various tables to remove the trouble complained of: but from a due consideration of what is here done, it is apprehended such tables will not hereafter be much wanted.

Digitized by Google

SECTION V.

30. *Of the Variation of the Compaſs.*

The *magnetic poles* are thoſe points of the world, towards which the north and ſouth ends of the needle in the ſea compaſs are directed.

Magnetical meridians are imaginary lines, paſſing through the magnetic poles.

The *variation of the compaſs* is the difference between the bearings of the *true* and *magnetic* north poles; and is meaſured by an arc of the horizon contained between the true and magnetic north points of it.

The variation is named *eaſt*, when the magnetic north point is to the eaſtward of the true north: but when to the weſtward, it is named *weſt* variation.

The magnetic amplitude of a celeſtial object is its bearing by the compaſs when in the horizon.

The magnetic azimuth of a celeſtial object is its bearing by the compaſs when above the horizon.

The variation is found by comparing the true and magnetic amplitudes or azimuths of celeſtial objects together.

The uſe of the variation is to correct the courſes which a ſhip has ſteered by the compaſs.

31. PROBLEM.

Given the true and magnetic amplitudes or azimuths of a celeſtial object: Required the variation of the compaſs.

SOLUTION.

Let the true and magnetic amplitudes or azimuths, be reckoned from the north; and named eaſt when the obſervation is made in the forenoon; but weſt when made in the afternoon.

Then the difference between the true and magnetic amplitudes or azimuths, is the variation of the compaſs.

And is of the ſame name as the true amplitude or azimuth, if the true is greater than the magnetic: but when the true is leſs than the magnetic, the variation is of a contrary name to the true amplitude, or azimuth.

For, let N repreſent the true north point of the horizon, and the arc OWN the true amplitude or azimuth: it is evident, that if the arc OW*n*, repreſenting the magnetic amplitude or azimuth, be leſs than OWN, then the magnetic north point of the compaſs will fall on the ſame ſide of the true north, that the amplitude or azimuth is on; but when greater, *n* falls on the contrary ſide. Plate XIV. Fig. 8.

EXAM.

Exam. I. *The Sun was observed to rise 70° from the north by the compass, when his true amplitude was N. 81° 45′ E.: What was the variation, and which way?*

True amplitude	=	81° 45′ E.
Magnetic amplitude	=	70 00
The variation	=	11 45 E.

Exam. II. *The Sun was observed by the compass to set WSW. when his true amplitude was N. 126° 17′ W.: Required the variation of the compass, and which way.*

True amplitude	=	126° 17′ W.
Mag. amplitude	=	112 30 = 10 pts.
The variation	=	13 47 W.

Exam. III. *Suppose the Sun's true azimuth be N. 84° 40′ W. when his bearing was W. b. S. by the compass: Required the quantity and quality of the variation.*

True azimuth	=	84° 40′ W.
Mag. azimuth	=	101 15 = 9 pts.
The variation	=	16 35 E.

Exam. IV. *When the Sun was observed to bear ESE. his true azimuth was found to be N. 88° 46′ E.: What was the quantity and name of the variation?*

True azimuth	=	88° 46′ E.
Mag. azimuth	=	112 30
The variation	=	23 44 W.

The manner of finding the variation being known, the courses may be corrected by the following rules.

32. PROBLEM.

Given the course set, and the variation of the compass: Required the true course the ship steers.

Solution.

Let the person suppose himself looking the way the ship sails; then the course steered by the compass must be altered as many degrees, or points and parts of a point, as the variation amounts to toward the right hand, if the variation be east; but it must be altered the like quantity towards the left hand, if the variation be west.

Exam. I. *Suppose the variation is 1½ point W.; to correct these courses, NNW.; SW. ½ W.; SE. b. S. ¾ E.; ENE. ¼ E.*

Courses set	NNW. 2 pts.	SW.½W.4½ pts.	SE.b.S.¾E.3¾ pts.	ENE¼E 6¼
Variation	Add 1½ pts.	Subtr. 1½ pts.	Add 1½ pts.	Subtract 1½
Cor.co.	NW.b.N.½W.3½ pts.	SW. b. S. 3.	SE.b.E.¼E.5¼	NE. ¾ E. 4¾

Exam. II. *The variation is 18° E.; to correct the following courses.*

Courses set	N.E. b. N.=33° 45′	S. b. E.=11° 15′	S.W.b.W.=56° 15′	NW.=45° 00′
Variation	Add 18 00	Subt. 18 00	Add 18 00	Subtr. 18 00
Cor. cour.	N. 51 45 E.	S. 6 45 W.	S. 74 15 W.	N. 27 00

Digitized by Google

SECTION VI.

33. *Of finding the Ship's drift, or leeway.*

When a ſhip turns to windward, or is cloſe hauled on a wind, ſhe generally runs to the leeward of her intended courſe.

LEEWAY is the angle which the ſhip's real courſe makes with her intended courſe, occaſioned by contrary winds, and a rough ſea.

The leeway made by different ſhips, under the ſame circumſtances of wind and ſails, will be different; and even the ſame ſhip, when differently laden, and having more or leſs ſail abroad, will make more or leſs leeway. However, the following precepts for allowing for the leeway have been generally given by Engliſh writers; they were firſt publiſhed by W. Jones, Eſq. who had them from Mr. John Buckler.

34. *Allowances for Leeway.*

1ſt. When a ſhip is cloſe hauled, has all her ſails ſet, the water ſmooth, and a moderate gale of wind, ſhe is then ſuppoſed to make little or no leeway.

2d. Allow one point, when it blows ſo freſh that the ſmall ſails are taken in.

3d. Allow two points, when the top-ſails muſt be cloſe reefed.

4th. Allow two points and a half, when one top-ſail muſt be handed.

5th. Allow three points and a half, when both top-ſails are to be taken in.

6th. Allow four points when the fore courſe is handed.

7th. Allow five points, when trying under the main-ſail only.

8th. Allow ſix points, when both main and fore courſes are taken in.

9th. Allow ſeven points, when the ſhip tries a hull, or all ſails handed.

When the wind has blown hard on any point of the compaſs, and ſhifts to the oppoſite point, the ſhip will make leſs leeway than ſhe did before.

But in all theſe caſes reſpect muſt be had to the roughneſs of the ſea, and the trim of the ſhip.

35. PROBLEM.

Given the place of the wind, the courſe ſet, and the leeway. Required the true courſe the ſhip makes.

RULE. Count the neareſt way of the compaſs from the wind to the courſe ſet, and as many points and parts beyond as the leeway amounts to; and it gives the true courſe which the ſhip makes.

EXAM. I. *The wind NW. b. N. the courſe ſet NE. b. N. leeway 1 point: What is the courſe made good?*

The wind NW. b. N.	
Courſe ſet NE. by N.	= 3 points.
And the leeway	= 1 point
True courſe NE.	= 4 points.

Here, counting the neareſt way in the compaſs from NW. b. N. to NE. by N. and one point farther for the leeway, becauſe the wind drives her farther towards the eaſt, will give NE. for the true courſe that the ſhip makes.

EXAM. II. *The wind SE. b. S. a ſhip is cloſe hauled with her ſtarboard tacks aboard, and both top-ſails handed: What is her true courſe?*

The wind SE. by S.	
Courſe ſet E. b. N.	=7 points.
Subtract leeway	=3½ points.
True co. NE. by N. ½ E.	=3½ points.

The ſhip being cloſe hauled, is ſuppoſed to be 6 pts. from the wind, and muſt be in the NE. quarter, being on her ſtarb. tacks: then counting 6 pts. from SE. b. S. gives E. by N. 7 pts.; from which the leeway is to be taken.

Digitized by Google

SECTION VII.

Of Instruments for taking Altitudes.

The altitude of the Sun, or any other celestial object, may be observed by instruments contrived after various ways; those only which are best adapted for use at sea, will be here considered.

Of DAVIS'S QUADRANT.

36. *The Description and Use.* Plate XIV. Fig. 9.

The instrument most in use at sea, until about the year 1740, is by us called DAVIS'S QUADRANT, and by foreigners the ENGLISH QUADRANT. It consists of two arches, making together ninety degrees, and is therefore called a quadrant. Those arches are fixed in the same plane, one above, and the other below a straight bar, the length of which is equal to the radius of the lower arch, and about three times the radius of the upper arch; and they are connected and supported by proper braces.

The upper, or, as it is commonly called, the GREATER ARCH usually contains 65 degrees, not subdivided into smaller parts; and the LESSER ARCH contains 25 degrees, which, on account of their larger size, are subdivided into smaller parts, and these, by the help of diagonal divisions, and 11 concentric circles, are usually subdivided into single minutes.

There are three pieces called vanes, so fitted to the instrument as to stand at right angles to its plane.

First, The HORIZON VANE is fitted to slip on the end of the bar or radius, close to the center of the two arches. In this vane there is a long slit, through which the horizon, that is, the line where the sky and water apparently meet, is to be seen.

Secondly, The SIGHT VANE, which is so fitted as to slide along the lesser arch of 25 degrees, having a sharp edge to cut the division it stands at; and in a line with this edge is a small hole, through which the horizon is to be seen through the slit in the horizon vane.

Thirdly, The SHADE VANE, which is fitted to slide on the greater, or 65 arch. The upper line of the shade cast by this vane is to fall on the edge of the slit in the horizon vane during the time of observation.

Instead of the shade vane there is generally used another, called the GLASS VANE, because it has a convex lens (or, as usually called, a burning glass) fitted to it, which collects the Sun's rays into a bright spot on the horizon vane.

AB, is the bar or radius. BC, the lesser or 25 arch. DE, the greater or 65 arch. *a b*, *c g*, *h i*, are braces which fix the arches to the radius, and strengthen the instrument. G the horizon vane. H the sight vane. F the shade or glass vane. ☉FA a ray of the Sun. ∠DAC a right angle, or 90°.

37. *To observe the Sun's altitude or zenith distance by Davis's Quadrant.* See Plate XIV. Figure 9.

First, Put the horizon vane on to the end A of the bar AB; and let it go close to the shoulder at A. Set the shade or glass vane on the arch

DE to an even degree, about 10 or 15 degrees lefs than what the zenith diftance is judged to be; and put the fight vane H about the middle of the arch BC: obferving that the fhade and fight vanes be thruft clofe to the backs of the arches.

Secondly, Turn your back to the Sun, hold the plane of the inftrument in an upright pofition, look through the hole in the fight vane, and raife or lower the quadrant until the bright fpot caft by the Sun through the glafs vane, falls on the ⊖ in the line drawn through the flit in the horizon vane; then, if the horizon is feen through the flit in the horizon vane, even with the ⊖, the quadrant will give the Sun's altitude or zenith diftance at that time.

Thirdly, But if the fky appears through the flit inftead of the horizon, flide the fight vane H higher, until the horizon coincides with the bright fpot falling on ⊖; or if the fea appears inftead of the horizon, flide the fide vane H lower, until the fpot and horizon come together, and the obfervation at that time is made.

Fourthly, To the degrees between D and F add thofe between C and H, their fum gives the zenith diftance; but the degrees between B and H, added to thofe between F and E, fhew the altitude.

38. Now to find the latitude, the *meridional* altitude or *meridional* zenith diftance of the Sun is wanted. Therefore begin fome time before noon, and having taken an obfervation as above directed, wait a minute or two, and obferve again; and if the fea appears through the horizon vane the Sun has got higher, therefore flide the fight vane lower, till the folar fpot and horizon coincide; and thus continue obferving at fhort intervals, until the fky appearing inftead of the fea fhews that the Sun has paft the meridian; when this happens, let the vane ftand as at the laft alteration, and add the degrees in the greater arc to the degrees and minutes in the leffer, their fum gives the meridional zenith diftance.

If inftead of the bright folar fpot, the upper border of the fhade be made to fall upon the horizon line, at the time the horizon is feen through the flit in that line, then the fum of the arcs is the zenith diftance of the Sun's upper edge or limb, to which add 16 minutes, and the fum is the diftance of the Sun's center from the zenith *.

39. One great objection againft this inftrument is the trouble and time loft in fliding the fight vane up or down, which fometimes cannot be done without taking the quadrant from the eye, by which means an opportunity may be loft of making the obfervation. But this defect is removed by having an index or ruler fitted to the quadrant; one end of it moving round the center to which the horizon vane is fixed, and the other carrying the fight vane along the arch. By this contrivance the fight vane may be readily raifed higher, or lowered, by the motion of the index about its center, without taking the inftrument from the eye.

---

* This rule is given by moft writers; but as the extremity of every fhadow caft by the fun is penumbral, too faint at the very extremity to be perceptible, and fo nearly dark before it is really fo, that the limit of the penumbra cannot be diftinguifhed, it is obvious that it cannot be proper for practice, where the obferver muft neceffarily take the middle between the two: nothing muft therefore be allowed for the Sun's femi-diameter.

40. There

Digitized by Google

40. There is another instrument, called a FORE STAFF, or CROSS STAFF, that has been long used at sea for taking the altitudes of celestial objects, particularly the stars. In using this instrument the observer holds one end of the staff, which is a three-feet rod, close to one side of his eye, and slides a transum or cross piece, which is in an upright position, along the staff, until one end of the cross touches the star, and the other end the horizon at the same time; then the division of the staff, which the cross stands against, is the altitude, But the many inconveniencies which attend the use of the cross-staff, make it now of little note, especially since the use of Hadley's quadrant is become more general; as this instrument far surpasses all others for observing altitudes and distances of celestial objects at sea, both in ease and accuracy.

Of HADLEY'S QUADRANT.

41. *The Description and Use.* Pl. XIV. Fig. 11.

This instrument consists of the following parts:

I. The arch BC, which is generally an octant, or eighth part of a circle; but is more useful when it is a sextant, or sixth part of a circle.

II. The index D, with its Vernier's scale.

III. The speculum E.

IV. Two horizon glasses, F and G, with their adjusters.

V. Two skreens, K, K.

VI. Two sight vanes, H, I.

I. *Of the Octant.*

The octant consists of the two radius's or bars AB, AC; the arch or limb BC; and the two braces, L, M, which are to strengthen and prevent it from warping. Although the arch contains only the eighth part of the circumference of a circle, or 45 degrees, it is divided into 90 primary divisions, each of which stands for a degree; they are numbered 0, 10, 20, 30, *&c.* to 90, beginning at each end of the arch for the convenience of numbering both ways, either for altitudes or zenith distances. Every degree is subdivided into two or three parts, and these again into single minures, either by diagonals, or Vernier's method, which is better.

II. *Of the Index.*

The index D is a flat bar, moveable round the center of the instrument; that part of the index which slides over the graduated arch BC, has either a sharp edge to cut the diagonal divisions, when the limb is so divided, or has Vernier's scale on it.

From the bottom of the index a piece of brass turns up against the back of the instrument, with a screw in it, serving to fasten the index against any division.

Digitized by Google

When the index is moved along the arch, it ſhould be taken hold of by the bottom part, and not by the middle.

The principles, upon which the Vernier's ſcale depends, were ſhewn in Book V. Art. 219; but it may be proper to add ſome general directions in this place, by which learners may be enabled to read the degrees and minutes ſhewn by the index.

The generality of Hadley's quadrants are of 15 or 18 inches radius, and have each degree on its limb divided into three parts, of 20 minutes each. The breadth of the Vernier's ſcale is therefore equal to 7 degrees; and as theſe ſeven degrees are divided into 21 parts on the limb, each of 20 minutes; the ſcale is divided into 20 equal parts: conſequently each diviſion on the ſcale is larger than each diviſion on the limb by $\frac{1}{20}$th part of a diviſion on the limb, or $\frac{1}{20}$th of 20 minutes; that is, each diviſion on the ſcale exceeds each on the limb by 1 minute of a degree: conſequently, if any one diviſion of the Vernier's ſcale ſtands againſt one of the diviſions on the limb, no other diviſion on the ſcale can coincide with a diviſion on the limb.

Now the middle line of the index D, which is the moveable radius of the quadrant, is the index, or pointer, of the Vernier's ſcale, and is uſually its middle line; there being 10 diviſions, or minutes, on each ſide, numbered 5, 10, to the right, and 15, 10, to the left; that is, the firſt 10 minutes of the ſcale is reckoned in order from the middle line or index to the right; and the latter 10 minutes is to be reckoned from the left-hand end of the ſcale toward the right, and ends at the middle line, where the others began.

Suppoſe the middle line, or index of the Vernier ſtood againſt 48°, and ſomewhat more than one ſubdiviſion on the arch of the inſtrument. Examine, firſt towards the right hand of the ſcale, if any of its diviſions ſtand againſt a diviſion on the arch; and ſuppoſe that the 7th diviſion from the middle one is found to do ſo, theſe ſeven muſt be added to what the middle line on the Vernier ſtood beyond on the arch; that is, to $48\frac{1}{3}°$, or 48° 20′, and the whole will be 48° 27′ that the index of the inſtrument ſtood at on the arch. But if none of the right-hand diviſions ſtand againſt a diviſion on the arch, examine thoſe on the left-hand, beginning at the extreme one, and proceeding toward the middle; and let the 16th diviſion be that which coincides with a diviſion on the limb (for ſome one will); then thoſe 16 added to 48° 20′ make 48° 36′ for what the index ſtood at. A magnifying glaſs, or double convex lens of a ſhort focus, will aſſiſt the obſerver in diſtinguiſhing that diviſion on the Vernier which coincides with, or ſtands againſt a diviſion on the arch.

III. *Of the Speculum.*

The ſpeculum is a flat piece of glaſs, quickſilvered on one ſide like a common looking-glaſs, and fixed to the index by means of a braſs frame, directly over the center of it; its ſurface coinciding nearly with the firſt diviſion of the Vernier, and exactly perpendicular to the plane of the inſtrument. The poſition of its ſurface muſt therefore alter as the index turns on its center.

The uſe of the ſpeculum is to receive the rays from the object obſerved, and reflect them on the horizon glaſſes.

IV. Of

Digitized by Google

IV. *Of the Horizon Glasses.*

These are small pieces of looking-glass placed on one of the radii, the face of one of them being parallel, and that of the other perpendicular to the speculum when the index stands at O; they receive the reflected rays of observed objects from the speculum, and transmit them to the eye of the observer.

The glass F has only its lower part quicksilvered, and set in brass work; the upper part being left transparent, that the horizon may be seen through it.

In the middle of the glass G is a transparent slip, through which the horizon is to be seen.

Both of these glasses are so mounted, as to have their positions set truly by their adjusters at the back, should the frame of the instrument be warped.

V. *Of the Skreens.*

These are two pieces of coloured glass set in frames, to prevent the Sun's rays from hurting the eye during the time of observation. When they are used with the glass F, they are to be where the figure shews them; but when used with the glass G, they are to be set at their hole *r* above G.

VI. *Of the Sight Vanes.*

That at H is used with the glass G in back observations: and the sight vane I, which has two holes, is used with the glass F in fore observations.

For with this instrument an observation may be made with the face turned from the object, which is called a back observation; or with the face turned toward the object, which is called a fore observation: but before any observation is attempted, the instrument should be examined to see if it is fit for use.

To rectify or adjust Hadley's Quadrant.

42. I. *For the fore Observation.*

Bring the index D close to the button *b*, that the middle of the Vernier's scale may stand against 0 degrees. Hold the plane of the instrument vertical with the arch downward; look through the right-hand hole in the vane I, and direct the sight through the transparent part of the glass F to the horizon. Now if the horizon line, seen both in the quicksilvered part, and through the transparent part, should coincide, or make one straight line, the glass F is truly adjusted. But if one of the horizon lines stand above the other, slacken the screw in the middle of the lever, behind the glass E, and turn the screw at the end of the lever backward or forward, as there is occasion, until the horizon lines coincide; fasten the screw in the middle of the lever, and then the horizon glass is adjusted.

43. II.

Digitized by Google

43. II. *For the back Obſervation.*

Turn the button *b* on one ſide, find the dip of the horizon on your height above the water in the following table (Art. 55.) and ſet the middle line of the index D as many minutes before O degrees, as there are in twice that dip. Hold the plane of the inſtrument vertically, with the arch downward; look through the hole in the vane H, and if the horizon line, ſeen through the tranſparent ſlit in the glaſs G, coincide with the image of the horizon ſeen in the quickſilvered part of the ſame glaſs, then the glaſs G is in its proper poſition. If not, ſlacken the ſcrew pin in the middle of the lever, behind the glaſs G, and, looking through the vane H as before, turn the ſcrew at the end of the lever backward or forward, as it is wanted, until the horizon lines coincide; then tighten the middle ſcrew, and the glaſs G is adjuſted. In ſetting this glaſs by the oppoſite horizon, the head ſhould be held a little backward, not to intercept the light from behind. The horizon ſeen from behind will be inverted; that is, the water will appear above, and the ſky below: if the two horizon lines croſs one another, the inſtrument is not held upright.

To take the Sun's Altitude with Hadley's Quadrant.

44. I. *By the fore Obſervation.*

Fix the ſkreens K above the horizon glaſs F, uſing either or both of them, according to the ſtrength of the Sun's rays, by turning one or both of the frames of theſe glaſſes cloſe againſt the plane or face of the inſtrument; then the face being turned towards the Sun, hold the quadrant by the braces L, M, or by either radius, as is found moſt convenient, ſo as to be in a vertical poſition with the arch downward; put the eye cloſe to the left-hand hole in the vane I; look at the horizon through the tranſparent part of the horizon glaſs F; at the ſame time, move the index D with the left-hand, until the image of the Sun, ſeen in the quickſilvered part, falls in with the line of the horizon, taking either the upper or under edge of the ſolar image. Swing your body gently from ſide to ſide, and if that edge of the Sun which is obſerved touch the horizon line like a tangent, without cutting it, the obſervation is well made: and the degrees on the arch, reckoned from that end next your body, give the altitude of that edge of the Sun which was brought to the horizon.

If the lower edge was obſerved, then 16 minutes added to the ſaid degrees, give the altitude of the Sun's center; but if the upper edge was uſed, the 16 minutes muſt be ſubtracted.

45. II. *By the back Obſervation.*

Put the ſtem of the ſkreens K into the hole next the horizon glaſs G, uſing them as before ſaid, according to the ſtrength of the Sun's rays. Then the back being turned to the Sun, hold the inſtrument by the radius C and brace L, in a vertical poſition with the arch downward; put the eye cloſe to the hole in the vane H, look for the horizon through

Digitized by Google

through the tranſparent ſlit in the glaſs G; with the right-hand move the index D, until the image of the Sun, ſeen in the quickſilvered part of the glaſs G, ſtands in the horizon line, ſeen through the tranſparent ſlit, uſing either the upper or under edge of the Sun, as is moſt convenient. Swing your body gently to the right and left, to try if the Sun's edge runs along the horizon; if it does, the obſervation is well made, and the degrees reckoned from that end of the arch fartheſt from your body, will give the altitude of that part of the Sun which was obſerved.

If the Sun's lower edge was obſerved, then 16 minutes ſubtracted from the ſaid degrees, will give the altitude of the Sun's center; but if the upper edge was obſerved, then 16 minutes are to be added.

In either of theſe obſervations, if the altitude of the center could be obſerved, there would then be no need of uſing the 16 minutes.

46. The fore obſervation is rather moſt convenient, eſpecially in great altitudes, becauſe there is a much larger ſcope above and below the altitude wanted, than there is in the back obſervation, which, on account of the obliquity of the ſpeculum and horizon glaſs, is more contracted in its uſe. And indeed the back obſervations need never be uſed for the Sun, when there is a clear horizon forward, or under the Sun: when this is hazy and ill defined, it is beſt to uſe the back obſervation, if the horizon is clear that way; it is proper, therefore, that the horizon glaſs G ſhould be always in readineſs, by having it well adjuſted; and becauſe the former method is not readily attained by beginners, we ſhall annex another ſomewhat more convenient.

47. *Another way to adjuſt for the back Obſervation.*

Take the altitude of the lower edge of the Sun by the fore obſervation, as near to noon as can be; then put the ſkreens into the hole near the vane H, and turning your back to the Sun, and holding the inſtrument properly, taking care not to move the index, look for the horizon line through the tranſparent ſlit of the glaſs G; and if the horizon line touches the upper edge of the Sun's image in the glaſs G, it is properly adjuſted: if they do not touch, turn the glaſs by the lever behind it, till they do.

This operation muſt be done quickly, before the Sun ſenſibly alters in altitude; and may be frequently repeated to make the fore and back obſervations agree.

To take the Altitude of a Star by Hadley's Quadrant.

48. I. *By the fore Obſervations.*

Look directly up at the ſtar through the vane I, and tranſparent part of the glaſs H, the index D being cloſe to the button *b*; then will the image of the ſtar, by reflection, be ſeen in the ſilvered part right againſt the ſtar, ſeen through the other part. Move the index forward, and as the image deſcends, turn the quadrant round its center, keeping it all the time in a vertical poſition, and the image of the ſtar on the ſilvered part

Digitized by Google

part of the horizon glaſs, till it comes down to the horizon ſeen through the tranſparent part; and the obſervation is made.

49. If the altitude of the ſtar is pretty great, ſome other ſtars, beſide that wanted, may appear by reflection from the great ſpeculum, on the horizon glaſs G; theſe will dance with the motion of the inſtrument, but the true ſtar will remain at reſt about the middle of the glaſs, and ſo the others cannot be miſtaken for it.

For the principles of the conſtruction ſee the Appendix.

50. Hadley's Quadrants, within a few years paſt, having been applied to take the obſervations neceſſary for finding the longitude at ſea, it has been found that ſuch obſervations required a degree of accuracy, of which the inſtruments conſtructed in the common way were not capable: and expert mariners having complained of theſe defects, different workmen have applied ſundry articles to the quadrants to remedy the inconveniencies complained of; ſome of which follow.

1ſt. A ſcrew to the lower end of the index, to regulate its motion when brought by the hand to a diviſion ſhewing nearly the contact required; and a magnifying glaſs to read off the diviſions ſhewn on the limb by the Vernier.

2d. A ſmall tube, or teleſcope, inſtead of the ſight vanes, to direct the line of ſight parallel to the plane of the quadrant; which tube is to be ſcrewed into a ring fixed to a ſquare ſtem that ſlides in the ſocket made for the ſight-vane, and by the help of a ſcrew at the back of the quadrant this ſtem may be raiſed or lowered, ſo as to move the axis of the teleſcope to point to any part of the horizon glaſs which is judged fitteſt for the obſervation.

3d. The arch has alſo been extended from an octant to a ſextant, or the ſixth part of a circle; by which means angles exceeding 90 degrees may be obſerved; and ſuch angles are often wanted in taking the angular diſtance between the Moon and Sun, or Moon and Star. Alſo, for the convenience of holding the inſtrument eaſily in ſuch obſervations, a ſtout handle is fixed to the back, which is a very neceſſary addition.

4th. The ſpeculum being liable, in the ordinary way of fitting it, to be bent; and conſequently the ſame obſervation would have different meaſures, according as the object happened to be reflected from different parts of the ſpeculum; this has been lately rectified by a new manner of ſetting the ſpeculum in its frame.

5th. A new method of adjuſting the glaſſes for the back obſervation has lately been diſcovered, very accurate in principle, and ready in practice, by the ingenious Mr. *Peter Dollond*, Optician to his Majeſty; who alſo thought of the method of preventing the index ſpeculum from being bent in its frame. By his adjuſtments, angles of any magnitude under 180 degrees may be taken; *viz.* by the fore obſervation all under 120°, with a ſextant; and by the back obſervation, all between 90 and 180 degrees.

6th. Although Mr. Hadley at firſt directed that the line of ſight ſhould be parallel to the plane of the inſtrument; and for placing and preſerving it ſo, propoſed, that two parallel wires ſhould be fixed in the teleſcope parallel to the plane of the quadrant, and that the con-

Digitized by Google

tact of the objects should be observed in the middle between the two wires; yet these circumstances not being sufficiently attended to, the two parallel wires had been neglected in fabricating the instrument; these two parallel wires are now replaced in the focus of the eye-glass, so as to divide the diameter of the field of view into three equal parts; and when the telescope is adjusted parallel to the plane of the instrument, it will remain so during the observation.

7th. As every glass mirror has two reflections, *viz.* one from the face, and one from the silvered back surface, these double reflections cause not only some confusions among the reflected rays, but considerable errors in the observations, if the face and back of the glass be not parallel planes: and as none of these can happen from a plane mirror which has but one reflection, the upper part of the index speculum is now made with its back rough ground and blacked; by this means the rays only which fall on its face will be reflected; and these are found sufficient when the object observed is tolerably bright; but when it is otherwise, the object may be observed from the lower part of the speculum, which is silvered; the line limiting these two parts is parallel to the plane of the quadrant. These two improvements were directed by the Rev. Dr. *Maskelyne*, Astronomer Royal.

The methods, by which these several adjustments are to be made, together with some other particulars relating to the use of the instrument, are fully treated of in the book which accompanies the sale of Mr. *Dollond*'s quadrants.

51. *To make an Artificial Horizon.*

One great inconvenience that mariners have to struggle with at sea, is the frequent want of an horizon. For though the atmosphere may be clear enough to give a view of the Sun or other objects, at the height of 10 or 12 degrees and upwards, yet all below that height is often so hazy as to hinder a distinct sight of the horizon; and consequently an observation made at such a time cannot have the desired correctness. And although water in a vessel will have its surface horizontal, and an observavation may be made on the image of the Sun, seen in it when that water is perfectly still, yet the tremulous motion of its surface, from the least wind or motion of the ship, prevents this expedient from being generally used at sea; and therefore many methods have been proposed; among which *Serson*'s whirling Speculum, or Top, was, for a while, thought a proper instrument, but it has been found imperfect. Some artists use the following method:

Into a wooden, or iron, circular box, of about 2½ or 3 inches diameter, and about ½ inch deep, pour about a pound or more of quicksilver; and on this lay a metal speculum, or piece of plain glass, the diameter of which is about ⅓ of an inch less than that of the box; this will float in the quicksilver, and shew the image of the Sun very steady. This apparatus being slung in jimbals will preserve a tolerable good horizon.

The speculum, or glass, should be homogeneous, and have parallel sides. There are some workmen, who can work the two planes of a piece of glass, so that they should be demonstratively parallel.

Or the fine surface of the quicksilver will do of itself, when the motion is not great.

In all observations made with these artificial horizons, a piece of coloured glass should be fixed before the sight vane, to preserve the eye; and the skreens K may be taken off.

Corrections of the apparent or observed Altitude.

In observations of the Sun, it is usual to observe his upper or lower edge; to which his semidiameter being applied, gives the apparent place of the center. For this purpose, among the tables, page 255, is one shewing the Sun's semidiameter for every ten days throughout the year; as this is constantly altering with his distance from the Earth: but it is generally reckoned sufficiently accurate to allow 16 minutes for the Sun's semidiameter.

Every altitude observed at sea must be corrected: two corrections are common to the center of every object; and three to the Moon.

52. I. The Dip of the Horizon.

The observer's eye being raised above the level of the sea, he sees an horizon below the level of the true one; and consequently the instrument gives an altitude too great, when a fore observation is used; and too small, with a back observation, unless the latter of the two methods for adjusting the back horizon glass be used.

As this error depends on the height of the eye above the water, and that on the size of the ship; a table of these corrections to different elevations has been computed and inserted for ready use. The principles upon which these computations depend are given in the Appendix to this IXth Book.

53. II. The Refraction.

The vapours in the atmosphere cause celestial objects to appear higher, or with greater altitudes, than they really have. These refractions, which are greatest at the horizon, and diminish in quantity as the altitudes increase, have been collected by eminent astronomers, and are here disposed of in the following table; the apparent altitude, above the true horizon, is to be diminished by the quantity of the refraction on that altitude.

For the principles, see the Appendix.

54. III. Parallax.

From the explanation of parallax, at Art. 66. B. V. it is evident, that the Moon, when seen at the same time from the surface and center of the Earth, will not appear in the same place in the heavens; and this arises from the semidiameter of the earth bearing a sensible proportion to the distance between the Earth and Moon, which on a mean is about $\frac{1}{60}$, a quantity that considerably affects the observations on that planet; and therefore must be allowed for. But the distance of the Moon from the Earth constantly altering, between the Apogee and Perigee, the parallax also will be continually altering. The Moon's horizontal parallax, which lies between the limits of 53 minutes and 62 min. is given in the Nautical Almanac for every twelve hours throughout the year;

§ which

Digitized by Google

which being known, her parallax to every two degrees of altitude, and every minute of horizontal parallax, may be found in the following table:

55. TABLES for correcting the observed ALTITUDES of CELESTIAL OBJECTS.

The semi-diam. of the Sun.				Dip. of Horizon.			Refractions of the Sun, Moon, and Stars, in Altitude.										
Day of month.	Sun's semi-diam.		Day of month.	Alt. of Eye.	Dip. of Hor.		App. Alt.	Ref.		App. Alt.	Ref.		App. Alt.	Ref.	App. Alt.	Ref.
	M.	S.		feet.	M.	S.	Deg.	M.	S	Deg.	M.	S.	Deg.	S.	Deg.	S.
Jan. 1	16	19	31	5	2	8	2	18	35	16	3	17	35	81	54	41
10	16	19	21	8	2	42	2½	16	24	17	3	4	36	78	56	38
20	16	18	11	10	3	1	3	14	36	18	2	54	37	76	58	35
Feb. 1	16	17	Dec. 1	12	3	18	3½	13	6	19	2	44	38	73	60	33
10	16	15	21	15	3	42	4	11	51	20	2	35	39	70	62	30
20	16	13	11	18	4	3	4½	10	48	21	2	27	40	68	64	28
Mar. 1	16	11	Nov. 1	20	4	16	5	9	54	22	2	20	41	65	66	25
10	16	8	21	25	4	46	5½	9	8	23	2	14	42	63	68	23
20	16	6	11	30	5	14	6	8	28	24	2	7	43	61	70	21
Apr. 1	16	2	Oct. 1	35	5	39	6½	7	51	25	2	2	44	59	72	18
10	15	59	21	40	6	2	7	7	20	26	1	56	45	57	74	16
20	15	57	11	45	6	24	8	6	29	27	1	51	46	55	76	14
May 1	15	54	Sept. 1	50	6	44	9	5	48	28	1	47	47	53	78	12
10	15	52	21	55	7	4	10	5	15	29	1	42	48	51	80	10
20	15	51	11	60	7	23	11	4	47	30	1	38	49	49	82	8
June 1	15	49	Aug. 1	65	7	41	12	4	23	31	1	35	50	48	84	6
10	15	48	21	75	8	16	13	4	3	32	1	31	51	46	86	4
20	15	47	11	85	8	48	14	3	45	33	1	28	52	44	88	2
30	15	47	July 1	100	9	33	15	3	30	34	1	24	53	43	90	0

56. TABLES of the MOON'S PARALLAX in ALTITUDE.

Alt. obs. ☽	Horizontal parallaxes.										Alt. obs. ☽	Horizontal parallaxes.										Augmentation of the ☽'s semi-diam.	
	53'	54'	55'	56'	57'	58'	59'	60'	61'	62'		53'	54'	55'	56'	57'	58'	59'	60'	61'	62'	Moon's Alt.	Aug. S diam.
Deg	'	'	'	'	'	'	'	'	'	'	Deg.	'	'	'	'	'	'	'	'	'	'	°	'
1	53	54	55	56	57	58	59	60	61	62	50	34	35	35	36	37	37	38	39	39	40	0	0
7	53	54	55	56	57	58	59	60	61	62	52	32	33	34	34	35	36	36	37	38	39	5	1
12	52	53	54	55	56	57	58	59	60	61	54	31	32	32	33	33	34	35	35	36	37	10	3
14	51	52	53	54	55	56	57	58	59	60	56	29	30	31	31	32	32	33	34	34	35	15	4
16	51	52	53	54	55	56	57	58	58	59	58	28	29	29	30	30	31	31	32	32	33	20	6
18	50	51	52	53	54	55	56	57	58	59	60	26	27	27	28	28	29	29	30	30	30	25	7
20	50	51	52	53	54	54	55	56	57	58	62	25	25	26	26	27	27	28	28	29	29	30	8
22	49	50	51	52	53	54	55	56	56	57	64	24	24	24	24	25	25	26	26	27	27	35	9
24	48	49	50	51	52	53	54	55	56	57	66	22	22	22	23	23	24	24	24	25	25	40	10
26	47	48	49	50	51	52	53	54	55	56	68	20	20	21	21	21	22	22	22	23	23	45	11
28	47	48	49	49	50	51	52	53	54	55	70	18	18	19	19	19	20	20	20	21	21	50	12
30	46	47	48	48	49	50	51	52	53	54	72	17	17	17	17	18	18	18	18	19	19	55	13
32	45	46	47	47	48	49	50	51	52	53	74	15	15	15	15	16	16	16	16	17	17	60	14
34	44	45	46	46	47	48	49	50	51	52	76	13	13	13	14	14	14	14	14	15	15	65	15
36	43	44	44	45	46	47	48	48	49	50	78	11	11	11	12	12	12	12	12	13	13	70	15
38	42	43	43	44	45	46	46	47	48	49	80	9	9	10	10	10	10	10	10	11	11	75	16
40	40	41	42	43	44	44	45	46	47	48	82	7	7	8	8	8	8	8	8	8	9	80	16
42	39	40	41	42	42	43	44	45	45	46	84	6	6	6	6	6	6	6	6	6	7	85	16
44	38	39	40	40	41	42	42	43	44	45	86	4	4	4	4	4	4	4	4	4	4	90	16
46	36	37	38	39	40	40	41	42	42	43	88	2	2	2	2	2	2	2	2	2	2		
48	35	36	37	37	38	39	39	40	41	42	90	0	0	0	0	0	0	0	0	0	0		

SECTION

SECTION VIII.

Of Comparing and Correcting Time.

57. PROBLEM I.

Given the eſtimated account of the ſhip's longitude from London; to find the correſponding times at the ſhip, and at London.

RULES.

Let the given time be always reckoned from the preceding noon; and turn the degrees in the difference of longitude into time. (V. 133)

I. Then eaſt diff. long. in time, ſubtracted from the ſhip's time, gives Lond. time, P. M. from the noon uſed.

And eaſt diff. longitude in time, added to London time, gives the ſhip's time, P. M. from the noon uſed.

Note, If it be neceſſary to borrow 24^h, the London time will be on the day preceding the given one.

Or, if the Sun exceed 24^h, the exceſs above 24^h is the ſhip's time on the following day.

II. Weſt diff. longitude in time, added to the ſhip's time, gives Lond. time, for the noon uſed.

Or, The exceſs above 24^h, is Lond. time on the following day.

And weſt. diff. long. in time, ſubtracted from Lond. time, gives the ſhip's time from the noon uſed; or on the preceding day, if 24^h were borrowed.

EXAMPLES.

I. *What London time anſwers to a ſhip's noon, at a place 4 hours to the eaſtward of London?*

Here ſhip's time is 24^h from preceding noon.

Then $24^h - 4^h = 20^h$ P. M. London time, on the day before.

Or, Ship's noon anſwers to 8 o'clock morning at London.

II. *When it is 8 o'clock in the morning at London, what is the correſponding time at a ſhip 4h. to the eaſtward?*

Here 8 o'clock morning, is 20^h P. M. from noon of preceding day.

Then 20^h P. M. $+ 4^h = 24^h$ P. M. ſhip's time.

Or, 8 o'clock in the morning at London anſwers to noon in the ſhip.

III. *What London time is it, when it is noon at a ſhip 5h. to the weſt of London?*

0^h P. M. $+ 5^h$ W. $= 5^h$ P. M. at London.

IV. *When it is 5h. P. M. at London, what hour is it at a ſhip 5h. W. of London?*

5^h P. M. $- 5^h$ W. $= 0^h$ P. M. or noon in the ſhip.

V. *What*

Digitized by Google

V. *What London time answers to 2h. 38m. P.M at a ship 22 deg. to the east of London?*

22° E. makes $1^h\ 28^m$. (V. 133)
Then $2^h\ 38^m$ P.M.—$1^h\ 28^m$ E. $=1^h\ 10^m$ P.M. at London.

VI. *When it is 1h. 10m. P.M. at London, what time is it at a ship 22° E. of London?*

22° E. makes $1^h\ 28^m$. (V. 133)
Then $1^h\ 10^m$ P.M. + $1^h\ 28^m$ E. $=$ $2^h\ 38^m$ P.M. at the ship.

VII. *What time is it at London, when a ship 40° W. of London reckons it 3h. 20m. P.M.*

40° W. $=2^h\ 40^m$ W. (V. 133)
Then $3^h\ 20^m$ P.M. + $2^h\ 40^m$ W. $=7^h\ 0^m$ P.M. London.

VIII. *When it is 7h. P.M. at London, what ship's time is it 40° W. of London?*

40° W. $=2^h\ 40^m$ W. (V. 133)
Then 7^h P.M.—$2^h\ 40^m$ W. $=3^h\ 30^m$ P.M. ship.

IX. *What London time answers to 5h. 26m. P.M. at a ship 120° E. of London?*

120° E. makes 8^h E. (V. 133)
Then $29^h\ 26^m$ P.M.—8^h E. $=21^h\ 26^m$ P.M. the preceding day.
Or, $9^h\ 26^m$ in the morn. at Lond.

X. *When it is 9h. 26m. morning at London, what ship's time is it at 120° E. of London?*

120° E. makes 8^h E. (V. 133)
Then $21^h\ 26^m$ P.M. + 8^h E $=29^h\ 26^m$ P.M. or $5^h\ 26^m$ on the following day.

XI. *What London time answers to 5h. 42m. P.M. in a ship 110° W. of London?*

110° W. $=7^h\ 20^m$ W. (V. 133)
Then $5^h\ 42^m$ P.M. + $7^h\ 20^m$ W. $=13^h\ 2^m$ P.M. Or $1^h\ 2^m$ in the morning at London.

XII. *What is it at a ship 110° W. of London, when it is 1h. 2m. in the morning at London?*

110° W. $=7^h\ 20^m$ W. (V. 133)
Then $13^h\ 2^m$ P.M.—$7^h\ 20^m$ W. $=5^h\ 42^m$ P.M. ship.

XIII. *A ship 28° 30′ E. of London, reckons $7^h\ 42^m$ in the morning: what hour is it at London?*

28° 30′ E. $=1^h\ 54^m$ E.
Then $19^h\ 42^m$ P.M.—$1^h\ 54^m$ E. $=17^h\ 48^m$ P.M
Or, 48^m after 5 in the morning.

XIV. *When it is 5h. 48m. morning at London, what hour is it at a ship 28° 30′ E. of London?*

28° 30′ E. $=1^h\ 54^m$ E
Then $17^h\ 48^m$ P.M. + $1^h\ 54^m$ E. $=19^h\ 42^m$ P.M. ship.
Or, $7^h\ 42^m$ in the morning.

XV. *What London time answers to 6h. 45m. in the morning, at a ship 66° W. of London?*

66° W. $=4^h\ 24^m$ W.
Then $18^h\ 45^m$ P.M. + $4^h\ 24^m$ W. $=23^h\ 9^m$ P.M.
Or, $11^h\ 9^m$ in the morning at London.

XVI. *When it wants 51m. of noon at London, what hour is it at a ship 66° W. of London?*

66° W. $=4^h\ 24^m$ W.
Then $23^h\ 9^m$ P.M.—$4^h\ 24^m$ W. $=18^h\ 45^m$ P.M.
Or, Time at the ship is $6^h\ 45^m$ morning.

Digitized by Google

XVII. *When it is 4h. 26m. morning, at a ship 98° 45′ E. of London: what hour is it there?*

98° 45′ E. = 6^h 35^m E.
Then 16^h 26^m P. M — 6^h 35^m E. = 9^h 51^m P. M. at London.

XVIII. *What hour is it at a ship 98° 45′ E. of London, when it is 9h. 51m. P. M. at London?*

98° 45′ E. = 6^h 35^m E.
Then 9^h 51^m P. M. + 6^h 35^m E. = 16^h 26^m P. M.
Or, 4^h 26^m morning at the ship.

XIX. *What London time answers to 10h. 40m. morning, at a ship 160° W. of London?*

160° W. = 10^h 40^m W.
Then 22^h 40^m P. M. + 10^h 40^m W. = 33^h 20^m P. M. or 9^h 20^m P. M. at London, on the following day.

XX. *When it is 9h. 20m. P. M. at London, what hour is it at a ship 160° W. of London?*

160° W. = 10^h 40^m W.
Then 33^h 20^m P. M. — 10^h 40^m W. = 22^h 40^m ship; or, 10^h 40^m morning at the ship, on the preceding day.

These twenty examples have been introduced, because experience hath shewn that a variety is necessary to most beginners.

58. PROBLEM II.

To find the apparent time at sea, and thereby to regulate, or compare, the going of a watch.

I. *By equal Altitudes.* (V. 215, 297.)

The ship lying by, let the Sun's altitude be taken at any time in the forenoon, 3, 4, or 5 hours distant from noon, set down that time and altitude. In the afternoon, wait until the Sun has the same altitude exactly (the index of the quadrant being already set to the morning altitude) and note down that time; then the half sum of these two times is the apparent time shewn by the clock or watch, when the Sun was on the meridian of that place.

If it were wanted to reduce the apparent time to mean time,

Seek in the Nautical Almanack * for the given day, and take out the equation of time; which applied, as its title directs, to the apparent time, gives the mean time. Astronomical tables are usually fitted to mean time.

As it is possible that an altitude taken in the morning cannot have a corresponding one in the evening by the interposition of clouds; it is best to take several in the forenoon; in order to have a greater probability of securing a corresponding altitude in the afternoon; and if several observations of equal altitudes can be made on both sides of the meridian, it will be best to find the noon to each pair, and take a mean of all the noons thus found for the true one.

* The Nautical Almanack is published annually, under the direction of the Commissioners of Longitude, which Almanack every skilful mariner should have with him at Sea.

If

Digitized by Google

If equal altitndes are taken within six weeks or two months of an equinox, it will be proper to make an allowance for the change in the Sun's declination between the forenoon and afternoon observations, as is shewn in Book V. Articles 217, 297.

If there is reason to suspect, that the watch gains or loses considerably in a day, other sets of observations should be taken on successive days, by which the daily variation of the watch may be found, and allowed for.

EXAM. I. *May 20th, 1772, at 8h 40m forenoon, and at 3h 16m afternoon, by my watch, the Sun had equal altitudes: required the going of the watch?*

Add together	12h 0m
	+ 8 40
	+ 3 16
Take the half sum	23 56
Rem. noon by the watch	= 11 58
Apparent noon	= 12 0
Watch too slow	2 min.
May 20th. ap. noon	11 58
Equal time subtr.	4
Mean noon, by watch	11 54

EXAM. II. *March 18, 1772, being in latitude 49° N. at 8h 10m 58s forenoon, and at 3h 58m 34s afternoon, the Sun had equal altitudes: how did the watch go?*

Add together	12h 0m 0s
	+ 8 10 58
	+ 3 58 34
Take half the sum	24 9 32
Gives the middle time	12 4 46
Corr. on mid. time	19
Noon by watch	12 4 27
Apparent noon	12 0 0
Watch too fast	4 27
March 18th ap. noon	12 4 27
Equa. time add	8 4
Mean noon, by watch	12 12 31

II. *By an observation of the Sun's altitude.*

1st. At a convenient time take the altitude of the Sun's upper or lower limb, which correct for the semidiameter, dip, and refraction; by which the correct zen. dist. of the Sun's center will be known.

2d. At the time of the observation find the Ship's lat. and long. by account; (VIII. 60) and correct the Sun's decl. for the day, by the diff. of long. and time from noon; and thereby get the true polar distance.

3d. With the co-latit. polar-dist. and zen. dist. find the hour angle: (V. 152.) Which turned into time, shews the app. time when the obser. was made.

III. *By an observation of a Star's altitude.*

1st. Correct the observed altitude by the dip and refraction. (55.)
2d. Find the ship's latitude and longitude by account. (VIII. 60.)
3d. Seek the Star's decl. or polar dist. and its right ascension. (V. 312.)
4th. With the co-lat. polar dist. and zen. dist. find the hour angle. (V. 155.)

X 2 5th. Apply

Digitized by Google

5th. Apply the hour angle (in time) to the ſtar's right aſcenſion, and it gives the right aſcenſion of the mid-heaven. (V. 133.)

6th. Find the Sun's right aſcenſion to the place and time. (V. 288.)

7th. The difference between the Sun's right aſcenſion and that of the mid-heaven is the apparent time of the obſervation. Regulate the watch by the apparent time thus found.

The logarithmic work for the Sun in Art. 2d, or for the ſtar in Art. 3d, may be performed by either of the following rules.

RULE I. Let the diff. between the co-lat. and polar diſt. be called D. Find the half ſum, and half diff. of the zen. diſt. and D.

Then, To the ar. co. of the log. ſines of the co-lat. and polar diſt. Add the log. ſines of the ſaid half ſum and half diff.

And Half the ſum of theſe four logs. is the log. ſine of ½ the hour angle.

RULE II Add together the co-alt. co-lat. and polar diſt. call the half ſum A.

Let the diff. between the half ſum A and co-alt. be called D.

Then, To ar. co. of the log. ſines of the co-lat. and polar diſt. Add the log. ſines of A and D.

And Half the ſum of theſe 4 logs. is the log. co-ſine of ½ the hour angle.

EXAMPLES.

I. *January 26, 1780, at 2h 56m 56s P. M. by my watch, the true alt. of the ſun's center was 9° 44′, the ſhip's lat. 51° 42′ N. long. 33° W. Required the error of the watch?*

Time by watch	2h	56′	56″
33°W.=(V. 133.)	2	12	00
Eſtim. time at Grenw.(57)	5	8	56
Sun's dec. Jan. 26th noon	18°	43′	24″
Decr.of decl. in 5h9′(V.281)		3	13
Sun's decl. at ſhip	18	40	11S.
Add	90	00	00
Polar diſtance	108	40	11

Co-lat. 38° 18′ ar. co. log. ſine 0,20776
Po.diſt. 108 40 ar. co. log. ſine 0.02347
D = 70 22
Co. alt. 80 16
2)150 38(75°19′ log. ſine 9,98558
2)9 54 (4 57 log. ſine 8,93594
2)19,15275
22 9 log. ſine 9,57638
2
44 18=2h 57′ 12″ app. time.
2 56 56 watch time.
0 0 16 watch ſlow.

II. *May 24th, 1780, being in lat. 43° 16′ N. long. 23° 30′ E. at 7h 16½m forenoon, the true alt. of the Sun's center was found to be 29° 4′: how was the watch?*

Time at the ſhip (May 23)	19h	16′	30″
Long.23° 30′E.(V.133)=	1	34	00
Eſtim. time at Greenw.	17	42	30
Sun's dec. May 23d. noon	20°	45	22″N.
Incr. of decl. in 17h 42′	+	8	8
Sun's decl. at ſhip	20	53	30 N.
Sun's polar diſtance	69	6	30

Co. alt. 60° 56′
Co. lat. 46 44 ar. co. log. ſine 0,13777
Po.diſt. 69 6 ar. co. log. ſine 0,02956
Sum 176 46
½Sum 88 23 log. ſine 9,99983
Co. alt. 60 56
Diff. 27 27 log. ſine 9,66368
2)19.83084
34 36½ log. co. ſine 9,91542
69 13 =4h 36′ 52″ before noon.
19 23 8 app. time.
19 16 30 time by watch.
6 38 watch too ſlow.

May

Digitized by Google

May 12th, 1780, at sea, in latitude 29° 11′ N. long. 95° 5′ W. the true altitude of the star Antares was found to be 14° 53′ at 9h 1′ 5″ by a watch: What was the error of that watch?

		Rt. ascen. Antares	16h 15′ 57″
Long. 95° 5′ W. = (V. 133.)	6h 20′ 20″.	R. ascen. Sun at noon	3 19 29
Antares south nearly	12 56 28		12 56 28
Sum (long. being W.)	19 16 48	gives incr. rt. asc. subt.	3 10
		Antares on the meridian at	12 53 18

Antares Zen. dist.	75° 7′		
Polar dist.	115 56	Ar. co. log. sin.	0,04609
Co. latit.	60 49	Ar. co. log. sin.	0,05895
Sum	251 52		
Half sum	125 56	log. sine	9,90832
Zenith. dist.	75 7		
Difference	50 49	log. sine	9,88937
			2)19,90273
	26 37	log. co. sine	9,95136
	2		

53 14 = (V. 133.)	3h 32′ 56″	star short of meridian.
	12 53 18	star on the meridian.
	9 20 18	app. time.
	9 1 5	time by watch.
	19 17	watch too slow.

SECTION IX.

59. *To find the Latitude at Sea.*

Find the meridian altitude or zenith distance of the Sun or Star by Article 37, or 44, or 45, or 48, 49.

Apply the corrections for the dip of the horizon, the refraction in Art. 52, 53, 55, and semi-diameter, if the object be the sun.

Seek the Sun's or Star's declination in the tables at Art. 309, 312, Book V.; or in the Nautical Almanack, observing to correct the Sun's decl. for places more than 8° or 10° to the E. or W. of London, as at Art. 311, Book V.

In latitudes near the poles, when the Sun's declination exceeds the co-latitude, the Sun does not then set; and therefore two altitudes may be taken on the meridian; the least of which is called the altitude below the pole. The same may be understood of any other celestial object, which does not set.

Digitized by Google

Let the declination and the altitude, or zenith distance, be always named either north or south, according to the season of the year, and the situation of the object; and when it so happens that either of them is nothing, it may then be named either north or south at pleasure.

These remarks being premised, all the varities of working a meridian observation for the latitude are contained in the solution of the following Problem:

PROBLEM I.

The declination of the Sun or a Star, and also its correct meridian altitude, or zenith distance being known; to find the latitude of the place of observation.

WHEN THE OBJECT RISES AND SETS.

60. CASE I. *If the zen. dist. and decl. have the same name.*

RULE. Their difference shews the latitude required.

Like the declination, when it is greater than the zenith distance; but unlike, when it is less.

61. CASE II. *If the zen. dist. and decl. have contrary names.*

RULE. Their sum shews the latitude required.

And is always like the declination.

When altitudes are given, take them from 90° for zenith distances.

62. WHEN THE OBJECT DOES NOT SET.

If the greatest meridian altitude or zenith distance can be taken, the preceding rules will serve; but when the least, or that below the pole, can only be taken: then

RULE. To the meridian altitude below the pole, add the co-declination, the sum shews the latitude, of the same name with the declination.

The demonstrations of these rules will be shewn in the Appendix.

EXAM. I. *The Sun's meridional zenith distance was observed to be 48° 20′ southerly, when he entered the sign Aries: Required the lat. of the place?*

The zenith distance	48° 20′ S.
Declination	00 00 S.
Lat. sought	48 20 N. (60)

EXAM. II. *When the Sun entered the sign Libra, his meridian altitude was observed to be 53° 32′ in the north: What is the latitude of that place?*

The co-alt. or zen. dist.	36° 28′ N.
Declination	00 00 S.
Lat. sought	36 28 S. (61)

EXAM.

Exam. III. *At sea the Sun was observed in the zenith, when his declination was 22° 10′ N.: What is the latitude of that place?*

The zenith distance	00° 00′ N.
Declination	22 10 N.
Lat. sought	22 10 N.(60)

Exam. IV. *The Sun's merid. zenith distance was observed 21° 08′ S. when his decl. was the same: Required the latitude of the place of observation.*

The zenith distance	21° 08 S.
Declination	21 08 S.
Lat. sought	00 00 S.(60)

Exam. V. *The Sun was observed to be 47° 25′ distant from the zenith in the south, when his declination was 14° 18′ S.: What is the lat. of the place of observation?*

The zenith distance	47° 25′ S.
Declination	14 18 S.
Lat. sought	33 07 N.(60)

Exam. VI. *The Sun's meridian altitude was observed to be 54° 27′ north, when his declination was 19° 57′, north: Required the latitude of the place.*

The co-alt. or zen. dist.	35° 33′ N.
Declination	19 57 N.
Lat. sought	15 36 S. (60)

Exam. VII. *When the Sun's declination was 23° 09′ S. his meridian zenith distance was observed to be 8° 25′ S.: Required the latitude of the place.*

The zenith distance	8° 25′ S.
Declination	23 09 S.
Lat. sought	15 44 S.(60)

Exam. VIII. *The Sun having 23° 11′ N. declination, his meridian altitude was found to be 79° 23′ N.: What is the latitude of the place of observation?*

The co-alt. or zen. dist.	10° 37′ N.
Declination	23 11 N.
Lat. sought	12 34 N. (60)

Exam. IX. *The Sun's meridian zenith distance was observed to be 32° 57′ S. when his declination was 10° 38′ N.: What is the latitude of the place?*

The zenith distance	32° 57′ S.
Declination	10 38 N.
Lat. sought	43 35 N. (61)

Exam. X. *Suppose the meridian altitude of the Sun was observed to be 48° 14′ N. when his decl. was 17° 38′ S.: Required the latitude of the place.*

The co-alt. or zen. dist.	41° 46′ N.
Declination	17 38 S.
Lat. sought	59 24 S. (61.)

Exam. XI. *Observed the meridian altitude of the star Arcturus to be 61° 14′ S.: Required the latitude.*

Mer. zen. dist.	28° 46′ S.
Arct. declin.	20 26 N.(V.312)
Lat. sought	49 12 N.

Exam. XII. *The altitude of the Star Syrius, when on the meridian, was 24° 32′ S.: Required the latitude.*

Mer. zen. dist.	65° 28′ S.
Syrius's declin.	16 25 S.(V.312)
Lat. required	49 03 N.

Digitized by Google

63. Examples, wherein the foregoing Corrections are introduced.

I. *By a fore observation, the altitude of the Sun's lower edge was found, by a Hadley's quadrant, to be 40° 20′ S. when the declination was 9° 56′ N. the eye being 20 feet above the horizon: Required the latitude of that place.*

Apparent alt. ☉ lower edge	40	20′ S.
Semidiameter. Add	0	16
Apparent altitude ☉ center	40	36
Dip. of the heriz. Subtract	0	4
App. alt. cor. by the dip.	40	32
Refraction. Subtract	0	1
True altitude ☉ center	40	31
True zenith distance	49	29 S.
Declination	9	56 N.
Latitude (61)	59	25 N.

II. *By a back observation, with Hadley's quadrant, the apparent altitude of the Sun's lower edge was 25° 12 S. when the declination was 21° 14′ S. and the eye 30 feet above the horizon: In what latitude was that observation made?*

Apparent alt. ☉ lower edge	25°	12′ S.
Semidiameter. Subtract	0	16
Apparent altitude ☉ center	24	56
Dip of the horizon. Add	0	5
App. alt. cor. by the dip	25	01
Refraction. Subtract	0	2
True altitude ☉ center	24	59
True zenith distance	65	1 S.
Declination	21	14 S.
Latitude (60)	43	47 N.

III. *Suppose an observer, whose eye is 35 feet above the water, should find the meridian altitude of Sirius to be 53° 35′ S. by the fore observation with a Hadley's quadrant: Required the latitude of the place of observation.*

Apparent alt. of Sirius	53°	35′	0″ S.
Dip. of the horiz. Subt.		5	40
Appar. alt. above hor.	53	29	40
Refraction. Subtract	0	0	40
True altitude of Sirius	53	29	00
True zenith distance	36	31	00 S.
Sirius's decl. (V. 312)	16	25	08 S.
Latitude (60)	20	5	52 N.

IV. *In a ship where the eye of the observer is 25 feet above the horizon, suppose the meridian altitude of Arcturus should be found 61° 21′ S. by a back observation with Hadley's quadrant: What latitude was that ship in?*

Appar. alt. of Arcturus	61°	21′	0″ S.
Apparent zenith dist.	28	39	0
Dip of the horiz. Add		4	46
Zen. dist. clear of the dip	28	43	46
Refraction. Add	0	0	30
True zenith distance	28	44	16 S.
Arcturus's decl. (V.312)	20	29	15 N.
Latitude (61)	49	12	31 N.

Digitized by Google

V. *May 26, 1780, in longitude 67° 30′E. of London, and the eye 18 feet high, the meridian altitude of the Sun's lower limb was 26° 12′N. by a fore observation: Required the ship's latitude.*

Ship's time		24h 00′ P. M. May 25.
Lon. 67° 30′ E. =		4 30 E.
Lond. time		19 30 P. M. 6h 30 × 3.
May 25, ☉ decl.		21° 6′ 19″ N. diff 10′ 18″
Incr. of decl.		8 12 (V. 285)
At the ship		21 14 31 N. decl.
App. alt. ☉ lower limb		26° 12′
Semi-diameter	+	16
App. alt. ☉ center		26 28
Dip. on 18 feet	−	4
		26 24 00
Refraction	−	1 55
True alt. ☉ center		26 22 05
Zenith dist.		63 37 55 N.
Declination		21 14 31 N.
Latitude		42 23 24 S.

VI. *June 12th, 1780, in a high northern latitude, 83°W. of London, and the eye 20 feet high, the meridian altitude of the Sun's lower limb below the pole, was 8° 15′N. by a fore observation: Required the latitude.*

Ship's time		12h 0m P. M.
Long. 83°W. =		5 40 W.
Lond. time		17 40 P. M. = 4h 25′ × 4.
June 12, ☉ decl.		23 13 17 N. diff. 3 16.
Incr. of decl.		2 28
At the ship		23 15 45 N. declin.
App. alt. ☉ lower limb		8° 15′ N.
Semidiameter	+	16
App. alt. ☉ center		8 31
Dip. on 20 feet		4
		8 27
Refraction	−	6 18
True alt. ☉ center		8 20 42 N.
☉ co-declination		66 44 15 N.
Latitude		75 4 57 N.

This method of finding the latitude from the meridian altitude of a celestial object is the most easy, when it can be put in practice: but as that is not always the case at sea, the Problems in Section VI. Book V. were introduced to supply the defect; from whence it has been judged proper to deduce some of the following most practical methods.

Preparation.

Take one, two, or more altitudes of the Sun in the forenoon, noting the time of each by a watch: if the meridian altitude cannot be obtained, take one, two, or more altitudes in the afternoon, noting also the times by the watch.

Let the morning altitudes, if there are three, be taken at equal intervals of time, if possible; if not, let the afternoon observations be taken at the same altitudes with the morning ones.

64. Problem II.

When three zenith distances between the limits of 30 and 70° are taken within an hour of noon, at equal intervals of time between 15 and 30 minntes.

Case I. If the first and third zenith distances are equal:

Rule. The middle one is the meridian zenith distance.

EXAMPLE. *On a day when the Sun's declination was 18° 34′N. ſome time near noon his zenith diſtance was found to be 32° 29′S.; and 22 minutes after, the zenith diſtance was 32° 11′: and 22 minutes afterwards the zenith diſtance was 32° 29′: Required the latitude of that place.*

Here are equal zenith diſtances, at equal intervals of time from the middle obſervation; which therefore is a meridian obſervation.

Then 32° 11′S. + 18° 34′N. = 50° 45′N. the latitude. (61)

(65) CASE II. If the two firſt, or two laſt, zenith diſtances are equal, that on the meridian falls between thoſe equal ones.

RULE. From one of the equal zenith diſtances, take one eighth part of the difference between it and the greater zenith diſtance; and the remainder is that on the meridian.

EXAMPLE. *Within an hour of noon, and at intervals of 22 minutes by a watch, the following zenith diſtances were obſerved, viz. 1ſt.* 32° $50\frac{3}{5}$′; *2d.* 32° $15\frac{1}{2}$′; *3d.* 32° $15\frac{1}{2}$′: *Required the meridian zenith diſtance.*

1ſt. 32° 50,6′ }
2d. 32° 15,5 } diff. 35,1′; its $\frac{1}{8}$ = 4,8′; then 32° 15,5 — 4,8 = 32° 10,7′.

The meridian zenith diſtance is 32° 11′.

(66) CASE III. When the three zenith diſtances are all unequal:

If the two firſt are aſcending, or two laſt deſcending, then noon falls in that interval whoſe two zenith diſtances are neareſt to equality.

RULE. Let the difference between the greateſt and middle be called A,
the difference between the firſt and laſt be called B.
the difference between B and four times A be called C.
the difference between B and C be called D.

Then C multiplied by itſelf, and the product divided by four times D, the quotient is a number of minutes, which ſubtract from the greateſt zenith diſtance leaves the meridian zenith diſtance.

EXAM. I. *In north latitude, the Sun was thrice obſerved near noon, when the zenith diſtance and times by a watch were as follow:*

1ſt. At 11*h.* 27*m. the zenith diſtance* = 32° 51′,
2d. 11*h.* 51*m. the zenith diſtance* = 32 14,
3d. 12*h.* 15*m. the zenith diſtance* = 32 19.

Required the meridian zenith diſtance.

Zenith diſtance,	1ſt. 32° 51′		
	2d. 32 14	A = 37	4A — B = 148 — 32 = 116 = C.
	3d. 32 19	B = 32	C — B = 116 — 32 = 84 = D.

And $\frac{116 \times 116}{84 \times 4}$ = 40′, the correction.

Then 32° 51′ — 40′ = 32° 11′, is the meridian zenith diſtance.

EXAM.

Digitized by Google

EXAM. II. *In north latitude, three observations were made of the Sun near noon, at equal intervals of time, viz.*

1st. At 11*h.* 2*m. the zenith distance was* 34° 11′
11*h.* 20*m.* 35 9,
11*h.* 38*m.* 32 29,

Required the meridian zenith distance.

Here A = 62; B = 102; C = 146; D = 44.

And $\frac{146 \times 146}{44 \times 4} = 121' = 2°\ 1'$, the correction.

Then 34° 11′ — 2° 1′ = 32° 10′, is the meridian zenith distance.

EXAM. III. *In the torrid zone, the Sun having* 19° 48′ *S. decl., three observations were taken at equal intervals of time, near noon, viz.*

At 10*h.* 56*m. the zen. dist. was* 36 41 S. } *Required the latitude.*
11 22 34 26
11 48 33 16

Here A = 2° 15′ = 135′; B = 3° 25′ = 205′; C = 335; D = 130;

And $C^2 = 112225$; 4D = 520. Then $\frac{112225}{520} = 216' = 3°\ 36'$.

And 36° 41′ — 3 36′ = 33° 05′, the meridian zenith distance.

Then 33° 05′ — 19° 48′ = 13° 17′ N. the latitude sought. (60.)

EXAM. IV. *In a low north latitude, the Sun having* 14° 24′ *S. declination; when the watch shewed* 11*h.* 42*m.,* 12*h.* 20*m., and* 12*h.* 58*m., the Sun's zenith distances were* 43° 19′, 43° 23′, *and* 45° 19′, *respectively: Required the latitude.*

11h. 42m. zen. dist.	43° 19′	B = 2° 0′ = 120.	
12 20	43 23	A = 1 56 = 116.	4A = 464.
12 58	45 19	C = 344.	
		D = 224.	4D = 896.

2L, C	344	5,07312	Greatest zenith distance	45°	19′
L, 4D subtr.	896	2,95231	Take the correction	2	12
L, correction	132	2,12081	Meridian zenith distance	48	7 S.
			Declination	14	24 S.
			Latitude (60)	28	43N.

67. PROBLEM III.

When three zenith distances, between the limits of 30° *and* 70° *are taken within an hour and a half of noon, at unequal intervals of time.*

RULE 1st. Let the difference in minutes between the greatest and middle zenith distances be called A; and the interval of time called *a*: the difference between the first and last zenith distances be called B: and the corresponding interval of time called *b*.

2d. Let the difference between the products of A by *b* and B by *a* be taken.

From the logarithm of this difference take the logarithm of *b*, there remains a logarithm, which call N.

3d. Add

§

3d. Add together the logarithm of N.
twice the log. of the diff. between a and $\frac{1}{2}b$.
Ar co. log. of the diff. between a and b.
Ar co. logarithm of a.

Their ſum gives a logarithm, which call M.

4th. Seek the numbers to N, M, $\frac{1}{2}$B; their ſum gives E.

From four times E take B, remains C; and B taken from C, leaves D.

And the logarithm of four times D taken from twice the logarithm of C, gives the logarithm of the correction in minutes.

5th. Then the greateſt zenith diſtance leſſened by the correction, gives the meridian zenith diſtance.

EXAM. I. *Three obſervations being made of the Sun, at a place in north latitude, viz. at* 10*h.* 40*m. the zenith diſtance was* 35° 53′,
11 9 *was* 33 44½,
11 51 *was* 32 14,
How much was the Sun's meridian zenith diſtance?

10h. 40m.		zen. diſt. 35° 53′		
11 9	a=29m.	33 44,5	A=128,5′	$a \backsim \frac{1}{2}b$=6,5
11 51	b=71	32 14	B=219	$a \backsim b$=42.

128,5 × 71 = (A × b =)9123,5, 219 × 29 = (B × a =)6351; the diff. = 2772,5

Logarithm diff.=2772,5		3,44287	$\frac{1}{2}$B = 109,5	
Logarithm b=	71	1,85126	N = 39,5	
Logarithm N=	39,5	1,59161	M = 1,3	
Twice log. $a \backsim \frac{1}{2}b$=	6,5	1,62583	E = 150,3 and 4E=601,2	
Ar. co. log. $a \backsim b$=	42	8,37675	B = 219	
Ar. co. log. a =	29	8,53760	C = 382,2	
Logarithm M=	1,3	0. 3179	D = 163,2 and 4D=652,8.	
Twice log. C=	382,2	5,10458	Greateſt zenith diſtance	35° 53′
Logarithm 4D=	652,8	2,81478	Correction 223=	3 43
Log. correction =	223	2,34980	Merid. zenith diſtance	32 10′

EXAM. II. *To the northward of the tropic of Cancer, when the Sun's declination was* 14° 24′*S.; at the times* 11*h.* 42*m.,* 12*h.* 26*m.,* 12*h.* 58*m., ſhewn by a watch, the Sun's zenith diſtances were* 43° 19′, 43° 33′, 45° 19′, *reſpectively: Required the latitude.*

11h. 42m.		1ſt. zen. diſt. 43° 12′		
12 26	b=76m.	2d. 43 33	B=120	$a \backsim \frac{1}{2}b$= 6
12 58	a=32	3d. 45 19	A=106	$a \backsim b$=44.

A × b = 106 × 76 = 8056; B × a = 120 × 32 = 3840; diff. of prod. 4216.

L	4216	3,62490	$\frac{1}{2}$B = 60	
L, b	76	1,[illegible]8081	N = 55,5	
L, N	55,5	1,74409	M = 1,4	
2L, $a \backsim \frac{1}{2}b$	6	1,55630	E = 116,9 and 4E=467,6	
L′, $a \backsim b$	44	8,35655	B = 120	
L′, a	32	8,49485	C = 347,6	
L, M	1,4	0,15179	D = 227,6, and 4D=910,4	
2L, C	347,6	5,08216	Greateſt zenith diſtance	45° 19′
L, 4D	910,4	2,95923	Correction 133 =	2 13
K, correction	132,7	2,12293	Merid. zenith diſtance	43 6 S.
			Declination	14 24 S.
			Latitude	28 42 N.

68. PROBLEM IV.

When three altitudes are taken at equal intervals of time, at any diſtance from noon : See Book V. Artitle 202.

RULE 1ſt. Seek the natural ſines of the three given altitudes. (V. 185)

Call the difference between the firſt and third altitudes, D; between the ſecond and third, F.

Put E for the ſum of D and twice F, when the degrees in the third altitude fall between thoſe of the firſt and ſecond; otherwiſe put E for the difference between D and twice F.

2d. Add together the log. co-tang. of half one interval of time (in deg.) the log. of E, and the ar. co-log. of D (each in numbers)

Their ſum is the logarithmic tangent of an angle A; or of its ſupplement, if the firſt altitude exceeds the third: convert the angle A into time. (V. 133)

To A add one interval; then the difference between this ſum and ſix hours will ſhew the time from noon, when the laſt obſervation was made.

Hence, by the intervals, the other times are known relative to the noon of the place of obſervation.

3d. Add together the ar. co. log, co-ſine of A.
the ar. co. log. ſine of one interval obſerved,
and the log. of D, their ſum is the log. of a number B.

4th. To the logarithm of B add twice the logarithmic ſine of half the leaſt time from noon; ſeek the number, and add it to the natural ſine of the greateſt altitude, the ſum is the natural ſine of the meridian altitude.

5th. The number B leſſened by the natural ſine of the meridian altitude, gives the natural ſine of the midnight depreſſion.

Then the half ſum, and the half difference, being taken, of the degrees and minutes anſwering to the ſines of the meridian altitude and midnight depreſſion, give the co-latitude and declination. (V. 185)

If the zenith falls between the equator and the Sun, the half ſum is the co-declination, and the half difference is the latitude.

EXAM. I. *Between the tropics, the Sun's altitude was obſerved ſome time in the forenoon, to be 73° 22′; after waiting 26 minutes, its altitude was 78° 50′, and 26 minutes after, its altitude was 82° 55′: Required the latitude of that place.*

(See Book V. note to art. 185.)

73° 22′, nat. ſine	,95816	,03421 = D	and ,01161 = E;
78 50	,98107	,01130 = F	alſo 26 m. = 6° 30′
82 55	,99237	,02260 = 2F	its half = 3 15

L, t′ 3° 15′	11,24577	L′s,′A	80° 30′	0,78239
L, E = 0,01161	8,06483	L′s,′,	6 30	0,94614
L′, D = 0,03421	1,46584	L, D	0,03421	8,53416
		L, B	1,8310	10,26269
L, t, A = 80° 30′	10,77644	2 L s,	1° 30′ $\left(=\frac{12\text{ m.}}{2}\right)$	6,83584
			0,001255	7,09853
			,99237	

Or A = 5 hours 22 minutes.
Now 5 h. 22 m. + 26 m. = 5 h. 48 m.
Then 6 h. — 5 h. 48 m = 0 h. 12 m.
So the greater alt was at 11 h. 48 m.
the middle at 11 22
the leaſt at 10 56

Mer. alt. 0,99362 = nat. ſine 83° 32′.
Mid. dep. 0,8374 = nat. ſine 56 52
half ſum = 70° 12′ the co-declinat.
half diff. = 13 20 the latitude.

EXAM.

EXAM. II. *In the north temperate zone, the Sun having south declination, his altitude was observed to be* 8° 37½′; *and* 66 *minutes afterwards, his altitude was* 13° 51½′; *and* 66 *minutes after that, his altitude was* 16° 34′: *Required the latitude.*

At some time, alt.	8° 37½′ nat. sine	,14997	,13517 = D.	
66 m.	13 51½	,23955	,04559 = F.	
66 m.	16 34	,28514		
		2F = ,09118 & E = ,04398.		

66 m. = 16° 30′. And 6 h.—1 h. 6 m. = 4 h. 54 m.

L,t′	8° 15′	10,83865
L,E =	0,04398	8,64325
L′,D =	0,13517	0,86913
L,t,A =	65° 59	10,35103

Or A = 4 h. 23 m. 56 s.
Now 4h. 23m. 56s. + 1h. 6m. = 5 29. 56.
And 6h.—5h. 29m. 56s = 0h. 30m. 4s.
11 29 56 at last alt.
10 23 56 mid. alt.
9 17 56 least alt.

L,s′,A	65° 59′	0,39040
L,s′,	16 30	0,54666
L,D	0,13517	9.13087
L,B	1,1693	10,06793
2L,s,	3° 45½′	7,63312
	0,005024	7,70105
Greater alt.	0,28514	
s, merid. alt.	0.29016 = 16° 52′	
s, dep.	0,8792 = 61 33	

the ½ sum = 39° 12½′ the co-latitude
the ½ diff. = 22 20½ the declination.

EXAM. III. *In a high north latitude, and the Sun to the eastward of the meridian, his altitude was observed to be* 41° 53′; *and* 2 *h.* 16 *m. after, his altitude was* 50° 23½′; *and* 2 *h.* 16 *m. after that, his altitude, was again observed to be* 44° 54′: *Required the latitude.*

In the forenoon,	alt. 41° 53′ sine	,66762	D = ,03825
1st interval 2 h. 16 m. = 34° 0	50° 23½	,77042	
2d interval 2 h. 16 m.	44 54	,70587	F = ,06455
			2F = ,12910

Here as the 3d. altit. falls between 1st. and 2d; D + 2F = E = ,16735

Now L,t′,	17° 0′	10,51466
L,E	0,16735	9,22362
L′,D	0,03825	1,41737
L,t,A	86° 0′	11,15565

And 86° = 5 h. 44 m.
5 h. 44 m. + 2 h. 16 m. = 8 h. 0 m.
8 h.—6 h. = 2 h. à noon at 3d. alt.
1st. altitude at 9 h. 28 m.
2d. altitude at 11 44
3d. altitude at 2 0

L,′s′,A	86° 0′	1,15642
L,′s,	34 0	6,25244
L,D	0,03825	8,58263
L,B	0,98060	9,99149
2L,s,	15° $(=\frac{2h.}{2})$	8,82599
	0,06569	8,81748
	,70587, sine 3d altitude.	
50° 30′	,77156, sine merid. altitude.	
	,98060, number B.	
12 4	,20904, sine of mid. depres.	

Hence the latitude is 58° 43′ N.; and declination 19° 13′ N.

EXAM.

Exam. IV. *In a low northern latitude, and the Sun having south declination, his altitude was observed in the forenoon to be* 61° 47′; *and* 2 *h.* 30 *m. after, his altitude was* 64° 29½′, *and* 2 *h.* 30 *m. after, his altitude was* 36° 5¼′: *Required the latitude.*

Forenoon		alt. 61° 47′	sine ,88117	*	
1st interval 2 h. 30 m. = 37° 30′		64 29½	,90249		D = ,29215
2d interval 2 h. 30 m.		36 5¼	,58902		F = ,31347
					2F = ,62694
					2F—D = E = ,33479

Now L,t,s = 18° 45 — 10,46922
L,E = 0,33579 — 9,52477
L',D = 0,29215 — 0,53439

L,t,A 106° 30′ — 10,52838
And A = 7 h. 6 m.
7 h. 6 m. + 2 h. 30 m. = 9 h. 36 m.
And 9 h. 36 m. — 6 h. = 3 h. 36 m.
the 3d. alt. at 3 h. 36 m. P. M.
2d. 1 6 P. M.
1st. 10 36 A. M.

L's, 73° 30′ — 0,54666
L's, 37 30 — 0,21555
L,D 0,29215 — 9,46561
L,B 1,6897 — 10,22782
2 L,s, 27° — 9,31409
0,34826 — 9,5[illegible]191
58902
69° 36′ ,93728, sine merid. altitude.
B 1,6897
48° 48′ ,7524, sine mid. depression.
Hence latitude 30° 48′ N.
Declination 10 24 N.

69. PROBLEM V.

When three altitudes are taken at unequal intervals of time †.

Rule 1st. Let the interval between the 1st and 3d times be called M,
between the 1st and 2d *m*,
between the 2d and 3d *n*,
and let the times M, *m*, *n*, be converted into degrees. (V. 133)
Seek the natural sines of the three observed altitudes. (IV. 256)
And let the difference between the 1st and 3d be called D,
between the 2d and 3d F.

2d. Add together the log. sines of ½ *m* and ½ *n*, gives the log. of ½ A.

3d. To the log. co-sine of ½ *m* add the log. sine of ½ *n*, the sum is the log. of ½ B.

4th. Add together the ar. co. log. of D, the log. of F, and the log. sine of ½ M, the sum is log. of ½ C.

Take the difference between the numbers ½ B and ½ C, call it ½ E.
Or let ½ E be the sum of ½ B and ½ C, when the degrees in the 3d altitude fall between those of the 1st and 2d altitudes.

5th. From the logarithm of ½ E take the logarithm of ½ A, the remainder (10 being added to the index) is the logarithmic tangent of an arc G; or of its supplement, when the first altitude exceeds the second.

* See Book IV. 256. † See Book V. Article 200.

Take

Digitized by Google

Take the difference between G and the complement of ½ M, the remainder is an arc H, ſhewing the time from noon when the laſt altitude was taken. Hence the other times are known.

6th. Add together the ar. co. log. co-ſine of G,
the ar. co. log. ſine of ½ M,
and, the log of D, their ſum is the log. of a number I.

7th. To log. of I add twice the log. ſine of ½ H, the ſum is the log. of K.

8th. The number K added to the natural ſine of the third altitude gives the natural ſine of the meridian altitude.

And the number I leſſened by the natural ſine of the meridian altitude, gives the natural ſine of the midnight depreſſion.

The half ſum and half difference of the degrees ſhewing the meridian altitude and midnight depreſſion, will give the co-latitude and declination; or co-declination and latitude, when the zenith falls between the Sun and the equator. (V. 185.)

EXAM. I. *In north latitude, the Sun having ſouth declination; at 8 h. 40 m. 10 h. 00 m. and 11 h. 48 m. by a watch, the altitudes of the Sun were 30° 41¼′, 45° 37⅓′ and 56° 44′, reſpectively: Required the latitude.*

M=3h. 8m.	=47°	1ſt alt.	=30° 41¼′	nat. ſine 0,51037			
m=1 20	=20	2d	=45 27⅓	0,71474	}	D=0,32578
n=1 48	=27	3d	=56 44	0,83615	}	F=0,12141

L,s,½m	10° 0′	9,23967
L,s,½n	13 30	9,36818
L,½A	0,04054	8,60785
L,s′,½m	10° 0′	9,99335
L,s,½n	13 30	9,36818
L,½B	0,22990	9,36153
L,D	0,32578	0,48707
L,F	0,12141	9,08425
L,s,½M	23° 30′	9,60070
L,½C	0,14860	9,17202
L,½E	0,08130	8,91009
L,t,∠G	63° 30′	10,30224
	66 30=compl. of ½ M.	
H=	3 0=0h. 12 m. à noon.	

Here ½B—½C=½E.
And log ½E—log. ½A=L,t,G.
Alſo 12h.—12 m.=11 h. 48 m. the time of the laſt altitude.
So the watch ſhewed true time.

L′,s′,G	63° 30′	0,35047
L′,s,½M	23 30	0,39930
L,D	0,32578	9,51293
L,I	1,83110	10,26270
2L,s,½H	1° 30′	6,83584
L,K	0,00125	7,09854
	0,83615=ſine 3d. alt.	
56° 52′	0,8374 =ſine mer. alt.	
83° 34′	0,99370=ſine mid. dep.	

Hence latit.=13° 21′ N.
Declination=19 47 S.

EXAM. II. *The Sun's altitude was 16° 34′; and 50 minutes after, the altitude was 14° 16′; and 82 minutes after the altitude was 8° 37½′: Required the latitude.*

M=

M=2h. 12m.=33° 0'	1ſt. alt.=16° 34' nat. ſin. 0,28514			D=0,13517
m=0 50 =12 30	2d. =14 16 0,25486			
n=1 22 =20 30	3d. = 8 37½ 0,14997			F=0,10489
Ls,½m	6° 15'	9,03690	Here ½C−½B=½E.	
Ls,½n	10 15	9,25028	And Lt, of ſupplement of C.	
			Alſo 2h. 42m. is time at 3d. altitude,	
L,½A	0,01937	8,28718	1 20 at 2d. altitude,	
			12 30. at 3d. altitude.	
Ls',½m	6° 15'	9,99741	L's,G 114° 0'	0,39069
Ls,½n	10 15	9,25028	L's,½M 16 30	0,54666
			L,D 0,13517	9,13089
L,½B	0,17689	9,24769		
			L,I 1,17007	10,06824
L',D	0,13517	0,86911	2Ls,½H 20° 15'	9,07845
L,F	0,10489	9,02073		
Ls,½M	16° 30'	9,45334	L,K 0,14017	9,14669
L,½C	0,22038	9,34318	0,14997=ſine of 3d. alt.	
L,½E	0,04349	8,63839	16° 52' ,29014=ſine merid. alt.	
Lt,∠G	114° 0'	10,35121		
	73 30=compl. of ½ M.		61 38 ,87993=ſine mid. depr.	
	H=40 30=2h. 42m. à noon.		Hence lat.=50° 45' N. Decl. 22° 23' S.	

EXAM. III. *Some time in May, and in a high northern latitude, three ſucceſſive altitudes of the Sun were,* 41° 53', 50° 7⅓', 44° 54⅑'; *the intervals of time being 2 h. 2 m. and 2 h. 30 m.: Required the latitude.*

M=4h. 32m.=68° 0'	1ſt. alt.=41° 53' nat. ſin. 0,66762			D=0,03827
m=2 2 =30 30	2d. =50 7⅓ 0,76743			
n=2 30 =37 30	3d. =44 54⅑ 0,70589			F=0,06154
Ls,½m	15° 15'	9,42001	Here ½C+½B=½E.	
Ls,½n	18 45	9,50710	Alſo 2h. 0m. = time at 3d. altitude	
			11 30 = time at 2d. altitude	
L,½A	0,08455	8,92711	9 28 = time at 1ſt. altitude	
Ls',½m	15° 15'	9,98443	L's,G 86° 0'	1,15642
Ls,½n	18 45	9,50710	L's,½M 34 0	0,25244
			L,D 0,03827	8,58286
L,½B	0,31012	9,49153		
			L,I 0,98112	9,99172
L',D	0,03827	1,41714	2Ls,½H 15° 0'	8,82599
L,F	0,06154	8,78916		
Ls,½M	34° 0'	9,74756	L,K 0,06572	8,81771
L,½C	0,89921	9,95386	0,70589=ſine of 3d. alt.	
L,½E	1,20933	10,08254	50° 30' 0,77161=ſine merid. alt.	
Lt,∠G	86° 0'	11,15543	12 6 0,20951=ſine mid-n. depr.	
	56 0=compl. of ½ M.		Hence lat.=58° 42' N.	
			Declinat.=19 12 N.	
	H=30 0=2h. from noon.			

EXAM. IV. *Suppose three successive altitudes of the Sun were, 61° 47′, 66° 39½′, 36° 5¼′, taken at intervals of 2h. 14m. and 2h. 46m. Required the time of the day, and the latitude.*

M=5h. 0m.=75° 0′	1st. alt.	=61° 47′	nat. sin. 0,88117		
m=2 14 =33 30	2d.	=66 39½	0,91726		D=0,29215
n=2 46 =41 30	3d.	=36 5¼	0,58902		F=0,32824

L s, ½m	16° 45′	9,45969
L s, ½n	20 45	9,54936
L, ½A	0,10211	9,00905
L s′, ½m	16° 45′	9,98117
L s, ½n	20 45	9,54936
L, ½B	0,33926	9,53053
L′D,	0,29215	0,53439
L, F	0,32824	9,51619
L, ½M	37° 30′	9,78445
L, ½C	0,68396	9,83503
L, ½E	0,34470	9,53744
L t, ∠G	106° 30′	10,52839
	52 30=comp. of ½ M.	
H=54	C=3h. 36m. à noon.	

Here ½G—½B=½E.
And G is a supplement.
Also 3h. 36m.=time at 3d. alt.
12 50 =time at 2d. alt.
10 36 =time at 1st. alt.

L′s, G	106° 30′	0,54666
L′s, ½M	37 30	0,21555
L, D	0,29215	9,46561
L, I	1,68969	10,22782
2Ls, ½H	27° 0′	9,31409
L, K	0,34825	9,54191

0,58902=sine of the 3d alt.
69° 36′ 0,93727=sine merid. alt.
48 48 0,75242=sine mid. depr.

Hence latitude = 30° 48′ N.
Declination = 10 24 N.

70. PROBLEM VI.

Given two altitudes of the Sun, the interval of time between the two observations, the Sun's declination, and the latitude by dead reckoning; to find the true latitude.

SOLUTION.

1st. Convert the interval of time into degrees, and take its half. Also take the half sum and half difference of the two altitudes.

First Operation.

2d. Add together the five following logarithms.
log. co-s. of the half sum of the two latitudes.
log. sine of the half diff. of the two altitudes.
Ar. co. log. sine of the half interval.
Ar. co. log. co-s. of the declination.
Ar. co. log. co-s. of the lat. by account; their sum * is the log. sine of an arc.

3d. Take the diff. between this arc and the half interval; and the half of this diff. is half the time from noon, when the greater altitude was taken, or half their sum is the time from noon, when the less altitude was taken.

4th. Add together the three following logarithms.
log. co-sine of the declination.
log. co-sine of the latitude by account.
Twice log. sine of half the time from noon, in degrees.

* Rejecting the tens in the sum of the indices in this and the following logarithmic work.

Seek

Seek the number to the logarithm of the sum, then that number doubled is a number, called the correction; which being added to the natural sine of that observed altitude, half the time of which from noon was taken, gives the natural sine of the mer. alt. which is by it known: and hence the lat. is known by Problem I.

71. REMARKS.

But to know if the latitude thus found is accurate, make a *second operation*. Thus,

To the sum of the first four logs. used in the 2d article of the rule, add the ar. co. log. co-sine of the latitude found by article 4th. The sum is the log. sine of an arc.

Work by the 3d and 4th articles, for a corrected latitude; and if it comes out the same, within a minute or two, as that found by the first operation, it may be esteemed the true latitude.

Or, if the difference between the results of the two operations do not exceed about ¼th of the difference between the latitude assumed, and that first found, the last result may be accounted sufficiently correct.

But if the difference between the results of both operations is much greater than the said ¼th part, then a third operation with the last found latitude will generally give the latitude exact enough.

When the latitudes found by the first and second operations have one greater and one less than the latitude by account; or if these latitudes found differ by a degree or more; then make a third operation with the half sum, or mean, of these two latitudes; and if the latitude found differs from the said mean, half their sum will generally give the latitude very near the truth.

When both observations are made in the forenoon, or both in the afternoon;

The half interval is half the difference of the times from noon:

And the first found arc is half the sum of the times from noon.

But when the observations are, one before, and the other after, noon;

The ½ interval is the ½ sum; and the first found arc is the ½ diff. of the times from noon.

The ½ diff. added to the ½ sum gives the time of the observation farthest from noon.

And the ½ diff. taken from the ½ sum gives the time of the observ. nearest to noon.

72. The times of observation should be taken to seconds, or at least to quarters, or thirds of a minute of time. They are best when taken between the times of 9h. A. M. and 3h. P. M.: the interval of time between the observations ought not to exceed five hours, nor be much le[ss] than the time from noon at the taking of the greatest altitude: in general the interval should not be much less than about ¾ of an hour.

73. This problem is best suited to situations, where the Sun's meridian zenith distance is not much less than half the latitude: for in latitudes where the Sun approaches near to the zenith, the observations are to be taken much nearer to noon; and the rule instead of approximating, will in some cases give the results of successive operations wider and wider from the truth; in such cases it is best to apply Prob. II.

Digitized by Google

74. About the year 1740, Mr. *John Douwes*, a mathematician at Amsterdam, and examiner of the marine cadets there, first communicated to the sea officers of Holland a solution of this problem, by the help of a set of solar tables which he had computed for that purpose. Manuscript copies coming into the hands of several English officers, who held the method in high esteem, it was in the autumn of the year 1759 published, without any demonstration; but one has since been given by several persons. In particular Dr. Pemberton communicated to the Royal Society the whole composition, and shewed the limits, or where the method diverges, together with other useful particulars. This curious paper of the Doctor's was published in the Philosophical Transactions for the year 1760.

Mr. Douwes's tables consist of four columns; in the first column stands the time to every half minute, extended to six hours: the second column, called half the lapsed time, contains the arithmetical complement of the logarithmic sines of the degrees corresponding to the times they stand against, in the first column: the third column, called middle times, are the logarithms of twice the natural sines of the times, in degrees, which they stand against: and in the fourth column are the logarithmic versed sines of the times, in degrees, they stand against. But the preceding solution requires no other tables than such as are in the common books of navigation *.

EXAM. I. *At 9h. 18m. and at 11h. 30m. by a watch, the Sun's altitudes were respectively 8° 37½′, and 16° 34′; the Sun's declination was 22° 23′S.; and the latitude by account 50° 40′N.: Required the true latitude.*

9h. 18m. } 2h. 12m.=33°; altitudes { 8° 37½′
11 30 } { 16 34 nat. sine 0,28514.

25 11½ | 12° 35¾′=½ sum alts.
2) 7 56½ | 3 58¼=½ diff. alts.

½ interval or ½ diff. times } =16° 30′

L′s, ½ sum alts.	=12° 35¾′	9,98942
Ls, ½ diff. alts.	= 3 58¼	8,84041
L′s, ½ diff. times	=16 30	0,54666
L′s′, declinat.	=22 23	0,03402
L′s′, latitude	=50 40	0,19803
L, an arc	=23 57½	9,60854
	16 30	
	7 27½	
Its half	= 3 43¾ à t. from noon.	

Ls′, declinat.	=22° 23′	9,96598
Ls′, latitude	=50 40	9,80197
2Ls, ½ time	= 3 43¾	8,82317
		8,82317
L, ½ correct.	=,00247	7,39429
Correction	=,00494 to be added.	
nat. s, of 16° 34′	,28514 great alt.	
s, merid. alt.	=,29008	16° 52′
Meridional zenith distance		73 8 S.
Declination		22 23 S.
True latitude		50 45 N.

* Among the several publications of these solar tables, the most extensive and useful is in the Nautical Almanac for the year 1771.

EXAM.

Exam. II. *At 12h. 12m. and at 3h. 20m. by a watch, the Sun's altitudes were 56° 44⅛′, and 30° 41¼′ respectively; the Sun's declination was 19° 48′ S. and the latitude, by dead reckoning, 13° 14′ N.: Required the true latitude.*

12h 12m, 3 20	3h. 8 m. = 47°; altitudes	56° 44⅛′, 30 41¼		nat. sine 0,83615.
half diff. times = 23° 30′		87 25⅜	43 43	= ½ sum altitudes.
	2)	26 3	13 1½	= ½ diff. altitudes.

Ls′, ½ sum alts.	= 43° 43′	9,85900	
Ls, ½ diff. alts.	= 13 1½	9,35290	
L′s, ½ diff. times	= 23 30	0,39930	
L′s′, declination	= 19 48	0,02647	
L′s′, latitude	= 13 14	0,01169	
Ls, an arc	= 26 29½	9,64936	
	23 30.		
	2 59⅓		
Its half	= 1 29⅔		tim. fr. n.

Ls′, declinat.	= 19° 48′	9,97353
Ls′, latitude	= 13 14	9,98831
2Ls, ½ time	= 1 29⅔	8,41630
		8,41630
L, ½ correct.	= ,000623	6,79444
Correction	= ,00125	to be added.
s, great alt.	= ,83615	
s, merid. alt.	= ,83740 = 56° 52′	
Merid. zenith distance	= 33 8 S.	
Declination	= 19 48 S.	
True latitude	= 13 20 N.	

Exam. III. *Required the latitude of a place from the following observations made with a regulated watch and a Hadley's quadrant.*

Altitude 41° 53′ at 9h. 28m. A. M. }
Altitude 44 54 at 2h. 0m. P. M. } interval 4h. 32m. = 68°.

86 47	43 23½	= ½ sum of the altitudes:	declination 19° 12′ N.
2)			
3 1	1 30½	= ½ diff. altitudes:	lat. by account 59 0 N.

Ls′, ½ sum alts.	= 43° 23½′	9,86134
Ls, ½ diff. alts.	= 1 30½	8,42030
L′s, ½ sum times	= 34 0	0,25244
L′s′, declinat.	= 19 12	0,02485
L′s′, latitude	= 59 0	0,28816
Ls, ½ diff. times	= 4 2	8,84711
à noon at 1st alt.	= 38 2 = 2h. 32⅛ m.	
à noon at 2d alt.	= 29 58 = 1h. 59′ 52″	

Ls′, declinat.	= 19° 12′	9,97514
Ls′, latitude	= 59 0	9,71184
2Ls, ½ time	= 14 59	9,41252
		9,41252
L, ½ correction	= ,03251	8,51202
Correction	= ,06502	to be added.
s, altitude 44° 54′	,70589	
s, merid. altitude	,77091 = 50° 26′	
Hence the latitude	= 58 46 N.	

Exam.

Exam. IV. *Being by my dead reckoning in lat 30° 30′ N. the declination being 10° 24′.; the Sun's altitude in the forenoon was 61° 47′, and 5 hours after, in the afternoon, his altitude was 36° 5¼′: Required the true latitude.*

The interval, or diff. of time = 5h.
diff. time 2h. 30m. = 37° 30′.

Altitudes	61° 47′ nat. ſine ,88117		
	36 5¼		
	97 52¼	48 56⅛	= ½ ſum alt.
	2		
	25 41¾	12 51	= ½ diff. alts.

Ls′, ½ ſum alts. =	48°	56⅛′	9,81750
Ls, ½ diff. alts. =	12	51	9,34713
L′s, ½ diff. times =	37	30	0,21555
L s′, declinat. =	10	24	0,00720
L′s′, latitude =	30	30	0,06468
Ls, ½ ſum times =	16	27	9,45206
à noon at 1ſt alt. =	21	3 = 1h.24¾m.	
à noon at 2d. alt.	55	57 = 3h.35⅘m.	

1ſt altitude, at 10h. 35¼ min.
2d altitude, at 3h. 35⅘ min.

Ls′, declinat.	=	10° 24′	9.99280
Ls′, latitude	=	30 30	9.93532
2Ls, ½ times	=	10 31	9.26165
			9,26165
L ½ correct.	=	,02828	8,45142
Correction	=	,05656 to be added.	
s, greateſt alt.	=	,88117	
s, merid. altitude	,93773 = 69° 40′		
Merid. zenith diſtance		= 20 20 S.	
Sun's declination		= 10 24 N.	
Latitude		= 30 44 N.	

Second Operation.

Sum of the 1ſt four logs.		9,38738
L′s′, new lat. is	= 30 44	0,06573
Ls, ½ ſum times	= 16 30	9,45311

à noon at 1ſt alt. = 21 0 = 1h. 24m.
à noon at 2d alt. = 54 0 = 3h. 36m.
1ſt altitnde at 10h. 36m. A. M.
2d altitude at 3h. 36m. P. M.

Ls′, declinat.	=	10 24	9.99280
Ls′, new lat.	=	30 44	9.93427
2Ls, ½ time	=	10 30	9,26063
			9,26063
L, ½ correct.	=	,02808	8,44833
Correction	=	,05616 to be added.	
s, greateſt alt.	=	,88117	
s, merid. alt.	=	,93733 = 69° 39′.	

Hence the true latitude will be 30° 48 N.

Exam.

EXAM. V. *Being by account in latitnde 16° 20′ S. and the Sun's declination 22° 48′ S.; at 8h 31m 44s forenoon, the altitude of the Sun's center was 40° 38′; and at 1h 17m 44s P. M. its altitude was 70° 26′: Required the true latitude.*

Times 13 17 44	Alts. 70 26 Nat. sine = 0,94225
8 31 44	40 38
4 46 = 71° 30′; its ½ = 35° 45′.	111 4; ½ sum = 55° 32′.
	29 48; ½ diff. = 14 54.

L. s, ½ sum alts.	= 55 32	9,75276	L. s, declination	= 22° 48′	9,96466
L. s, ½ diff. alts.	= 14 54	9,41016	L. s, latitude	= 16 20	9,98211
L. s, ½ sum times	= 35 45	0,23340	L. s, ½ least time	= 9 43	9,22731
L. s, declination	= 22 48	0,03534	L. s, ½ least time	= 9 43	9,22731
L. s, latitude	= 16 20	0,01789			
			L. No. ½ correct.	= ,02520	8,40139
L. s, ½ diff. times	= 16 19	9,44955			
			Correction	= ,05040 to be added.	
Least time	= 19 26, its ½ = 9° 43′.		N. s, gr. alt.	= ,94225	
			N. s, mer. alt.	= ,99265 = 80° 03′	
			Mer. zenith distance		6 57 S.
			Sun's declination		22 48 S.
			Latitude		15 51 S.

Second Operation.

Sum of the four first logs.		9,43166	L. s, decl.	= 22° 48′	9,96466
L. s, latitude	= 15 51	0,01683	L. s, latitude	= 15 51	9,98317
			L. s, ½ least time	= 9 43¼	9,22749
L. s, ½ diff. times	= 16 18½	9,44849	L. s, ½ least time	= 9 43¼	9,22749
	35 45				
			L. No ½ correct.	= ,02528	8,40281
Least time	= 19 26½, its ½ = 9° 43¼′				
			Correction	= ,05056 to be added.	
			N. s, gr. alt.	= ,94225	
			N. s, mer. alt.	= ,99281 = 83° 07′.	

Hence the true latitude may be taken at 15° 55′ S.

Suppose the latitude, declination, and altitudes the same as above; but the times had been at 8h 31m 44s, and 10h 42m 16s in the forenoon; or at 1h 17m 44s and 3h 28m 16s in the afternoon; to correct the latitude by account.

Times 10h 42m 16s	Or 3h 28m 16s
8 31 44	1 17 44
2 10 32	2 10 32 = 32° 38′; its ½ = 16° 19′ = ½ diff. times.

Consequently, in the first part of the operation, if the 16° 19′ be used instead of 35° 45′; the sum of the five logs. will give the log. of 35° 45′, for the half sum of the times; and half the least time will be 9° 43′: therefore the same result will be obtained, and the final latitude will be 15° 55′ S.

If three zenith distances, circumstanced as in Problem II. or III. could be taken, the latitude would be found with less trouble.

Digitized by Google

EXAM. VI. *Wanting to go through the 8° N. channel among the Maldives, and being by account in lat. 7° 20′ N. with 22° 48′ N. declination, at $7^h\ 25\frac{2}{3}^m$ forenoon, I found the true altitude of the Sun's center was $22\frac{1}{2}°$; and at $10^h\ 31\frac{4}{5}^m$ its altitude was 63° 40′: Required the ship's true latitude.*

Time	10^h	31^m	48^s	Alts 63°	40′	N.s, ,89623
	7	25	40	22	30	
Interval	3	6	8 = 46° 32′; its ½ = 23° 16′	86	10; 43 05 = ½ sum alt.	
				2		
				41	10; 20 35 = ½ diff. alts.	

L's, ½ sum alts.	= 43° 05′	9,86354	L's, declinat.	= 22 48	9,96467
L's, ½ diff. alts.	= 20 35	9,54601	L,s, latitude	= 7 20	9,99643
L's, ½ diff. times	= 23 16	0,40339	L,s, ½ l. time	= 11 1½	9,28157
L's, declination	= 22 48	0,03533	L,s, ½ l. time	= 11 1½	9,28157
L's, declination	= 7 20	0,00357	L, N° ½ correct.	= ,03344	8,52424
			Correction	= ,06688	
L s, latitude	= 7 20	9,85184	N. s, gr. alt.	= ,89623	
Least tim. à noon = 22	3, its ½ = 11° 1½′		N.s, merid. alt.	= ,96311 = 74° 23′.	
			Mer. zen. dist.	= 15 37N	
			Declination	= 22 48N.	
			Latitude	= 7 11N.	

Second Operation.

Sum of the four first logs.		9,84827	L,s decl.	= 22° 48′	9,96467.
L's, latitude	= 7° 11′	0,00342	L,s, latitude	= 7 11	9,99658
			L,s, ½ l. time	= 11 0¼	9,28108
L s, ½ sum times	45 17½	9,85169	L,s, ½ l. time	= 11 0¼	9.28108
½ diff. times	23 16		L, N° ½ correct.	= ,03337	8,52341
			Correction	,06674	
Least time à noon 22	1½, its ½ = 11° 0¼′			,89623	
			N.s, mer. alt.	,90297 = 74° 21′.	
			Hence the latitude is 7° 9′ N.		

If the altitude had been at $1^h\ 28^m\ 12^s$, and at $4^h\ 34^m\ 20^s$, both afternoon, the latitude would have been the same.

But had the times been at $7^h\ 25^m\ 40^s$ forenoon, and at $1^h\ 28^m\ 12^s$ afternoon: or, at $10^h\ 31^m\ 48^s$ forenoon, and at $4^h\ 34^m\ 20^s$ afternoon, with the same altitudes, declination, and latitude, by account, to correct the latitude.

Times	13^h	28^m	12^s		Or	16^h	34^m	20^s
	7	25	40			10	31	48
	6	2	32	sum of the times		6	2	32
	3	1	16 = 45° 19′					

Then the log. of 45° 19′ being used for the third log. instead of that of 23° 16′, the sum of these five logs. will be the log. of 23° 16′, the half difference of the times; and, consequently, the least time will be the same as in the former operation; and the final result for the latitude will be the same.

I EXAM.

Exam. VII. *Wanting to make the English Channel, I observed the true altitude of the Sun's center 24° 30′, and 3h 4m after, its altitude was 52° 16′; our latitude by account was 49° 12′, and the Sun's declination 23°: Required the ship's true latitude.*

3h 4m=46°; its ½=23° the ½ interval.

2d alt.=52° 16′ Nat. sine 79087
1st alt.=24 30

76 46	38° 23′
2	
27 46	13 53

L,s, ½ sum alts.	=38° 23′	9,89425
L,s, ½ diff. alts.	=13 53	9,38011
L′,s, ½ interval	=23 0	0,40812
L′,s′, declination	=23 0	0,03597
L′s′, latitude	=49 12	0,18481
L,s, ½ sum times	=53 09	9,90326
Last time à noon	=30 9, its ½ =15° 4½′	

L,s′, declination	=23 0	9,96403
L,s′, latitude	=49 12	9,81519
L,s, ½ least time	=15 4½	9,41512
L,s, ½ least time	=15 4½	9,41512
L, N° ½ correct.	=04069	8,60946
Correction	08137	
	=79087	
N.s, mer. alt.	=87224=60° 43′	
	Zen. dist=29 17	
	Decl.=23 0	
	Latitude 52 17	

Second Operation.

Sum of four first logs.		9,71845
L′s′, latitude	= 52° 17′	0,21342
L,s, ½ sum times	= 58 44	9,93187
	23 0	
Least time à noon	35 44, its ½ =17° 52′	
Latitude	52 17 first found.	
Latitude	49 15 second found.	
	101 32	
Mean latitude	50 46	

L,s′, decl.	= 23° 0′	9,96403
L,s′, latitude	= 52 17	9,78658
L,s, ½ l. time	= 17 52	9,48686
L,s, ½ l. time	= 17 52	9,48686
L, N° ½ correct.	= 05301	8,72433
	10602	
	79087	
	89689=63° 45′	
Zen. dist.	26 15	
Decl.	23 0	
Latitude	49 15	

Third Operation.

Sum of four first logs.		9,71845
L′,s′, latitude	= 50° 46′	0,19895
L,s, ½ sum times	= 55 46	9,91740
	23 0	
Least t. à noon	= 32 46, its ½ =16° 23′	

L,s′, decl	= 23° 0′	9,96403
L,s′, latitude	= 50 46	9,80105
L,s, ½ least time	= 16 23	9,45034
L,s, ½ least time	= 16 23	9,45035
L, N° ½ correct.	=04632	8,66577
	09264	
	79087	
N.s, mer. alt.	88351=62° 04′	
Zen. dist.	37 56	
Decl.	23 0	
Latitude	50 56	
Former mean latitude	50 46	
	101 42	
True latitude	50 51	

In

In the preceding Problem it was ſuppoſed that both the altitudes were taken at the ſame place; but as this can ſeldom happen at ſea, it is neceſſary to ſhew how the latitude may be obtained when the altitudes are obſerved at two different, but not very diſtant places.

75. PROBLEM VII.

Given the latitude by account, the Sun's declination, two obſerved altitudes, the interval of time, and the courſe and diſtance run, between the obſervations; to find the latitude correſponding with the noon of that day.

SOLUTION.

1ſt. Find the latitude by account at the time, when the greater altitude was taken.

2d. Let the bearing of the Sun be taken by the compaſs at the inſtant when the leaſt altitude was obſerved, and take the difference between that bearing and the ſhip's courſe by compaſs.

3d. With this angle, or its ſupplement, if more than 90 degrees, and the diſtance run by the ſhip between the obſervations, find the difference of latitude in the traverſe table.

4th. This difference of latitude muſt be added to the firſt altitude, if the angle between the Sun and ſhip's tract be leſs than 90°; but it muſt be ſubtracted from it, if that angle be greater than 90°, to give the firſt altitude, as it would have been found, if it had been obſerved at the ſame place where the ſecond was.

5th. With theſe altitudes (thus reduced to the ſame zenith), the obſerved interval of time, together with the declination and the latitude by account, at the greateſt altitude, find the meridian altitude by the preceding problem; and hence the latitude will be obtained for the time, when the greater altitude was obſerved.

6th. If the latitude be required for noon, with the courſes run by the ſhip, corrected for variation of the compaſs and lee-way (32, 35,) and her diſtance run by the log. find the difference of latitude made good from the time when the greater altitude was obſerved at noon; which being applied to the latitude, found above, at the time of the greater altitude, will give the latitude at noon.

REMARK. If the Sun's bearing could be taken with ſufficient accuracy at either obſervation, it would render the other obſervation uſeleſs; for, with the azimuth, the polar diſtance and the zenith diſtance, taken at any time, the latitude and hour from noon may be found. But although the Sun's azimuth cannot be obſerved with ſufficient exactneſs for this purpoſe, it may for obtaining the correction to be applied to one of the altitudes to reduce it to what it would have been found, if it had been taken where the other was. For the ſmall error incident to the correction of the zenith diſtance, by being computed from an azimuth ſomewhat erroneous, will bear to the error in that azimuth, a ratio but little different from that of the ſine of the diſtance run by the ſhip to the co-ſecant

Digitized by Google

co-secant of the angle which the ship's course makes with the azimuth circle that the Sun was on *. Or, instead of observing the sun's azimuth, it may be computed from the latitude by account, sufficiently exact for the purpose of obtaining this correction, as was proposed by Dr. Pemberton.

Note, In the second operation of the Examples to the VIth and VIIth Problems, the arith. compl. of the co-sine of the latitude is added to the sum of the four first logarithms, according to the precept in Problem VI. by which means the conformity of the second operations with the first is more expressly shewn; yet the same logarithm would be produced by deducting the co-sine of the latitude from the said sum.

EXAM. I. *Sailing S. E. 11 knots an hour, at* 9h 36m *forenoon, the true altitude of the Sun's center was* 52° 2′, *and his bearing was S.* 60° 30′ *E. and at* 11h 24m, *his altitude wae* 63° 45′; *the latitude by account at this time being* 48° 46′ *N. and the Sun's declination* 23° 20′ *N.: Required the latitude at the time when the latter altitude was observed.*

Now 11h. 24m.—9h. 36m.=1h. 48m. is the interval of time.
And 1h. : 1h. 48m. : : 11kn. : 20kn. nearly the dist. run in 1h. 48m.
Also 60° 30′ the Sun's rhumb, lessened by 45° the ship's rhumb, leaves 15° 30′ for the diff. of rhumbs.
Then with the course 15° 30′, and dist. 20m. the diff. lat. is 19m.
And 52° 2′+19′=52° 21′ for the lesser altitude corrected; or fitted to the zenith where the greatest altitude was taken.

Now 1h. 48m.	= 27° 0′		Alts. 63° 45′	N. S. 89687	
half interval	= 13 30		52 21	N. S. 79176	
			half sum 58 3; half diff. 5° 42′.		
L.s ½ sum alts.	= 58° 03′	9,72360	L.s declin.	= 23° 20′	9,96294
L.s ½ diff. alts.	= 5 42	8,99704	L.s lat.	= 48 46	9,81897
L.s ½ diff. times	= 13 30	0,63182	L.s, ½ l. time	= 4 10	8,86128
L.s declination	= 23 20	0,03706	L.s, ½ l. time	= 4 10	8,86128
L.s lat.	= 48 46	0,18103	L. N° ½ corr.	= ,003195	7,50447
			Correction	= ,00639	
L.s ½ sum times	= 21 50	9,57055	N.s least alt.	= ,89687	
L.r. time à noon	= 8 20, its ½=4 10		N.s mer. alt.	= ,90326 =	64 35
			mer. zen. dist.		25 25 S.
			Declin.		23 20 N.
			Lat.		48 45 N.

Here the lat. 48° 45′ computed, differing by 1 minute only from the latitude by account, may be taken for the true latitude.

* Cotes. Æstim. Err. in Mixt. Math. Theorem. 22.

EXAM.

Exam. II. *Being by account in latitude 51° 6′ N. when the Sun's declination was 22° 23′ S.; at 9h. 18m. A. M. the Sun's altitude was 8° 37½′, when he bore S. 36° 45′ E.; and having run NW. b. W. eight knots an hour, at 10h. 40m. the Sun's altitude was 14° 46′: Required the latitude at the time when the second observation was taken.*

Here the observed difference of time is 1h. 22m.
Now 1h. : 1h. 22m. : : 8kn. : : 11nk. nearly the dist. run betw. the obs.
Here the Sun's rhumb. is S. 36° 45′ E.
And the ship's rhumb. is N. 56 15 W.
The angle comprehended between them is 160° 30′.
Its supplement is 19° 30′, which as a course, with the dist. 11, gives 10⅜ for a diff. lat.
And the ship running northward from the Sun lessens the altitude.
Then 8° 37½′—10½′=8° 27′ is the alt. to be used at the 2d observation.

To find the latitude by Problem VII.

10h. 40′ } interval=1h. 22m.=20° 30′. Alts. { 14° 46′ | ½ sum = 11° 36½′.
9 18 } half diff. times=10 15 { 8 27 | ½ diff. = 3 9½.

L`s, ½ sum alts. =	11° 36½′	9,99102	Ls`, declination	22° 23′	9,96598
Ls, ½ diff. alts. =	3 9½	8,74111	Ls`, latitude	51 6	9,79793
L`s, ½ diff. times =	10 15	0,74972	2Ls, ½ time	10 37	8,53075
L`s`, declination =	22 23	0,03402			
L`s`, latitude =	51 6	0,20207	L, ½ correction	,019705	8,29466
Ls, ½ sum times =	31 29	9,74794	Correction	,03941	
			Nat. sine	,25488 of 14° 46′	
Least time	21 14 from noon.				
			s, of 17° 07′	,29429 merid alt.	
			And 72 53 = merid. zen. distance.		

Then 72° 53′—22° 23′=50° 30′ N. is the latitude. (60)

Second Operation.

Sum of the four first logs.		9,51587	Ls`, declination =	22° 23′	9,96598
L`s`, latitude	50° 30′	0,19649	Ls`, latitude =	50 30	9,80351
			2Ls, ½ least time	10 24	8,51305
Ls, ½ sum times	31 34	9,71236			
			L, ½ correction	0,019165	8,28954
Least time	20 48 fr. noon.				

Then the correction 0,03833+0,25488 the nat. sine of 14° 46′ gives 0,29321 the nat. sine of 17° 03′ the merid. alt. and the merid. zen. dist. =72° 57′.

Therefore the latitude will be 50° 34′ N.

And by making a third operation, the latitude sought will be found to be 50° 34′ N. The same to a mile as it was before.

Exam.

Digitized by Google

EXAM. III. *Running with a brisk gale ten knots an hour, on a W. S. W. course; at 10h 36m forenoon, the altitude of the Sun's center was observed to be 61° 47'; and at 3h 36m P. M. his altitude was again found to be 36° 5', and his bearing S. 80° 30' W. by our account, the latitude at 10h 36m was 30° N. and the Sun's declination 10° 24' N.: Required the latitude at the time of the first observation.*

Here the observed difference of time is five hours.

And 1h : 5h : : 10kn : 50kn. the distance run between the observations.

When, as in this case, the Sun's bearing is taken at the second observation, the opposite point to the ship's course must be used in reducing that altitude to the same situation with the first.

Now the Sun's rhumb is S. 80° 30' W. or N. 80° 30' E.

And the opposite point to the ship's course, is N. 67 30 E.

Their diff. is 13° 08', which as a course, with the dist. 50, gives diff. lat. 49m. Then 36° 5'—49'=35° 16'.

Then 36° 5'—49=35° 16' is the corrected alt. for the 2d observation.

To find the latitude by Problem VII.

Interval 5h. =75° 0'	Alts. 61° 47'	½ sum alts. =48° 31½'.	
½ Interval =37 30	35 16	½ diff. alts. =13 15½.	
L s', ½ sum alts. =48° 31½'	9,82105	L,s', decl. = 10° 24'	9,99281
L s, ½ diff. alts. =13 15½	9,36048	L,s', latitude = 30 0	9,93753
L's, ½ sum times=37 30	0,21555	L,s, ½ time = 10 14	9,24958
L's, decl. =10 24	0,00719	L,s, ½ time = 10 14	9,24958
L's, latitude =30 0	0,06247	L, N° ½ corr. =0,026885	8,42950
		Correction =,05377	
L s, ½ diff. times =17 2	9,46674	N. s, of 35 16=,88117	
Lea. time à noon=20 28; its ½=10° 14'		N. s, mer. alt.=,93494=69° 13'	
		And the latitude at noon 31° 11' N.(61)	

By a 2d operation the latitude will be found to be 31° 26' N. by a 3d 31° 30' N., and by a 4th 31° 30' N.

By working with the latitude 29° 41', which the ship was in at the 2d observation, the final result will be the same, as is shewn in the following practical form of placing the work of these Examples: 9,40427 is the sum of the four first logarithms.

First Operation.		*Second Operation.*		*Third Operation.*	
9,40427	9,99281	9.40427	9,99281	9,40427	9,99281
0,06109	9 93891	0,06724	9,93276	0,06869	9,93131
9,46536	9,66056	9,47151	9,66240	9,47296	9,66289
16° 58½'	9.66056	17° 13½'	9,66240	17° 17'	9,66289
37 30	9.25284		9,2537		9,24990
	,17900	37 30	0,17798	37 30	0,17779
54 28½	0,35800	54 43½	0,35596	54 47	0,35558
27 14¼	0,57740	27 21¾	0,57740	27 23¼	0,57740
	,93540		9.3336		,93298
Mer. alt.	69° 18'	Mer. alt.	68° 58'	Mer. alt.	68° 54'
Zen. dist.	20 42	Zen. dist.	21 02	Zen. dist.	21 6
Decl.	10 24	Decl.	10 24	Decl.	10 24
Latitude	31 6	Latitude	31 26	Latitude	31 30 N.

EXAM.

Digitized by Google

EXAM. IV. *January* 20, 1780, *being by account in latitude* 56° 30′ *S. longitude* 64° *W. at* 7*h.* 32*m. and at* 10*h.* 28*m. forenoon, by fore observations, the altitudes of the Sun's lower limb, were* 29° 47½′, *and* 49° 52¾′; *and his bearing at the former N.* 80° *E. the eye* 20 *feet above the water, and between the observations the ship had run* 8 *knots an hour, on a course S.* 50′ *E.: Required the mid-day latitude.*

Now ship time $19^h\ 32^m$ P.M. + $4^h\ 16^m$ W. = $23^h\ 58^m$. Or, $11^h\ 58^m$ A.M. London. (57.)
Or, $22^h\ 28^m$ P.M. + $4^h\ 16^m$ W. = $26^h\ 44^m$. Or, $2^h\ 44^m$ P.M. Lond. time. (57.)

The Sun's declination fitted to these times, are 20° 8′, and 20° 7′. (V. 281.)

App. alt. ☉ lower edge	29 47 30	And, 49 52 45
☉ ½ diameter +	16 20	16 20
App. alt. ☉ center	30 3 50	50 9 05
Dip. on 20 feet	4 15	4 15
	29 59 35	50 4 50
Refraction	1 38	48
True alt. ☉ center	29 57 57	50 4 2
Or,	29 58	50 4

Now the interval is $2^h\ 56^m$. And 1^h : $2^h\ 56^m$: : 8kn : 23kn : the distance run.

With the course S. 50 E. and distance 23^m the diff. lat. is 15^m.

Then 56° 30′ + 15′ = 56° 45′ the latitude in at second observation.

Again. The difference between the Sun's bearing N. 80 E. and the ship's course N. 130° E. gives 50°.

And with the course 50° and dist. 23^m the diff. lat. is 15^m.

So 29° 58′ + 15′ = 30° 13′ the corrected alt. at 1st observation.

The interval = $2^h\ 56^m$ = 44°	Alt. 50° 4′	½ sum alts. = 40° 08½
Its half = 22	30 13	½ diff. alts. = 9 55½

First Operation.		*Second Operation.*		*Third Operation.*	
9,88335	9,97262	9,57363	9,97262	9,57363	9,97262
9,23643	9,74189	0,26331	9,73669	0,26157	9,73843
0,42647	9,72873	9,83694	9,73249	9,83520	9,73126
0,22738	9,72873	43° 23′	9,73249	43° 10½′	9,73126
0,25811	9,17197	22	9.17429	22	3.17357
9,85174	,14860	65 23	,14940	65 10½	,14910
42° 45′	,29720	32 41½		32 35¼	,29820
22	,50327	Correction,	29880		,50327
64 45	,80047	Least alt.	,50327		,8014
32 28½	53° 11′	Mer. alt.	,80207	Mer. alt.	53° 16′
Zen. dist.	36 49 N.	Mer. alt.	53° 20′	Mer. zen. dist.	36 44
Decl.	20 8 S.	Zen. dist.	36 40	Declination	20 8
Latitude	56 57	Declination	20 8	Latitude	56 52
		Latitude	56 48		

Digitized by Google

But working with the latitude 56° 45′, and the declination 20° 7′, at the second observation.

First Operation.

9,88330		9,97266
9,23643		9,73901
0,42647		9,73081
0,02734		9,73081
0,26099		9,17329
9,83453		,14904
43° 06′	Cor.	,29808
22 00		,50327
65 06		,80135
32 33		
	Mer. alt.	53° 16′
	Zen. dist.	36 44 N.
	Declination	20 07 S.
	Latitude	56 51 S.

Second Operation.

9,57354		9,97266
0,26215		9,73785
9,83569		9,73160
43° 14′		9,73160
22		9,17371
65 14	N°	,14920
32 37	Corr.	,29840
	N.s, least alt.	,50327
	N.s, mer. alt.	,80167
	Merid. alt.	53° 17′
	Zen. dist.	36 43 N.
	Declination	20 07 S.
	Latitude	56 50 S.

Hence it appears, that in the work of such examples as the preceding, it is almost indifferent, whether the latitude by account and declination relates to the observation nearest to noon, or farthest from noon. However, for the sake of uniformity, it may be recommended to use the latitude, the declination, and the natural sine, which do all relate to the same altitude.

It will be shewn in the Appendix how this problem was considered by *Facio*; but his solution requiring too many trigonometrical operations to be of ready use, the preceding method by approximation was substituted instead thereof.

76. Mr. *Richard Graham*'s method of solving this problem, published in the Philosophical Transactions for the year 1734, N° 435, by a kind of instrumental operation, may indeed give the latitude within some minutes of the truth with ease and expedition: it is, in substance, as follows:

Description of the Instrument.

To the meridian of a globe (properly divided) let a piece of a like meridian, called the beam compass, about 110 degrees long, and divided like the former, be fitted, and made to slide on the upper side of the meridian *. Moreover let two sliding Vernier's scales be fitted to

* In Mr. Graham's instrument, made on purpose for this problem, the beam compass slides under the meridian.

those

those circles, dividing each degree into every five minutes. The beam compass must be so applied, that a pin, on which it turns as a center, and fixed exactly at o degrees, or one end of it, may pass through a hole at the beginning of the divisions of the Vernier which is to slide on the meridian, that pin serving as the center of motion of the beam compass, when the Vernier is screwed to the meridian: the other Vernier is to slide on the beam compass, and carry with it a pointer, or index, at the beginning of its divisions.

With this Instrument the problem is thus solved:

At the time of the first observation, let the Sun's bearing be also observed, and take the difference between the rhumbs on which the Sun was observed, and the rhumb on which the ship steered between the observations: Then say,

As radius is to the co-sine of that difference of rhumbs, so is the distance run between the observations, to the minutes of correction to be applied to the first zenith distance, and is to be added when the ship sails from the Sun, otherwise it is to be subtracted.

Then slide the Vernier's scale on the meridian to the given declination, and the Vernier on the beam compass to the first zenith distance as corrected, and let these scales be fixed by their screws. Rectify the globe for noon (VI. 59), turn it till the hour-index points at the time of the first observation; there hold the globe fast, and move the beam compass on its center, nearly into the azimuth of the Sun at that observation, and describe an arc on the globe with the pointer of the Vernier.

Slide the Vernier on the beam compass to the second observed zenith distance; turn the globe (the proper way) till the hour-index points at the time of the second observation; there hold the globe fast, and with the beam compass cut the former arc, their intersection will shew the place of the ship at the time of the second observation: bring the meridian over that point, and the latitude is found; also the hour-index will point at the true time of the day when the last observation was made.

SECTION

Digitized by Google

SECTION X.

77. *To find the Longitude at Sea.*

If an accurate account could be kept of the true courſes which a ſhip has ſteered, as directed by the compaſs, and of the diſtance ſhe has run, as meaſured by the log, or by any other contrivance; then both the latitude and longitude of the place where the ſhip is at any time, would be known on ſettling the ſhip's account to that time.

For the courſe and diſtance being known, the difference of latitude and departure is readily found by the traverſe table; and the difference of longitude being alſo found (VIII. 60), the true lat. and longitude are known.

But as the ſhip's motion is liable to be diſturbed from a variety of cauſes, ſuch as, a continual deflection from the courſe ſet, by the ſhip's playing to the right and left round her center of gravity, and the unequal care of the helmſmen: and the diſtance ſailed being faulty, on account of tumbling ſeas rolling with or againſt the ſhip; the unſteadineſs of the wind; unknown currents; ſudden ſtorms, and many other circumſtances, which ſeem impoſſible to be allowed for; her place, aſſigned by theſe means, may juſtly be ſuſpected to be erroneous. Mariners judge of this by finding the ſhip's latitude every day, if they can, by obſervations of the Sun or Stars; and if the latitude, found by their reckoning, agrees what that found by obſervation, it is preſumed that the ſhip's place is well determined: but if they diſagree, they conclude that the account of longitude ſtands in need of correction; the latitude found by obſervation being always to be depended on.

78. The error in the ſhip's reckoning is frequently attributed to unknown currents. For, from cauſes yet undetermined, there are many and various motions of the water in the open ſeas, as well as thoſe obſerved near the ſhores, where the motions may be tolerably well accounted for. Some of the currents obſerved in the great ſeas may perhaps be owing to the tide's following the Moon, and to the libratory motion which the waters may derive from thence; and the unſettled ſetting and drift of theſe currents may poſſibly depend on the change in the Moon's declination. However, it is well known from obſervations, that the trade-winds occaſion a conſiderable current within their limits, particularly within the Torrid Zone, where the motion is perpetually towards the weſt, at the rate of 8 or 10 miles a day. But at the extremities of the trade-winds, or near the latitudes of 30 degrees north or ſouth, it is likely, that the currents are compounded of the ſaid weſtern motion, and of one toward the equator (by obſervation 2. Art. 84. B. VI.): therefore all ſhips, ſailing within theſe limits, ſhould allow a courſe each day for this current.

Although ſome of the methods recommended for correcting a ſea reckoning are little better than gueſs-work, as it cannot be known with certainty whether the ſhip is to the eaſtward or weſtward of the point in which the reckoning places her; yet it was judged proper to introduce them here, as they may ſometimes be uſeful.

Digitized by Google

Methods of Correcting the Reckoning of Longitude.

79. METHOD I. *When the error is supposed to happen from a current.*

Consider whether the difference may not have been occasioned by a current, and, if it is possible, try it (by Article 47, Book VII.); or make such an estimate of its setting and drift, as may be judged reasonable. Then with the setting and drift, as a course and distance, find the difference of latitude and departure, with which increase or diminish the dead reckoning; and if the latitude, thus corrected, agrees with the latitude by observation, the departure, thus corrected, may be safely taken as true, and so the ship's place determined with regard to longitude.

EXAM. I. *Suppose a ship in 24 hours finds by her dead reckoning, she has made 96 miles of diff. lat. N., and 38 miles of departure W.; but by observation, finds her difference of latitude is 112, and on trial finds a current, which in 24 hours makes 16 miles of diff. lat. N., and 10 miles of depart. E.: What is the ship's departure?*

Diff. lat. by account	96 m. N.	Departure by account	38 m. W.
Diff. lat. by current	16 m. N.	Departure by current	10 m. E.
True diff. lat.	112 m. N.		28 m. W.

Here the dead reckoning corrected by the current gives the difference of latitude 112 miles, which is the same as found by observation; therefore the departure 28 is taken as the true one.

EXAM. II. *Yesterday noon we were in latitude 36° 15′ N., and have sailed these 24 hours, 1st. SE. ½ E. 55 m. 2d. NE. by N. 20 m. 3 d. WSW. 70 m. 4th. S. by W. ½ W. 20 m.; and all the time in a current setting SSW. ¾ W. ⅝ m. an hour: By an observation this day at noon, we were in latitude 34° 58′ N.: Required the true departure the ship has made?*

Courses.	Dist.	N.	S.	E.	W.
SE. ½ E.	55		34,9	42,5	
NE. b. N.	20	16,6		11,4	
WSW.	70		26,8		64,7
S. b. W. ½ W.	20		19,1		5,8
SSW. ¾ W.	15		12,8		7,7
		16,6	93,6	53,6	78,2
		diff. lat.	77,0	dep.	24,6

Departed lat.	36° 15′ N.	
Present lat.	34 58 N.	
Diff. latitude	1 17=77 m.	

Here the current being taken into the account, produces a diff. lat. by dead reckoning equal to that found by observation; and therefore the departure by the dead reckoning is taken as the true departure.

80. ME-

80. METHOD II. *When the error is thought to arise from the courses and distances.*

If the difference of latitude is much more than the departure, or the direct course has been within three points of the meridian; it is most likely the error is in the distance.

And if the departure is much greater than the difference of latitude, or the direct course is within three points of the parallel, or more than five points from the meridian, the error may be ascribed to the course.

But if the courses are in general near the middle of the quadrant, the error may be either in the course, or in the distance, or in both.

For, to cause an alteration in the difference of latitude, the first of these cases requires a greater error in the course than can well be supposed to have been committed; in the second case, the distance must be so faulty as would scarce escape observation; and in the last, it is often doubtful whether to attribute the error to the course or distance; but it is usually corrected in both.

81. CASE I.

When, by the dead reckoning, the diff. lat. is more than once and a half the departure: Or, which is the same, when the course is less than three points.

RULE. To the diff. lat. and the departure by account, find the course.

With this course, and the meridional diff. lat. by observation, find the diff. of long.

EXAM. *Yesterday noon we were in lat.* 39° 18′ *N., and by an observation are this day noon in lat.* 37° 48′ *N.; our dead reckoning gives* 116 *miles of southing, and* 64 *miles of easting: Required the ship's true difference of long.*

By the TRAVERSE TABLE.

The diff. lat. 116, and the departure 64, gives the course 29 degrees.

The course 29 degrees, and the meridional diff. lat. by observ. 115, gives the diff. long. 64.

82. CASE II.

When by the dead reckoning the departure is more than once and a half the difference of latitude: or, the course is more than five points.

RULE. With the diff. of latitude by observation, and departure by account, find the course and distance.

With the co-mid. latitude by observation, and depart. by account, find the diff. longitude.

EXAM. *Yesterday noon we were in latitude* 48° 52′ *N., and were to-day at noon in latitude* 50° 18′ *N.; our dead reckoning shews we have made* 68 *miles of northing, and* 112 *miles of westing: Required the true difference of longitude the ship has made.*

By the TRAVERSE TABLE.

The diff. lat. 86 and departure 112, gives $52\frac{1}{2}$° for the course, and 132 for the distance.

The co-mid. latitude 40° 25′, and the departure 112, give 173 miles for difference of longitude.

Digitized by Google

83. CASE III.

When the difference of latitude and departure by account is nearly equal, or the direct course has been between three and five points of the meridian.

RULE. With the diff. of latitude and departure by account, since the last observation, find the course.

With this course, and the diff. of lat. by observation, find another departure.

Take half the sum of these two departures for the true one.

With the true departure and diff. of lat. by observations, find the true course.

With the true course and meridional diff. of lat. by observation, find the diff. of longitude.

EXAM. *The last 24 hours we have made 84 miles of northing, and 76 of easting; we were yesterday noon in latitude 52° 40′ N., and are this noon in latitude 54° 22′ N.: What difference of longitude has the ship made?*

By the TRAVERSE TABLE.

To the diff. latitude 84 and departure 76, the course is 42°.

With the course 42° and diff. lat. by observ. 102, find the departure 91,8.

The sum of the two departures 76 and 91,8 is 167,8, its half is 83,9.

With dep. 83,9, and diff. of lat. by observ. 102, find the course 39°.

With this course and 171,6, the merid. diff. of lat. find 139, the diff. long.

84. Dr. Halley, having collected a great multitude of observations made on the variation of the needle in many parts of the world, was enabled, by the help of the latitudes and longitudes of the places of those observations, to draw certain lines on a Mercator's chart, shewing the variation of the compass in all the places over which they passed, in the year 1700, the time he published the first chart of this kind, called the Variation Chart. Consequently, the longitude of any of those places could be found by the chart, having its latitude and the variation of the needle in that place given.

85. METHOD III. *To find the longitude at sea by the variation chart.*

Find the variation of the compass: for which see Article 28.

Draw a parallel of lat. on the chart through the lat. found by observ.

And the point where it cuts the curved line, which is marked with the variation that was observed, will be the ship's place.

EXAM. *A ship finds, by a good observation, that she is in the latitude of 18° 20′ N.; and that the variation of the compass is 4° west: Required the ship's place.*

Lay a ruler over 18,20 N. parallel to the equator, and the point where its edge cuts the curve of 4° west variation, gives the ship's place, which will be found in about longitude 27° 10′ west from London.

86. This method is attended with two inconveniencies.

First, That wherever the variation lines run east or west, or nearly so, this way of finding the longitude becomes imperfect. But this imperfection is at present found chiefly on the west coasts of Europe, between the latitudes of 45° and 53°; on the eastern shores of North America, and in some parts of the Western Ocean and Hudson's Bay; there-

Digitized by Google

therefore, for the other parts of the world, a variation chart may be esteemed of great use.

87. But the variation curves, even where they run east and west, may be sometimes applied to good use in correcting the latitude, when meridian observations cannot be had, as it frequently happens on the northern coasts of America, in the Western Ocean, and about Newfoundland. For if the variation can be obtained exactly, the east and west curve answering to that variation on the chart will shew the latitude.

Secondly, As the deflection of the magnetical meridian from the true one is subject to continual alteration, a chart to which the variation lines are suited for any year, must in time become useless, unless new lines, shewing the state of the variation at that time, be drawn on that chart. But as the change in the variation is very slow, if new variation charts were published every seven or eight years, it would fully answer the purpose wanted.

88. Notwithstanding the great use which Dr. Halley's Variation Chart afforded to most mariners, yet it has been almost useless, for want of public encouragement to renew it from time to time. However, in the year 1746, Mr. William Mountaine, F. R. S. and Mr. James Dodson, published a new Variation Chart, fitted for that year, which was well received; and several instances of its great utility having been communicated to them, they drew the Variation lines again for the year 1756, and the year following published the third Variation Chart. They also presented to the Royal Society a curious paper concerning the variation of the magnetic needle, with a set of tables annexed, containing the result of upwards of fifty thousand observations, in six periodical reviews, from the year 1700 to 1756, inclusive, and adapted to every five degrees of latitude and longitude, in the more frequented oceans: which paper and tables were printed in the Society's Transactions for the year 1757.

The engraving of new plates on every publication of such charts, is a charge too great for private persons to incur; and should, like the Nautical Almanac, be done at the expence of the public; especially as the use of it is so easy, and so well suited to the knowledge and time of mariners in general.

89. METHOD IV. *To find the longitude by the help of a perfect time-keeper.*

This method is a mechanical solution of the following problem.

The time in any unknown place, relative to the meridian of that place, being given, to find what o'clock it is, at that instant, under the meridian of some known place; suppose London or Greenwich.

If a clock or watch were so contrived, as to go uniformly in all seasons and in all places; such a watch, being regulated to London or Greenwich time, would shew always the time of the day at London or Greenwich: then the time of the day under any other meridian being found, the difference between that time and the London or Greenwich time corresponding to it, would give the difference of longitude.

90. That very excellent artist, Mr. *John Harrison*, after more than thirty

thirty years close attention to this subject, has discovered many curious inventions to remove the irregularities to which all watch and clock-work were liable, that were constructed by the common methods. His inventions are so extraordinary, and seem so well adapted to remove the imperfections of clocks, that the commissioners for the longitude granted him some considerable gratuities to enable him to bring his notions to the desired perfection. Experiments of his watch were made in the latter end of the year 1761, and in the beginning of the year 1762, between Portsmouth and Jamaica; and although the result did not fully come up to the wishes of the public, yet it proved sufficient to induce the commissioners to enable Mr. Harrison to make a second trial, between Portsmouth and Barbadoes; which succeeded so well, that the commissioners of longitude ordered him the sum of 10,000 pounds, upon his disclosing the mechanism of his WATCH, to a number of proper persons appointed to receive his communications; which have since been published, and watches of a similar construction have been made by other artists, which have succeeded equally with that which had been made by the inventor himself. Mr. Harrison has even improved his former works; and it is probable, that such watches may hereafter become more common, and be afforded for less than 100l. or a fourth part of their present value.

But to whatever degree of perfection such a movement may be brought, yet as every mechanic instrument must be liable to be injured by various accidents, it is certainly to be wished, that astronomical methods could be also so far improved, that the marine artist might be enabled to find his longitude from time to time with sufficient exactness by celestial observations.

91. Various astronomical methods have been proposed for finding the longitude at sea, some of which will hereafter be mentioned.

These methods chiefly depend on having an Ephemeris or Almanac adapted to the meridian of some known place, suppose Greenwich, for which the Nautical Almanac is fitted; which Ephemeris shall contain the Sun's place, right ascension, declination, the times of the planets passing the meridian, as also the rising and setting, the times of the eclipses of the Sun and Moon, together with those of Jupiter's satellites; the distances of the Moon from the Sun and some zodiacal stars at certain times, for every day in the year; and, in general, the times when any other remarkable celestial appearances may be seen at the place for which the Ephemeris is calculated. Then, as these celestial appearances are seen nearly at the same instant of absolute time from all parts of the Earth where they are visible: by knowing the relative times of the day, when such appearances are seen in two distant places, the difference of those times is known, and consequently the difference of longitude between those places.

92. METHOD V. *By the Sun's declination.*

By some of the means shewn in Book V. between the Articles 185 and 204, or by any other means, let observations of the Sun be taken, from which his declination may be computed at those times.

Take the difference between this computed declination, and that for the noon of the same day at London, as shewn by the Ephemeris; from which take also the daily difference of declination at that time, and say,

As

As the daily difference of declination is to the above-found difference; so is 360 *degrees to the difference of longitude.*

Exam. *Suppose from certain observations made on the* 18*th of April* 1764, *the Sun's declination should be found to be* 11° 10′ 4″: *Required the longitude of the place of observation.*

On April 18th the decl. at London is 11° 5′ 26″ } daily diff. is 20′ 39″.
19th it is 11 26 5 }

The difference between 11° 10′ 4″ and 11° 5′ 26″ is 4′ 38″.

Then 20′ 39″ : 4′ 38″ : : 360° : 80° : 46½′, the diff. of long. east of London;

Because the observed declination was greater than that at London.

Had it been less, the difference of longitude would have been westward.

Here a small error in the declination computed, will make a very considerable error in the difference of longitude; and the method is only inserted as a caution to beginners.

93. Method VI. *By the Moon's culminating.*

Seek in the Ephemeris for the time of her coming to the meridian on the given day, and on the day following, and take their difference; also take the difference between the times of culminating on the same day, as found in the Ephemeris, and as observed; and say,

As the daily difference in the Ephemeris is to the difference between the Ephemeris and observation; so is 360 *degrees to the difference of longitude.*

For as the whole difference arises in a day, or by the running through 360°: of course any part of that difference will require a proportional part of 360 degrees; upon the supposition of the Moon's motion being uniform during 24 hours, which it is not.

Exam. *Suppose at sea, the Moon's center was observed to pass the meridian on a certain known day at* 57 *minutes after one in the morning: Required the longitude of that place.*

In the Ephemeris I find the Moon's center passes the meridian of London on that day at 1h. 47m. and the next day at 2h. 31m. the diff. is 44m. and the time observed is 10m. later than at London.

Then, as 44m. : 10m. : : 360° : 81° 49′. Which shews that the place is 81° 49′ to the west of the meridian of London.

Here also a small error in the time of the Moon's culminating, will produce a great error in the difference of longitude; and this is mentioned on the same account as the former method was.

94. Method VII. *By the eclipses of Jupiter's satellites.*

On the day preceding the evening on which it is proposed to observe the eclipse, seek the time it will happen at London, in the Nautical Almanac.

Let the difference of longitude between London and the place of observation (known by the dead reckoning at sea, or by the printed maps) be turned into time; and if eastward, be added to the London time of the eclipse, but subtracted, if westward; and it will give the time nearly when the eclipse is to be looked for in that place. But it will be proper to begin to observe 20 or 30 minutes sooner; and let the instant when the eclipse begins or ends be noted, as shewn by a watch previously regulated to the time at the place of observation (58): then the difference

Digitized by Google

between this time and the London time, converted into degrees, will ſhew the difference of longitude; and if the London time be leſs than the obſerved time, the diff. of longitude is eaſt; otherwiſe it is weſt.

95. The beginning of theſe eclipſes, called *immerſions*, generally happen on the weſt ſide of Jupiter; and the endings, called *emerſions*, to the eaſtward of the planet; and both happen at a very ſmall diſtance from the planet, ſeldom exceeding its half diameter.

The beſt obſervations for finding the difference of longitude, are thoſe made on the firſt ſatellite, or that which moves neareſt to Jupiter; but it ſhould be obſerved, that its emerſions are not viſible from the time of Jupiter's conjunction with the Sun, to the time of his oppoſition; and the immerſions are not viſible from the time of the planet's oppoſition to the Sun, to the time of its conjunction.

Exam. *Suppoſe by the Almanac for* 1773, *an immerſion of Jupiter's firſt ſatellite is viſible at London on October* 23*d*, *at* 13*h*. 23*m*. 15*ſ*. *and I am, by my dead reckoning, in longitude* 72 *deg. to the weſt of London; I obſerved on the ſame day the immerſion at* 8*h*. 40*m*. 45*ſ*.: *Required the difference of longitude.*

The difference between 13h. 23m. 15ſ. and 8h. 40m. 45ſ. is 4h. 42m. 30ſ.

And 4h. 42m. 0ſ. is equal to 70° 32′ for the diff. of log. weſtward.

96. The eclipſes of Jupiter's ſatellites may be well obſerved by one of Dollond's new achromatic teleſcopes, of three feet in length, or by a reflecting teleſcope of about 18 or 24 inches focal length. As theſe eclipſes happen almoſt daily, they prove the moſt ready means of determining the longitudes of places at land, and by them the longitudes of ſea-coaſts may be better aſcertained than they are at preſent; and whenever Jupiter is to be ſeen, they might be applied at ſea, even oftener than they would be wanted, could they be obſerved with ſufficient accuracy in a ſhip under ſail.

97. Method VIII. *By eclipſes of the Moon.*

This is performed much in the ſame manner as by the laſt method.

For if in two or more diſtant places, where an eclipſe of the Moon is viſible, the times of the beginning or ending are carefully obſerved, as alſo the times when any number of digits were eclipſed; or when the Earth's ſhadow begins to touch, or to leave any remarkable ſpot on the Moon's face; then will the difference of the times, when the obſervations of like kind were made, give the difference of longitude between the places of obſervation. But theſe eclipſes happen too ſeldom to derive any general uſe from them.

98. Method IX. *By an occultation of a fixed ſtar by the Moon.*

An occultation of a fixed ſtar by the Moon is, when a ſtar, lying in the line of the Moon's motion, is eclipſed by that planet.

The method of computing the difference of longitude between London, and a place where the time of the occultation is obſerved, is ſhewn in Halley's Aſtronomical Tables: and the method of delineating ſuch an occultation is ſhewn in De la Caille's Elements of Aſtronomy.

But the method of finding the difference of longitude by an occultation, is rather too intricate and tedious to become of general uſe at ſea.

99. The

Digitized by Google

99. The great Dr. Halley, and after him the Abbé de la Caille, and others, have reckoned the best astronomical method for finding the longitude at sea to be, when the distance of the Moon from the Sun, or from a Star is used: for the Moon's daily mean motion being about 13 degrees, her hourly mean motion is about half a degree, or 1 min. of a degree in two minutes of time; and so an error of one minute of a degree in position will produce an error of two minutes in time, or half a degree in longitude. And if by observation it is determined what part of her daily motion the Moon has run through, during the interval between a certain point of time under a known meridian, and the instant of time when the observations are made on her under an unknown meridian, then her daily motion at that time will have to the part thereof, determined by observation, the same ratio which 24 hours have to the interval of time taken to describe that arc.

100. M. de la Caille, in the prosecution of his method, directs a number of observations to be made one after another, in which the interval of time is to be diligently noted: and observes, that many errors will be apt to arise here from the instrument, the observations, and the calculations, which must jointly affect the longitude deduced; so that the most experienced artist ought not, in general, to expect on a single set of observations to find his longitude nearer than to two or three degrees of the truth. He therefore proposes, that each set of observations should be taken by two or more observers at the same time; by which, from a mean taken between them, the longitude may probably be found within a degree and a half; although it may happen, that by an extraordinary degree of diligence and skill, and by a lucky compensation of errors, a result within a degree of the truth may be obtained. But the Rev. Dr. Maskelyne, the Astronomer Royal, who has had great experience in this matter, recommends the set of observations to be divided among different persons, each observing at the same time his respective part, and the computations to be made, either from a good Ephemeris, or from the best Lunar tables, in which case the result may in general determine the longitude at sea within a degree of the truth.

101. Since Sir Isaac Newton's discovery of the true cause of the inequalities in the Moon's motion, which had from the earliest times perplexed astronomers, attempts have been made to form juster tables of her motion than before were possible to be effected; and here the late professor Mayer of Gottengen has succeeded so well, and his tables come so near the truth in every part of the Moon's orbit, that they may be confided in for determining the longitude of a ship at sea, whenever the Moon is to be seen, within a degree at most; which has been proved by a comparison of the Tables with the observations made at Greenwich observatory by the late Dr. Bradley, and by the present Astronomer Royal.

Digitized by Google

Preparatives for finding the longitude by an observed distance of the Moon from the Sun or a Star.

102. First. *To observe the angular distance between the Moon and any celestial object.*

I. *Between the Moon and the Sun.*

Turn down one of the screens, and hold the Hadley's quadrant so, that its plane shall pass through the Sun and Moon: look at the Moon through the transparent part of the horizon glass; and keeping her there, gently move the index till the Sun's image is brought into the silvered part of that glass: bring the nearest limbs of both objects into contact, and let the quadrant librate a little on the lunar ray, by which means the Sun will appear to rise and fall by the side of the Moon; and in this motion the nearest limbs are to be made to touch one another exactly by moving the index; when this is effected, the observation is completed, and the degrees cut by the Vernier's scale will shew their angular distance.

103. II. *Between the Moon and a Star.*

If the Moon is very bright, turn down the lightest screen, and direct the plane of the quadrant through both objects: look at the star, as in a fore observation, through the clear part of the horizon glass: keep it there, and, by moving the index, bring the Moon's image into the silvered part of the same glass; let the quadrant gently librate about the star's ray, and the Moon will appear to rise and fall by the star; between the librations move the index till the Moon's enlightened limb is touched by the middle of the star, as by a tangent, and the observation is made.

REMARKS.

104. The enlightened limb of the Moon is always to be brought into contact with the Sun or star, even though the Moon's image is made to pass beyond the Sun or star, before the desired contact can be obtained.

Between the new and full Moons the enlightened limb is turned toward the west: and during the time from the full to the new Moon, the enlightened limb is turned to the east.

The observed distance of the nearest limbs of the objects, is to be increased by the sum of their semi-diameters; but when the contact is observed of their farthest limbs, by bringing one over the other, then the observed distance is to be lessened by the sum of their semi-diameters.

The stars have no apparent semi-diameters; but that of the Sun and Moon will be found in the Nautical Almanac for any given month and day.

105. When the face of the quadrant is held upward, the motion of the index forward brings the right-hand object, by reflection, into contact with the left-hand one seen directly; and when its face is held downward, the like motion of the index brings the left-hand object, by reflection, into contact with the right-hand one seen directly.

Therefore in north lat. the quadrant is to be used with its face upward, when the object to be seen by reflection is to the right-hand, or

Digitized by Google

or westward of that seen directly. But when the object to be seen directly lies to the westward of that to be seen by reflection, the quadrant is to be used with its face downward.

106. A readiness in the use of the quadrant both ways, is to be obtained by practice only, which the learner may make familiar to himself by observing the position of land objects; and to attain an accuracy in observations let him select 6, 8, 10, or more objects lying around his view; and, beginning with any one of them, take the angular distance of the 1st and 2d, the 2d and 3d, the 3d and 4th, and so on all round, ending with the last and first; and the sum of all these angles should make 360 degrees.

In a Hadley's quadrant of 15 inches radius, if the limb and the Vernier's scale are well divided, the measure of an arc may be read to thirds or quarters of a minute, with the assistance of a magnifying glass.

107. Secondly. *To correct the apparent angular distance observed between the Moon and any other celestial object: or to reduce the distance, observed at the surface, to what it would appear if observed from the center of the earth.*

It was shewn in Book V. Art. 66, that the apparent place, in which the Moon is seen in the heavens from the surface of the earth, is generally not her true place on account of the parallax; so that her apparent place should be corrected, as well for the error of parallax as for that of refraction: the same may be observed of the Sun; but the parallax of the stars is too small to affect their places sensibly, and therefore the refraction only is to be applied to them. Because the apparent places of celestial objects want correction, their apparent distance does also stand in need of being corrected, especially where the Moon is concerned; how to do this is shewn in the following precepts.

1st. In the triangle formed by the observed distance of the objects and their zenith distances, find the angles at each object comprehended between the observed distance and respective vertical or azimuth circle. (IV. 154)

2d. By the Almanac find the Moon's horizontal parallax at the time of observation, reduced to the meridian of the Almanac.

3d. Say, as radius is to the co-sine of the Moon's altitude;
So is the horizontal parallax to the parallax in altitude.

4th. Say, as radius is to the co-sine of the said angle at the Moon;
So is the diminished parallax to one error in distance.

Which is to be subtracted, if the angle at the Moon is acute; otherwise it is to be added.

5th. Also say, as rad. is to the cos. of the said angle at the Sun or star;
So is the refraction on its zenith distance to an error in dist.

Which is to be added, when the angle at the Sun or star is acute, otherwise this error is to be subtracted.

EXAM.

Digitized by Google

EXAM. I. *Suppose on the 6th of August 1772, in a place 96 degrees to the west of London, at 5h. 36m. P. M. by a watch, the distance of the nearest limbs of the Sun and Moon should be observed to be 68° 10′ 24″, at the time the altitude of the Sun's lower limb is 31° 44′ 12″, and the altitude of the Moon's lower limb is 23° 44′ 12″, the height of the eye above the water being allowed for: Required what would be the true distance of the centers of the Sun and Moon.*

By the Almanac, the semi-diameters of the Sun and Moon at that time will be found to be each of 15′ 48″. Hence the apparent altitude of the Sun's center is 32°, of the Moon's center is 24°, and the apparent distance of the centers is 68° 42′.

Also 96° W. is 6h. 24m. to which 5h. 36m. being added, give 12h. P.M. at London; and the Moon's horizontal parallax at the given London time is 58′ 39″=58,65.

James Macully's Book.

Given the Sun's zenith distance	58°
the Moon's zenith distance	66
the distance of their centers	68 42′.

Required ∠ of position at the ☽.			*Required the ∠ of position at the ⊙.*		
68° 42′	Working by Art. 154. B. IV.		68° 42′	Working by Art. 154. B. IV.	
66 0	L's, 68° 42′	0,03073	58 0	L's, 68° 42′	0,03073
58 0	L's, 66 0	0,03927	60 0	L's, 58 0	0,07158
2 42	Ls, 30 21	9,70353	10 42	Ls, 38 21	9,79272
60 42	30°21′ Ls, 27 39	9,66658	70 42	35°21′ Ls, 27 39	9,66658
55 18	27 39	19,44011	55 18	27 39	19,56161
	s, 31 39½	9,72005		s, 37 8	9,78080
∠ at the moon =	63 19		∠ at the Sun =	74 16	

As Rad.		10,00000
To s', ☽'s alt.	24°	9,96073
So horizon. paral.	58 65′	1,76827
To paral. in alt.	53,58	1,72900
Deduct refraction	2,3	
Error in alt.	51,28	

As Rad.		10,00000	As Rad.		10,00000
To s' ∠ at ☽	63° 19′	9,65230	To s', ∠ at ⊙	74° 16′	9,43323
So error in alt.	51, 28	1,70995	So error in refr.	1,8	0,25527
To error in dist.	23, 03	1,36225	To error in dist.	0,488′	1,68850
Which is subtractive.			Which is to be added.		

Now 23,03—0,488=22,54′=22′ 32″ Subtractive.

Then 68° 42′—0° 22′ 32″=68° 19′ 28″. Which is the true distance of the centers of the Sun and Moon at the time of observation, as would be seen at the Earth's center.

EXAM.

Exam. II. *Suppose in the year 1762, in latitude 32° 12′ N. and longitude 38° 30′ W. of Greenwich by account on May 9th, at 12h. 34m. 19s. the apparent distance of the star Spica Virginis from the Moon's center was observed to be 51° 28′ 35″, and at the same time, the apparent altitude of Regulus was 24° 48′, and that of the Moon's center was 12° 30′: Required the true distance of the star from the Moon's center.*

The Work.

51° 29′		0,10656			51° 29′		0,10656
65 12		0,04202			77 30		0,01042
13 43					26 1		
3					65 12		
91 13	45° 36½′	9,85404			91 13	45° 36½′	9,85404
63 47	31 53½	9,72289			39 11	19 35½	9,52545
		19,72551					19,49647
46° 48½′	s,	9,86275				34° 3½′	9,74823
s,93 37	8,79990	s	12° 30′	9,98958	s,68 7		9,57138
123″	2,08990		56′,25	1,75012	50′,72		1,70518
7″,76	0,88980		54,92	1,73970	18′ 54″		1,27656
			20		0 7¾		
			50,72		19 01¾		
				App. dist.	51 28 35		
				True dist.	51 9 33		

The precepts by which these examples are worked are derived from principles shewn in the Appendix; but the operations may be somewhat shortened, thus:

In a triangle with the three sides, *viz.* the two apparent zenith distances, and the apparent distance of the centers, find the difference of azimuth.

With this difference of azimuth, and the corrected zenith distances, find the true distance of the centers.

This work may be done very compendiously by the following precepts, from Book IV. Art. 253, 255.

108. *A compendium for finding the true distance between the Moon and Sun, or Star, from their observed altitudes and distance.*

Precepts.

1st. To the Arith. Comp. of the log. sine of half the apparent distance, add the log. sine of half the diff. of the apparent altitudes; the sum is the log. sine of a first arc.

2d. To the log. sine of half the apparent distance, add the log. co-sine of the first arc, reject radius, and the sum is the log. sine of a second arc.

3d. Add together twice the log. sine of the second arc, and the Arith. Complements of the log. co-sines of the two apparent altitudes, their sum is the log. of a third arc.

4th.

4th. To the log. of the third arc, add the log. co-fines of the correct altitudes, the fum is the log. of a fourth arc.

5th. From half the log. of the 4th arc, take the log. fine of half the diff. of the corrected altitudes, there remains the log. tangent of a 5th arc.

6th. From half the log. of the 4th arc, take the log. fine of the 5th arc, and there remains the log. fine of half the true diftance.

Thefe precepts being expreffed in the following fhort way, may affift the memory, and render the operation more eafy.

1ft. L`,s, ½ ap. dift. + L,s, ½ diff. ap. alts.	= L,s,	1ft. arc.
2d. L,s, ½ ap. dift. + L,s`, 1ft. arc	= L,s,	2d. arc.
3d. 2L,s, 2d. arc + L`,s`, one ap. alt. + L`,s`, oth. ap. alt.	= L,	3d. arc.
4th. L, 3d. arc + L,s`, one cor. alt + L,s`, oth. cor. alt.	= L,	4th. arc.
5th. ½L, 4th arc — L,s, ½ diff. cor. alts.	= L,t,	5th. arc.
6th. ½L, 4th arc — L,s, 5th arc	= L,s,	½ cor. dift.

Applying thefe precepts to the preceding examples, the work will ftand in the following order.

Exam. I. (See page 298) *Here are given the apparent altitudes of the centers, viz. of the Sun 32°; of the Moon 24°; and their apparent diftance 68° 42′; and the Moon's horizontal parallax 58′ 39″: Required the true diftance.*

Dift. = 68° 42′; its ½ = 34° 21′	Alt. ☉	= 32° 0′ 0″	Alt. ☽	= 24 0′ 0″
Ap. alt. ☉ = 32°	Refr. —	= 1 31	Refr. —	= 2 7*
Ap. alt. ☽ = 24	Cor. alt. ☉	= 31 58 29	Alt. cor.	= 23 57 53
Diff. = 8; ½ diff. = 4°.	Cor. alt. ☽	= 24 51 32	Paral. +	= 53 39†
	Diff. cor. alts.	= 7 6 57	Cor. alt. ☽	= 24 51 32
	½ Diff. cor. alts.	= 3 33 28		

L,s` ½ dift.	= 34 21	0,24853	9,75147	L,s, ½ dift.
L,s, ½ diff. ap. alts.	= 4 0	8,84358		
L,s, 1ft. arc.		9,09211	9,99666	L,s`, 1ft. arc.
			9,74813	L,s, 2d. arc.
			9,74813	L,s, 2d. arc.
			0,07158	L`,s`, ☉ alt. 32°
			0,03927	L`,s`, ☽ alt. 24°
			19,60711	L, 3d. arc.
			9,92854	L,s`, ☉ cor. alt. 31° 58½′.
			9,99778	L,s`, ☽ cor. alt. 24° 51½′.
			39,49343	L, 4th. arc.
½ L,s, 4th. arc.		19,74671	19,74671	½L, 4th. arc.
			8,70277	L,s, ½ diff. cor. alts. 3° 33′ 28″
L,s, 5th. arc.		9,99733	10,95394	L,t, 5th. arc.
L,s, ½ cor. dift.	= 34° 9′ 44″	9,74938		
True dift.	= 68 19 28			

* The refractions are taken from table, art. 55.

† The parallax is taken from table, art. 56.

But the parallax in alt. may readily be found by the Gunter's fcale, thus:
The extent, on the fines, from rad. to the co-fine of the alt.
Will reach on the numbers from the hor. par. to the paral. in alt.

Exam.

EXAM. II. *Given the observed distance of the Moon from the Sun 85°; the Sun's alt. 5° 0′; the Moon's alt. 30° 0′; and her horizontal parallax 60° 0′: Required the true distance.*

Now rad. : s′, 30° : : 60′ : 51′ 58″=par. in alt. by Gunter's Scale.

Dist. = 85° 0′; its ½=42° 30′.		☉ 5° 0′ 0″ ☽ 30° 0′ 0″
☽'s alt. = 30° 00′		− 9 54 − 1 38
☉'s alt. = 5 00		4 50 06 29 58 22
		30 50 20 + 51 58
Diff. = 25 00		26 0 14 30 50 20
½ diff. = 12 30½ ap. alts.		13 00 7½ diff. true alts.
L′,s, 42 30	0,17032	9,82968 L,s, 42 30
L′,s, 12 30	0,33534	
L′,s, 1st. arc	9,50566	9,97648 L,s′, 1st. arc
		9,80616 L,s, 2d. arc.
		9,80616 L,s, 2d. arc
		0,06247 L′s′, 30° 0′
		0,00166 L′s′, 5 0
		19,67645 L, 3d. arc
		9,99845 L,s′, 4° 50′
		9,93380 L,s′, 30 50
		39,60870 L, 4th. arc
½L, 4th. arc	19,80435	19,80435 ½L, 4th. arc
		9,35215 L,s, 13° 0′
L,s, 5th. arc	9,97450	10,45220 L,s, 5th. arc.
½Dist. 42° 31′ 15′	9,82985	
85 2 30 the true dist.		

EXAM. III. *Suppose the apparent dist. of the Moon and a Star was 51° 28′ 35″; the Star's altitude 24° 48′; the Moon's altitude 12° 30′, and her horizontal parallax 56′ 15″: Required the true distance.*

Dist. 51° 28′ 35″; its ½=25° 44′ 17½″		✳ 24° 48′ 0″ ☽ 12° 30′ 0″
Ap. alt. ✳ 24° 48′		− 2 3 − 4 12
☽ 12 30		24 45 57 12 25 48
Diff. = 12 18		13 20 48 + 55 0
½ diff. = 6 09 ap. alts.		11 25 9 13 20 48
		5 42 34½=½ diff. true alts.
L′,s, 25° 44′ 17″	0,36226	9,63774 L,s, 25° 44′ 17½″
L,s, 6 9	9,02992	
L,s, 1st. arc.	9,39218	9,98636 L,s′, 1st. arc
		9,62410 L,s, 2d. arc
		9,62410 L,s, 2d. arc
		0,04202 L′,s, 24° 48′
		0,01042 L′s′, 12 30
		19,30064 L,s, 3d. arc
		9,95810 L,s′, 24° 46′
		9,98810 L,s′, 13 21
		39,24684 L, 4th. arc
½L,s, 4th. arc.	19,62342	19,62342 ½L, 4th. arc
		8,99775 L,s, 5° 42′ 34″
L,s, 5th. arc	9,98816	10,62567 L,s, 5th. arc
½ Dist. 25° 34′ 50″	9,63526	
Dist. 51 9 40		

EXAM.

Exam. IV. *Let the apparent distance of the Moon and a Star be 102° 30′; the Star's alt. 15° 25′; the Moon's alt. 27° 30′; and her hor. par. 57′ 3″: Required the true distance.*

Dist. 102° 30′; its ½=51° 15′.		✱ 15° 25′ 0″	☽ 27° 30′ 0″
Ap. alt. ✱ 15° 25′		− 3 25	− 1 49
☽ 27 30		15 21 35	27 28 11
Diff. 12 5		28 18 47	+ 50 36
½ diff. 6 2½ ap. alts.		12 57 12	28 18 47
		6 28 36=½ diff.	true alts.
L, s, 51° 15′	0,10797	9,89203	L, s, 51° 15′
L, s, 6 2½	9,02223		
L, s, 1st. arc	9,13020	9,99601	L, s′, 1st. arc
		9,88804	L, s, 2d. arc
		9,88804	L, s, 2d. arc
		0,01591	L′s′, 15° 25′
		0,05207	L′s′, 27 30
		19,84406	L, 3d. arc
		9,94466	L, s′, 28° 18¼′
		9,98420	L, s′, 15 21½
		29,77292	L, 4th. arc
½ L, 4th. arc	19,88646	19,88646	½ L, 4th. arc
		9,05223	L, s, 6° 28½′
L, s, 5th. arc	9,99539	10,83423	L, s, 5th. arc.
½ Dist. 51° 5′ 36″	9,89107		
Dist. 102 11 12			

109. But of all the methods which have yet been thought of for reducing the apparent distance of the Moon from the Sun or a star to the true, the following one, derived from that invented by Mr. *Witchell*, late head master of the Royal Academy at Portsmouth, and printed in the Nautical Almanac for 1772, is perhaps best adapted to the disposition and capacities of seamen in general; as it is very short, requires the logarithms only to four places of figures besides the index, which may always be taken out at sight without making any proportions, and yet the result will be sufficiently exact.

Precepts.

1st. From the Sun's refraction (55) take his parallax in altitude (V. 319.) and the remainder will be the correction of the Sun's altitude. The correction of a star's altitude is its refraction.

2d. Take the proportional logarithm of the Moon's horizontal parallax out of the Nautical Almanac, increase its index by 10, and subtract the log. co-sine of the ☽'s apparent altitude from the sum: the remainder will be the proportional log. of her parallax in altitude; from which take the Moon's refraction (55), and there will remain the correction of her altitude.

3d. Add the Sun's apparent altitude to the Moon's, and take half the sum: subtract the less from the greater, and take half the difference. Add together the co-tangent of the half sum, the tangent of the half difference, and the co-tangent of half the observed distance: the sum, rejecting 20 from the index, is the log. tangent of an arc A.

4th. When the Sun's altitude is greater than the Moon's, take the difference between A and half the apparent distance; but if the Moon's altitude be greatest, take their sum; and to the co-tangent of this sum or difference, add the co-tangent of the Sun's apparent altitude, and the proportional

proportional log. of the correction of the ſun's altitude; their ſum, when 20 is rejected from the index, is the proportional log. of the firſt correction of the apparent diſtance.

5th. If the diff. of arch A, and half the apparent diſtance was taken in the preceding article, take now their ſum; but if their ſum was then taken, take now their difference, and to the log. co-tangent of this ſum or difference, add the log. co-tangent of the moon's apparent altitude, and the proportional log. of the correction of the moon's altitude: the ſum, rejecting 20 from the index, is the proportional log. of the ſecond correction.

6th. If the arch A be leſs than half the apparent diſtance, the firſt correction muſt always be added to, and the ſecond ſubtracted from, the apparent diſtance. But when the arch A is greater than half the apparent diſtance, both the firſt and ſecond corrections muſt be added, if the ſun's altitude be leſs than the moon's; but if the moon's be leaſt, both muſt be ſubtracted, to give the corrected diſtance of the ſun and moon.

7th. Add together the proportional log. of the ſum and difference of the correction of the moon's altitude, and the ſecond correction of the obſerved diſtance, the log. tangent of the corrected diſtance, and the conſtant log. 1,5820: the ſum, rejecting 10 from the index, is the proportional logarithm of the third correction; to be added to the corrected diſtance when it is leſs than 90°, but ſubtracted when it is above, and this gives the true diſtance required.

Exam. I. (See page 300 and 302.) *Given the apparent altitude of the Sun's center 32°, that of the Moon's center 24°, and the apparent diſtance of their centers 68° 42′, when the Moon's horizontal parallax was 58′ 39″: Required the true diſtance.*

The refr. on the ſun's alt.		1′	31″
The ſun's paral. in alt.		0	8
Correct. of the ſun's alt.		1	23
Sun's app. alt.	32°	00′	
Moon's app. alt.	24	00	
Sum	56	00	
Difference	8	00	
App. diſtance	68	42	08
Firſt correction +			22½
Second correction	—	23	6
Corrected diſt.	68	19	16½
Third correction	+		7½
True diſtance	68	19	24

The ☽'s hor. paral.	58′	39″	P. L.	10,4870
Moon's app. alt.	24°	00′	coſ.	9,9607
Moon's par. in alt.	53′	35″	P. L.	0,5263
Refraction	2	7		
Correct. ☽'s alt.	51	28		
half is	28°	00′	co-tang.	10,2743
half is	4	00	tang.	8,8446
half is	34	21	co-tang.	10,1653
Arc A	10	53	tang.	9,2842
Diff.	23	28	co-tang.	10,3024
Sun's alt.	32	00	co-tang.	10,2042
Corr. ☉'s alt.	1′	23″	P. L.	2,1143
Firſt correct.	0	22½	P. L.	2,6809
Sum	45°	14′	co-tang.	9,9965
Moon's alt.	24	00	co-tang.	10,3514
Corr. ☽'s alt.	51′	28″	P. L.	0,5437
Second corr.	23	6	P. L.	0,8916
Sum	1° 14′	34″	P. L.	0,3827
Difference	28	22	P. L.	0,8024
Corrected diſt.	68°	19′	tang.	10,4005
Conſtant logarithm				1,5820
Third corr.	0′	7″½	P. L.	3,1079

EXAM. II. (See 301 and 303.) *Let the apparent distance of the Moon and a Star be 51° 28′ 35″, the Star's altitude 24° 48′, the Moon's altitude 12° 30′, and her horizontal parallax 56′ 15″: What is their true distance?*

The refract. on the *'s alt. is 2′ 3″

☽'s hor. paral.	56′ 15″	P. L.	10,5051
☽'s app. alt.	12° 30′	s,	9,9896
☽'s par. in alt.	54′ 55″	P. L.	0,5155
☽'s refraction	4 12		
Corr. ☽'s alt.	50 43		

App. alt. ☽	12°	30′	
App. alt. *	24	48	
Sum	37	18	
Difference	12	18	
Observed dist.	51	28	35″
First correction	—		8
2d correction	—	18	54
Corrected dist.	51	9	33
3d correction	+		15
True distance	51	9	48

Note. The true distance, computed with the utmost exactness by spherical trigonometry, is 51° 9′ 54″.

half is	18°	39′	t	10,4717
half is	6	9	t	9,0324
half is	25	44	t	10,3170
Arch A	33	31	t	9,8211
Difference	7	47	t	10,8643
Star's alt.	24	48	t	10,3353
*'s refract.	2′	3″	P. L.	1,9435
1st correction	0	8	P. L.	3,1431
Sum	59°	15′	t	9,7745
☽'s alt.	12	30	t	10,6542
Corr. ☽'s alt.	50′	43″	P. L.	0,5501
2d correction	18	54	P. L.	0,9788
Sum	69	37	P. L.	0,4126
Difference	31	49	P. L.	0,7526
Corrected dist.	51°	10′	t	10,0941
Constant logarithm				1,5820
3d correction	0′	15″	P. L.	2,8413

EXAM. III. *Let the apparent distance of the Moon and Sun be 102° 30′, the Sun's alt. 15° 25′, the Moon's 27° 30′, and her horizontal parallax 57′ 03″: Required the true distance.*

Refraction on the sun's alt.	3′ 25″		
Parallax in alt. (V. 319)	8		
Correction of the sun's alt.	3 17		

☽'s hor. parall.	57′ 03″	P. L.	10,4990
☽'s app. alt.	27° 30′	s,	9,9479
☽'s parall. in alt.	50′ 36″	P. L.	0,5511
☽'s refraction	1 49		
Correct. ☽'s alt.	48 47		

App. alt. ☽	27°	30′	
App. alt. ☉	15	25	
Sum	42	55	
Difference	12	5	
Observed dist.	102	30	
First correction	+	1	49
2d correction	—	20	37
Corrected dist.	102	11	12
3d correction	—		4
True distance	102	11	8

The half is	21°	27′	t	10,4057
The half is	6	2	t	9,0240
The half is	51	15	t	9,9045
The arch A	12	11	t	9,3342
The sum	63	26	t	9,6990
The sun's alt.	15	25	t	10,5595
Correct. ☉'s alt.	3′	17″	P. L.	1,7389
1st correction	1	49	P. L.	1,9974
The difference	39°	4′	t	10,0906
The ☽'s alt.	27	30	t	10,2835
Correct. ☽'s alt.	48′	47″	P. L.	0,5670
2d correction	20	37	P. L.	0,9411
Sum	69	24	P. L.	0,4139
Difference	28	10	P. L.	0,8050
Corrected dist.	102°	11′	t	10,6657
Constant logarithm				1,5820
3d correction	0′	4″	P. L.	3,4671

SECONDLY.

Digitized by Google

SECONDLY.

110. *To find the time at which two proposed celestial objects may be seen at a given distance; if observed from the center of the Earth under the meridian for which an Ephemeris is calculated.*

In the Nautical Almanac there are, ready computed, the distances of the enlightened limb of the moon from the sun, or from certain fixed stars every day, at the hours 3, 6, 9, 12, 15, 18, 21, and at noon.

Therefore seek in that Almanac amongst the computed distances of the proposed objects on the day given for the given distance, which if found there, the time is there also.

But if the given distance falls between two computed ones, A, B, (as it generally will) the corresponding time is to be found by proportional parts:

Saying, *As the difference of the computed distances* A, B,
Is to the difference between A *and the given distance;*
So are three hours of time,
To the proportional time to be added to that of the distance A.

EXAM. *At what time on the 21st of July, 1773, will the distance between the Virgin's spike and the Moon's enlightened limb, be equal to* 54° 56¼′, *as seen from the center of the Earth under the meridian of Greenwich?*

On the 21st of July the given distance falls between the computed distances at 9h. and at midnight, viz. between A=55° 31′ 30″, and B=53° 51′ 53″; so that the time is between 9h. and 12h. P. M.

The difference between A and B is 1° 39′ 37″=5977″, and the difference between A and 54° 56¼′ is 0° 35′ 15″=2115″.

Then 5977″ : 2115″ : : 3h. : 1h. 3m. 59s.

And 9h.+1h. 3m. 59s.=10h. 3m. 59s. the time required.

111. *To find the longitude from observations made on the altitudes of the Moon and Sun, or Star, and of their distance.*

PRECEPTS.

1st. Let the watch be adjusted to true time, or its error found, a few hours before or after the time of observation. (58)

2d. Let three persons, each having a good Hadley's quadrant, make observations; one taking the apparent angular distance of the moon from the sun or star; another taking the altitude of the moon; and the third, taking the altitude of the sun or star. These observations are to be made at one and the same time, which another person is to note by the watch. (44. 102)

3d. Let the observed altitudes be corrected for the centers of the objects, and then the distance be corrected by parallax, &c. to have the true distance of the centers. (108. 109)

4th. Find the time at Greenwich, when this true distance happened. (110)

5th. The difference between the Greenwich time and the ship's time, is the difference of longitude.

Digitized by Google

Remarks.

The best times of the day for taking the distance between the moon and sun, is from about half an hour after sun-rise to about ten o'clock in the forenoon; and in the afternoon nearly from two o'clock to half an hour of sun-set; because the apparent time may then be derived from the altitudes of the sun taken with the distance, in which case the watch is not necessary. If a watch be used, the altitudes for regulating it may be taken during any part of these intervals, and the distance, &c. at any time whatsoever, from half an hour after sun rising, to half an hour before it sets.

These observations may be taken during the four days preceding the moon's first quarter, and the four days following the last quarter; which make eight days in each lunation, or about a fourth part of the time between new moon and new moon, with a quadrant; but with a sextant for the four days preceding, and the four days following the quadratures also; that is, 15 or 16 days in each lunation.

The best time for making observations between the moon and star, is during the evening or morning twilight; or when the sea horizon can be seen distinct enough to take an altitude sufficiently accurate; and when the moon has between 5° and 15° of altitude, or not exceeding 20°; although any altitude may be used with a distinct horizon.

Choose a known star to the eastward or westward of the moon, lying nearly in the line of the moon's path; that is, in a right line conceived to pass through the moon's center perpendicular to the right line joining her cusps, or horns: but between the full moon and her quadratures the direction of her shortest diameter points out her path.

The distance of the star from the meridian should be two hours at least, but a greater distance is better, if the apparent time be deduced from it; but if a watch be used, and the apparent time be deduced from other altitudes, this is not material; and the star's altitude should not be less than 5 degrees.

If two, three, or more sets of observations be made, as near to each other as possible, and the means of the times by the watch, of the distances, and of the respective altitudes, be taken, these means may be esteemed a set of observations more to be depended on than any single set: or the longitudes may be computed to each set, and the mean of the results be taken for the true longitude.

Exam-

Digitized by Google

Exam. I. *Being by account in latitude 40° N. and longitude 28° W. of Greenwich, on the 24th of July, 1772; the watch being well regulated to apparent time, and the Hadley quadrants well adjusted, the distance between the nearest limbs of the Sun and Moon, and the altitudes of their lower limbs were observed as follows, the height of the eye being allowed for: Required the ship's true longitude.*

	Time	Sun's alt.	Moon's alt.	Dist.
	21h. 24m.	48° 41′.	8° 10′	60° 43½′
	21 26	48 59	8 40	60 44½
Means	21 25	48 50	8 25	60 44

Now Sh. time 21h. 25m. P.M. + 1h. 52m. W. = 23h. 17m. P.M. at Greenw. (57)

At this time by almanac, the sun's ½ diam. = 15′ 48″ } Sum 31′ 02″
Moon's ½ diam. = 15 14 }
Her hor. parallax = 55 54

Then 60° 44′ + 31′ 02″ = 61° 15′ 02″ the apparent distance.
And 48 50 + 15 48 = 49 5 48 the alt. of sun's center.
And 8 25 + 15 14 = 8 40 14 the alt. of moon's center.
Also rad. : s 8° ⅔ : : 55′ 54″ : 55′ 10″ the par. in alt. by the Gunter.

Now dist. 61° 15′ 2″; its ½ = 30° 37′ 31″
☉ ap. alt. 49 5 48
☽ ap. alt. 8 40 14
Diff. 40 12 34
½ Diff. 20 12 47 of app. alts.

L,s, 30° 37′ 31″ 0,29292
L,s, 20 12 47 9,53846
L,s, 1st. arc 9,83138

½ L,s, 4th arc 19,57282

L,s, 5th arc 9,86993
½ Dist. 30 18 9,70289
60 36 the true distance.

☉ alt. 49° 5′ 48″ ☽ alt. 8° 40′ 14″
Ref. — 49 — 6 1
☉ 49 4 49 8 34 13
☽ 9 29 23 Par. + 55 10
Diff. 39 35 36 9 29 23
19 47 48 = ½ diff. true alts.

9,70708 L,s, 30° 37′ 31″

9,86619 L,s, 1st. arc
9,57327 L,s, 2d. arc
9,57327 L,s, 2d. arc
0,18389 L,s, 49° 5′ 48″
0,00499 L,s, 8 40 14
19,33542 L, 3d. arc
9,81621 L,s, 49° 4′ 59″
9,99401 L,s, 9 29 23
39,14564 L, 4th. arc
19,57282 ½ L 4th. arc.
9,52979 L,s, 19° 47′ 48″
10,04303 L,s, 5th.

Again, by the Nautical Almanac 1772.
The dist. at 21 h. is 61° 37′ 35″ = A. And 61° 37′ 35″ = A. (109)
24th. is 60 11 37 = B. 60° 36 0 at ship.
1 25 58 = 85′ 58″ 1 1 35 = 61′ 35″
Now (I. 40) 85′ 58″ = 85,966; and 61′ 35″ = 61,5833.
Then (I. 46) As 85,96 : 61,583 : : 3h. : 2h. 8m. 56s. time above A.

	21 time A.
Greenwich time	23 08 56
Ship's time	21 25 0
True diff. longitude	1 43 56
By account diff. long.	1 52
Error	8 4 = 2° 1′.

EXAM. II. *Suppose in 1773, Nov. 6th, at 14h. 15m. 14s. apparent time; being by account in lat. 48° 19′S. long 116° 15′ E. the observed distance between Aldebaran and the Moon's farthest limb should be 58° 30′¼; the Star's alt. 25° 10′; the alt. of the Moon's lower limb 8° 2′ 50″: Required the ship's true longitude.*

Now Sh. time 14h. 15m. 14s. P.M.—7h. 45m. E=6h. 30m. 14s. at Greenw. (57)
At this time ☽'s semi-diam.=15′ 10″; and hor. parallax 55′ 40″ by Alman.
And 58° 30′ 15″—15′ 10″ = 58° 15′ 5″ the apparent distance.
And 8 2 50 + 15 10 = 8 18 the ap. alt. of ☽'s center.

Then dist. 58° 15′ 5″; its ½=29° 7′ 32″		✱ 25° 10′ 0	☽ 8° 18′ 00″
✱'s alt. = 25 10		— 2 1	— 6 17
☽'s alt. = 8 18		25 7 59	8 11 43
Diff. = 16 52		9 6 43	+ 55 0
½ diff. = 8 26		16 1 16	9 6 43
		8 0 38=½ diff. true alts.	
L, s, 29° 7′ 32″	0,31271	9,68728 L, s, 29° 7′ 32″.	
L, s, 8 26 0	9,16631		
L, s, first arc	9,47903	9,97934 L, s, 1st. arc	
		9,66662 L, s, 2d. arc	
		9,66662 L, s, 2d. arc	
		0,04332 L, s, 25° 10′	
		0,00457 L, s, 8 18	
		19,38113 L, 3d. arc	
		9,95680 L, s, 25° 08′	
		9,99448 L, s, 9 07	
		39,33241 L, 4th. arc	
½ L, 4th. arc	19,66620	19,66620 ½ L, 4th arc	
		9,14412 L, s, 8° 0′ 38″	
L, s, 5th. arc	9,98123	10,52208 L, s, 5th. arc.	
½ Dist. 28° 57′ 22″	9,68497		
57 54 44 the true distance.			

Now here is given the ship's time 14h. 15m. 14s. and the Corrected distance between the Moon's center and Aldebaran 57° 54′ 44″, Required the ship's longitude.

By the Nautical Almanac: The dist. at 6h. is 57° 38′ 35″ A 57° 38′ 35″ A. (109)
The dist. at 9h. 59 11 43 B 57 54 44 Ship.

1 33 8(=93′ 8″) 16 9

Now (I. 40) 93′ 8″=93, 133′; and 16′ 9″=16,11.
Then (I. 46) As 93,133′ : 16,15′ :: 3h. : 0h. 31m. 13s. time above A.
6h. time A.

Greenwich time	6	31	13
Ship's time	14	15	14
True diff. longitude	7	44	1
Diff. long. by account	7	45	

Error 59″=14¾′ East.

EXAM.

EXAM. III. *Suppose on the 13th of April 1772, on board a Ship in lat. 50°N. and long. 50°W. of Greenwich by account, with a watch and instruments well adjusted, the following observations were taken of the Star Pollux and the Moon's nearest limb, then to the east of the Star, the height of the eye being allowed for: Required the Ship's true longitude.*

Time		Alt. ☽'s lower L.		Alt. ✱		dist.
9h. 0m. P. M;		16° 45′ 0″;		54° 50′;		45° 12′.
9 7		16 15 30		54 20		45 14
9 14		15 45 0		53 50		45 16
27 21	Sum	48 45 30	Sum	163 00	Sum	135 42
Mean 9 7 P. M.	mean alt. ☽	16 15 10	✱	54 20		45 14

Now Sh. tim. 9h. 7m. P. M. + 3h. 20m. W. = 12h. 27m. P. M. Gr. tim. (57)
At this time by Alman. the ☽'s semi-diam. = 16′ 26″
and horiz. parallax = 60 18.

Then 45° 14′ + 16′ 26″ = 45° 30′ 26″ the apparent distance.
And 16 15 10 + 16′ 26″ = 16° 31′ 36″ the alt. of the Moon's center.
Also rad. : s 16°½ : : 60′ 18″ : 57′ 15″ the paral. in alt. by the Gunter.

Now dist. 45° 30′ 26″; its ½ is 22° 45′ 13″			✱ 54° 20′ 0″		☽ 16° 31′ 36″.	
✱'s ap. alt.	54° 20′ 0″		Ref. — 41		— 3 11	
☽'s ap. alt.	16 31 36		✱ 54 19 19		16 28 25	
Diff.	37 48 24		☽ 17 25 40	Par. +	57 15	
½ Diff.	18 54 12 ap. alts.		Diff. 36 53 39		17 25 40	
			18 26 50 = ½ diff. true alts.			
L, s,	22 45 13	0,41254	9,58746	L, s, 22° 45′ 13″		
L, s,	18 54 12	9,51050				
L, s, 1st. arc		9,92394	9,73747	L, s, 1st. arc		
			9,32493	L, s, 2d arc		
			9,32493	L, s, 2d. arc		
			0,23:28	L, s, 54° 20′		
			0,01832	L, s, 16° 31′ 36″		
			18,90246	L, 3d. arc		
			9,76584	L, s, 54 19 19		
			9,97959	L, s, 17 25 40		
			38,64789	L, 4th. arc		
			19,32394 ½	L, 4th. arc		
½ L, 4th. arc		19,32394	9,50027	L, s, 18 26 50		
			9,82367	L, s, 5th. arc		
L, s, 5th. arc		9,74390				
½ Dist. 22° 20′ 52″		9,58004				
44 41 44 the true distance.						

Again, by the Nautical Almanac 1772, April 13th.
The dist. at 12h. is 44° 28′ 30″ = A and 44° 28′ 30″ = A. (109)
at 15h. is 46 13 32 = B 44 41 44 at Ship.
Diff. 1 45 2 = 105′ 2″ 0 13 14
Now (I. 40) 105′ 02″ = 105,033; and 13′ 14″ = 13,233′
Then (I. 46) As 105,033 : 13,233 : : 3h. : 0h. 22m. 40s. time above A.

	12	time A.
	12 22 40	Greenwich time.
	9 7 0	Ship's time.
True diff. longitude	3 15 40	
By acc. diff. long.	3 20 0	
Error	4 20 = 1° 5′	

Digitized by Google

112. METHOD XI. *To find the longitude at sea by an observation of the distance only.*

PRECEPTS.

1st. Find the Greenwich time: to which, find (57)
The right ascensions and declinations of the Sun and Star,
The right ascension and declination of the Moon,
And the horary angles between the meridians of the ship, Moon, and Sun or Star.

2d. With the Sun or Star's horary angle, the polar distrnce, and the ship's co-latitude, find the zenith distance. (IV. 253)
With the Moon's horary angle, her polar distance, and the ship's co-latitude, find her zenith distance. (IV. 253)

3d. These true altitudes are to be altered by adding the refractions, and subtracting parallax (in the Moon's), to have the apparent altitudes.

4th. With the apparent altitudes, the true altitudes, and the observed distance, find the true distance. (108)

5th. To this distance find the Greenwich time. (109)
Then the difference between this time and the ship time is the difference of longitude.

REMARKS.

The right ascension and declination of the stars are found for the year 1780, in Art. 312. Book V.: to which are to be applied the yearly variations, taken as many times as years since 1780.

The right ascensions and declinations for the Sun are found (in tables V. 309, 310, or) in the Nautical Almanac for the noon of each day; and for the intermediate times by proportional parts. (V. 283, 284, 288).

The right ascensions and declinations of the Moon are given in the Nautical Almanac for every noon and midnight; the parts for intermediate times may be found accurately enough by proportional parts.

The proportional parts for right ascensions and declinations are readily found, near enough, by the table, Art. 311. Book V.

The horary angles are found by the following precepts.

The ship time in degrees, added to the Sun's right ascension in degrees, gives the right ascension of the mid-heaven; rejecting 360 degrees, when the sum is above that number.

The horary angle at the Sun is equal to the ship time.

The horary angle at a Star is equal to the difference between the Star's right ascension, and that of the mid-heaven.

The horary angle at the Moon is equal to the difference between the Moon's right ascension and that of the mid-heaven.

Note. The declination of an object, applied to 90 degrees, gives the polar distance of that object.

EXAM.

Digitized by Google

EXAM. I. 1772, *November 15th, at 21h. P. M. suppose in a ship, in latitude 30° S. and longitude by account 7° E. of Greenwich, the distance of the nearest limbs of the Sun and Moon was observed to be 112° 26′ 10″: What was the true longitude of that ship.*

Ship's time, $21^h\ 0^m$ P. M.—$0^h\ 28^m$ E.=$20^h\ 32^m$ P. M. Greenwich time.
Nov. 15. ☉'s ½ diam.=16′ 14″; ☽'s ½ diam. 15′ 34″; hor. parallax 57′ 7″.

For the Sun's right ascension.

Nov. 15. ☉ r. a.=$15^h\ 25^m\ 22\frac{1}{2}^s$		diff. $4^m\ 8^s$
16.	$15\ 29\ 30\frac{1}{2}$	
$24^h : 20^h\ 32^m :: 4^m\ 8^s : 3^m\ 32^s$ +		
	$15^h\ 25^m\ 22^s$	
☉'s right ascension	15 28 54	
	Or 232° 13′ 30″	

For the Sun's declination.

18° 43′ 37″	diff. 14′ 54″	
18 58 31		
$24^h : 20^h\ 32'' :: 14'\ 54'' : 12'\ 43^s$ +		
		18 43 37
☉'s declination		18 56 20 S.

For the ☽'s right ascension.

Nov. 15. mid. ☽'s r. a. 118° 17′	diff. 6° 38′	
16. noon 124 55		
12 : 8 32 :: 6° 38′ : 4° 43′ +		
	118 17	
☽'s right asc.	123 0	

For the ☽'s declination.

15° 41′	diff. 1° 15′	
14 26		
12 : 8 32 :: 1° 15′ : 0° 53′		
		15 41
☽'s declination		14 48 N.

Ship's time	315° 0′	=21 hours.
☉'s right asc.	232 13 30	
	547 13 30	
	360	
Mid heav.	187 13 30	
☽'s right asc.	123 0	
☽'s horar. ang.	64 13 30	
☉'s horar. angle	45 0	

For the Sun's altitude.

Given ☉'s ∠=45°; its ½=22° 30′.

½∠☉	22° 30′	2, L, s,	9,58284 / 9,58284
Pol. dif.	71 3 40″	L, s,	9,97583
Co-lat.	60 0	L, s,	9,93753
Diff.	11 3 40		39,07904
		19,53952	19,53952
½ diff.	5 31 50	L, s,	8,98397
		9,98380	10,55555
	21° 4¼′	9,55572	
	42 8½=☉'s zen. distance.		
	47 51½=☉'s true altitude.		

For the Moon's altitude.

G. ☽'s ∠=64° 13′ 30″; its ½=32° 6′ 45″

½∠☽	32° 6¾′	2 L, s,	9,72557 / 9,72557
Pol. dif.	104 48	L, s,	9,98535
Co-lat.	60 0	L, s,	9,93753
Diff.	44 48		39,37402
		19,68701	19,68701
½ diff.	22 24	L, s,	9,58100
		9,89609	10,10601
	38° 10′ 00″	9,79092	
	76 20	☽'s zenith distance.	
	13 40	☽'s true altitude.	

To

To find the true distance of the centers of the Sun and Moon.

Now 112° 26′ 10″ + 16′ 14″ + 15′ 35″ = 112° 57′ 58″ = apparent distance.
Dist. 112 57 58; its ½ = 56° 28′ 59″.

⊙'s alt.	37 30 0	☽'s alt. 14° 31′ 0″	⊙ true alt.	37° 30′
Ref. +	1 15	+ 3 32	☽ true alt.	14 31
Ap.alt. ⊙	37 31 15	14 34 32		23 59
Ap.alt. ☽	13 39 32	Par. —55 0		
	23 51 43	13 39 32	½ diff. true alts.	11 59 30
	11 55 52 = ½ diff. app. alts.			

L's, 56 28 59	0,07898	9,92102	L s, 56° 28′ 59″.
L,s, 11 55 52	9,31541		
L,s, 1st arc	9,39439	9,98621	L,s, 1st. arc.
		9,90723	L,s, 2d. arc.
		9,90723	L,s, 2d. arc.
		0,10066	L',s', 37° 31′ 15″
		0,01246	L',s', 13 39 32
		19,92758	L, 3d. arc.
		9,89947	L,s', 37 30
		9,98592	L,s', 14 31
		39,81296	L, 4th arc.
½ L, 4th arc.	19,90648	19 90648	½ L, 4th arc.
		9,31758	L,s, 11 59 30
L,s, 5th arc.	9,98604	10,58890	L,t, 5th arc.
56 22	9,92044		

112 44 the true distance of the Sun's and Moon's centers.

To find the Longitude.

Nov. 15. at 18h dist.	113° 51′ 27″	113° 51′ 27″
21	112 21 8	112 44 0
	1 30 19 = 90′ 19″	1 7 27 = 67′ 27″.

Now (I. 40) 90′ 19″ = 90,316′; and 67′ 27″ = 67,45.
And (I. 46) 90,316 : 67,45 : : 3h : 2h 14 38

	18
Greenwich time for the true dist.	20 14 38
Ship's time for that distance	21
Difference of longitude in time	0 45 22
In degrees, &c,	11 20 30 E.
Diff. longitude by reckoning	7 0 0
Error in reckoning	4 20 30

EXAM.

EXAM. II. *November 9, 1769, a Ship in latitude 24° 15′ N. longitude 47° 14′ W. of Greenwich: observed the distance of the Star Aquila to be 58° 35′¼ from the Moon's nearest limb, at 6h. 31m. 4s. apparent time: Required the ship's true longitude.*

Now 6h 31m 4s P.M. + 3h 8m 56s W. = 9h 40m P.M. at Greenwich.

For the Sun's right ascension.

Nov. 9. ☉ R. A. 14h 59m 47s diff. = 4m 3s
10 15 3 50
Then 24 : 9 40 : : 43 : 1 38 +
14 59 47
15 1 25 = 225° 21′

For ✱ Aquila's right ascension.

1764. ✱ R. A. 19h 39m 16s
5 years variat. + 12
1769. ✱'s R. A. 19 39 28 = 294° 52′.

For ✱ Aquila's right declination.

1764. ✱'s declination 8° 15′ 41″
5 years variation + 42
1769. ✱'s declination 8 16 23 N.

For ☽'s right ascension.

Nov. 9. n. ☽'s R. A. 348° 16′ diff. = 6° 15′.
9. midn. 354 31
Now 12h : 9h 40 : : 6° 15′ : 5° 2′ +
348 16
☽'s R. A. 353 18

For ☽'s declination.

Nov. 9. n. ☽'s decl. 0° 38′ N. diff. 2° 36′
9. midn. 3 14
12h : 9h 40 : : 2° 36′ : 2° 6′ +
0 38
☽'s declination 2 44 N.

Ship's-time 97° 46′ = 6h 31m 4s.
Sun's right ascension 225 21

R. A. mid. heaven	323	7	323°	7′	
Star's R. A.	294	52	353	18	☽'s R. A.
✱ west of sh. meridian	28	15	30	11	☽'s east of meridian.

To find the Star's altitude.

Given h. ∠ 28° 15′			
Half = 14° 7′½	2 L. s		9,38746 9,38746
✱'s P. D. 81° 43′ 37″	L. s		9,99546
Co-lat. 65 45	L. s		9,95288
Diff. 15 58 37			38,73026
		19,36513	19,36513
½ Diff. 7 59¼	L. s		9,14292
		9,93333	10,22221
15 41		9,43180	

Zen. dist. 31 22, and 58 38 = ✱'s t. alt.

To find the Moon's altitude.

Given h. ∠ 30° 11′			
½ pol. ∠ = 15° 5′½	2 L. s		9,41558 9,41558
☽'s P. D. 87° 22′	L. s		9,99951
Co-lat. 65 45	L. s		9,95988
Diff. 21 31			38,79055
		19,39527	19,39527
½ Diff. 10 45½	L. s		9,27106
		9,90282	10,12421
18 6½		9,49245	

36 13, and 53 47 = ☽'s tr. alt.

To

Digitized by Google

To find the true distance between Aquila and ☽'s center.

Nov. 9, 1769. ☽ ½ diam.=15′ 52″. Dist. of centers 58° 51′ 37″.
Hor. paral. 58′ 12″. Then rad. : s, 53°⅔ : : 58′ 12″ : 34′ 30″, by Gunter.

Dist. 58° 51′ 37″; its ½ 29° 25′ 48″		✱'s alt.	58° 38′ 0″	☽'s	53° 38′ 0″
☉'s alt.	58 38	Refr.	+ 0 35	+	0 42
☽'s alt.	53 38	✱	58 38 35		53 38 42
		☽	53 4 12	—	34 30
Diff.	5 0		5 34 23		53 4 12
½ diff.	2 30 of the true alts.	½ diff.	2 47 12 app. alts.		

L, s, 29° 25′ 48″	0,30860	9,69140	L, s, 29° 25′ 48″.
L, s, 2 47 12	8,68679		
L, s, 1st arc.	8,99539	9,99786	
		9,68926	L, t, 2d. arc.
		9,68926	L, s, 2d. arc.
		0,28370	L, s, 58 38 35
		0,22125	L, s, 53 4 12
		19,88347	L, 3d. arc.
		9,71643	L, s, 58 38
		9,77302	L, s, 53 38
		39,37292	L, 4th arc.
½ L, 4th arc	19,68646	19,68646	½ L, 4th arc
		8,63938	L, s, 2 30
L, s, 5th arc.	9,99825	11,04708	L, t, 5th arc.
29 11 40	9,68821		

58 23 20 the true dist. of ✱ from ☽'s center.

To find the Longitude.

Nov. 9. at 9h P. M. ✱ à ☽	58 1 37		58 1 37
12h	59 29 51		58 23 20
	1 28 14 = 88′ 14″		21 43

Now, (I. 40) 1 28 14=88,23′; and 21′ 43″=21,716.
And, (I. 46) 88,23 : 21,716 : : 3h : 0h 43m 32s

	9
Apparent time at Greenwich	9 43 32
Ship	6 31 4
Difference of times	3 12 28=48° 7′ diff. longitude.
Longitude by account	3 8 56
Error	3 32=0° 53′

SEC-

SECTION XI.

Of a Ship's reckoning.

113. A Ship's Reckoning is that account, by which it can be known at any time where the ſhip is, and on what courſe or courſes ſhe muſt ſteer to gain her port.

114. Dead Reckoning is that account deduced from the occurrences, which are written on the log-board.

The Log Board is a large ſquare board, or pannel of wainſcot, painted black, on which is written in chalk whatever is thought worthy of notice from day to day; and for a proper diſpoſition of ſuch notes, the board is uſually divided into five columns. The column on the left hand contains the 24 hours from the noon of one day to the noon of the next; in the ſecond and third columns are the knots and fathoms the ſhip is found to run per hour, ſet againſt the hours when the log was hove; the fourth column contains the courſes the ſhip ſteers; and in the fifth, or right-hand column, is written the winds, the alteration of the ſails, the buſineſs doing aboard, and what other remarks the officer of the watch thinks proper to inſert. For it ſhould be obſerved, that it is uſual to divide a ſhip's company into two parts, called the ſtarboard and larboard watches, who do the duty of the ſhip for four hours and four hours alternately.

The Log Book is a book ruled like the log-board, in order to contain the daily copies of the remarks written on the log-board, which is the only authentic record of the ſhip's tranſactions; and theſe are, by the perſons who keep *Journals*, tranſcribed every day at noon into their log-books, from which they make the neceſſary deductions relative to the ſhip's place.

115. A Sea Journal is a book, in which is truly entered the moſt remarkable daily occurrences relating to the ſhip during her voyage outward and homeward.

There are various ways of keeping ſea journals, according to the different notions of mariners concerning the articles proper to be entered.

Some writers direct to keep ſuch a kind of journal, as contains only an abſtract of each day's tranſactions, ſpecifying the weather, what ſhips or lands were ſeen, accidents on board, the latitude, longitude, meridional diſtance, courſe, and run. Theſe particulars are to be drawn from the ſhip's log-book, or that kept by the perſon himſelf; for moſt good mariners keep private log-books.

Other authors recommend the keeping but one account, including the log-book and all the work of each day, with the deductions drawn from it. This method is adopted in this treatiſe, becauſe it repreſents to the beginner the whole of each day's work: but when he is well verſed in this method, he may abridge what part of it he pleaſes. But it is conceived, that a journal neatly kept, with all the particulars of the work commodiouſly ranged, will give more ſatisfaction to thoſe who may afterwards have occaſion to inſpect it, than a journal containing the heads only, with all the intermediate parts ſuppreſſed.

The method here made choice of, to introduce the young mariner into this capital part of navigation, is, by ſhewing him firſt how to work a few ſeparate

separate days works independent one of another; and then to proceed to a continued journal of several successive days works; for the doing of which it was judged necessary to premise the following observations.

116. I. Mariners reckon time in the astronomical manner, beginning at noon, and counting from thence 24 hours to the next noon. The first 12 hours, from noon to midnight, they mark with P. M. signifying after mid-day; and the second 12 hours, from mid-night to noon, they mark with A M. signifying after mid-night; and end their day's work on the noon of the nominal day. Hence their ship account is 12 hours earlier than the civil account of time; and consequently the Sun's declination, and other daily astronomical matters *fitted for noon*, must be sought for on the day according to their account of time: but if they are wanted for any other time of the day, they must be taken out for the day which precedes the given nautical day, which they are wanted for.

Thus that day's account which is marked Sunday the 9th of October, began on Saturday noon, and ends on Sunday noon.

II. If there is an observation for an amplitude or an azimuth, let that amplitude or azimuth be worked as is shewn between Article 22, and 28; and then find the variation as is shewn at Article 29; taking care, in these operations, that the declination for the proper day, time, and longitude, be used as shewn above, and in Book V. article 286.

III. Correct each course by the variation thus found, as at Article 30; also correct these corrected courses by the proper allowance for leeway, as is shewn at Articles 31, 32.

IV. Write these corrected courses in a Traverse Table, sum up the knots and fathoms, allowing eight fathoms to a knot, belonging to those hours in which the ship kept on the same course, and write the several sums as distances in the Traverse Table, against their respective courses.

V. Complete the Traverse Table as shewn in Book VII. 36, find the present latitude and longitude as shewn in Article 72, 73, 74, Book VIII. and the following examples, and then will the ship's place be obtained by dead reckoning.

VI. The present longitude each day may be found either by middle latitude or by Mercator's sailing; the one being preferable, when sailing nearly on a parallel of latitude, and the other when sailing near the meridian. In what follows, Mercator's sailing is used, when the course is less than five points, and middle latitude sailing when it is above.

VII. As the greatest trouble in using the Traverse Table, is to find a corresponding difference of latitude and departure, or meridional difference of latitude and difference of longitude, nearly equal to two given numbers, it has been judged proper to annex the two first figures of the natural tangent of the course, to the degrees at the top and bottom of the Traverse Table (VII. 67.); by which means the course may be found with greater facility from the diff. of lat. and departure, or from the merid. diff. of lat. and the diff. of long. Thus: Add cyphers to the depart. or to the diff. of long. and divide by the diff. of lat. or by the merid. diff. of lat.; look for the two first figures of the quotient amongst the numbers annexed to the degrees at the top or bottom of the Traverse Table, and the degree where it is found is the course or bearing sought. Let 672 merid. diff. of lat. and 353 diff. of long. be given to find the courses. 353, with cyphers annexed, being divided by 672 gives 53 in the quotient, which is found annexed to 28°, the course required.

Digitized by Google

117. EXAM. I. *August 25th, 1792, Yesterday noon we were in the latitude of 46° 28′ N. longitude 22° 18′ W. and have sailed till this day noon as by the log-board, the tide having all the time set S. b. E. 2½ miles an hour: Required the ship's place, and the direct course and distance made good.*

LOG-BOARD.

H.	K.	F.	Courses.	Winds
1	6	3	NNE.	West.
2	6	2		
3	6	0		
4	6	4		
5	6	0		
6	6	1	ENE.	NW.
7	6	6		
8	5	2		
9	5	6		
10	5	4		
11	5	5		
12	5	3	E. b. S.	North.
1	5	7		
2	6	2		
3	6	0		
4	6	3		
5	6	4		
6	7	0	SSE.	
7	6	5		
8	7	3		
9	7	5		
10	7	1		
11	7	7		
12	7	3		

TRAVERSE TABLE.

Courses.	Dis.	N.	S.	E.	W.
NNE.	31	28,6		11,9	
ENE.	35	13,4		32,3	
E. b. S.	36		7,0	35,3	
SSE.	51		47,1	19,5	
S. b. E.	60		58,8	11,7	
		42,0	112,9	110,7	Dep.
			42,0		
		D. lat.	70,9		

Depart. lat.	= 46° 28′ N.	M. P. = 3156
Diff. lat.	= 1 11 S.	
Pres. lat.	= 45 17 N.	M. P. = 3054
Sum lats.	= 91 45	M. D. lat. = 102
Middle lat.	= 45 52	
Co-middle lat.	= 44 08	
Dep. longitude	= 22 18 W.	
Difference long.	= 2 39 E.	Or 2° 40′.
Present long.	= 19 39 W.	
Direct course	= S. 57° 15′ E.	
Distance	= 131 miles.	

The courses and winds in the log-board being examined, it appears that the ship goes large, and has no leeway; therefore the several courses from the log-board are entered on the Traverse Table without alteration.

Next, the fathoms and knots belonging to each course are summed up, and the results are put in the column of distances in the Traverse Table; and to these courses and distances the whole difference of latitude and departure is found. (VII. 36)

Then the present lat. is found by VI. 51; the co-mid. lat. by VIII. 45; the present long. by VIII. 64; and the course and distance by VII. 33.

Or by Mercator's having found the present lat. find the meridional diff. lat. = 102 by VIII. 52; and the course and distance by VII. 33.

Then the diff. long. being found by VIII. 65, will be 2° 40′, differing by one mile from that found by middle latitude.

118. EXAM.

Digitized by Google

118. Exam. II. *June 27, 1771, Being yesterday noon in latitude 25° 30′ S. and longitude 10° 15′ E. we have sailed till this day noon, as per log-board, in a current setting S. 2½ miles an hour, the variation 1½ point west: Required the ship's place.*

Log-Board.

H.	K.	F.	Courses.	Winds.
1	6	0	S. W.	WNW.
2	6	2		
3	6	4		
4	6	0		
5	5	3		
6	6	0	S. b. W.	W. b. S.
7	5	1		
8	5	4		
9	5	2		
10	5	3		
11	5	0		
12	5	2	SSW.	West.
1	5	2		
2	5	0		
3	4	6		
4	5	0		
5	5	1		
6	5	2	SE.b.S.	SW.b.S.
7	5	4		
8	5	4		
9	6	0		
10	6	0		
11	5	4		
12	5	5		

Traverse Table.

Courses.	Dis.	N.	S.	E.	W.
S.b.W.½W.	30		28,7		8,7
S. b. E.½E.	32		30,6	9,3	
S½E.	30		29,9	2,9	
SE.b.E.½	39		18,4	34,4	
S.b.E.½E.	60		57,4	17,4	
		D. lat.	165,0	64,0	8,7
				8,7	
				55,3	Dep.

Diff. lat. = 2° 45′ S.
Dep. lat. = 25 30 S. Merid. pts. 1583

Present lat. = 28 15 S. Merid. pts. 1768

Sum of lats. = 53 45 M. diff. lat. 185

Mid. lat. = 26 52

Co-mid. lat. = 63 08

Dep. long. = 10 15 E.
Diff. long. = 1 02 E. Or, 1° 1′ E.

Present long. = 11 17 E.

Course is S. 18° 30′ E.
Distance is 174 miles.

The courses and winds in the log-board being examined, it appears that the ship is close hauled on each tack, and one point leeway being allowed (32) reduces the courses to SW. b. S., S. b. W., SE., SSE., and take a course for the current S.: these several courses being corrected by Art. 30, for the variation 1½ point west, give those in the Traverse Table; to which the whole difference of latitude and departure is to be found as before.

And hence the present latitude and longitude may be found either by middle latitude, or Mercator's sailing; for as the ship is so near the equator, the difference will be almost insensible.

If a greater accuracy is required, which is very rarely wanted, especially in such small latitudes, the diff. of long. may be found to each course, as shewn in Book VIII. 77, 78, and thence the whole diff. long may be collected; but there will be no material difference found by such operation.

119. Exam.

Digitized by Google

119. Exam. III. *Yesterday noon we were in lat. 33° 40′ N., long. 16° 20′ W., the sun was observed to set 50° 18′ from the north point of the compass; we have sailed till this day noon, as per log-board, in a current setting WSW. 1½ mile an hour: Required the ship's place, and her course and distance to the west end of the Island of Madeira, June 4th, 1772.*

Log-Board.

H.	K.	F.	Courses.	Winds.
1	6	2	S. b. W.	West.
2	6	0		
3	6	3		
4	7	0		
5	7	2		
6	7	3		
7	7	2	SW. b. S.	W. b. N.
8	7	2		
9	7	4		
10	7	6		
11	7	4		
12	8	1		
1	8	0		
2	8	5		
3	8	2		
4	7	5	SW. b. W.	NW.
5	7	3		
6	6	3		
7	6	2		
8	6	0		
9	6	2		
10	6	1		
11	6	0		
12	6	1		

Traverse Table.

Courses.	Dis.	N.	S.	E.	W.
S. 1° E.	40		40,0	0,7	
S. 10W.	70		68,9		12.2
S. 44W.	58		41,7		40,3
S. 55W.	36		20,6		29,5
		D. lat.	171,2	0,7	82,0
					0,7
				Dep.	81,3

Before the courses can be corrected to put in the Traverse Table, the variation of the compass must be found from the Sun's true amplitude; which may be done by article 22, or by working the proportion in article 23, either by logarithms or the Gunter.

June 4th, 1772, the declination is 22° 32′N.

As cos. 33° 40′ : rad. : : sin. 22° 32′ : sin. 27° 22′

So that the true amplitude = 62° 38′ W.

Mag. amplitude = 50 18

(29) Variation = 12 20

The courses in the log-board being corrected by this variation and the lee-way in the 2d. course, will give the courses fitted for the Traverse Table.

Depart. latitude	= 33° 40′ N.	
Diff. latitude	= 2 51 S.	
Present latitude	= 30 49 N.	
Sum of latitudes	= 64 29	
Middle latitude	= 32 14	
Co-middle latitude	= 57 46	
Depart. longitude	= 16 20 W.	
Diff. longitude	= 1 36 W.	
Present longitude	= 17 56 W.	

		M. P.
Madeira's lat.	= 32° 25′ N.	2058
Present latitude	= 30 49 N.	1945
Diff. latitude	= 1 36	113
Sum of latitudes	= 63 14	
Middle latitude	= 31 37	
Co-mid. latitude	= 38 23	
Madeira's long.	= 17 21 W.	
Present long.	= 17 56 W.	
Diff. longitude	= 0 35′ E.	

The course (57)=N. 17° 15′ E.
The distance = 101 miles.

In the work for the amplitude the lat. at Sun-set was taken the same as at noon; for although there were about 46m. of southing in that time, and so the lat. at Sun-set was about 32′ 54″, yet the amplitude being only about 15 less, the alteration in variation would scarcely affect the diff. lat. and dep. found from the courses so corrected.

120. EXAM. IV. *Being yesterday noon in lat.* 19° 30′ *S., long.* 0° 10′ *E; this forenoon we observed the Sun's altitude to be* 10° 40′, *when he was* 80° 30′ *from the north point of the compass, and his declination* 17° 27′ *N.; we have sailed till this day noon, as per log-board, in a current setting by the compass WNW.* ½ *mile an hour: Required the ship's place, with her direct course and distance to the Island of St. Helena.*

LOG-BOARD.

H.	K.	F.	Courses.	Winds.
1	6	7	N. b. E.	E. b N.
2	6	2		
3	6	4		
4	6	3		
5	6	1		
6	6	0		
7	5	4	North.	E.N.E
8	5	4		
9	5	0		
10	5	3		
11	5	6		
12	5	0		
1	5	7		
2	6	4	NNW.	NE.
3	6	4		
4	7	0		
5	7	3		
6	7	4		
7	7	5		
8	7	0		
9	7	2		
10	7	0		
11	6	3		
12	6	0		

TRAVERSE TABLE.

Courses.	Dis.	N.	S.	E.	W.
N. 13°.30 W.	38	36,9			8,9
N. 24 45 W.	38	34,5			15,9
N. 47 15 W.	76	51,7			55,6
N. 81 00 W.	12	1,9			11,8
		125,0			92,2
		D. lat.			Dep.

Before the courses can be corrected, an azimuth must be worked as in articles 26 and 27.

	90° 00′		90° 00′		90° 00′
Decl.	17 27	Lat.	19 30	Alt.	10 40
A =	107 27	Co-lat.	70 30	Co-alt.	79 20
D =	8 50			Co-lat.	70 30
Sum	116 17	58° 08′ = ½ sum.		D =	8 50
Diff.	98 37	49 19 = ½ diff.			

Then by the Gunter, the extent from 58° 8′ to 79° 20′ on the sines, will reach from 70° 30′ to some point beyond 90°; rest one foot there, and extend the other to 49° 19′; this extent will reach from the beginning of the versed sines to the versed sine of 67°, the azimuth from the south. Hence the variation will be 13° 30′ W.; with which the courses in the log-board are to be corrected; as well as for the lee-way; the ship being close hauled.

For the ship's place.

Depart. latitude	=	19° 30′ S.
Difference of latitude	=	2 05 S.
Present latitude	=	17 25 S.
Sum of latitudes	=	36 55
Middle latitude	=	11 27
Co-middle latitude	=	71 33
Depart longitude	=	0 10 E.
Diff. longitude	=	1 36 W.
Present longitude	=	1 26 W.

For the bearing and dist. of St. Helena.

St. Helena's lat.	=	16° 00′ S.	M. P. 973
Present latitude	=	17 25 S.	1061
Diff. latitude	=	1 25.	88
Sum latitudes	=	33 25	
Middle latitude	=	16 42	
Co. mid. lat.	=	73 18	
St. Helena's long.	=	5 53 W.	
Present long.	=	1 26 W.	
Diff. long.	=	4 27 = 267 m.	

Course N. 71° 30′ W. (57)

Distance 270 miles.

Here the azimuth is worked with yesterday's lat.; if it had been worked with this day's latitude the variation would have been 12° 30′.

In

In the following Journal almost all the circumstances which can possibly attend a day's work, in any common voyage, are introduced. The ship is taken from the River *Thames*, conducted through the *Downs*, down the *English Channel*, and from thence over the Ocean, until she comes in sight of her port; namely, Fonchal in the island of Madeira. In this navigation care has been taken to point out the usual business that occurs in the like circumstances of wind, weather, &c. The courses and distances run down the channel are such, as produce the bearings and distances of the places mentioned; and vessels frequently keep a track not very different from that which is here assumed. The astronomical observations are adapted to the times and places where they are put down; and it is apprehended, that the whole is conducted in such a manner, as might possibly have happened.

It is usual, in Journals, to mark the days of the week with the characters of the planets.

Thus ☉ stands for Sunday.
☽ Monday.
♂ Tuesday.
☿ Wednesday.
♃ Thursday.
♀ Friday.
♄ Saturday.

Digitized by Google

JOURNAL *of a Voyage from England, toward Madeira, in his Majesty's Ship the Neptune*, LUCIUS MANLEY, *Esq*; *Commander, kept by* FRANCIS DRAKE, *Master's Mate*, 1772.

Winds.	REMARKS.
NW.b.W. NE. NNW.	♃. July 2d. At 2 P.M. the Pilot came on board; ordered the ship to be cast loose from the shear-hulk at Deptford, and made sail down the river. At 5 P.M. made fast to the shear-hulk at Woolwich, the wind not permitting us to proceed farther. At 4 A.M. cast loose from the hulk, and at 10 anchored in Long-Reach; moored with a cable each way *.
NW.	♀. July 3d. Employed taking the gunner's stores on board Read the articles of war to the ship's company, and punished Simon Sturdy with 12 lashes, for drunkenness and disobedience. Fine weather and moderate wind.
W.b.S.	♄. July 4th. Light airs and fine weather. A.M. unmoored, and sailed down the river to Gravesend. At noon anchored with the small bower † in 6 fathoms.
NNE.	☉. July 5th. At 6 A.M. weighed and turned to windward down the reach; and at noon anchored in the Hope, in 7 fathoms. Fine weather and moderate wind.
Westerly.	☽. July 6th. Brisk wind and cloudy weather. At 6 P.M. weighed and sailed; and at 2 A.M. anchored with the best bower at the Nore, in 9 fathoms. At 7 weighed and sailed.
NNW.	♂. July 7th. At 3 P.M. came to in Margate road with the best bower. At 8 A.M. weighed and made sail. Brisk wind and hazy weather.
Variable: westerly.	☿. July 8th. At 3 P.M. came to anchor in the Downs in 7 fathoms, and moored with a cable each way *. The town of Deal bearing WNW. and the South Foreland

† It is customary on board ships of war, as well as other ships that make long voyages, to have four large anchors, nearly of the same size, called the *small bower*, *best bower*, *sheet*, and *spare* anchors; the two first being always ready at the bows of the ship to moor with, or to let go as occasions require. The other two are suspended over the side farther aft, near the fore-chains, to be used along with the former in very bad weather, or to supply their places when they are lost. Beside these, each ship of war has three smaller anchors; namely, the stream anchor, which is about one-fourth part as big as one of the former, and two kedge-anchors, with cables and hausers proper for them, to be used in warping the ship from place to place, into and out of harbours, or to steady the ship on some occasions.

* When a ship is *moored*, she lies in the mid-way between two anchors; and when she is *moored with a cable each way*, the anchors are two cable lengths, or 200 fathoms asunder, and the ship rides in the mid-way between them. To place a ship thus in a stream, or in a tide's way, one of the bower anchors is let go, and the length of two cables veered out as the ship falls down the stream; the other bower is then let go, and the cable veered out as the other is hove in, until the ship is in the middle between the two anchors.

Journal

Digitized by Google

Journal from England toward Madeira, 1772.

Winds.	Remarks.
	SW. b. S. ſent the pilot on ſhore. Moderate wind, and cloudy with ſhowers.
WNW.	♃ July 9th. The former part of theſe 24 hours briſk wind and cloudy weather; the middle ſtrong gales with rain. At 6 P. M. got down the top-gallant-yards. At 8 ſtruck the yards, top-maſts, and top-gallant maſts. At 2 A. M. exceeding ſtrong wind with rain: let go the ſheet-anchor under foot.
NW.	♀ July 10th. More moderate: P. M. hove up the ſheet-anchor, and got up the yards and top-maſts. A. M. overhauled the rigging, and ſet it up. Cloudy weather with ſome rain.
North.	♄ July 11th. Briſk wind, and flying clouds. P. M. ſtowed the boats, cleared the decks, and made all ready for going to ſea. At 6 A. M. unmoored. At 8 weighed and ſailed; and at noon the South Foreland bore NW. diſtant 5 miles.

Journal from England toward Madeira.

H	K.	F.	Courſes.	Winds.	Remarks on ☉, July 12th, 1772.
1	1	2	SSW. ¾W.	N. ½W.	Little wind and fine weather.
2	1	2			Stowed the anchors. Set top-gallant ſails
3	2				and ſteering ſails.
4	3				The South Foreland North.
5	3	2	W. ½N.		
6	3	2			
7	3				Took in ſteering ſails and top-gallant ſails.
8	3			North.	Moderate wind and fine weather.
9	2	6			
10	2	6			
11	3	2			
12	3		Weſt.	N. b. E.	Ditto weather.
1	3				
2	3	2	WNW. ½W.		Fairlight point N. b. W. about 4 miles.
3	3	2			
4	3	4			Moderate wind and clear weather.
5	3	6			
6	4	2			Beachy head N. b. W. about 6 miles.
7	5	4	W ½N.		
8	6	4			Briſk gales and cloudy.
9	7				Took in a reef of each top-ſail.
10	7	4			
11	8				
12	8	4			Bembridge Point NW. 5 leagues.

Digitized by Google

Journal from England toward Madeira,

Ho.	K.	F.	Courses.	Winds.	Remarks on ☽, July 13th, 1772.
1	7	6	WNW.	N. b. E.	Fresh gales and flying clouds.
2	7	6			Dunnose WNW. about 7 miles.
3	7	5	West.		
4	7	4			Ditto weather.
5	7	4		North.	
6	7	4			
7	7	6			The bill of Portland NW. b. N.
8	7	4	WNW. ½W.	N. b. E.	Shortened sail.
9	6	2			
10	6				
11	6				
12	6				Weather as above.
1	5	4			
2	5	4			
3	5	2			
4	4				Moderate wind and clear.
5	4				
6	4	2			The Start WNW. 4 leagues.
7	6				Let out all reefs.
8	6	4			Brisk wind and fine weather.
9	6	4	WNW. ½N.	NNE.	
10	6	4			
11	6	5			Merid. alt. ☉'s L. L. 61° 28½′ S.
12	6	5			Ram-head NE. ¾ E.

Course.	Dist.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S31°W.	15	12½	7½	50° 5½′ N.	0° 12′ W.	Ram-h. NNE. ¾ E. 5 leag.

Here the meridian alt. of the Sun's lower limb being 61° 28½′ S. the refraction (55) will be 30″ to be subtracted. Suppose the height of the observer's eye to be 21 feet, and the dip of the horizon (55) will be 4′ 22″, to be subtracted also. By the same art. the Sun's semi-diameter on the 13th of July is 15′ 47″, to be added; consequently the correction of the ap. alt. of the Sun's l. l. will be 11′ to be added: and the true alt. of his center was 61° 39½′: hence his true meridian zen. dist. was 28° 20½′ S.; and as the Sun's decl. for that day will be found 21° 45′ N. for the noon of a place 4° W. of London, the lat. of the ship at noon was 50° 5½′ N. The Ram-head lies in lat. 50° 18′ N.: the ship is therefore 12′, 5 south of the Ram-head. Moreover, the Ram-head bearing NE. ¾ E. by compass, the ship may be supposed to have sailed from thence SW. ¾ W.; or, because there are two points west variation in the Channel, SSW. ¾ W. true: now under 2¾ points in the traverse table; and against 12′, 5 in the diff. of lat. col. stands 15′ nearly in the dist. col. for the distance which the ship was from the Ram-head at noon, and the true bearing of the Ram-head from her is NNE. ¾ E.

Again, the merid. parts to lat. 50° 18′, are 3502,6, and to 50° 5½′ 3483,1; of course the merid. diff. of lat. is 19,5, which being sought for in the diff. of lat. col. under 2¾ points in the trav. table, will be found to stand against 11′, 8 in the col. of dep.: 11′, 8, or 12′, is therefore the diff. of long. which the ship is west of the merid. of the Ram-head, the Ram-head being NE. from it: and this is also the *long. made* in this case. Thus the ship's place is ascertained at noon, and her *departure* (as it is generally expressed) *taken* from the Ram-head.

But the method which seamen generally use *in taking their departure* from any point of land, is to set the point by the compass, and guess, as near as they can, how far the ship is from it. They then take the opposite point of the compass for the course which the ship may be supposed to have sailed from that point, correct it for variation of the compass (32), and with this course and the estimated dist. they find the diff. of lat. and dep. as in any other course, and dist., run by the log.

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♂, July 14th, 1772.
1	5	6	SW.	WNW.	Brisk wind and clear.
2	6				
3	6				
4	6				Wind as above: cloudy.
5	5	2			
6	3	4	SW. ½ S.	WNW. ½ W.	
7	3	4			
8	3	4	SW. b. S.	W. b. N.	Moderate wind and cloudy.
9	3				
10	2	2			
11	2	2			
12	1	6	SW.b.W.	NW. b. W.	Foggy, with drizzling rain.
1	2				
2	1	6			
3	2				
4	2				Ditto Weather.
5	2				
6	2				
7	1	6			
8	1	6			Tacked ship. Weather as above,
9	2		NW. ½ N.	WSW. ½ W.	
10	2				
11	1	6			
12	1	2			Light Breezes and foggy.

Course.	Dist.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S. b. W.	59	58	11½	49° 7½′ N.	0° 29½′ W.	Ramh. N. 15° E. dist. 24 l.

Here, the ship being close on a wind, and making little way a-head, may be supposed to make a point and half lee-way: and the variation being two points westerly, her course by compass is altered 3½ points, or the sum of these two toward the left hand, when on the starboard tack, and ½ a point, or their diff. when on the larboard, to obtain the true courses put down in the first col. of the traverse table. The distances to each course are added up, reckoning 8 fathoms to make a knot, and put in the second col. against their respective courses; and the remaining part of the table is filled up by B. VII. art. 36.

The Traverse Table.

True course.	Dist.	N.	S.	E.	W.
S. ½ W.	29	—	28,9	—	2,8
South.	7	—	7,0	—	—
S. ½ E.	11	—	10,9	1,1	—
S. b.W. ½ W.	17	—	16,3	—	4,9
NW.	7	4,9	—	—	4,9
		4,9	63,1	1,1	12,6
			4,9		1,1
			58,2		11,5

In the traverse table (VII. 67.) I find that 58,2 stands in the diff. of lat. col. against 11,5 in the dep. col. under 11° in the courses; consequently the course made good by the ship for the whole day, is S. 11°W. Moreover, under this course, 58,2 stands in the diff. of lat. col. against somewhat more than 59 in the col. of distances, which is therefore the distance made good in the whole day.

Again, if from 50° 5½′N. the lat. in yesterday at noon there be taken 58m. the diff. of lat. made since, S. there will remain 49° 7½′ N. for the *lat. in* this day at noon, by account, and which must be taken as the true *lat. in.* because there was no observation. The mer. parts to these two latitudes will be found 3483,1 and 3393,5: hence the mer. diff. of lat. is 89,6, which stands in the diff. of lat. col. (under 11°) against 17½ in the dep. col.: and 17½ being added to 12′, the long. made yesterday at noon, because both are W., gives 29½′ for the *long. made* this day at noon.

To find how the Ram-head bears, and its dist. from the ship, take 3393,5 the mer. parts to the ship's lat. from 3502,6 the mer. parts to the lat. of the Ram-head, and their diff. 109,1, will be found in the diff. of lat. col. against 29′,5, the long. made, in the dep. col. under 15°; consequently the Ram-head bears N. 15° E. from the ship, because the ship is S. and W. from it. Lastly, 49° 7½′, ship's lat. being taken from 50° 18′, lat. of the Ram-head, leaves 70,5 diff. of lat.; which, under 15°, stands against the dist. 73 miles, or 24⅓ leagues, the dist. required.

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courſes.	Winds.	Remarks on ☿, July 15th, 1772.
1	2	4	NW. b. W.	SW. b. W.	Little wind, and foggy weather.
2	2				
3	2		NW.	WSW.	
4	2				Weather ditto.
5	1	6	NNW.	Weſt.	
6	2				
7	1	4	NW. b. W.	SW.b.W.	
8	2				Tacked ſhip. Thick fog.
9	2	4	SSW.	Weſt.	
10	2	4			
11	2	4	SW. b. S.	W. b. N.	
12	2	4			Weather as above.
1	1	6			
2	1	4			
3	1	4			
4	1	6	WSW.	NW.	Ditto Weather.
5	1	2	W. b. S.	NW. b. N.	
6	2				
7	1				
8	1	4			Very hazy: little wind.
9	2	2			
10	1	7	WSW.		
11	3		Weſt.	North.	
12	4				Weath. do. mer. alt. ☉'s l. l. 62° 25′ S.

Courſe.	Diſ.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and diſt. at noon.
S.53°W.	29	17	23	48° 50½′ N.	1° 4½′ W.	Ramh. N. 25° E. diſt. 32 l.

By obſerving the directions given for working the two preceding day's works, the ſeveral operations will ſtand as follow. Noting only, that although the ſhip ran twice on a NW.b.W. courſe, viz. from noon to 2 o'clock, and from 6 to 8, yet that courſe is put down only once in forming the traverſe table from the log., becauſe as the ſhip is at the ſame diſt. from the wind in both, and runs nearly at the ſame rate, the lee-way which ſhe makes, and of conſequence her true courſe, will be the ſame; but the diſtances which ſhe ran both times are added into one ſum, namely: 4½ and 3½=8m. and put down againſt that courſe. On the contrary, when ſhe runs twice WSW. that courſe is put down twice; becauſe being cloſe to the wind one time, and a point free the other, ſhe would make more lee-way from 3 o'clock to 4, than ſhe did from 9 to 10, and therefore the true courſes would be different; 1½ points being allowed in the former caſe, and only ¾ of a point in the latter.

Dip of the horizon	(55)	4′ 22″
Refraction	(55)	0 30
Sum		4 52
Sun's ſemi-diameter	(55)	15 47
Difference		10 55
App. alt. ☉'s l. l.		62° 25 00 S.
True mer. alt. ☉'s cent.		62 35 55
True zenith diſt.		27 24 5 S.
Sun's declination (V. 309)		21 26 10 N.
Latitude obſerved		48 50 15 N.

Lat. from 49′ 07½″	mer. pts.	3393,5
Lat. in. 48 50	mer. pts.	3366,9
Diff. of long. 0° 35′ W.		26,6
Long. from 0 29½ W.		
Long. made 1 04½ W.		

For the bearing and diſt. at noon.

Lat. Ramh. 50° 18′ N.	mer. pts.	3502,6
Lat. in 48 50 N.	mer. pts.	3366,9

Diſt. 32 leag. { 1 28=88m. N. 25° E. 2)135,7 67,85

The Traverse Table.

True courſe.	Diſt.	N.	S.	E.	W.
NW.b.W.½W.	8	3,8	—	—	7,1
NW. ½ W.	4	2,5	—	—	3,1
NNW. ½ W.	4	3,5	—	—	1,9
S. b. E. ½ E.	5	—	4,8	1,5	—
S. ½ E.	10	—	10,0	1,0	—
SSW. ½ W.	2	—	1,8	—	0,9
SW. b. S. ½ W	8	—	6,2	—	5,1
SW. b. S. ¼ W.	2	—	1,6	—	1,2
WSW.	7	—	2,7	—	6,5
		9,8	27,1	2,5	25,8
			9,8		2,5
Cour. S. 53° W.	diſt. 29m.		17,3		23,3

Lat. from 49 7½ N.
Lat. in by acc. 48 50 N.

long. made=64,5m.
half of each 32, 25

Journal

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♃, July 16th, 1772.
1	3	6	W. b. S.	North.	Moderate wind and hazy.
2	4	2			
3	6		WSW.		A great swell from the NNE.
4	5				Ditto weather.
5	5				Shortened sail.
6	5				
7	4				
8	3	4			The weather as above.
9	3	4			
10	4				
11	5				
12	5			NE.	Ditto weather.
1	5				
2	4	4			
3	4				
4	4				Moderate wind and flying clouds.
5	4				Sun rose by compass N. 79° 30′ E.
6	4				Variation 22° 16′ W.
7	3	5			Set the top-gallant sails.
8	3	5			Moderate wind and fine weather.
9	3				Set the steering sails.
10	2	4			
11	3	3			The swell continues from the NNE.
12	3	3			Dit. weath. Mer. alt. ☉'s l. l. 63° 37′ S.

Course.	Dis.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dis. at noon.
S. 41° W.	108	81	71	47° 28′ N.	2° 51½′ W.	Ram-h. N. 34° E. dis. 68 l.

Traverse Table.

True Cour.	Dist.	S.	W.
SW. b. W.	8	4,4	6,6
SW.	91	64,4	64,4
South.	12	12,0	
		80,8	71,0
Lat. from		48° 50′ N.	
Diff. of lat.		1 21 S.	
Lat. in by acc.		47 29 N.	

1st. At 5 A. M. or 17h. it was 17¼h. at Greenwich (57): at this time the sun's decl. was 21° 19′ N. By working the log. up to the time, the lat. of the ship will be found 47° 49′ N. Hence the true ampl. of the sun at rising was N. 57° 14′ E.; that by compass was observed above to be 79° 30′ E.; consequently the variation is 22° 16′ W. (31) or two points nearly.

2. The swell setting from the NNE. toward the SSW. must carry the ship along with it; for this reason a SSW. course is introduced in the traverse, which variation allowed, is due S; and it is supposed the ship was set that way 12 miles in the 24 hours.

3. The true lat. observed will be found 47° 28′ N.; and as that by account is 47° 29′ N. the diff. of lat. by observation, and not that by account, must be used with the departure in finding the course and dist. made good, and diff. of longitude.

Lat. fr. 48° 50′ N. Meridional parts 3366,9
Lat. in 47 28 N. Meridional parts 3244,0 Long. from 1° 4½′ W.
Diff. lat. 1 22=82m. } Mer. diff. lat.=122,9, half=61,45 } d. lon. 1 47 W.
Depart. 71m. } Gives the course S. 41° W.
Longit. made 2 51½ W.

Lat. Ram-head 50° 18′ N. Meridional parts 3502,6, $\frac{1}{3}$ part is 57,2 }
Lat. ship 47 28 N. Meridional parts 3244.0 }
Diff. of lat. 2 50 Mer. diff. lat. 258,6; $\frac{1}{3}$ part is 86,2 }
One third part 56,7. Hence the Ramh. bears N. 33½° E. dist. 68 leag.

Here, because the meridional diff. of lat. and diff. of long. are greater than can be found in the table, one third of each is taken to find the course; then this course, and one third of the proper diff. of lat. give the distance in leagues.

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♀, July 17th, 1772.
1	4		WSW.	NNW.	Moderate wind and clear. Hauled down lower steering sails.
2	4	2			
3	4	2			
4	4	2			Ditto weather.
5	4				
6	3	3	SW. b. W.	NW.b.W.	Hauled down fore-top-mast steer. sails.
7	4	3			Clued up and handed top-gallant sails.
8	4	6			Weather as above.
9	4				
10	4				
11	3	4			
12	3				Moderate wind and cloudy.
1	3	4	SW. b. S.	W. b. N.	
2	3	4			
3	4				
4	4				Squally weather. Tacked ship.
5	4		NNW.	West.	
6	3	2			
7	3				
8	3				Brisk wind and cloudy. Tacked.
9	3	4	S. b. W.	W. b. S.	
10	4	4			
11	4				
12	4				Very hazy. Mer. alt. ☉'s l. l. 64° 30′ S.

Course.	Dis.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S 19° W.	67	58	20	46° 25′ N.	3° 23½′ W.	Ramh. N. 30° E. dist. 90 lea.

The Traverse Table.

Course.	Dist.	N.	S.	E.	W.
SW.	21		14,9		14,9
S.b.W.½W.	27		25,8		7,8
S. ½E.	15		14,9	1,5	
NNW.½W.	13	11,5			6,1
SSE. ½E.	16		14,1	7,5	
		11,5	69,7	9,0	28,8
			11,5		9,0
			58,2		19,8

Working the traverse by the foregoing directions, the diff. of lat. will be 58,2 and the depart. 19,8, and hence the lat. by account will be 46° 30′ N.: but the true lat. observed will be found only 46° 25′ N. consequently the course by compass, or distance run by the log. or both, must be erroneous, and therefore the reckoning must be corrected by one of the three cases at Art. 81, 82, 83, Now 58,2 is found in the diff. of lat. col. against 19,8 in the depart. col. under 19°; which is therefore the course by account for the 24h. Consequently the correction must be made by art. 81. Now the diff. of lat. by observation is 63, with which, and the course by account S. 19° W. as the true course, find the dist.=67 miles. Moreover, the mer. parts to the *lat. from*, and *lat. in*, are 3244,0 and 3151,7; consequently the mer. diff. of lat. will be 92,3, which under the course 19°, gives 32′ for the diff. of longitude. The long. made is therefore 3° 23½′ W. and the Ram-head will be found to bear N. 30° E, distant 90 leagues.

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♄, July 18th, 1772.
1	4	5	South.	WSW.	Moderate wind, and hazy.
2	4		S. b. E.	SW. b. W.	
3	3	2			
4	3		South.	WSW.	Ditto weather.
5	3	2			
6	4		SSE.	SW.	Az. ☉'s cent. by comp. N. 53° 56′ W.
7	3		NW. b. N.	W. b. S.	Alt. of his l. l. 15° 56′ var. obs. 22° 12′ W.
8	3				Weather as above.
9	2		NW.	WSW.	
10	2				
11	1	5			
12	1	4			Rainy, unsettled weather.
1	2	2	NW. b. N.	W. b. S.	
2	2	2			
3	2				
4	2				Squally, with rain.
5	2	4			
6	3				
7	3				
8	2	6			Weather as above.
9	2	4			
10	2	3	NNW.	West.	
11	2				
12	1	6			Foggy, with rain.

Course.	Dif.	D. L.	Dep.	Latit. in.	Long. made.	Bearings and dist. at noon.
N32°W	19	16½	10	46°41½′N.	3° 38½′W.	Ramh. N. 33½°E. dist. 87 l.

1st. To work the azim. and from thence determine what var. must be allowed in correcting the courses. By art. 52, 53, 55, the true alt. of the Sun's cent. was 16° 4′. By V. 286, the Sun's decl. was 21° 3′N., and, working the log. up to the time, the lat. of the ship was 46° 10′N. Hence (28) the true azim. was N. 76° 8′W. and therefore the variat. (31) 22° 12′W.: consequently two points may still be allowed in correcting the courses.

2d. Having formed the traverse table, and worked the log. as in the margin, I find the diff. of lat. for the whole day is 16½m. N. and the dep. 10,1 W. Hence the course made good is N. 32° W. and the distance 19m. Moreover, the lat. by account is 46° 41½′N. and this is taken for the *lat. in*, as there was no observation. The mer. diff. of lat. is 24,0, which gives, under 32° in the courses, 15′ for the diff. of long. Consequently the *long. made* is 3° 38½′ W.

The Traverse Table,

True course.	Dist.	N.	S.	E.	W.
SE. b. S. ½E.	11		8,5	7,0	
SE. ½E.	7		4,4	5,4	
SE. b. E. ½E.	4		1,9	3,5	
NW.b.N.½W.	28	21,6			17,8
NW. ½W.	7	4,4			5,4
NNW. ½W.	6	5,3			2,8
		31,3	14,8	15,9	26,0
		14,8			15,9
Diff. of lat.		16,5	Dep.		10,1

Lat. from	46° 25′ N.	m. pts.	3151,7
Lat. in	46 41½ N.	m. pts.	3175,7
Diff. of long.	0 15 W.	m. diff. lat.	24,0
Long. from	3 23½ W.		
Long. made	3 38½ W.		

Lat. Ram-head	50° 18′ N. mer. parts 3502,6			
Lat. ship	46 41½ N. mer. parts 3175,7			
Diff. of lat.	33 36½ 216,5	10)326,9	Long. made=10)218,5	
One third is	72,2	32,69	21,85	
Hence dist. is 87 leagues.		Bearing is N. 33½° E.		

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ☉, July 19th, 1772.
1	5	7	WSW.	NW.	Brisk wind and cloudy.
2	3	4	S. W. ½ W.		
3	2				
4	1	2			Moderate wind and cloudy weather.
5	1	2			
6	3	3	SW. b. W.		
7	4	5			
8	4				The weather as above.
9	4				
10	4				
11	4				
12	4				Ditto weather.
1	3	4			
2	3	6			
3	3	4			
4	3	6			Ditto weather.
5	3	6			
6	4				
7	3	5			
8	3	3			Brisk wind and cloudy.
9	3	6	SW. ½W.		
10	3	3			
11	3	3			
12	4	2			Very hazy. Mer. alt. ☉'s l. l. 65° 13'S.

Course.	Dif.	D. L.	Dep.	Latit. in.	Long. made.	Bearings & dist. at noon.
		74	43,4	45° 20'N.	4° 44½'W.	Ram-h. N. 33° E. d. 118. l.

The Traverse Table.

True Course.	Dist.	N.	S.	E.	W.
SW. b. S.	6	—	5,0	—	3,3
SSW. ¾ W.	57	—	48,9	—	29,3
SSW. ½W.	23	—	20,3	—	10,8
Diff. of lat.			74,2	—	43,4
			1 14 S.		
Latit. from			46 41½N.		
Lat. in by acc.			45 27½N.		

A point is only allowed for lee-way on the WSW. course, because the ship went fast through the water. A quarter of a point only is allowed on the SW. b. W. course, because she was a point free; and none on the SW. ½W. course, as she was then 7½ points from the wind.

On casting up the traverse table, it appears that the diff. of lat. is only 74 m. S., consequently the lat. by account is 45° 27½' N. whereas the true lat. observed will be found no more than 45° 20'N. Now to correct this error, and determine by which of the three cases (81, 82, 83,) it is to be done; as there has been no observation since the 17th, take the diff. of lat. made the 18th from that made the 19th, one being N. and the other S., and the remainder (57,7) will be the diff. of lat. made good on both days: also add the two departures together, because both are W., and the sum (53,5) is the departure for both days. This diff. of lat. and dep. give S. 43°W. for the course; the correction must therefore be made by Case III. This course by account and 65, diff. of lat. by observation, gives 60,6 depart., half the sum of this and that by account is 57,0; this depart. and 65 diff. of lat. by observation, give S. 41°W. for the true course. This course and 93,4, merid. diff. of lat. by observation give 81' diff. of long. for both days, which being added to 3° 23½', the *long. made* on the 17th, gives 4° 45'W. for the *long. made* on the 19th. The bearing of the Ram-head N. 33° E. and dist. 118 leagues, will be found in the same manner as on the preceding days.

Journal

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ☽, July 20th, 1772.
1	4	4	SW. b.W.	NW. b. W.	Moderate wind and clear.
2	4	4			
3	3	4			
4	1	4			Light airs intermixed with calms.
5	1	2	SW.	WNW.	Tried the current which set W. b. N.
6	2	4			½ N. ¾ of a k. an ho.
7	3	4			Brisk wind and cloudy: took in a reef
8	3	5			of each top-sail.
9	3	4	SW. b.W.	NW. b.W.	
10	3	6			
11	2				Took in 2d reef of the top-sails.
12	3		S.W.	WNW.	Squally, with heavy rain.
1	2	5	SW. b. S.	W. b. N.	Handed the mizen top-sail.
2	2	5			Close reefed the fore top-sail.
3	2	3			
4	2	4			Squally, with showers.
5	3				
6	3	4	SSW.	West.	Close reefed the main top-sail.
7	4				
8	4				Heavy squalls of wind and foggy.
9	3		South.	WSW.	Saw Cape Ortagal S. b. E. about 7 leag.
10	2	6			
11	2				Handed the top sails.
12	2	2			Strong wind in squalls.

Course.	Dist.	D. L.	Dep.	Lat. in.	Long. made.	Bearing and dist. at noon.
S.10°W.	68	67,2	11,3	44° 13′ N.	5° 1′ W	Ramh. N. 29°E. dist. 139 l.

In working this day's log the following particulars must be observed.

Only 1¼ points are allowed for leeway whilst the ship was running on the first SW. b. W. course, because, although she was close-hauled, she went well through the water, which may therefore be supposed to have been pretty smooth.

A point and half is allowed on the first SW. course, because we may presume the sea began to have more motion; and, moreover, toward the latter end of the time a reef of each top-sail was taken in.

The TRAVERSE TABLE.

True Course.	Dist.	N.	S.	E.	W.
S. b.W ¾ W.	14	—	13,2	—	4,7
S. ½ W.	11	—	10,9	—	1,1
S.b.W. ¼ W.	9	—	8,7	—	2,2
S. ¼ W.	3	—	3,0	—	0,2
S. ¾ E.	13	—	12,9	1,9	—
SSE.	12	—	11,1	4,6	—
SE. b. E.	10	—	5,6	8,3	—
Curt. W. ½ S.	18	—	1,8	—	17,9
			67,2	14,8	26,1
Diff. latit.		1° 7′S.			14,8
Latit. from	45 20 N.				11,3
Latitude in	44 13 N.				

The second time the ship went on these courses 1¾ points were allowed, because some part of the time the top-sails were double reefed: the same quantity is allowed on the SW. b. S. course. On the SSW. course two points were allowed, because the topsails were close reefed; and three points were allowed when she went south, because the top-sails were handed part of the time.

The current setting WNW. ½ W. by compass, or W. ½ S. true, ¾ of a mile an hour, or 18 miles in the 24h; it is put down as if it was a course and dist. run by the ship, and worked as such. The remaining parts of this day's work are performed in the common manner; and the results will be found as they are put down under their proper titles above, the lat. by acc. being taken as the true lat. because there was no observation.

Journal

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♂, July 21st, 1772.
1	2		S. b. W.	W. b. S.	Strong wind and foggy.
2	2				
3	2				Wore ship. C. Ortagal SW. 5 or 6 m.
4	2		NNW.	West.	Weather as above.
5	2				
6	2				Hauled up the mainsail.
7	2				Brought too under the miz. stay-sail.
8	Up		NW. off NNE.	Variable.	
9	Up		NW. off N. b. E.		Wore ship. Balanced the miz. & set it.
10	Up		NW.b.W. off WSW.		
11	Up		WNW. off SW.b.W.		Set the fore-sail.
12	3		WSW.	East.	More moderate.
1	5				Set the main-sail.
2	5				
3	5	4			
4	5	3			Moderate wind with rain.
5	4				Set the top-sails.
6	3				
7	3		W. b. S.		Let a reef out of the top-sails.
8	3	4	West.		Moderate wind with rain.
9	3				
10	2				Let out all reefs.
11	2				
12	2				The Groyn Lights, SE. b. S. 4 or 5 lea.

Course.	Dist.	D. L.	Dep.	Latit. in.	Long. made	Bearings and dist. at noon.
S. 52° W.	40	24,7	31½	43° 48′ N.	5° 45′ W.	Ramh. N. 31° E. dist. 152l.

The TRAVERSE TABLE.

True Course.	Dist.	N.	S.	E.	W.
SE. ½ E.	6	—	3,8	4,6	—
N. ½ W.	8	8,0	—	—	0,8
NE. b. N.	1	0,8	—	0,6	—
NNE. ½ E.	1	0,9	—	0,5	—
S. ½ W.	1	—	1,0	—	0,1
S. ½ E.	1	—	1,0	0,1	—
SW.	31	—	21,9	—	21,9
SW. b. W.	3	—	1,7	—	2,5
WSW.	13	—	5,0	—	12,0
		9,7	34,4	5,8	37,3
			9,7		5,8
Diff. of lat.			24′ 7		31,5
Latitude from		44° 13 N.			
Latitude in		43° 48,3			

In working the log for these 24h. it is necessary to remark that 3½ points are allowed on the S. b. W. course, because both top-sails are handed: the like quantity is allowed on the NNW. course.

When a ship is brought to, as it is usually expressed, the tiller is put close over to leeward, which brings her head round to the wind. The wind having then very little power on the sails, the ship loses her way through the water, which ceasing to act on the rudder, her head falls off from the wind, the sail which she has set fills, and gives her fresh way through the water; which acting on the rudder brings her head again to the wind: thus the ship has a kind of vibratory motion, coming up to the wind and falling off from it again, alternately. Now the points of the compass which she comes up and falls off to, are noted, and put down in the log, in the manner they are above at the hours 8, 9, 10, 11, P. M. and the middle point between them taken for the ship's course; on which the proper lee-way and variation is to be allowed, and such distance as she may be supposed to drive. In the instances given above 6 points have been allowed for lee-way, and the ship has been supposed to drive a mile an hour. There is nothing particular in the remaining parts of this day's work: the several results are as put down under their respective titles.

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♀, July 22d, 1772.
1			Ship's head round the comp.		Calm and cloudy.
2					
3					
4					
5					
6					
7					
8					Calm and foggy.
9	1		S. b. E.	SW. b. W.	
10	2				
11	2				
12	1				Little wind, and foggy.
1	2		NW. ½ N.	Variable.	
2	2	6			
3	3				
4	3	2			Ditto, and hazy.
5	2		NNW.	West.	
6	2				
7	2		SSW.		
8	2				Ditto, and fine weather.
9	2				
10	2				
11	2				
12	2				Flying clouds. Mer. alt. ☉'s l. l. 66° 23′ S.

Course.	Dif.	D. L.	Dep.	Latit. in.	Long. made	Bearings and dist. at noon.
		4	1,6	43° 35′ N.	5° 53′ W.	Ramh. N. 31° E. dist. 157 lea.

The dip. of the horizon			4′	22″
Refraction	(55)			25
Sum			4	47
The sun's semi-diam.			15	48
Difference			11	1
App. alt. ☉'s l. l.		66°	23	0 S.
True alt. ☉'s center		66°	34	1
Sun's zenith dist.		23	25	59 S.
Sun's declination		20	9	11 N.
Latitude observ.		43	35	10 N.

The latitude, by account, differing 9 miles from that observed, the reckoning must be corrected, as in the following operation.

The Traverse Table.

True Course.	Dist.	N.	S.	E.	W.
SE. ½ E.	6	—	3,8	4,6	—
NW.	11	7,8	—	—	7,8
NNW. ½ W.	4	3,5	—	—	1,9
S. b. E. ½ E.	12	—	11,5	3,5	—
		11,3	15,3	8,1	9,7
			11,3		8,1
Difference of latit.			4,0		1,6
Latitude from		43° 48 N.			
Latit. by account		43 44 N.			

	S.	W.
☽ the 20th.	67,2	11,3
♂ the 21st.	24,7	31,5
☿ the 22d.	4,0	1,6
	95,9	44,4

these give the course S. 25° W.; consequently the correction must be made by Case 1. Art. 81.

Latitude from	45° 20′ N.	Meridional parts	3058,3
Latitude in	43 35 N.	Meridional parts	2911,2
True dif. lat.	105′ = 1° 45′	Merid. diff. lat.	147,1
		Course	S. 25° W.

Dif. of lon. 1° 8½′ W.
Long. 19th 4 44½ W.
Longit. made 5 53 W.

and the Ram-head will be found to bear N. 31° E. and be dist. 157 leagues.

Journal

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♃, July 23d, 1772.
1	3		WSW.	NNW.	Moderate wind, and hazy.
2	3	6			
3	3				
4	2	6		North.	Ditto weather.
5	2	4			
6	2	4			
7	2	4			
8	4			N. b. E.	Cape Finisterre SSW. 6 or 7 leagues.
9	3	2	SW.		
10	3	6			
11	3	6			
12	3	6			Weather as above.
1	3	6			
2	3	4			
3	3	4			
4	3	5			Moderate wind, and flying clouds.
5	3	6			
6	4				About ½ past 6 A. M. ob. the dist. of the
7	4	4			nearest l. of the $\odot$ and ☽ 84° 34′ 25″.
8	5				App. alt. $\odot$'s l. l. 19° 15½′, the app. alt.
9	5				of the ☽'s u. l. 59° 00⅓′. Hence the
10	5				lon. of the ship by these ob. is 10° 8′ W.
11	5				Error of the acc. in long. 48½′ too much.
12	5				Merid. alt. $\odot$'s l. l. 67° 28′ S.

Course.	Dist.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S. 28½° W.	89	78	42	42° 18′ N.	6° 50′ W.	N. 30° E. dist. 185 l.

The TRAVERSE TABLE.

True Course.	Dist.	S.	W.
SW.	24	17,0	17,0
SSW.	66	61,0	25,3
Diff. of lat.		78,0	42,3
		1 18 S.	
Latitude from		43 35 N.	
Latitude in		42 17 N.	

The ship going large the whole 24h. no leeway is to be allowed in working the log.

In deducing the longitude of the ship from the observed distance of the sun and moon, the sun's semi-diameter found in the Nautical Almanac is 15′ 48″, that of the moon 14′ 55″, and its augmentation, according to the altitude (56) 14′; hence the apparent distance of their centers was 85° 5′ 22″, the apparent altit. of the sun's center was 19° 27′, and that of the moon's 58° 41′: and it will be found (109) that the arch A was 25° 34′, the first correction + 2′ 13″, the second — 14′ 00″, and the third + 1″. The true distance was therefore 84° 53′ 36″, and (110) the time at Greenwich 19h. 14m. At this time the sun's declination was 19° 59′ 36″ N. and by working the log up to ½ past 6 A. M. the latitude will be found 42° 42′ N. and, lastly, the true altit. of the sun was 19° 24′ 24″: hence the time at the ship was 18h. 33m. 22s. and the long. 10° 9½′ W.

It will be found, on working the log, that the ship made 44′ W. diff. of long. from noon, the preceding day to ½ past 6 A. M. which gives 6° 37′ W. for the long. made at the time of observation; add the long. of the Ramhead, 4° 21′ W. and their sum, 10° 58′ W. is the long. of the ship by account; consequently the reckoning of long. is too great by 48′½.

Again, because Cape Finisterre bore SSW. by compass at 8 P. M., the ship was then under the same meridian. By working the log up to that time the long. of the ship was 10° 37½′ W. which is the long. of Cape Finisterre by account, and allowing 48½′ for the error of account, there will remain 9° 49′ W. for the long. of Cape Finisterre by the observation.

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♀, July 24th, 1772.
1	6		SW.		Brisk wind and clear weather.
2	6				
3	6				
4	6				Weather as above.
5	6				
6	6				
7	7				Observed azim. ☉'s cent. N. 50° 19′ W.
8	7				& the alt. of his l. l. 7° 56′, var. 20° 9′ W.
9	6	6			Weather as above.
10	6	4			
11	6	3			
12	7				Ditto weather.
1	7				
2	6	4			
3	6				
4	6				Ditto weather.
5	6				
6	6				About ½ past 6 A. M. ob. dist. limbs sun
7	6				& ☽ 73° 13′ 54″, alt. ☉ l. l. 20° 25′ ⅘ alt.
8	6				of ☽'s u. l. 64° 41′ ⅕. long. ded. 11° 25′ ¼ W.
9	6				Brisk wind and clear weather.
10	6				
11	6				
12	6				Merid. alt. sun's l. l. 69° 31′ S.

Course.	Dis.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dis. at noon.
S. 25° W	150	136	63½	40° 2′ N.	8° 14′ W.	Ram-h. N. 29° E. dis. 235 l.

The Traverse Table.

True Course.	Dis.	S.	W.
S. 25° W.	150	135,9	63,4

Diff. of lat.	2° 16′ S.	
Lat. from	42 18 N.	2806,0
Lat. in	40 02 N.	2625,3
Diff. of long.	1° 24′ W.	180,7
Long. from	6 50 W.	
Long. made	8 14 W.	

Hence the Ram-head bore N. 29° E dis. 235 leagues.

1. At 7h. ship's time, it was 7¼h. at Greenwich (57) consequently the Sun's decl. from the Nautical Almanac was 19° 53′ N. The corrected alt. of the sun will be found 8° 1′, and the lat. of the ship, by working the log up to 7h. 41° 39′ N. Hence the true azimuth was N. 70° 28′ W. and the variation of the compass 20° 9′ W. And, allowing this variation, the work of the log for the whole day will be as in the margin: the two latitudes agreeing exactly. 2d. By working the log up to ½ past 6 A. M. the lat. of the ship at that time will be found 40° 32′ N. and the long. corrected according to yesterday's observation 11° 23′ W. The estimate time at Greenwich will hence be 19¼h, when the Sun's semi-diameter, in the Nautical Almanac, was 15′ 48″, that of the Moon 15′ 2″, her horizontal parallax 55′ 11″, and the augmentation of her diameter (56) 14″. Hence the app. alt. of the ☉'s cent. will be found 20° 37′, of the Moon's 64° 22′, and the app. dist. of their centers 73° 44′ 58″. From these *data*, the arc A (109) will come out 30° 17½′, the 1st correction of the app. dist. + 2′ 7″, the second — 5′ 38″, the third + 0′ 1″, and, consequently, the true dist. 73° 41′ 28″; which gives (110) 19h. 28′ 25″ for the app. time at Greenwich when the dist. of the ☽ and ☉ was observed. At this time the declin. of the Sun will be found 19° 47′ N. with which the lat. of the ship 40° 32′ N. (as above) and 20° 35′, the Sun's true alt. the time at the ship will be found 18h 42′ 25″: the diff. of those times is 46′ 0″ = 11° 30′ W. the long. of the ship, and therefore the error of account is by this observation 47′ too much.

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♄, July 25th, 1772.
1	7		SW.	NE.	Brisk wind and clear weather.
2	6	4			
3	6	4			
4	7				Ditto weather.
5	7				
6	7	2			
7	7	4			
8	7				Brisk wind and hazy.
9	7				
10	7				
11	6	4			
12	6	3			Ditto weather.
1	6	4			
2	6	5			
3	6	4			
4	6	4			Ditto weather.
5	6	2			
6	6				
7	6				
8	6				Brisk wind and cloudy.
9	6		SW. b. W.		
10	6				
11	6		SW. b. S.		
12	6				Ditto weather, mer. alt. ⊙'s l. l. 71° 40′ S.

Course.	Dif.	D.L.	Dep.	Latit. in.	Long. made.	Bearings and dist. at noon.
S. 25° W	156	142	66	37° 40′ N.	9° 39′ W.	Ram h. N. 28½° E. dis. 288 le.

This Day's work will stand as follows:

Dip of horizon (55)	4′ 22″	
Refraction (55)	0 18	
Sum	4 40	
Sun's semi-diam.	15 48	
Difference	11 08	
App. alt. ⊙'s l. l.	71 40 00	S.
True alt. center	71 51 08	
Zenith distance	18 8 52	S.
Sun's declination	19 30 56	N.
Latitude in	37 39 48	N.
Latitude from	40 2 0	N.
Diff. of lat. observed	2 22 12	

The Traverse Table.

True course.	Dif.	S.	W.
S. 25° W.	100	90,63	42,26
	33	29,91	13,95
S. 36 W.	12	9,71	7,05
S. 14 W.	12	11,64	2,90
	2)	141,89	66,16
S. 25 W.	78	70,94	33,08
	2		
Distance	156		

Meridional parts	2443,0
Meridional parts	2625,3
Merid. diff. of lat.	182,3
half	91,15

Half the diff. of longitude 42½′

Difference of longitude	1° 25	W.
Longitude from	8 14	W.
Longitude made	9 39	W.

Lat. Ram-head	50° 18′ N.	Meridional parts	3502,6
Lat. of the ship	37 40 N.	Meridional parts	2443,0
Prop. dif. of lat.	12 38	Merid. dif. of lat.	1059,6
One-tenth part	75,8		105,96

Long. made = 9,39 — 57,9

One-tenth of dist.	86,5 miles	Bearing	N. 28½° E.
Whole distance	288 leagues.		

Journal

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ☉, July 26th, 1772.
1	6		SW.	NE.	Brisk wind and cloudy.
2	6	4			
3	6	4			
4	6	4			Brisk wind and cloudy.
5	6	4			
6	6	4			Variation observed by azimuth 17° 11′W.
7	6	4			
8	6	6			Brisk wind and cloudy.
9	6	4			
10	6	3			
11	6	3			
12	6	4			Brisk wind and flying clouds.
1	5	4			
2	5	4			
3	5	4			Ditto weather.
4	5	4			At 2m. 16s. after 4 A.M. by wa. ob. dis. far.
5	6				l. of the ☽ from α Ariet. 40° 33′ 43″, alt. of
6	6				α Ar. 65° 56′, & that of the ☽'s l. l. 29° 43¼′.
7	6				At 6.32m.44s. by wa. alt. ☉'s l.l. was 16° 53′.
8	5	4			Weather as above.
9	5	2			Saw a sail in the NE. quarter.
10	5	2			
11	5	4			
12	5	6			Ditto weather, mer. alt. ☉'s l. l. 73° 36′ S

Course.	Dif.	D.L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S28°W.	145	128	68	35° 30⅓′ N.	10° 12¼′ W.	Ram-head N.27°E. dist. 332 leag. Funchal S.36° W. dist. 72 leagues.

The merid. alt. observed this day gives 35° 30⅓′ N. for the lat. The true diff. of lat. observed is therefore 129,7, which, with the dep. 68,1, gives S. 27° ¾ W. for the true course; and this course with 161,4, the true merid. diff. of lat. gives 85 for the diff. of long. W. The long. made is therefore 11° 4′ W.

The Traverse Table.

True course.	Dist.	S.	W.
S. 28° W.	145	128,0	68,1
Diff. of latitude		2 8 S.	
Latitude from		37 40 N.	
Lat. by account		35 32 N.	

In order to deduce the true long. of the ship from the observed dist. of the moon from α Arietis, the app. time found from the alt. of the Sun at 6h. 32m. 44s. A. M. was 6h. 29m. 32s. consequently the watch was 3m. 12s. too fast, and therefore the app. time when the dist. was observed was 3h. 59m. 4s. or 15h. 59m. 4s. Hence the time at Greenwich was 17h. at which time the ☽'s horizontal parallax was 56′ 26″, her semi-diameter 15′ 22″, its augment. according to her alt. 8″, and consequently the app. dist. of the star from the ☽'s center was 40° 18′ 13″, the app. alt. of her cent. 29° 55′, and that of the star 65° 52′. Hence the arch A comes out 38° 38′, the first correction—19″, the second—44′ 54″, and the third +3″; therefore the true dist. was 39° 33′ 03″, and (110.) the time at Greenwich 16h. 55m. 36s. the diff. between which and the time at the ship, found above, is 56m. 32s.=14° 8′ W. But by working the log up to half past 6 A. M. the time when the Sun's alt. was taken, I find the long. of the ship by account was 15° 8′ W. the error of account is therefore, by this observation, one degree too much. By the first observation it was 48½′, and by the second 47′; the mean of the three is 51¾. It may hence be concluded that the true long. made this day at noon was only 10° 12¼′ W. The bearing of the Ram-head will therefore be N. 27° E. dist. 332 leagues, and that of Funchal in Madeira, the lat. of which is 32° 36′ N. and long. 17° 06′ W., S. 36° W. dist. 72 leagues.

 Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ☽, July 27th, 1772.
1	5	4	SW.	NE.	Moderate wind and cloudy.
2	5	4			
3	5		SW. b. S.		
4	4	6			Ditto Weather.
5	4	3			
6	4	3			
7	4	6			
8	4	6			Weather still as above.
9	4	5			
10	4	5			
11	5				
12	4	5			Moderate wind and hazy.
1	5				
2	5				
3	4				
4	4				Ditto weather.
5	4				
6	4	4			
7	4	4			
8	4	2			Moderate wind and hazy.
9	4	5			At 9h. 13m. 4s. by watch the alt of the
10	5				Sun's l. l. was 48° 53¾′, and the az. of his
11	4	3			cent. S. 63° E. At 11h. 45′ 19″ the alt. of
12	4	6			his l. l. was 74° 31′. Cloudy weather.

Course.	Dist.	D. L.	Dep.	Latit. in.	Long. made.	Bearings and dist. at noon.
S 18° W.	116	110	34,7	33°40′ N.	10° 56¼′ W.	Ramh. N. 25½° E. dist. 369 l.

The TRAVERSE TABLE.

True course.	Dist.	S.	W.
S. 28° W.	11	0,7	5,2
S. 17° W.	101	96,6	29,5
		106,3	34,7
Diff. of lat.		1° 46½′	S.
Lat. from		35 30½	N.
Lat. by account		33 44	N.

Allowing 17° W. variation, the traverse table will stand as in the margin where the lat. by account is 33° 44′ N.

The first of the altitudes taken this forenoon, when corrected for dip of the horizon, refraction, and semi-diameter, will be 49° 4½′: the angle comprehended between the Sun's bearing at that time, and the course by compass, is 97°; which, with 12 miles, the dist. run between the observations, give 1½ diff. of lat. to be subtracted; and therefore the first altitude, when reduced to what it would have been if observed where the second was, will be 49° 3′. The second altitude, when corrected for dip, &c. will be 74° 42′; the interval between the observations 2h. 32m. 15s. the lat. of the ship by account at the second observation was 33° 45′ N. and the Sun's declination 19° 4½′ N. Hence (75) the true lat. of the ship, at ¾ past 11 A.M. will be found 33° 41′ N.: and as she made about a mile of southing afterwards, the true lat. of the ship at noon was 33° 40′ N. According to this, the true diff. of lat. was 110,3, with which, and the course 18° W. found with the diff. of lat. and depart. by account, find the dist. 116m. This course, with 134,0, mer. diff. of lat. gives 43½′ for the diff. of long.; and, therefore, taking the long. made yesterday to be 10° 13¼′ W. as corrected by the lunar observations, the long. made this day will be 10° 56¼′ W. and hence the Ram-head bore N. 25½° E. and was dist. 369 leagues.

Journal

Digitized by Google

Journal from England toward Madeira.

Ho.	K.	F.	Courses.	Winds.	Remarks on ♂, July 28th, 1772.
1	4	2	SW.	NE.	Moderate wind and hazy.
2	3	2	W. b. S.		
3	3	4			
4	3	6			Moderate wind and clear weather.
5	3	6			
6	4	2			
7	4	2			Land seen from the mast-head, which we
8	4	4	West.		take to be Porto Sancto.
9	3	4			Weather as above.
10	4				
11	3		W. ½ S.		
12	3				Weather the same.
1	2				
2	1				
3	3				
4	3	2			Moderate wind and hazy.
5	3	4			
6	3	4			
7	3	4			
8	3	4			Porto Sancto N. W. b. N.
9	3				Weather as above.
10	3	4	W b. S.	NNW.	Porto Sancto North.
11	4	2			At noon Porto Sancto NE. ½E. Funchal in
12	4	3			Madei. SW. b. W. Mer. alt. ☉'s L.L. 75°50' S.

Course.	Dif.	D. L.	Dep.	Lat. in.	Long. made.	Bearings and dist. at noon.
S 54° W.	89	51½	73	32°48½' N	12° 23¼' W.	Funchal S. 39° W. dist. 5 lea.

The Traverse Table.

True course.	Dist.	S.	W.
S. 28° W.	4	3,5	1,9
S. 62 W.	23	0,8	20,3
S. 73 W.	12	3,5	11,5
S. 67 W.	32	12,5	29,5
S. 52 W.	12	7,4	9,5
		37,7	72,7

In working the log. for these 24 h. 17° of west variation are allowed, and also 10° for lee-way on the latter W. b. S. course, because the ship was then only seven points from the wind. The traverse table will be as in the margin, where it appears that the diff. of latit. by the dead-reckoning will be only 37,7 m. whereas, by the observation, the ship has made 51,5 m. the latit. observed being 32° 48½' N. To correct this, I find the course made good, according to the dead-reckoning, is S. 62½° W., the correction must therefore be made by Case II. (82). Now against 51,5, the diff. of lat. by observation, in the column of diff. of latitude, and against 72,7 in the depart. column, stands 89, in the dist. col. over 54½° for the course. The sum of the lat. from and lat. in is 66° 28½'; half of which is 33° 14¼', the middle lat. and the compt. of this is 56° 45¾'; over which, as a course, and against 72,7, depart. stands 87 in the dist. col. for the diff. of long. and, consequently, the log. made this day at noon was 12° 23¾' W. Hence the Ram-head bore N. 27½° E. and was distant 394 leagues.

Again, Funchal, which is in latit. 32° 37' N., bore SW. b. W. by compass; that is, S. 39° W. true: and, the latit. of the ship being 32° 48½' N. the diff. of lat. was 11,5, and the meridional diff. of lat. 13,7: the ship was therefore 15 m. dist. from thence; and east of it in long. 11¼; consequently the longit. of Funchal, by this account is 16° 56' W. of Greenwich.

Digitized by Google

APPENDIX,

Containing the Principles, upon which some of the preceding Precepts are founded.

124. I. *The Theory of Davis's Quadrant.* Plate XIV. Fig. 9.

To shew that the arcs DF + HC make the zenith distance.

The line AH is horizontal.

Therefore the arc *f*BH = height of the Sun above the horizon.

Now the arc *f*BH = arc FE + BH.

Also the arc *dfc* = 90°; = alt. and zen. dist. taken together.

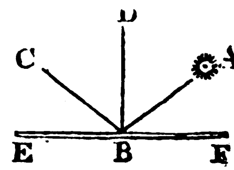
Therefore the zen. dist. = arcs *fd* + HC = arc DF + HC.

125. *Allowing the Sun's semidiameter in using the Shade vane.* Fig. 10.

AB represents the Sun, the center of which is C, and its rays pass over the top of an upright wall DE. It is evident, that no part of the Sun can be seen from *a*, and that the whole can but just be seen from *b*; the shadow will therefore begin to terminate at *a*, and wholly end at *b*, going off gradually from total darkness at *a* to total brightness at *b*, neither the beginning nor end of this penumbral part being perceptible; consequently, neither the upper or lower limb can be observed accurately; but we shall be able to come nearer to one or the other, the brighter the Sun shines. On account of this uncertainty, seamen are obliged to take the middle Point between these, which gives the altitude, or zenith dist. of C, the center. Nothing, therefore, must be allowed for the Sun's semi-diameter.

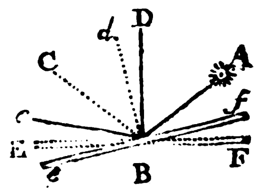
126. II. *Of the Theory of Hadley's Quadrant.*

To what has already been said of this most excellent instrument, it has been judged proper to shew also, upon what principles it is constructed.

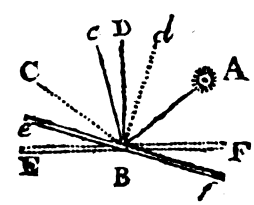


A ray of light AB falling on a mirror, or polished plane, EF, will be reflected in the line BC, so that the angle of reflection DBC, shall be equal to the angle of incidence DBA, DB being perpendicular to EF: or ∠FBA is equal to ∠EBC.

Let the angle of incidence DBA, be 30°, the angle of reflection DBC will be 30° also; and the like in other inclinations.



If, while the radiant A remains in the same place, the mirror EF, by revolving round B, moves into the position *fe*; then the alteration in the angle between the incident and reflected ray, will be double the angle shewing the change of position in the mirror.

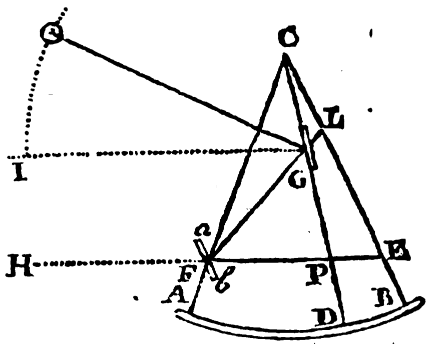


Suppose the mirror changes 10° from the radiant, then the perpendicular BD goes 10° farther from the radiant A, into the position B*d*; and the incident angle *d*BA is 40°; and the reflected angle *d*B*c* is 40°; so the angle ABC is altered from 60° to 80°; a difference of 20°, for 10° change of position in the mirror.

Suppose the mirror to change in position 10° towards the radiant A, then the perpendicular is changed into B*d*, 10° nearer to the radiant. And the angle DBA of of 30° becomes *d*BA of 20° = ∠*d*BC; so that the angle ABC is 40°, whereas ABC was 60°; that is, by altering the position of the mirror 10° the angle ABC was altered 20 degrees.

The following proposition was received from a friend: *

127. *With a Hadley's quadrant, the angle of elevation under which the object is seen, is equal to twice the arch the index has passed over.*



The instrument or angle ACB, is 45 degrees: *ab* is a reflecting glass fixed parallel to CB: CD is the index, with the reflecting glass at G, so fixed as to be parallel to *ab*, when CD coincides with CB:

⊙ the Sun, ⊙ G a solar ray reflected from G to F, and from F to E, the place of the eye:

HFE the horizontal line at the time of the observation.

Then is the angle of elevation IGO equal to twice the angle BCD.

For the reflected ∠ DGF = incident ∠ ⊙GC = ∠ CGL. (I. 93)

And the reflected ∠ *b*FE = incident ∠ *a*FG = ∠ FLE = ∠ FEL. (I. 95)

Now ∠ IGC = (∠ HPC = (∠ PCE + (∠ PEC = ∠ FLE =) ∠ GCL + ∠ CGL. (I. 96)

Or (∠ IGC = (∠ IG⊙ + ∠ ⊙GC = 2∠ BCD + ∠ CGL;

Then ∠ IG⊙ = 2∠ BCD.

128. III. *Of the Dip of the Horizon.* Plate XIV. Fig. 12.

The eye being raised above the level of the sea observes an horizon below the level of the true one.

Thus let *asf* be the surface of the sea, ES the height of the eye above that surface, and AF the observer's horizon. Then the eye looking along E*a* for the horizon which dips below the true one by the arc A*a*, the apparent altitude *a*B of an object B must evidently be lessened by the arc A*a*. But if the observer has his back towards the object B; then looking along the line E*f*, the apparent horizon now becoming the line *f*E*c*, and dipping below the true one by the arc F*f*, or A*c*; it is plain the apparent altitude *c*B is too little, and must be augmented by the arc A*c* = F*f*.

Consequently in the fore observations, the altitude must be lessened by the horizontal dip; and in the back observations, the altitude must be increased by the dip; but in zenith distances, add the dips forward, and subtract them backward.

129. *To compute the Horizontal Dips.*

Let C be the earth's center, E the eye, and the tangent E*f* meeting the surface in *f*, where the sky and water seem to meet; then C*f*E is a triangle right-angled at *f*, in which are known C*f* = CS = 20899059 feet, the Earth's semidiameter; and CE = (CS + SE) the height of the eye added to the Earth's radius: Then as CE : rad. : : C*f* : sin. ∠ CE*f*, the complement of which is the ∠ FE*f*, the dip sought.

---

* Mr. William Payne.

Digitized by Google

130. IV. *Of Refraction.*

Celestial objects, the nearer they are to the horizon, are seen through a larger portion of the atmosphere, and consequently have a greater quantity to be allowed for refraction, than when they are seen with greater altitudes.

Tables of refraction have been given by many astronomers, but that which is esteemed the most correct, was formed from the observations of the late celebrated Dr. Bradley; who also found a rule for correcting common tables of refraction: which is,

Increase any given altitude by thrice the refraction on that altitude.

Then to the log. co-tangent of that sum, add the log. 1,75587.

The sum lessened by 10 in the index is the log. number of seconds in the refraction; which is more correct than the table.

Here 1,75587 is the log. of 57″ the mean refraction on an alt. of 45°.

This rule is fitted to a mean warmth and weight of the atmosphere, viz. to the height 50 in Fahrenheit's Thermometer, and to the height 29,6 of the Barometer. For other states of the air, Dr. Bradley gave a rule for a farther correction; but it is apprehended, that neither of these corrections need be applied to the table of refractions, for any observations but such where there is wanted a precision not to be obtained at sea.

131. V. *Demonstrations of the Rules at Articles* 60, 61, 62.

See Plate XIV. Figures 13, 14, 15.

Let the circle HZRN represent the meridian of the place, HR the horizon, and Z its zenith or pole: let PS represent the axis, P being the north, and S the south pole; the line EQ the equator, ☉ the place of the Sun, the arc Z ☉ the zenith distance, and E ☉ the declination.

Now the latitude is expressed either by the height of the pole above the horizon, or by the distance of the equator from the zenith; consequently the arc RP (=HS), or the arc ZE, being known will give the latitude.

But the arc ZE is always equal to the sum of the arcs Z ☉ and E ☉ when of contrary names; or to their difference when of the same name.

When the object does not set, its least altitude R ☉ added to the arc P ☉, or co-declination gives RP, the height of the pole above the horizon; or the latitude sought: the same may be understood, were the least altitude above the south point of the horizon to be observed. Fig. 15, 132.

Hence it will be easy to construct any of these cases. Thus:

Set the zenith distance from Z, to the left if south, but to the right if north; and this gives ☉ the place of the Sun.

Set the declination from ☉, to the right if south, but to the left if north; and this gives E the place of the equator.

Then drawing the diameter EQ, and the diameter PS at right angles to EQ, the latitude will be north or south, according as P or S falls above the horizon.

133. VI.

133. VI. *Of Facio's Problem.*

In the year 1728 Mr. *Nicholas Facio Duillier*, F. R. S. publiſhed a pamphlet, intitled, *Navigation Improved*, in which he conſidered more at large, than had been done before, the problem for finding the latitude from two obſervations of the Sun's altitude out of the meridian, with the time between them, which he ſtates in the following terms.

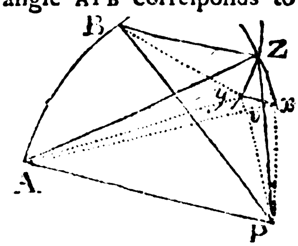
134. PROBLEM.

To find the latitude, by two altitudes of the Sun, and the time between them, ſuppoſing the obſervations to have been made from the ſame place, or from different places, whether at ſea or land. And likewiſe to find the hours, and the Sun's azimuths, at the times of both obſervations.

Thus he propoſes expreſsly to diſtinguiſh between the caſe, when the two obſervations are made in the ſame place, and when, by the motion of the ſhip, in the interval between them, they are made under different zenith's; which does not appear to have been attempted before. He alſo extends the interval of time between the obſervations farther than is uſually done, not confining them within the compaſs of one day; but makes them ſo remote, that the change in the Sun's declination may be neceſſary to be taken notice of.

His method of proceeding is this:

Suppoſing P the elevated pole, A and B the two places of the Sun, and AP, PB, AB, arcs of great circles paſſing through the points P, A, and B. Then if PA be the diſtance of the Sun from the pole P in the firſt obſervation, and PB its diſtance in the ſecond, the angle APB correſponds to the time between the obſervations, whether that angle repreſents the whole interval of time, or only its difference from one or more entire days, Z alſo denoting the zenith of the place, when both the obſervations are made under the ſame.



Here, if the interval of time be large, AP may be different from PB. Therefore in the triangle APB from AP, BP, and the angle APB, he finds the ſide AB; then from the three ſides AB, BP, and AB, either of the angles PAB, PBA may be known; alſo from AZ, ZB and AB in the triangle AZB, either of the angles ABZ, BAZ; and in the laſt place, from theſe angles with ABP, or BAP, may be deduced the angle ZAP or ZBP, whence in either of the triangles PAZ or PBZ, PZ may be computed, the diſtance of the zenith Z from the pole.

He likewiſe farther propoſes to compute the angles APZ, BPZ for aſſigning the diſtance of each obſervation from noon, in order to determine the time of the day when they were reſpectively made.

All theſe trigonometrical operations he performs by one axiom (See Art. 251. Book IV.) in the doctrine of ſpherical triangles, which had

7 been

Digitized by Google

been applied by others alſo, not only to the finding of an angle from three ſides given, but likewiſe to the computing of the third ſide from two ſides, and an angle between them.

But when the ſhip is in motion, Z is not to be conſidered as the zenith of the ſhip in either obſervation. However, in the firſt obſervation the ſhip's zenith will always be in a circle deſcribed on A, as a pole, and with the interval AZ, ſuppoſe in *x*, and in the other obſervation will be in a circle deſcribed to the pole B with the interval BZ, ſuppoſe in *y*, the arch *x y* denoting the ſhip's courſe, making with the meridian of the firſt obſervation the angle P *x y*.

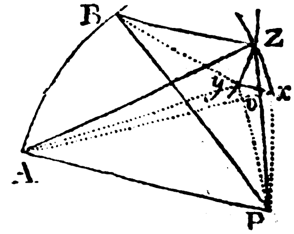
This angle P *x y*, and the length of the arc *x y* are to be aſſigned by the compaſs and log-line.

Now when the ſhip has been in motion during the interval between the obſervations, and theſe two additional *data* are added to the altitudes of the Sun, and the interval of time, *Facio* proceeds thus:

Having found the point Z, as before, he computes in the triangle AZP, from AP, AZ, PZ, the angle AZP; alſo in the triangle BZP from BP, BZ, PZ, the angle BZP, and from the angles AZP, BZP, the angle AZB, which (the angles AZ*x* and BZ*y* being both right) will be equal to *y* Z *x*.

Then ſuppoſing the diſtance run *x y* to be ſo ſmall an arch, that the triangle *x* Z *y* may be conſidered as rectilinear without any ſenſible error; and alſo that the angle *x* P Z is ſo ſmall, that *x y* meeting P Z in *v*, the angle P *v y* may be aſſumed, as not ſenſibly differing from the angle of the ſhip's courſe; whence the angle BZP having been computed, and thence the angle *y* Z *v* known (B Z *y* being a right angle) from the angles *y* Z *v* and Z *v y*, the angle Z *y x*, which is the complement of the angle which the ſhip's courſe makes with BZ, will be known; then from the angles *x* Z *y*, Z *y x*, together with the ſide *y x*, he finds the ſide Z *x*; and laſtly, in the triangle P*x* Z from *x* Z, Z P, and the angle *x* Z P, the ſide P*x* is found for the complement of the ſhip's latitude at the firſt obſervation; as alſo the angle Z P *x*, and thence the angle A P *x*, the diſtance of the obſervation with the Sun in A from the meridian, in which that obſervation was made.

And farther, *Facio* conſidering this computation, though it came very near the truth, as an approximation only, from the aſſumption of the angles *yx*P, and Z *v x*, as equal, and the triangle Z *x y* as rectilinear, he proceeds to correct the latitude, and the angle *x* P Z thus found, as follows:



He aſſumes at pleaſure two values for Z *x* (or rather for the arch of a great circle paſſing through Z and *x*) one ſomewhat greater, and the other ſomewhat leſs, than the value of Z *x* now computed. Then for each value of Z *x*, he finds in the triangle P *x* Z from the ſides P Z, Z *x*, and the angle P Z *x*, the ſide P *x* and angle *x* P Z; and in the triangle P *x y* from P *x* now found with *x y*, and the angle P *x y* given from the courſe and diſtance run by the ſhip from *x* to *y*, he computes P *y*, and the angle *x* P *y*. Then from

Digitized by Google

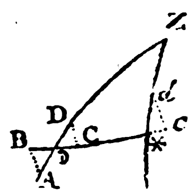
from the angles xPZ, xPy finding the angle yPZ, and thence yPB, at length in the triangle BPy from PB, Py, and the angle BPy computes By.

If By, thus computed, comes out equal to BZ, then is the value of Zx, whence it is deduced, rightly assumed; but if the value in both the computations differ from the truth Px, and the angle ZPx are to be corrected by the simple rule of false position.

But this method of *Facio* is attended with an operose calculation, even though the second correction, which will always be but small, should be neglected. And the expedient proposed by Mr. Graham (Philosophical Transactions, N° 435) of observing by an azimuth compass, the angle which the ship's course makes with the azimuth circle of the Sun in one of the observations, which has been explained above (Book IX. Article 76) is much more simple.

135. VII. *Of Mr. de la Caille's Scales.*

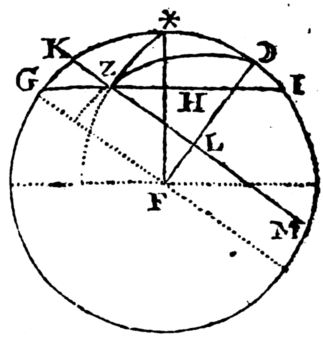
As the preceding methods of computing the true distance of the Moon from the Sun, or from a fixed star, requires a calculation, by some supposed too operose for mariners in general to be easily reconciled to; an instrument, accompanied with three compound scales, is proposed by the late able astronomer, the Abbé de la Caille. These scales are not described with sufficient distinctness to enable a workman to make them with accuracy; but the first consists only of two scales of natural sines set at right angles to one another, and is necessary only in his method, which requires, besides the distance of the Moon from the star, the altitudes of that star to be observed a little time before the distance is taken, and both the altitude and azimuth of the Moon to be observed some little time after, (supposing all the observations to be taken by one person.) The other two scales are the principal, and are contrived for assigning the effect of the Moon's parallax, and the refraction both of the Moon and star upon their apparent distance; and are grounded on this principle, that the effect of the Moon's parallax on the observed distance, is to the parallax in altitude as the co-sine of the angle between the Moon's azimuth circle and her distance from the star to the radius; and that the like proportion obtains in regard to the refraction of the Moon and the star.



If Z be the zenith of any place, ZA the azimuth circle in which the Moon is at ☽; but by her parallax appearing in A, and Z ✳ be the azimuth wherein the star is placed at ✳; a perpendicular, as AB, being let fall on ☽ ✳ from A; the parallax in altitude, ☽ A, will be to ☽ B, the effect of that parallax on the distance ☽ ✳, as radius to the co-sine of the angle A ☽ B.

In like manner if ☽ be the place of the Moon, ☽ D the effect of the refraction on her altitude, and ☽ C be the effect of that refraction on the distance ☽ ✳; ☽ D will be to ☽ C, as radius to the co-sine of the angle D ☽ C: and the refraction of the star will have a similar effect on the distance ☽ ✳.

Now



Now the triangle z ☽ * being projected orthographically on the circle passing through ☽ *, as in the annexed figure, in which F *, F ☽ are drawn from the center F: through z let GHI, perpendicular to * F, and KLM, perpendicular to F ☽, be drawn; then is GZ the versed sine, and ZH the co-sine of the angle z * G, to the radius GH; and also KZ the versed sine, and ZL the co-sine of the angle z ☽ * to the radius KL; moreover, FH is the co-sine of the arch z * (= * G), and FL is the co-sine of the arch z ☽ (= ☽ K), to the radius of the circle G * ☽.

Hence if in any circle lines as F *, F ☽, be drawn from the center, making an angle * F ☽ equal to the apparent distance of the Moon and star, and FH be taken equal to the sine of the star's altitude, and FL the sine of the Moon's altitude; the perpendiculars HG, and LK, being drawn intersecting each other in z, LK will be to LZ as the Moon's refraction, or parallax in altitude, to their effect on the distance. And in like manner GH will be to HZ, as the refraction of the star to the effect of that refraction on the distance of the star from the moon. But, moreover, in regard to the Moon's parallax, KL is the sine of the arch ☽ z, the Moon's distance from the zenith, to the radius F ☽ of the circle; and consequently the Moon's horizontal parallax will be to the effect of her parallax on the distance from the star, as F ☽, the semidiameter of the circle, to LZ.

Upon these principles the two scales, relating to the parallax and the refraction, are to be constructed. But the method is attended with this inconvenience, that when the arch ☽ * is small, the lines HZ, LZ, will cross each other so very obliquely, as to make their true magnitude too uncertain; and this the author of the method seems not to have been unapprized of, by requiring that the distance should not be less than 10 degrees.

Digitized by Google

136. VIII. *Of the times of the Moon's phases, and the time of High Water.*

The methods given in Book VI. at Articles 130, 135, 136, for computing the Moon's age, southing, and time of high-water, frequently give those times many hours wide of the truth, and may occasion fatal accidents. It has therefore been judged proper to shew how the times of high-water are to be found more accurately, unless when the tides are made irregular by strong winds.

In the Nautical Almanac, the first page of every month contains the Moon's phases at Greenwich; which are easily transferred to any other place, the longitude of which is known, by the following

Rule. To the Greenwich time of the proposed phase apply the difference of longitude in time (57), and it will give the time of that phase at the place proposed.

Exam. I. *At what times in May 1773 did the several phases of the Moon happen at Canton in China?*

Canton is E. of Greenwich (113° $1\frac{1}{2}'$=) 7h. 32m.

Then the times at Canton for the Moon's phases in May 1773, will be

Full Moon	6 d.	12 h.	34 m.	(=6 d. 5 h. 2 m. + 7 h. 32 m.
Last Quarter	13	7	0	
New Moon	21	10	15	
First Quarter	29	4	55	

Exam. II. *At what times in March 1773 did the several phases of the Moon happen at Halifax in Nova Scotia?*

Halifax is west of Greenwich (63° 31'=) 4 h. 14 m.

Then at Halifax the times of the phases required will be

First Quarter	1 d.	0 h.	17 m.	(=1 d. 4 h. 31 m.—4 h. 14 m.)
Full Moon	8	6	41	
Last Quarter	14	22	15	
New Moon	22	12	8	
First Quarter	30	17	45	

107. Of

Digitized by Google

137. *Of the time of High-water.*

The times of high-water at the syzigies are nearly the same in most places; but the times of high-water from day to day between the syzigies do not alter 48 minutes, as is usually reckoned in pilotage; the difference being sometimes more, sometimes less, according as the waters are acted on, either by the sum of the attractive forces of the Sun and Moon, or by their difference, considered in respect to the places of the Earth and Moon relative to the Sun.

The following table * being used with the time of either phase of the Moon, will, in general, shew the time of high-water within a quarter of an hour of the truth at any known port, when the tides are not greatly influenced by the winds.

138. TABLE.

Of the correction to be applied to the time of high-water on the syzigies, to give the time of high-water on any other day.

Interv. of time.	After n. moon	Before 1st qu.	After 1st qu.	Before f. moon	After f. moon	Before 3d qu.	After 3d qu.	Before n. moon	Interv. of time.
	Addit.	Addit.	Addit	Subtr.	Addit.	Addit.	Addit.	Subtr	
D. H.	H. M.	H. M.	H. M.	H. M.	H. M	H. M.	H. M.	H. M.	D. H.
0 0	0 0	5 6	5 6	0 0	0 0	5 6	5 6	0 0	0 0
6	0 8	4 51	5 22	0 9	0 8	4 51	5 22	0 9	6
12	0 17	4 37	5 40	0 18	0 17	4 37	5 40	0 18	12
18	0 26	4 23	6 0	0 27	0 26	4 23	6 0	0 27	18
1 0	0 36	4 9	6 20	0 37	0 36	4 9	6 20	0 37	1 0
6	0 45	3 56	6 39	0 47	0 45	3 56	6 39	0 47	6
12	0 54	3 44	6 58	0 57	0 54	3 44	6 58	0 57	12
18	1 2	3 32	7 18	1 7	1 2	3 32	7 18	1 7	18
2 0	1 11	3 21	7 37	1 17	1 11	3 21	7 37	1 17	2 0
6	1 19	3 11	7 56	1 28	1 19	3 11	7 56	1 28	6
12	1 28	3 1	8 14	1 39	1 28	3 1	8 14	1 39	12
18	1 37	2 50	8 31	1 51	1 37	2 50	8 31	1 51	18
3 0	1 46	2 40	8 47	2 4	1 46	2 40	8 47	2 4	3 0
6	1 54	2 30	9 2	2 16	1 54	2 30	9 2	2 16	6
12	2 3	2 21	9 17	2 29	2 3	2 21	9 17	2 29	12
18	2 12	2 12	9 31	2 44	2 12	2 12	9 31	2 44	18
4 0	2 21	2 3	9 44	2 58	2 21	2 3	9 44	2 58	4 0

If the time to be sought in this table is between the hours in the outside columns, the equation is to be corrected by proportional parts.

* From M. de la Caille.

James Macully's Book.

Digitized by Google

139. ## PROPOSITION I.

The time of high-water in any port on the syzigies, or days of new and full moon being known, to find the time of high-water in that port on any other day.

SOLUTION.

1st. In the Nautical Almanac, seek in the given month, or in that immediately preceding or following it, for the time of that phase which happens nearest to the given day; and take the difference of those times.

2d: In table (138.) this diff. of time gives an equation, which being applied to the time of the syzigie high-water for the given port (IV. 137) as its title directs, gives the time of the afternoon high-water in that port.

But if the time of the morning high water is required.

1st. Do as directed in the 1st article above, and increase the said diff. by 12 hours, if the given day falls before the phase.
Or diminish it by 12 hours, when after the phase.

2d. The equation to this time (138) applied to the syzigie time (IV. 137) gives the morning time of high-water.

EXAM. I. *At Portsmouth, where it is high-water on the syzigies at 11h. 15m.: Required the afternoon and morning times of high-water on the 13th of January, and on the 2d of February, in the year 1773.*

Here the nearest phase to January 13, is Jan. 15d. 10h. 10m.
So the time proposed is 2d. 10h. 10m. before the 3d or last quarter.
To 2d. 10h. and before 3d. 9h. the equation is 3h. 5m.
Then 11h. 15m. + 3h. 5m. = 14h. 20m. or high-water at 2h. 20m. P.M.
Again 2d. 10h. 10m. + 12h. = 2d. 22h. 10m. the eq. to which is 2h. 44m.
Then 11h. 15m. + 2h. 44m. = 13h. 59m. or high-water at 1h. 59m. A.M.
To Feb. 2d. the nearest phase is the 1st quarter, on Jan. 30d. 7h. 53m.
And as Feb. 2d. may be called Jan. 33d.
Their diff. or time after the first quarter, is 2d. 16h. 7m.
The equation to which is 8h. 26m.
Then 11h. 15m. + 8h. 26m. = 19h. 41m. Or high-water at 7h. 41m. P.M.
Again 2d. 16h. 7m. — 12h. = 2d. 4h. 7m.; the equ. to which is 7h. 50m.
Then 11h. 15m. + 7h. 50m. = 19h. 5m. Or high-water at 7h. 5m. A.M.

EXAM. II. *On the 11th of March 1773, required the times of high-water at Halifax in Nova Scotia, where the syzigie time of high-water is at 7h. 30m.*

Halifax is W. of Greenwich (63° 20′ =) 4h. 13m. 20s.
The nearest phase to March 11 is full moon, at 8d. 10h. 55m.
Which fitted to Halifax becomes 8d. 6h. 41m. 40s. (136)
March 11, is after full moon, 2d. 17h. 19m. its equation is 1h. 35m.
Then 7h. 30m. + 1h. 35m. = 9h. 5m. P.M. the time of high-water.
Again 2d. 17h. 19m. — 12h. = 2d. 5h. 19m.; its equation is 1h. 18m.
Then 7h. 30m. + 1h. 18m. = 8h. 48m. A.M. the time of high-water.

140. ## PROPOSITION II.

The time of high water in any port being observed on any day, to find the time of high-water in that port on the syzigies.

SOLUTION.

1st. By the difference of longitude reduce the given time to Greenwich time. (57)

2d. Take the difference between this time and that of the Moon's nearest phase. (136)

3d. The

Digitized by Google

3d. The equation in table, Art. 138. to this diff. applied to the said Greenwich time, contrary to what its title directs, will give the syzigie time of high water at that port.

Exam. I. *Suppose the time of high-water was observed in a port to be at 5h. P. M. when it wanted 3d. 17h. of the time of new moon; Required the time of high-water there on the day of new moon.*

Now 3d. 17h. before new moon give an equation of 2h. 41m.
The column directs subtraction, the contrary is addition.
Then 5h.+2h.41m.=7h.41m. P. M. the syzigie time of high-water.
Also 3d. 17h.+12h.=4d. 5h. the equation to which is 3h. 10m.+
Then 5h.+3h.10m.=8h. 10m. A.M. the time of new moon high-water.

Exam. II. *Suppose on the 19th of March, 1773, at 8h. 11m. P. M. it was observed to be high-water in the river Senegal? What is the time of high-water on the full and change days?*

The river Senegal is west of Greenwich (16° 20′=) 1h. 5m.

The nearest phase to March 19th, is the third quarter, at 15d. 2h. 29m. which fitted to Senegal, makes 15d. 1h. 24m.

The 19th day is after the third quarter, 3d. 22½h.; its equation is 9h. 41m. which is subtractive, contrary to its title in the table.

Then 8h. 11m.—9h. 41m.=10h. 30m. the time of high-water on the days of the full and change of the moon in the river Senegal.

141. *Of the cause why the moon appears to rise nearly at the same time for several days together at some seasons of the year.*

There are few mariners who have not observed at certain times, that the moon appears to rise or set for several days together at the same time nearly, notwithstanding that she is known to be retarded nearly 48 minutes in each day's motion.

This appearance arises chiefly from the daily alteration of 5 or 6 degrees in the moon's declination, when she is near the celestial equator. Now a change in the declination of celestial bodies will cause them to rise or set sooner or later, as well as when the observer changes his latitude.

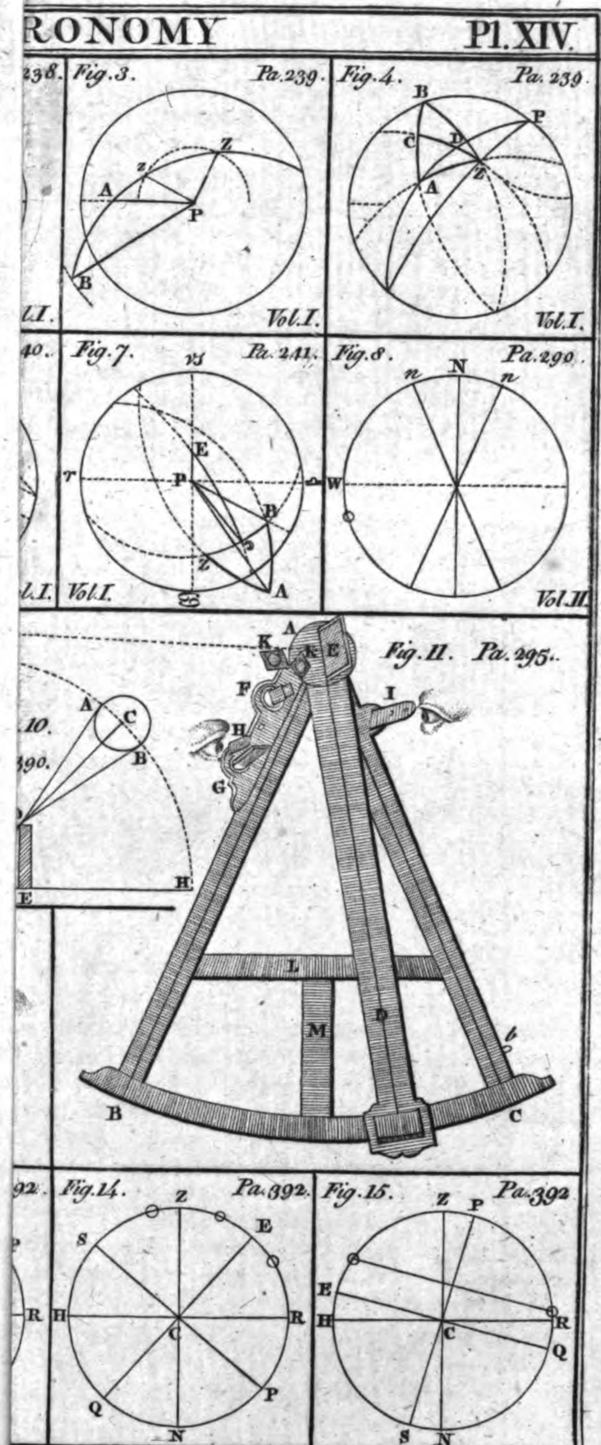
Thus in the latitude of 50 degrees, when the Sun has 6° of declination, he rises at 5h. 31m.; but when he has no declination, he rises at 6 o'clock; so that a change of 6° in declination near the equinox accelerates the rising 29 minutes.

By a like change in the moon's declination her rising or setting may be quickened or delayed half an hour; but half an hour's acceleration diminishes a great part of the 48 minutes of daily retardation which she ought to have; and if to this be joined the apparent acceleration which may be caused by a less velocity in the motion of the moon near her apogee, and also that which may arise from an alteration of 3 or 4 degrees in the ship's latitude in 24 hours; it will follow, that the rising of the moon will not appear to be sensibly retarded for several days together.

Now the same cause which accelerates the rising retards the setting; so when the moon appears to rise for several days together about the same hour, its setting will appear to be retarded nearly the double of 48 minutes, or about an hour and half. On the contrary, if its setting is nearly about the same hour for several days, its rising will appear to be retarded almost double of its known daily motion.

Articles

Digitized by Google



Page 352

Digitized by Google

Articles 142, 143, 144, 145.

LOGARITHMIC TABLES.

I. The LOGARITHMS of NUMBERS from 1 to 120.

II. The LOGARITHMIC SINES, TANGENTS and SECANTS, to every Point and Quarter-Point of the COMPASS.

III. The LOGARITHMS of NUMBERS, from 100 to 10000.

IV. The LOGARITHMS of the SINES and TANGENTS to every Degree and Minute of the QUADRANT.

Digitized by Google

142. A TABLE

Of Numbers and their Logarithms from 1 to 120.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0,00000	21	1,32222	41	1,61278	61	1,78533	81	1,90849	101	2,00432
2	0,30103	22	1,34242	42	1,62325	62	1,79239	82	1,91381	102	2,00860
3	0,47712	23	1,36173	43	1,63347	63	1,79934	83	1,91908	103	2,01284
4	0,60206	24	1,38021	44	1,64345	64	1,80618	84	1,92428	104	2,01703
5	0,69897	25	1,39794	45	1,65321	65	1,81291	85	1,92942	105	2,02119
6	0,77815	26	1,41497	46	1,66276	66	1,81954	86	1,93450	106	2,02531
7	0,84510	27	1,43136	47	1,67210	67	1,82607	87	1,93952	107	2,02938
8	0,90309	28	1,44716	48	1,68124	68	1,83251	88	1,94448	108	2,03342
9	0,95424	29	1,46240	49	1,69020	69	1,83885	89	1,94939	109	2,03743
10	1,00000	30	1,47712	50	1,69897	70	1,84510	90	1,95424	110	2,04139
11	1,04139	31	1,49136	51	1,70757	71	1,85126	91	1,95904	111	2,04532
12	1,07918	32	1,50515	52	1,71600	72	1,85733	92	1,96379	112	2,04922
13	1,11394	33	1,51851	53	1,72428	73	1,86332	93	1,96848	113	2,05308
14	1,14613	34	1,53148	54	1,73239	74	1,86923	94	1,97313	114	2,05690
15	1,17609	35	1,54407	55	1,74036	75	1,87506	95	1,97772	115	2,06070
16	1,20412	36	1,55630	56	1,74819	76	1,88081	96	1,98227	116	2,06446
17	1,23045	37	1,56820	57	1,75587	77	1,88649	97	1,98677	117	2,06819
18	1,25527	38	1,57978	58	1,76343	78	1,89209	98	1,99123	118	2,07[illegible]88
19	1,27875	39	1,59106	59	1,77085	79	1,89763	99	1,99564	119	2,07555
20	1,30103	40	1,60206	60	1,77815	80	1,90309	100	2,00000	120	2,07918

143. A TABLE

Of Logarithmic Sines, Tangents and Secants, to every Quarter-Point of the Compass.

Pts.	Sines.	Co-sines.	Tangents.	Co-tang.	Secants.	Co-secan.	
0	0,00000	10,00000	0,00000	Infinite.	10,00000	Infinite.	8
0¼	8,69079	9,99948	8,69132	11,30868	10,00052	11,30921	7¾
0½	8,99130	9,99790	8,99340	11,00660	10,00210	11,00870	7½
0¾	9,16652	9,99527	9,17125	10,82875	10,00473	10,83348	7¼
1	9,29024	9,99157	9,29866	10,70134	10,00843	10,70976	7
1¼	9,38557	9,98679	9,39878	10,60122	10,01321	10,61443	6¾
1½	9,46282	9,98088	9,48194	10,51806	10,01912	10,53718	6½
1¾	9,52748	9,97384	9,55365	10,44635	10,02616	10,47252	6¼
2	9,58284	9,96562	9,61722	10,38277	10,03438	10,41716	6
2¼	9,63099	9,95616	9,67483	10,32517	10,04384	10,36901	5¾
2½	9,67339	9,94543	9,72796	10,27204	10,05457	10,32661	5½
2¾	9,71105	9,93335	9,77770	10,22230	10,06665	10,28895	5¼
3	9,74474	9,91985	9,82489	10,17511	10,08015	10,25526	5
3¼	9,77503	9,90483	9,87020	10,12980	10,09517	10,22497	4¾
3½	9,80236	9,88819	9,91417	10,08583	10,11181	10,19764	4½
3¾	9,82708	9,86979	9,95729	10,04271	10,13021	10 17292	4¼
4	9,84948	9,84948	10,00000	10,00000	10,15052	10,15052	4
	Co-sines.	Sines.	Co-tang.	Tangents.	Co-secan.	Secants.	Pts.

Digitized by Google

Numbers from 100 to 1599. Logs. from ,00000 to ,20385.

No	0	1	2	3	4	5	6	7	8	9
100	,00000	,00043	,00087	,00130	,00173	,00217	,00260	,00303	,00346	,00389
101	,00432	,00475	,00518	,00561	,00604	,00647	,00689	,00732	,00775	,00817
102	,00860	,00903	,00945	,00988	,01030	,01072	,01115	,01157	,01199	,01242
103	,01284	,01326	,01368	,01410	,01452	,01494	,01536	,01578	,01620	,01662
104	,01703	,01745	,01787	,01828	,01870	,01912	,01953	,01995	,02036	,02078
105	,02119	,02160	,02202	,02243	,02284	,02325	,02366	,02407	,02449	,02490
106	,02531	,02572	,02612	,02653	,02694	,02735	,02776	,02816	,02857	,02898
107	,02938	,02979	,03019	,03060	,03100	,03141	,03181	,03222	,03262	,03302
108	,03342	,03383	,03423	,03463	,03503	,03543	,03583	,03623	,03663	,03703
109	,03743	,03782	,03822	,03862	,03902	,03941	,03981	,04021	,04060	,04100
110	,04139	,04179	,04218	,04258	,04297	,04336	,04376	,04415	,04454	,04493
111	,04532	,04571	,04610	,04650	,04689	,04727	,04766	,04805	,04844	,04883
112	,04922	,04961	,04999	,05038	,05077	,05115	,05154	,05192	,05231	,05269
113	,05308	,05346	,05385	,05423	,05461	,05500	,05538	,05576	,05614	,05652
114	,05690	,05729	,05767	,05805	,05843	,05881	,05918	,05956	,05994	,06032
115	,06070	,06108	,06145	,06183	,06221	,06258	,06296	,06333	,06371	,06408
116	,06446	,06483	,06521	,06558	,06595	,06633	,06670	,06707	,06744	,06781
117	,06819	,06856	,06893	,06930	,06967	,07004	,07041	,07078	,07115	,07151
118	,07188	,07225	,07262	,07298	,07335	,07372	,07408	,07445	,07482	,07518
119	,07555	,07591	,07628	,07664	,07700	,07737	,07773	,07809	,07846	,07882
120	,07918	,07954	,07990	,08027	,08063	,08099	,08135	,08171	,08207	,08243
121	,08279	,08314	,08350	,08386	,08422	,08458	,08493	,08529	,08565	,08600
122	,08636	,08672	,08707	,08743	,08778	,08814	,08849	,08884	,08920	,08955
123	,08991	,09026	,09061	,09096	,09132	,09167	,09202	,09237	,09272	,09307
124	,09342	,09377	,09412	,09447	,09482	,09517	,09552	,09587	,09621	,09656
125	,09691	,09726	,09760	,09795	,09830	,09864	,09899	,09934	,09968	,10003
126	,10037	,10072	,10106	,10140	,10175	,10209	,10243	,10278	,10312	,10346
127	,10380	,10415	,10449	,10483	,10517	,10551	,10585	,10619	,10653	,10687
128	,10721	,10755	,10789	,10823	,10856	,10890	,10924	,10958	,10992	,11025
129	,11059	,11093	,11126	,11160	,11193	,11227	,11260	,11294	,11327	,11361
130	,11394	,11428	,11461	,11494	,11528	,11561	,11594	,11628	,11661	,11694
131	,11727	,11760	,11793	,11826	,11860	,11893	,11926	,11959	,11992	,12024
132	,12057	,12090	,12123	,12156	,12189	,12222	,12254	,12287	,12320	,12352
133	,12385	,12418	,12450	,12483	,12516	,12548	,12581	,12613	,12646	,12678
134	,12710	,12743	,12775	,12808	,12840	,12872	,12905	,12937	,12969	,13001
135	,13033	,13066	,13098	,13130	,13162	,13194	,13226	,13258	,13290	,13322
136	,13354	,13386	,13418	,13450	,13481	,13513	,13545	,13577	,13609	,13640
137	,13672	,13704	,13735	,13767	,13799	,13830	,13862	,13893	,13925	,13956
138	,13988	,14019	,14051	,14082	,14114	,14145	,14176	,14208	,14239	,14270
139	,14301	,14333	,14364	,14395	,14426	,14457	,14488	,14520	,14551	,14582
140	,14613	,14644	,14675	,14706	,14737	,14768	,14799	,14829	,14860	,14891
141	,14922	,14953	,14983	,15014	,15045	,15076	,15106	,15137	,15168	,15198
142	,15229	,15259	,15290	,15320	,15351	,15381	,15412	,15442	,15473	,15503
143	,15534	,15564	,15594	,15625	,15655	,15685	,15715	,15746	,15776	,15806
144	,15836	,15866	,15897	,15927	,15957	,15987	,16017	,16047	,16077	,16107
145	,16137	,16167	,16197	,16227	,16256	,16286	,16316	,16346	,16376	16406
146	,16435	,16465	,16495	,16524	,16554	,16584	,16613	,16643	,16673	,16702
147	,16732	,16761	,16791	,16820	,16850	,16879	,16909	,16938	,16967	,16997
148	,17026	,17056	,17085	,17114	,17143	,17173	,17202	,17231	,17260	,17289
149	,17319	,17348	,17377	,17406	,17435	,17464	,17493	,17522	,17551	,17580
150	,17609	,17638	,17667	,17696	,17725	,17754	,17782	,17811	,17840	,17869
151	,17898	,17926	,17955	,17984	,18013	,18041	,18070	,18099	,18127	,18156
152	,18184	,18213	,18241	,18270	,18298	,18327	,18355	,18384	,18412	,18441
153	,18469	,18498	,18526	,18554	,18583	,18611	,18639	,18667	,18696	,18724
154	,18752	,18780	,18808	,18837	,18865	,18893	,18921	,18949	,18977	,19005
155	,19033	,19061	,19089	,19117	,19145	,19173	,19201	,19229	,19257	,19285
156	,19312	,19340	,19368	,19396	,19424	,19451	,19479	19507	,19535	,19562
157	,19590	,19618	,19645	,19673	,19700	,19728	,19756	,19783	19811	,19838
158	,19866	,19893	,19921	,19948	,19976	,20003	,20030	20058	20085	,20112
159	,20140	,20167	,20194	,20222	,20249	,20276	,20303	20330	20358	,20385
No	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 1600 to 2199. Logs. from ,20412 to ,34223.

N°	0	1	2	3	4	5	6	7	8	9
160	,20412	,20439	,20466	,20493	,20520	,20547	,20575	,20602	,20629	,20656
161	,20683	,20710	,20736	,20763	.20790	,20817	,20844	,20871	,20898	,20925
162	,20951	,20978	,21005	,21032	,21059	,21085	,21112	,21139	,21165	,21192
163	,21219	,21245	,21272	,21299	,21325	,21352	,21378	,21405	,21431	,21458
164	,21484	,21511	,21537	,21564	,21590	,21617	,21643	,21669	,21696	,21722
165	,21748	,21775	,21801	,21807	,21854	,21880	,21906	,21932	21958	,21985
166	,22011	,22037	,22063	,22089	,22115	,22141	,22167	,22194	,22220	,22246
167	,22272	,22298	,22324	,22350	,22376	,22401	,22427	,22453	,22479	,22505
168	,22531	,22557	,22583	,22608	,22634	,22660	,22686	,22712	,22737	,22763
169	,22789	,22814	,22840	,22866	,22891	,22917	,22943	,22968	,22994	,23019
170	,23045	,23070	,23096	,23121	,23147	,23172	,23198	,23223	,23249	,23274
171	,23300	,23325	,23350	,23376	,23401	,23426	,23452	,23477	,23502	,23528
172	,23553	,23578	,23603	,23629	,23654	,23679	,23704	,23729	,23754	,23779
173	,23805	,23830	,23855	,23880	,23905	,23930	,23955	,23980	,24005	,24030
174	,24055	,24080	,24105	,24130	,24155	,24180	,24204	,24229	,24254	,24279
175	,24304	,24329	,24353	,24378	,24403	,24428	,24452	,24477	,24502	,24527
176	,24551	,24576	,24601	,24625	,24650	,24674	,24699	,24724	,24748	,24773
177	,24797	,24822	,24846	,24871	,24895	,24920	,24944	,24969	,24993	,25018
178	,25042	,25066	,25091	,25115	,25139	,25164	,25188	,25212	,25237	,25261
179	,25285	,25310	,25334	,25358	,25382	,25406	,25431	,25455	,25479	,25503
180	,25527	,25551	,25575	,25600	,25624	,25648	,25672	,25696	,25720	,25744
181	,25768	,25792	,25816	,25840	,25864	,25888	,25912	,25935	,25959	,25983
182	,26007	,26031	,26055	,26079	,26102	,26126	,26150	,26174	,26198	,26221
183	,26245	,26269	,26293	,26316	,26340	,26364	,26387	,26411	,26435	,26458
184	,26482	,26505	,26529	,26553	,26576	,26600	,26623	,26647	,26670	,26694
185	,26717	,26741	,26764	,26788	,26811	,26834	,26858	,26881	,26905	,26928
186	,26951	,26975	,26998	,27021	.27045	,27068	,27091	,27114	,27138	,27161
187	,27184	,27207	,27231	,27254	,27277	,27300	,27323	,27346	,27370	,27393
188	,27416	,27439	,27462	,27485	,27508	,27531	,27554	,27577	,27600	,27623
189	,27646	,27669	,27692	,27715	,27738	,27761	,27784	,27807	.27830	,27852
190	,27875	,27898	,27921	,27944	,27967	,27989	,28012	,28035	,28058	,28081
191	,28103	,28126	,28149	,28171	28194	,28217	,28240	,28262	,28285	,28307
192	,28330	,28353	,28375	,28398	,28421	,28443	,28466	,28488	,28511	,28533
193	,28556	,28578	,28601	,28623	28646	,28668	,28691	,28713	,28735	,28758
194	,28780	,28803	,28825	,28847	:28870	,28892	,28914	,28937	,28959	,28981
195	,29003	,29026	,29048	,29070	,29092	.29115	,29137	,29159	,29181	,29203
196	,29226	,29248	,29270	,29292	,29314	,29336	,29358	,29380	,29403	,25425
197	,29447	,29469	,29491	,29513	,29535	,29557	,29579	,29601	,29623	,29645
198	29667	,29688	,29710	,29732	,29754	,29776	,29798	,29820	,29842	,29863
199	,29885	,29907	,29929	,29951	,29973	,29994	,30016	,30038	,30060	,30081
200	,30103	,30125	,30146	,30168	,30190	,30211	,30233	,30255	,30276	,30298
201	,30320	,30341	,30363	,30384	,30406	,30428	,30449	,30471	,30492	,30514
202	,30535	,30557	,30578	,30600	,30621	,30642	,30664	,30685	,30707	,30728
203	,30750	,30771	,30792	,30814	,30835	,30856	,30878	,30899	,30920	,30942
204	,30963	,30984	,31006	,31027	,31048	,31069	,31091	,31112	,31133	,31154
205	,31175	,31197	,31218	,31239	,31260	,31281	,31302	,31323	,31345	,31366
206	,31387	,31408	,31429	,31450	,31471	,31492	,31513	,31534	,31555	,31576
207	,31597	,31618	,31639	,31660	,31681	,31702	,31723	,31744	,31765	,31785
208	,31806	,31827	,31848	,31869	,31890	,31911	,31931	,31952	,31973	,31994
209	,32015	,32035	,32056	,32077	,32098	,32118	,32139	,32160	,32181	,32201
210	,32222	,32243	,32263	,32284	,32305	,32325	,32346	,32366	,32387	,32408
211	,32428	,32449	,32469	,32490	,32510	,32531	,32552	,32572	,32593	,32613
212	,32634	,32654	,32675	,32695	,32715	,32736	,32756	,32777	,32797	,32818
213	,32838	,32858	,32879	,32899	,32919	,32940	,32960	,32980	,33001	,33021
214	,33041	,33062	,33082	,33102	,33122	,33143	,33163	,33183	,33203	,33224
215	,33244	,33264	,33284	,33304	,33325	,33345	,33365	,33385	,33405	,33425
216	.33445	.33465	,33486	,33506	,33526	,33546	,33566	,33586	,33606	,33626
217	,33646	.33666	,33686	,33706	,33726	,33746	,33766	,33786	,33806	,33826
218	,33846	,33866	,33885	,33905	,33925	,33945	,33965	,33985	,34005	,34025
219	.34044	,34064	,34084	,34104	,34124	,34143	,34163	,34183	,34203	.34223
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 2200 to 2799. Logs. from ,34242 to ,44700.

N°	0	1	2	3	4	5	6	7	8	9
220	,34242	,34262	,34282	,34301	,34321	,34341	,34361	,34380	,34400	,34420
221	,34439	,34459	,34479	,34498	,34518	,34537	,34557	,34577	,34596	,34616
222	,34635	,34655	,34674	,34694	,34713	,34733	,34753	,34772	,34792	,34811
223	,34830	,34850	,34869	,34889	,34908	,34928	,34947	,34967	,34986	,35005
224	,35025	,35044	,35064	,35083	,35102	,35122	,35141	,35160	,35180	,35199
225	,35218	,35238	,35257	,35276	,35295	,35315	,35334	,35353	,35372	,35392
226	,35411	,35430	,35449	,35468	,35488	,35507	,35526	,35545	,35564	,35583
227	,35603	,35622	,35641	,35660	,35679	,35698	,35717	,35736	,35755	,35774
228	,35793	,35813	,35832	,35851	,35870	,35889	,35908	,35927	,35946	,35965
229	,35984	,36003	,36021	,36040	,36059	,36078	,36097	,36116	,36135	,36154
230	,36173	,36192	,36211	,36229	,36248	,36267	,36286	,36305	,36324	,36342
231	,36361	,36380	,36399	,36418	,36436	,36455	,36474	,36493	,36511	,36530
232	,36549	,36568	,36586	,36605	,36624	,36642	,36661	,36680	,36698	,36717
233	,36736	,36754	,36773	,36791	,36810	,36829	,36847	,36866	,36884	,36903
234	,37922	,36940	,36959	,36977	,36996	,37014	,37033	,37051	,37070	,37088
235	,37107	,37125	,37144	,37162	,37181	,37199	,37218	,37236	,37254	,37273
236	,37291	,37310	,37328	,37346	,37365	,37383	,37401	,37420	,37438	,37457
237	,37475	,37493	,37511	,37530	,37548	,37566	,37585	,37603	,37621	,37639
238	,37658	,37676	,37694	,37712	,37731	,37749	,37767	,37785	,37803	,37822
239	,37840	,37858	,37876	,37894	,37912	,37931	,37949	,37967	,37985	,38003
240	,38021	,38039	,38057	,38075	,38093	,38112	,38130	,38148	,38166	,38184
241	,38202	,38220	,38238	,38256	,38274	,38292	,38310	,38328	,38346	,38364
242	,38382	,38399	,38417	,38435	,38453	,38471	,38489	,38507	,38525	,38543
243	,38561	,38578	,38596	,38614	,38632	,38650	,38668	,38686	,38703	,38721
244	,38739	,38757	,38775	,38792	,38810	,38828	,38846	,38863	,38881	,38899
245	,38917	,38934	,38952	,38970	,38987	,39005	,39023	,39041	,39058	,39076
246	,39094	,39111	,39129	,39146	,39164	,39182	,39199	,39217	,39235	,39252
247	,39270	,39287	,39305	,39322	,39340	,39358	,39375	,39393	,39410	,39428
248	,39445	,39463	,39480	,39498	,39515	,39533	,39550	,39568	,39585	,39602
249	,39620	,39637	,39655	,39672	,39690	,39707	,39724	,39742	,39759	,39777
250	,39794	,39811	,39829	,39846	,39863	,39881	,39898	,39915	,39933	,39950
251	,39967	,39985	,40002	,40019	,40037	,40054	,40071	,40088	,40106	,40123
252	,40140	,40157	,40175	,40192	,40209	,40226	,40243	,40261	,40278	,40295
253	,40312	,40329	,40346	,40364	,40381	,40398	,40415	,40432	,40449	,40466
254	,40483	,40500	,40518	,40535	,40552	,40569	,40586	,40603	,40620	,40637
255	,40654	,40671	,40688	,40705	,40722	,40739	,40756	,40773	,40790	,40807
256	,40824	,40841	,40858	,40875	,40892	,40909	,40926	,40943	,40959	,40976
257	,40993	,41010	,41027	,41044	,41061	,41078	,41095	,41111	,41128	,41145
258	,41162	,41179	,41196	,41212	,41229	,41246	,41263	,41280	,41296	,41313
259	,41330	,41347	,41363	,41380	,41397	,41414	,41430	,41447	,41464	,41481
260	,41497	,41514	,41531	,41547	,41564	,41581	,41597	,41614	,41631	,41647
261	,41664	,41681	,41697	,41714	,41731	,41747	,41764	,41780	,41797	,41814
262	,41830	,41847	,41863	,41880	,41896	,41913	,41929	,41946	,41963	,41979
263	,41996	,42012	,42029	,42045	,42062	,42078	,42095	,42111	,42127	,42144
264	,42160	,42177	,42193	,42210	,42226	,42243	,42259	,42275	,42292	,42308
265	,42325	,42341	,42357	,42374	,42390	,42406	,42423	,42439	,42455	,42472
266	,42488	,42504	,42521	,42537	,42553	,42570	,42586	,42602	,42619	,42635
267	,42651	,42667	,42684	,42700	,42716	,42732	,42749	,42765	,42781	,42797
268	,42813	,42830	,42846	,42862	,42878	,42894	,42911	,42927	,42943	,42959
269	,42975	,42991	,43008	,43024	,43040	,43056	,43072	,43088	,43104	,43120
270	,43136	,43152	,43169	,43185	,43201	,43217	,43233	,43249	,43265	,43281
271	,43297	,43313	,43329	,43345	,43361	,43377	,43393	,43409	,43425	,43441
272	,43457	,43473	,43489	,43505	,43521	,43537	,43553	,43569	,43584	,43600
273	,43616	,43632	,43648	,43664	,43680	,43696	,43712	,43727	,43743	,43759
274	,43775	,43791	,43807	,43823	,43838	,43854	,43870	,43886	,43902	,43917
275	,43933	,43949	,43965	,43981	,43996	,44012	,44028	,44044	,44059	,44075
276	,44091	,44107	,44122	,44138	,44154	,44170	,44185	,44201	,44217	,44232
277	,44248	,44264	,44279	,44295	,44311	,44326	,44342	,44358	,44373	,44389
278	,44404	,44420	,44436	,44451	,44467	,44483	,44498	,44514	,44529	,44545
279	,44560	,44576	,44592	,44607	,44623	,44638	,44654	,44669	,44685	,44700
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 2800 to 3399. Logs. from ,44716 to ,53135.

N°	0	1	2	3	4	5	6	7	8	9
280	,44716	,44731	,44747	,44762	,44778	,44793	,44809	,44824	,44840	,44855
281	,44871	,44886	,44902	,44917	,44932	,44948	,44963	,44979	,44994	,45010
282	,45025	,45040	,45056	,45071	,45086	,45102	,45117	,45133	,45148	,45163
283	,45179	,45194	,45209	,45225	,45240	,45255	,45271	,45286	,45301	,45317
284	,45332	,45347	,45362	,45378	,45393	,45408	,45423	,45439	,45454	,45469
285	,45484	,45500	,45515	,45530	,45545	,45561	,45576	,45591	,45606	,45621
286	,45637	,45652	,45667	,45682	,45697	,45712	,45728	,45743	,45758	,45773
287	,45788	,45803	,45818	,45834	,45849	,45864	,45879	,45894	,45909	,45924
288	,45939	,45954	,45969	,45984	,46000	,46015	,46030	,46045	,46060	,46075
289	,46090	,46105	,46120	,46135	,46150	,46165	,46180	,46195	,46210	,46225
290	,46240	,46255	,46270	,46285	,46300	,46315	,46330	,46344	,46359	,46374
291	,46389	,46404	,46419	,46434	,46449	,46464	,46479	,46494	,46509	,46523
292	,46538	,46553	,46568	,46583	,46598	,46613	,46627	,46642	,46657	,46672
293	,46687	,46702	,46716	,46731	,46746	,46761	,46776	,46790	,46805	,46820
294	,46835	,46849	,46864	,46879	,46894	,46909	,46923	,46938	,46953	,46967
295	,46982	,46997	,47012	47026	,47041	,47056	,47070	,47085	,47100	,47114
296	,47129	,47144	,47159	,47173	,47188	,47202	,47217	,47232	,47246	,47261
297	,47276	,47290	,47305	,47319	,47334	,47349	,47363	,47378	,47392	,47407
298	,47422	,47436	,47451	,47465	,47480	,47494	,47509	,47524	,47538	,47553
299	,47567	,47582	,47596	,47611	,47625	,47640	,47654	,47669	,47683	,47698
300	,47712	,47727	,47741	,47756	,47770	,47784	,47799	,47813	,47828	,47842
301	,47857	,47871	,47885	,47900	,47914	,47929	,47943	,47958	,47972	,47986
302	,48001	,48015	,48029	,48044	,48058	,48073	,48087	,48101	,48116	,48130
303	,48144	,48159	,48173	,48187	,48202	,48216	,48230	,48244	,48259	,48273
304	,48287	,48302	,48316	,48330	,48344	,48359	,48373	,48387	,48401	,48416
305	,48430	,48444	,48458	,48473	,48487	,48501	,48515	,48530	,48544	,48558
306	,48572	,48586	,48601	,48615	,48629	,48643	,48657	,48671	,48686	,48700
307	,48714	,48728	,48742	,48756	,48770	,48785	,48799	,48813	,48827	,48841
308	,48855	,48869	,48883	,48897	,48911	,48926	,48940	,48954	,48968	,48982
309	,48996	,49010	,49024	,49038	,49052	,49066	,49080	,49094	,49108	,49122
310	,49136	,49150	,49164	,49178	,49192	,49206	,49220	,49234	,49248	,49262
311	,49276	,49290	,49304	,49318	,49332	,49346	,49360	,49374	,49388	,49402
312	,49415	,49429	,49443	,49457	,49471	,49485	,49499	,49513	,49527	,49541
313	,49554	,49568	,49582	,49596	,49610	,49624	,49638	,49651	,49665	,49679
314	,49693	,49707	,49721	,49734	,49748	,49762	,49776	,49790	,49803	,49817
315	,49831	,49845	,49859	,49872	,49886	,49900	,49914	,49927	,49941	,49955
316	,49969	,49982	,49996	,50010	,50024	,50037	,50051	,50065	,50079	,50092
317	,50106	,50120	,50133	,50147	,50161	,50174	,50188	,50202	,50215	,50229
318	,50243	,50256	,50270	,50284	,50297	,50311	,50325	,50338	,50352	,50365
319	,50379	,50393	,50406	,50420	,50433	,50447	,50461	,50474	,50488	,50501
320	,50515	,50529	,50542	,50556	,50569	,50583	,50596	,50610	,50623	,50637
321	,50650	,50664	,50678	,50691	,50705	,50718	,50732	,50745	,50759	,50772
322	,50786	,50799	,50813	,50826	,50839	,50853	,50866	,50880	,50893	,50907
323	,50920	,50934	,50947	,50961	,50974	,50987	,51001	,51014	,51028	,51041
324	,51054	,51068	,51081	,51095	,51108	,51121	,51135	,51148	,51162	,51175
325	,51188	,51202	,51215	,51228	,51242	,51255	,51268	,51282	,51295	,51308
326	,51322	,51335	,51348	,51362	,51375	,51388	,51402	,51415	,51428	,51441
327	,51455	,51468	,51481	,51495	,51508	,51521	,51534	,51548	,51561	,51574
328	,51587	,51601	,51614	,51627	,51640	,51654	,51667	,51680	,51693	,51706
329	,51720	,51733	,51746	,51759	,51772	,51786	,51799	,51812	,51825	,51838
330	,51851	,51865	,51878	,51891	,51904	,51917	,51930	,51943	,51957	,51970
331	,51983	,51996	,52009	,52022	,52035	,52048	,52061	,52075	,52088	,52101
332	,52114	,52127	,52140	,52153	,52166	,52179	,52192	,52205	,52218	,52231
333	,52244	,52257	,52270	,52283	,52297	,52310	,52323	,52336	,52349	,52362
334	,52375	,52388	,52401	,52414	,52427	,52440	,52453	,52466	,52479	,52492
335	,52504	,52517	,52530	,52543	,52556	,52569	,52582	,52595	,52608	,52621
336	,52634	,52647	,52660	,52673	,52686	,52699	,52711	,52724	,52737	,52750
337	,52763	,52776	,52789	,52802	,52815	,52827	,52840	,52853	,52866	,52879
338	,52892	,52905	,52917	,52930	,52943	,52956	,52969	,52981	,52994	,53007
339	,53020	,53033	,53046	,53058	,53071	,53084	,53097	,53110	,53122	,53135
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 3400 to 3999. Logs. from ,53148 to ,60195.

N°	0	1	2	3	4	5	6	7	8	9
340	,53148	,53161	,53173	,53186	,53199	,53212	,53224	,53237	,53250	,53263
341	,53275	,53288	,53301	,53314	,53326	,53339	,53352	,53364	,53377	,53390
342	,53403	,53415	,53428	,53441	,53453	,53466	,53479	,53491	,53504	,53517
343	,53529	,53542	,53555	,53567	,53580	,53593	,53605	,53618	,53631	,53643
344	,53656	,53668	,53681	,53694	,53706	,53719	,53732	,53744	,53757	,53769
345	,53782	,53794	,53807	,53820	,53832	,53845	,53857	,53870	,53882	,53895
346	,53908	,53920	,53933	,53945	,53958	,53970	,53983	,53995	,54008	,54020
347	,54033	,54045	,54058	,54070	,54083	,54095	,54108	,54120	,54133	,54145
348	,54158	,54170	,54183	,54195	,54208	,54220	,54233	,54245	,54258	,54270
349	,54283	,54295	,54307	,54320	,54332	,54345	,54357	,54370	,54382	,54394
350	,54407	,54419	,54432	,54444	,54456	,54469	,54481	,54494	,54506	,54518
351	,54531	,54543	,54555	,54568	,54580	,54593	,54605	,54617	,54630	,54642
352	,54654	,54667	,54679	,54691	,54704	,54716	,54728	,54741	,54753	,54765
353	,54777	,54790	,54802	,54814	,54827	,54839	,54851	,54864	,54876	,54888
354	,54900	,54913	,54925	,54937	,54949	,54962	,54974	,54986	,54998	,55011
355	,55023	,55035	,55047	,55060	,55072	,55084	,55096	,55108	,55121	,55133
356	,55145	,55157	,55169	,55182	,55194	,55206	,55218	,55230	,55242	,55255
357	,55267	,55279	,55291	,55303	,55315	,55328	,55340	,55352	,55364	,55376
358	,55388	,55400	,55413	,55425	,55437	,55449	,55461	,55473	,55485	,55497
359	,55509	,55522	,55534	,55546	,55558	,55570	,55582	,55594	,55606	,55618
360	,55630	,55642	,55654	,55666	,55678	,55691	,55703	,55715	,55727	,55739
361	,55751	,55763	,55775	,55787	,55799	,55811	,55823	,55835	,55847	,55859
362	,55871	,55883	,55895	,55907	,55919	,55931	,55943	,55955	,55967	,55979
363	,55991	,56003	,56015	,56027	,56038	,56050	,56062	,56074	,56086	,56098
364	,56110	,56122	,56134	,56146	,56158	,56170	,56182	,56194	,56205	,56217
365	,56229	,56241	,56253	,56265	,56277	,56289	,56301	,56312	,56324	,56336
366	,56348	,56360	,56372	,56384	,56396	,56407	,56419	,56431	,56443	,56455
367	,56467	,56478	,56490	,56502	,56514	,56526	,56538	,56549	,56561	,56573
368	,56585	,56597	,56608	,56620	,56632	,56644	,56656	,56667	,56679	,56691
369	,56703	,56714	,56726	,56738	,56750	,56761	,56773	,56785	,56797	,56808
370	,56820	,56832	,56844	,56855	,56867	,56879	,56891	,56902	,56914	,56926
371	,56937	,56949	,56961	,56972	,56984	,56996	,57008	,57019	,57031	,57043
372	,57054	,57066	,57078	,57089	,57101	,57113	,57124	,57136	,57148	,57159
373	,57171	,57183	,57194	,57206	,57217	,57229	,57241	,57252	,57264	,57276
374	,57287	,57299	,57310	,57322	,57334	,57345	,57357	,57368	,57380	,57392
375	,57403	,57415	,57426	,57438	,57449	,57461	,57473	,57484	,57496	,57507
376	,57519	,57530	,57542	,57553	,57565	,57576	,57588	,57600	,57611	,57623
377	,57634	,57646	,57657	,57669	,57680	,57692	,57703	,57715	,57726	,57738
378	,57749	,57761	,57772	,57784	,57795	,57807	,57818	,57830	,57841	,57852
379	,57864	,57875	,57887	,57898	,57910	,57921	,57933	,57944	,57955	,57967
380	,57978	,57990	,58001	,58013	,58024	,58035	,58047	,58058	,58070	,58081
381	,58092	,58104	,58115	,58127	,58138	,58149	,58161	,58172	,58184	,58195
382	,58206	,58218	,58229	,58240	,58252	,58263	,58274	,58286	,58297	,58309
383	,58320	,58331	,58343	,58354	,58365	,58377	,58388	,58399	,58410	,58422
384	,58433	,58444	,58456	,58467	,58478	,58490	,58501	,58512	,58524	,58535
385	,58546	,58557	,58569	,58580	,58591	,58602	,58614	,58625	,58636	,58647
386	,58659	,58670	,58681	,58692	,58704	,58715	58726	,58737	,58749	,58760
387	,58771	,58782	,58794	,58805	,58816	,58827	,58838	,58850	,58861	,58872
388	,58883	,58894	,58906	,58917	,58928	,58939	,58950	,58961	,58973	,58984
389	,58995	,59006	,59017	,59028	,59040	,59051	,59062	,59073	,59084	,59095
390	,59106	,59118	,59129	,59140	,59151	,59162	,59173	,59184	,59195	,59207
391	,59218	,59229	,59240	,59251	,59262	,59273	,59284	,59295	,59306	,59318
392	,59329	,59340	,59351	,59362	,59373	,59384	,59395	,59406	,59417	,59428
393	,59439	,59450	,59461	,59472	,59483	,59494	,59506	,59517	,59528	,59539
394	,59550	,59561	,59572	,59583	,59594	,59605	,59616	,59627	,59638	,59649
395	,59660	,59671	,59682	,59693	,59704	,59715	,59726	,59737	,59748	,59759
396	,59770	,59780	,59791	,59802	,59813	,59824	,59835	,59846	,59857	,59868
397	,59879	,59890	,59901	,59912	,59923	,59934	,59945	,59956	,59966	,59977
398	,59988	,59999	,60010	,60021	,60032	,60043	,60054	,60065	,60076	,60086
399	,60097	,60108	,60119	,60130	,60141	,60152	,60163	,60173	,60184	,60195
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 4000 to 4599. Logs. from ,60206 to ,66266.

N°	0	1	2	3	4	5	6	7	8	9
400	,60206	,60217	,60228	,60239	,60249	,60260	,60271	,60282	,60293	,60304
401	,60314	,60325	,60336	,60347	,60358	,60369	,60379	,60390	,60401	,60412
402	,60423	,60433	,60444	,60455	,60466	,60477	,60487	,60498	,60509	,60520
403	,60530	,60541	,60552	,60563	,60574	,60584	,60595	,60606	,60617	,60627
404	,60638	,60649	,60660	,60670	,60681	,60692	,60703	,60713	,60724	,60735
405	,60746	,60756	,60767	,60778	,60788	,60799	,60810	,60820	,60831	,60842
406	,60853	,60863	,60874	,60885	,60895	,60906	,60917	,60927	,60938	,60949
407	,60959	,60970	,60981	,60991	,61002	,61013	,61023	,61034	,61045	,61055
408	,61066	,61077	,61087	,61098	,61109	,61119	,61130	,61140	,61151	,61162
409	,61172	61183	,61194	,61204	,61215	,61225	,61236	,61247	,61257	,61268
410	,61278	,61289	,61300	,61310	,61321	,61331	,61342	,61352	,61363	,61374
411	,61384	,61395	,61405	,61416	,61426	,61437	,61448	,61458	,61469	,61479
412	,61490	,61500	,61511	,61521	,61532	,61542	,61553	,61563	,61574	,61584
413	,61595	,61606	,61616	,61627	,61637	,61648	,61658	,61669	,61679	,61690
414	,61700	,61711	,61721	,61731	,61742	,61752	,61763	,61773	,61784	,61794
415	,61805	,61815	,61826	,61836	,61847	,61857	,61868	,61878	,61888	,61899
416	,61909	,61920	,61930	,61941	,61951	,61961	,61972	,61982	,61993	,62003
417	,62014	,62024	,62034	,62045	,62055	,62066	,62076	,62086	,62097	,62107
418	,62118	,62128	,62138	,62149	,62159	,62170	,62180	,62190	,62201	,62211
419	,62221	,62232	,62242	,62252	,62263	,62273	,62284	,62294	,62304	,62315
420	,62325	,62335	,62346	,62356	,62366	,62377	,62387	,62397	,62408	,62418
421	,62428	,62439	,62449	,62459	,62469	,62480	,62490	,62500	,62511	,62521
422	,62531	,62542	,62552	,62562	,62572	,62583	,62593	,62603	,62613	,62624
423	,62634	,62644	,62655	,62665	,62675	,62685	,62696	,62706	,62716	,62726
424	,62737	,62747	,62757	,62767	,62778	,62788	,62798	,62808	,62818	,62829
425	,62839	,62849	,62859	,62870	,62880	,62890	,62900	,62910	,62921	,62931
426	,62941	,62951	,62961	,62972	,62982	,62992	,63002	,63012	,63022	,63033
427	,63043	,63053	,63063	,63073	,63083	,63094	,63104	,63114	,63124	,63134
428	,63144	,63155	,63165	,63175	,63185	,63195	,63205	,63215	,63225	,63236
429	,63246	,63256	,63266	,63276	,63286	,63296	,63306	,63317	,63327	,63337
430	,63347	,63357	,63367	,63377	,63387	,63397	,63407	,63417	,63428	,63438
431	,63448	,63458	,63468	,63478	,63488	,63498	,63508	,63518	,63528	,63538
432	,63548	,63558	,63568	,63579	,63589	,63599	,63609	,63619	,63629	,63639
433	,63649	,63659	,63669	,63679	,63689	,63699	,63709	,63719	,63729	,63739
434	,63749	,63759	,63769	,63779	,63789	,63799	,63809	,63819	,63829	,63839
435	,63849	,63859	,63869	,63879	,63889	,63899	,63909	,63919	,63929	,63939
436	,63949	,63959	,63969	,63979	,63988	,63998	,64008	,64018	,64028	,64038
437	,64048	,64058	,64068	,64078	,64088	,64098	,64108	,64118	,64128	,64137
438	,64147	,64157	,64167	,64177	,64187	,64197	,64207	,64217	,64227	,64237
439	,64246	,64256	,64266	,64276	,64286	,64296	,64306	,64316	,64326	,64335
440	,64345	,64355	,64365	,64375	,64385	,64395	,64404	,64414	,64424	,64434
441	,64444	,64454	,64464	,64473	,64483	,64493	,64503	,64513	,64523	,64532
442	,64542	,64552	,64562	,64572	,64582	,64591	,64601	,64611	,64621	,64631
443	,64640	,64650	,64660	,64670	,64680	,64689	,64699	,64709	,64719	,64729
444	,64738	,64748	,64758	,64768	,64777	,64787	,64797	,64807	,64816	,64826
445	,64836	,64846	,64856	,64865	,64875	,64885	,64895	,64904	,64914	,64924
446	,64933	,64943	,64953	,64963	,64972	,64982	,64992	,65002	,65011	,65021
447	,65031	,65040	,65050	,65060	,65070	,65079	,65089	,65099	,65108	,65118
448	,65128	,65137	,65147	,65157	,65167	,65176	,65186	,65196	,65205	,65215
449	,65225	,65234	,65244	,65254	,65263	,65273	,65283	,65292	,65302	,65312
450	,65321	,65331	,65341	,65350	,65360	,65369	,65379	,65389	,65398	,65408
451	,65418	,65427	,65437	,65447	,65456	,65466	,65475	,65485	,65495	,65504
452	,65514	,65523	,65533	,65543	,65552	,65562	,65571	,65581	,65591	,65600
453	,65610	,65619	,65629	,65639	,65648	,65658	,65667	,65677	,65686	,65696
454	,65706	,65715	,65725	,65734	,65744	,65753	,65763	,65772	,65782	,65792
455	,65801	,65811	,65820	,65830	,65839	,65849	,65858	,65868	,65877	,65887
456	,65896	,65906	,65916	,65925	,65935	,65944	,65954	,65963	,65973	,65982
457	,65992	,66001	,66011	,66020	,66030	,66039	,66049	,66058	,66068	,66077
458	,66087	,66096	,66106	,66115	,66124	,66134	,66143	,66153	,66162	,66172
459	,66181	,66191	,66200	,66210	,66219	,66229	,66238	,66247	,66257	,66266
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 4600 to 5199. Logs. from ,66276 to ,71592.

N°	0	1	2	3	4	5	6	7	8	9
460	,66276	,66285	,66295	,66304	,66314	,66323	,66332	,66342	,66351	,66361
461	,66370	,66380	,66389	,66398	,66408	,66417	,66427	,66436	,66445	,66455
462	,66464	,66474	,66483	,66492	,66502	,66511	,66521	,66530	,66539	,66549
463	,66558	,66567	,66577	,66586	,66596	,66605	,66614	,66624	,66633	,66642
464	,66652	,66661	,66671	,66680	,66689	,66699	,66708	,66717	,66727	,66736
465	,66745	,66755	,66764	,66773	,66783	,66792	,66801	,66811	,66820	,66829
466	,66839	,66848	,66857	,66867	,66876	,66885	,66894	,66904	,66913	,66922
467	,66932	,66941	,66950	,66960	,66969	,66978	,66987	,66997	,67006	,67015
468	,67025	,67034	,67043	,67052	,67062	,67071	,67080	,67089	,67099	,67108
469	,67117	,67127	,67136	,67145	,67154	,67164	,67173	,67182	,67191	,67201
470	,67210	,67219	,67228	,67237	,67247	,67256	,67265	,67274	,67284	,67293
471	,67302	,67311	,67321	,67330	,67339	,67348	,67357	,67367	,67376	,67385
472	,67394	,67403	,67413	,67422	,67431	,67440	,67449	,67459	,67468	,67477
473	,67486	,67495	,67504	,67514	,67523	,67532	,67541	,67550	,67560	,67569
474	,67578	,67587	,67596	,67605	,67614	,67624	,67633	,67642	,67651	,67660
475	,67669	,67678	,67688	,67697	,67706	,67715	,67724	,67733	,67742	,67752
476	,67761	,67770	,67779	,67788	,67797	,67806	,67815	,67825	,67834	,67843
477	,67852	,67861	,67870	,67879	,67888	,67897	,67906	,67916	,67925	,67934
478	,67943	,67952	,67961	,67970	,67979	,67988	,67997	,68006	,68015	,68024
479	,68034	,68043	,68052	,68061	,68070	,68079	,68088	,68097	,68106	,68115
480	,68124	,68133	,68142	,68151	,68160	,68169	,68178	,68187	,68196	,68205
481	,68215	,68224	,68233	,68242	,68251	,68260	,68269	,68278	,68287	,68296
482	,68305	,68314	,68323	,68332	,68341	,68350	,68359	,68368	,68377	,68386
483	,68395	,68404	,68413	,68422	,68431	,68440	,68449	,6845	,68467	,68476
484	,68485	,68494	,68502	,68511	,68520	,68529	,68538	,68547	,68556	,68565
485	,68574	,68583	,68592	,68601	,68610	,68619	,68628	,68637	,68646	,68655
486	,68664	,68673	,68681	,68690	,68699	,68708	,68717	,68726	,68735	,68744
487	,68753	,68762	,68771	,68780	,68789	,68797	,68806	,68815	,68824	,68833
488	,68842	,68851	,68860	,68869	,68878	,68886	,68895	,68904	,68913	,68922
489	,68931	,68940	,68949	,68958	,68966	,68975	,68984	,68993	,69002	,69011
490	,69020	,69028	,69037	,69046	,69055	,69064	,69073	,69082	,69090	,69099
491	,69108	,69117	,69126	,69135	,69144	,69152	,69161	,69170	,69179	,69188
492	,69197	,69205	,69214	,69223	,69232	,69241	,69249	,69258	,69267	,69276
493	,69285	,69293	,69302	,69311	,69320	,69329	,69338	,69346	,69355	,69364
494	,69373	,69381	,69390	,69399	,69408	,69417	,69425	,69434	,69443	,69452
495	,69461	,69469	,69478	,69487	,69496	,69504	,69513	,69522	,69531	,69539
496	,69548	,69557	,69566	,69574	,69583	,69592	,69601	,69609	,69618	,69627
497	,69636	,69644	,69653	,69662	,69671	,69679	,69688	,69697	,69705	,69714
498	,69723	,69732	,69740	,69749	,69758	,69767	,69775	,69784	,69793	,69801
499	,69810	,69819	,69827	,69836	,69845	,69854	,69862	,69871	,69880	,69888
500	,69897	,69906	,69914	,69923	,69932	,69940	,69949	,69958	69966	,69975
501	,69984	,69992	,70001	,70010	,70018	,70027	,70036	,70044	,70053	,70062
502	,70070	,70079	,70088	,70096	,70105	,70114	,70122	,70131	,70140	,70148
503	,70157	,70165	,70174	,70183	,70191	,70200	,70209	,70217	,70226	,70234
504	,70243	,70252	,70260	,70269	,70278	,70286	,70295	,70303	,70312	,70321
505	,70329	,70338	,70346	,70355	,70364	,70372	,70381	,70389	,70398	,70406
506	,70415	,70424	,70432	,70441	,70449	,70458	,70467	,70475	,70484	,70492
507	,70501	,70509	,70518	,70526	,70535	,70544	,70552	,70561	,70569	,70578
508	,70586	,70595	,70603	,70612	,70621	,70629	,70038	,70646	,70655	,70663
509	,70672	,70680	,70689	,70697	,70706	,70714	,70723	,70731	,70740	,70748
510	,70757	,70766	,70774	,70783	,70791	,70800	,70808	,70817	,70825	,70834
511	,70842	,70851	,70859	,70868	,70876	,70885	,70893	,70902	,70910	,70919
512	,70927	,70935	,70944	,70952	,70961	,70969	,70978	,70986	,70995	,71003
513	,71012	,71020	,71029	,71037	,71046	,71054	,71062	,71071	,71079	,71088
514	,71096	,71105	,71113	,71122	,71130	,71139	,71147	,71155	,71164	,71172
515	,71181	,71189	,71198	,71206	,71214	,71223	,71231	,71240	,71248	,71257
516	,71265	,71273	,71282	,71290	,71299	,71307	,71315	,71324	,71332	,71341
517	,71349	,71357	,71366	,71374	,71383	,71391	,71399	,71408	,71416	,71425
518	,71433	,71441	,71450	,71458	,71466	,71475	,71483	,71492	,71500	,71508
519	,71517	,71525	,71533	,71542	,71550	,71559	,71567	,71575	,71584	,71592
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 5200 to 5799. Logs. from ,71600 to ,76335.

N°	0	1	2	3	4	5	6	7	8	9
520	,71600	,71609	,71617	,71625	,71634	,71642	,71650	,71659	,71667	,71675
521	,71684	,71692	,71700	,71709	,71717	,71725	,71734	,71742	,71750	,71759
522	,71767	,71775	,71784	,71792	,71800	,71809	,71817	,71825	,71834	,71842
523	,71850	,71858	,71867	,71875	,71883	,71892	,71900	,71908	,71917	,71925
524	,71933	,71941	,71950	,71958	,71966	,71975	,71983	,71991	,71999	,72008
525	,72016	,72024	,72032	,72041	,72049	,72057	,72066	,72074	,72082	,72090
526	,72099	,72107	,72115	,72123	,72132	,72140	,72148	,72156	,72165	,72173
527	,72181	,72189	,72198	,72206	,72214	,72222	,72230	,72239	,72247	,72255
528	,72263	,72272	,72280	,72288	,72296	,72304	,72313	,72321	,72329	,72337
529	,72346	,72354	,72362	,72370	,72378	,72387	,72395	,72403	,72411	,72419
530	,72428	,72436	,72444	,72452	,72460	,72469	,72477	,72485	,72493	,72501
531	,72509	,72518	,72526	,72534	,72542	,72550	,72558	,72567	,72575	,72583
532	,72591	,72599	,72607	,72616	,72624	,72632	,72640	,72648	,72656	,72665
533	,72673	,7268[illegible]	,72689	,72697	,72705	,72713	,72722	,72730	,72738	,72746
534	,72754	,72762	,72770	,72779	,72787	,72795	,72803	,72811	,72819	,72827
535	,72835	,72843	,72852	,72860	,72868	,72876	,72884	,72892	,72900	,74908
536	,72916	,72925	,72933	,72941	,72949	,72957	,72965	,72973	,72981	,72989
537	,72997	,73006	,73014	,7302[illegible]	,73030	,73038	,73046	,73054	,73062	,73070
538	,73078	,73086	,73094	,73102	,73111	,73119	,73127	,73135	,73143	,73151
539	,73159	,73167	,73175	,73183	,73191	,73199	,73207	,73215	,73223	,73231
540	,73239	,73247	,73255	,73263	,73272	,73280	,73288	,73296	,73304	,73312
541	,73320	,73328	,73336	,73344	,73352	,73360	,73368	73376	,73384	,73392
542	,73400	,73408	,73416	,73424	,73432	,73440	,73448	,73456	,73464	,73472
543	,73480	,73488	,73496	,73504	,73512	,73520	,73528	,73536	,73544	,73552
544	,73560	,73568	,73576	,73584	,73592	,73600	,73608	,73616	,73624	,73632
545	,73640	,73648	,73656	,73664	,73672	,73679	,73687	,73695	,73703	,73711
546	,73719	,73727	,73735	,73743	,73751	,73759	,73767	,73775	,73783	,73791
547	,73799	,73807	,73815	,73823	,73830	,73838	,73846	,73854	,73862	,73870
548	,7387[illegible]	,73886	,73894	,73902	,73910	,73918	,73926	,73933	,73941	,73949
549	,73957	,73965	,73973	,73981	,73989	,73997	,74005	,74013	,74020	,74028
550	,74036	,74044	,74052	,74060	,74068	,74076	,74084	,74092	,74099	,74107
551	,74115	,74123	,74131	,74139	,74147	,74155	,74162	,74170	,74178	,74186
552	,74194	,74202	,74210	,74217	,74225	,74233	,74241	,74249	,74257	,74265
553	,74273	,74280	,74288	,74296	,74304	,74312	,74320	,74327	,74335	,74343
554	,74351	,74359	,74367	,74374	,74382	,74390	,74398	,74406	,74414	,74421
555	,74429	,74437	,74445	,74453	,74461	,74468	,74476	,74484	,74492	,74500
556	,74507	,74515	,74523	,74531	,74539	,74547	,74554	,74562	,74570	,74578
557	,74586	,74593	,74601	,74609	,74617	,74624	,74632	,74640	74648	,74656
558	,74663	,74671	,74679	,74687	,74695	,74702	,74710	,74718	,74726	,74733
559	,74741	,74749	,7475[illegible]	,74764	74772	,74780	,74788	,74796	,74803	,74811
560	,74819	,74827	,74834	,74842	,74850	,74858	,74865	,74873	,74881	,74889
561	,74896	,74904	,74912	,74919	,74927	,74935	,74943	,74950	,74958	,74966
562	,74974	,74981	,74989	,74997	,75005	,75012	,75020	,75028	,75035	,75043
563	,75051	,75059	,75066	,75074	,75082	,75089	,75097	,75105	,75113	,75120
564	,75128	,75136	,75143	,75151	,75159	,75166	,75174	,75182	,75189	,75197
565	75205	,75213	,75220	,75228	,75236	,75243	,75251	,75259	,75266	,75274
566	,75282	,75289	,75297	,75305	,75312	,75320	,75328	,75335	,75343	,75351
567	,75358	,75366	,75374	,75381	,75389	,75397	,75404	,75412	,75420	,75427
568	,75435	,75442	,75450	,75458	,75465	,75473	,75481	,75488	,75496	,75504
569	,75511	,75519	,75526	,75534	,75542	,75549	,75557	,75565	,75572	,75580
570	,75587	,75595	,75603	,75610	,75618	,75626	,75633	,75641	,75648	,75656
571	,75664	,75671	,75679	,75686	,75694	,75702	,75709	,75717	,75724	,75732
572	,75740	,75747	,75755	,75762	,75770	,75778	,75785	,75793	,75800	,75808
573	,75815	,75823	,75831	,75838	,75846	,75853	,75861	,75868	,75876	,75884
574	,75891	,75899	,75906	,75914	,75921	,75929	,75937	,75944	,75952	,75959
575	,75967	,75974	,75982	,75989	,75997	,76005	,76012	,76020	,76027	,76035
576	,76042	,76050	,76057	,76065	,76072	,76080	,76087	,76095	,76103	,76110
577	,76118	,76125	,7613[illegible]	,76140	,76148	,76155	,76163	,76170	,76178	,76185
578	,76193	,76200	,76208	,76215	,76223	,76230	,76238	,76245	,76253	,76260
579	,76268	,76275	,76283	,76290	,76298	,76305	,76313	,76320	,76328	,76335
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 5800 to 6399. Logs. from ,76343 to ,80611.

N°	0	1	2	3	4	5	6	7	8	9
580	,76343	,76350	,76358	,76365	,76373	,76380	,76388	76395	,76403	,76410
581	,76418	,76425	,76433	,76440	,76447	,76455	,76462	,76470	,76477	,76485
582	,76492	,76500	,76507	,76515	,76522	,76530	,76537	,76544	,76552	,76559
583	,76567	,76574	,76582	,76589	,76597	,76604	,76612	,76619	,76626	,76634
584	,76641	,76649	,76656	,76664	,76671	,76678	,76686	,76693	,76701	,76708
585	,76716	,76723	,76730	,76738	,76745	,76753	,76760	,76768	,76775	,76782
586	,76790	,76797	,76805	,76812	,76819	,76827	,76834	,76842	,76849	,76856
587	,76864	,76871	,76879	,76886	,76893	,76901	,76908	,76916	,76923	,76930
588	,76938	,76945	,76952	,76960	,76967	,76975	,76982	,76989	,76997	,77004
589	,77012	,77019	,77026	,77034	,77041	,77048	,77056	,77063	,77070	,77078
590	,77085	,77093	,77100	,77107	,77115	,77122	,77129	,77137	,77144	,77151
591	,77159	,77166	,77173	,77181	,77188	,77195	,77203	,77210	,77217	,77225
592	,77232	,77240	,77247	,77254	,77261	,77269	,77276	,77283	,77291	,77298
593	,77305	,77313	,77320	,77327	,77335	,77342	,77349	,77357	,77364	,77371
594	,77379	,77386	,77393	,77401	,77408	,77415	,77422	,77430	,77437	,77444
595	,77452	,77459	,77466	,77474	,77481	,77488	,77495	,77503	,77510	,77517
596	,77525	,77532	,77539	,77546	,77554	,77561	,77568	,77576	,77583	,77590
597	,77597	,77605	,77612	,77619	,77627	,77634	,77641	,77648	,77656	,77663
598	,77670	,77677	,77685	,77692	,77699	,77706	,77714	,77721	,77728	,77735
599	,77743	,77750	,77757	,77764	,77772	,77779	,77786	,77793	,77801	,77808
600	,77815	,77822	,77830	,77837	,77844	,77851	,77859	,77866	,77873	,77880
601	,77887	,77895	,77902	,77909	,77916	,77924	,77931	,77938	,77945	,77952
602	,77960	,77967	,77974	,77981	,77988	,77996	,78003	,78010	,78017	,78025
603	,78032	,78039	,78046	,78053	,78061	,78068	,78075	,78082	,78089	,78096
604	,78104	,78111	,78118	,78125	,78132	,78140	,78147	,78154	,78161	,78168
605	,78176	,78183	,78190	,78197	,78204	,78211	,78219	,78226	,78233	,78240
606	,78247	,78254	,78262	,78269	,78276	,78283	,78290	,78297	,78305	,78312
607	,78319	,78326	,78333	,78340	,78347	,78355	,78362	,78369	,78376	,78383
608	,78390	,78397	,78405	,78412	,78419	,78426	,78433	,78440	,78447	,78455
609	,78462	,78469	,78476	,78483	,78490	,78497	,78504	,78512	,78519	,78526
610	,78533	,78540	,78547	,78554	,78561	,78569	,78576	,78583	,78590	,78597
611	,78604	,78611	,78618	,78625	,78633	,78640	,78647	,78654	,78661	,78668
612	,78675	,78682	,78689	,78696	,78704	,78711	,78718	,78725	,78732	,78739
613	,78746	,78753	,78760	,78767	,78774	,78781	,78789	,78796	,78803	,78810
614	,78817	,78824	,78831	,78838	,78845	,78852	,78859	,78866	,78873	,78880
615	,78888	,78895	,78902	,78909	,78916	,78923	,78930	,78937	,78944	,78951
616	,78958	,78965	,78972	,78979	,78986	,78993	,79000	,79007	,79014	,79021
617	,79029	,79036	,79043	,79050	,79057	,79064	,79071	,79078	,79085	,79092
618	,79099	,79106	,79113	,79120	,79127	,79134	,79141	,79148	,79155	,79162
619	,79169	,79176	,79183	,79190	,79197	,79204	,79211	,79218	,79225	,79232
620	,79239	,79246	,79253	,79260	,79267	,79274	,79281	,79288	,79295	,79302
621	,79309	,79316	,79323	,79330	,79337	,79344	,79351	,79358	,79365	,79372
622	,79379	,79386	,79393	,79400	,79407	,79414	,79421	,79428	,79435	,79442
623	,79449	,79456	,79463	,79470	,79477	,79484	,794[illegible]	,79498	,79505	,79511
624	,79518	,79525	,79532	,79539	,79546	,79553	,79560	,79567	,79574	,79581
625	,79588	,79595	,79602	,79609	,79616	,79623	,79630	,79637	,79644	,79650
626	,79657	,79664	,79671	,79678	,79685	,79692	,79699	,79706	,79713	,79720
627	,79727	,79734	,79741	,79748	,79754	,79761	,79768	,79775	,79782	,79789
628	,79796	,79803	,79810	,79817	,79824	,79831	,79837	,79844	,79851	,79858
629	,79865	,79872	,79879	,79886	,79893	,79900	,79906	,79913	,79920	,79927
630	,79934	,79941	,79948	,79955	,79962	,79969	,79975	,79982	,79989	,79996
631	,80003	,80010	,80017	,80024	,80030	,80037	,80044	,80051	,80058	,80065
632	,80072	,80079	,80085	,80092	,80099	,80106	,80113	,80120	,80127	,80134
633	,80140	,80147	,80154	,80161	,80168	,80175	,80182	,80188	,80195	,80202
634	,80209	,80216	,80223	,80229	,80236	,80243	,80250	,80257	,80264	,80271
635	,80277	,80284	,80291	,80298	,80305	,80312	,80318	,80325	,80332	,80339
636	,80346	,80353	,80359	,80366	,80373	,80380	,80387	,80393	,80400	,80407
637	,80414	,80421	,80428	,80434	,80441	,80448	,80455	,80462	,80468	,80475
638	,80482	,80489	,80496	,80502	,80509	,80516	,80523	,80530	,80536	,80543
639	,80550	,80557	,80564	,80570	,80577	,80584	,80591	,80598	,80604	,80611
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 6400 to 6999. Logs. from ,80618 to ,84504.

N°	0	1	2	3	4	5	6	7	8	9
640	,80618	,80625	,80632	,80638	,80645	,80652	,80659	,80665	,80672	,80679
641	,80686	,80693	,80699	,80706	,80713	,80720	,80726	,80733	,80740	,80747
642	,80753	,80760	,80767	,80774	,80781	,80787	,80794	,80801	,80808	,80814
643	,80821	,80828	,80835	,80841	,80848	,80855	,80862	,80868	,80875	,80882
644	,80889	,80895	,80902	,80909	,80916	,80922	,80929	,80936	,80942	,80949
645	,80956	,80963	,80969	,80976	,80983	,80990	,80996	,81003	,81010	,81017
646	,81023	,81030	,81037	,81043	,81050	,81057	,81064	,81070	,81077	,81084
647	,81090	,81097	,81104	,81111	,81117	,81124	,81131	,81137	,81144	,81151
648	,81157	,81164	,81171	,81178	,81184	,81191	,81198	,81204	,81211	,81218
649	,81224	,81231	,81238	,81245	,81251	,81258	,81265	,81271	,81278	,81285
650	,81291	,81298	,81305	,81311	,81318	,81325	,81331	,81338	,81345	,81351
651	,81358	,81365	,81371	,81378	,81385	,81391	,81398	,81405	,81411	,81418
652	,81425	,81431	,81438	,81445	,81451	,81458	,81465	,81471	,81478	,81485
653	,81491	,81498	,81505	,81511	,81518	,81525	,81531	,81538	,81544	,81551
654	,81558	,81564	,81571	,81578	,81584	,81591	,81598	,81604	,81611	,81617
655	,81624	,81631	,81637	,81644	,81651	,81657	,81664	,81671	,81677	,81684
656	,81690	,81697	,81704	,81710	,81717	,81723	,81730	,81737	,81743	,81750
657	,81757	,81763	,81770	,81776	,81783	,81790	,81796	,81803	,81809	,81816
658	,81823	,81829	,81836	,81842	,81849	,81856	,81862	,81869	,81875	,81882
659	,81889	,81895	,81902	,81908	,81915	,81921	,81928	,81935	,81941	,81948
660	,81954	,81961	,81968	,81974	,81981	,81987	,81994	,82000	,82007	,82014
661	,82020	,82027	,82033	,82040	,82046	,82053	,82060	,82066	,82073	,82079
662	,82086	,82092	,82099	,82105	,82112	,82119	,82125	,82132	,82138	,82145
663	,82151	,82158	,82164	,82171	,82178	,82184	,82191	,82197	,82204	,82210
664	,82217	,82223	,82230	,82236	,82243	,82249	,82256	,82263	,82269	,82276
665	,82282	,82289	,82295	,82302	,82308	,82315	,82321	,82328	,82334	,82341
666	,82347	,82354	,82360	,82367	,82373	,82380	,82387	,82393	,82400	,82406
667	,82413	,82419	,82426	,82432	,82439	,82445	,82452	,82458	,82465	,82471
668	,82478	,82484	,82491	,82497	,82504	,82510	,82517	,82523	,82530	,82536
669	,82543	,82549	,82556	,82562	,82569	,82575	,82582	,82588	,82595	,82601
670	,82607	,82614	,82620	,82627	,82633	,82640	,82646	,82653	,82659	,82666
671	,82672	,82679	,82685	,82692	,82698	,82705	,82711	,82718	,82724	,82730
672	,82737	,82743	,82750	,82756	,82763	,82769	,82776	,82782	,82789	,82795
673	,82802	,82808	,82814	,82821	,82827	,82834	,82840	,82847	,82853	,82860
674	,82866	,82872	,82879	,82885	,82892	,82898	,82905	,82911	,82918	,82924
675	,82930	,82937	,82943	,82950	,82956	,82963	,82969	,82975	,82982	,82988
676	,82995	,83001	,83008	,83014	,83020	,83027	,83033	,83040	,83046	,83052
677	,83059	,83065	,83072	,83078	,83085	,83091	,83097	,83104	,83110	,83117
678	,83123	,83129	,83136	,83142	,83149	,83155	,83161	,83168	,83174	,83181
679	,83187	,83193	,83200	,83206	,83213	,83219	,83225	,83232	,83238	,83244
680	,83251	,83257	,83264	,83270	,83276	,83283	,83289	,83296	,83302	,83308
681	,83315	,83321	,83327	,83334	,83340	,83347	,83353	,83359	,83366	,83372
682	,83378	,83385	,83391	,83398	,83404	,83410	,83417	,83423	,83429	,83436
683	,83442	,83448	,83455	,83461	,83467	,83474	,83480	,83487	,83493	,83499
684	,83506	,83512	,83518	,83525	,83531	,83537	,83544	,83550	,83556	,83563
685	,83569	,83575	,83582	,83588	,83594	,83601	,83607	,83613	,83620	,83626
686	,83632	,83639	,83645	,83651	,83658	,83664	,83670	,83677	,83683	,83689
687	,83696	,83702	,83708	,83715	,83721	,83727	,83734	,83740	,83746	,83753
688	,83759	,83765	,83771	,83778	,83784	,83790	,83797	,83803	,83809	,83816
689	,83822	,83828	,83835	,83841	,83847	,83853	,83860	,83866	,83872	,83879
690	,83885	,83891	,83897	,83904	,83910	,83916	,83923	,83929	,83935	,83942
691	,83948	,83954	,83960	,83967	,83973	,83979	,83985	,83992	,83998	,84004
692	,84011	,84017	,84023	,84029	,84036	,84042	,84048	,84055	,84061	,84067
693	,84073	,84089	,84086	,84092	,84098	,84105	,84111	,84117	,84123	,84130
694	,84136	,84142	,84148	,84155	,84161	,84167	,84173	,84180	,84186	,84192
695	,84198	,84205	,84211	,84217	,84223	,84230	,84236	,84242	,84248	,84255
696	,84261	,84267	,84273	,84280	,84286	,84292	,84298	,84305	,84311	,84317
697	,84323	,84330	,84336	,84342	,84348	,84354	,84361	,84367	,84373	,84379
698	,84386	,84392	,84398	,84404	,84410	,84417	,84423	,84429	,84435	,84441
699	,84448	,84454	,84460	,84466	,84473	,84479	,84485	,84491	,84497	,84504
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 7000 to 7599. Logs. from ,84510 to ,88076.

No	0	1	2	3	4	5	6	7	8	9
700	,84510	,84516	,84522	,84528	,84535	,84541	,84547	,84553	,84559	,84566
701	,84572	,84578	,84584	,84590	,84597	,84603	,84609	,84615	,84621	,84628
702	,84634	,84640	,84646	,84652	,84658	,84665	,84671	,84677	,84683	,84689
703	,84696	,84702	,84708	,84714	,84720	,84726	,84733	,84739	,84745	,84751
704	,84757	,84763	,84770	,84776	,84782	,84788	,84794	,84800	,84807	,84813
705	,84819	,84825	,84831	,84837	,84844	,84850	,84856	,84862	,84868	,84874
706	,84880	,84887	,84893	,84899	,84905	,84911	,84917	,84924	,84930	,84936
707	,84942	,8494	,84954	,84960	,84967	,84973	,84979	,84985	,84991	,84997
708	,85003	,85009	,85016	,85022	,85028	,85034	,85040	,85046	,85052	,85058
709	,85065	,85071	,85077	,85083	,85089	,85095	,85101	,85107	,85114	,85120
710	,85126	,85132	,85138	,85144	,85150	,85156	,85163	,85169	,85175	,85181
711	,85187	,85193	,85199	,85205	,85211	,85217	,85224	,85230	,85236	,85242
712	,85248	,85254	,85260	,85266	,85272	,85278	,85285	,85291	,85297	,85303
713	,85309	,85315	,85321	,85327	,85333	,85339	,85345	,85352	,85358	,85364
714	,85370	,85376	,85382	,85388	,85394	,85400	,85406	,85412	,85418	,85425
715	,85431	,85437	,85443	,85449	,85455	,85461	,85467	,85473	,85479	,85485
716	,85491	,85497	,85503	,85509	,85516	,85522	,85528	,85534	,85540	,85546
717	,85552	,85558	,85564	,85570	,85576	,85582	,85588	,85594	,85600	,85606
718	,85612	,85618	,85625	,85631	,85637	,85643	,85649	,85655	,85661	,85667
719	,85673	,85679	,85685	,85691	,85697	,85703	,85709	,85715	,85721	,85727
720	,85733	,85739	,85745	,85751	,85757	,85763	,85769	,85775	,85781	,85787
721	,85794	,85800	,85806	,85812	,85818	,85824	,85830	,85836	,85842	,85848
722	,85854	,85860	,85866	,85872	,85878	,85884	,85890	,85896	,85902	,85908
723	,85914	,85920	,85926	,85932	,85938	,85944	,85950	,85956	,85962	,85968
724	,85974	,85980	,85986	,85992	,85998	,86004	,86010	,86016	,86022	,86028
725	,86034	,86040	,86046	,86052	,86058	,86064	,86070	,86076	,86082	,86088
726	,86094	,86100	,86106	,86112	,86118	,86124	,86130	,86136	,86141	,86147
727	,86153	,86159	,86165	,86171	,86177	,86183	,86189	,86195	,86201	,86207
728	,86213	,86219	,86225	,86231	,86237	,86243	,86249	,86255	,86261	,86267
729	,86273	,86279	,86285	,86291	,86297	,86303	,86308	,86314	,86320	,86326
730	,86332	,86338	,86344	,86350	,86356	,86362	,86368	,86374	,86380	,86386
731	,86392	,86398	,86404	,86410	,86415	,86421	,86427	,86433	,86439	,86445
732	,86451	,86457	,86463	,86469	,86475	,86481	,86487	,86493	,86499	,86504
733	,86510	,86516	,86522	,86528	,86534	,86540	,86546	,86552	,86558	,86564
734	,86570	,86576	,86581	,86587	,86593	,86599	,86605	,86611	,86617	,86623
735	,86629	,86635	,86641	,86646	,86652	,86658	,86664	,86670	,86676	,86682
736	,86688	,86694	,86700	,86705	,86711	,86717	,86723	,86729	,86735	,86741
737	,86747	,86753	,86759	,86764	,86770	,86776	,86782	,86788	,86794	,86800
738	,86806	,86812	,86817	,86823	,86829	,86835	,86841	,86847	,86853	,86859
739	,86864	,86870	,86876	,86882	,86888	,86894	,86900	,86906	,86911	,86917
740	,86923	,86929	,86935	,86941	,86947	,86953	,86958	,86964	,86970	,86976
741	,86982	,86988	,86994	,86999	,87005	,87011	,87017	,87023	,87029	,87035
742	,87040	,87046	,87052	,87058	,87064	,87070	,87075	,87081	,87087	,87093
743	,87099	,87105	,87111	,87116	,87122	,87128	,87134	,87140	,87146	,87151
744	,87157	,87163	,87169	,87175	,87181	,87186	,87192	,87198	,87204	,87210
745	,87216	,87221	,87227	,87233	,87239	,87245	,87251	,87256	,87262	,87268
746	,87274	,87280	,87286	,87291	,87297	,87303	,87309	,87315	,87320	,87326
747	,87332	,87338	,87344	,87349	,87355	,87361	,87367	,87373	,87379	,87384
748	,87390	,87396	,87402	,87408	,87413	,87419	,87425	,87431	,87437	,87442
749	,87448	,87454	,87460	,87466	,87471	,87477	,87483	,87489	,87495	,87500
750	,87506	,87512	,87518	,87523	,87529	,87535	,87541	,87547	,87552	,87558
751	,87564	,87570	,87576	,87581	,87587	,87593	,87599	,87604	,87610	,87616
752	,87622	,87628	,87633	,87639	,87645	,87651	,87656	,87662	,87668	,87674
753	,87679	,87685	,87691	,87697	,87703	,87708	,87714	,87720	,87726	,87731
754	,87737	,87743	,87749	,87754	,87760	,87766	,87772	,87777	,87783	,87789
755	,87795	,87800	,87806	,87812	,87818	,87823	,87829	,87835	,87841	,87846
756	,87852	,87858	,87864	,87869	,87875	,87881	,87887	,87892	,87898	,87904
757	,87910	,87915	,87921	,87927	,87933	,87938	,87944	,87950	,87955	,87961
758	,87967	,87973	,87978	,87984	,87990	,87996	,88001	,88007	,88013	,88018
759	,88024	,87030	,88036	,88041	,88047	,88053	,88058	,88064	,88070	,88076
No	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 7600 to 8199. Logs. from ,88081 to ,91376.

N°	0	1	2	3	4	5	6	7	8	9
760	,88081	,88087	,88093	,88098	,88104	,88110	,88116	,88121	,88127	,88133
761	,88138	,88144	,88150	,88156	,88161	,88167	,88173	,88178	,88184	,88190
762	,88195	,88201	,88207	,88213	,88218	,88224	,88230	,88235	,88241	,88247
763	,88252	,88258	,88264	,88270	,88275	,88281	,88287	,88292	,88298	,88304
764	,88309	,88315	,88321	,88326	,88332	,88338	,88343	,88349	,88355	,88360
765	,88366	,88372	,88377	,88383	,88389	,88395	,88400	,88406	,88412	,88417
766	,88423	,88429	,88434	,88440	,88446	,88451	,88457	,88463	,88468	,88474
767	,88480	,88485	,88491	,88497	,88502	,88508	,88513	,88519	,88525	,88530
768	,88536	,88542	,88547	,88553	,88559	,88564	,88570	,88576	,88581	,88587
769	,88593	,88598	,88604	,88610	,88615	,88621	,88627	,88632	,88638	,88643
770	,88649	,88655	,88660	,88666	,88672	,88677	,88683	,88689	,88694	,88700
771	,88705	,88711	,88717	,88722	,88728	,88734	,88739	,88745	,88750	,88756
772	,88762	,88767	,88773	,88779	,88784	,88790	,88795	,88801	,88807	,88812
773	,88818	,88824	,88829	,88835	,88840	,88846	,88852	,88857	,88863	,88868
774	,88874	,88880	,88885	,88891	,88897	,88902	,88908	,88913	,88919	,88925
775	,88930	,88936	,88941	,88947	,88953	,88958	,88964	,88969	,88975	,88981
776	,88986	,88992	,88997	,89003	,89009	,89014	,89020	,89025	,89031	,89037
777	,89042	,89048	,89053	,89059	,89064	,89070	,89076	,89081	,89087	,89092
778	,89098	,89104	,89109	,89115	,89120	,89126	,89131	,89137	,89143	,89148
779	,89154	,89159	,89165	,89170	,89176	,89182	,89187	,89193	,89198	,89204
780	,89209	,89215	,89221	,89226	,89232	,89237	,89243	,89248	,89254	,89260
781	,89265	,89271	,89276	,89282	,89287	,89293	,89298	,89304	,89310	,89315
782	,89321	,89326	,89332	,89337	,89343	,89348	,89354	,89360	,89365	,89371
783	,89376	,89382	,89387	,89393	,89398	,89404	,89409	,89415	,89421	,89426
784	,89432	,89437	,89443	,89448	,89454	,89459	,89465	,89470	,89476	,89481
785	,89487	,89492	,89498	,89504	,89509	,89515	,89520	,89526	,89531	,89537
786	,89542	,89548	,89553	,89559	,89564	,89570	,89575	,89581	,89586	,89592
787	,89597	,89603	,89609	,89614	,89620	,89625	,89631	,89636	,89642	,89647
788	,89653	,89658	,89664	,89669	,89675	,89680	,89686	,89691	,89697	,89702
789	,89708	,89713	,89719	,89724	,89730	,89735	,89741	,89746	,89752	,89757
790	,89763	,89768	,89774	,89779	,89785	,89790	,89796	,89801	,89807	,89812
791	,89818	,89823	,89829	,89834	,89840	,89845	,89851	,89856	,89862	,89867
792	,89873	,89878	,89883	,89889	,89894	,89900	,89905	,89911	,89916	,89922
793	,89927	,89933	,89938	,89944	,89949	,89955	,89960	,89966	,89971	,89977
794	,89982	,89988	,89993	,89998	,90004	,90009	,90015	,90020	,90026	,90031
795	,90037	,90042	,90048	,90053	,90059	,90064	,90069	,90075	,90080	,90086
796	,90091	,90097	,90102	,90108	,90113	,90119	,90124	,90129	,90135	,90140
797	,90146	,90151	,90157	,90162	,90168	,90173	,90179	,90184	,90189	,90195
798	,90200	,90206	,90211	,90217	,90222	,90227	,90233	,90238	,90244	,90249
799	,90255	,90260	,90266	,90271	,90276	,90282	,90287	,90293	,90298	,90304
800	,90309	,90314	,90320	,90325	,90331	,90336	,90342	,90347	,90352	,90358
801	,90363	,90369	,90374	,90380	,90385	,90390	,90396	,90401	,90407	,90412
802	,90417	,90423	,90428	,90434	,90439	,90444	,90450	,90455	,90461	,90466
803	,90472	,90477	,90482	,90488	,90493	,90499	,90504	,90509	,90515	,90520
804	,90526	,90531	,90536	,90542	,90547	,90553	,90558	,90563	,90569	,90574
805	,90580	,90585	,90590	,90596	,90601	,90607	,90612	,90617	,90623	,90628
806	,90633	,90639	,90644	,90650	,90655	,90660	,90666	,90671	,90677	,90682
807	,90687	,90693	,90698	,90703	,90709	,90714	,90720	,90725	,90730	,90736
808	,90741	,90747	,90752	,90757	,90763	,90768	,90773	,90779	,90784	,90789
809	,90795	,90800	,90806	,90811	,90816	,90822	,90827	,90832	,90838	,90843
810	,90848	,90854	,90859	,90865	,90870	,90875	,90881	,90886	,90891	,90897
811	,90902	,90907	,90913	,90918	,90923	,90929	,90934	,90940	,90945	,90950
812	,90956	,90961	,90966	,90972	,90977	,90982	,90988	,90993	,90998	,91004
813	,91009	,91014	,91020	,91025	,91030	,91036	,91041	,91046	,91052	,91057
814	,91062	,91068	,91073	,91078	,91084	,91089	,91094	,91100	,91105	,91110
815	,91116	,91121	,91126	,91132	,91137	,91142	,91148	,91153	,91158	,91164
816	,91169	,91174	,91180	,91185	,91190	,91196	,91201	,91206	,91212	,91217
817	,91222	,91228	,91233	,91238	,91243	,91249	,91254	,91259	,91265	,91270
818	,91275	,91281	,91286	,91291	,91297	,91302	,91307	,91312	,91318	,91323
819	,91328	,91334	,91339	,91344	,91350	,91355	,91360	,91365	,91371	,91376
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 8200 to 8799. Logs. from ,91381 to ,94443.

N°	0	1	2	3	4	5	6	7	8	9
820	,91381	,91387	,91392	,91397	,91403	,91408	,91413	,91418	,91424	,91429
821	,91434	,91440	,91445	,91450	,91455	,91461	,91466	,91471	,91477	,91482
822	,91487	,91492	,91498	,91503	,91508	,91514	,91519	,91524	,91529	,91535
823	,91540	,91545	,91551	,91556	,91561	,91566	,91572	,91577	,91582	,91587
824	,91593	,91598	,91603	,91609	,91614	,91619	91624	,91630	,91635	,91640
825	91645	,91651	,91656	,91661	,91666	,91672	91677	,91682	,91687	,91693
826	,91698	,91703	,91709	,91714	,91719	,91724	,91730	,91735	,91740	,91745
827	,91751	,91756	,91761	,91766	,91772	,91777	,91782	,91787	,91793	,91798
828	,91803	,91808	,91814	,91819	,91824	,91829	,91834	,91840	,91845	,91850
829	91855	,91861	,91866	,91871	,91876	,91882	,91887	,91892	,91897	,91903
830	,91908	,91913	,91918	,91923	,91929	,91934	,91939	,91944	,91950	,91955
831	,91960	,91965	,91971	,91976	,91981	,91986	,91991	,91997	,92002	,92007
832	,92012	,92018	,92023	,92028	,92033	,92038	,92044	,92049	,92054	,92059
833	,92064	,92070	,92075	,92080	,92085	,92091	,92096	,92101	,92106	,92111
834	,92117	,92122	,92127	,92132	,92137	,92143	,92148	,92153	,92158	,92163
835	,92169	,92174	,92179	,92184	92189	,92195	,92200	,92205	,92210	,92215
836	,92221	,92226	,92231	,92236	,92241	,92247	,92252	,92257	,92262	,92267
837	,92273	,92278	,92283	,92288	,92293	,92298	,92304	,92309	,92314	,92319
838	,92324	,92330	,92335	,92340	,92345	,92350	,92355	,92361	92366	,92371
839	,92376	,92381	,92387	,92392	,92397	,92402	,92407	,92412	92418	,92423
840	,92428	,92433	,92438	,92443	,92449	,92454	,92459	,92464	,92469	,92474
841	,92480	,92485	,92490	,92495	,92500	,92505	,92511	,92516	,92521	,92526
842	,92531	,92536	,92542	,92547	,92552	,92557	,92562	,92567	,92572	,92578
843	,92583	,92588	,92593	,92598	,92603	,92609	,92614	,92619	,92624	,92629
844	,92634	,92639	,92645	,92650	,92655	,92660	,92665	,92670	,92675	,92681
845	,92686	,92691	,92696	,92701	,92706	,92711	,92716	,92722	,92727	,92732
846	,92737	,92742	,92747	,92752	,92758	,92763	,92768	,92773	,92778	,92783
847	,92788	,92793	,92799	,92804	,92809	,92814	,92819	,92824	,92829	,92834
848	,92840	,92845	,92850	,92855	,92860	,92865	,92870	,92875	,92881	,92886
849	,92891	,92896	,92901	,92906	,92911	,92916	,92921	,92927	,92932	,92937
850	,92942	,92947	,92952	,92957	,92962	,92967	,92973	,92978	,92983	,92988
851	,92993	,92998	,93003	,93008	,93013	,93018	,93024	,93029	,93034	,93039
852	,93044	,93049	,93054	,93059	,93064	,93069	,93075	,93080	,93085	,93090
853	,93095	,93100	,93105	,93110	,93115	93120	,93125	,93131	,93136	,93141
854	,93146	,93151	,93156	,93161	,93166	,93171	,93176	93181	,93186	,93192
855	,93197	,93202	,93207	,93212	,93217	,93222	,93227	,93232	,93237	,93242
856	,93247	,93252	,93258	,93263	,93268	,93273	,93278	,93283	,93288	,93293
857	,93298	,93303	,93308	,93313	,93318	,93323	,93328	,93334	,93339	,93344
858	,93349	,93354	,93359	,93364	,93369	,93374	,93379	,93384	,93389	,93394
859	,93399	,93404	,93409	,93414	,93420	,93425	,93430	,93435	,93440	,93445
860	,93450	,93455	,93460	,93465	,93470	,93475	,93480	,93485	,93490	,93495
861	,93500	,93505	,93510	,93515	,93520	,93526	,93531	,93536	,93541	,93546
862	,93551	,93556	,93561	,93566	,93571	,93576	,93581	,93586	,93591	,93596
863	,93601	,93606	,93611	,93616	,93621	,93626	,93631	,93636	,93641	,93646
864	,93651	,93656	,93661	,93666	,93671	,93676	,93682	,93687	,93692	,93697
865	,93702	,93707	,93712	,93717	,93722	,93727	,93732	,93737	,93742	,93747
866	,93752	,93757	,93762	,93767	,93772	,93777	,93782	,93787	,93792	,93797
867	,93802	,93807	,93812	,93817	,93822	,93827	,93832	,93837	,93842	,93847
868	,93852	,93857	,93862	,93867	,93872	,93877	,93382	,93887	,93892	,93897
869	,93902	,93907	,93012	,93917	,93922	,93927	,93932	,93937	,93942	,93947
870	,93952	,93957	,93962	,93967	,93972	,93977	,93982	,93987	,93992	,93997
871	,94002	,94007	,94012	,94017	,94022	,94027	,94032	,94037	,94042	,94047
872	,94052	,94057	,94062	,94067	,94072	,94077	,94082	,94086	,94091	,94096
873	,94101	,94106	,94111	,94116	,94121	,94126	,94131	,94136	,94141	,94146
874	,94151	,94156	,94161	,94166	,94171	,94176	,94181	94186	,94191	,94196
875	,94201	,94206	,94211	,94216	,94221	,94226	,94231	,94236	,94240	,94245
876	,94250	,94255	,94260	,94265	,94270	,94275	,94280	,94285	,94290	,94295
877	,94300	,94305	,94310	,94315	,94320	,94325	,94330	,94335	,94340	,94344
878	,94349	,94354	,94359	,94364	,94369	,94374	,94379	,94384	,94389	,94394
879	,94399	,94404	,94409	,94414	,94419	,94424	,94429	,94433	94438	,94443
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 8800 to 9399. Logs. from ,94448 to ,97308.

N°	0	1	2	3	4	5	6	7	8	9
880	,94448	,94453	,944[illegible]	,94463	,94468	,94473	,94478	,94483	,94488	,94493
881	,94498	,94503	,94507	,94512	,94517	,94522	,94527	,94532	,94537	,94542
882	,94547	,94552	,94557	,94562	,94567	,94571	,94576	,94581	,94586	,94591
883	,94596	,94601	,94606	,94611	,94616	,94621	,94626	,94630	,94635	,94640
884	,94645	,94650	,94655	,94660	,94665	,94670	,94675	,94680	,94685	,94689
885	,94694	,94699	,94704	,94709	,94714	,94719	,94724	,94729	,94734	,94738
886	,94743	,94748	,94753	,94758	,94763	,94768	,94773	,94778	,94783	,94787
887	,94792	,94797	,94802	,94807	,94812	,94817	,94822	,94827	,94832	,94836
888	,94841	,94846	,94851	,94856	,94861	,94866	,94871	,94876	,94880	,94885
889	,94890	,94895	,94900	,94905	,94910	,94915	,94919	,94924	,94929	,94934
890	,94939	,94944	,94949	,94954	,94959	,94963	,94968	,94973	,94978	,94983
891	,94988	,94993	,94998	,95002	,95007	,95012	,95017	,95022	,95027	,95032
892	,95036	,95041	,95046	,95051	,95056	,95061	,95066	,95071	,95075	,95080
893	,95085	,95090	,95095	,95100	,95105	,95109	,95114	,95119	,95124	,95129
894	,95134	,93139	,95143	,95148	,95153	,95158	,95163	,95168	,95173	,95177
895	,95182	,95187	,95102	,95197	,95202	,95207	,95211	,95216	,95221	,95226
896	,95231	,95236	,95240	,95245	,95250	,95255	,95260	,95265	,95270	,95274
897	,95279	,95284	,95289	,952[illegible]4	,95299	,95303	,953[illegible]	,95313	,95318	,95323
898	,95328	,95332	,95337	,95342	,95347	,95352	,95357	,95361	,95366	,95371
899	,95376	,95381	,95386	,95390	,95395	,95400	,95405	,95410	,95415	,95419
900	,95424	,95429	,95434	,95439	,95444	,95448	,95453	,95458	,95463	,95468
901	,95472	,95477	,95482	,95487	,95492	,95497	,95501	,95506	,95511	,95516
902	,95521	,95525	,95530	,95535	,95540	,95545	,95550	,95554	,9555[illegible]	,95564
903	,95569	,95574	,95578	,95583	,95588	,95593	,95598	,95602	,9560[illegible]	,95612
904	,95617	,95622	,95626	,95631	,95636	,95641	,95646	,95650	,9565[illegible]	,95660
905	,95665	,95670	,95674	,95679	,95684	,95689	,95694	,95698	,9570[illegible]	,95708
906	,95713	,95718	,95722	,95727	,95732	,95737	,95742	,95746	,95751	,95756
907	,95761	,95766	,95770	,95775	,95780	,95785	,95789	,95794	,9579[illegible]	,95804
908	,95809	,95813	,95818	,95823	,95828	,95832	,95837	,95842	,958[illegible]	,95852
909	,95856	,95861	,95866	,9587[illegible]	,95875	,95880	,95885	,95890	,958[illegible]	,95899
910	,95904	,95909	,95914	,95918	,95923	,95928	,95933	,95938	,9594[illegible]	,95947
911	,95952	,95957	,95961	,95966	,95971	,95976	,95980	,95985	,9599[illegible]	,95995
912	,95999	,96004	,96009	,96014	,96019	,96023	,96028	,96033	,96038	,96042
913	,96047	,96052	,96057	,96061	,96066	,96071	,96076	,96080	,9608[illegible]	,96090
914	,96095	,96099	,96104	,96109	,96114	,96118	,96123	,96128	,9613[illegible]	,96137
915	,96142	,96147	,96152	,96156	,96161	,96166	,96171	,96175	,9618[illegible]	,96185
916	,96190	,96194	,96199	,96204	,96209	,96213	,96218	,96223	,9622[illegible]	,96232
917	,96237	,96242	,96246	,96251	,96256	,96261	,96265	,96270	,96275	,96280
918	,96284	,96289	,96294	,96298	,96303	,96308	,96313	,96317	,96322	,96327
919	,96332	,96336	,96341	,96346	,96350	,96355	,96360	,96365	,96369	,96374
920	,96379	,96383	,96388	,96393	,96398	,96402	,96407	,96412	,96417	,96421
921	,96426	,96431	,96435	,96440	,96445	,96450	,96454	,96459	,96464	,96468
922	,96473	,96478	,96483	,96487	,96492	,96497	,96501	,96506	,96511	,96515
923	,96520	,96525	,96530	,96534	,96539	,96544	,96548	,96553	,96558	,96562
924	,96567	,96572	,96577	,96581	,96586	,96591	,96595	,96600	,96605	,96609
925	,96614	,96619	,96624	,96628	,96633	,96638	,96642	,96647	,96652	,96656
926	,96661	,96666	,96670	,96675	,96680	,96685	,96689	,96694	,96699	,96703
927	,96708	,96713	,96717	,96722	,96727	,96731	,96736	,96741	,96745	,96750
928	,96755	,96759	,96764	,96769	,96774	,96778	,96783	,96788	,9679[illegible]	,96797
929	,96802	,96806	,96811	,96816	,96820	,96825	,96830	,96834	,9683[illegible]	,96844
930	,96848	,96853	,96858	,96862	,96867	,96872	,96876	,96881	,9688[illegible]	,96890
931	,96895	,96900	,96904	,96909	,96914	,96918	,96923	,96928	,96932	,96937
932	,96942	,96946	,96951	,96956	,96960	,96965	,96970	,96974	,96979	,96984
933	,96988	,96993	,96997	,97002	,97007	,97011	,97016	,97021	,97025	,97030
934	,97035	,97039	,97044	,97049	,97053	,97058	,97063	,97067	,97072	,97077
935	,97081	,97086	,97090	,97095	,97100	,97104	,97109	,97114	,97118	,97123
936	,97128	,97132	,97137	,97141	,97146	,97151	,97155	,97160	,97165	,97169
937	,97174	,97179	,97183	,97188	,97192	,97197	,97202	,97206	,97211	,97216
938	,97220	,97225	,97230	,97234	,97239	,97243	,97248	,97253	,97257	,97262
939	,97267	,97271	,97276	,97280	,97285	,97290	,97294	,97299	,97304	,97308
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

Numbers from 9400 to 9999. Logs. from ,97313 to ,99996.

N°	0	1	2	3	4	5	6	7	8	9
940	,97313	,97317	,97322	,97327	,97331	,97336	,97340	,97345	,97350	,97354
941	,97359	,97364	,97368	,97373	,97377	,97382	,97387	,97391	,97396	,97400
942	,97405	,97410	,97414	,97419	,97424	,97428	,97433	,97437	,97442	,97447
943	,97451	,97456	,97460	,97465	,97470	,97474	,97479	,97483	,97488	,97493
944	,97497	,97502	,97506	,97511	,97516	,97520	,97525	,97529	,97534	,97539
945	,97543	,97548	,97552	,97557	,97562	,97566	,97571	,97575	,97580	,97585
946	,97589	,97594	,97598	,97603	,97607	,97612	,97617	,97621	,97626	,97630
947	,97635	,97640	,97644	,97649	,97653	,97658	,97663	,97667	,97672	,97676
948	,97681	,97685	,97690	,97695	,97699	,97704	,97708	,97713	,97717	,97722
949	,97727	,97731	,97736	,97740	,97745	,97749	,97754	,97759	,97763	,97768
950	,97772	,97777	,97781	,97786	,97791	,97795	,97800	,97804	,97809	,97813
951	,97818	,97823	,97827	,97832	,97836	,97841	,97845	,97850	,97855	,97859
952	,97864	,97868	,97873	,97877	,97882	,97886	,97891	,97896	,97900	,97905
953	,97909	,97914	,97918	,97923	,97928	,97932	,97937	,97941	,97946	,97950
954	,97955	,97959	,97964	,97968	,97973	,97978	,97982	,97987	,97991	,97996
955	,98000	,98005	,98009	,98014	,98019	,98023	,98028	,98032	,98037	,98041
956	,98046	,98050	,98055	,98059	,98064	,98068	,98073	,98078	,98082	,98087
957	,98091	,98096	,98100	,98105	,98109	,98114	,98118	,98123	,98127	,98132
958	,98137	,98141	,98146	,98150	,98155	,98159	,98164	,98168	,98173	,98177
959	,98182	,98186	,98191	,98195	,98200	,98204	,98209	,98214	,98218	,98223
960	,98227	,98232	,98236	,98241	,98245	98250	,98254	,98259	,98263	,98268
961	,98272	,98277	,98281	,98286	,98290	,98295	,98299	,98304	,98308	,98313
962	,98318	,98322	,98327	,98331	,98336	,98340	,98345	,98349	,98354	,98358
963	,98363	,98367	,98372	,98376	,98381	,98385	,98390	,98394	,98399	,98403
964	,98408	,98412	,98417	,98421	,98426	,98430	,98435	,98439	,98444	,98448
965	,98453	,98457	,98462	,98466	,98471	,98475	,98480	,98484	,98489	,98493
966	,98498	,98502	,98507	98511	,98516	,98520	,98525	,98529	,98534	,98538
967	,98543	,98547	,98552	,98556	,98561	,98565	,98570	,98574	,98579	,98583
968	,98588	,98592	,98597	,98601	,98605	,98610	,98614	,98619	,98623	,98628
969	,98632	,98637	,98641	,98646	,98650	,98655	,98659	,98664	,98668	,98673
970	,98677	,98682	,98686	,98691	,98695	,98700	,98704	,98708	,98713	,98717
971	,98722	,98726	,98731	,98735	,98740	,98744	,98749	,98753	,98758	,98762
972	,98767	,98771	,98776	,98780	,98784	,98789	,98793	,98798	,98802	,98807
973	,98811	,98816	,98820	,98825	,98829	,98834	,98838	,98843	,98847	,98851
974	,98856	,98860	,98865	,98869	,98874	,98878	,98883	,98887	,98892	,98896
975	,98900	,98905	,98909	,98914	,98918	,98923	,98927	,98932	,98936	,98941
976	,98945	,98949	,98954	,98958	,98963	,98967	,98972	,98976	,98981	,98985
977	,98989	,98994	,98998	,99003	,99007	,99012	,99016	,99021	,99025	,99029
978	,99034	,99038	,99043	,99047	,99052	,99056	,99061	,99065	,99069	,99074
979	,99078	,99083	,99087	,99092	,99096	,99100	,99105	,99109	,99114	,99118
980	,99123	,99127	,99131	,99136	,99140	,99145	99149	,99154	,99158	,99162
981	,99167	,99171	,99176	,99180	,99185	,99189	,99193	,99198	,99202	,99207
982	,99211	,99216	,99220	,99224	,99229	,99233	,99238	,99242	,99247	,99251
983	,99255	,99260	,99264	,99269	,99273	,99277	,99282	,99286	,99291	,99295
984	,99300	,99304	,99308	,99313	,99317	,99322	,99326	,99330	,99335	,99339
985	,99344	,99348	,99352	,99357	,99361	,99366	,99370	,99374	,99379	,99383
986	,99388	,99392	,99396	,99401	,99405	,99410	,99414	,99419	,99423	,99427
987	,99432	,99436	,99441	,99445	,99449	,99454	,99458	,99463	,99467	,99471
988	,99476	,99480	,99484	,99489	,99493	,99498	,99502	,99506	,99511	,99515
989	,99520	,99524	,99528	,99533	,99537	,99542	,99546	,99550	,99555	,99559
990	,99564	,99568	,99572	,99577	,99581	,99585	,99590	,99594	,99599	,99603
991	,99607	,99612	,99616	,99621	,99625	,99629	,99634	,99638	,99642	,99647
992	,99651	,99656	,99660	,99664	,99669	,99673	,99677	,99682	,99686	,99691
993	,99695	,99699	,99704	,99708	,99712	,99717	,99721	,99725	,99730	,99734
994	,99739	,99743	,99747	,99752	,99756	,99760	,99765	,99769	,99774	,99778
995	,99782	,99787	,99791	,99795	,99800	,99804	,99808	,99813	,99817	,99822
996	,99826	,99830	,99835	,99839	,99843	,99848	,99852	,99856	,99861	,99865
997	,99870	,99874	,99878	,99883	,99887	,99891	,99896	,99900	,99904	,99909
998	,99913	,99917	,99922	,99926	,99930	,99935	,99939	,99943	,99948	,99952
999	,99957	,99961	,99965	,99970	,99974	,99978	,99983	,99987	,99991	,99996
N°	0	1	2	3	4	5	6	7	8	9

Digitized by Google

0 Degree.					
M	Sine	Co-fine	Tang.	Co-tang.	
0	0,00000	10,00000	0,00000	Infinite.	60
1	6,46373	9,99999	6,46373	13,53627	59
2	6,76476	9,99999	6,76476	13,23524	58
3	6,94085	9,99999	6,94085	13,05915	57
4	7,06579	9,99999	7,06579	12,93421	56
5	7,16270	9,99999	7,16270	12,83730	55
6	7,24188	9,99999	7,24188	12,75812	54
7	7,30882	9,99999	7,30882	12,69118	53
8	7,36682	9,99999	7,36682	12,63318	52
9	7,41797	9,99999	7,41797	12,58203	51
10	7,46373	9,99999	7,46373	12,53627	50
11	7,50512	9,99999	7,50512	12,49488	49
12	7,54291	9,99999	7,54291	12,45709	48
13	7,57767	9,99999	7,57767	12,42233	47
14	7,60985	9,99999	7,60986	12,39014	46
15	7,63982	9,99999	7,63982	12,36018	45
16	7,66784	9,99999	7,66785	12,33215	44
17	7,69417	9,99999	7,69418	12,30582	43
18	7,71900	9,99999	7,71900	12,28100	42
19	7,74248	9,99999	7,74248	12,25752	41
20	7,76475	9,99999	7,76476	12,23524	40
21	7,78594	9,99999	7,78595	12,21405	39
22	7,80615	9,99999	7,80615	12,19385	38
23	7,82545	9,99999	7,82546	12,17454	37
24	7,84393	9,99999	7,84394	12,15606	36
25	7,86166	9,99999	7,86167	12,13833	35
26	7,87870	9,99999	7,87871	12,12129	34
27	7,89509	9,99999	7,89510	12,10490	33
28	7,91088	9,99999	7,91089	12,08911	32
29	7,92612	9,99998	7,92613	12,07387	31
30	7,94084	9,99998	7,94086	12,05914	30
31	7,95508	9,99998	7,95510	12,04490	29
32	7,96887	9,99998	7,96889	12,03111	28
33	7,98223	9,99998	7,98225	12,01775	27
34	7,99520	9,99998	7,99522	12,00478	26
35	8,00779	9,99998	8,00781	11,99219	25
36	8,02002	9,99998	8,02004	11,97996	24
37	8,03192	9,99997	8,03194	11,96806	23
38	8,04350	9,99997	8,04353	11,95647	22
39	8,05478	9,99997	8,05481	11,94519	21
40	8,06578	9,99997	8,06581	11,93419	20
41	8,07650	9,99997	8,07653	11,92347	19
42	8,08696	9,99997	8,08700	11,91300	18
43	8,09718	9,99997	8,09722	11,90278	17
44	8,10717	9,99996	8,10720	11,89280	16
45	8,11693	9,99996	8,11696	11,88304	15
46	8,12647	9,99996	8,12651	11,87349	14
47	8,13581	9,99996	8,13585	11,86415	13
48	8,14495	9,99996	8,14500	11,85500	12
49	8,15391	9,99996	8,15395	11,84605	11
50	8,16268	9,99995	8,16273	11,83727	10
51	8,17128	9,99995	8,17133	11,82867	9
52	8,17971	9,99995	8,17976	11,82024	8
53	8,18798	9,99995	8,18804	11,81196	7
54	8,19610	9,99995	8,19616	11,80384	6
55	8,20407	9,99994	8,20413	11,79587	5
56	8,21189	9,99994	8,21195	11,78805	4
57	8,21958	9,99994	8,21964	11,78036	3
58	8,22713	9,99994	8,22720	11,77280	2
59	8,23456	9,99994	8,23462	11,76538	1
60	8,24186	9,99993	8,24192	11,75808	0
	Co-fine	Sine	Co-tan.	Tangent	M
89 Degrees.					

1 Degree.					
M	Sine.	Co-fine	Tang.	Co-tang.	
0	8,24186	9,99993	8,24192	11,75808	60
1	8,24903	9,99993	8,24910	11,75090	59
2	8,25609	9,99993	8,25616	11,74384	58
3	8,26304	9,99993	8,26312	11,73688	57
4	8,26988	9,99992	8,26996	11,73004	56
5	8,27661	9,99992	8,27669	11,72331	55
6	8,28324	9,99992	8,28332	11,71668	54
7	8,28977	9,99992	8,28986	11,71014	53
8	8,29621	9,99991	8,29629	11,70371	52
9	8,30255	9,99991	8,30263	11,69737	51
10	8,30879	9,99991	8,30888	11,69112	50
11	8,31495	9,99991	8,31505	11,68495	49
12	8,32103	9,99990	8,32112	11,67888	48
13	8,32702	9,99990	8,32711	11,67289	47
14	8,33292	9,99990	8,33302	11,66698	46
15	8,33875	9,99990	8,33886	11,66114	45
16	8,34450	9,99989	8,34461	11,65539	44
17	8,35018	9,99989	8,35029	11,64971	43
18	8,35578	9,99989	8,35590	11,64410	42
19	8,36131	9,99989	8,36143	11,63857	41
20	8,36678	9,99988	8,36689	11,63311	40
21	8,37217	9,99988	8,37229	11,62771	39
22	8,37750	9,99988	8,37762	11,62238	38
23	8,38276	9,99987	8,38289	11,61711	37
24	8,38796	9,99987	8,38809	11,61191	36
25	8,39310	9,99987	8,39323	11,60677	35
26	8,39818	9,99986	8,39832	11,60168	34
27	8,40320	9,99986	8,40334	11,59666	33
28	8,40816	9,99986	8,40830	11,59170	32
29	8,41307	9,99985	8,41321	11,58679	31
30	8,41792	9,99985	8,41807	11,58193	30
31	8,42272	9,99985	8,42287	11,57713	29
32	8,42746	9,99984	8,42762	11,57238	28
33	8,43216	9,99984	8,43231	11,56768	27
34	8,43680	9,99984	8,43696	11,56304	26
35	8,44139	9,99983	8,44156	11,55844	25
36	8,44594	9,99983	8,44611	11,55389	24
37	8,45044	9,99983	8,45061	11,54939	23
38	8,45489	9,99982	8,45507	11,54493	22
39	8,45930	9,99982	8,45948	11,54052	21
40	8,46366	9,99982	8,46385	11,53615	20
41	8,46798	9,99981	8,46817	11,53183	19
42	8,47226	9,99981	8,47245	11,52755	18
43	8,47650	9,99980	8,47669	11,52331	17
44	8,48069	9,99980	8,48089	11,51911	16
45	8,48485	9,99980	8,48505	11,51495	15
46	8,48896	9,99979	8,48917	11,51083	14
47	8,49304	9,99979	8,49325	11,50675	13
48	8,49708	9,99979	8,49729	11,50271	12
49	8,50108	9,99978	8,50130	11,49870	11
50	8,50504	9,99978	8,50527	11,49473	10
51	8,50897	9,99977	8,50920	11,49080	9
52	8,51287	9,99977	8,51310	11,48690	8
53	8,51673	9,99977	8,51696	11,48304	7
54	8,52055	9,99976	8,52079	11,47921	6
55	8,52434	9,99976	8,52459	11,47541	5
56	8,52810	9,99975	8,52835	11,47165	4
57	8,53183	9,99975	8,53208	11,46792	3
58	8,53552	9,99974	8,53578	11,46422	2
59	8,53919	9,99974	8,53945	11,46055	1
60	8,54282	9,99974	8,54308	11,45692	0
	Co-fine	Sine	Co-tan	Tangent	M
88 Degrees.					

Digitized by Google

2 Degrees.

M	Sine	Co-sine.	Tang.	Co-tang.	
0	8,54282	9,99974	8,54308	11,45692	60
1	8,54642	9,99973	8,54669	11,45331	59
2	8,54999	9,99973	8,55027	11,44973	58
3	8,55354	9,99972	8,55382	11,44618	57
4	8,55705	9,99972	8,55734	11,44266	56
5	8,56054	9,99971	8,56083	11,43917	55
6	8,56400	9,99971	8,56429	11,43571	54
7	8,56743	9,99970	8,56773	11,43227	53
8	8,57084	9,99970	8,57114	11,42886	52
9	8,57421	9,99969	8,57452	11,42548	51
10	8,57757	9,99909	8,57788	11,42212	50
11	8,58089	9,99968	8,58121	11,41879	49
12	8,58419	9,99968	8,58451	11,41549	48
13	8,58747	9,99967	8,58779	11,41221	47
14	8,59072	9,99967	8,59105	11,40895	46
15	8,59395	9,99966	8,59428	11,40572	45
16	8,59715	9,99966	8,59749	11,40251	44
17	8,60033	9,99965	8,60068	11,39932	43
18	8,60349	9,99965	8,60384	11,39616	42
19	8,60662	9,99964	8,60698	11,39302	41
20	8,60973	9,99964	8,61009	11,38991	40
21	8,61282	9,99963	8,61319	11,38681	39
22	8,61589	9,99963	8,61626	11,38374	38
23	8,61894	9,99962	8,61931	11,38069	37
24	8,6219·	9,99962	8,62234	11,37766	36
25	8,62497	9,99961	8,62535	11,37465	35
26	8,62795	9,99961	8,62834	11,37166	34
27	8,63091	9,99960	8,63131	11,36869	33
28	8,63385	9,99960	8,63426	11,36574	32
29	8,63678	9,99959	8,63718	11,36282	31
30	8,63968	9,99959	8,64009	11,35991	30
31	8,64256	9,99958	8,64298	11,35702	9
32	8,64543	9,99958	8,64585	11,35415	28
33	8,64827	9,99957	8,64870	11,35130	27
34	8,65110	9,99956	8,65154	11,34846	26
35	8,65391	9,99956	8,65435	11,34565	25
36	8,65670	9,99955	8,65715	11,34285	24
37	8,65947	9,99955	8,65993	11,34007	23
38	8,66223	9,99954	8,66269	11,33731	22
39	8,66497	9,99954	8,66543	11,33457	21
40	8,66769	9,99953	8,66816	11,33184	20
41	8,67039	9,99952	8,67087	11,32913	19
42	8,67308	9,99952	8,67356	11,32644	18
43	8,67575	9,99951	8,67624	11,32376	17
44	8,67841	9,99951	8,67890	11,32110	16
45	8,68104	9,99950	8,68154	11,31846	15
46	8,68367	9,99949	8,68417	11,31583	14
47	8,68627	9,99949	8,68678	11,31322	13
48	8,68886	9,99948	8,68938	11,31062	12
49	8,69144	9,99947	8,69196	11,30804	11
50	8,69400	9,99947	8,69453	11,30547	10
51	8,69654	9,99946	8,69708	11,30292	9
52	8,69907	9,99946	8,69962	11,30038	8
53	8,70159	9,99945	8,70214	11,29786	7
54	8,70409	9,99944	8,70465	11,29535	6
55	8,70658	9,99944	8,70714	11,29286	5
56	8,70905	9,99943	8,70962	11,29038	4
57	8,71151	9,99942	8,71208	11,28792	3
58	8,71395	9,99942	8,71453	11,28547	2
59	8,716,8	9,99941	8,71697	11,28303	1
60	8,71880	9,99940	8,71940	11,28060	0
	Co-sine	Sine	Co-tan	Tangent.	M

87 Degrees.

3 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	8,71880	9,99940	8,71940	11,28060	60
1	8,72120	9,99940	8,72181	11,27819	59
2	8,72359	9,99939	8,72420	11,27580	58
3	8,72597	9,99938	8,72659	11,27341	57
4	8,72834	9,99938	8,72896	11,27104	56
5	8,73069	9,99937	8,73132	11,26868	55
6	8,73303	9,99936	8,73366	11,26634	54
7	8,73535	9,99936	8,73600	11,26400	53
8	8,73767	9,99935	8,73832	11,26168	52
9	8,73997	9,99934	8,74063	11,25937	51
10	8,74226	9,99934	8,74292	11,25708	50
11	8,74454	9,99933	8,74521	11,25479	49
12	8,74680	9,99932	8,74748	11,25252	48
13	8,74906	9,99932	8,74974	11,25026	47
14	8,75130	9,99931	8,75199	11,24801	46
15	8,75353	9,99930	8,75423	11,24577	45
16	8,75575	9,99929	8,75645	11,24355	44
17	8,75795	9,99929	8,75867	11,24133	43
18	8,76015	9,99928	8,76087	11,23913	42
19	8,76234	9,99927	8,76306	11,23094	41
20	8,76451	9,99926	8,76525	11,23475	40
21	8,76667	9,99926	8,76742	11,23258	39
22	8,76883	9,99925	8,76958	11,23042	38
23	8,77097	9,99924	8,77173	11,22827	37
24	8,77310	9,99923	8,77387	11,22613	36
25	8,77522	9,99923	8,77600	11,22400	35
26	8,77733	9,99922	8,77811	11,22189	34
27	8,77943	9,99921	8,78022	11,21978	33
28	8,78152	9,99920	8,78232	11,21768	32
29	8,78360	9,99920	8,78441	11,21559	31
30	8,·8566	9,99919	8,78649	11,21351	30
31	8,78774	9,99918	8,78855	11,21145	29
32	8,78979	9,99917	8,79061	11,20939	28
33	8,79183	9,99917	8,79266	11,20734	27
34	8,79386	9,99916	8,79470	11,20530	26
35	8,79588	9,99915	8,79673	11,20327	25
36	8,79789	9,99914	8,79875	11,20125	24
37	8,79990	9,99913	8,80076	11,19924	23
38	8,80189	9,99913	8,80277	11,19723	22
39	8,80388	9,99912	8,80476	11,19524	21
40	8,80585	9,99911	8,80674	11,19326	20
41	8,80782	9,99910	8,80872	11,19128	19
42	8,80978	9,99909	8,81068	11,18932	18
43	8,81173	9,99909	8,81264	11,18736	17
44	8,81367	9,99908	8,81459	11,18541	16
45	8,81560	9,99907	8,81653	11,18347	15
46	8,81752	9,99906	8,81846	11,18154	14
47	8,81944	9,99905	8,82038	11,17962	13
48	8,82134	9,99904	8,82230	11,17770	12
49	8,82324	9,99904	8,82420	11,17580	11
50	8,82513	9,99903	8,82610	11,17390	10
51	8,82701	9,99902	8,82799	11,17201	9
52	8,82888	9,99901	8,82987	11,17013	8
53	8,83075	9,99900	8,83175	11,16825	7
54	8,83261	9,99899	8,83361	11,16639	6
55	8,83446	9,99898	8,83547	11,16453	5
56	8,83630	9,99898	8,83732	11,16268	4
57	8,83813	9,99897	8,83916	11,16084	3
58	8,83996	9,99896	8,84100	11,15900	2
59	8,84177	9,99895	8,84282	11,15718	1
60	8,84358	9,99894	8,84464	11,15536	0
	Co-sine	Sine	Co-tan.	Tangent.	M

86 Degrees.

Digitized by Google

4 Degrees.					
M	Sine	Co-sine	Tang	Co-tang.	
0	8,84[illegible]	9,99894	8,84464	11,15536	60
1	8,84539	9,99893	8,84646	11,15354	59
2	8,84718	9,99892	8,84826	11,15174	58
3	8,84897	9,9989[illegible]	8,85006	11,14994	57
4	8,85075	9,99891	8,85185	11,14815	56
5	8,85252	9,99890	8,85363	11,14637	55
6	8,85429	9,99889	8,85540	11,14460	54
7	8,8560[illegible]	9,99888	8,85717	11,14283	53
8	8,85780	9,99887	8,85893	11,14107	52
9	8,85955	9,99886	8,86069	11,13931	51
10	8,86128	9,99885	8,86243	11,13757	50
11	8,86301	9,99884	8,86417	11,13583	49
12	8,86474	9,99883	8,86591	11,13409	48
13	8,86645	9,99882	8,86763	11,13237	47
14	8,86816	9,99881	8,86935	11,13065	46
15	8,86987	9,99880	8,87106	11,12894	45
16	8,87156	9,99879	8,87277	11,12723	44
17	8,87325	9,99879	8,87447	11,12553	43
18	8,87494	9,99878	8,87616	11,12384	42
19	8,87661	9,99877	8,87785	11,12215	41
20	8,87829	9,99876	8,87953	11,12047	40
21	8,87995	9,99875	8,88120	11,11880	39
22	8,88161	9,99874	8,88287	11,11713	38
23	8,88326	9,99873	8,88453	11,11547	37
24	8,88490	9,99872	8,88618	11,11382	36
25	8,88654	9,99871	8,88783	11,11217	35
26	8,88817	9,99870	8,88948	11,11052	34
27	8,88980	9,99869	8,89111	11,10889	33
28	8,89142	9,99868	8,89274	11,10726	32
29	8,89304	9,99867	8,89437	11,10563	31
30	8,89464	9,99866	8,89598	11,10402	30
31	8,89625	9,99865	8,89760	11,10240	29
32	8,89784	9,99864	8,89920	11,10080	28
33	8,89943	9,99863	8,90080	11,09920	27
34	8,90102	9,99862	8,90240	11,09760	26
35	8,90260	9,99861	8,90399	11,09601	25
36	8,90417	9,99860	8,90557	11,09443	24
37	8,90574	9,99859	8,90715	11,09285	23
38	8,90730	9,99858	8,90872	11,09128	22
39	8,90885	9,99857	8,91029	11,08971	21
40	8,91040	9,99856	8,91185	11,08815	20
41	8,91195	9,99855	8,91340	11,08660	19
42	8,91349	9,99854	8,91495	11,08505	18
43	8,91502	9,99853	8,91650	11,08350	17
44	8,91655	9,99852	8,91803	11,08197	16
45	8,91807	9,99851	8,91957	11,08043	15
46	8,91959	9,99850	8,92110	11,07890	14
47	8,92110	9,99848	8,92262	11,07738	13
48	8,92261	9,99847	8,92414	11,07586	12
49	8,92411	9,99846	8,92565	11,07435	11
50	8,92561	9,99845	8,92716	11,07284	10
51	8,92710	9,99844	8,92866	11,07134	9
52	8,92859	9,99843	8,93016	11,06984	8
53	8,93007	9,99842	8,93165	11,06835	7
54	8,93154	9,99841	8,93313	11,06687	6
55	8,93301	9,99840	8,93462	11,06538	5
56	8,93448	9,99839	8,93609	11,06391	4
57	8,93594	9,99838	8,93756	11,06244	3
58	8,93740	9,99837	8,93903	11,06097	2
59	8,93885	9,99836	8,94049	11,05951	1
60	8,94030	9,99834	8,94195	11,05805	0
	Co-sine	Sine	Co-tan.	Tangent.	M
85 Degrees					

5 Degrees					
M	Sine	Co-sine	Tang.	Co-tang.	
0	8,94030	9,99834	8,94195	11,05805	60
1	8,94174	9,99833	8,94340	11,05660	59
2	8,94317	9,99832	8,94485	11,05515	58
3	8,94461	9,99831	8,94630	11,05370	57
4	8,94603	9,99830	8,94773	11,05227	56
5	8,94746	9,99829	8,94917	11,05083	55
6	8,94887	9,99828	8,95060	11,04940	54
7	8,95029	9,99827	8,95202	11,04798	53
8	8,95170	9,99825	8,95344	11,04656	52
9	8,95310	9,99824	8,95486	11,04514	51
10	8,95450	9,99823	8,95627	11,04373	50
11	8,95589	9,99822	8,95767	11,04233	49
12	8,95728	9,99821	8,95908	11,04092	48
13	8,95867	9,99820	8,96047	11,03953	47
14	8,96005	9,99819	8,96187	11,03813	46
15	8,96143	9,99817	8,96325	11,03675	45
16	8,96280	9,99816	8,96464	11,03536	44
17	8,96417	9,99815	8,96602	11,03398	43
18	8,96553	9,99814	8,96739	11,03261	42
19	8,96689	9,99813	8,96877	11,03123	41
20	8,96825	9,99812	8,97013	11,02987	40
21	8,96960	9,99810	8,97150	11,02850	39
22	8,97095	9,99809	8,97285	11,02715	38
23	8,97229	9,99808	8,97421	11,02579	37
24	8,97363	9,99807	8,97556	11,02444	36
25	8,97496	9,99806	8,97691	11,02309	35
26	8,97629	9,99804	8,97825	11,02175	34
27	8,97762	9,99803	8,97959	11,02041	33
28	8,97894	9,99802	8,98092	11,01908	32
29	8,98026	9,99801	8,98225	11,01775	31
30	8,98157	9,99800	8,98358	11,01642	30
31	8,98288	9,99798	8,98490	11,01510	29
32	8,98419	9,99797	8,98622	11,01378	28
33	8,98549	9,99796	8,98753	11,01247	27
34	8,98679	9,99795	8,98884	11,01116	26
35	8,98808	9,99793	8,99015	11,00985	25
36	8,98937	9,99792	8,99145	11,00855	24
37	8,99066	9,99791	8,99275	11,00725	23
38	8,99194	9,99790	8,99405	11,00595	22
39	8,99322	9,99788	8,99534	11,00466	21
40	8,99450	9,99787	8,99662	11,00338	20
41	8,99577	9,99786	8,99791	11,00209	19
42	8,99704	9,99785	8,99919	11,00081	18
43	8,99830	9,99783	9,00046	10,99954	17
44	8,99956	9,99782	9,00174	10,99826	16
45	9,00082	9,99781	9,00301	10,99699	15
46	9,00207	9,99780	9,00427	10,99573	14
47	9,00332	9,99778	9,00553	10,99447	13
48	9,00456	9,99777	9,00679	10,99321	12
49	9,00581	9,99776	9,00805	10,99195	11
50	9,00704	9,99775	9,00930	10,99070	10
51	9,00828	9,99773	9,01055	10,98945	9
52	9,00951	9,99772	9,01179	10,98821	8
53	9,01074	9,99771	9,01303	10,98697	7
54	9,01196	9,99769	9,01427	10,98573	6
55	9,01318	9,99768	9,01550	10,98450	5
56	9,01440	9,99767	9,01673	10,98327	4
57	9,01561	9,99765	9,01796	10,98204	3
58	9,01682	9,99764	9,01918	10,98082	2
59	9,01803	9,99763	9,02040	10,97960	1
60	9,01923	9,99761	9,02162	10,97838	0
	Co-sine	Sine	Co-tan.	Tangent.	M
84 Degrees.					

6 Degrees.

M	Sine	Co-fine.	Tang.	Co-tang.	
0	9,01923	9,9976	9 02162	10,97838	60
1	9,02043	9,99760	9,02283	10,97717	59
2	9,02163	9,99759	9,02404	10,97596	58
3	9,02283	9,99757	9,02525	10,97475	57
4	9,02402	9,99756	9,02645	10,97355	56
5	9,02520	9,99755	9,02766	10,97234	55
6	9 02639	9,99753	9,02885	10,97115	54
7	9,02757	9,99752	9,03005	10,96995	53
8	9,02874	9,99751	9,03124	10,96876	52
9	9,02992	9,99749	9,03242	10,96758	51
10	9,03109	9,99748	9,03361	10,90639	50
11	9,03226	9,99747	9,03479	10,96521	49
12	9,03342	9,99745	9,03597	10,90403	48
13	9,03458	9,99744	9,03714	10,96286	47
14	9,03574	9,99742	9,03832	10,96168	46
15	9,03690	9,99741	9,03948	10,96052	45
16	9,03805	9,99740	9,04065	10,95935	44
17	9,03920	9,99738	9,04181	10,95819	43
18	9.04034	9,99737	9,04297	10,95703	42
19	9,04149	9,99736	9,04413	10,95587	41
20	9,04262	9,99734	9,04528	10,95472	40
21	9,04376	9,99733	9,04643	10,95357	39
22	9,04490	9.99731	9,04758	10,95242	38
23	9,04603	9,99730	9,04873	10,95127	37
24	9,04715	9,99728	9,04987	10 95013	36
25	9,04828	9,99727	9,05101	10,94899	35
26	9,04940	9,99726	9,05214	10,94786	34
27	9,05052	6,99724	9,05328	10,94672	33
28	9,05164	9,99723	9,05441	10,94559	32
29	9,05275	9,99721	9 05553	10,94447	31
30	9,05386	9,99720	9,05666	10,94334	30
31	9,05497	9,99718	9,05778	10,94222	29
32	9,05607	9,99717	9,05890	10,94110	28
33	9,05717	9,99716	9,06002	10,93998	27
34	9,05827	9,99714	9,06113	10,93887	26
35	9,05937	9,99713	9,06224	10,93776	25
36	9,06046	9,99711	9,06335	10,93665	24
37	9,06155	9,99710	9,06445	10,93555	23
38	9,06264	9,99708	9,06556	0,93444	22
39	9,06372	9,99707	9,06666	10,93334	21
40	9,06481	9,99705	9,06775	10,93225	20
41	9,06589	9,99704	9,06885	10,93115	19
42	9,06696	9,99702	9,06994	10,93006	18
43	9,06804	9,99701	9,07103	10,92897	17
44	9,06911	9,99699	9,07211	10,92789	16
45	9,07018	9,99698	9,07320	10,92680	15
46	9,07124	9,99696	9,07428	10,92572	14
47	9,07231	9,99695	9,07536	10,92464	13
48	9,07337	9,99693	9,07643	10,92357	12
49	9,07442	9,99692	9,07751	10,92249	11
50	9,07548	9,99690	9,07858	10,92142	10
51	9,07653	9,99689	9,07964	10,92036	9
52	9,07758	9,99687	9,08071	10,91929	8
53	9,07863	9,99686	9,08177	10,91823	7
54	9,07968	9,99684	9,08283	10,91717	6
55	9,08072	9,99683	9,08389	10,91611	5
56	9,08176	9,99681	9,08495	10,91505	4
57	9,08280	9,99680	9,08600	10,91400	3
58	9,08383	9,99678	9,08705	10,91295	2
59	9,08486	9,99677	9,08810	10,91190	1
60	9,08589	9,99675	9,08914	10,91086	0
	Co-fine.	Sine	Co-tan.	Tangent.	M

83 Degrees.

7 Degrees.

M	Sine	Co-fine	Tang.	Co-tang.	
0	9,08589	9,99675	9,08914	10,91086	60
1	9,08692	9,99674	9,09019	10,90981	59
2	9,08795	9,99672	9,09123	10,90877	58
3	9,08897	9,99670	9,09227	10,90773	57
4	9,08999	9,99669	9,09330	10,90670	56
5	9,09101	9,99667	9,09434	10,90566	55
6	9,09202	9,99666	9,09537	10,90463	54
7	9,09304	9,99664	9,09640	10,90360	53
8	9,09405	9,99663	9,09742	10,90258	52
9	9,09506	9,99661	9,09845	10,90155	51
10	9,09606	9,99659	9,09947	10,90053	50
11	9,09707	9,99658	9,10049	10,89951	49
12	9,09807	9,99656	9,10150	10,89850	48
13	9,09907	9,99655	9,10252	10,89748	47
14	9,10006	9,99653	9,10353	10,89647	46
15	9,10106	9,99651	9,10454	10,89546	45
16	9,10205	9,99650	9,10555	10,89445	44
17	9,10304	9,99648	9,10656	10,89344	43
18	9,10402	9,99647	9,10756	10,89244	42
19	9,10501	9,99645	9,10856	10,89144	41
20	9,10599	9,99643	9,10956	10,89044	40
21	9,10697	9,99642	9,11056	10,88944	39
22	9,10795	9,99640	9,11155	10,88845	38
23	9.10893	9,99638	9,11254	10,88746	37
24	9,10990	9,99637	9,11353	10,88647	36
25	9,11087	9,99635	9,11452	10,88548	35
26	9,11184	9,99633	9,11551	10,88449	34
27	9,11281	9,99632	9,11649	10,88351	33
28	9,11377	9,99630	9,11747	10,88253	32
29	9,11474	9,99629	9,11845	10,88155	31
30	9,11570	9,99627	9,11943	10,88057	30
31	9,11666	9,99625	9,12040	10,87960	29
32	9,11761	9,99624	9,12138	10,87862	28
33	9,11857	9,99622	9,12235	10,87765	27
34	9,11952	9,99620	9,12332	10,87668	26
35	9,12047	9,99618	9,12428	10,87572	25
36	9,12142	9,99617	9,12525	10,87475	24
37	9,12236	9,99615	9,12621	10,87379	23
38	9,12331	9,99613	9,12717	10,87283	22
39	9,12425	9,99612	9,12813	10.87187	21
40	9,12519	9,99610	9,12909	10,87091	20
41	9,12612	9,99608	9,13004	10,86996	19
42	9,12706	9,99607	9,13099	10,86901	18
43	9,12799	9,99605	9,13194	10,86806	17
44	9,12892	9,99603	9,13289	10,86711	16
45	9,12985	9,99601	9,13384	10,86616	15
46	9,13078	9,99600	9,13478	10,86522	14
47	9,13171	9,99598	9,13573	10,86427	13
48	9,13263	9,99596	9,13667	10,86333	12
49	9,13355	9,99595	9.13761	10,86239	11
50	9,13447	9,99593	9,13854	10,86146	10
51	9,13539	9,99591	9,13948	10,86052	9
52	9,13630	9,99589	9,14041	10,85959	8
53	9,13722	9,99588	9,14134	10,85866	7
54	9,13813	9,99586	9,14227	10,85773	6
55	9,13904	9,99584	9,14320	10,85680	5
56	9,13994	9,99582	9,14412	10,85588	4
57	9,14085	9,99581	9,14504	10,85496	3
58	9,14175	9,99579	9,14597	10,85403	2
59	9,14266	9,99577	9,14688	10,85312	1
60	9,14356	9,99575	9,14780	10,85220	0
	Co-fine	Sine	Co-tan.	Tangent.	M

82 Degrees.

Digitized by Google

8 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,14356	9,99575	9,14780	10,85220	60
1	9,14445	9,99573	9,14872	10,85128	59
2	9,14535	9,99572	9,14963	10,85037	58
3	9,14624	9,99570	9,15054	10,84946	57
4	9,14714	9,99568	9,15145	10,84855	56
5	9,14803	9,99566	9,15236	10,84764	55
6	9,14891	9,99565	9,15327	10,84673	54
7	9,14980	9,99563	9,15417	10,84583	53
8	9,15069	9,99561	9,15508	10,84492	52
9	9,15157	9,99559	9,15598	10,84402	51
10	9,15245	9,99557	9,15688	10,84312	50
11	9,15333	9,99556	9,15777	10,84223	49
12	9,15421	9,99554	9,15867	10,84133	48
13	9,15508	9,99552	9,15956	10,84044	47
14	9,15596	9,99550	9,16046	10,83954	46
15	9,15683	9,99548	9,16135	10,83865	45
16	9,15770	9,99546	9,16224	10,83776	44
17	9,15857	9,99545	9,16312	10,83688	43
18	9,15944	9,99543	9,16401	10,83599	42
19	9,16030	9,99541	9,16489	10,83511	41
20	9,16116	9,99539	9,16577	10,83423	40
21	9,16203	9,99537	9,16665	10,83335	39
22	9,16289	9,99535	9,16753	10,83247	38
23	9,16374	9,99533	9,16841	10,83159	37
24	9,16460	9,99532	9,16928	10,83072	36
25	9,16545	9,99530	9,17016	10,82984	35
26	9,16631	9,99528	9,17103	10,82897	34
27	9,16716	9,99526	9,17190	10,82810	33
28	9,16801	9,99524	9,17277	10,82723	32
29	9,16886	9,99522	9,17363	10,82637	31
30	9,16970	9,99520	9,17450	10,82550	30
31	9,17055	9,99518	9,17536	10,82464	29
32	9,17139	9,99517	9,17622	10,82378	28
33	9,17223	9,99515	9,17708	10,82292	27
34	9,17307	9,99513	9,17794	10,82206	26
35	9,17391	9,99511	9,17880	10,82120	25
36	9,17474	9,99509	9,17965	10,82035	24
37	9,17558	9,99507	9,18051	10,81949	23
38	9,17641	9,99505	9,18136	10,81864	22
39	9,17724	9,99503	9,18221	10,81779	21
40	9,17807	9,99501	9,18306	10,81694	20
41	9,17890	9,99499	9,18391	10,81609	19
42	9,17973	9,99497	9,18475	10,81525	18
43	9,18055	9,99495	9,18560	10,81440	17
44	9,18137	9,99494	9,18644	10,81356	16
45	9,18220	9,99492	9,18728	10,81272	15
46	9,18302	9,99490	9,18812	10,81188	14
47	9,18383	9,99488	9,18896	10,81104	13
48	9,18465	9,99486	9,18979	10,81021	12
49	9,18547	9,99484	9,19063	10,80937	11
50	9,18628	9,99482	9,19146	10,80854	10
51	9,18709	9,99480	9,19229	10,80771	9
52	9,18790	9,99478	9,19312	10,80688	8
53	9,18871	9,99476	9,19395	10,80605	7
54	9,18952	9,99474	9,19478	10,80522	6
55	9,19033	9,99472	9,19561	10,80439	5
56	9,19113	9,99470	9,19643	10,80357	4
57	9,19193	9,99468	9,19725	10,80275	3
58	9,19273	9,99466	9,19807	10,80193	2
59	9,19353	9,99464	9,19889	10,80111	1
60	9,19433	9,99462	9,19971	10,80029	0
	Co-sine	Sine	Co-tan.	Tangent	M
81 Degrees.					

9 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,19433	9,99462	9,19971	10,80029	60
1	9,19513	9,99460	9,20053	10,79947	59
2	9,19592	9,99458	9,20134	10,79866	58
3	9,19672	9,99456	9,20216	10,79784	57
4	9,19751	9,99454	9,20297	10,79703	56
5	9,19830	9,99452	9,20378	10,79622	55
6	9,19909	9,99450	9,20459	10,79541	54
7	9,19988	9,99448	9,20540	10,79460	53
8	9,20067	9,99446	9,20621	10,79379	52
9	9,20145	9,99444	9,20701	10,79299	51
10	9,20223	9,99442	9,20782	10,79218	50
11	9,20302	9,99440	9,20862	10,79138	49
12	9,20380	9,99438	9,20942	10,79058	48
13	9,20458	9,99436	9,21022	10,78978	47
14	9,20535	9,99434	9,21102	10,78898	46
15	9,20613	9,99432	9,21182	10,78818	45
16	9,20691	9,99429	9,21261	10,78739	44
17	9,20768	9,99427	9,21341	10,78659	43
18	9,20845	9,99425	9,21420	10,78580	42
19	9,20922	9,99423	9,21499	10,78501	41
20	9,20999	9,99421	9,21578	10,78422	40
21	9,21076	9,99419	9,21657	10,78343	39
22	9,21153	9,99417	9,21736	10,78264	38
23	9,21229	9,99415	9,21814	10,78186	37
24	9,21306	9,99413	9,21893	10,78107	36
25	9,21382	9,99411	9,21971	10,78029	35
26	9,21458	9,99409	9,22049	10,77951	34
27	9,21534	9,99407	9,22127	10,77873	33
28	9,21610	9,99404	9,22205	10,77795	32
29	9,21685	9,99402	9,22283	10,77717	31
30	9,21701	9,99400	9,22361	10,77639	30
31	9,21836	9,99398	9,22438	10,77562	29
32	9,21912	9,99396	9,22516	10,77484	28
33	9,21987	9,99394	9,22593	10,77407	27
34	9,22062	9,99392	9,22670	10,77330	26
35	9,22137	9,99390	9,22747	10,77253	25
36	9,22211	9,99388	9,22824	10,77176	24
37	9,22286	9,99385	9,22901	10,77099	23
38	9,22361	9,99383	9,22977	10,77023	22
39	9,22435	9,99381	9,23054	10,76946	21
40	9,22509	9,99379	9,23130	10,76870	20
41	9,22583	9,99377	9,23206	10,76793	19
42	9,22657	9,99375	9,23283	10,76717	18
43	9,22731	9,99372	9,23359	10,76641	17
44	9,22805	9,99370	9,23435	10,76565	16
45	9,22878	9,99368	9,23510	10,76490	15
46	9,22952	9,99366	9,23586	10,76414	14
47	9,23025	9,99364	9,23661	10,76339	13
48	9,23098	9,99362	9,23737	10,76263	12
49	9,23171	9,99359	9,23812	10,76188	11
50	9,23244	9,99357	9,23887	10,76113	10
51	9,23317	9,99355	9,23962	10,76038	9
52	9,23390	9,99353	9,24037	10,75963	8
53	9,23462	9,99351	9,24112	10,75888	7
54	9,23535	9,99348	9,24186	10,75813	6
55	9,23607	9,99346	9,24261	10,75739	5
56	9,23679	9,99344	9,24335	10,75665	4
57	9,23752	9,99342	9,24410	10,75590	3
58	9,23823	9,99340	9,24484	10,75516	2
59	9,23895	9,99337	9,24558	10,75442	1
60	9,23967	9,99335	9,24632	10,75368	0
	Co-sine	Sine	Co-tan.	Tangent	M
80 Degrees.					

Digitized by Google

10 Degrees.

M	Sine	Co-sine	Tang.	Co-tang	
0	9,23967	9,99335	9,24632	10,75368	60
1	9,24039	9,99333	9,24706	10,75294	59
2	9,24110	9,99331	9,24779	10,75221	58
3	9,24181	9,99328	9,24853	10,75147	57
4	9,24253	9,99326	9,24926	10,75074	56
5	9,24324	9,99324	9,25000	10,75000	55
6	9,24395	9,99322	9,25073	10,74927	54
7	9,24466	9,99319	9,25146	10,74854	53
8	9,24536	9,99317	9,25219	10,74781	52
9	9,24607	9,99315	9,25292	10,74708	51
10	9,24677	9,99313	9,25365	10,74635	50
11	9,24748	9,99310	9,25437	10,74563	49
12	9,24818	9,99308	9,25510	10,74490	48
13	9,24888	9,99306	9,25582	10,74418	47
14	9,24958	9,99304	9,25655	10,74345	46
15	9,25028	9,99301	9,25727	10,74273	45
16	9,25098	9,99299	9,25799	10,74201	44
17	9,25168	9,99297	9,25871	10,74129	43
18	9,25237	9,99294	9,25943	10,74057	42
19	9,25307	9,99292	9,26015	10,73985	41
20	9,25376	9,99290	9,26086	10,73914	40
21	9,25445	9,99288	9,26158	10,73842	39
22	9,25514	9,99285	9,26229	10,73771	38
23	9,25583	9,99283	9,26301	10,73699	37
24	9,25652	9,99281	9,26372	10,73628	36
25	9,25721	9,99278	9,26443	10,73557	35
26	9,25790	9,99276	9,26514	10,73486	34
27	9,25858	9,99274	9,26585	10,73415	33
28	9,25927	9,99271	9,26655	10,73345	32
29	9,25995	9,99269	9,26726	10,73274	31
30	9,26063	9,99267	9,26797	10,73203	30
31	9,26131	9,99264	9,26867	10,73133	29
32	9,26199	9,99262	9,26937	10,73063	28
33	9,26267	9,99260	9,27008	10,72992	27
34	9,26335	9,99257	9,27078	10,72922	26
35	9,26403	9,99255	9,27148	10,72852	25
36	9,26470	9,99252	9,27218	10,72782	24
37	9,26538	9,99250	9,27288	10,72712	23
38	9,26605	9,99248	9,27357	10,72643	22
39	9,26672	9,99245	9,27427	10,72573	21
40	9,26739	9,99243	9,27496	10,72504	20
41	9,26806	9,99241	9,27566	10,72434	19
42	9,26873	9,99238	9,27635	10,72365	18
43	9,26940	9,99236	9,27704	10,72296	17
44	9,27007	9,99233	9,27773	10,72227	16
45	9,27073	9,99231	9,27842	10,72158	15
46	9,27140	9,99229	9,27911	10,72089	14
47	9,27206	9,99226	9,27980	10,72020	13
48	9,27273	9,99224	9,28049	10,71951	12
49	9,27339	9,99221	9,28117	10,71883	11
50	9,27405	9,99219	9,28186	10,71814	10
51	9,27471	9,99217	9,28254	10,71746	9
52	9,27537	9,99214	9,28323	10,71677	8
53	9,27602	9,99212	9,28391	10,71609	7
54	9,27668	9,99209	9,28459	10,71541	6
55	9,27734	9,99207	9,28527	10,71473	5
56	9,27799	9,99204	9,28595	10,71405	4
57	9,27864	9,99202	9,28662	10,71338	3
58	9,27930	9,99200	9,28730	10,71270	2
59	9,27995	9,99197	9,28798	10,71202	1
60	9,28060	9,99195	9,28865	10,71135	0
	Co-sine	Sine	Co-tan.	Tangent	M

79 Degrees.

11 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,28060	9,99195	9,28865	10,71135	60
1	9,28125	9,99192	9,28933	10,71067	59
2	9,28190	9,99190	9,29000	10,71000	58
3	9,28254	9,99187	9,29067	10,70933	57
4	9,28319	9,99185	9,29134	10,70866	56
5	9,28384	9,99182	9,29201	10,70799	55
6	9,28448	9,99180	9,29268	10,70732	54
7	9,28512	9,99177	9,29335	10,70665	53
8	9,28577	9,99175	9,29402	10,70598	52
9	9,28641	9,99172	9,29468	10,70532	51
10	9,28705	9,99170	9,29535	10,70465	50
11	9,28769	9,99167	9,29601	10,70399	49
12	9,28833	9,99165	9,29668	10,70332	48
13	9,28896	9,99162	9,29734	10,70266	47
14	9,28960	9,99160	9,29800	10,70200	46
15	9,29024	9,99157	9,29866	10,70134	45
16	9,29087	9,99155	9,29932	10,70068	44
17	9,29150	9,99152	9,29998	10,70002	43
18	9,29214	9,99150	9,30064	10,69936	42
19	9,29277	9,99147	9,30130	10,69870	41
20	9,29340	9,99145	9,30195	10,69805	40
21	9,29403	9,99142	9,30261	10,69739	39
22	9,29466	9,99140	9,30326	10,69674	38
23	9,29529	9,99137	9,30391	10,69609	37
24	9,29591	9,99135	9,30457	10,69543	36
25	9,29654	9,99132	9,30522	10,69478	35
26	9,29716	9,99130	9,30587	10,69413	34
27	9,29779	9,99127	9,30652	10,69348	33
28	9,29841	9,99124	9,30717	10 69283	32
29	9,29903	9,99122	9 30782	10,69218	31
30	9,29966	9,99119	9,30846	10,69154	30
31	9,30028	9,99117	9,30911	10,69089	29
32	9,30090	9,99114	9,30975	10,69025	28
33	9,30151	9,99112	9,31040	10,68960	27
34	9,30213	9,99109	9,31104	10,68896	26
35	9,30275	9,99106	9,31168	10,68832	25
36	9,30336	9,99104	9,31233	10,68767	24
37	9,30398	9,99101	9,31297	10,68703	23
38	9,30459	9,99099	9,31361	10,68639	22
39	9,30521	9,99096	9,31425	10,68575	21
40	9,30582	9,99093	9,31489	10,68511	20
41	9,30643	9,99091	9,31552	10,68448	19
42	9,30704	9,99088	9,31616	10,68384	18
43	9,30765	9,99086	9,31679	10,68321	17
44	9,30826	9,99083	9,31743	10,68257	16
45	9,30887	9,99080	9,31806	10,68194	15
46	9,30947	9,99078	9,31870	10,68130	14
47	9,31008	9,99075	9,31933	10,68067	13
48	9,31068	9,99072	9,31996	10,68004	12
49	9,31129	9,99070	9,32059	10,67941	11
50	9,31189	9,99067	9,32122	10,67878	10
51	9,31250	9,99064	9,32185	10,67815	9
52	9,31310	9,99062	9,32248	10,67752	8
53	9,31370	9,99059	9,32311	10,67689	7
54	9,31430	9,99056	9,32373	10,67627	6
55	9,31490	9,99054	9,32436	10,67564	5
56	9,31549	9,99051	9,32498	10,67502	4
57	9,31609	9,99048	9,32561	10,67439	3
58	9,31669	9,99046	9,32623	10,67377	2
59	9,31728	9,99043	9,32685	10,67315	1
60	9,31788	9,99040	9,32747	10,67253	0
	Co-sine	Sine	Co-tan.	Tangent.	M

78 Degrees.

Digitized by Google

12 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,31788	9,99040	9,32747	10,67253	60
1	9,31847	9,99038	9,32810	10,67190	59
2	9,31907	9,99035	9,32872	10,67128	58
3	9,31966	9,99032	9,32933	10,67067	57
4	9,32025	9,99030	9,32995	10,67005	56
5	9,32084	9,99027	9,33057	10,66943	55
6	9,32143	9,99024	9,33119	10,66881	54
7	9,32202	9,99022	9,33180	10,66820	53
8	9,32261	9.99019	9,33242	10,66758	52
9	9,32319	9,99016	9,33303	10,66697	51
10	9,32378	9,99013	9,33365	10.66635	50
11	9,32437	9,99011	9,33426	10,66574	49
12	9,32495	9,99008	9,33487	10,66513	48
13	9,32553	9,99005	9,33548	10,66452	47
14	9,32612	9,99002	9,33609	10,66391	46
15	9,32670	9,99000	9,33670	10,66330	45
16	9,32728	9,98997	9,33731	10,66269	44
17	9,32786	9,98994	9,33792	10,66208	43
18	9,32844	9,98991	9,33853	10,66147	42
19	9,32902	9,98989	9,33913	10,66087	41
20	9,32960	9,98986	9,33974	10,66026	40
21	9,33018	9,98983	9,34034	10,65966	39
22	9,33075	9,98980	9,34095	10,65 05	38
23	9,33133	9,98978	9,34155	10,65845	37
24	9,33190	9,98975	9,34215	10,65785	36
25	9,33248	9,98972	9,34276	10,65724	35
26	9,33305	9,98969	9,34336	10,65664	34
27	9,33362	9,98967	9,34396	10,65604	33
28	9,33420	9,98964	9,34456	10,65544	32
29	9,33477	9,98961	9,34516	10,65484	31
30	9,33534	9,98958	9,34576	10,65424	30
31	9,33591	9,98955	9,34635	10,65365	29
32	9,33647	9,98953	9,34695	10,65305	28
33	9,33704	9,98950	9,34755	10,65245	27
34	9,33761	9,98947	9,34814	10,65186	26
35	9,33818	9,98944	9,34874	10,65126	25
36	9,33874	9,98941	9,34933	10,65067	24
37	9,33931	9,98938	9,34992	10,65008	23
38	9,33987	9,98936	9,35051	10,64949	22
39	9,34043	9,98933	9,35111	10,64889	21
40	9,34100	9,98930	9,35170	10,64830	20
41	9,34156	9,98927	9,35229	10,64771	19
42	9,34212	9,98924	9,35288	10,64712	18
43	9,34268	9,98921	9,35346	10,64653	17
44	9,34324	9,98919	9,35405	10,64595	16
45	9,34380	9,98916	9,35464	10,64536	15
46	9,34436	9,98913	9,35523	10,64477	14
47	9,34491	9,98910	9,35581	10,64419	13
48	9,34547	9,98907	9,35640	10,64360	12
49	9,34602	9,98904	9,35698	10,64302	11
50	9,34658	9,98901	9,35757	10,64243	10
51	9,34713	9,98898	9,35815	10,64185	9
52	9,34769	9,98896	9,35873	10,64127	8
53	9,34824	9,98893	9,35931	10,64069	7
54	9,34879	9,98890	9,35989	10,64011	6
55	9,34934	9,98887	9,36047	10,63953	5
56	9,34989	9,98884	9,36105	10,63895	4
57	9,35044	9,98881	9,36163	10,63837	3
58	9,35099	9,98878	9,36221	10,63779	2
59	9,35154	9,98875	9,36279	10,63721	1
60	9,35209	9,98872	9,36336	10,63664	0
	Co-sine	Sine	Co-tan.	Tangent	M
77 Degrees.					

13 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,35209	9,98872	9,36336	10,63664	60
1	9,35263	9,98869	9,36394	10,63606	59
2	9,35318	9,98867	9,36452	10,63548	58
3	9,35373	9,98864	9,36509	10,63491	57
4	9,35427	9,98861	9,36566	10,63434	56
5	9,35481	9,98858	9,36624	10,63376	55
6	9,35536	9,98855	9,36681	10,63319	54
7	9,35590	9,98852	9,36738	10,63262	53
8	9,35644	9,98849	9,36795	10,63205	52
9	9,35698	9,98846	9,36852	10.63148	51
10	9,35752	9,98843	9,36909	10,63091	50
11	9,35806	9,98840	9,36966	10,63034	49
12	9,35860	9,98837	9,37023	10,62977	48
13	9,35914	9,98834	9,37080	10,62920	47
14	9,35968	9,98831	9,37137	10,62863	46
15	9,36022	9,98828	9,37193	10,62807	45
16	9,36075	9,98825	9,37250	10,62750	44
17	9,36129	9,98822	9,37306	10,62694	43
18	9,36182	9,98819	9,37363	10,62637	42
19	9,36236	9,98816	9,37419	10,62581	41
20	9,36289	9,98813	9,37476	10,62524	40
21	9,36342	9,98810	9,37532	10,62468	39
22	9,36395	9,98807	9,37588	10,62412	38
23	9,36449	9,98804	9,37644	10,62356	37
24	9,36502	9,98801	9,37700	10,62300	36
25	9,36555	9,98798	9,37756	10,62244	35
26	9,36607	9,98795	9,37812	10,62188	34
27	9,36660	9,98792	9,37868	10,62132	33
28	9,36713	9,98789	9,37924	10,62076	32
29	9,36766	9,98786	9,37980	10,62020	31
30	9,36819	9,98783	9,38035	10,61965	30
31	9,36871	9,98780	9,38091	10,61909	29
32	9,36924	9,98777	9,38147	10,61853	28
33	9,36976	9,98774	9,38202	10,61798	27
34	9,37028	9,98771	9,38257	10,61743	26
35	9,37081	9,98768	9,38313	10,61687	25
36	9,37133	9,98765	9,38368	10,61632	24
37	9,37185	9,98762	9,38423	10,61577	23
38	9,37237	9,98759	9,38479	10,61521	22
39	9,37289	9,98756	9,38534	10,61466	21
40	9,37341	9,98753	9,38589	10,61411	20
41	9,37393	9,98750	9,38644	10,61356	19
42	9,37445	9,98746	9,38699	10,61301	18
43	9,37497	9,98743	9,38754	10,61246	17
44	9,37549	9,98740	9,38808	10,61192	16
45	9,37600	9,98737	9,38863	10,61137	15
46	9,37652	9,98734	9,38918	10,61082	14
47	9,37703	9,98731	9,38972	10,61028	13
48	9,37755	9,98728	9,39027	10,60973	12
49	9,37806	9,98725	9,39082	10,60918	11
50	9,37858	9,98722	9,39136	10,60864	10
51	9,37909	9,98719	9,39190	10,60810	9
52	9,37960	9,98715	9,39245	10,60755	8
53	9,38011	9,98712	9,39299	10,60701	7
54	9,38062	9,98709	9,39353	10,60647	6
55	9,38113	9,98706	9,39407	10,60593	5
56	9,38164	9,98703	9,39461	10,60539	4
57	9,38215	9,98700	9,39515	10,60485	3
58	9,38266	9,98697	9,39569	10,60431	2
59	9,38317	9,98694	9,39623	10,60377	1
60	9,38368	9,98690	9,39677	10,60323	0
	Co-sine	Sine	Co-tan.	Tangent.	M
76 Degrees.					

Digitized by Google

14 Degrees.					
M	Sine.	Co-fine	Tang.	Co-tang.	
0	9,38368	9,98690	9,39677	10,60323	60
1	9,38418	9,98687	9,39731	10,60269	59
2	9,38469	9,98684	9,39785	10,60215	58
3	9,38519	9,98681	9,39838	10,60162	57
4	9,38570	9,98678	9,39892	10,60108	56
5	9,38620	9,98675	9,39945	10,60055	55
6	9,38670	9,98671	9,39999	10,60001	54
7	9,38721	9,98668	9,40052	10,59948	53
8	9,38771	9,98665	9,40106	10,59894	52
9	9,38821	9,98662	9,40159	10,59841	51
10	9,38871	9,98659	9,40212	10,59788	50
11	9,38921	9,98656	9,40266	10,59734	49
12	9,38971	9,98652	9,40319	10,59681	48
13	9,39021	9,98649	9,40372	10,59628	47
14	9,39071	9,98646	9,40425	10,59575	46
15	9,39121	9,98643	9,40478	10,59522	45
16	9,39170	9,98640	9,40531	10,59469	44
17	9,39220	9,98636	9,40584	10,59416	43
18	9,39270	9,98633	9,40636	10,59364	42
19	9,39319	9,98630	9,40689	10,59311	41
20	9,39369	9,98627	9,40742	10,59258	40
21	9,39418	9,98623	9,40795	10,59205	39
22	9,39467	9,98620	9,40847	10,59153	38
23	9,39517	9,98617	9,40900	10,59100	37
24	9,39566	9,98614	9,40952	10,59048	36
25	9,39615	9,98610	9,41005	10,58995	35
26	9,39664	9,98607	9,41057	10,58943	34
27	9,39713	9,98604	9,41109	10,58891	33
28	9,39762	9,98601	9,41161	10,58839	32
29	9,39811	9,98597	9,41214	10,58786	31
30	9,39860	9,98594	9,41266	10,58734	30
31	9,39909	9,98591	9,41318	10,58682	29
32	9,39958	9,98588	9,41370	10,58630	28
33	9,40006	9,98584	9,41422	10,58578	27
34	9,40055	9,98581	9,41474	10,58526	26
35	9,40103	9,98578	9,41526	10,58474	25
36	9,40152	9,98574	9,41578	10,58422	24
37	9,40200	9,98571	9,41629	10,58371	23
38	9,40249	9,98568	9,41681	10,58319	22
39	9,40297	9,98565	9,41733	10,58267	21
40	9,40346	9,98561	9,41784	10,58216	20
41	9,40394	9,98558	9,41836	10,58164	19
42	9,40442	9,98555	9,41887	10,58113	18
43	9,40490	9,98551	9,41939	10,58061	17
44	9,40538	9,98548	9,41990	10,58010	16
45	9,40586	9,98545	9,42041	10,57959	15
46	9,40634	9,98541	9,42093	10,57907	14
47	9,40682	9,98538	9,42144	10,57856	13
48	9,40730	9,98535	9,42195	10,57805	12
49	9,40778	9,98531	9,42246	10,57754	11
50	9,40825	9,98528	9,42297	10,57703	10
51	9,40873	9,98525	9,42348	10,57652	9
52	9,40921	9,98521	9,42399	10,57601	8
53	9,40968	9,98518	9,42450	10,57550	7
54	9,41016	9,98515	9,42501	10,57499	6
55	9,41063	9,98511	9,42552	10,57448	5
56	9,41111	9,98508	9,42603	10,57397	4
57	9,41158	9,98505	9,42653	10,57347	3
58	9,41205	9,98501	9,42704	10,57296	2
59	9,41252	9,98498	9,42755	10,57245	1
60	9,41300	9,98494	9,42805	10,57195	0
	Co-fine	Sine	Co-tan.	Tangent.	M
75 Degrees.					

15 Degrees.					
M	Sine	Co-fine	Tang.	Co-tang	
0	9,41300	9,98494	9,42805	10,57195	60
1	9,41347	9,98491	9,42856	10,57144	59
2	9,41394	9,98488	9,42906	10,57094	58
3	9,41441	9,98484	9,42957	10,57043	57
4	9,41488	9,98481	9,43007	10,56993	56
5	9,41535	9,98477	9,43057	10,56943	55
6	9,41582	9,98474	9,43108	10,56892	54
7	9,41628	9,98471	9,43158	10,56842	53
8	9,41675	9,98467	9,43208	10,56792	52
9	9,41722	9,98464	9,43258	10,56742	51
10	9,41768	9,98460	9,43308	10,56692	50
11	9,41815	9,98457	9,43358	10,56642	49
12	9,41861	9,98453	9,43408	10,56592	48
13	9,41908	9,98450	9,43458	10,56542	47
14	9,41954	9,98447	9,43508	10,56492	46
15	9,42001	9,98443	9,43558	10,56442	45
16	9,42047	9,98440	9,43607	10,56393	44
17	9,42093	9,98436	9,43657	10,56343	43
18	9,42139	9,98433	9,43707	10,56293	42
19	9,42186	9,98429	9,43756	10,56244	41
20	9,42232	9,98426	9,43806	10,56194	40
21	9,42278	9,98422	9,43855	10,56145	39
22	9,42324	9,98419	9,43905	10,56095	38
23	9,42370	9,98415	9,43954	10,56046	37
24	9,42416	9,98412	9,44004	10,55996	36
25	9,42461	9,98409	9,44053	10,55947	35
26	9,42507	9,98405	9,44102	10,55898	34
27	9,42553	9,98402	9,44151	10,55849	33
28	9,42599	9,98398	9,44201	10,55799	32
29	9,42644	9,98395	9,44250	10,55750	31
30	9,42690	9,98391	9,44299	10,55701	30
31	9,42735	9,98388	9,44348	10,55652	29
32	9,42781	9,98384	9,44397	10,55603	28
33	9,42826	9,98381	9,44446	10,55554	27
34	9,42872	9,98377	9,44495	10,55505	26
35	9,42917	9,98373	9,44544	10,55456	25
36	9,42962	9,98370	9,44592	10,55408	24
37	9,43007	9,98366	9,44641	10,55359	23
38	9,43053	9,98363	9,44690	10,55310	22
39	9,43098	9,98359	9,44738	10,55262	21
40	9,43143	9,98356	9,44787	10,55213	20
41	9,43188	9,98352	9,44836	10,55164	19
42	9,43233	9,98349	9,44884	10,55116	18
43	9,43278	9,98345	9,44933	10,55067	17
44	9,43323	9,98342	9,44981	10,55019	16
45	9,43367	9,98338	9,45029	10,54971	15
46	9,43412	9,98334	9,45078	10,54922	14
47	9,43457	9,98331	9,45126	10,54874	13
48	9,43502	9,98327	9,45174	10,54826	12
49	9,43546	9,98324	9,45222	10,54778	11
50	9,43591	9,98320	9,45271	10,54729	10
51	9,43635	9,98317	9,45319	10,54681	9
52	9,43680	9,98313	9,45367	10,54633	8
53	9,43724	9,98309	9,45415	10,54585	7
54	9,43769	9,98306	9,45463	10,54537	6
55	9,43813	9,98302	9,45511	10,54489	5
56	9,43857	9,98299	9,45559	10,54441	4
57	9,43901	9,98295	9,45606	10,54394	3
58	9,43946	9,98291	9,45654	10,54346	2
59	9,43990	9,98288	9,45702	10,54298	1
60	9,44034	9,98284	9,45750	10,54250	0
	Co-fine	Sine	Co-tan.	Tangent.	M
74 Degrees.					

Digitized by Google

16 Degrees.

M	Sine.	Co-fine	Tang.	Co-tang.	
0	9,44034	9,98284	9,45750	10,54250	60
1	9,44078	9,98281	9,45797	10,54203	59
2	9,44122	9,98277	9,45845	10,54155	58
3	9,44166	9,98273	9,45892	10,54108	57
4	9,44210	9,98270	9,45940	10,54060	56
5	9,44253	9,98266	9,45987	10,54013	55
6	9,44297	9,98262	9,46035	10,53965	54
7	9,44341	9,98259	9,46082	10,53918	53
8	9,44385	9,98255	9,46130	10,53870	52
9	9,44428	9,98251	9,46177	10,53823	51
10	9,44472	9,98248	9,46224	10,53776	50
11	9,44516	9,98244	9,46271	10,53729	49
12	9,44559	9,98240	9,46319	10,53681	48
13	9,44602	9,98237	9,46366	10,53634	47
14	9,44646	9,98233	9,46413	10,53587	46
15	9,44689	9,98229	9,46460	10,53540	45
16	9,44733	9,98226	9,46507	10,53493	44
17	9,44776	9,98222	9,46554	10,53446	43
18	9,44819	9,98218	9,46601	10,53399	42
19	9,44862	9,98215	9,46648	10,53352	41
20	9,44905	9,98211	9,46694	10,53306	40
21	9,44948	9,98207	9,46741	10,53259	39
22	9,44992	9,98204	9,46788	10,53212	38
23	9,45035	9,98200	9,46835	10,53165	37
24	9,45077	9,98196	9,46881	10,53119	36
25	9,45120	9,98192	9,46928	10,53072	35
26	9,45163	9,98189	9,46975	10,53025	34
27	9,45206	9,98185	9,47021	10,52979	33
28	9,45249	9,98181	9,47068	10,52932	32
29	9,45292	9,98177	9,47114	10,52886	31
30	9,45334	9,98174	9,47160	10,52840	30
31	9,45377	9,98170	9,47207	10,52793	29
32	9,45419	9,98166	9,47253	10,52747	28
33	9,45462	9,98162	9,47299	10,52701	27
34	9,45504	9,98159	9,47346	10,52654	26
35	9,45547	9,98155	9,47392	10,52608	25
36	9,45589	9,98151	9,47438	10,52562	24
37	9,45632	9,98147	9,47484	10,52516	23
38	9,45674	9,98144	9,47530	10,52470	22
39	9,45716	9,98140	9,47576	10,52424	21
40	9,45758	9,98136	9,47622	10,52378	20
41	9,45801	9,98132	9,47668	10,52332	19
42	9,45843	9,98128	9,47714	10,52286	18
43	9,45885	9,98125	9,47760	10,52240	17
44	9,45927	9,98121	9,47806	10,52194	16
45	9,45969	9,98117	9,47852	10,52148	15
46	9,46011	9,98113	9,47897	10,52103	14
47	9,46053	9,98109	9,47943	10,52057	13
48	9,46095	9,98106	9,47989	10,52011	12
49	9,46136	9,98102	9,48035	10,51965	11
50	9,46178	9,98098	9,48080	10,51920	10
51	9,46220	9,98094	9,48126	10,51874	9
52	9,46262	9,98090	9,48171	10,51829	8
53	9,46303	9,98087	9,48217	10,51783	7
54	9,46345	9,98083	9,48262	10,51738	6
55	9,46386	9,98079	9,48307	10,51692	5
56	9,46428	9,98075	9,48353	10,51647	4
57	9,46469	9,98071	9,48398	10,51602	3
58	9,46511	9,98067	9,48443	10,51557	2
59	9,46552	9,98063	9,48489	10,51511	1
60	9,46594	9,98060	9,48534	10,51466	0
	Co-fine	Sine	Co-tan.	Tangent.	M

73 Degrees.

17 Degrees.

M	Sine	Co-fine	Tang.	Co-tang.	
0	9,46594	9,98060	9,48534	10,51466	60
1	9,46635	9,98056	9,48579	10,51421	59
2	9,46676	9,98052	9,48624	10,51376	58
3	9,46717	9,98048	9,48669	10,51331	57
4	9,46758	9,98044	9,48714	10,51286	56
5	9,46800	9,98040	9,48759	10,51241	55
6	9,46841	9,98036	9,48804	10,51196	54
7	9,46882	9,98032	9,48849	10,51151	53
8	9,46923	9,98029	9,48894	10,51106	52
9	9,46964	9,98025	9,48939	10,51061	51
10	9,47005	9,98021	9,48984	10,51016	50
11	9,47045	9,98017	9,49029	10,50971	49
12	9,47086	9,98013	9,49073	10,50927	48
13	9,47127	9,98009	9,49118	10,50882	47
14	9,47168	9,98005	9,49163	10,50837	46
15	9,47209	9,98001	9,49207	10,50793	45
16	9,47249	9,97997	9,49252	10,50748	44
17	9,47290	9,97993	9,49296	10,50704	43
18	9,47330	9,97989	9,49341	10,50659	42
19	9,47371	9,97986	9,49385	10,50615	41
20	9,47411	9,97982	9,49430	10,50570	40
21	9,47452	9,97978	9,49474	10,50526	39
22	9,47492	9,97974	9,49519	10,50481	38
23	9,47533	9,97970	9,49563	10,50437	37
24	9,47573	9,97966	9,49607	10,50393	36
25	9,47613	9,97962	9,49652	10,50348	35
26	9,47654	9,97958	9,49696	10,50304	34
27	9,47694	9,97954	9,49740	10,50260	33
28	9,47734	9,97950	9,49784	10,50216	32
29	9,47774	9,97946	9,49828	10,50172	31
30	9,47814	9,97942	9,49872	10,50128	30
31	9,47854	9,97938	9,49916	10,50084	29
32	9,47894	9,97934	9,49960	10,50040	28
33	9,47934	9,97930	9,50004	10,49996	27
34	9,47974	9,97926	9,50048	10,49952	26
35	9,48014	9,97922	9,50092	10,49908	25
36	9,48054	9,97918	9,50136	10,49864	24
37	9,48094	9,97914	9,50180	10,49820	23
38	9,48133	9,97910	9,50223	10,49777	22
39	9,48173	9,97906	9,50267	10,49733	21
40	9,48213	9,97902	9,50311	10,49689	20
41	9,48252	9,97898	9,50355	10,49645	19
42	9,48292	9,97894	9,50398	10,49602	18
43	9,48332	9,97890	9,50442	10,49558	17
44	9,48371	9,97886	9,50485	10,49515	16
45	9,48411	9,97882	9,50529	10,49471	15
46	9,48450	9,97878	9,50572	10,49428	14
47	9,48490	9,97874	9,50616	10,49384	13
48	9,48529	9,97870	9,50659	10,49341	12
49	9,48568	9,97866	9,50703	10,49297	11
50	9,48607	9,97861	9,50746	10,49254	10
51	9,48647	9,97857	9,50789	10,49211	9
52	9,48686	9,97853	9,50833	10,49167	8
53	9,48725	9,97849	9,50876	10,49124	7
54	9,48764	9,97845	9,50919	10,49081	6
55	9,48803	9,97841	9,50962	10,49038	5
56	9,48842	9,97837	9,51005	10,48995	4
57	9,48881	9,97833	9,51048	10,48952	3
58	9,48920	9,97829	9,51092	10,48908	2
59	9,48959	9,97825	9,51135	10,48865	1
60	9,48998	9,97821	9,51178	10,48822	0
	Co-fine	Sine	Co-tan.	Tangent.	M

72 Degrees.

Digitized by Google

18 Degrees.						19 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.		M	Sine	Co-sine	Tang.	Co-tang	
0	9,48998	9,97821	9,51178	10,48822	60	0	9,51264	9,97567	9,53697	10,46303	60
1	9,49037	9,97817	9,51221	10,48779	59	1	9,51301	9,97563	9,53738	10,46262	59
2	9,49076	9,97812	9,51264	10,48736	58	2	9,51337	9,97558	9,53779	10,46221	58
3	9,49115	9,97808	9,51306	10,48694	57	3	9,51374	9,97554	9,53820	10,46180	57
4	9,49153	9,97804	9,51349	10,48651	56	4	9,51411	9,97550	9,53861	10,46139	56
5	9,49192	9,97800	9,51392	10,48608	55	5	9,51447	9,97545	9,53902	10,46098	55
6	9,49231	9,97796	9,51435	10,48565	54	6	9,51484	9,97541	9,53943	10,46057	54
7	9,49269	9,97792	9,51478	10,48522	53	7	9,51520	9,97536	9,53984	10,46016	53
8	9,49308	9,97788	9,51520	10,48480	52	8	9,51557	9,97532	9,54025	10,45975	52
9	9,49347	9,97784	9,51563	10,48437	51	9	9,51593	9,97528	9,54065	10,45935	51
10	9,49385	9,97779	9,51606	10,48394	50	10	9,51629	9,97523	9,54106	10,45894	50
11	9,49424	9,97775	9,51648	10,48352	49	11	9,51666	9,97519	9,54147	10,45853	49
12	9,49462	9,97771	9,51691	10,48309	48	12	9,51702	9,97515	9,54187	10,45813	48
13	9,49500	9,97767	9,51734	10,48266	47	13	9,51738	9,97510	9,54228	10,45772	47
14	9,49539	9,97763	9,51776	10,48224	46	14	9,51774	9,97506	9,54269	10,45731	46
15	9,49577	9,97759	9,51819	10,48181	45	15	9,51811	9,97501	9,54309	10,45691	45
16	9,49615	9,97754	9,51861	10,48139	44	16	9,51847	9,97497	9,54350	10,45650	44
17	9,49654	9,97750	9,51903	10,48097	43	17	9,51883	9,97492	9,54390	10,45610	43
18	9,49692	9,97746	9,51946	10,48054	42	18	9,51919	9,97488	9,54431	10,45569	42
19	9,49730	9,97742	9,51988	10,48012	41	19	9,51955	9,97484	9,54471	10,45529	41
20	9,49768	9,97738	9,52031	10,47969	40	20	9,51991	9,97479	9,54512	10,45488	40
21	9,49806	9,97734	9,52073	10,47927	39	21	9,52027	9,97475	9,54552	10,45448	39
22	9,49844	9,97729	9,52115	10,47885	38	22	9,52063	9,97470	9,54593	10,45407	38
23	9,49882	9,97725	9,52157	10,47843	37	23	9,52099	9,97466	9,54633	10,45367	37
24	9,49920	9,97721	9,52199	10,47800	36	24	9,52135	9,97461	9,54673	10,45327	36
25	9,49958	9,97717	9,52242	10,47758	35	25	9,52171	9,97457	9,54714	10,45286	35
26	9,49996	9,97713	9,52284	10,47716	34	26	9,52207	9,97453	9,54754	10,45246	34
27	9,50034	9,97708	9,52326	10,47674	33	27	9,52242	9,97448	9,54794	10,45206	33
28	9,50072	9,97704	9,52368	10,47632	32	28	9,52278	9,97444	9,54835	10,45165	32
29	9,50110	9,97700	9,52410	10,47590	31	29	9,52314	9,97439	9,54875	10,45125	31
30	9,50148	9,97696	9,52452	10,47548	30	30	9,52350	9,97435	9,54915	10,45085	30
31	9,50185	9,97691	9,52494	10,47506	29	31	9,52385	9,97430	9,54955	10,45045	29
32	9,50223	9,97687	9,52536	10,47464	28	32	9,52421	9,97426	9,54995	10,45005	28
33	9,50261	9,97683	9,52578	10,47422	27	33	9,52456	9,97421	9,55035	10,44965	27
34	9,50298	9,97679	9,52620	10,47380	26	34	9,52492	9,97417	9,55075	10,44925	26
35	9,50336	9,97674	9,52661	10,47339	25	35	9,52527	9,97412	9,55115	10,44885	25
36	9,50374	9,97670	9,52703	10,47297	24	36	9,52563	9,97408	9,55155	10,44845	24
37	9,50411	9,97666	9,52745	10,47255	23	37	9,52598	9,97403	9,55195	10,44805	23
38	9,50449	9,97662	9,52787	10,47213	22	38	9,52634	9,97399	9,55235	10,44765	22
39	9,50486	9,97657	9,52829	10,47171	21	39	9,52669	9,97394	9,55275	10,44725	21
40	9,50523	9,97653	9,52870	10,47130	20	40	9,52705	9,97390	9,55315	10,44685	20
41	9,50561	9,97649	9,52912	10,47088	19	41	9,52740	9,97385	9,55355	10,44645	19
42	9,50598	9,97645	9,52953	10,47047	18	42	9,52775	9,97381	9,55395	10,44605	18
43	9,50635	9,97640	9,52995	10,47005	17	43	9,52811	9,97376	9,55434	10,44566	17
44	9,50673	9,97636	9,53037	10,46963	16	44	9,52846	9,97372	9,55474	10,44526	16
45	9,50710	9,97632	9,53078	10,46922	15	45	9,52881	9,97367	9,55514	10,44486	15
46	9,50747	9,97627	9,53120	10,46880	14	46	9,52916	9,97363	9,55554	10,44446	14
47	9,50784	9,97623	9,53161	10,46839	13	47	9,52951	9,97358	9,55593	10,44407	13
48	9,50821	9,97619	9,53202	10,46798	12	48	9,52986	9,97353	9,55633	10,44367	12
49	9,50858	9,97615	9,53244	10,46756	11	49	9,53021	9,97349	9,55673	10,44327	11
50	9,50896	9,97610	9,53285	10,46715	10	50	9,53056	9,97344	9,55712	10,44288	10
51	9,50933	9,97606	9,53327	10,46673	9	51	9,53092	9,97340	9,55752	10,44248	9
52	9,50970	9,97602	9,53368	10,46632	8	52	9,53126	9,97335	9,55791	10,44209	8
53	9,51007	9,97597	9,53409	10,46591	7	53	9,53161	9,97331	9,55831	10,44169	7
54	9,51043	9,97593	9,53450	10,46550	6	54	9,53196	9,97326	9,55870	10,44130	6
55	9,51080	9,97589	9,53492	10,46508	5	55	9,53231	9,97322	9,55910	10,44090	5
56	9,51117	9,97584	9,53533	10,46467	4	56	9,53266	9,97317	9,55949	10,44051	4
57	9,51154	9,97580	9,53574	10,46426	3	57	9,53301	9,97312	9,55989	10,44011	3
58	9,51191	9,97576	9,53615	10,46385	2	58	9,53336	9,97308	9,56028	10,43972	2
59	9,51227	9,97571	9,53656	10,46344	1	59	9,53370	9,97303	9,56067	10,43933	
60	9,51264	9,97567	9,53697	10,46303	0	60	9,53405	9,97299	9,56107	10,43893	0
	Co-sine	Sine	Co-tan.	Tangent.	M		Co-sine	Sine	Co-tan.	Tangent	
71 Degrees.						70 Degrees.					

20 Degrees.					
M	Sine	Co-fine	Tang.	Co-tang.	
0	9,53405	9,97299	9,56107	10,43893	60
1	9,53440	9,97294	9,56146	10,43854	59
2	9,53475	9,97289	9,56185	10,43815	58
3	9,53509	9,97285	9,56224	10,43776	57
4	9,53544	9,97280	9,56264	10,43736	56
5	9,53578	9,97276	9,56303	10,43697	55
6	9,53613	9,97271	9,56342	10,43658	54
7	9,53647	9,97266	9,56381	10,43619	53
8	9,53682	9,97262	9,56420	10,43580	52
9	9,53716	9,97257	9,56459	10,43541	51
10	9,53751	9,97252	9,56498	10,43502	50
11	9,53785	9,97248	9,56537	10,43463	49
12	9,53819	9,97243	9,56576	10,43424	48
13	9,53854	9,97238	9,56615	10,43385	47
14	9,53888	9,97234	9,56654	10,43346	46
15	9,53922	9,97229	9,56693	10,43307	45
16	9,53957	9,97224	9,56732	10,43268	44
17	9,53991	9,97220	9,56771	10,43229	43
18	9,54025	9,97215	9,56810	10,43190	42
19	9,54059	9,97210	9,56849	10,43151	41
20	9,54093	9,97206	9,56887	10,43113	40
21	9,54127	9,97201	9,56926	10,43074	39
22	9,54161	9,97196	9,56965	10,43035	38
23	9,54195	9,97192	9,57004	10,42996	37
24	9,54229	9,97187	9,57042	10,42958	36
25	9,54263	9,97182	9,57081	10,42919	35
26	9,54297	9,97178	9,57120	10,42880	34
27	9,54331	9,97173	9,57158	10,42842	33
28	9,54365	9,97168	9,57197	10,42803	32
29	9,54399	9,97163	9,57235	10,42765	31
30	9,54433	9,97159	9,57274	10,42726	30
31	9,54466	9,97154	9,57312	10,42688	29
32	9,54500	9,97149	9,57351	10,42649	28
33	9,54534	9,97145	9,57389	10,42611	27
34	9,54567	9,97140	9,57428	10,42572	26
35	9,54601	9,97135	9,57466	10,42534	25
36	9,54635	9,97130	9,57504	10,42496	24
37	9,54668	9,97126	9,57543	10,42457	23
38	9,54702	9,97121	9,57581	10,42419	22
39	9,54735	9,97116	9,57619	10,42381	21
40	9,54769	9,97111	9,57658	10,42342	20
41	9,54802	9,97107	9,57696	10,42304	19
42	9,54836	9,97102	9,57734	10,42266	18
43	9,54869	9,97097	9,57772	10,42228	17
44	9,54903	9,97092	9,57810	10,42190	16
45	9,54936	9,97087	9,57849	10,42151	15
46	9,54969	9,97083	9,57887	10,42113	14
47	9,55003	9,97078	9,57925	10,42075	13
48	9,55036	9,97073	9,57963	10,42037	12
49	9,55069	9,97068	9,58001	10,41999	11
50	9,55102	9,97063	9,58039	10,41961	10
51	9,55136	9,97059	9,58077	10,41923	9
52	9,55169	9,97054	9,58115	10,41885	8
53	9,55202	9,97049	9,58153	10,41847	7
54	9,55235	9,97044	9,58191	10,41809	6
55	9,55268	9,97039	9,58229	10,41771	5
56	9,55301	9,97035	9,58267	10,41733	4
57	9,55334	9,97030	9,58304	10,41696	3
58	9,55367	9,97025	9,58342	10,41658	2
59	9,55400	9,97020	9,58380	10,41620	1
60	9,55433	9,97015	9,58418	10,41582	0
	Co-fine	Sine	Co-tan.	Tangent	M
69 Degrees.					

21 Degrees.					
M	Sine	Co-fine	Tang.	Co-tang.	
0	9,55433	9,97015	9,58418	10,41582	60
1	9,55466	9,97010	9,58455	10,41545	59
2	9,55499	9,97005	9,58493	10,41507	58
3	9,55532	9,97001	9,58531	10,41469	57
4	9,55564	9,96996	9,58569	10,41431	56
5	9,55597	9,96991	9,58606	10,41394	55
6	9,55630	9,96986	9,58644	10,41356	54
7	9,55663	9,96981	9,58681	10,41319	53
8	9,55695	9,96976	9,58719	10,41281	52
9	9,55728	9,96971	9,58757	10,41243	51
10	9,55761	9,96966	9,58794	10,41206	50
11	9,55793	9,96962	9,58832	10,41168	49
12	9,55826	9,96957	9,58869	10,41131	48
13	9,55858	9,96952	9,58907	10,41093	47
14	9,55891	9,96947	9,58944	10,41056	46
15	9,55923	9,96942	9,58981	10,41019	45
16	9,55956	9,96937	9,59019	10,40981	44
17	9,55988	9,96932	9,59056	10,40944	43
18	9,56021	9,96927	9,59094	10,40906	42
19	9,56053	9,96922	9,59131	10,40869	41
20	9,56085	9,96917	9,59168	10,40832	40
21	9,56118	9,96912	9,59205	10,40795	39
22	9,56150	9,96907	9,59243	10,40757	38
23	9,56182	9,96903	9,59280	10,40720	37
24	9,56215	9,96898	9,59317	10,40683	36
25	9,56247	9,96893	9,59354	10,40646	35
26	9,56279	9,96888	9,59391	10,40609	34
27	9,56311	9,96883	9,59429	10,40571	33
28	9,56343	9,96878	9,59466	10,40534	32
29	9,56375	9,96873	9,59503	10,40497	31
30	9,56408	9,96868	9,59540	10,40460	30
31	9,56440	9,96863	9,59577	10,40423	29
32	9,56472	9,96858	9,59614	10,40386	28
33	9,56504	9,96853	9,59651	10,40349	27
34	9,56536	9,96848	9,59688	10,40312	26
35	9,56568	9,96843	9,59725	10,40275	25
36	9,56599	9,96838	9,59762	10,40238	24
37	9,56631	9,96833	9,59799	10,40201	23
38	9,56663	9,96828	9,59835	10,40165	22
39	9,56695	9,96823	9,59872	10,40128	21
40	9,56727	9,96818	9,59909	10,40091	20
41	9,56759	9,96813	9,59946	10,40054	19
42	9,56790	9,96808	9,59983	10,40017	18
43	9,56822	9,96803	9,60019	10,39981	17
44	9,56854	9,96798	9,60056	10,39944	16
45	9,56886	9,96793	9,60093	10,39907	15
46	9,56917	9,96788	9,60130	10,39870	14
47	9,56949	9,96783	9,60166	10,39834	13
48	9,56980	9,96778	9,60203	10,39797	12
49	9,57012	9,96772	9,60240	10,39760	11
50	9,57044	9,96767	9,60276	10,39724	10
51	9,57075	9,96762	9,60313	10,39687	9
52	9,57107	9,96757	9,60349	10,39651	8
53	9,57138	9,96752	9,60386	10,39614	7
54	9,57169	9,96747	9,60422	10,39578	6
55	9,57201	9,96742	9,60459	10,39541	5
56	9,57232	9,96737	9,60495	10,39505	4
57	9,57264	9,96732	9,60532	10,39468	3
58	9,57295	9,96727	9,60568	10,39432	2
59	9,57326	9,96722	9,60605	10,39395	1
60	9,57358	9,96717	9,60641	10,39359	0
	Co-fine	Sine	Co-tan.	Tangent.	M
68 Degrees.					

Digitized by Google

22 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,57358	9,96717	9,60641	10,39359	60
1	9,57389	9,96711	9,60677	10,39323	59
2	9,57420	9,96706	9,60714	10,39286	58
3	9,57451	9,96701	9,60750	10,39250	57
4	9,57482	9,96696	9,60786	10,39214	56
5	9,57514	9,96691	9,60823	10,39177	55
6	9,57545	9,96686	9,60859	10,39141	54
7	9,57576	9,96681	9,60895	10,39105	53
8	9,57607	9,96676	9,60931	10,39069	52
9	9,57638	9,96670	9,60967	10,39033	51
10	9,57669	9,96665	9,61004	10,38996	50
11	9,57700	9,96660	9,61040	10,38960	49
12	9,57731	9,96655	9,61076	10,38924	48
13	9,57762	9,96650	9,61112	10,38888	47
14	9,57793	9,96645	9,61148	10,38852	46
15	9,57824	9,96640	9,61184	10,38816	45
16	9,57854	9,96634	9,61220	10,38780	44
17	9,57885	9,96629	9,61256	10,38744	43
18	9,57916	9,96624	9,61292	10,38708	42
19	9,57947	9,96619	9,61328	10,38672	41
20	9,57978	9,96614	9,61364	10,38636	40
21	9,58008	9,96608	9,61400	10,38600	39
22	9,58039	9,96603	9,61436	10,38564	38
23	9,58070	9,96598	9,61472	10,38528	37
24	9,58101	9,96593	9,61508	10,38492	36
25	9,58131	9,96588	9,61544	10,38456	35
26	9,58162	9,96582	9,61579	10,38421	34
27	9,58192	9,96577	9,61615	10,38385	33
28	9,58223	9,96572	9,61651	10,38349	32
29	9,58253	9,96567	9,61687	10,38313	31
30	9,58284	9,96562	9,61722	10,38278	30
31	9,58314	9,96556	9,61758	10,38242	29
32	9,58345	9,96551	9,61794	10,38206	28
33	9,58375	9,96546	9,61830	10,38170	27
34	9,58406	9,96541	9,61865	10,38135	26
35	9,58436	9,96535	9,61901	10,38099	25
36	9,58467	9,96530	9,61936	10,38064	24
37	9,58497	9,96525	9,61972	10,38028	23
38	9,58527	9,96520	9,62008	10,37992	22
39	9,58557	9,96514	9,62043	10,37957	21
40	9,58588	9,96509	9,62079	10,37921	20
41	9,58618	9,96504	9,62114	10,37886	19
42	9,58648	9,96498	9,62150	10,37850	18
43	9,58678	9,96493	9,62185	10,37815	17
44	9,58709	9,96488	9,62221	10,37779	16
45	9,58739	9,96483	9,62256	10,37744	15
46	9,58769	9,96477	9,62292	10,37708	14
47	9,58799	9,96472	9,62327	10,37673	13
48	9,58829	9,96467	9,62362	10,37638	12
49	9,58859	9,96461	9,62398	10,37602	11
50	9,58889	9,96456	9,62433	10,37567	10
51	9,58919	9,96451	9,62468	10,37532	9
52	9,58949	9,96445	9,62504	10,37496	8
53	9,58979	9,96440	9,62539	10,37461	7
54	9,59009	9,96435	9,62574	10,37426	6
55	9,59039	9,96429	9,62609	10,37391	5
56	9,59069	9,96424	9,62645	10,37355	4
57	9,59098	9,96419	9,62680	10,37320	3
58	9,59128	9,96413	9,62715	10,37285	2
59	9,59158	9,96408	9,62750	10,37250	1
60	9,59188	9,96403	9,62785	10,37215	0
	Co-sine	Sine	Co-tan.	Tangent.	M
67 Degrees.					

23 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,59188	9,96403	9,62785	10,37215	60
1	9,59218	9,96397	9,62820	10,37180	59
2	9,59247	9,96392	9,62855	10,37145	58
3	9,59277	9,96386	9,62890	10,37110	57
4	9,59307	9,96381	9,62926	10,37074	56
5	9,59336	9,96376	9,62961	10,37039	55
6	9,59366	9,96370	9,62996	10,37004	54
7	9,59396	9,96365	9,63031	10,36969	53
8	9,59425	9,96360	9,63066	10,36934	52
9	9,59455	9,96354	9,63101	10,36899	51
10	9,59484	9,96349	9,63135	10,36865	50
11	9,59514	9,96343	9,63170	10,36830	49
12	9,59543	9,96338	9,63205	10,36795	48
13	9,59573	9,96333	9,63240	10,36760	47
14	9,59602	9,96327	9,63275	10,36725	46
15	9,59632	9,96322	9,63310	10,36690	45
16	9,59661	9,96316	9,63345	10,36655	44
17	9,59690	9,96311	9,63379	10,36621	43
18	9,59720	9,96305	9,63414	10,36586	42
19	9,59749	9,96300	9,63449	10,36551	41
20	9,59778	9,96294	9,63484	10,36516	40
21	9,59808	9,96289	9,63519	10,36481	39
22	9,59837	9,96284	9,63553	10,36447	38
23	9,59866	9,96278	9,63588	10,36412	37
24	9,59895	9,96273	9,63623	10,36377	36
25	9,59924	9,96267	9,63657	10,36343	35
26	9,59954	9,96262	9,63692	10,36308	34
27	9,59983	9,96256	9,63726	10,36274	33
28	9,60012	9,96251	9,63761	10,36239	32
29	9,60041	9,96245	9,63796	10,36204	31
30	9,60070	9,96240	9,63830	10,36170	30
31	9,60099	9,96234	9,63865	10,36135	29
32	9,60128	9,96229	9,63899	10,36101	28
33	9,60157	9,96223	9,63934	10,36066	27
34	9,60186	9,96218	9,63968	10,36032	26
35	9,60215	9,96212	9,64003	10,35997	25
36	9,60244	9,96207	9,64037	10,35963	24
37	9,60273	9,96201	9,64072	10,35928	23
38	9,60302	9,96196	9,64106	10,35894	22
39	9,60331	9,96190	9,64140	10,35860	21
40	9,60359	9,96185	9,64175	10,35825	20
41	9,60388	9,96179	9,64209	10,35791	19
42	9,60417	9,96174	9,64243	10,35757	18
43	9,60446	9,96168	9,64278	10,35722	17
44	9,60474	9,96162	9,64312	10,35688	16
45	9,60503	9,96157	9,64346	10,35654	15
46	9,60532	9,96151	9,64381	10,35619	14
47	9,60561	9,96146	9,64415	10,35585	13
48	9,60589	9,96140	9,64449	10,35551	12
49	9,60618	9,96135	9,64483	10,35517	11
50	9,60646	9,96129	9,64517	10,35483	10
51	9,60675	9,96123	9,64552	10,35448	9
52	9,60704	9,96118	9,64586	10,35414	8
53	9,60732	9,96112	9,64620	10,35380	7
54	9,60761	9,96107	9,64654	10,35346	6
55	9,60789	9,96101	9,64688	10,35312	5
56	9,60818	9,96095	9,64722	10,35278	4
57	9,60846	9,96090	9,64756	10,35244	3
58	9,60875	9,96084	9,64790	10,35210	2
59	9,60903	9,96079	9,64824	10,35176	1
60	9,60931	9,96073	9,64858	10,35142	0
	Co-sine	Sine	Co-tan.	Tangent.	M
66 Degrees.					

Digitized by Google

24 Degrees.

M	Sine	Co-fine	Tang.	Co-tang.	
0	9,60931	9,96073	9,64858	10,35142	60
1	9,60960	9,96067	9,64892	10,35108	59
2	9,60988	9,96062	9,64926	10,35074	58
3	9,61016	9,96056	9,64960	10,35040	57
4	9,61045	9,96050	9,64994	10,35006	56
5	9,61073	9,96045	9,65028	10,34972	55
6	9,61101	9,96039	9,65062	10,34938	54
7	9,61129	9,96034	9,65096	10,34904	53
8	9,61158	9,96028	9,65130	10,34870	52
9	9,61186	9,96022	9,65164	10,34836	51
10	9,61214	9,96017	9,65197	10,34803	50
11	9,61242	9,96011	9,65231	10,34769	49
12	9,61270	9,96005	9,65265	10,34735	48
13	9,61298	9,96000	9,65299	10,34701	47
14	9,61326	9,95994	9,65333	10,34667	46
15	9,61354	9,95988	9,65366	10,34634	45
16	9,61382	9,95982	9,65400	10,34600	44
17	9,61411	9,95977	9,65434	10,34566	43
18	9,61438	9,95971	9,65467	10,34533	42
19	9,61466	9,95965	9,65501	10,34499	41
20	9,61494	9,95960	9,65535	10,34465	40
21	9,61522	9,95954	9,65568	10,34432	39
22	9,61550	9,95948	9,65602	10,34398	38
23	9,61578	9,95942	9,65636	10,34364	37
24	9,61606	9,95937	9,65669	10,34331	36
25	9,61634	9,95931	9,65703	10,34297	35
26	9,61662	9,95925	9,65736	10,34264	34
27	9,61689	9,95920	9,65770	10,34230	33
28	9,61717	9,95914	9,65803	10,34197	32
29	9,61745	9,95908	9,65837	10,34163	31
30	9,61773	9,95902	9,65870	10,34130	30
31	9,61800	9,95897	9,65904	10,34096	29
32	9,61828	9,95891	9,65937	10,34063	28
33	9,61856	9,95885	9,65971	10,34029	27
34	9,61883	9,95879	9,66004	10,33996	26
35	9,61911	9,95873	9,66038	10,33962	25
36	9,61939	9,95868	9,66071	10,33929	24
37	9,61966	9,95862	9,66104	10,33896	23
38	9,61994	9,95856	9,66138	10,33862	22
39	9,62021	9,95850	9,66171	10,33829	21
40	9,62049	9,95844	9,66204	10,33796	20
41	9,62076	9,95839	9,66238	10,33762	19
42	9,62104	9,95833	9,66271	10,33729	18
43	9,62131	9,95827	9,66304	10,33696	17
44	9,62159	9,95821	9,66337	10,33663	16
45	9,62186	9,95815	9,66371	10,33629	15
46	9,62214	9,95810	9,66404	10,33596	14
47	9,62241	9,95804	9,66437	10,33563	13
48	9,62268	9,95798	9,66470	10,33530	12
49	9,62296	9,95792	9,66503	10,33497	11
50	9,62323	9,95786	9,66537	10,33463	10
51	9,62350	9,95780	9,66570	10,33430	9
52	9,62377	9,95775	9,66603	10,33397	8
53	9,62405	9,95769	9,66636	10,33364	7
54	9,62432	9,95763	9,66669	10,33331	6
55	9,62459	9,95757	9,66702	10,33298	5
56	9,62486	9,95751	9,66735	10,33265	4
57	9,62513	9,95745	9,6676[illegible]	10,33232	3
58	9,62541	9,95739	9,6680[illegible]	10,33199	2
59	9,62568	9,95733	9,66834	10,331[illegible]	1
60	9,6259[illegible]	[illegible]95728	[illegible]686	10,3313[illegible]	
	Co-fine		Co-tan	Tangen[illegible]	

65 Degrees.

25 Degrees.

M	Sine	Co-fine	Tang.	Co-tang.	
0	9,62595	9,95728	9,66867	10,33133	60
1	9,62622	9,95722	9,66900	10,33100	59
2	9,62649	9,95716	9,66933	10,33067	58
3	9,62676	9,95710	9,66966	10,33034	57
4	9,62703	9,95704	9,66999	10,33001	56
5	9,62730	9,95698	9,67032	10,32968	55
6	9,62757	9,95692	9,67065	10,32935	54
7	9,62784	9,95686	9,67098	10,32902	53
8	9,62811	9,95680	9,67131	10,32869	52
9	9,62838	9,95674	9,67163	10,32837	51
10	9,62865	9,95668	9,67196	10,32804	50
11	9,62892	9,95662	9,67229	10,32771	49
12	9,62918	9,95657	9,67262	10,32738	48
13	9,62945	9,95651	9,67295	10,32705	47
14	9,62972	9,95645	9,67327	10,32673	46
15	9,62999	9,95639	9,67360	10,32640	45
16	9,63026	9,95633	9,67393	10,32607	44
17	9,63052	9,95627	9,67426	10,32574	43
18	9,63079	9,95621	9,67458	10,32542	42
19	9,63106	9,95615	9,67491	10,32509	41
20	9,63133	9,95609	9,67524	10,32476	40
21	9,63159	9,95603	9,67556	10,32444	39
22	9,63186	9,95597	9,67589	10,32411	38
23	9,63213	9,95591	9,67622	10,32378	37
24	9,63239	9,95585	9,67654	10,32346	36
25	9,63266	9,95579	9,67687	10,32313	35
26	9,63292	9,95573	9,67719	10,32281	34
27	9,63319	9,95567	9,67752	10,32248	33
28	9,63345	9,95561	9,67785	10,32215	32
29	9,63372	9,95555	9,67817	10,32183	31
30	9,63398	9.95549	9,67850	10,32150	30
31	9,63425	9,95543	9,67882	10,32118	29
32	9,63451	9,95537	9,67915	10,32085	28
33	9,63478	9,95531	9,67947	10,32053	27
34	9,63504	9,95525	9,67980	10,32020	26
35	9,63531	9,95519	9,68012	10,31988	25
36	9,63557	9,95513	9,68044	10,31956	24
37	9,63583	9,95507	9,68077	10,31923	23
38	9,63610	9,95500	9,68109	10,31891	22
39	9,63636	9,95494	9,68142	10,31858	21
40	9,63662	9,95488	9,68174	10,31826	20
41	9,63689	9,95482	9,68206	10,31794	19
42	9,63715	9,95476	9,68239	10,31761	18
43	9,63741	9,95470	9,68271	10,31729	17
44	9,63767	9,95464	9,68303	10,31697	16
45	9,63794	9,95458	9,68336	10,31664	15
46	9,63820	9,95452	9,68368	10,31632	14
47	9,63846	9,95446	9,68400	10,31600	13
48	9,63872	9,95440	9,68432	10,31568	12
49	9,63898	9,95434	9,68465	10,31535	11
50	9,63924	9,95427	9,68497	10,31503	10
51	9,63950	9,95421	9,68529	10,31471	9
52	9,63976	9,95415	9,68561	10,31439	8
53	9,64002	9,95409	9,68593	10,31407	7
54	9.64028	9,95403	9,68626	10,31374	6
55	9,64054	9,95397	9,68658	10,31342	5
56	9,64080	9,95391	9,68690	10,31310	4
57	9,64106	9,95384	9,68722	10,31278	3
58	9,6413[illegible]	9,95378	9,68754	10,31246	2
59	9.641[illegible]	9,95372	9,68786	10,31214	1
[illegible]	9,64184	9,9[illegible]366	9,68818	10,31182	0
	Co-fine	Sine	Co-tan.	Tangent.	M

64 Degrees.

Digitized by Google

26 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,64184	9,95366	9,68818	10,31182	60
1	9,64210	9,95360	9,68850	10,31150	59
2	9,64236	9,95354	9,68882	10,31118	58
3	9,64262	9,95348	9,68914	10,31086	57
4	9,64288	9,95341	9,68946	10,31054	56
5	9,64313	9,95335	9,68978	10,31022	55
6	9,64339	9,95329	9,69010	10,30990	54
7	9,64365	9,95323	9,69042	10,30958	53
8	9,64391	9,95317	9,69074	10,30926	52
9	9,64417	9,95310	9,69106	10,30894	51
10	9,64442	9,95304	9,69138	10,30862	50
11	9,64468	9,95298	9,69170	10,30830	49
12	9,64494	9,95292	9,69202	10,30798	48
13	9,64519	9,95286	9,69234	10,30766	47
14	9,64545	9,95279	9,69266	10,30734	46
15	9,64571	9,95273	9,69298	10,30702	45
16	9,64596	9,95267	9,69329	10,30671	44
17	9,64622	9,95261	9,69361	10,30639	43
18	9,64647	9,95254	9,69393	10,30607	42
19	9,64673	9,95248	9,69425	10,30575	41
20	9,64698	9,95242	9,69457	10,30543	40
21	9,64724	9,95236	9,69488	10,30512	39
22	9,64749	9,95229	9,69520	10,30480	38
23	9,64775	9,95223	9,69552	10,30448	37
24	9,64800	9,95217	9,69584	10,30416	36
25	9,64826	9,95211	9,69615	10,30385	35
26	9,64851	9,95204	9,69647	10,30353	34
27	9,64877	9,95198	9,69679	10,30321	33
28	9,64902	9,95192	9,69710	10,30290	32
29	9,64927	9,95185	9,69742	10,30258	31
30	9,64953	9,95179	9,69774	10,30226	30
31	9,64978	9,95173	9,69805	10,30195	29
32	9,65003	9,95167	9,69837	10,30163	28
33	9,65029	9,95160	9,69868	10,30132	27
34	9,65054	9,95154	9,69900	10,30100	26
35	9,65079	9,95148	9,69932	10,30068	25
36	9,65104	9,95141	9,69963	10,30037	24
37	9,65130	9,95135	9,69995	10,30005	23
38	9,65155	9,95129	9,70026	10,29974	22
39	9,65180	9,95122	9,70058	10,29942	21
40	9,65205	9,95116	9,70089	10,29911	20
41	9,65230	9,95110	9,70121	10,29879	19
42	9,65255	9,95103	9,70152	10,29848	18
43	9,65281	9,95097	9,70184	10,29816	17
44	9,65306	9,95090	9,70215	10,29785	16
45	9,65331	9,95084	9,70247	10,29753	15
46	9,65356	9,95078	9,70278	10,29722	14
47	9,65381	9,95071	9,70309	10,29691	13
48	9,65406	9,95065	9,70341	10,29659	12
49	9,65431	9,95059	9,70372	10,29628	11
50	9,65456	9,95052	9,70404	10,29596	10
51	9,65481	9,95046	9,70435	10,29565	9
52	9,65506	9,95039	9,70466	10,29534	8
53	9,65531	9,95033	9,70498	10,29502	7
54	9,65556	9,95027	9,70529	10,29471	6
55	9,65580	9,95020	9,70560	10,29440	5
56	9,65605	9,95014	9,70592	10,29408	4
57	9,65630	9,95007	9,70623	10,29377	3
58	9,65655	9,95001	9,70654	10,29346	2
59	9,65680	9,94995	9,70685	10,29315	1
60	9,65705	9,94988	9,70717	10,29283	0
	Co-sine	Sine	Co-tan.	Tangent	M
63 Degrees.					

27 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,65705	9,94988	9,70717	10,29283	60
1	9,65729	9,94982	9,70748	10,29252	59
2	9,65754	9,94975	9,70779	10,29221	58
3	9,65779	9,94969	9,70810	10,29190	57
4	9,65804	9,94962	9,70841	10,29159	56
5	9,65828	9,94956	9,70873	10,29127	55
6	9,65853	9,94949	9,70904	10,29096	54
7	9,65878	9,94943	9,70935	10,29065	53
8	9,65902	9,94936	9,70966	10,29034	52
9	9,65927	9,94930	9,70997	10,29003	51
10	9,65952	9,94923	9,71028	10,28972	50
11	9,65976	9,94917	9,71059	10,28941	49
12	9,66001	9,94911	9,71090	10,28910	48
13	9,66025	9,94904	9,71121	10,28879	47
14	9,66050	9,94898	9,71153	10,28847	46
15	9,66075	9,94891	9,71184	10,28816	45
16	9,66099	9,94884	9,71215	10,28785	44
17	9,66124	9,94878	9,71246	10,28754	43
18	9,66148	9,94871	9,71277	10,28723	42
19	9,66173	9,94865	9,71308	10,28692	41
20	9,66197	9,94858	9,71339	10,28661	40
21	9,66221	9,94852	9,71370	10,28630	39
22	9,66246	9,94845	9,71401	10,28599	38
23	9,66270	9,94839	9,71431	10,28569	37
24	9,66295	9,94832	9,71462	10,28538	36
25	9,66319	9,94826	9,71493	10,28507	35
26	9,66343	9,94819	9,71524	10,28476	34
27	9,66368	9,94813	9,71555	10,28445	33
28	9,66392	9,94806	9,71586	10,28414	32
29	9,66416	9,94799	9,71617	10,28383	31
30	9,66441	9,94793	9,71648	10,28352	30
31	9,66465	9,94786	9,71679	10,28321	29
32	9,66489	9,94780	9,71709	10,28291	28
33	9,66513	9,94773	9,71740	10,28260	27
34	9,66537	9,94767	9,71771	10,28229	26
35	9,66562	9,94760	9,71802	10,28198	25
36	9,66586	9,94753	9,71833	10,28167	24
37	9,66610	9,94747	9,71863	10,28137	23
38	9,66634	9,94740	9,71894	10,28106	22
39	9,66658	9,94734	9,71925	10,28075	21
40	9,66682	9,94727	9,71955	10,28045	20
41	9,66706	9,94720	9,71986	10,28014	19
42	9,66731	9,94714	9,72017	10,27983	18
43	9,66755	9,94707	9,72048	10,27952	17
44	9,66779	9,94700	9,72078	10,27922	16
45	9,66803	9,94694	9,72109	10,27891	15
46	9,66827	9,94687	9,72140	10,27860	14
47	9,66851	9,94680	9,72170	10,27830	13
48	9,66875	9,94674	9,72201	10,27799	12
49	9,66899	9,94667	9,72231	10,27769	11
50	9,66922	9,94660	9,72262	10,27738	10
51	9,66946	9,94654	9,72293	10,27707	9
52	9,66970	9,94647	9,72323	10,27677	8
53	9,66994	9,94640	9,72354	10,27646	7
54	9,67018	9,94634	9,72384	10,27616	6
55	9,67042	9,94627	9,72415	10,27585	5
56	9,67066	9,94620	9,72445	10,27555	4
57	9,67090	9,94614	9,72476	10,27524	3
58	9,67113	9,94607	9,72506	10,27494	2
59	9,67137	9,94600	9,72537	10,27463	1
60	9,67161	9,94593	9,72567	10,27433	0
	Co-sine	Sine	Co-tan.	Tangent.	M
62 Degrees.					

Digitized by Google

28 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,67161	9,94593	9,72567	10,27433	60
1	9,67185	9,94587	9,72598	10,27402	59
2	9,67208	9,94580	9,72628	10,27372	58
3	9,67232	9,94573	9,72659	10,27341	57
4	9,67256	9,94567	9,72689	10,27311	56
5	9,67280	9,94560	9,72720	10,27280	55
6	9,67303	9,94553	9,72750	10,27250	54
7	9,67327	9,94546	9,72780	10,27220	53
8	9,67350	9,94540	9,72811	10,27189	52
9	9,67374	9,94533	9,72841	10,27159	51
10	9,67398	9,94526	9,72872	10,27128	50
11	9,67421	9,94519	9,72902	10,27098	49
12	9,67445	9,94513	9,72932	10,27068	48
13	9,67468	9,94506	9,72963	10,27037	47
14	9,67492	9,94499	9,72993	10,27007	46
15	9,67515	9,94492	9,73023	10,26977	45
16	9,67539	9,94485	9,73054	10,26946	44
17	9,67562	9,94479	9,73084	10,26916	43
18	9,67586	9,94472	9,73114	10,26886	42
19	9,67609	9,94465	9,73144	10,26856	41
20	9,67633	9,94458	9,73175	10,26825	40
21	9,67656	9,94451	9,73205	10,26795	39
22	9,67680	9,94445	9,73235	10,26765	38
23	9,67703	9,94438	9,73265	10,26735	37
24	9,67726	9,94431	9,73295	10,26705	36
25	9,67750	9,94424	9,73326	10,26674	35
26	9,67773	9,94417	9,73356	10,26644	34
27	9,67796	9,94410	9,73386	10,26614	33
28	9,67820	9,94404	9,73416	10,26584	32
29	9,67843	9,94397	9,73446	10,26554	31
30	9,67866	9,94390	9,73476	10,26524	30
31	9,67890	9,94383	9,73507	10,26493	29
32	9,67913	9,94376	9,73537	10,26463	28
33	9,67936	9,94369	9,73567	10,26433	27
34	9,67959	9,94362	9,73597	10,26403	26
35	9,67982	9,94355	9,73627	10,26373	25
36	9,68006	9,94349	9,73657	10,26343	24
37	9,68029	9,94342	9,73687	10,26313	23
38	9,68052	9,94335	9,73717	10,26283	22
39	9,68075	9,94328	9,73747	10,26253	21
40	9,68098	9,94321	9,73777	10,26223	20
41	9,68121	9,94314	9,73807	10,26193	19
42	9,68144	9,94307	9,73837	10,26163	18
43	9,68167	9,94300	9,73867	10,26133	17
44	9,68190	9,94293	9,73897	10,26103	16
45	9,68213	9,94286	9,73927	10,26073	15
46	9,68237	9,94279	9,73957	10,26043	14
47	9,68260	9,94273	9,73987	10,26013	13
48	9,68282	9,94266	9,74017	10,25983	12
49	9,68305	9,94259	9,74047	10,25953	11
50	9,68328	9,94252	9,74077	10,25923	10
51	9,68351	9,94245	9,74107	10,25893	9
52	9,68374	9,94238	9,74137	10,25863	8
53	9,68397	9,94231	9,74166	10,25834	7
54	9,68420	9,94224	9,74196	10,25804	6
55	9,68443	9,94217	9,74226	10,25774	5
56	9,68466	9,94210	9,74256	10,25744	4
57	9,68489	9,94203	9,74286	10,25714	3
58	9,68512	9,94196	9,74316	10,25684	2
59	9,68534	9,94189	9,74345	10,25655	1
60	9,68557	9,94182	9,74375	10,25625	0
	Co-sine	Sine	Co-tan.	Tangent.	M

61 Degrees

29 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,68557	9,94182	9,74375	10,25625	60
1	9,68580	9,94175	9,74405	10,25595	59
2	9,68603	9,94168	9,74435	10,25565	58
3	9,68625	9,94161	9,74465	10,25535	57
4	9,68648	9,94154	9,74494	10,25506	56
5	9,68671	9,94147	9,74524	10,25476	55
6	9,68694	9,94140	9,74554	10,25446	54
7	9,68716	9,94133	9,74583	10,25417	53
8	9,68739	9,94126	9,74613	10,25387	52
9	9,68762	9,94119	9,74643	10,25357	51
10	9,68784	9,94112	9,74673	10,25337	50
11	9,68807	9,94105	9,74702	10,25298	49
12	9,68829	9,94098	9,74732	10,25268	48
13	9,68852	9,94090	9,74762	10,25238	47
14	9,68875	9,94083	9,74791	10,25209	46
15	9,68897	9,94076	9,74821	10,25179	45
16	9,68920	9,94069	9,74851	10,25149	44
17	9,68942	9,94062	9,74880	10,25120	43
18	9,68965	9,94055	9,74910	10,25090	42
19	9,68987	9,94048	9,74939	10,25061	41
20	9,69010	9,94041	9,74969	10,25031	40
21	9,69032	9,94034	9,74998	10,25002	39
22	9,69055	9,94027	9,75028	10,24972	38
23	9,69077	9,94020	9,75058	10,24942	37
24	9,69100	9,94012	9,75087	10,24913	36
25	9,69122	9,94005	9,75117	10,24883	35
26	9,69144	9,93998	9,75146	10,24854	34
27	9,69167	9,93991	9,75176	10,24824	33
28	9,69189	9,93984	9,75205	10,24795	32
29	9,69212	9,93977	9,75235	10,24765	31
30	9,69234	9,93970	9,75264	10,24736	30
31	9,69256	9,93963	9,75294	10,24706	29
32	9,69279	9,93955	9,75323	10,24677	28
33	9,69301	9,93948	9,75353	10,24647	27
34	9,69323	9,93941	9,75382	10,24618	26
35	9,69345	9,93934	9,75411	10,24589	25
36	9,69368	9,93927	9,75441	10,24559	24
37	9,69390	9,93920	9,75470	10,24530	23
38	9,69412	9,93912	9,75500	10,24500	22
39	9,69434	9,93905	9,75529	10,24471	21
40	9,69456	9,93898	9,75558	10,24442	20
41	9,69479	9,93891	9,75588	10,24412	19
42	9,69501	9,93884	9,75617	10,24383	18
43	9,69523	9,93876	9,75647	10,24353	17
44	9,69545	9,93869	9,75676	10,24324	16
45	9,69567	9,93862	9,75705	10,24295	15
46	9,69589	9,93855	9,75735	10,24265	14
47	9,69611	9,93847	9,75764	10,24236	13
48	9,69633	9,93840	9,75793	10,24207	12
49	9,69655	9,93833	9,75822	10,24178	11
50	9,69677	9,93826	9,75852	10,24148	10
51	9,69699	9,93819	9,75881	10,24119	9
52	9,69721	9,93811	9,75910	10,24090	8
53	9,69743	9,93804	9,75939	10,24061	7
54	9,69765	9,93797	9,75969	10,24031	6
55	9,69787	9,93789	9,75998	10,24002	5
56	9,69809	9,93782	9,76027	10,23973	4
57	9,69831	9,93775	9,76056	10,23944	3
58	9,69853	9,93768	9,76086	10,23914	2
59	9,69875	9,93760	9,76115	10,23885	1
60	9,69897	9,93753	9,76144	10,23856	0
	Co-sine	Sine	Co-tan.	Tangent.	M

60 Degrees.

Digitized by Google

30 Degrees.					
M	Sine	Co sine.	Tang.	Co-tang.	
0	9,69897	9,93753	9.76.44	10,23850	60
1	9,69919	9,93746	9,76173	10,23827	59
2	9,69941	9,93738	9,76202	10,23798	58
3	9,69963	9,93731	9,76231	10,23769	57
4	9,69984	9,93724	9,76261	10,23739	56
5	9,70006	9,93717	9,76290	10,23710	55
6	9,70028	9,93709	9,76319	10,23681	54
7	9,70050	9,93702	9,76348	10,23652	53
8	9,70072	9,93695	9,76377	10,23623	52
9	9,70093	9,93687	9,76406	10,23594	51
10	9,70115	9,93680	9,76435	10,23565	50
11	9,70137	9,93673	9,76464	10,23536	49
12	9,70159	9,93665	9,76493	10,23507	48
13	9,70180	9,93658	9,76522	10,23478	47
14	9,70202	9,93650	9,76551	10,23449	46
15	9,70224	9,93643	9,76580	10,23420	45
16	9,70245	9,93636	9,76609	10,23391	44
17	9,70267	9,93628	9,76639	10,23361	43
18	9,70288	9,93621	9,76668	10,23332	42
19	9,70310	9,93614	9,76697	10,23303	41
20	9,70332	9,93606	9,76725	10,23275	40
21	9,70353	9,93599	9,76754	10,23246	39
22	9,70375	9,93591	9,76783	10,23217	38
23	9,70396	9,93584	9,76812	10,23188	37
24	9,70418	9,93577	9,76841	10,23159	36
25	9,70439	9,93569	9,76870	10,23130	35
26	9,70461	9,93562	9,76899	10,23101	34
27	9,70482	9,93554	9,76928	10,23072	33
28	9,70504	9,93547	9,76957	10,23043	32
29	9,70525	9,93539	9,76986	10,23014	31
30	9,70547	9,93532	9,77015	10,22985	30
31	9,70568	9,93525	9,77044	10,22956	29
32	9,70590	9,93517	9,77073	10,22927	28
33	9,70611	9,93510	9,77101	10,22899	27
34	9,70633	9,93502	9,77130	10,22870	26
35	9,70654	9,93495	9,77159	10,22841	25
36	9,70675	9,93487	9,77188	10,22812	24
37	9,70697	9,93480	9,77217	10,22783	23
38	9,70718	9,93472	9,77246	10,22754	22
39	9,70739	9,93465	9,77274	10,22726	21
40	9,70761	9,93457	9,77303	10,22697	20
41	9,70782	9,93450	9,77332	10,22668	19
42	9,70803	9,93442	9,77361	10,22639	18
43	9,70824	9,93435	9,77390	10,22610	17
44	9,70846	9,93427	9,77418	10,22582	16
45	9,70867	9,93420	9,77447	10,22553	15
46	9,70888	9,93412	9,77476	10,22524	14
47	9,70909	9,93405	9,77505	10,22495	13
48	9,70931	9,93397	9,77533	10,22467	12
49	9,70952	9,93390	9,77562	10,22438	11
50	9,70973	9,93382	9,77591	10,22409	10
51	9,70994	9,93375	9,77619	10,22381	9
52	9,71015	9,93367	9,77648	10,22352	8
53	9,71036	9.93360	9,77677	10,22323	7
54	9,71058	9,93352	9,77706	10,22294	6
55	9,71079	9,93344	9,77734	10,22266	5
56	9,71100	9,93337	9,77763	10,22237	4
57	9,71121	9,93329	9,77791	10,22209	3
58	9,71142	9,93322	9,77820	10,22180	2
59	9,71163	9,93314	9,77849	10,22151	1
60	9,71184	9,93307	9,77877	10,22123	0
	Co-sine.	Sine	Co tan.	Tangent.	M
59 Degrees.					

31 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,71184	9,93307	9,77877	10,22123	60
1	9,71205	9,93299	9,77906	10,22094	59
2	9,71226	9,93291	9,77935	10,22065	58
3	9,71247	9,93284	9,77963	10,22037	57
4	9,71268	9,93276	9,77992	10,22008	56
5	9,71289	9,93269	9,78020	10,21980	55
6	9,71310	9,93261	9,78049	10,21951	54
7	9,71331	9,93253	9,78077	10,21923	53
8	9,71352	9,93246	9,78106	10,21894	52
9	9,71373	9,93238	9,78135	10,21865	51
10	9,71393	9,93230	9,78163	10,21837	50
11	9,71414	9,93223	9,78192	10,21808	49
12	9,71435	9,93215	9,78220	10,21780	48
13	9,71456	9,93207	9,78249	10,21751	47
14	9,71477	9,93200	9,78277	10,21723	46
15	9,71498	9,93192	9,78306	10,21694	45
16	9,71519	9,93184	9,78334	10,21666	44
17	9,71539	9,93177	9,78363	10,21637	43
18	9,71560	9,93169	9,78391	10,21609	42
19	9,71581	9,93161	9,78419	10,21581	41
20	9,71602	9,93154	9,78448	10,21552	40
21	9,71622	9,93146	9,78476	10,21524	39
22	9,71643	9,93138	9,78505	10,21495	38
23	9,71664	9,93131	9,78533	10,21467	37
24	9,71685	9,93123	9,78562	10,21438	36
25	9,71705	9,93115	9,78590	10,21410	35
26	9,71726	9,93107	9,78618	10,21382	34
27	9,71747	9.93100	9,78647	10,21353	33
28	9,71767	9,93092	9,78675	10,21325	32
29	9,71788	9,93084	9,78704	10,21296	31
30	9,71809	9,93077	9,78732	10,21268	30
31	9,71829	9,93069	9,78760	10,21240	29
32	9,71850	9,93061	9,78789	10,21211	28
33	9,71870	9,93053	9,78817	10,21183	27
34	9,71891	9,93046	9,78845	10,21155	26
35	9,71911	9,93038	9,78874	10,21126	25
36	9,71932	9,93030	9,78902	10,21098	24
37	9,71952	9,93022	9,78930	10,21070	23
38	9,71973	9,93014	9,78959	10,21041	22
39	9,71993	9,93007	9,78987	10,21013	21
40	9,72014	9,92999	9,79015	10,20985	20
41	9,72034	9,92991	9,79043	10,20957	19
42	9,72055	9,92983	9,79072	10,20928	18
43	9,72075	9,92976	9,79100	10,20900	17
44	9,72096	9,92968	9,79128	10,20872	16
45	9,72116	9,92960	9,79156	10,20844	15
46	9,72137	9,92952	9,79185	10,20815	14
47	9,72157	9,92944	9,79213	10,20787	13
48	9,72177	9,92936	9,79241	10,20759	12
49	9,72198	9,92929	9,79269	10.20731	11
50	9,72218	9.92921	9,79297	10,20703	10
51	9,72238	9,92913	9,79326	10,20674	9
52	9.72259	9,92905	9,79354	10,20646	8
53	9,72279	9,92897	9,79382	10,20618	7
54	9,72299	9,92889	9,79410	10,20590	6
55	9,72320	9,92881	9,79438	10,20562	5
56	9,72340	9,92874	9,79466	10,20534	4
57	9,72360	9,92866	9,79495	10,20505	3
58	9,72381	9,92858	9,79523	10,20477	2
59	9,72401	9,92850	9,79551	10,20449	1
60	9,72421	9,92842	9,79579	10,20421	0
	Co-sine	Sine	Co-tan.	Tangent.	M
58 Degrees.					

Digitized by Google

32 Degrees.					
M	Sine	Co-fine	Tang.	Co-tang.	
0	9,72421	9,9284	9,79579	10,20421	60
1	9,72441	9,92834	9,79607	10,20393	59
2	9,72461	9,92826	9,79635	10,20365	58
3	9,72482	9,92818	9,79663	10,20337	57
4	9,72502	9,92810	9,79691	10,20309	56
5	9,72522	9,92803	9,79719	10,20281	55
6	9,72542	9,92795	9,79747	10,20253	54
7	9,72562	9,92787	9,79776	10,20224	53
8	9,72582	9,92779	9,79804	10,20196	52
9	9,72602	9,92771	9,79832	10,20168	51
10	9,72622	9,92763	9,79860	10,20140	50
11	9,72643	9,92755	9,79888	10,20112	49
12	9,72663	9,92747	9,79916	10,20084	48
13	9,72683	9,92739	9,79944	10,20056	47
14	9,72703	9,92731	9,79972	10,20028	46
15	9,72723	9,92723	9,80000	10,20000	45
16	9,72743	9,92715	9,80028	10,19972	44
17	9,72763	9,92707	9,80056	10,19944	43
18	9,72783	9,92699	9,80084	10,19916	42
19	9,72803	9,92691	9,80112	10,19888	41
20	9,72823	9,92683	9,80140	10,19860	40
21	9,72843	9,92675	9,80168	10,19832	39
22	9,72863	9,92667	9,80195	10,19805	38
23	9,72883	9,92659	9,80223	10,19777	37
24	9,72902	9,92651	9,80251	10,19749	36
25	9,72922	9,92643	9,80279	10,19721	35
26	9,72942	9,92635	9,80307	10,19693	34
27	9,72962	9,92627	9,80335	10,19665	33
28	9,72982	9,92619	9,80363	10,19637	32
29	9,73002	9,92611	9,80391	10,19609	31
30	9,73022	9,92603	9,80419	10,19581	30
31	9,73041	9,92595	9,80447	10,19553	29
32	9,73061	9,92587	9,80474	10,19526	28
33	9,73081	9,92579	9,80502	10,19498	27
34	9,73101	9,92571	9,80530	10,19470	26
35	9,73121	9,92563	9,80558	10,19442	25
36	9,73140	9,92555	9,80581	10,19414	24
37	9,73160	9,92546	9,80614	10,19386	23
38	9,73180	9,92538	9,80642	10,19358	22
39	9,73200	9,92530	9,80669	10,19331	21
40	9,73219	9,92522	9,80697	10,19303	20
41	9,73239	9,92514	9,80725	10,19275	19
42	9,73259	9,92506	9,8075	10,19247	18
43	9,73278	9,92498	9,80781	10,19219	17
44	9,7[illegible]298	9,92490	9,80808	10,19192	16
45	9,73318	9,92482	9,80836	10,19164	15
46	9,73337	9,92473	9,80864	10,19136	14
47	9,73357	9,92465	9,80892	10,19108	13
48	9,73377	9,92457	9,80919	10,19081	12
49	9,73396	9,92449	9,80947	10,19053	11
50	9,73416	9,92441	9,80975	10,19025	10
51	9,73435	9,92433	9,81003	10,18997	9
52	9,73455	9,92425	9,81030	10,18970	8
53	9,73474	9,92416	9,81058	10,18942	7
54	9,73494	9,92408	9,81086	10,18914	6
55	9,73513	9,92400	9,81113	10,18887	5
56	9,73533	9,92392	9,81141	10,18859	4
57	9,73552	9,92384	9,81169	10,18831	3
58	9,73572	9,92376	9,81196	10,18804	2
59	9,73591	9,92367	9,81224	10,18776	1
60	9,73611	9,92359	9,81252	10,18748	0
	Co-fine	Sine	Co-tan.	Tangent.	M
57 Degrees.					

33 Degrees.					
M	Sine.	Co-fine	Tang.	Co-tang.	
0	9,73611	9,92359	9,81252	10,18748	60
1	9,73630	9,92351	9,81279	10,18721	59
2	9,73650	9,92343	9,81307	10,18693	58
3	9,73669	9,92334	9,81335	10,18665	57
4	9,73689	9,92326	9,81362	10,1863[illegible]	56
5	9,73708	9,92318	9,81390	10,18610	55
6	9,73727	9,92310	9,81418	10,18582	54
7	9,73747	9,92302	9,81445	10,18555	53
8	9,73766	9,92293	9,81473	10,18527	52
9	9,73785	9,92285	9,81500	10,18500	51
10	9,73805	9,92277	9,81528	10,18472	50
11	9,73824	9,92269	9,81556	10,18444	49
12	9,73843	9,92260	9,81583	10,18417	48
13	9,73863	9,92252	9,81611	10,18389	47
14	9,73882	9,92244	9,81638	10,18362	46
15	9,73901	9,92235	9,81666	10,18334	45
16	9,73921	9,92227	9,81693	10,18307	44
17	9,73940	9,92219	9,81721	10,18279	43
18	9,73959	9,92211	9,81748	10,18252	42
19	9,73978	9,92202	9,81776	10,18224	41
20	9,73997	9,92194	9,81803	10,18197	40
21	9,74017	9,92186	9,81831	10,18169	39
22	9,74036	9,92177	9,81858	10,18142	38
23	9,74055	9,92169	9,81886	10,18114	37
24	9,74074	9,92161	9,81913	10,18087	36
25	9,74093	9,92152	9,81941	10,18059	35
26	9,74113	9,92144	9,81968	10,18032	34
27	9,74132	9,92136	9,81996	10,18004	33
28	9,74151	9,92127	9,82023	10,17977	32
29	9,74170	9,92119	9,82051	10,17949	31
30	9,74189	9,92111	9,82078	10,17922	30
31	9,74208	9,92102	9,82106	10,17894	29
32	9,74227	9,92094	9,82133	10,17867	28
33	9,74246	9,92086	9,82161	10,17839	27
34	9,74265	9,92077	9,82188	10,17812	26
35	9,74284	9,92069	9,82215	10,17785	25
36	9,74303	9,92060	9,82243	10,17757	24
37	9,74322	9,92052	9,82270	10,17730	23
38	9,74341	9,92044	9,82298	10,17702	22
39	9,74360	9,92035	9,82325	10,17675	21
40	9,74379	9,92027	9,82352	10,17648	20
41	9,74398	9,92018	9,82380	10,17620	19
42	9,74417	9,92010	9,82407	10,17593	18
43	9,74436	9,92002	9,82435	10,17565	17
44	9,74455	9,91993	9,82462	10,17538	16
45	9,74474	9,91985	9,82489	10,17511	15
46	9,74493	9,91976	9,82517	10,17483	14
47	9,74512	9,91968	9,82544	10,17456	13
48	9,74531	9,91959	9,82571	10,17429	12
49	9,74549	9,91951	9,82599	10,17401	11
50	9,74568	9,91942	9,82626	10,17374	10
51	9,74587	9,91934	9,82653	10,17347	9
52	9,74606	9,91925	9,82681	10,17319	8
53	9,74625	9,91917	9,82708	10,17292	7
54	9,74644	9,91908	9,82735	10,17265	6
55	9,74662	9,91900	9,82762	10,17238	5
56	9,74681	9,91891	9,82790	10,17210	4
57	9,74700	9,91883	9,82817	10,17183	3
58	9,74719	9,91874	9,82844	10,17156	2
59	9,74737	9,91866	9,82871	10,17129	1
60	9,74756	9,91857	9,82899	10,17101	0
	Co-fine	Sine	Co-tan	Tangent.	M
56 Degrees.					

Digitized by Google

34 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,74756	9,91857	9,82899	10,17101	60
1	9,74775	9,91849	9,82926	10,17074	59
2	9,74794	9,91840	9,82953	10,17047	58
3	9,74812	9,91832	9,82980	10,17020	57
4	9,74831	9,91823	9,83008	10,16992	56
5	9,74850	9,91815	9,83035	10,16965	55
6	9,74868	9,91806	9,83062	10,16938	54
7	9,74887	9,91798	9,83089	10,16911	53
8	9,74906	9,91789	9,83117	10,16883	52
9	9,74924	9,91781	9,83144	10,16856	51
10	9,74943	9,91772	9,83171	10,16829	50
11	9,74961	9,91763	9,83198	10,16802	49
12	9,74980	9,91755	9,83225	10,16775	48
13	9,74999	9,91746	9,83252	10,16748	47
14	9,75017	9,91738	9,83280	10,16720	46
15	9,75036	9,91729	9,83307	10,16693	45
16	9,75054	9,91720	9,83334	10,16666	44
17	9,75073	9,91712	9,83361	10,16639	43
18	9,75091	9,91703	9,83388	10,16612	42
19	9,75110	9,91695	9,83415	10,16585	41
20	9,75128	9,91686	9,83442	10,16558	40
21	9,75147	9,91677	9,83470	10,16530	39
22	9,75165	9,91669	9,83497	10,16503	38
23	9,75184	9,91660	9,83524	10,16476	37
24	9,75202	9,91651	9,83551	10,16449	36
25	9,75221	9,91643	9,83578	10,16422	35
26	9,75239	9,91634	9,83605	10,16395	34
27	9,75258	9,91625	9,83632	10,16368	33
28	9,75276	9,91617	9,83659	10,16341	32
29	9,75294	9,91608	9,83686	10,16314	31
30	9,75313	9,91599	9,83713	10,16287	30
31	9,75331	9,91591	9,83740	10,16260	29
32	9,75350	9,91582	9,83768	10,16232	28
33	9,75368	9,91573	9,83795	10,16205	27
34	9,75386	9,91565	9,83822	10,16178	26
35	9,75405	9,91556	9,83849	10,16151	25
36	9,75423	9,91547	9,83876	10,16124	24
37	9,75441	9,91538	9,83903	10,16097	23
38	9,75459	9,91530	9,83930	10,16070	22
39	9,75478	9,91521	9,83957	10,16043	21
40	9,75496	9,91512	9,83984	10,16016	20
41	9,75514	9,91504	9,84011	10,15989	19
42	9,75533	9,91495	9,84038	10,15962	18
43	9,75551	9,91486	9,84065	10,15935	17
44	9,75569	9,91477	9,84092	10,15908	16
45	9,75587	9,91469	9,84119	10,15881	15
46	9,75605	9,91460	9,84146	10,15854	14
47	9,75624	9,91451	9,84173	10,15827	13
48	9,75642	9,91442	9,84200	10,15800	12
49	9,75660	9,91433	9,84227	10,15773	11
50	9,75678	9,91425	9,84254	10,15746	10
51	9,75696	9,91416	9,84280	10,15720	9
52	9,75714	9,91407	9,84307	10,15693	8
53	9,75733	9,91398	9,84334	10,15666	7
54	9,75751	9,91389	9,84361	10,15639	6
55	9,75769	9,91381	9,84388	10,15612	5
56	9,75787	9,91372	9,84415	10,15585	4
57	9,75805	9,91363	9,84442	10,15558	3
58	9,75823	9,91354	9,84469	10,15531	2
59	9,75841	9,91345	9,84496	10,15504	1
60	9,75859	9,91336	9,84523	10,15477	0
	Co-sine	Sine	Co-tan.	Tangent.	M

55 Degrees.

35 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,75859	9,91336	9,84523	10,15477	60
1	9,75877	9,91328	9,84550	10,15450	59
2	9,75895	9,91319	9,84576	10,15424	58
3	9,75913	9,91310	9,84603	10,15397	57
4	9,75931	9,91301	9,84630	10,15370	56
5	9,75949	9,91292	9,84657	10,15343	55
6	9,75967	9,91283	9,84684	10,15316	54
7	9,75985	9,91274	9,84711	10,15289	53
8	9,76003	9,91266	9,84738	10,15262	52
9	9,76021	9,91257	9,84764	10,15236	51
10	9,76039	9,91248	9,84791	10,15209	50
11	9,76057	9,91239	9,84818	10,15182	49
12	9,76075	9,91230	9,84845	10,15155	48
13	9,76093	9,91221	9,84872	10,15128	47
14	9,76111	9,91212	9,84899	10,15101	46
15	9,76129	9,91203	9,84925	10,15075	45
16	9,76146	9,91194	9,84952	10,15048	44
17	9,76164	9,91185	9,84979	10,15021	43
18	9,76182	9,91176	9,85006	10,14994	42
19	9,76200	9,91167	9,85033	10,14967	41
20	9,76218	9,91158	9,85059	10,14941	40
21	9,76236	9,91149	9,85086	10,14914	39
22	9,76253	9,91141	9,85113	10,14887	38
23	9,76271	9,91132	9,85140	10,14860	37
24	9,76289	9,91123	9,85166	10,14834	36
25	9,76307	9,91114	9,85193	10,14807	35
26	9,76324	9,91105	9,85220	10,14780	34
27	9,76342	9,91096	9,85247	10,14753	33
28	9,76360	9,91087	9,85273	10,14727	32
29	9,76378	9,91078	9,85300	10,14700	31
30	9,76395	9,91069	9,85327	10,14673	30
31	9,76413	9,91060	9,85354	10,14646	29
32	9,76431	9,91051	9,85380	10,14620	28
33	9,76448	9,91042	9,85407	10,14593	27
34	9,76466	9,91033	9,85434	10,14566	26
35	9,76484	9,91023	9,85460	10,14540	25
36	9,76501	9,91014	9,85487	10,14513	24
37	9,76519	9,91005	9,85514	10,14486	23
38	9,76537	9,90996	9,85540	10,14460	22
39	9,76554	9,90987	9,85567	10,14433	21
40	9,76572	9,90978	9,85594	10,14406	20
41	9,76590	9,90969	9,85620	10,14380	19
42	9,76607	9,90960	9,85647	10,14353	18
43	9,76625	9,90951	9,85674	10,14326	17
44	9,76642	9,90942	9,85700	10,14300	16
45	9,76660	9,90933	9,85727	10,14273	15
46	9,76677	9,90924	9,85754	10,14246	14
47	9,76695	9,90915	9,85780	10,14220	13
48	9,76712	9,90905	9,85807	10,14193	12
49	9,76730	9,90896	9,85834	10,14166	11
50	9,76747	9,90887	9,85860	10,14140	10
51	9,76765	9,90878	9,85887	10,14113	9
52	9,76782	9,90869	9,85913	10,14087	8
53	9,76800	9,90860	9,85940	10,14060	7
54	9,76817	9,90851	9,85967	10,14033	6
55	9,76835	9,90842	9,85993	10,14007	5
56	9,76852	9,90832	9,86020	10,13980	4
57	9,76870	9,90823	9,86046	10,13954	3
58	9,76887	9,90814	9,86073	10,13927	2
59	9,76904	9,90805	9,86100	10,13900	1
60	9,76922	9,90796	9,86126	10,13874	0
	Co-sine	Sine	Co-tan.	Tangent.	M

54 Degrees.

36 Degrees.					
M	Sine	Co-sine.	Tang.	Co-tang.	
0	9,76922	9,90796	9,86126	10,13874	60
1	9,76939	9,90787	9,86153	10,13847	59
2	9,76957	9,90777	9,86179	10,13821	58
3	9,76974	9,90768	9,86206	10,13794	57
4	9,76991	9,90759	9,86232	10,13768	56
5	9,77009	9,90750	9,86259	10,13741	55
6	9,77026	9,90741	9,86285	10,13715	54
7	9,77043	9,90731	9,86312	10,13688	53
8	9,77061	9,90722	9,86338	10,13662	52
9	9,77078	9,90713	9,86365	10,13635	51
10	9,77095	9,90704	9,86392	10,13608	50
11	9,77112	9,90694	9,86418	10,13582	49
12	9,77130	9,90685	9,86445	10,13555	48
13	9,77147	9,90676	9,86471	10,13529	47
14	9,77164	9,90667	9,86498	10,13502	46
15	9,77181	9,90657	9,86524	10,13476	45
16	9,77199	9,90648	9,86551	10,13449	44
17	9,77216	9,90639	9,86577	10,13423	43
18	9,77233	9,90630	9,86603	10,13397	42
19	9,77250	9,90620	9,86630	10,13370	41
20	9,77268	9,90611	9,86656	10,13344	40
21	9,77285	9,90602	9,86683	10,13317	39
22	9,77302	9,90592	9,86709	10,13291	38
23	9,77319	9,90583	9,86736	10,13264	37
24	9,77336	9,90574	9,86762	10,13238	36
25	9,77353	9,90565	9,86789	10,13211	35
26	9,77370	9,90555	9,86815	10,13185	34
27	9,77387	9,90546	9,86842	10,13158	33
28	9,77405	9,90537	9,86868	10,13132	32
29	9,77422	9,90527	9,86894	10,13106	31
30	9,77439	9,90518	9,86921	10,13079	30
31	9,77456	9,90509	9,86947	10,13053	29
32	9,77473	9,90499	9,86974	10,13026	28
33	9,77490	9,90490	9,87000	10,13000	27
34	9,77507	9,90480	9,87027	10,12973	26
35	9,77524	9,90471	9,87053	10,12947	25
36	9,77541	9,90462	9,87079	10,12921	24
37	9,77558	9,90452	9,87106	10,12894	23
38	9,77575	9,90443	9,87132	10,12868	22
39	9,77592	9,90434	9,87158	10,12842	21
40	9,77609	9,90424	9,87185	10,12815	20
41	9,77626	9,90415	9,87211	10,12789	19
42	9,77643	9,90405	9,87238	10,12762	18
43	9,77660	9,90396	9,87264	10,12736	17
44	9,77677	9,90386	9,87290	10,12710	16
45	9,77694	9,90377	9,87317	10,12683	15
46	9,77710	9,90368	9,87343	10,12657	14
47	9,77727	9,90358	9,87369	10,12631	13
48	9,77744	9,90349	9,87396	10,12604	12
49	9,77761	9,90339	9,87422	10,12578	11
50	9,77778	9,90330	9,87448	10,12552	10
51	9,77795	9,90320	9,87475	10,12525	9
52	9,77812	9,90311	9,87501	10,12499	8
53	9,77829	9,90301	9,87527	10,12473	7
54	9,77846	9,90292	9,87554	10,12446	6
55	9,77862	9,90282	9,87580	10,12420	5
56	9,77879	9,90273	9,87606	10,12394	4
57	9,7789[illegible]	9,90263	9,87633	10,12367	3
58	9,77913	9,90254	9,87659	10,12[illegible]41	2
59	9,77930	9,90244	9,87685	10,12315	1
60	9,77946	9,90235	9,87711	10,12289	0
	Co-sine	Sine	Co-tan	Tangent.	M
53 Degrees.					

37 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,77946	9,90235	9,87711	10,12289	60
1	9,77963	9,90225	9,87738	10,12262	59
2	9,77980	9,90216	9,87764	10,12236	58
3	9,77997	9,90206	9,87790	10,12210	57
4	9,78013	9,90197	9,87817	10,12183	56
5	9,78030	9,90187	9,87843	10,12157	55
6	9,78047	9,90178	9,87869	10,12131	54
7	9,78063	9,90168	9,87895	10,12105	53
8	9,78080	9,90159	9,87922	10,12078	52
9	9,78097	9,90149	9,87948	10,12052	51
10	9,78113	9,90139	9,87974	10,12026	50
11	9,78130	9,90130	9,88000	10,12000	49
12	9,78147	9,90120	9,88027	10,11973	48
13	9,78163	9,90111	9,88053	10,11947	47
14	9,78180	9,90101	9,88079	10,11921	46
15	9,78197	9,90091	9,88105	10,11895	45
16	9,78213	9,90082	9,88131	10,11869	44
17	9,78230	9,90072	9,88158	10,11842	43
18	9,78246	9,90063	9,88184	10,11816	42
19	9,78263	9,90053	9,88210	10,11790	41
20	9,78280	9,90043	9,88236	10,11764	40
21	9,78296	9,90034	9,88262	10,11738	39
22	9,78313	9,90024	9,88289	10,11711	38
23	9,78329	9,90014	9,88315	10,11685	37
24	9,78346	9,90005	9,88341	10,11659	36
25	9,78362	9,89995	9,88367	10,11633	35
26	9,78379	9,89985	9,88393	10,11607	34
27	9,78395	9,89976	9,88420	10,11580	33
28	9,78412	9,89966	9,88446	10,11554	32
29	9,78428	9,89956	9,88472	10,11528	31
30	9,78445	9,89947	9,88498	10,11502	30
31	9,78461	9,89937	9,88524	10,11476	29
32	9,78478	9,89927	9,88550	10,11450	28
33	9,78494	9,89918	9,88577	10,11423	27
34	9,78510	9,89908	9,88603	10,11397	26
35	9,78527	9,89898	9,88629	10,11371	25
36	9,78543	9,89888	9,88655	10,11345	24
37	9,78560	9,89879	9,88681	10,11319	23
38	9,78576	9,89869	9,88707	10,11293	22
39	9,78592	9,89859	9,88733	10,11267	21
40	9,78609	9,89849	9,88759	10,11241	20
41	9,78625	9,89840	9,88786	10,11214	19
42	9,78642	9,89830	9,88812	10,11188	18
43	9,78658	9,89820	9,88838	10,11162	17
44	9,78674	9,89810	9,88864	10,11136	16
45	9,78691	9,89801	9,88890	10,11110	15
46	9,78707	9,89791	9,88916	10,11084	14
47	9,78723	9,89781	9,88942	10,11058	13
48	9,78739	9,89771	9,88968	10,11032	12
49	9,78756	9,89761	9,88994	10,11006	11
50	9,78772	9,89752	9,89020	10,10980	10
51	9,78788	9,89742	9,89046	10,10954	9
52	9,78805	9,89732	9,89073	10,10927	8
53	9,78821	9,89722	9,89099	10,10901	7
54	9,78837	9,89712	9,89125	10,10875	6
55	9,78853	9,89702	9,89151	10,10849	5
56	9,78869	9,89693	9,89177	10,10823	4
57	9,78886	9,89683	9,89203	10,10797	3
58	9,78902	9,89673	9,89229	10,10771	2
59	9,78918	9,89663	9,89255	10,10745	1
60	9,78934	9,89653	9,89281	10,10719	0
	Co-sine	Sine	Co-tan.	Tangent.	M
52 Degrees.					

Digitized by Google

38 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,78934	9,89653	9,89281	10,10719	60
1	9,78950	9,89643	9,89307	10,10693	59
2	9,78967	9,89633	9,89333	10,10667	58
3	9,78983	9,89624	9,89359	10,10641	57
4	9,78999	9,89614	9,89385	10,10615	56
5	9,79015	9,89604	9,89411	10,10589	55
6	9,79031	9,89594	9,89437	10,10563	54
7	9,79047	9,89584	9,89463	10,10537	53
8	9,79063	9,89574	9,89489	10,10511	52
9	9,79079	9,89564	9,89515	10,10485	51
10	9,79095	9,89554	9,89541	10,10459	50
11	9,79111	9,89544	9,89567	10,10433	49
12	9,79128	9,89534	9,89593	10,10407	48
13	9,79144	9,89524	9,89619	10,10381	47
14	9,79160	9,89514	9,89645	10,10355	46
15	9,79176	9,89504	9,89671	10,10329	45
16	9,79192	9,89495	9,89697	10,10303	44
17	9,79208	9,89485	9,89723	10,10277	43
18	9,79224	9,89475	9,89749	10,10251	42
19	9,79240	9,89465	9,89775	10,10225	41
20	9,79256	9,89455	9,89801	10,10199	40
21	9,79272	9,89445	9,89827	10,10173	39
22	9,79288	9,89435	9,89853	10,10147	38
23	9,79304	9,89425	9,89879	10,10121	37
24	9,79319	9,89415	9,89905	10,10095	36
25	9,79335	9,89405	9,89931	10,10069	35
26	9,79351	9,89395	9,89957	10,10043	34
27	9,79367	9,89385	9,89983	10,10017	33
28	9,79383	9,89375	9,90009	10,09991	32
29	9,79399	9,89364	9,90035	10,09965	31
30	9,79415	9,89354	9,90061	10,09939	30
31	9,79431	9,89344	9,90086	10,09914	29
32	9,79447	9,89334	9,90112	10,09888	28
33	9,79463	9,89324	9,90138	10,09862	27
34	9,79478	9,89314	9,90164	10,09836	26
35	9,79494	9,89304	9,90190	10,09810	25
36	9,79510	9,89294	9,90216	10,09784	24
37	9,79526	9,89284	9,90242	10,09758	23
38	9,79542	9,89274	9,90268	10,09732	22
39	9,79558	9,89264	9,90294	10,09706	21
40	9,79573	9,89254	9,90320	10,09680	20
41	9,79589	9,89244	9,90346	10,09654	19
42	9,79605	9,89233	9,90371	10,09629	18
43	9,79621	9,89223	9,90397	10,09603	17
44	9,79636	9,89213	9,90423	10,09577	16
45	9,79652	9,89203	9,90449	10,09551	15
46	9,79668	9,89193	9,90475	10,09525	14
47	9,79684	9,89183	9,90501	10,09499	13
48	9,79699	9,89173	9,90527	10,09473	12
49	9,79715	9,89162	9,90553	10,09447	11
50	9,79731	9,89152	9,90578	10,09422	10
51	9,79746	9,89142	9,90604	10,09396	9
52	9,79762	9,89132	9,90630	10,09370	8
53	9,79778	9,89122	9,90656	10,09344	7
54	9,79793	9,89112	9,90682	10,09318	6
55	9,79809	9,89101	9,90708	10,09292	5
56	9,79825	9,89091	9,90734	10,09266	4
57	9,79840	9,89081	9,90759	10,09241	3
58	9,79856	9,89071	9,90785	10,09215	2
59	9,79872	9,89060	9,90811	10,09189	1
60	9,79887	9,89050	9,90837	10,09163	0
	Co-sine	Sine	Co-tan.	Tangent	M

51 Degrees.

39 Degrees.

M	Sine	Co-sine	Tang	Co-tang.	
0	9,79887	9,89050	9,90837	10,09163	60
1	9,79903	9,89040	9,90863	10,09137	59
2	9,79918	9,89030	9,90889	10,09111	58
3	9,79934	9,89020	9,90914	10,09086	57
4	9,79950	9,89009	9,90940	10,09060	56
5	9,79965	9,88999	9,90966	10,09034	55
6	9,79981	9,88989	9,90992	10,09008	54
7	9,79996	9,88978	9,91018	10,08982	53
8	9,80012	9,88968	9,91043	10,08957	52
9	9,80027	9,88958	9,91069	10,08931	51
10	9,80043	9,88948	9,91095	10,08905	50
11	9,80058	9,88937	9,91121	10,08879	49
12	9,80074	9,88927	9,91147	10,08853	48
13	9,80089	9,88917	9,91172	10,08828	47
14	9,80105	9,88906	9,91198	10,08802	46
15	9,80120	9,88896	9,91224	10,08776	45
16	9,80136	9,88886	9,91250	10,08750	44
17	9,80151	9,88875	9,91276	10,08724	43
18	9,80166	9,88865	9,91301	10,08699	42
19	9,80182	9,88855	9,91327	10,08673	41
20	9,80197	9,88844	9,91353	10,08647	40
21	9,80213	9,88834	9,91379	10,08621	39
22	9,80228	9,88824	9,91404	10,08596	38
23	9,80244	9,88813	9,91430	10,08570	37
24	9,80259	9,88803	9,91456	10,08544	36
25	9,80274	9,88793	9,91482	10,08518	35
26	9,80290	9,88782	9,91507	10,08493	34
27	9,80305	9,88772	9,91533	10,08467	33
28	9,80320	9,8876	9,91559	10,08441	32
29	9,80336	9,8875	9,91585	10,08415	31
30	9,80351	9,88741	9,91610	10,08390	30
31	9,80366	9,88730	9,91636	10,08364	29
32	9,80382	9,88720	9,91662	10,08338	28
33	9,80397	9,88709	9,91688	10,08312	27
34	9,80412	9,88699	9,91713	10,08287	26
35	9,80428	9,88688	9,91739	10,08261	25
36	9,80443	9,88678	9,91765	10,08235	24
37	9,80458	9,88668	9,91791	10,08209	23
38	9,80473	9,88657	9,91816	10,08184	22
39	9,80489	9,88647	9,91842	10,08158	21
40	9,80504	9,88636	9,91868	10,08132	20
41	9,80519	9,88626	9,91893	10,08107	19
42	9,80534	9,88615	9,91919	10,08081	18
43	9,80550	9,88605	9,91945	10,08055	17
44	9,80565	9,88594	9,91971	10,08029	16
45	9,80580	9,88584	9,91996	10,08004	15
46	9,80595	9,88573	9,92022	10,07978	14
47	9,80610	9,88563	9,92048	10,07952	13
48	9,80625	9,88552	9,92073	10,07927	12
49	9,80641	9,88542	9,92099	10,07901	11
50	9,80656	9,88531	9,92125	10,07875	10
51	9,80671	9,88521	9,92150	10,07850	9
52	9,80686	9,88510	9,92176	10,07824	8
53	9,80701	9,88499	9,92202	10,07798	7
54	9,80716	9,88489	9,92227	10,07773	6
55	9,80731	9,88478	9,92253	10,07747	5
56	9,80746	9,88468	9,92279	10,07721	4
57	9,80762	9,88457	9,92304	10,07696	3
58	9,80777	9,88447	9,92330	10,07670	2
59	9,80792	9,88436	9,92356	10,07644	1
60	9,80807	9,88425	9,92381	10,07619	0
	Co-sine	Sine	Co-tan.	Tangent	M

50 Degrees.

Digitized by Google

40 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	
0	9,80807	9,88425	9,92381	10,07619	60
1	9,80822	9,88415	9,92407	10,07593	59
2	9,80837	9,88404	9,92433	10,07567	58
3	9,80852	9,88394	9,92458	10,07542	57
4	9,80867	9,88383	9,92484	10,07516	56
5	9,80882	9,88372	9,92510	10,07490	55
6	9,80897	9,88362	9,92535	10,07465	54
7	9,80912	9,88351	9,92561	10,07439	53
8	9,80927	9,88340	9,92587	10,07413	52
9	9,80942	9,88330	9,92612	10,07388	51
10	9,80957	9,88319	9,92638	10,07362	50
11	9,80972	9,88308	9,92663	10,07337	49
12	9,80987	9,88298	9,92689	10,07311	48
13	9,81002	9,88287	9,92715	10,07285	47
14	9,81017	9,88276	9,92740	10,07260	46
15	9,81032	9,88266	9,92766	10,07234	45
16	9,81046	9,88255	9,92792	10,07208	44
17	9,81061	9,88244	9,92817	10,07183	43
18	9,81076	9,88234	9,92843	10,07157	42
19	9,81091	9,88223	9,92868	10,07132	41
20	9,81106	9,88212	9,92894	10,07106	40
21	9,81121	9,88201	9,92920	10,07080	39
22	9,81136	9,88191	9,92945	10,07055	38
23	9,81151	9,88180	9,92971	10,07029	37
24	9,81166	9,88169	9,92996	10,07004	36
25	9,81180	9,88158	9,93022	10,06978	35
26	9,81195	9,88148	9,93048	10,06952	34
27	9,81210	9,88137	9,93073	10,06927	33
28	9,81225	9,88126	9,93099	10,06901	32
29	9,81240	9,88115	9,93124	10,06876	31
30	9,81254	9,88105	9,93150	10,06850	30
31	9,81269	9,88094	9,93175	10,06825	29
32	9,81284	9,88083	9,93201	10,06799	28
33	9,81299	9,88072	9,93227	10,06773	27
34	9,81314	9,88061	9,93252	10,06748	26
35	9,81328	9,88051	9,93278	10,06722	25
36	9,81343	9,88040	9,93303	10,06697	24
37	9,81358	9,88029	9,93329	10,06671	23
38	9,81372	9,88018	9,93354	10,06646	22
39	9,81387	9,88007	9,93380	10,06620	21
40	9,81402	9,87996	9,93406	10,06594	20
41	9,81417	9,87985	9,93431	10,06569	19
42	9,81431	9,87975	9,93457	10,06543	18
43	9,81446	9,87964	9,93482	10,06518	17
44	9,81461	9,87953	9,93508	10,06492	16
45	9,81475	9,87942	9,93533	10,06467	15
46	9,81490	9,87931	9,93559	10,06441	14
47	9,81505	9,87920	9,93584	10,06416	13
48	9,81519	9,87909	9,93610	10,06390	12
49	9,81534	9,87898	9,93636	10,06364	11
50	9,81549	9,87887	9,93661	10,06339	10
51	9,81563	9,87877	9,93687	10,06313	9
52	9,81578	9,87866	9,93712	10,06288	8
53	9,81592	9,87855	9,93738	10,06262	7
54	9,81607	9,87844	9,93763	10,06237	6
55	9,81622	9,87833	9,93789	10,06211	5
56	9,81636	9,87822	9,93814	10,06186	4
57	9,81651	9,87811	9,93840	10,06160	3
58	9,81665	9,87800	9,93865	10,06135	2
59	9,81680	9,87789	9,93891	10,06109	1
60	9,81694	9,87778	9,93916	10,06084	0
	Co-sine	Sine	Co-tan.	Tangent	M
49 Degrees.					

41 Degrees.					
M	Sine	Co-sine	Tang.	Co-tang.	M
0	9,81694	9,87778	9,93916	10,06084	60
1	9,81709	9,87767	9,93942	10,06058	59
2	9,81723	9,87756	9,93967	10,06033	58
3	9,81738	9,87745	9,93993	10,06007	57
4	9,81752	9,87734	9,94018	10,05982	56
5	9,81767	9,87723	9,94044	10,05956	55
6	9,81781	9,87712	9,94069	10,05931	54
7	9,81796	9,87701	9,94095	10,05905	53
8	9,81810	9,87690	9,94120	10,05880	52
9	9,81825	9,87679	9,94146	10,05854	51
10	9,81839	9,87668	9,94171	10,05829	50
11	9,81854	9,87657	9,94197	10,05803	49
12	9,81868	9,87646	9,94222	10,05778	48
13	9,81882	9,87635	9,94248	10,05752	47
14	9,81897	9,87624	9,94273	10,05727	46
15	9,81911	9,87613	9,94299	10,05701	45
16	9,81926	9,87601	9,94324	10,05676	44
17	9,81940	9,87590	9,94350	10,05650	43
18	9,81954	9,87579	9,94375	10,05625	42
19	9,81969	9,87568	9,94401	10,05599	41
20	9,81983	9,87557	9,94426	10,05574	40
21	9,81998	9,87546	9,94452	10,05548	39
22	9,82012	9,87535	9,94477	10,05523	38
23	9,82026	9,87524	9,94503	10,05497	37
24	9,82041	9,87513	9,94528	10,05472	36
25	9,82055	9,87501	9,94554	10,05446	35
26	9,82069	9,87490	9,94579	10,05421	34
27	9,82084	9,87479	9,94604	10,05396	33
28	9,82098	9,87468	9,94630	10,05370	32
29	9,82112	9,87457	9,94655	10,05345	31
30	9,82126	9,87446	9,94681	10,05319	30
31	9,82141	9,87434	9,94706	10,05294	29
32	9,82155	9,87423	9,94732	10,05268	28
33	9,82169	9,87412	9,94757	10,05243	27
34	9,82184	9,87401	9,94783	10,05217	26
35	9,82198	9,87390	9,94808	10,05192	25
36	9,82212	9,87378	9,94834	10,05166	24
37	9,82226	9,87367	9,94859	10,05141	23
38	9,82240	9,87356	9,94884	10,05116	22
39	9,82255	9,87345	9,94910	10,05090	21
40	9,82269	9,87334	9,94935	10,05065	20
41	9,82283	9,87322	9,94961	10,05039	19
42	9,82297	9,87311	9,94986	10,05014	18
43	9,82311	9,87300	9,95012	10,04988	17
44	9,82326	9,87288	9,95037	10,04963	16
45	9,82340	9,87277	9,95062	10,04938	15
46	9,82354	9,87266	9,95088	10,04912	14
47	9,82368	9,87255	9,95113	10,04887	13
48	9,82382	9,87243	9,95139	10,04861	12
49	9,82396	9,87232	9,95164	10,04836	11
50	9,82410	9,87221	9,95190	10,04810	10
51	9,82424	9,87209	9,95215	10,04785	9
52	9,82439	9,87198	9,95240	10,04760	8
53	9,82453	9,87187	9,95266	10,04734	7
54	9,82467	9,87175	9,95291	10,04709	6
55	9,82481	9,87164	9,95317	10,04683	5
56	9,82495	9,87153	9,95342	10,04658	4
57	9,82509	9,87141	9,95367	10,04632	3
58	9,82523	9,87130	9,95393	10,04607	2
59	9,82537	9,87119	9,95418	10,04582	1
60	9,82551	9,87107	9,95444	10,04556	0
	Co-sine	Sine	Co-tan.	Tangent	M
48 Degrees.					

Digitized by Google

42 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,82551	9,87107	9,95444	10,04556	60
1	9,82565	9,87096	9,95469	10,04531	59
2	9,82579	9,87085	9,95495	10,04505	58
3	9,82593	9,87073	9,95520	10,04480	57
4	9,82607	9,87062	9,95545	10,04455	56
5	9,82621	9,87050	9,95571	10,04429	55
6	9,82635	9,87039	9,95596	10,04404	54
7	9,82649	9,87028	9,95622	10,04378	53
8	9,82663	9,87016	9,95647	10,04353	52
9	9,82677	9,87005	9,95672	10,04328	51
10	9,82691	9,86993	9,95698	10,04302	50
11	9,82705	9,86982	9,95723	10,04277	49
12	9,82719	9,86970	9,95748	10,04252	48
13	9,82733	9.86959	9,95774	10,04226	47
14	9,82747	9,86947	9,95799	10,04201	46
15	9,82761	9,86936	9,95825	10,04175	45
16	9,82775	9,86924	9,95850	10,04150	44
17	9,82788	9,86913	9,95875	10,04125	43
18	9,82802	9,86902	9,95901	10,04099	42
19	9,82816	9,86890	9,95926	10,04074	41
20	9,82830	9,86879	9,95952	10,04048	40
21	9,82844	9,86867	9,95977	10,04023	39
22	6,82858	9,86855	9,96002	10,03998	38
23	9,82872	9,86844	9,96028	10,03972	37
24	9,82885	9,86832	9,96053	10,03947	36
25	9,82899	9,86821	9,96078	10,03922	35
26	9,82913	9,86809	9,96104	10,03896	34
27	9,82927	9,86798	9,96129	10,03871	33
28	9,82941	9,86786	9,96155	10,03845	32
29	9,82955	9,86775	9,96180	10,03820	31
30	9,82968	9,86763	9,96205	10,03795	30
31	9,82982	9,86752	9,96231	10,03769	29
32	9,82996	9,86740	9,96256	10,03744	28
33	9,83010	9,86728	9,96281	10,03719	27
34	9,83023	9,86717	9,96307	10,03693	26
35	9,83037	9,86705	9,96332	10,03668	25
36	9,83051	9,86694	9,96357	10,03643	24
37	9,83065	9,86682	9,96383	10,03617	23
38	9,83078	9,86670	9,96408	10,03592	22
39	9,83092	9,86659	9,96433	10,03567	21
40	9,83106	9,86647	9,96459	10,03541	20
41	9,83119	9.86635	9,96484	10,03516	19
42	9,83133	9,86624	9,96510	10,03490	18
43	9,83147	9,86612	9,96535	10,03465	17
44	9,83161	9,86600	9,96560	10,03440	16
45	9,83174	9,86589	9,96586	10,03414	15
46	9,83188	9,86577	9,96611	10,03389	14
47	9.83202	9,86565	9,96636	10,03364	13
48	9,83215	9,86554	9,96662	10,03338	12
49	9,83229	9,86542	9,96687	10,03313	11
50	9,83242	9,86530	9,96712	10,03288	10
51	9,83256	9,86518	9,96738	10,03262	9
52	9,83270	9,86507	9,96763	10,03237	8
53	9,83283	9,86495	9,96788	10,03212	7
54	9,83297	9,86483	9,96814	10,03186	6
55	9,83310	9,86472	9,96839	10,03161	5
56	9,83324	9,86460	9,96864	10,03136	4
57	9,83338	9,86448	9,96890	10,03110	3
58	9,83351	9,86436	9,96915	10,03085	2
59	9,83365	9,86425	9,96940	10,03060	1
60	9,83378	9,86413	9,96966	10,03034	0
	Co-sine	Sine	Co-tan.	Tangent.	M

47 Degrees.

43 Degrees.

M	Sine	Co-sine	Tang.	Co-tang.	
0	9,83378	9,86413	9,96966	10,03034	60
1	9,83392	9,86401	9,96991	10,03009	59
2	9,83405	9,86389	9,97016	10,02984	58
3	9,83419	9,86377	9,97042	10,02958	57
4	9,83432	9,86366	9,97067	10,02933	56
5	9,83446	9,86354	9,97092	10,02908	55
6	9,83459	9,86342	9,97118	10,02882	54
7	9,83473	9,86330	9,97143	10,02857	53
8	9,83486	9,86318	9,97168	10,02832	52
9	9,83500	9,86306	9,97193	10,02807	51
10	9,83513	9,86295	9,97219	10,02781	50
11	9,83527	9,86283	9,97244	10,02756	49
12	9,83540	9,86271	9,97269	10,02731	48
13	9,83554	9,86259	9,97295	10,02705	47
14	9,83567	9,86247	9,97320	10,02680	46
15	9,83581	9,86235	9,97345	10,02655	45
16	9,83594	9,86223	9,97371	10,02629	44
17	9,83607	9,86211	9,97396	10,02604	43
18	9,83621	9,86200	9,97421	10,02579	42
19	9,83634	9,86188	9,97447	10,02553	41
20	9,83648	9,86176	9,97472	10,02528	40
21	9,83661	9,86164	9,97497	10,02503	39
22	9,83674	9,86152	9,97523	10,02477	38
23	9,83688	9,86140	9,97548	10,02452	37
24	9,83701	9,86128	9,97573	10,02427	36
25	9,83715	9,86116	9,97598	10,02402	35
26	9,83728	9,86104	9,97624	10,02376	34
27	9,83741	9,86092	9,97649	10,02351	33
28	9,83755	9,86080	9,97674	10,02326	32
29	9,83768	9,86068	9,97700	10,02300	31
30	9,83781	9,86056	9,97725	10,02275	30
31	9,83795	9,86044	9,97750	10,02250	29
32	9,83808	9,86032	9,97776	10,02224	28
33	9,83821	9,86020	9,97801	10,02199	27
34	9,83834	9,86008	9,97826	10,02174	26
35	9,83848	9,85996	9,97851	10,02149	25
36	9,83861	9,85984	9,97877	10,02123	24
37	9,83874	9,85972	9,97902	10,02098	23
38	9,83887	9,85960	9,97927	10,02073	22
39	9,83901	9,85948	9,97953	10,02047	21
40	9,83914	9,85936	9,97978	10,02022	20
41	9,83927	9,85924	9,98003	10,01997	19
42	9,83940	9,85912	9,98029	10,01971	18
43	9,83954	9,85900	9,98054	10,01946	17
44	9,83967	9,85888	9,98079	10,01921	16
45	9,83980	9,85876	9,98104	10,01896	15
46	9,83993	9,85864	9,98130	10,01870	14
47	9,84006	9,85851	9,98155	10,01845	13
48	9,84020	9,85839	9,98180	10,01820	12
49	9,84033	9,85827	9,98206	10,01794	11
50	9,84046	9,85815	9,98231	10,01769	10
51	9,84059	9,85803	9,98256	10,01744	9
52	9,84072	9,85791	9,98281	10,01719	8
53	9,84085	9,85779	9,98307	10,01693	7
54	9,84098	9,85766	9,98332	10,01668	6
55	9,84112	9,85754	9,98357	10,01643	5
56	9,84125	9,85742	9,98383	10,01617	4
57	9,84138	9,85730	9,98408	10,01592	3
58	9,84151	9,85718	9,98433	10,01567	2
59	9,84164	9,85706	9,98458	10,01542	1
60	9,84177	9,85693	9,98484	10,01516	0
	Co-sine	Sine	Co-tan.	Tangent.	M

46 Degrees.

Digitized by Google

44 Degrees.

M	Sine	Co-sine	Tangent.	Co-tang.	
0	9,84177	9,85693	9,98484	10,01516	60
1	9,84190	9,85681	9,98509	10,01491	59
2	9,84203	9,85669	9,98534	10,01466	58
3	9,84216	9,85657	9,98560	10,01440	57
4	9,84229	9,85645	9,98585	10,01415	56
5	9,84242	9,85632	9,98610	10,01390	55
6	9,84255	9,85620	9,98635	10,01365	54
7	9,84269	9,85608	9,98661	10,01339	53
8	9,84282	9.85596	9,98686	10,01314	52
9	9,84295	9.85583	9,98711	10,01289	51
10	9,84308	9.85571	9,98737	10,01263	50
11	9,84321	9,85559	9,98762	10,01238	49
12	9,84334	9,85546	9,98787	10,01213	48
13	9,84347	9,85534	9,98812	10,01188	47
14	9,84360	9,85522	9,98838	10,01162	46
15	9,84372	9,85510	9,98863	10,01137	45
16	9.84385	9,85497	9,98888	10,01112	44
17	9.84398	9,85485	9,98913	10,01087	43
18	9,84411	9,85473	9,98939	10,01061	42
19	9,84424	9,85460	9,98964	10,01036	41
20	9,84437	9,85448	9,98989	10,01011	40
21	9,84450	9,85436	9,99015	10,00985	39
22	9,84463	9,85423	9,99040	10,00960	38
23	9,84476	9,85411	9,99065	10,00935	37
24	9,84489	9,85399	9,99090	10,00910	36
25	9,84502	9,85386	9,99116	10,00884	35
26	9,84515	9,85374	9,99141	10,00859	34
27	9,84528	9,85361	9,99166	10,00834	33
28	9,84540	9,85349	9,99191	10,00809	32
29	9,84553	9,85337	9,99217	10,00783	31
30	9,84566	9,85324	9,99242	10,00758	30
31	9,84579	9,85312	9,99267	10,00733	29
32	9,84592	9,85299	9,99293	10,00707	28
33	9,84605	9,85287	9,99318	10,00682	27
34	9,84618	9,85274	9,99343	10,00657	26
35	9,84630	9,85262	9,99368	10,00632	25
36	9,84643	9,85250	9,99394	10,00606	24
37	9,84656	9,85237	9,99419	10,00581	23
38	9.84669	9,85225	9.99444	10,00556	22
39	9.84682	9,85212	9,99469	10,00531	21
40	9,84694	9,85200	9,99495	10,00505	20
41	9,84707	9,85187	9,99520	10,00480	19
42	9,84720	9,85175	9,99545	10,00455	18
43	9,84733	9,85162	9.99570	10,00430	17
44	9,84745	9,85150	9,99596	10,00404	16
45	9,84758	9,85137	9,99621	10,00379	15
46	9,84771	9,85125	9,99646	10,00354	14
47	9,84784	9,85112	9,99672	10,00328	13
48	9,84796	9,85100	9,99697	10,00303	12
49	9,84809	9,85087	9,99722	10,00278	11
50	9,84822	9,85074	9,99747	10,00253	10
51	9,84834	9,85062	9,99773	10,00227	9
52	9,84847	9,85049	9,99798	10,00202	8
53	9,84860	9,85037	9,99823	10,00177	7
54	9,84873	9,85024	9,99848	10,00152	6
55	9,84885	9,85012	9,99874	10,00126	5
56	9,84898	9,84999	9 99899	10,00101	4
57	9,84911	9,84986	9,99924	10,00076	3
58	9,84923	9.84974	9,99949	10,00051	2
59	9,84936	9.84961	9,99975	10,00025	1
60	9.84949	9.84949	10,00000	10,00000	0
	Co-sine	Sine	Co-tang.	Tangent.	M

45 Degrees.

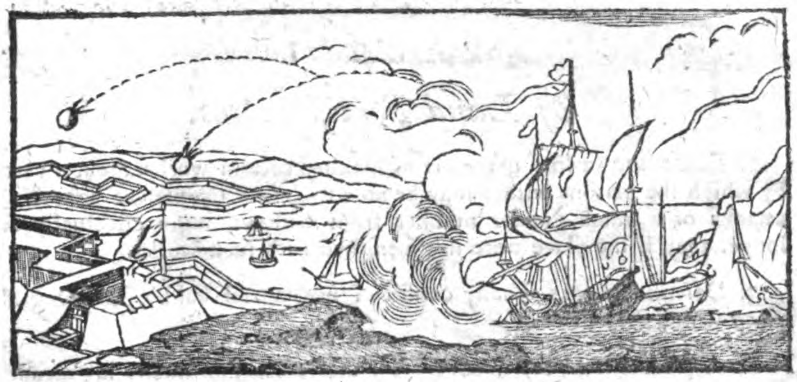
END OF BOOK IX.

James Macully's Book.

Digitized by Google

James Macully's Book.

Digitized by Google



A

TREATISE

OF

MARINE FORTIFICATION.

1. BY MARINE FORTIFICATION is meant the art of raiſing works for the defence of a harbour againſt the attacks of any kind of ſhipping.

As the works proper for this purpoſe depend in a great meaſure on the principles employed in the fortification of towns, it will be neceſſary to give ſome general notions of the uſual methods of fortifying, previous to the meaſures that ſeem moſt effectual to the ſecuring of harbours.

It is not intended in this tract to give a complete ſyſtem of fortification; and conſequently the reader will not be perplexed with the different ſyſtems, as they are called, of this and that *Engineer*; many of them being the productions of dabblers in the art, who, having diverted themſelves with whimſical ſcratchings on paper, publiſhed their conceits for a like amuſement to others; and gravely compared their *pretty drawings* with the approved works of experienced Engineers. It is high time that moſt of their names and notions were forgot, and that thoſe who hereafter may write on this ſubject, ſhould confine themſelves to the deſcription of ſuch works only as are moſt in uſe, and which by experience have been found to be moſt conducive to the defence of the place, and the retardation of the approaches of the enemy. And this is what is briefly attempted in the following pages.

 PART

Digitized by Google

PART I.

Of Land Fortifications.

2. FORTIFICATION is the art of making certain works about a place, by which the perfons within may be able to defend themfelves againft the attacks of a much greater number from without, more effectually and longer than if the place were not furnifhed with fuch works.

3. Defenfive works ufually confift of moats and banks, covering the place which they defend.

4. A place is faid to be covered, either when the enemy is prevented from coming to that place by a body of troops or other hindrance; or, when a fufficiently ftrong bank, raifed before that place, prevents thofe without from feeing them within.

5. Defenfive works are of various kinds; the moft fimple are ufually called lines.

SECTION I.

Of Lines or Intrenchments.

6. A LINE, or an INTRENCHMENT, confifts of a bank of earth, and a ditch, and it is of two forts.

Firft, Such as the trenches carried on in a fiege, where the bank is between the ditch and the enemy or town; and here the earth is thrown up againft the town, becaufe the workmen are thereby better covered in carrying on the works.

Secondly, Such as ferve to inclofe a town or camp, fecure a pafs, cover the entrance into a country, or other place, &c.; in thefe the ditch is between the bank and the enemy.

The firft fort is ufually called trenches or approaches: and the fecond is generally called lines; which are the fort that will be here more particularly treated on.

7. Lines are generally made to fhut up an avenue or entrance to fome place; the fides of that entrance being covered by rivers, woods, mountains, moraffes, or other obftructions not eafy to be paffed by an army; though there have been cafes where lines were conftructed in plain countries; but then they were carried quite round the place they were to defend, as the lines furrounding a camp, called lines of circumvallation. Lines are likewife thrown up to ftop the progrefs of an army, as thofe made by Marfhal Villars and others. However, in what follows it will be fuppofed that the line is to cover a pafs that can be attacked only in front.

8. The making of lines greatly depends on the nature of the place, and the time that can be taken to conftruct them; thofe made at leifure being very different from thofe made in hafte.

The

Digitized by Google

The works usually thrown up in haste are called *temporary*, serving chiefly on a present emergency: those made at leisure are generally intended to last many years, and are kept in repair, under a probability of their being frequently attacked. But whether the work be temporary or lasting, it is necessary that it be adapted to the materials at hand, or that can be procured with the least expence and trouble.

A road or pass may be advantageously held by few men against a much greater number, many ways; as by turning a water-course, planting stakes, felling trees, digging ditches, making a fence of stones, &c. But the way now most usually practised is to make a line after the method contained in the following precepts.

9. *To throw up a line across a pass.*

1st. Having chosen the place most convenient for the line, let a rope, or haybands, or twisted straw or grass, be run quite across the way along the intended place of the line, pegged to the ground at every 4 or 5 yards; and at the distance of about 10 or 12 feet before the line, toward the enemy, let such another line, or a row of stakes, be carried in a position parallel to the first rope.

2d. Range the labourers or troops within those limits, either single, in pairs, or treble, &c. according to their number, or the time in which the work is to be done, each being furnished with proper digging tools.

3d. Let the earth, as they dig it up in this breadth, be thrown on the other side of the first rope, until a bank of about 5 or 6 feet thick and 6 or 7 feet high be raised; observing that the sides of the ditch be sloped in the same manner that the earth naturally rolls down the bank; and continue the digging till the ditch is about 5 or 6 feet deep, the breadth of the bottom being about $\frac{1}{3}$ of the breadth staked out at top. And while the ditch is digging, if the earth as it is thrown up be trodden down, the bank will be more compact; or a few hand-rammers (such as the paviours use) kept constantly going, will render the work more firm and durable.

4th. Let the inner side of the bank be pared with the spade into such a slope, as a man standing upright may easily touch, with his arm extended straight before him; and at the foot of this bank, let a *foot-bank* or step be raised, of such a height, that a man standing on it may easily fire his musket over the bank; that is, let the top of the foot-bank be about four feet and half lower than the top of the bank or *breast-work*.

5th. If there is time and opportunity, let the workmen throw up the loose and scattered earth upon the bank, on both sides, and flap or beat it with the flats of their shovels to make it the more neat and compact. Also make a gentle slope to the top of the *foot-bank*, that the troops may ascend it more easily; and let the *crown* or *top* of the *breast-work* be

Digitized by Google

ſloped ſo that a muſket laid flat on it may ſtrike the ground with its ſhot about 5 or 6 feet beyond the ditch.

When the ſoil is clay, ſand, turf, or mould, the workmen will need only ſpades and ſhovels; when gravelly or ſtony, one man ſhould break the ground with a pick-axe or mattock, while another throws it upon the bank, where a third ſhould ſpread it level and tread it down.

10. A work of this kind being completed, the troops behind the *line* may wait the coming of an enemy with leſs concern: For 1ſt, the bank or breaſt-work ſecures them from the enemy's fire. 2d. And when they ſtand on the foot-bank, they are more than $\frac{2}{3}$ covered, while the enemy are wholly expoſed; and conſequently the troops within may make three of their ſhots tell for one of the enemy's. 3d. They can, by going off the foot-bank, be quite covered while they load again. And on the whole, they are in no great danger of being forced from the lines while they have courage enough to keep poſſeſſion of them, except the enemy are greatly ſuperior in numbers and cannon.

The magnitude of lines are generally proportioned to the little time that can be ſpared to throw them up, and to the ſtrength of the enemy who are to attack them. The following ſorts are what have been practiſed on ſeveral emergencies, and the rate at which men ordinarily work on ſuch occaſions.

11. *A* TABLE *of the dimenſions of Lines.*

Breaſt-work			Ditch			Expence.	
Thickneſs at top	Height within	Height without	Upper breadth	Lower breadth	Depth	Solid content	Days works.
4 feet	$7\frac{1}{2}$ feet	6 feet	8 feet	$2\frac{2}{3}$ feet	5 feet	$4\frac{2}{3}$ ft.	1
5	$7\frac{1}{2}$	6	10	$3\frac{1}{4}$	$5\frac{1}{2}$	$6\frac{1}{12}$	$1\frac{1}{2}$
6	$7\frac{1}{2}$	6	12	4	6	8	2
7	$7\frac{1}{2}$	6	14	$4\frac{2}{3}$	$6\frac{1}{2}$	10	$2\frac{1}{2}$
8	$7\frac{1}{2}$	6	16	$5\frac{1}{3}$	7	12	3
9	$7\frac{1}{2}$	6	18	6	$7\frac{1}{2}$	15	$3\frac{1}{2}$

The days work here is one yard in length.

In the firſt, 100 men will complete 100 yards in length of this kind of lines in one day; 200 men in half a day; 400 men in a quarter of a day, and ſo on.

12. When lines are thrown up at leiſure, then the ditch is uſually 18 feet broad at top, 7 or 8 feet deep, and the ſides of the ditch are ſo ſloped, as to leave only 6 feet breadth at bottom; the breaſt-work, or parapet, is about 7 feet thick on the top or crown, and 7 or 8 feet high.

In Plate XV. fig. 1. ſhews the heights, depths, and breadths of the ſeveral parts of a line, well deſigned and finiſhed.

Where

Digitized by Google

Where IL represents the ground line, or surface of the place.
AB, the breadth of the ditch at the top.
CD, the breadth of the ditch at bottom.
FAC, is the slope or scarp of the parapet and ditch.
DBK, is the counterscarp.
EF, the top or crown of the parapet or breast-work.
EG, the inner slope of the parapet.
HG, the top of the foot-bank.
HI, the slope of the foot-bank.
BKL, a small sloping bank called the glacis.

13. *This figure is called a section or profile, and may be thus drawn.*

1st. In the ground-line, lay off, from any scale of equal parts, the distances I a=6 feet, ab=4 ft. bc=$1\frac{1}{2}$ ft. cd=7 ft. dA=$4\frac{1}{2}$ ft. Af=6 feet, fg=6 ft. gB=6 ft. BL=5 ft.

2d. Through a, b, c, d, e, f, g, B, draw lines perpendicular to IL.

3d. Make aH=$2\frac{1}{2}$ ft. =bG, cE=7 ft. dF=6 ft. fC=8 ft. =gD.

4th. Draw IA, HG, GE, EF, FAC, CD, DB, which continue till it meets the line FL, and the profile is constructed.

14. When lines are made to cover a camp, or a large tract of land where a considerable body of troops are posted, the work is not made in one straight, or uniformly bending line; but at certain distances, the lines projecting in saliant angles toward the enemy. These projections, saliant angles, are called REDENTS, or FLANKERS; because the fire from them takes the enemy in flank or sideways as they march to attack the lines.

The distance between the saliant angles of the *flankers* is usually between the limits of 200 and 260 yards; the ordinary flight of a musket-ball, point blank, being generally within those limits; although muskets a very little elevated, will do effectual service at the distance of 360 yards.

15. A flanker consists of two lines, called faces, meeting in a point, and forming an angle called the *saliant angle*, or *flanked angle*.

The part of the line between two adjacent flankers is called the *curtin*.

The *gorge* of a flanker is the distance between its faces taken at their intersection with the curtins.

16. In Plate XV. fig. 2. shews the forms of the usual lines; where the figures, CAB, cab, are redents or flankers.

AC, AB, ac, ab, the faces.
CB, cb, the gorges.
AD, ad, the capitals.
Bb, the curtin.
The angle CAB, cab, the saliant, or flanked, angle.

The distance of the saliant angles is about 240 yards on a mean.
The length of the capital is usually between 40 and 50 yards.
The length of the gorges is also about 60 or 70 yards.

 17. To

Digitized by Google

17. *To make a Plan of lines with redents.* Plate XV. Fig. 3.

1st. Let the line EEEE, &c. be fo drawn, if poffible, that wherever there is a bend or angle, it may either be at once, or twice, or thrice, &c. the length of about 240 yards from one another, whereby a redent will always be where there is an angle.

2d. In this line lay off diftances of 240 yards each, as from E to E, E to E, &c. reckoning from the bends toward each end, whether it happens that the line will, or will not be exactly meafured by a repetition of the 240 yards.

3d. At each point E draw the *capital* EF in a perpendicular pofition to the direction of the line in that point, and make the *capitals* about 40 or 50 yards long.

4th. On each fide of E take the *half gorge*, EG, EG, each of about 30 or 35 yards, and draw the *faces* FG, FG; and the out-line, or *mafter-line* of the curtins and redents are formed.

5th. Parallel to each *curtin* and *face* draw lines, within, at the diftances from the *mafter-line*, of 7 feet, 8 feet, 12 feet, and 18 feet.

Then the breadth of 7 feet reprefents the plan of the *parapet*.

	of 1 foot	its inner flope.
	of 4 feet	the top of the *foot-bank*.
	of 6 feet	the foot-bank flope.

6th. On the outfide of the *mafter-line*, draw lines at the diftances of $10\frac{1}{2}$, $16\frac{1}{2}$, and $22\frac{1}{2}$ feet, parallel to each curtin and face; and thefe will reprefent the plans of the *fcarp*, *ditch*, and *counterfcarp*; obferving that the faliant angles of the counterfcarp are rounded before the angles of the redents.

When the plans are drawn from a large fcale, all the lines before mentioned are drawn; but when the plan is drawn from a fmall fcale, as of 20 yards or more to an inch, then the plan is ufually reprefented by four parallel lines; one without the mafter-line, reprefenting the counterfcarp or out-line of the *ditch*; and two within, reprefenting the breadths of the *parapet* and *foot-bank*.

Sometimes a fhort line is haftily formed by a CHEVAUX DE FRISE; which is a beam of 6 or 8 inches fquare, and 10 or 12 feet long; the fides being bored through with holes about an inch and half diameter, and 6 inches diftant from one another; through each hole goes a ftaff of about 5 or 6 feet long, armed at both ends with an iron fpike, fo that which way foever it is laid along, one row of pikes is prefented againft the enemy. A line is formed of thefe pieces by chaining together a fufficient number of them end to end.

In countries where there is plenty of wood, a line may be formed by laying, in a pofition pointing to the enemy, the ftems of trees and their larger branches, piled one on another to a fufficient height, and the interftices filled with earth. Such a work, called an ABBATIS, affords an excellent defence; as was experienced at Ticonderoga.

SECTION

Digitized by Google

SECTION II.

18. *Of Batteries.*

When lines are to be vigorously defended against a potent enemy, it is proper to raise *batteries*; that is, works from which cannon may play on the troops as they advance to the attack: these batteries are either *open* or *covered*.

19. An OPEN BATTERY is only a number of cannon, generally *field-pieces* (that is, such as carry a ball not exceeding 9 pounds weight) ranged in a line or row abreast of one another, on some natural small elevation of the ground; or an artificial bank of about a yard or two high. These cannon are ranged at about 15 or 16 feet distant from one another, having their shot and loading utensils lying by their side; and the powder lodged in a hole at some distance behind the battery. A less distance than about 15 feet from gun to gun might occasion danger, considering the hot service for which such batteries are erected.

20. A COVERED BATTERY is when the cannon and gunners are covered by a bank made of brushwood, faggots, and earth; of about 18 or 20 feet thick, and 7 or 8 feet high. The cannon used in such batteries are generally from 9 to 18 pounders; and sometimes 24 pounders are used in them.

21. The faggots, or, as they are most usually called, the FASCINES, are made of the middling-sized loppings of trees, under an inch diameter, and are of three different lengths, 6, 9, and 12 feet, according to the work they are intended for: they are usually bound or tied round with wyths; the shortest in two places, the next in three, and the longest have four bands. These fascines are commonly 8 or 9 inches thick throughout, the ends being cut so as not to be tapering.

The fascines are fixed to the ground, and to one another, by stakes called PICKETS, like birch broom-sticks, but stronger; they are about an inch, or inch and half thick, and from 3 to 6 feet long; the 6 feet ones are in number about $\frac{2}{3}$ of the 3 feet pickets, but much stronger.

All *field batteries* consist of four chief parts, namely, the *ditch*, the *parapet*, the *platform*, and the *magazine*.

22. *Of the Ditch.*

The ditch is usually dug in the front and sides, and sometimes quite round; and serves not only to furnish the earth necessary for the parapet, but it also prevents the enemy from entering the battery so readily as he might otherwise do. The ditch in front is commonly 18 or 20 feet broad, and the depth about 7 or 8 feet; the sides sloping toward the bottom, which is about 6 feet wide; but the ditches on the sides are about 10 feet wide, and 6 feet deep. These are the dimensions usually given; but the general practice seems to be, only to get earth sufficient for the work, and not mind the regularity of the ditch: for as these works in attacks are usually done by night, the keeping strictly to the assigned dimensions is hardly practicable.

Digitized by Google

23. *Of the Parapet.*

The parapet is generally raiſed about 3 or 4 feet diſtant from the brink of the ditch, the ſpace left between, called the BERM or FORELAND, ſerving to lodge the rubbiſh beat down by the enemy's ſhot, that it may not fall into the ditch.

The thickneſs of the parapet ſhould be about 18 or 20 feet, in order to be cannon proof, and about 7 or 8 feet high, when the enemy has no command above the battery. But if they have a command over this height, the parapet ſhould be raiſed high enough to cover the men while they load the guns.

The length of the parapet depends on the number of guns to be employed in the battery.

24. Thus for one gun, allow 8 yards in length.

And 6 yards more for every other gun.

So 2 guns has 14 yards; 3 guns 20 yards; 4 guns 26 yards, &c.

25. There ſhould be great care taken that the battery be not *enfiladed* or *raked* by the enemy's cannon: neglects of this kind are often fatal to the officers and gunners, as was well known at the ſiege of Carthagena, anno 1741. But this is eaſily prevented by raiſing at one, or both ends of the parapet, a bank acroſs the battery called an *epaulement*, of the ſame thickneſs and height with the parapet, and about 15 or 18 feet long.

26. The parapet conſiſts of two parts, namely, the *wall* and the *merlons*.

The WALL is that part of the parapet which is contained in one piece from end to end, and is about $2\frac{1}{2}$ or three feet high.

The MERLONS are detached pieces of the parapet, leaving openings called EMBRASURES, through which the cannon deliver their ſhot.

The embraſures ſhould be cut as much as is poſſible perpendicular to the parapet; therefore the battery ſhould be parallel, or nearly ſo, to the object to be battered: for the direct ſhots have moſt force; and oblique embraſures weaken the merlons, or parts of the parapet ſtanding between the embraſures.

27. The embraſures are uſually about 2 or $2\frac{1}{2}$ feet wide on the inſide, and about 9 or 10 feet on the outſide; ſo that the cannon may be traverſed from the right to the left, and command a pretty large extent in front. The diſtance from the middle of one embraſure to the middle of the next ſhould be about 18 feet, in order to leave ſufficient room for the working of the guns, and the ſtowage of the ſhot and other neceſſaries.

28. *Of the Platform.*

The PLATFORM is a floor made to faciliate the rolling of the carriage wheels, and to prevent them from ſinking into the ground by the weight of the cannon, eſpecially in wet weather.

Platforms are generally laid ſloping toward the parapet 9 or 10 inches; this carries off the rain, prevents the gun from recoiling ſo much when fired as it would do if laid level; and when loaded, it is more eaſily brought to the embraſure.

4 29. In

Digitized by Google

29. In temporary batteries the platforms are made of planks laid acroſs ſome ground timbers or ſleepers; there is uſually a platform made to each gun; it is about 18 feet long, 8 feet broad next the parapet, and about 14 feet broad at the tail, the intermediate ſpaces between the platforms ſerving for the ſhot and other neceſſaries.

30. When a platform is to be laid on marſhy ground; firſt lay a floor or two of faſcines; cover theſe with *hurdles* of 12 or 15 feet long and 6 or 7 broad; on theſe lay a floor of 3 or 4 inches of earth, in which the ſleepers are to be laid, and over them the planks.

31. When a battery is built of ſtone or brick, the platform is generally a flat-ſtone pavement ranging the whole length of the battery. This, on account of its reſiſting the injuries of the weather for a long time, is to be preferred to planks; but in caſe of a bombardment ſuch a platform is to be avoided, becauſe the ſhells will not only break the pavement, but alſo, by driving about the broken ſtones, do the troops much miſchief.

32. *Of the Magazine.*

The magazine to a field battery is uſually made about 50 or 60 yards behind the platform. It is a cavity dug in the ground about 4 feet deep, and the earth thrown between the pit and the platform; the ſides of the pit are ſometimes planked round to keep it dry, and prevent the earth from crumbling in; and the powder barrels placed there, are covered with hurdles and earth, or tanned hides, to preſerve the powder from wet and fire.

The communication to the magazine is by a ſloping trench beginning to deſcend about 5 or 6 yards behind the platform; and the earth thrown on that ſide, where it will moſt conveniently cover the perſons, who remove the barrels of powder from the great magazine to the battery, or ſmall magazine.

33. When there are many cannon in battery, and the ſervice is quick, it is cuſtomary to have to every two pieces a ſmall magazine to hold 20 or 30 barrels of powder. This is placed about 15 or 20 yards behind the platform, and againſt the merlon between the cannon; and as theſe barrels are uſed, they are replaced by others from the great magazine.

At each magazine a centinel is placed to prevent accidents.

And to prevent perſons coming into the battery and magazines who have no buſineſs there, a trench is ſometimes dug behind the magazine, and carried into the trenches which communicate between the magazine and battery.

34. *To conſtruct a Faſcine battery.*

For one gun provide 600 faſcines of 9 ft. 100 of 6 ft. 120 of 3 ft. And, for every other piece 400 100; 100;
each faſcine being about 9 inches thick; and let there be three or four pickets for every faſcine, for many will break in driving.

Trace the limits of the parapet in two parallel lines about 18 feet diſtant, allowing 8 yards in length for one gun, and 6 yards for every other gun; and along theſe lines cut a trench about half ſpade deep.

Lay

Digitized by Google

Lay a row of 9 feet faſcines along one trench, obſerving that their ends be well jammed one into the other, and let each be pegged down with two pickets, driven into the ground till the head is ſunk into the faſcine.

Cloſe to this row lay another, the two end ones being of 6 feet, and the reſt 9 feet, which will prevent the joinings in this row from falling againſt the joinings in the firſt row: let theſe alſo be ſtaked down as before. Cloſe to the ſecond row lay a third, all of 9 feet. Cloſe to the third lay a fourth, the two end ones being 6 feet, and the reſt 9 feet. In this manner lay the rows of faſcines within the limits ſtaked out, which will be covered with 24 rows; then over this floor of faſcines throw earth to fill up the hollows, and let the whole be trod or rammed down.

On the firſt floor lay a ſecond, obſerving, that as in the firſt floor every ſecond row ended with 6 feet faſcines, ſo in the ſecond floor every odd row ſhould end with 6 feet ones, and the joinings of no two faſcines in this floor will fall over the joining of the faſcines below them. Let the outſide rows in the ſecond floor be ſo placed over thoſe in the lower, that there be a little ſloping preſerved, the work narrowing upward. The pickets which ſtake down this floor are to be driven up to the head, and the channels or hollows in the floor are to be filled up with earth. In this manner lay four floors, which will raiſe the work to about $2\frac{1}{2}$ or 3 feet, and that part of the breaſt-work called the wall will be completed.

35. *To ſtake out the Merlons.*

Meaſure from each end of the wall 12 feet, there place a ſtake; and plant other ſtakes at every intermediate 18 feet; this being done on the inſide of the wall, let other ſtakes be planted on the outſide, either directly oppoſite the former, or in the line toward the place where the gun is more particularly intended to deliver its ſhot. Plant other ſtakes on the inſide, one a foot diſtant on each ſide the former, and this will leave ſpaces of two feet each for the inner opening of the embraſures: then on the outſide, plant other ſtakes at 5 or 6 feet diſtance from the former ones, one on each ſide, and ſpaces of 10 or 12 feet will be marked out for the outſide openings of the embraſures.

In the direction of the pickets, which limit the inner and outer openings of the embraſures, let ſingle rows of faſcines be ſtaked down acroſs the wall, and theſe will be the ſides of the embraſures. Fill the intermediate ſpaces or merlons with rows of faſcines laid lengthwiſe to the wall, and this will be the firſt floor of the merlon, which is to be picketted down, and the hollows filled with earth as before directed. Let other floors be raiſed in like manner, until the merlons are carried up about 5 or 6 feet, or more if neceſſary; and on the top of each let a bed or floor of earth be laid about 8 or 12 inches thick.

Acroſs the top of the inner opening of the embraſure, lay a bundle of 10 or 12 faſcines bound together, or as many ſtuft into a kind of baſket open at both ends, and the bundle well ſtaked to the merlons.

Provide a *blind* made of planks 3 or 4 inches thick to fit the inner opening of the embraſure, which is to be put up while the gunners are loading the piece, to preſerve them from the fire of the muſketry.

The

Digitized by Google

The cheeks or sides of the embrasures are to slope, so as to have the top wider than the bottom; which not only leaves a greater opening for the blast of the gun, but these slopes, in works of this kind, give a greater degree of strength to support themselves against the bearing of the upper parts.

36. *To construct the Platforms.*

Against each embrasure lay on the ground five pieces of timber, called sleepers, about 18 feet long, and 6 or 8 inches square; let the ends next the embrasure be placed at such a distance from one another, that the distance from out to out be about 6 feet, the other ends spreading about 12 or 14 feet from out to out; drive two stakes about 3 inches square into the ground on both sides of each end of every sleeper, by which they will be kept steady in their places, and let the earth be well rammed and beat up close to them: but observe to let the tails of the sleepers be raised about 6 or 8 inches higher than the ends next the wall, to prevent the cannon from recoiling too much when fired.

Cover the sleepers with planks about two inches thick laid cross-wise; that next the embrasures being about 8 feet long, the rest gradually increasing, so that the plank at the tail be about 14 feet long; and let the planks be nailed to the sleepers.

On this floor fix a piece of timber about 6 or 8 inches square next the embrasure, to serve as a spur for the carriage wheels to knock against (which is therefore usually called the *knocker)* when the gun is run up to the wall; observing that the spur be laid parallel to the object to be battered.

The whole platform should be of oak, if it can be had.

37. If there is any danger of the battery's being raked by the enemy's cannon, let an *epaulement* or *screen* be raised at one or both ends of the parapet, joining to it, and constructed by floors of fascines, laid as before shewn: then all the straggling twigs of the fascines being cut off, the battery is constructed.

A battery thus made will do in case of haste, and where earth enough is not easily had: but as it is subject to be fired when the wood is dry, it is not so much in use as another sort called a coffer battery; especially where wood is scarce and earth plenty.

A Coffer Battery is that, where the sides only of the wall and merlons are formed of fascines, and all the cavities or included spaces filled with earth.

38. *To make a Coffer battery.*

The place of the battery being determined, mark out with a line the limits of the parapet 18 or 20 feet thick; and 3 or 4 feet before the parapet mark out with lines or stakes the limits of the ditch, 10 or 12 feet broad, or more if earth is wanted; allowing 8 yards in length for one gun, and 6 yards more for every other gun.

On the outlines of the parapet, cut a trench 5 or 6 inches wide and deep, and there lay a row of fascines, the ends being jammed one into the other; let these be staked down. Lay on them another row, so that the

joinings

Digitized by Google

joinings of these be not directly over the joinings of the lower one, and the knots of all the bands turned inwards; stake these down; and on them lay in like manner a third and fourth row, &c. until the height be about 3 feet. The same kind of work being done at the ends, and for the epaulement if wanted, the coffer for the wall will be made.

Then let the men be disposed along the place intended for the ditch, and with the proper tools break the ground and throw it into the coffer; where, as the earth is thrown in, another set of men are to spread it, and stamp it down with rammers; and this work is to be continued until the coffer is filled.

39. When the wall is finished, let the embrasures be staked out as before (35), and a coffer formed in like manner for each merlon, which is also to be filled with earth and rammed down.

The other articles in the preceding battery are to be followed in this, the only difference being in the making of the parapet.

When a proper place for a temporary battery is destitute both of dry earth and wood, then materials must be carried to the place; these usually are *gabions* and *earth-sacks*.

The EARTH-SACKS are only bags to carry earth in.

A GABION is a large basket without a bottom: they are of various sizes, as from 3 feet high and 2½ or 3 feet diameter, to 6 or 8 feet high and 6 or 7 feet diameter.

40. *To make a Gabion battery.*

Along the line marked out for the battery, let the gabions be planted in the places where the merlons are to be: the gabions used are of 5, 6, and 7 feet diameter, and 8 feet high. Each merlon must have 7; that is, 3 within of six feet diameter, next two of 7 feet diameter, and on the outside two of 5 feet diameter; observing to leave proper openings for the embrasures, about 2 feet on the inside, and 9 or 10 on the outside.

Or thus: Let the merlons be made of gabions 5 feet diameter; then put four within, three in the middle, and two on the outside; this construction being rather stronger than the former.

The ends and epaulements are also formed by three rows of gabions.

The floors or bottoms of the embrasures are to be filled with gabions about three feet high, and of a proper diameter to fill up the spaces between the merlons.

The gabions being placed are to be filled with earth brought from the nearest places in the earth-sacks; or else they may be filled with dung mingled with sand; and in cases of necessity, they may be filled with large faggots, or billet wood, observing that the voids between the gabions are filled also.

Batteries of this construction are usually made on marshy or rocky ground.

41. The *Sieur Remy*, in his Memoirs of Artillery, has given a table for the ready finding of all the requisites for the construction of temporary batteries, and for their daily service, the pieces being 24 pounders; and although these batteries are calculated only for sieges, and are of the coffer-kind, yet from this table may be derived such notions, as will greatly help young artists on other occasions.

It

Digitized by Google

It is also proper to mention the number of fascines and pickets, that is usually expected every day from the labour of each man employed in that service.

Of fascines 5 or 6 feet long, and 5 or 6 inches thick, bound with two wyth bands each, one man will make 16 or 18 in a day, with two pickets to each.

Of fascines 8 or 9 feet long by 8 or 9 inches thick, and two pickets to each, one man usually makes 10 or 12 in a day.

Of fascines 12 feet long by 9 inches thick, with three pickets to each, 8 or 10 are usually expected from the day's work of one man.

The days here understood are such in which the men may work about 12 hours.

In the following table C. stands for hundred.

42. *A* TABLE *for constructing of Batteries.*

Number of 24 pounders in battery.	Length of the parapet in yards.	Number of workmen to construct the battery.	Number of workmen's tools used at the battery, *viz.* shovels, spades, pickaxes, mattocks, &c.	Fascine-makers, each a bill and hatchet.	Fascines of 8 or 9 feet by 8 or 9 inches.	Fascines of 12 feet by 8 or 9 inches.	Fascines of 5 or 6 feet by 5 or 6 inches, made by the cavalry.	Pickets from 3 to 6 feet long, and about 1½ inch thick.	Mallets to drive the pickets.	Handbills, 2 for each embrasure, beside spare hatchets.	Planks for the platforms, 2 or 2½ inches thick.	Gunners to serve in the battery.	Soldiers to assist the gunners.	Powder for 100 rounds, at 12lb. each per day.	Shot of 24 pounds for 100 rounds.
2	14	50	70	15	120	40	2 C	520	10	4	32	4	12	24 C	2 C
3	20	60	85	20	165	60	3 C	740	14	6	48	6	18	36 C	3 C
4	26	70	100	25	210	80	4 C	960	18	8	64	8	24	48 C	4 C
5	32	80	115	30	255	100	5 C	1180	22	10	80	10	30	60 C	5 C
6	38	90	130	35	300	120	6 C	1400	26	12	96	12	36	72 C	6 C
7	44	100	145	40	345	140	7 C	1620	30	14	112	14	42	84 C	7 C
8	50	110	160	45	390	160	8 C	1840	34	16	128	16	48	96 C	8 C
9	56	120	175	50	435	180	9 C	2060	38	18	144	18	54	108 C	9 C
10	62	130	190	55	480	200	10 C	2280	42	20	160	20	60	120 C	10 C
11	68	140	205	60	525	220	11 C	2500	46	22	176	22	66	132 C	11 C
12	74	150	220	65	570	240	12 C	2720	50	24	192	24	72	144 C	12 C
13	80	160	235	70	615	260	13 C	2940	54	26	208	26	78	156 C	13 C
14	86	170	250	75	660	280	14 C	3160	58	28	224	28	84	168 C	14 C
15	92	180	265	80	705	300	15 C	3380	62	30	240	30	90	180 C	15 C
16	98	190	280	85	750	320	16 C	3600	66	32	256	32	96	192 C	16 C

Digitized by Google

43. When batteries are erected at leisure, and are wanted to stand for some years, it is best to make them of stone or brick, or good loamy earth, according as the materials are nearest at hand, or can be most easily procured.

When made of stone, the thickness of the parapet is usually about 4 or 5 feet; but this thickness is varied, according to the quality of the stone, or to the size of the cannon that may be brought by an enemy to fire on it.

Parapets of brick are of 5, 6, 8, or even 10 feet thickness, according to the goodness of the materials, or the service it is to endure; and the angles are generally of stone.

A parapet made of good earth, and 18 or 20 feet thick, with the surface covered with green turf, will resist the injuries of the weather for several years, and stand the shock of an enemy's cannon the best of any.

44. As these perpetual batteries are generally raised somewhat above the level of the adjacent land or water which they are to command; so it is usual to make the floors of the embrasures sloping, the drip being on the outside, about a foot or foot and half below the sill of the inner opening, that the cannon may be pointed downward.

When the embrasures are cut through an earthen parapet, they are commonly lined with brick; or at least the angles are made of masonry, these parts being the most subject to be injured by the weather.

The best embrasures are those made with a neck, by which a part of the opening becomes more contracted, and consequently is better adapted to preserve the gunners and cannon from the enemy's shot, than when the cheeks of the embrasures are made straight.

45. Although the axis or middle line of an embrasure should, if possible, be at right angles to the length of the parapet, yet it may sometimes be necessary to have them oblique. When this happens, the inside of the parapet is notched, or so cut away, to leave proper room for the front of the platform, that the wheels of the carriage may be drawn up against the inner opening for the axis of the gun to lie in the axis of the embrasure; but then the outside of the parapet is to be strengthened, to compensate for what is cut away within.

The foregoing particulars, relating to embrasures, will be sufficiently illustrated by the following precepts for their construction.

46. *To construct the Plans of embrasures.*

FIRST. *For the plain embrasure,* Plate XV. Fig. 4.

1st. Draw the axis AB perpendicular to the parapet.
2d. For the front opening, make AC=AD, each from 4 to 5 feet.
3d. For the inner opening, make BF=BE, each from 1 to 1¼ feet.
4th. Draw FD, EC, for the cheeks of the embrasure required.

47. SE-

Digitized by Google

47. SECONDLY. *For the necked embrasures.* Plate XV. Fig. 5.

1st. Having drawn the cheeks for a plain embrasure as before; from B, the middle of the inner opening, draw BC, BD.

2d. In the axis AB, take BG=2½ or 3 feet; through G draw IH at right angles to BA, cutting BC, BD, in H, I, and join EH, FI.

Then DIF, CHE, are the angular cheeks, IH being the neck or narrowing of the embrasure.

48. THIRDLY. *For an oblique embrasure.* Plate XV. Fig. 6.

1st. Draw the axis *a b* in the direction where the gun is to command, and through any convenient point I, taken in *a b*, draw NN at right angles to *a b*.

2d. Make IN=4 or 5 feet for the front opening, IP=1 or 1½ feet for the inner opening, and IQ=4 feet for the front of the platform.

3d. Through N, P, Q, and parallel to *a b*, draw NC, ND, cutting the front of the parapet in C, D; and P *p*, Q *q*, cutting the inside of the parapet in *q*, *q*.

4th. Through *q* draw *q r* parallel to NN, cutting the former lines in F, B, E, *r*; join ED, FC, and draw *r s* parallel to a line through B and C.

Then the space *q r s* being cut away, the wheels of the carriage can knock against the line *q r*, and the axis of the gun will lie in the line B *a* intended for the axis of the embrasure.

It is evident that the parapet is considerably weakened by the cuts for these oblique embrasures, and therefore should be strengthened on the outside.

49. *When the embrasures are to be expressed in the parapets of a plan drawn from a small scale, it is done thus.* Plate XV. Fig. 8.

On the inside of the parapet RS, lay off as many times 6 yards, in the points *c*, *c*, *c*, &c. as the length of the parapet will admit, unless you are restrained by particular circumstances; and from the points *c*, *c*, *c*, &c. draw lines to the front of the parapet, dividing it into parts of 3 yards each; then taking the parts opposite to the points *c* for the fronts of the embrasures, the other parts will represent the fronts of the merlons.

Shade all the merlons, leaving white angular spaces to express the embrasures, and strengthen the inner line of the parapet and the front lines of the merlons.

50. *Of the profiles of batteries.* Plate XV. Fig. 7.

Let the ground line of the battery be AB, BD that of the parapet, the inner slope of which DH is formed by making D *a*=1½ feet, and the perpendicular *a* H=6 or 7 feet; the crown of the parapet HI is formed by making *b* I a foot or two lower than *a* H; and the front of the battery I B is found by making *b* B=⅔ *b* I, when of earth, or=⅓ of *b* I when of masonry. Making DC=2½ or 3 feet, gives C the sill of the embrasure, the floor of which CG is to dip a foot or two below the level line CF.

The platform DE is 18 or 20 feet, the tail E rising about 6 inches above the level line AB, the lower double line represents the sleeper laid lengthwise, and the upper double line shaded with the lines across, express the ends of the planks laid on the sleepers.

A gun on its carriage, with the wheels against the knocker at D, is annexed to the figure, to assist the learner's apprehension.

SECTION

Digitized by Google

SECTION III.

Of additional works.

51. *Of Ramps.*

When a battery is raised above the level of the ground it is built on, there must be made gentle slopes for the cannon to be drawn up and down, and also for the easier communication of the troops posted there; these slopes, to distinguish them from the slope usually given to elevated works for their better security of standing, are called *Ramps*.

The base of the slopes commonly given to earth-banks for their support, is on the inside about a foot base for a foot of height, and on the outside is about 8 inches on a foot, or $\frac{2}{3}$ of the height; that is, they rise 12 inches, on 8 inches of base. But for the slopes of ramps, the rise is only about 2 inches on 12, or the length of the ramp's base is six times the height, and this is general, for the draught of carriages; but foot-ways need not be of so gentle a slope, a rise of one foot in three may do well enough; or, instead of ramps, stairs may be, and commonly are, used for the passage of the foot.

The breadth of a carriage-ramp is usually about 9 or 10 feet, that breadth being sufficient for the carriage and foot-way beside; but those for foot-passage only need not be above 3 or 4 feet wide.

Ramps may either rise on the side of an elevated work, or against a saliant angle of that work, or on each side of an entering angle: their representations in plans may be expressed as in the following constructions.

52. *To construct a Ramp on the side of a bank.* Plate XV. Fig. 9.

Let XX, ZZ, be lines expressing in a plan the slope of a bank equal to its height, which suppose to be 12 feet.

1st. Through A, the point where the ramp is to end, draw CB perpendicular to XX, and make AC of about 10 feet.

2d. In ZZ take BD=4 times AB, or 16 yards; through D draw AE; and through C draw CF parallel to AE, cutting XX in G, and ZZ in F.

3d. Through F draw, at right angles to GF, the line *f*E, cutting XX in *f*, and AE in E; join BE, and the lines GF, EA, EB express the ramp.

It is sometimes proper to have ramps rise on either hand for the convenience of carriages coming from the right or left; but they must then be so far asunder, that should a carriage be drawing up each at the same time, the horses of one may pass clear of those of the other.

To construct a Ramp in a saliant angle of a bank. Plate XV. Fig. 10.

53. FIRST METHOD. This is done in the same manner as in the side of a bank; observing that the end A is taken 6 or 7 yards from the saliant angle, when a ramp is to be constructed on both sides; otherwise the ramp may end at the saliant angle X.

54. SECOND

Digitized by Google

54. SECOND METHOD. Fig. 11. 1st. From X draw a line XN, bisecting the saliant angle; make XN=6 times the height, or equal to 12 yards, and on both sides draw a parallel line QR at the distance from XN of half the breadth of the way; suppose at 5 feet distance from XN.

2d. Bisect the angle XQR with the line QY, cutting the line ZZ in Y; join YR, and the plan is formed.

55. THIRD METHOD. Fig. 12. From X the saliant angle, with a radius of 6 times the height, suppose of 12 yards, describe the arc IL; and with 5 times the height, or ten yards, describe the arc KK, cutting ZI in O, and draw OP parallel to KL.

Make XM=2 or 3 yards, and draw the curved lines MO, MP, which in plans are best done by hand; or else draw right lines from M to O, and from M to P, and the plan of the ramp is made.

56. *Of Barbets.*

It often happens, that by raising the floor of part of a battery the guns placed on it have an advantageous command over some part of the neighbourhood; and when the guns thus raised fire over the crown of the parapet without any embrasures, it is called an OPEN BATTERY, or *Battery en barbe*, or plainly a BARBET.

These barbets may be made either in a curtin, or at the saliant angle of a flanker. They should always be 2½ or three feet lower than the crown of the parapet, and about 8 or 9 yards broad at the top, with a proper slope to the base, of a length suitable to the number of guns to be mounted on them, allowing about 5 or 6 yards for each, and have a proper *ramp* at each end to ascend them by.

57. To give a farther illustration of this article, here is added an explanation of the plan, and of the profile through the line BC. Plate XV. Fig. 13, 14, 15.

Let PQRVX be a common bank of a line, the parapet of which is RSTV; the inner slope RS being about 6 or 7 feet higher than QR: then the bank *mno*R, raised so high that the cannon can fire over the crown of the parapet ST, is the *barbet*, the height of which *ap* is about 3 or 4 feet.

On the top of the barbet a platform is raised as in other batteries.

Let the fig. 14, 15, represent part of the plan of a line, and one of its flankers or of a battery constructed in such a form; where A*a* is the length of the barbet or raised battery, suited to the number of guns to be used, which are to be drawn up the ramps put at the ends; the breadths being about 8 or 9 feet, and the length *a b* about 7 or 8 yards.

58. *Of Cavaliers.*

A cavalier is a battery raised above the other works, and covered by a parapet with embrasures.

Cavaliers are of various shapes, such as square (Plate XV.) fig. 17, or round, fig. 16, or like a horse-shoe, or a plane line; but when they are constructed in flankers, as is usually the case, fig. 18, they are of a like

Digitized by Google

figure to that flanker; leaving a space of about 8 or 10 yards or more, between the parapet of the flanker and the outline of the cavalier.

They should be faced with earth, or plank of brick, but not with stone; because the splinters knocked off by the enemy's cannon would greatly annoy the troops, that may be posted in the line below the cavalier.

Any other particulars will be sufficiently known from the figures; observing, in the plans, to represent their outside limits by a double line, to express the sloping of the earth, and to put a ramp in the gorge.

59. *Of Traverses.*

A traverse is a bank of earth thrown perpendicularly across a line, or other work, to prevent the enemy's cannon from taking that line.

These traverses may be from 12 to 18 feet thick, in order to be cannon proof, and their height about 6 or 7 feet; or more, if the line is exposed to any eminence from which the enemy has a command.

And to preserve a communication a passage of about 5 or 6 feet wide must be left at one end of the traverse.

60. The different ways of constructing these works are readily seen by the figures in Plate XV. fig. 19, 20, 21, 22.

Thus at A, fig. 19, it is formed by two equal short banks, the ends of which jut one beyond the other about 3 or 4 feet, leaving a passage of about 6 feet.

At B, C, and fig. 20, 21, the end of the traverse juts about 2 or 3 feet into the parapet, beside the passage. But as this greatly weakens the parapet, it is to be practised only in such places where there is sufficient thickness left; where nothing can be spared from the parapet, the traverse may be made as at E and F, fig. 22.

If any part of a work, thus shut in by one or more traverses, is likely to be defended by the musketry, then it is proper to add to the traverse one or more foot-banks within the defence, for the troops to mount on, when they want to fire over the traverse, leaving the upper foot-bank 4½ feet below the crown of the traverse.

61. *Of Palisades.*

Palisades are straight wooden stakes about 9 or 10 feet long and about the thickness of a middle-sized leg, but of a triangular or rectangular shape, according as they are of cleft quartering, or sawed stuff; and have one of their ends pointed. Their use is to form a line before those places, that are most likely to be taken by surprize.

The best are those made of oak, but where this is wanted, or on emergent occasions, the best are those which can most conveniently be procured.

In planting palisades it is usual to sink about three feet of them into the ground, the thick end downwards, and the pointed end upwards, and to set them about four inches from one another; the whole is braced together by pieces nailed across them near the tops, and secured by thick posts at the distance of every four or five yards.

Palisades

Digitized by Google

Palisades are found to be a very good defence against an enemy not greatly superior, and destitute of cannon; for the defendants may freely use their small arms at the time they are half covered by the palisades; whereas the assailants being quite exposed, attack with the disadvantage of at least two to one.

62. *Of Barriers.*

A barrier is a kind of fence or gate serving to shut up the roads or passages in works of any kind, to prevent their being carried by surprize; they are of various kinds; as

1st. A strong chain drawn across the passage, at about 3½ or 4 feet above the ground, and fastened at each end to an upright post.

2d. A beam laid horizontally across two upright posts.

3d. A BAR-GATE hanging by hinges to an upright post.

4th. A CHEVAUX DE FRISE, which is an horizontal beam usually cut with 6 sides, each of which is armed with iron spikes set within five or six inches one of the other. This beam is supported at each end by an upright post.

5th. A TURNSTILE, which consists of two or three pieces of timber framed crosswise, making four or six rays like the spokes of a wheel; this frame is put on a post in the middle of a passage to turn horizontally, so that two of its rays always stretch across the passage, and prevent more than one person at a time from passing the same way.

6th. A HERRISON, which is a chevaux de frise, turning horizontally on a post in the middle of a passage like a turnstile.

7th. KLINKETS are strong doors or gates made like palisades, and are hung and fastened as other gates are.

63. *Of Redoubts.*

A REDOUBT is usually a temporary work thrown up to strengthen the lines which shut up, or secure a *pass*. They are usually figures of three, four, five, or six sides, encompassed with a ditch and a bank of earth.

The bank encompassing such works generally consist of two parts, called *rampart* and *parapet*.

64. The RAMPART is a large bank surrounding a work or place, of a height sufficient to cover the habitable parts of the houses (if any) from a direct fire of the enemy; or to raise the defendants so, as to command the neighbourhood; and of a thickness sufficient to resist the efforts of an enemy's cannon for some time.

65. The PARAPET, or breast-work, is a bank raised on the rampart close to its outer edge, to cover and defend the troops posted behind it, on the rampart.

66. On those sides of the work likely to be attacked, the parapet is cut into embrasures and merlons, of the same size and shape as has been shewn at arts. 35, 46.

Digitized by Google

Against every merlon a *foot-bank* is raised on the inside for the musketry to stand on, when they are to fire over the crown of the parapet.

To every embrasure a platform is to be fitted, either of planks, as shewn in art. 36, or of stone, as described in art. 43.

When these redoubts are intended to defend lines or intrenchments, their faces or fronts should be so placed, that the shot discharged from them may fly directly to the front of those lines; for hereby the enemy may be so galled in flank, as to find it necessary to attack the redoubts, and so either weaken his attack on the lines, or cause him to lose time. But when redoubts are built more particularly to defend the spot on which they stand, their faces must front the places from which they may be battered, and also command the ways by which they may be approached.

67. The inner sides of square redoubts are usually between the limits of 12 yards and 32 yards; and when they are to be defended by musketry, the number of men necessary to the defence may be thus determined.

RULE. *Half the side squared gives the number of troops.*

EXAM. In a square redoubt, one side of which within is 24 yards, required the number of troops necessary for its defence:

Half of 24 is 12: then the square of 12 is 144 for the number of men.

AND, Twice the square root of a given number of men shews the length in yards of the side of a square redoubt proper to contain them.

Thus to contain 100 men, the square root of which number is 10, the side of the square redoubt must be 20 yards.

68. *To construct a square redoubt.* Plate XV. Fig. 23.

1st. Mark out a square, the side of which is adapted to the number of troops allotted for the defence; as AB for the inside of the rampart.

2d. About this square, at the distance of 10 or 12 feet, describe another square, the side of which CD is the inner boundary of the parapet.

3d. Make a parapet about 9 or 10 feet thick, the outline of which is the line EF; leave a berm about 3 or 4 feet broad, the side of which is GH, and dig a ditch about 16 feet wide, and about 6 or 7 feet deep, which let be rounded before the angles of the redoubt.

4th. Make the rampart from 4 feet to 9 or 10 feet high, according to circumstances; let the parapet be 6 or 7 feet higher, and let the foot-bank be $4\frac{1}{2}$ feet lower than the crown of the parapet.

5th. On the side most secure from the enemy make a bridge across the ditch, and a passage through the rampart. The breadth of this way should be about 4 or 5 feet, if the defence is to be by musketry only; but 9 or 10 feet if cannon are to be used; and in either case the passage is to be shut up by a strong gate.

But if the redoubt is to be defended by cannon, both the rampart and parapet should be at least 5 or 6 feet thicker.

69. As

Digitized by Google

69. As it is customary for troops to present their breasts to the parapet, and then fire direct before them, there will be a very considerable space before each angle of the work, that will be in a great measure without any defence. To remedy this defect in these works, it has been proposed to round the inside of the angles of the parapet, and post three or four men there to defend the angle; for more cannot well be applied. But this appearing also defective, Mr. Clairac has shewn an ingenious method to make the fire pretty nearly equal in all parts; which is done by cutting the inside of the parapet into notches, whose two sides, of a yard each, are at right angles to one another, and make half right angles with the sides of the work; the manner of which and its defence, will be plain from fig. 23. where the lines with dots at the ends represent the fire three different ways from the same side.

There are in many Treatises of Fortification directions to make a kind of temporary works called SCONCES, or FIELD-FORTS; some of which being pretty well contrived for defence, will be here explained; but one species of sconces, called STAR-FORTS, are such *wretched baubles*, that nothing more will be mentioned of them here, than that their plans are pretty things to stick on children's kites.

70. *To construct a Flanked Redoubt.* Plate XV. Figs. 24, 25, 26.

Having described the inner figure, where AB is an inner side of the redoubt, suppose of about 18 yards;

Parallel to this figure, at the distance of about four or five yards from it (or more if necessary), describe an outward figure, the sides of which are ED, EF, &c.

Divide each side, as ED, EF, &c. into three equal parts, one of which is EI, EL, &c.; and in these sides prolonged take DG, EH, &c. each equal to one of those three parts.

From the points G, H, &c. thus found, draw the lines of defence to the angles of the outward figure, as HD, &c.

From the points I, L, &c. draw the flanks, IK, LM, &c. perpendicular to the sides, ED, EF, &c. meeting the lines of defence in K, M, &c.

Or, *The flanks may be thus drawn.*

In the line DI continued towards E, take IP equal to twice IE. And from P, as a center with the radius PI, cut the line of defence in K, and draw the flank IK.

Then to each face (HK), flank (KI), and curtin (IG), make a parapet of about 7 feet thick (or more if necessary), which is expressed in the plan by lines drawn at that distance on the inside of the several parts.

Leave a proper berm of about 4 or 5 feet broad, and make a ditch of about 5 or 6 yards wide, the outer line of which, or counterscarp, is to be parallel to the faces and curtins only.

A redoubt thus constructed is more capable of defence than one without flanks: for the curtin IG is well defended by the flank IK; and the face HK has some defence from the part DG.

71. *Of Redans.*

A REDAN is a fortified line broken into several curtins and flanks; the defences of the flanks being all directed one way.

This is a very good work for the defence of any passage, such as a hollow way, a road, a river, or a harbour's entrance.

If the defence is intended chiefly for cannon, the distance of the flanks from one another should not exceed 300 yards, that being about the point-blank flight of a musket shot. But if the defence is chiefly intended for musketry, the distance of the flanks may be about 50 yards or less. In general the distance of the flanks should be regulated according to the number of them intended to be placed within the length of the line. The length of each flank should be about 15 or 18 feet, in order to admit one gun; but if more cannon than one are to be put in a flank, the flanks must be made proportionally longer.

And if the flanks are made about two or three feet lower than the curtins, there will be no danger of the troops posted in the saliant angle of one flank, being hit by those in the entering angle of the flank next behind.

72. *To construct a Redan.*

In the front line take the equal spaces AB, AB, &c. of the length proposed for the distance of the flanks, as suppose 50 yards; draw the perpendiculars AC, BD, of 18 feet each, and draw the faces BC, AD.

From the saliant angles A, B, draw the flanks AE, BF, at right angles to the faces, and the master line AEBFAE will be constructed.

Make a rampart, parapet, and foot-bank; ramps in the curtins, an embrasure in each flank, and as many in each face as convenient.

The thickness of the parapet, if of earth, may be from 9 to 12 feet; but if of masonry, about 4 or 5 feet will do.

SECTION

Digitized by Google

SECTION IV.

Of the Fortifying of Towns.

Towns are fortified by surrounding them with a rampart, moat and outworks.

73. The RAMPART of a town is a large bank of earth surrounding the place, of a height sufficient to cover the habitable parts of the houses from the direct fire of an enemy; and of a thickness sufficient to resist the efforts of his cannon for many days.

The rampart at certain distances, within the reach of musket shot, should have works projecting outwards, either contiguous to the rampart, or detached from it; and these projections are to be so contrived, as to flank or defend one another.

Projecting works contiguous to the ramparts are called *bastions*, and those detached from it are called *outworks*.

74. A BASTION is a projecting work consisting of four lines; namely, of two FACES forming a saliant angle; and of two FLANKS, which join one to the end of each face, and have their other ends joined to the rampart.

75. The CURTIN is that part of the rampart which lies between two bastions.

76. The PARAPET is a breast-work ranging quite round the faces, flanks, and curtins; of a height and strength proper to cover the troops posted on the rampart.

77. The MOAT is a large ditch dug on the outside of the rampart and some outworks, quite round the place; the earth that comes out of it serves to make the ramparts, parapets, and other elevated works.

The SCARP is that border or wall of the moat next the place, and the COUNTERSCARP is the opposite border or wall.

78. The COVERED-WAY is a sort of passage or street running quite round the moat next the counterscarp; and is covered on the side next the country by a bank or parapet.

79. The GLACIS is a gentle slope of earth descending from the parapet of the covered-way towards the country.

The *head of the glacis* is the highest part of it, or the top of the parapet next the covered-way. This part is sometimes called the counterscarp; but the soldiery usually call the covered-way and glacis together the counterscarp.

80. The OUTWORKS, or those detached from the rampart, are of various forms and uses; some to cover the principal parts of the rampart, and to retard the enemy's approaches towards the town, and others to secure those places, which, if neglected, might be of advantage to the besiegers.

Digitized by Google

81. *The names of the principal Parts of the Plan of a Fortress.* Plate XVI.

The figure HFBMN represents the plan of a bastion. Fig. 4.

a g	the thickness of the rampart.
a d	the breadth of the parapet.
m m m	the moat, ditch, or foss.
a a a a	the covered-way.
b b b b	the glacis.

82. *Of the principal Lines.*

The line AB represents the exterior side of the polygon, and LA its radius.

IK	the interior side	and LI its radius.
IA	the capital	CD the normal.
GH	the curtin	AH the line of defence.
GI	the demi-gorge, the breadth HN the gorge.	

The line HF represents the flank } of the bastion.
And BF the face } of the bastion.

83. *Of the principal Angles.*

The angle ALB represents the angle of the center.

∠ AAB	the angle of the polygon, or ∠ of the gorge.
∠ EGH	the angle of the curtin, or ∠ of the flank.
∠ GEA	the angle of the shoulder.
∠ FBM	the angle of the bastion, or flanked angle.
∠ BAH	the diminished angle.
∠ ADB	the exterior flanking angle, or the angle of the tenail.
∠ EHG	the interior flanking angle.
a p a	the angle of the counterscarp.

84. *The names of the principal parts of the Profile of a Fortress.*
Supposed to be taken through the line PR, Fig. 6.

The line A *a* represents the thickness of the rampart at its base.

AR	the inner slope } of the rampart.
BR	the inner height } of the rampart.
BC	the walk } of the rampart.
CD	the slope, and DE the top of the foot-bank.
EF	the inner face or slope } of the parapet.
FG	the top or crown } of the parapet.
QH	the outer slope or front } of the parapet.
HI	the face of the wall, called the scarp.
IK	the breadth of the moat.
KL	the outer wall of the moat, or counterscarp.
LM	the breadth of the covered-way.
MN	the slope, and NO the top of the foot-bank.
OP	the slope of the parapet, or inner face of the glacis.
PQ	the gentle slope, and P the head of the glacis.

Military

Digitized by Google

Military works of defence should be conformable to the principles which have from time to time been collected and established as fundamental propositions; such are the following.

85. GENERAL PRINCIPLES, *usually called* MAXIMS.

I. The plan of every place that is to be fortified, ought first to be circumscribed with one of the most convenient polygonal figures that can be fitted to that place, and this polygon to be fortified.

II. The more regular the circumscribing polygon is, the better.

III. It is a disadvantage to be under a necessity of extending the works about a fortress.

IV. Every side of the polygon, as much as is possible, should be equally fortified; that the enemy may not have it in his choice to attack a part more weak than the rest.

V. All works ought, as much as is possible, to be easy to build, hard to destroy, and not difficult to be repaired.

VI. The works about a fortress should be so contrived as to cover the defendants, discover the approaches of the enemy, and be adapted to the common weapons of defence.

VII. Each work should be defended from as many as may be, and liable to be attacked from as few places as possible.

VIII. These works made to defend one another should be sufficiently large to contain the troops and cannon necessary for that defence.

IX. Works which are to flank one another ought not to be at a greater distance than the point-blank flight of a musket-shot.

X. The works farthest distant from the body of the place should ever be lowest, that they may be commanded by those that are nearer.

XI. None of the works should, if it can be helped, be beyond the point-blank reach of the cannon within the town.

XII. Wet ditches are preferable for small places, dry ones for large places.

XIII. Bastions with large flanks and large gorges are most esteemed.

XIV. The flanked angle of a bastion should not be much less than a right one, but are better when obtuse, not exceeding 120 or 130 degrees.

XV. The faces of bastions should not differ much in length from 100 yards.

XVI. A curtin should not be much longer than 180 yards, nor much shorter than 100 yards.

XVII. The angle of the curtin should be between the limits of 90 and 100 degrees.

XVIII. The point-blank flight of a musket-ball is about 300 yards, or within the limits of 240 and 360 yards; and that of a battering cannon is about 1200 yards.

XIX. Battering cannon will drive a ball 14 or 15 feet into a bank of common earth at a distance of 300 or 400 yards.

From the foregoing maxims constructions have been made for all the regular polygons from four to twelve sides inclusive; and the quantity of the several lines and angles have been obtained from trigonometrical operations; the results of which are contained in the following table.

X 86.

86. *A* Table *shewing the measures of the principal lines and angles in all regular Fortresses from four to twelve sides inclusive.*

Calculated from the exterior side, normal and face being taken as known quantities in yards.

Names of the polygons.	Square.	Pentagon.	Hexagon.	Heptagon.	Octagon.	Nonagon.	Decagon.	Undecagon.	Dodecagon.
The exterior side in yards.	360	360	360	360	360	360	360	360	360
Radius of exterior side in yards.	254,56	306,24	360,00	414,82	470,36	526,28	582,50	638,78	695,46
Interior side in yards.	231,00	247,90	261,26	272,44	280,06	285,86	288,52	292,60	296,20
Radius of interior side in yards.	163,34	210,90	261,26	313,96	365,96	417,86	466,90	519,36	572,14
Capital in yards.	91,22	95,34	98,68	100,96	104,40	108,42	115,60	119,42	123,32
Normal in yards.	45	54	60	64	68	72	78	82	86
Curtin in yards.	156,06	154,22	152,80	151,80	150,54	149,40	147,34	142,90	138,68
Flank in yards.	40,54	48,92	54,54	58,32	62,12	65 92	71 66	73,96	76,18
Face in yards.	100	100	100	100	100	100	100	102	104
Line of defence in yards.	265,96	268,42	270,28	271,62	272,86	274,32	275,46	276,30	276,34
Demigorge in yards.	37,48	46,84	54,26	60,32	64,76	68,24	70,58	74,84	78,76
Angle of the center	90° 00′	72° 00′	60° 00′	51° 26′	45° 00′	40° 00′	36° 00′	32° 44′	30° 00′
Angle of the polygon.	90 00	108 00	120 00	128 34	135 00	140 00	144 00	147 16	150 00
Angle of the curtin.	97 01	98 21	99 13	99 47	100 21	100 54	101 43	102 15	102 46
Angle of the shoulder.	111 03	115 03	117 39	119 21	121 03	122 42	125 09	126 45	128 18
Angle of bastion, or flanked angle.	61 56	74 36	83 08	89 26	93 36	96 24	97 08	98 16	98 56
Diminished angle.	14 02	16 42	18 26	19 34	20 42	21 48	23 26	24 30	25 32
Exterior flanking angle.	151 56	146 36	143 08	140 52	138 36	136 24	133 08	131 00	128 56
Breadth of the foss, in yards.	30 yds.	30 yds.	36 yds.	40 yds.	40 yds.	40 yds.	42 yds.	44 yds.	46 yds.

By the help of this table, every thing relative to the master-line of any of these fortresses is readily constructed.

87. PROBLEM I.

To describe any of the polygons in the table.

FIRST. *To construct a polygon in a circle.* Plate XVI. Fig. 1.

1st. With the exterior radius of the given polygon describe a circle.

2d. Apply the exterior side equal to 360 yards within the circumference of that circle, from A to B, B to C, C to D, &c. as many times as the proposed polygon has sides.

3d. Draw the lines AB, BC, CD, &c. and the polygon will be constructed.

88. SECONDLY. *To construct a polygon upon the exterior side.* Plate XVI. Fig. 2.

1st. Draw the exterior side AB equal to 360 yards.

2d. At the ends A, B, make angles equal to the angle of the polygon, and in that position draw the lines AE, BC, each of the length of AB.

3d. At the points E, C, make angles as before, and in those positions draw the lines ED, CD, each of the same length as AB.

And thus proceed until the polygon is constructed.

Note, The two last lines may be found by describing intersecting arcs D, with the radius AB, from the centers E and C.

89. PROBLEM II.

To fortify any regular polygon in the table.
Or, To draw the MASTER-LINE of a regular fortress.

FIRST. *From the exterior side.* Plate XVI. Fig. 3.

1st. Make the exterior side AB equal to 360 yards, and find its middle C.

2d. Draw CD at right angles to AB, and make CD equal to the normal.

3d. Through D draw the lines of defence ADH, BDG.

4th. Make the faces AE, BF, each of their proper lengths.

5th. Transfer the distance FE from F to G, and from E to H.

6th. Draw the curtin GH, and the flanks EG, FH.

This work being done for every front or side, the master-line of the fortress will be described.

This method is most fit, when the master-line is to be laid down on a place where there were no works before.

90. SECONDLY. *To fortify from the curtin.* Fig. 3.

1st. Make the curtin GH of its proper length, for the given polygon.

2d. Make the angles of the curtin HGE, GHF, as in the table.

3d. In the lines GE, HF, take the flanks GE, HF, of their proper length.

4th. Make the angles of the shoulders GEA, HFB, as in the table.

5th. Make the faces FB, EA, of their proper lengths.

This

This method is proper to be used when a piece of an old fortification is to serve for a curtin to save expence.

91. THIRDLY. *To fortify from the interior side.* Fig. 3.

1st. Make the interior side IK of the length given in the table for the proposed polygon.

2d. From each end set off its proper demigorge KH and GI.

3d. On K and I as centers, with the extent of the capital, as in the table, describe arcs at B and A.

4th. On H and G as centers, with the length of the line of defence, as in the table, cut the former arcs in A and B.

5th. Draw the lines AH, BG; in which take the faces AE, BF, and draw the flanks EG, FH.

This method is useful when modern ramparts and bastions are to be annexed to simple walls surrounding a place.

In either of the above methods, the work here described for one front is to be applied to every front of the polygon; and it is recommended to the learner, that he apply the precepts given for one front to a complete polygon; and should a frequent repetition of these operations to a whole polygon become disagreeable, they may be done only on two fronts, which may be thus drawn.

Draw a capital line AL; make the angles LAB, LAA, each equal to half the angle of the polygon; and make the sides AB, AA, each equal to 360 yards.

92. PROBLEM III.

To construct the plan of a bastion. Plate XVI. Fig. 4.

1st. Draw a capital line BK, and make the angles MBK, FBK, each equal to half the flanked angle.

2d. Take the lines BF, BM, each of the length of the face.

3d. At the points F, M, make the angles of the shoulder BFH, BMN.

4th. Make the lines FH, MN, each of the length of the flank.

5th. At the points H, N, make the angles FHG, MN*a*, equal to the angle of the curtin, and draw the pieces of the curtin HG, N*a*.

This problem may be found useful on many occasions; particularly when the drawings of works in a bastion are to be represented with that bastion only, on a large scale, therefore it was here introduced, more especially for beginners, who are apt to be somewhat puzzled about constructing part of a work, independent of the whole.

93. PROBLEM IV.

The master-line of a fortress being given; to draw the plan of the rampart. Plate XVI. Fig. 5.

1st. Draw the lines *a g* perpendicular to each face, flank and curtin.

2d. In each of the lines *a g* take *a g* = 24 yards, *a b* = 20 yards.
a c = 8 yards, *a d* = 6 yards.

3d. Through

3d. Through the points *d*, *c*, *b*, *g*, draw lines parallel to the master-line; that is, to each face, flank, and curtin, intersecting one another.

Then the breadth of the rampart is represented	by $ag=24$ yards.
of the parapet	by $ad=6$ yards.
of the foot-bank	by $dc=2$ yards.
of the walk of the rampart	by $cb=12$ yards,
And of the slope of the rampart	by $bg=4$ yards.

The breadths of these parts of the ramparts are sometimes different, according to the quality of the earth, or other materials the work is to be built with.

Sometimes the bastions are made solid; that is, the rampart fills up the whole space contained within the faces, flanks, and neck. The plans of such are represented by continuing the pair of lines *b g*, forming the inner slope of the rampart, against the adjacent curtins, till they meet the capital in the breast of the bastion, as at R; but then this pair of lines is to be omitted against the flanks and faces of such bastions.

In plans drawn from a large scale it is usual to express the outside slope of the rampart by a pair of lines; that is, by drawing a parallel to the master-line about five or six feet distant from it on the outside.

The master-line is to be drawn the thickest; the inside of the parapet something finer; and the other lines as fine as they can be drawn.

94. Before any of the lines are drawn in ink (for it should be remarked that every thing is first to be drawn in black lead pencil), let the ramps be put in the inner slope of the rampart (52); the embrasures in the parapets of the flanks (46); the barbets in the saliant angles of the bastions, fig. 6. with their ramps (56); and the cavaliers, if any are to be, in the solid bastions, fig. 7. with their ramps and embrasures (58).

All these several parts being laid down with black lead pencil, let the lines be neatly drawn with Indian ink, taking care not to draw them beyond their proper terminations; for wherever superfluous ink lines are scraped off, the plans will never look well when they come to be washed with any colour.

When the plan is to be washed, that is, coloured with tints of Indian ink or other colours, leave the lower line of the inner slope of the rampart in lead pencil, which will make it appear softer when the drawing is cleaned off.

REMARKS.

95. In the middle of bastions, fig. 8. it is usual to build magazines for the stores of powder, bombs, and other fire-works, and also for the provisions for the troops, and lodging. For in these places they are not only more out of the way of doing damage to the town on an accident of blowing up, but they are also nearer at hand to be transported to the several works where they may be wanted; and here the troops may securely take their rest when relieved from duty.

These

Digitized by Google

These magazines are usually built about 20 yards long by 12 broad in the clear, and about 8 feet high in the upright, besides the rise of the semicircular vault: the side walls are about 8 or 9 feet thick at the foundations, and about 8 at top; the end walls about 5 at bottom and 4 at top: and that they may be bomb proof, the work is about three feet thick in the *reins*, or just above the springing of the arch, and eight or nine feet thick in the crown or top; this is effected by building the roof sloping on the outside, like the roof of a house.

These buildings are sometimes strengthened on each side by buttresses 6 feet by 4; and in each side wall there should be left in the solidity of the wall vent-holes to air the magazine: these vents wind round a kind of shaft of about a foot square. In each gable end, a small window is made to give light.

96. Magazines may be either in hollow or solid bastions; care being taken in the latter to leave an area about their walls, if the place is subject to damps. There are those, who would have the magazines at the foot of the rampart along the curtins, in order (as they say) that the bastion, by being left clear, may be disputed witb the enemy inch by inch at last; but as there are very few examples, since the modern practice of war, of such extraordinary resolution in the defendants after a breach is made, the reasons for having the bastions thus unincumbered with buildings, are rather ideal than real, and consequently can have but little weight. However, when the ditch furnishes earth enough, or it can be otherwise easily had, it has been the practice of the most celebrated engineers to make full bastions, especially if they were small and had narrow necks.

97. In the saliant angles of bastions, fig. 7. such as the flanked angle, and the angles of the shoulders, it is usual to make little centry-boxes of wood or stone, to secure the centinels from the inclemency of the weather and random shot. They are furnished in the sides with loop-holes, to see what is doing in the ditch and covered-way, and also to fire through on occasion.

The plans of these centry-boxes may be either square, round, or pentagonal, and their floors are on a level with the walk of the rampart; their communication is by a passage of about 3 feet wide, bricked on each side, cut through the parapet.

The centry-boxes built of stone are usually ornamented with mouldings, and the arms of the prince or state.

98. PROBLEM V.

The master-line of a fortress being given, to draw the plan of the foss and esplanade. Plate XVI. fig. 4.

1st. On the flanked angle B of each bastion, with the radius BC equal to the breadth of the foss, found in the table, describe an arc CC.

2d. Lay a ruler to touch each arc at C, and the angle E of the nearest shoulder of the next bastion, and in that direction draw the lines C*p*, meeting one another in *p*.

3d. From the flanked angle of each bastion draw lines B*q* at right angles to C*p*.

4th. In

Digitized by Google

4th. In each of the lines B *q*, take C *a* = 10 yards (Fig. 4.)
C *o* = 12 yards, and C *q* = 60 yards.

5th. Through the points, *a*, *o*, *q*, draw lines parallel to C *p*, meeting before the middles of the curtins at C and *t* (Fig. 3), and before the flanked angle of the bastions in *v*, *x*, *y*,.

Then will B C represent the breadth of the foss.

	C *q*	of the esplanade.
	C *o*	of the covered-way.
	a o	of the foot-bank.
	o q	of the glacis.
The arcs	C C represent	the roundings of the foss.
The lines	C *p*	the counterscarp.
	x C	the head of the glacis.
	x y	the ridges of the glacis.
	s t	the vallies of the glacis.
And	*y t*	the foot of the glacis.

The head of the glacis is to be drawn strong, and all the other lines are to be fine.

99. When the plan is to be washed, if the foot of the glacis be drawn in lead pencil only, the termination of the glacis, or its concourse with the adjoining lands, will appear more soft and neat.

In the colouring of the glacis it is usual first to lay a very light tint of colour over every plane, and then to strengthen the colour on every second plane, beginning at any saliant angle; the strongest tint to be next the head of the glacis, and to be washed gradually off; so that the limits of the lightest shade shall lie in a diagonal line from the foot of the glacis at a ridge, to the head of the valley, as from *y* to *s*.

Give a light touch of the pencil or brush, with a middling tint of Indian ink, along the inside of the line, denoting the foot-bank.

Wash the borders of the ditch near the scarp and counterscarp, softening the edge of the colour with a brush wet with fair water; in wet ditches the colour used is distilled verdigrise; but in dry ditches use bister.

The parapet is generally coloured with a middling tint of Indian ink.

100. By this method of drawing the counterscarp, all the foss is seen from the flanks, and consequently is defended by them; which must be more advantageous than if the counterscarp was directed to any other part of the flank, the intercepted part next the shoulder being by it rendered useless for the defence of the ditch; nevertheless, if it were on any account necessary, the direction of the wall of the ditch may point within the shoulder by the thickness of the parapet of the face, and still the foss would have the whole defence of the flank.

101. Fortifications in general would be very defective without fosses: for the wall or rampart need not be raised so high when there is a ditch, as they must be without one, to secure the place from surprizes by scaling, &c. Neither is a low wall so much exposed as a high one is in the modern methods of attack. Besides, a place is not so liable to the attempts of a surprize with a foss, as it would be without one; for the enemy, if discovered, may easily retreat while he is on a level with the country, which he would find some difficulty in doing from the bottom of a deep foss bounded

Digitized by Google

bounded by walls or banks nearly upright. Add to these, that the earth taken out of the ditch serves to make the ramparts, parapets, glacis, &c.

102. It may appear to some persons, that the broader and deeper a foss is, the better, as it would throw more difficulties in the way of the besiegers when they wanted to pass it; but some advantages are best waved, when, by taking them, greater disadvantages would ensue. For beside the great expence that the digging and removing so much earth would occasion, the enemy might see the foot of the wall at a greater distance in a broad ditch; and in a deep one, the cannon of the flanks could not dip low enough to defend the bottom. And on the whole, if the foss by its magnitude furnished more earth than was wanted, some inconvenience might arise in the disposing of the overplus.

103. Those fosses are best, which can be filled with water and drained at pleasure by the help of sluices or floodgates; because all the advantages that may be reaped either from a wet or dry foss, are by these means obtained: but as these cannot be had every where, the ditch must be adapted to the situation of the place.

In dry fosses a row of palisades is sometimes planted along the middle, either upright, or sloping towards the counterscarp 20° or 30° from the upright.

In some dry fosses, where water can be had, a trench called Cuvette *n n* (Fig. 12.) is dug along the middle, of about 12 or 15 feet wide and 6 feet deep, for the water to run in.

The breadth of the foss, although unequal in itself, is reckoned from the flanked angles, before which it is always rounded; the depth here may be from 15 to 20 feet, and thence rise gradually to the middle of the curtin where the depth is 4 or 5 feet less.

Of Gates.

104. A Gate, in a fortified place, is a passage through the rampart, which can be shut up or opened by the means of *doors* and a *portcullis*.

105. A Portcullis is either a Herse consisting of strong pieces of timber framed like a lattice, the lower ends of the upright pieces being shod with pointed iron, and the whole frame let down by chains or ropes: or Orgues, consisting of several long pieces of timber not framed together; each hanging by its particular rope or chain, the ends of which are wound round a windlass which lets them all down together.

The use of a portcullis is to stop the gateway in case of a surprize; and in this, the orgues are by much the best contrivance; for a herse may be broken to pieces by a *petard*, or by cannon shot: but should a beam in the orgues be struck off in the middle, the upper part will descend to supply the place of the part taken away.

Gates are either public or private.

106. Private or Postern gates are those passages through the rampart by which the troops can go out of the town unseen by the enemy, when they pass to and from the relief of the duty in the outworks; or on any other occasion which is to be concealed from the besiegers.

107. Pub-

107. PUBLIC GATES are the paſſages through the middles of the curtins, to which the great roads or public ways lead.

They are put in the middles of curtins, as being the beſt defended place in the out-line of the rampart.

The dimenſions of a public gateway are uſually about 13 or 14 feet high, and 9 or 10 feet wide, continued through the rampart with proper receſſes for the foot-paſſengers to ſtand in while the wheel-carriages paſs on. It is uſual to ornament the front of the gateway on the outſide with architecture either of the Tuſcan or Doric order, and to cover the paſſage with a ſtrong vault. Over the vault, cloſe to the town-wall, is erected a building of about 18 or 20 feet ſquare, in which is ſuſpended the portcullis; and on the inſide of the rampart there is generally raiſed another building, of about 100 feet in front and 30 deep, and high enough to contain one or two floors of rooms for one of the town-officers, the ground floor ſerving for guard-rooms for the troops who are on duty at the gates.

108. *To conſtruct the Plan of a Gate with the adjoining Buildings.* Pl. XVI. Fig. 9.

Let the line *ac* repreſent the thickneſs of the baſe of the rampart, and the middle line of the gateway; in which take theſe meaſures in feet: $af=4\frac{1}{2}$; $fr=6$; $rh=18$; $ci=30$; and $cm=15$: through theſe points, lines being drawn parallel to the curtin, take $fd=4\frac{1}{2}$; $fb=14$; $rg=9$; $ck=50$; and $kl=6$ feet, and complete the figure.

Then *bg* repreſents the plan of the frontiſpiece; *gh* of the portcullis room; *ik* of the arcade or guard-houſe; and *lk* is the breadth of the ſtairs to aſcend the rampart.

The plan, to which theſe directions refer, is on the right-hand ſide of the plate.

109. *Of the diſpoſition of the Streets and Buildings in a Fortreſs.*

When a new town is built and fortified, and all that relates to the rampart is fixed with regard to ſituation and ſize; then the plan of the ſtreets is to be conſidered; and here ſome authors have thought it convenient to adapt the poſition of the ſtreets to the climate the town is built in.

Thus in hot climates, they would have the ſtreets run NE. and SW.; NW. and SE.; for then the ſtreets will be ſhaded by the houſes from the mid-day ſun. In this manner *New Briſac*, part of *Malta*, and ſome other regular built towns are laid out. But in cold climates, they adviſe to place the ſtreets ſo as to run north and ſouth, eaſt and weſt, in order to have as much ſun heat as can be.

110. *To deſign a Plan of the Streets and Buildings.*

About the middle I. of the town deſcribe a ſquare, the ſides of which ſhall be parallel to the poſition of the ſtreets (already determined); this ſquare is called the great place of arms, and the ſize of it ſhould be pro-

Digitized by Google

portioned to that of the town, and to the number of troops designed for its defence. Thus in a square, make the side of the place of arms about 90 yards; in a pentagon, about 100; a hexagon, 120; a heptagon, 140; an octagon, about 160 yards, &c. In this place of arms the troops parade, or are assembled for their daily exercise.

In the continuation of each side of the square draw streets about 10 yards wide; likewise through the middle of each side draw a street about 12 yards broad; cross these streets perpendicularly with others about 8 yards wide; make the parallel distance of these cross streets about 40 yards, and continue all the lines to the rampart.

It is not necessary, that the middle streets going from the great place of arms L should terminate directly against the gate E, fig. 9. But it is somewhat more convenient, when the circumstances of the place will admit it to be so.

Make streets about 10 or 12 yards wide, parallel to the curtins, and bounded on one side by the rampart. About 15 yards distant from this street, within, draw another street about 9 yards wide. In the space H between these two streets, the barracks for lodging the officers and soldiers are built; and in the street next the rampart the piles of shot and bombs are sometimes placed.

The length of the plan of a barrack before a curtin is about 140 or 180 yards, and the plan of a pavilion I for the officers may be about 25 yards long by 16 or 18 yards broad.

Against those curtins where the public gates E are placed, the barracks are discontinued for about 40 yards on each side the gate, making an area about 80 yards long, and 36 broad, which serves for a lesser place of arms, where the guards of a gate-way draw up in case of a surprize: this area is also useful for the carriages that are going out to stop in, until those on the bridge coming in have entered the gate. In figures of 4, 5, or 6 sides this area is less.

The extremities I of the barracks next the gates and bastions are usually assigned for the officers pavilions, being the most airy places.

III. Of the rectangular plats made by the intersections of the streets, the most conveniently situated ones are to be chosen for the public buildings; such as the arsenal, church, town-house, market, house for the governor, and for the other chief officers in the service of the state; and on the remaining plats houses are built for the burghers.

Beside the guard-houses of the gates there should be others made on the ramparts for the centinels appointed for the night watch; these guard-chambers are often placed at the centers of the necks of bastions, when in those places there are no cavaliers or magazines of powder. They are also well disposed, when set on the middles of these curtins where there are no public gates, especially when there is a water-gate through which runs a canal or river.

The arsenal should be erected in a place the least liable to accidents of fire; and if there is a conveniency of water-carriage in the town, the arsenal should be placed as near the water as may be.

There are no general rules to be given for fixing the places on which the public buildings are to be erected, because the circumstances by which engineers regulate their plans are various. Therefore in the figure re-

Digitized by Google

referred to, which is a regular pentagon fortified in the common way, the ſtreets and buildings are laid out in imitation of their diſpoſition in *New Briſac*; which being in general eſteem is uſually propoſed as a pattern for beginners.

There are many writers on this ſubject, who propoſe to make the great place of arms, or parade, ſimilar to the figure of the town when regular; and from the angles and ſides of this parade, draw ſtreets to the middle of the baſtions and curtins; but as this diſpoſition ſpoils moſt of the corner houſes in the town by making the walls at oblique angles to one another, it was thought ſufficient barely to mention ſuch conſtructions.

Of Bridges.

112. The paſſage over the moats of fortified places is by bridges, moſt commonly made of timber, and ſupported by frames riſing from the bottom of the ditch: ſuch bridges are either *private* or *public*.

PRIVATE BRIDGES ſerve for the eaſy communication between the town and the outworks.

PUBLIC BRIDGES are thoſe by which carriages and paſſengers go over when they come into or depart from the town.

Bridges conſiſt of two parts, namely, the *fixed* and *moveable*.

The FIXED or DORMANT parts of a bridge are thoſe parts, which are ſtrongly joined to the ſupporting piers; and are never moved but in the caſes of repairs, or during a ſiege.

The MOVEABLE or DRAW-BRIDGE is a floor of timber framed together, one end of which ſerves as an axis, by which the other end may be drawn up or let down by ſome eaſy contrivance: the moſt common way is by a kind of balance called *plyers*.

The PLYERS are two timber levers about twice the length of the bridge they lift, and joined together by other timbers framed in the form of a St. Andrew's croſs, which ſerves as a counterpoiſe. The plyers are ſupported by two upright jaumbs, on which they ſwing; and the draw-bridge is raiſed or let down by the means of chains joined at the ends of the plyers and bridge.

The breadth of a public bridge is uſually about 16 feet, including the rails and footway of about 3 feet on each ſide: but the breadth of the draw-bridge is only 9 or 10 feet, and its length about 15 feet.

A draw-bridge is generally placed cloſe to the gate, whether it be the gate of the town or that of an outwork; and is then by the means of the plyers drawn up againſt the gate. But when a bridge is more than 40 yards long, it is uſual, beſide the draw-bridge at the gate, to put another about the middle of the bridge.

113. *To draw a Bridge in the Plan of a Fortreſs.*

Before the gates draw four lines acroſs the ditch, making three intervals or ſpaces, the middle one being 10 feet broad, and the ſpace on each ſide three feet.

 Divide

Digitized by Google

Divide the length of the bridge into parts of about 16 feet long each, to expreſs the diſtance between pier and pier, or the bays of building; and againſt each diviſion, on the outſide of the lines, make a ſquare of a foot, to expreſs the ends of the piers ſupporting the bridge.

Allow the bay next the gate for a draw-bridge; and if the length of the bridge exceeds 40 yards, allow the middle bay for another draw-bridge. Theſe are to be diſtinguiſhed by drawing two diagonals acroſs the middle interval of theſe bays, that of the other bays having lines drawn acroſs them at a ſmall diſtance from one another, and the ſpace on each ſide left white for the footway; which is to be broken off at each draw-bridge. See figs. 13, 15. Plate XVI.

114. *Of the Orillon and Retired Flank.*

When the beſiegers of a fortreſs have made a breach in the face of a baſtion ſufficiently perfect, and have every thing ready for the ſtorm, they croſs the ditch to the attack, if the beſieged will ſuffer it to be brought on. In this attack, the fire from the flanks is the moſt effectual defence; and cannon placed there, loaded with grape or caſe-ſhot, would do great execution. But of this the beſiegers are well aware, and therefore take care before-hand to diſmount all the cannon flanking their intended paſſage of the foſs; and as this cannot be well prevented by the beſieged, eſpecially when the flanks are plain ones, ſeveral of the moſt eminent engineers have propoſed, and actually built part of the flanks retired behind the ordinary limits, leaving at the ſhoulder of the baſtion a maſs of earth, commonly called an Orillon, which is to ſerve as a ſkreen between the enemy's direct fire and a part of the flank. In this covered part is reſerved one or two cannon, to be uſed only in the defence of the breach in the face of the next baſtion.

This notion of covering part of the flank is almoſt as old as the modern method of fortification.

115. *To conſtruct the Orillon and Retired Flank.* Plate XVI. Fig. 10.

1ſt. At right angles to the face A S, draw from the angle of the ſhoulder the line *s b* equal to 8 or 9 yards, and make *b* the center of the arc *s a*, forming the *orillon*.

2d. From a point *z*, in the face of the next baſtion, fig. 6, about 15 yards from the point A, draw through *a* a line *z m*; in which, and alſo in the line of defence A *r* produced, take the *briſures* or *breaks a m* and *r n*, each 10 yards.

3d. From *m* and *n*, with the radius *m n*, deſcribe arcs cutting in *d*, which make the center of the arc *m n*, or *concave flank*.

4th. In *d m* produced, which ſerves as the termination at this end, lay the ſeveral breadths of the parts of the rampart; as the parapet=6 yards, foot-bank=2 yards, walk=12 yards, and the ſlope=4 yards; then from the center *d*, through thoſe points, deſcribe arcs, meeting the parapet, foot-bank, and rampart lines of the *briſure*, theſe being in the continuation of the like lines drawn within the face of the next baſtion.

The

Digitized by Google

The parapet of the orillon is drawn parallel to s *a* at 6 yards diſtance.

The axis or middle line of each uncovered embraſure in the flank, ſhould tend toward a point about the middle of the foſs oppoſite the flanked angle of the next baſtion.

The wall in the upper briſure *a m*, as it cannot be battered, need not be above 2 or 3 feet thick to ſupport the earth behind it.

Through this wall there ſhould be a ſally-port coming out at the bottom of the foſs if a dry one, or a little above the water line in a wet foſs. The deſcent to this port is by a paſſage under the rampart of the flank; but in ſtraight flanks the ſally-port is in the curtin next the angle of the flank, the paſſage to it being under the rampart of the curtin.

The entrance into theſe ſally-ports is marked on the inner ſlope of the rampart againſt the letters *v*.

116. *Of Double Flanks.*

The progreſs of the works of the beſiegers generally depends on their having a greater army than is in the town beſieged, and of forming a greater fire on the town than it can return; therefore ſome engineers have endeavoured to hinder the progreſs of the beſiegers batteries, by furniſhing the town with an equal, or rather a ſuperior fire; and this has been propoſed to be effected by making ſecond and third flanks, one behind another, gradually more elevated than thoſe before. For as it is found convenient to ſilence the fire of the flanks, before the beſiegers can avail themſelves of the breach they make in the face of the baſtion; batteries are made againſt the flanks, and kept playing at the ſame time with thoſe againſt the faces. Now the batteries for the ruin of the flanks can be conveniently made only within 10 or 12 yards of the head of the glacis, and their length not greater than about 40 yards, containing at moſt about 6 or 7 cannon. But if the beſieged can by any artifice preſerve the cannon in the oppoſite flank, and have a greater number there than are in the battery oppoſed, their fire will of courſe be ſuperior, and ruin the battery intended to offend them; and this was expected to be accompliſhed by *double*, or *cazemated flanks*.

In ſome places two or three tier of cannon were placed one above the other, the upper ones being ſupported by vaulted work, as in the Tower of London; but ſuch having been found very inconvenient, on account of the great ſmother contained in the vaults, they have been generally conſtructed open.

The cazemated flanks have been condemned by many writers, becauſe they may be rendered uſeleſs by the enemy's bombs; were this objection juſt, it would hold againſt any ſmall work; for the beſiegers having once got the length to any place, may render that place alſo uſeleſs to the beſieged; and it would thence follow, that it were beſt not to have any places of defence. But as the utility of ſuch works has been commended by ſome of the moſt eminent engineers, it was judged proper to mention here how theſe flanks may be conſtructed.

Digitized by Google

SECTION V.

117. *Of Works for the Defence of the Fofs.*

Such works are ufually called *tenails*, or *ramfhorns*, or *caponiers*.

A Tenail is a work raifed in the ditch before the curtin upon the lines of defence.

A Ramshorn is a curved tenail raifed in the fofs before the flanks, and prefenting its convexity to the covered-way.

A Caponier is a kind of covered-way or gallery acrofs a dry ditch before the middle of the curtin; and limited between the lines of defence and the counterfcarp.

The *tenails* never rife above the common ground level, but are frequently two or three feet lower: they confift of a rampart of about 12 or 15 yards thick, covered by a parapet of cannon proof, with one or two foot-banks. Thefe works are placed at fuch a diftance from the curtins and flanks, that the fplinters of ftone knocked off them by the befiegers cannon may not hurt the troops pofted there to flank the enemy in their paffage of the fofs; which is the principal ufe they are made for.

The *caponier* is of like ufe, but is ufually funk about two or three feet lower than the bottom of the fofs. It is about two or three yards broad, and is covered by a parapet about 6 feet high on each fide, which flopes away like a glacis about 15 yards broad. It is frequently covered by a roof made with hurdles, to fuftain a floor of earth about a foot thick, and the whole fupported with thick planks mufket-proof, with convenient loop-holes for the defendants to fire through.

118. *To conftruct Tenails.* Plate XVI.

Firft fort with flanks, Fig. 11. Parallel to the curtins and flanks, draw the lines *e g* at 4 or 5 yards diftance, and E *e*, G *g*, at 10 yards diftance: from F, and D, the middles of CG, CE, draw the flanks F *f*, D *d*, at right angles to the lines of defence A *g*, B *e*; draw the curtin *df*, and put in the rampart, parapet, and foot-bank.

Second fort with faces only, Fig. 12. Take the diftances from the curtin and flanks, the fame as before; and to the lines of defence annex the rampart and parapet.

Third fort with faces and curtin, Fig. 3. When the lines of defence crofs one another in D, fo near the curtin that there is not room for the thicknefs of the rampart and its diftance from the curtin, make the face *a b*, *c d*, each of $\frac{2}{3}$ of *a* D, and draw the curtin *d b*.

119. *To conftruct a Caponier.* Fig. 12.

From the exterior flanking angle D draw a line D *p* to the angle of the counterfcarp *p*; on each fide of D *p* draw parallel lines, at the diftances of $1\frac{1}{2}$, $2\frac{1}{2}$, and 15 yards from D *p*; thefe lines being limited by the lines of defence and counterfcarp, form the caponier.

This work, which can be ufed only in a dry ditch, ferves, befides its defence of the fofs, for a convenient paffage between the town and its outworks; and in this cafe there is ufually a circular excavation made in the

the angle of the counterscarp, out of which the troops may defile without being seen by the enemy.

120. *To construct a Ramshorn.* Plate XVI. Fig. 13.

A line D*a* drawn from D, the angle of the shoulder, at right angles to the line of defence, its intersection *a* with BI, the other line of defence continued, gives the center *a*; from which, with the radius *a*D, describe the outline AC of the ramshorn, CD being equal to 10 yards; and annex a parapet, foot-bank, and walk, as in the other tenails.

This work seems preferable to either of the other tenails, both on account of its simplicity, and the defence for which it is constructed.

SECTION VI.

Of Outworks.

121. OUTWORKS are all those works advanced beyond the foss, serving to augment the defence of the town, to cover the gates, bridges, and other weak parts; to enclose those eminences, not too far distant, which command the town; to surround and defend the suburbs, if any; and, in fine, to throw so many difficulties in the way of the besiegers, that, by the length of the siege, the enemy may waste both his time and troops; besides, such protraction frequently affords an opportunity of obliging him to raise the siege, either by the approach of a relieving army, or by the setting in of a season unfit for military business.

The outworks recorded by engineers are various, such as *ravelins*, *half-moons*, *lunettes*, *counterguards*, *horn works*, *crown works*, *tenails*, and several others. But many of them having been found defective, are now disused in all new works and alterations; and therefore those only which are now in most esteem will be here treated of, referring the more inquisitive readers to the writings of *Mallet*, *Dedier*, *Le Blond*, *Muller*, and others.

122. The constructions of outworks depend on much the same principles as those of the place itself; to which may be added,

1st. Every part of an outwork ought to be flanked or defended either from some neighbouring work, or from the town itself; that the enemy may not find any place of real shelter among the outworks, without being at the labour of throwing up a covering for himself.

2d. As the chief defence depends on the musket, the parts mutually flanking one another ought to be within the ordinary reach of that weapon; that is, not exceeding about 300 yards.

3d. Every outwork ought to be commanded from the town; and therefore the more advanced works are ever to be the lowest. The gradation usually observed from work to work is about three feet; that is, the rampart of all works advanced before a place gradually diminish three feet in height from the rampart of that place; thus if the town ramparts are 18 feet high, the rampart of the next outwork is 15 feet high, that of the work next advanced is 12 feet, and so on; thus the more advanced outworks are commanded by those next within.

4th. The

Digitized by Google

4th. The flanked angle of an outwork ought not to be less than 60 degrees.

5th. Each outwork should be surrounded with a ditch communicating with the foss of the town. When all the ditches can be filled with water, they ought to be equally deep; but when that cannot be obtained, the ditches of outworks should be shallower than that of the town; by which means the front of the outworks will be better defended from the parts which flank them. These ditches are usually from about 20 to 24 yards broad, and rounded to that breadth before the saliant angles, with the counterscarps parallel to the faces or outlines of the work they encompass.

6th. The parapets of outworks are to be equally strong and high with those of the town, as they are to be cannon proof, and to cover the troops posted on the ramparts of those works. So that it is usual to make the parapets of outworks of about 18 feet thick, 6 or $6\frac{1}{2}$ feet high, with a foot-bank $4\frac{1}{2}$ feet lower than the crown or crest of the parapet; and the walk of the rampart about seven or eight yards broad, with a slope within of about once and a half its height.

When the plan of a fortification is to be drawn, in which are outworks, the counterscarp of the great foss is to remain in black-lead pencil, until the outworks are annexed in pencil also, with their fosses; then the covered way and glacis are to be drawn surrounding the fosses of all the works.

123. *Of the Ravelin.* Plate XVI. Figs. 14, 15, 16, 17.

A Ravelin is a work made before a curtin, serving to cover it and the adjoining flanks from the direct fire of an enemy. It is composed of two faces, AB, AC (fig. 14), and the two demigorges *p* B, *p* C, taken on the counterscarp.

To construct a ravelin. In a line drawn at right angles to the curtin through its middle, take the capital *p* A equal to about 100 yards, and draw the faces AB, AC, directed to points in the faces of the next bastions, about 10 yards distance from M, the angle of the shoulder.

In this work put a rampart of about 16 or 20 yards, and a parapet of about 6 yards; and before the faces put a foss of about 24 yards wide, rounded before the saliant angle A; also annex ramps in the slope of the rampart, and, if proper, construct a barbet in the saliant angle.

The gorge of the ravelin, or the part next the town, is left open, without any rampart; because the enemy cannot attack it there; and also, that it may be entirely commanded from the ramparts of the town.

REMARKS.

124. It is proper to make a ravelin before every curtin, as the flanks are by these means covered from the enemy, and cannot well be ruined before he is master of the ravelin; without which, he would have it in his power to batter the flanks from the counterscarp, both from before the curtin and the face of the bastion; the latter of these being the only place he can do it from, when a ravelin is interposed, of which he is not master.

Digitized by Google

master. But the difficulty of erecting a battery on the head of the glacis against the face of a bastion, is rather too great to be undertaken, while the place is defended by the whole fire of the adjacent face of the ravelin; and therefore the besiegers can scarcely hurt the flanks before they have taken the ravelin; consequently such works greatly augment the defence of a town.

125. As the face and foss of a ravelin is defended by part of the face of the opposite bastion; therefore the faces of the ravelin should be directed somewhat within the angle of the shoulder, at least as much as the breadth of the parapet and foot-bank of the flank; besides, by this construction they cover the flanks more effectually, which is one of the principal things wanted, as the flanks are of most importance, and to be preserved the longest.

126. In wet ditches, where the troops pass from the town to the ravelin in boats, it is proper to make a kind of harbour in the gorge of the ravelin, where the boats may lie covered from the fire of the enemy; and this may be done various ways: One is, by making an excavation limited by an arc described from A (fig. 15), the angle of the counterscarp, with a radius of about 20 yards. In dry fosses, it is proper to have either ramps or stairs in the gorge of the ravelin, to preserve a free communication, should the bridges be broken by the enemy's shot.

127. In some ravelins, (fig. 16) there is constructed a kind of *redoubt*, or KEEP, which is a small work similar to the ravelin, with a ditch of about 10 or 12 yards wide. The capital may be about 30 or 40 yards; and the work covered in the faces by a wall of a foot or two thick, furnished with loop-holes for the musketry to fire through.

This *keep* serves to secure a retreat for the troops who defend the ravelin, and on this account the defence of the breach in the ravelin may be more obstinately maintained; and even when the defendants are obliged to give way to a superior force, they may retire into the *keep*, and prevent the enemy from making a lodgment in the outward part of the ravelin, or at least greatly obstruct it; and cannot be driven from this place until the enemy has erected a battery, and brought cannon on the ravelin to batter the keep.

The construction may be otherwise made by taking the distance BA equal to about 20 yards on the gorge of the ravelin, and out of the rest forming the keep with its foss; the scarp and counterscarp being drawn parallel to the faces of the ravelin, the two fronts of which form a work covering the keep, and is usually called the counterguard.

128. The ravelins, called by some authors *half-moons*, have sometimes their corners at B and C, fig. 14, cut off, either parallel to the capital *p* A, or at right angles to the foss, making a kind of flank about 12 yards long, with its rampart and parapet. This serves to give a more direct fire along the covered-way, which is meant more particularly to be defending; but then it partly lays open the flanks, which the ravelins were originally intended to cover.

129. The celebrated General *Coehorn*, in the ravelins which he built at *Bergen-op-Zoom*, contrived a very good defence for the covered-way before the faces of the bastions, by making retired flanks in the breasts of the ravelin, where one or two cannon might be placed as secure from the

Digitized by Google

the enemy's fire, as those behind the orillon of a bastion. These covered cannon in the ravelin seem to have been intended for the defence of the covered-way on the last emergency, as those in the bastion were for the defence of the breach, when the besiegers brought on the storm. But the covered cannon in the ravelin seem to have this preference; that as towns are not usually given up until the enemy is master of the covered-way, the secreted guns in the ravelin have an opportunity of being employed in the use for which they were placed there; whereas the guns covered by the orillons are very rarely of any use, as there are few garrisons which stand the storm of the breach in a bastion.

130. *Coehorn's* ravelins may be imitated by the following construction. In the gorge of the ravelin take *a b*, fig. 17, equal to about 20 yards, draw the flank *b c* at right angles to *a b*, make *b c* equal to about 12 or 14 yards, and draw the cover *c d* parallel to *a b*. To the flank *b c* annex a rampart, parapet, embrasures, and ramp; and to prevent these flanks being raked from the enemy's batteries, particularly by the *ricochet*, or bounding shot, there may be made a traverse about 10 feet thick across the top of the flank at *c*, with a small mine under it, to blow up the traverse when the besieged are obliged to quit the ravelin, lest it should serve to cover the assailants from the fire of the town.

Coehorn has also made flanks at the corners *d* of the ravelin, which may be constructed by taking *a n* equal to 10 yards, and drawing *n e* parallel to *b c*, meeting *c d* in *d*; then *d e* is the flank required.

It seems proper, when such ravelins are used, that the faces should spread on those of the adjoining bastions 10 or 12 yards farther from the angle of the shoulder, than in ravelins which have no flanks; and this is done at *Bergen-op-Zoom*, where the faces of the ravelins would fall between 20 and 30 yards from the angle of the shoulder on the faces of the bastions.

131. *Of the Counterguard.*

A COUNTERGUARD is a work generally serving to cover a bastion: it is composed of two faces, forming a saliant angle before the flanked angle of a bastion.

To construct it. Plate XVI. Fig. 18.

Having described the ravelins, and drawn their fosses, in the counterscarp of the ravelin, take *a b* equal to about 24 yards, and draw the face *b c* parallel to the counterscarp of the foss before the bastion; and the outline of the counterguard will be determined; the inner boundary being the counterscarp of the grand foss.

In this work put a rampart about 16 or 18 yards broad, with a parapet of six yards, and annex the ramps and a barbet if necessary: Also make a foss of 24 yards in breadth, the counterscarp being parallel to the faces.

The counterguard seems to be, next to the ravelin, one of the most useful outworks; for it occupies but little ground, is of no great expence, covers the faces of the bastion so effectually, that they cannot be battered in breach, until the enemy has made himself master of this work;

and

Digitized by Google

and when he has it, he will meet with difficulties enough in finding earth to cover himſelf and erect his batteries; and muſt therefore be at a conſiderable trouble in bringing it from beyond the foſs, while he is expoſed to the fire of the faces of the neighbouring ravelins; which, with the flanks of the baſtions, are the defences of the counterguard.

132. *Of the Tenaillon.*

A Tenaillon is a work compoſed of a ravelin and two detached works called *lunettes*, which partly or wholly cover the faces of the ravelin from an enemy's direct fire.

When the detached works cover only the lower part of the faces of the ravelin, they are called *ſmall lunettes*: but when they cover the whole faces, they are called *great lunettes*, and this is the work which is here meant by the word *tenaillon*.

133. *To conſtruct a Tenaillon.* Plate XVI. Fig. 19.

Having deſcribed the ravelin and its foſs, the counterſcarp of which is *r t*; in the face *e f* continued, take *t v* equal to about 60 yards, and on the counterſcarp of the grand foſs take *r s* equal to 25 or 50 yards; then drawing *s v*, the figure *r s v t* is the *great lunette*; to which a rampart, parapet, and ramps are to be annexed againſt its faces *t v*, and branches *v s*, of the ſame kind with thoſe in the ravelin.

134. A great lunette may be conſiderably ſtrengthened by making acroſs its middle, at A, a retrenchment, conſiſting of a rampart, parapet, and a foſs about ſix or eight yards broad; and ſeven or eight feet deep; the parapet being drawn at right angles to the counterſcarp of the ravelin againſt the middle of its face; and the ditch of the retrenchment communicating with that of the ravelin.

A *tenaillon* is a work capable of affording great defence to the beſiegers, as was evident at the ſiege of *Liſle* in 1708, where the beſiegers were twice or thrice driven out of a tenaillon they had taken and retaken.

135. *Of a Horn-work.*

A Horn-work is a fortification compoſed of two long ſides, called branches, tending toward the town, and of a front formed by a curtin between two half-baſtions.

This work, when uſed, is ſometimes put before a baſtion, but oftener againſt a curtin.

136. *To conſtruct a Horn-work before a Curtin.* Plate XVI. Fig. 20.

In a line drawn from O, the angle of the counterſcarp, at right angles to the curtin, take OC equal to about 250 or 260 yards; through C draw AA at right angles to OC, and make CA, CA, each equal to half OC, ſo AA is equal to OC.

Take

Take the *normal* CD equal to $\frac{1}{6}$ of AA, through D draw the lines of defence AI; make the faces AB equal to $\frac{1}{2}$ AD; transfer the diſtance BB from B to I the line of defence, draw the flanks BI and curtin II, and draw the branches AQ toward ſome point in the face of the baſtion, about 8 or 10 yards from the angle of the ſhoulder.

Againſt the faces, flanks, curtin, and branches, put a rampart and parapet as in the ravelins; make a foſs of 24 yards in breadth before the flanked angles A, the counterſcarp of the foſs in the front being directed toward B, the angle of the ſhoulder, and the reſt drawn parallel to the branches.

A ſmall ravelin is uſually put before the curtin of a horn-work, for the ſame uſes as that before the curtin of the town. Make the capital CP about 60 yards, draw the faces as in the large ravelins, and make a foſs about 15 or 16 yards wide, the counterſcarp of which is parallel to the faces of the ravelin, which are to be furniſhed with a rampart and parapet.

137. Retrenchments are ſometimes made in the horn-work, as in the great lunette, and for the ſame reaſon, namely, to increaſe the difficulties of an enemy in a ſiege.

Alſo a ravelin with its foſs is made before the curtin of the town, independent of the horn-work, which it commands.

138. There is another work, called a Crown-work, the front of which conſiſts of a whole baſtion, two half-baſtions, and two curtins, and is bounded on the ſides by two long branches directed toward the town. This work is like two horn-works connected together, by their branches being put ſide to ſide.

Horn-works and *Crown-works* have been chiefly uſed to incloſe ſome riſing or hollow ground, or a ſuburb; but are now in general diſeſteem, on account that their defence is very ſmall in proportion to their coſt, a circumſtance by which all works ſhould be partly rated.

There are ſeveral other works called out-works, which may be found in the treatiſes written on Fortification, but are here omitted on account of the intended brevity of this work.

139. *Of the Covered-way and Glacis.*

When all the intended outworks are annexed to the plan, and the ſeveral foſſes are drawn, communicating one with another, the covered-way and glacis are to be drawn parallel to the counterſcarps of the foſſes; and a foot-bank is to range quite round the covered-way, at the foot of its parapet. The top of this foot-bank ſhould be at leaſt four feet broad, that there may be convenient room left for the troops to ſtand on, after the palliſades are planted, a row of them being always to run quite round the covered-way. The manner of ſetting them, as recommended by the moſt celebrated engineers, and particularly by the great marſhal *Vauban*, one of the moſt experienced men in military works that ever lived, is to put the palliſades on the upper foot-bank about a foot diſtant from the foot of the parapet, ſunk in the ground at leaſt three feet, and their top on a level with the head or creſt of the glacis.

Palliſades

Digitized by Google

Pallisades thus placed are not exposed to the cannon of the besiegers; the most they can do will be only to brush their points; neither can they be easily jumped over by the troops commanded to the attack of the covered-way, nor readily cut down; and their distance from the parapet leaves a space sufficient for men to go along to repair any disorder.

140. *Of Places of Arms.*

Places of Arms in the covered-way are spaces made at the entering and saliant angles, considerably larger than the street of the covered-way, and formed by turning the head of the glacis into two faces projecting toward the country; those at the saliant angles are formed by the roundings of the counterscarp; but those at the entering angles are thus constructed. Plate XVI. fig. 3.

In the head of the glacis take the gorges co, co, from 20 to 30 yards; draw the faces o *t*, o *t*, so that the angles *to* *a* be between 90 and 100 degrees; and parallel to those faces draw a glacis of about 50 yards.

The faces o*t* of the *entering places of arms* should not make angles greater than 100 degrees with the *branches of the covered-way* o *a*, because those branches could not then be defended so well by the musketry, as when their shot was delivered directly along the glacis, nearly parallel to the branches, which can only be done when the defences are nearly at right angles to the places defended.

Some writers have advised to round all the saliant angles of the places of arms, because those angles could then be defended by more men: perhaps there might be some advantage in notching the faces somewhat like a redan, as mentioned at Article 69.

141. The great *Coehorn* was so conscious of the advantage of places of arms at the entering angles for the defence of the covered-way, that he was very particular in their description, and took such care in the construction of those at *Bergen-op-Zoom*, that they very well answered his design, as was evident in the famous siege of this place in the year 1747.

Coehorn's Places of Arms may be thus imitated.

Plate XVI. fig. 21. where the work is on a larger scale, to be plainer.

Take the gorges *a b*, *a b*, about 45 yards, and the faces *b c*, *b c*, about 50 or 60 yards. At 10 yards distance from the faces, draw the *first lunette* A, with a ditch before its faces, both together being about ten or twelve yards broad, its ends being terminated by the line *a b*. Within this, at about 10 yards distance, draw a second lunette B of about five yards broad, its ends stretching about half-way the breadth of the covered-way. Behind the ends of each lunette, at the distance of two or three yards, put a traverse of about five yards thick, reaching from the counterscarp about two or three yards farther than the ends of the lunette. And about the angle of the counterscarp make a skreen of about six yards in each face and gorge; which screen is to be of brick-work with loop-holes for the musketry, to favour the retreat to the defendants when driven from their works in this well-contrived place of arms.

142. *Of*

Digitized by Google

142. *Of Traverses in the Covered-way.*

When the besiegers have pushed on their approaches so far, as to be within 30 or 40 yards of the head of the glacis, it will be in their power to rake the covered-way from some of their batteries; to prevent which, and also to shelter the troops in some measure from the ricochet or rebounding shot, traverses are thrown across the covered-way, particularly on each side of every place of arms, and in every branch of the covered-way where the length of that branch exceeds 50 or 60 yards.

Each traverse is furnished with a foot-bank; and a row of pallisades planted on the foot-bank; and the passage round its end should be furnished with klinkets or doors, to shut it up when necessary.

143. *Of Sally-ways.*

In the middle of some faces of the entering places of arms a sally-way is made, which is a passage cut through the parapet, or head of the glacis, to facilitate the sallies of the besieged. To make sally-ways in the places of arms saliant would be improper; because as those places are the most convenient to be first attacked, they should not by any means be weakened.

These passages are cut oblique to the faces of the places of arms, and wind toward the saliant angle in such a manner, as not to be easily enfiladed or raked; they rise gradually from the foot of the parapet, until they meet the slope of the glacis, at the distance of seven or eight yards from its head. The roads to the town commonly pass through these sally-ways; every one of which would be furnished with a good barrier, to shut up against surprizes and sudden attacks.

144. *Of Communication.*

Every detached work in a fortification should have a ready and free communication preserved, otherwise they might be disadvantageous to the place.

Communications are preserved in various other ways than by bridges, which are liable to be destroyed by the enemy's cannon. In dry fosses it is thus:

From the town to the tenail, by a subterraneous way under the rampart in the middle of the curtin into the foss, and rising thence by ramps or stairs into the tenail: from the tenail by a subterraneous way into the caponier, and thence to the ravelin, either by ramps, stairs, or a timber stage: from the ravelin to the works beyond, the communication is kept in like manner; or sometimes a way is sunk across a ditch, and covered with a parapet next the enemy; and the way from the foss to the places of arms is also by stairs, or by a timber stage.

Over wet ditches the troops are conveyed by boats, or rafts, or by little bridges about three feet wide lying nearly level with the water's edge; but the latter are inconvenient in the night, and much more so when the defendants are obliged to quit the work precipitately.

In the gorges of ravelins and other outworks, a space or passage five or six feet wide is left between the counterscarp and the end of the rampart, which serves for the communication between that work and the covered-way.

When

Digitized by Google

When wet foſſes are to be repreſented in plans, it is done by giving them a tint with diſtilled verdigriſe along the borders of their ſcarps and counterſcarps; but in printed plans it is expreſſed as in the ditch of the ravelin at fig. 15; and dry ditches are ſhewn in coloured plans by waſhing the ſaid borders with a tint of brown biſter; but in prints dry foſſes are expreſſed as in the ditch of the ravelin at fig. 14: And a cuvet is repreſented by a double line drawn along the middle of the foſs, as againſt the front BB of the polygon.

145. *Of Works beyond the Glacis.*

Sometimes, when earth is wanting to raiſe the ſeveral works to their proper height, or when the defence is to be increaſed, a foſs about 20 or 25 yards broad is ſunk at the foot of the glacis, encompaſſing either the whole or ſome convenient part of it. But then it is proper that the glacis ſhould ſlope quite to the bottom of this foſs, if it is a dry one, or a wet one which can be drained; for otherwiſe, when the enemy comes to be poſſeſſed of it, he would find a trench ready dug to ſkreen him from the fire of the covered-way, and other places.

To this advanced foſs is uſually annexed, when it can be, a covered-way and glacis; and there are not wanting fortifications, which have three covered-ways and glaciſes one before the other.

146. Before ſome of the ſaliant angles of the glacis there are ſometimes conſtructed a kind of work, called a *lunette*, or by ſome an *arrow*. It conſiſts only of a parapet and foot-bank forming two faces, making a ſaliant angle, the legs of which are parallel to the head of the glacis, through the ridge of which runs a narrow paſſage to the lunette.

147. Sometimes works called *redoubts* are conſtructed before the ſaliant angles; ſome of theſe works have foſſes, covered-way, and glacis; others are made to depend on their own defence; but to all theſe detached works a proper communication muſt be preſerved with the covered-way, and in ſuch a manner as not eaſily to be cut off. When this paſſage is two or three times as long as the glacis is broad, the paſſage ſhould have one or more traverſes acroſs it, to prevent its being raked; alſo, on either ſide, it ſhould be covered by a parapet and ſmall glacis.

148. *Of Profiles.*

The PROFILE of a work is a figure expreſſing the ſeveral heights, depths, and breadths of that work.

The profiles of works are regulated according to their uſe, and alſo according to the quality of the materials with which thoſe works are to be made.

Thus the ramparts of the town are ever thicker than thoſe of outworks; the breadth of the parapet only remains nearly the ſame in moſt works: beſides, a rampart made of good firm earth need not be ſo thick as one made of looſe and ſandy materials; from 20 to 24 yards will do in the former caſe; but leſs than 25 or 30 yards will not ſuffice with poor earth.

Profiles

Digitized by Google

Profiles are alſo regulated with regard to the expence intended to be beſtowed on the works; that is, according to the outſide coating or walling of the rampart and parapet, namely, whether it be done with earth or intire maſonry, or half one and half the other.

149. When a work of earth is raiſed, and the ſurface is covered or plaiſtered with a tenacious ſubſtance made of well-tempered earth or loam; this coating or plaiſtering is called *placcage* or *cruſting*.

And when the ſurface is covered with graſs turf, or, as it is moſt common, with clods of fat mould cut in the form of wedges, and called gazons or ſods, this kind of coating is called *gazonage* or *ſodding*.

150. When the whole front of a work, from the bottom of the foſs to the crown of the parapet, is covered or fronted with a wall of ſtone or brick, this kind of work is called *entire maſonry*.

151. When the front of the rampart, from the bottom of the foſs to the horizontal line, or ground level, or a little higher, is fronted with a wall of brick or ſtone, and the remaining part of the front is coated with earth, the work is called *half maſonry*.

Conſtruction of Profiles:

152. When the works are coated with earth. Plate XVI. fig. 22.

Let AHLQ repreſent the horizontal, or ground line, taken through the face of a baſtion, and acroſs the foſs, and through the covered-way and glacis: in this line take the following meaſures; namely,

AR = 3 or 4 yards; R c = 10 yards: $c\,d$ = 6 feet; $d\,e$ = $1\frac{1}{2}$ feet; $e\,g$ = 18 or 20 feet: $g\,a$ = 12 or 14 feet; a H = 9 feet; H l = 12 feet; $l\,m$ = breadth of the foſs; m L = 12 feet; L M = 5 yards; M p = $7\frac{1}{2}$ feet; p Q = 50 yards.

Through the points R, c, d, e, g, l, m, M, p, draw lines perpendicular to AQ.

In theſe lines take R B = 3 or 4 yards; c C = RB + 2 feet; d E = c C + $1\frac{1}{2}$ feet; e F = d E + $4\frac{1}{2}$ feet; g G = c F − $2\frac{1}{2}$ feet; l I = 18 feet; m K = 18 feet; M o = 2 feet; p P = 8 feet.

Draw the lines AB, BC, EF, FG, G a, HI, KL, L o, PQ. Then draw ED parallel to AH, and equal to 3 feet, and draw DC; alſo diſpoſe of the ſpace between o and P, in like manner as between C and F.

Then will the ſeveral parts of the profile be completed, and repreſented; namely, BA the inner, and G a the outſide, ſlopes of the rampart, to which BC is the walk; FE the inſide, and FG the crown of the parapet; CD the ſlope, and DE the top of the foot-bank; a H the berm or foreland; HI the ſcarp; KL the counterſcarp, and IK the bottom of the ditch; LM the covered-way; o N the ſlope, and NO the top, of the foot-bank; OP the inſide of the parapet, and PQ the ſlope of the glacis.

The palliſades k are put on the top NO of the foot-bank.

153. In ramparts coated with earth it is uſual to ſet a row of palliſades in the front of the rampart, as at h, about five or ſix feet below the crown of the parapet. Theſe are not planted upright, but nearly horizontal, the point dripping a little below the level; and this work, which is called *fraiſing* or *ſtaccage*, is done to prevent ſurprizes by ſcaling, and alſo to hinder deſertions.

154. In

Digitized by Google

154. In moſt ramparts coated with earth, whether of the town or out-works, it is uſual to plant on the berm, either a row of upright palliſades, as at *f*, or a quick-ſet hedge of thorn, which ſhould be kept conſtantly cut, to make it grow thick: either of theſe methods ſerves to cover the troops in going their rounds. Sometimes both palliſades and hedge are uſed, the hedge ſtanding foremoſt.

The ſaliant angles of all earth-works ſhould be rounded off; otherwiſe the weather would ſoon deſtroy the angular edges, and make them look worſe than the other parts.

155. *When the coating of the work is entire maſonry.* Fig. 23.

Having determined all the parts through the rampart to the line G *g*, as at Art. 152; in G *g* take GI=3 or 4 feet, for the upright face of the parapet; on I, with the radius of one foot, deſcribe a ſemicircle repreſenting the *cordon*, which is a large ſemicircular moulding that ranges along the whole front; take *g r* equal to 18 feet, and draw *r c s t* parallel to the ground line, and this repreſents the bottom of the foſs. Take *r c* and its parallel I *a*, each equal to 5 feet; draw the ſcarp I *c*, and draw *a b* parallel to G *g*, which continue to about 6 feet below *r c*, and this line repreſents the back of the wall; through *b* draw a line *b d m n* parallel to the ground line, and this repreſents the bottom line of the foundations, which is uſually about 6 feet below the bottoms of the foſſes; though in ſome caſes it muſt be more; and let the foundation line *b d* project about 2 feet before the ſcarp line I *c*. Draw a line about 3 feet behind the front line of the parapet G I, parallel to it, which will repreſent the thickneſs of the front wall of the parapet; to which muſt be annexed, at G, a little projection, of about 6 inches in ſally and height, to expreſs the coving ſtone; and the outlines of the profile of the rampart will be completed.

156. From the directions already given, it will be eaſy to conceive how to regulate the profiles of out-works, whether they are to be fronted with turf or maſonry; and according to Art. 155, where the other profiles of the maſonry annexed in the figures 24 and 25; that of 24 being a tenail before the curtin, of which no more than the parapet riſes above the ground level; and conſequently the walls to ſupport this work need not be ſo thick as thoſe are, which ſuſtain the lateral thruſt of higher banks; and for the ſame reaſon, the counterſcarp walls are of a leſs ſtrength. In the ravelin, fig. 25, the front is half maſonry, or the walling is carried up to the ground level, and the front of the rampart and parapet is ſuppoſed to be coated with earth; but the walling in this caſe ſhould project about 2 or 3 feet below the foot of the rampart, in order to preſerve a proper berm.

157. The walks of all ramparts, and alſo the covered-way, ſhould ſlope backward, in order to carry off the rain; this ſloping may be about half an inch, or an inch in a foot.

158. The ſcarping uſually given to earth facings is about 8 inches on 12, or the baſe of the ſlope is $\frac{2}{3}$ of the height; and the ſcarpings generally allowed to fronts of maſonry is about $\frac{1}{5}$ or $\frac{1}{6}$ of its height; and with regard to the thickneſs of the walls, Mr. *Vauban* uſually allowed about 5 feet at top, and gradually thickened toward the bottom by their

Digitized by Google

scarping of 1 foot in 5 of height; and this profile he has experimented in the works of 150 towns, where he has directed the building of more than 4000000 of cubic yards of walling. But in order to add a greater strength to his walls he places buttresses, built of rough stone, at distances of 18 feet from one another on the inside. These buttresses are in length about the thickness of the wall at the bottom, and their breadth on a mean, about half their length; and they are carried up as high as the cordon, which greatly contributed to take off the thrust of the bank against the wall.

159. At the flanked angles of bastions, and other works, the parapet should rise about a foot or two higher for about 12 or 14 yards on either side the angle, than along the rest of the faces, and the same should be observed for about 4 or 5 yards on each side of the more exposed saliant angles of the covered-way: for by these means, the troops ranged along those faces will be somewhat better defended from the ricochet, or bounding shot.

160. *Of Irregular Fortifications.*

When a town or other place is to be fortified, it generally happens that the polygon which best circumscribes its plan will be very irregular, and consequently the fortifying of that polygon will not fall under the rules already given for regular fortification: it is therefore proper to point out to a learner how he may proceed on such occasions.

161. Let the plan of the place be circumscribed, if possible, by a polygon, the angles of which are all saliant, none less than 60 degrees, nor much greater than 120; and none of the sides less than 200 yards, nor greater than 350. This polygon, which is to be the interior one, should have its sides not less distant from the houses than 50 yards; and the fortification is to be made from the interior side.

Through every angle of the polygon draw a line bisecting it; and on these lines, continued without the polygon, lay from the angular points the capitals, (in the Table, Art. 86) of those polygons, the angles of which are nearest to the angles in the given irregular polygon. Also on each side of the capital, from the said angles, lay the demigorges, corresponding to the capitals used on the sides of the polygon.

Then the lines of defence being drawn, and the corresponding faces laid on them, the *master-line* of the fortification to the given irregular polygon may be readily completed (as in Art. 91); to which the rampart, foss, and proper out-works, may be annexed, as before shewn.

162. In circumscribing the given place with a polygon proper to it, if it should so happen, that the sides, when drawn at the distance of 50 yards from the houses, make a polygon very different from that above directed; then must the positions and lengths of all those lines, or of some of them, be changed, and various ways tried, when the situation will admit of those various trials, until one is hit upon which will suit the place and come near the foresaid limits, which may be done by enclosing a larger space, and permitting the sides of the polygon to run farther from the houses in some places than 50 yards. And although by these means the fortification will be more extended, and thereby occasion a greater expence both in building and defending; yet as by its nearer approach to regularity, it will be stronger in itself, and more effectually answer the end of

Digitized by Google

of fortifying, the latter considerations may, on some accounts, be preferred to the former.

163. It should be observed, that regularity is not confined strictly to such polygons only as can be circumscribed by a circle, or nearly so; for a polygon inscribed in an oval kind of figure will have a great regularity, and may be made almost equally strong, by putting the stronger kind of out-works at the narrow ends. For as these ends, on account of their small breadth in proportion to the longer sides, cannot flank the approaches of an enemy so well as the longer sides, and as the enemy is not under a necessity of extending his works so much; consequently the smaller ends may be more advantageously attacked, and therefore should have their out-works stronger.

164. If the situation is such, that one or more of the sides of the circumscribing polygon cannot by any easy means be made less than 400 yards or more; then such sides should be divided into parts of some number of yards, between 200 and 350, as many as its length will admit of, which may then be considered as composed of so many polygonal sides. At every division, make such a bastion as the limits will admit, taking care that the faces of each are commanded by the adjacent flanks of the next bastions.

165. When any of the angles become too acute to make in that place a whole bastion, the angle may be diminished only on one side, making there a half bastion, and let the other side be either left as one line, or make two or three small flanks in it, in the nature of a redan (71); observing that the whole front is commanded by the flank of the next bastion. Or should the angle be too small even for a half-bastion, then both sides may be fortified in the manner of redans, and commanded from the flanks of the next bastions; but, in the case of these acute angles, the angular point should be made very solid, and the sides about such angle shorter than the others.

166. Should the polygon have one or more entering angles, which cannot be avoided; when that angle is near 90 degrees, and the adjacent sides do not each exceed 250 yards, those sides, with the assistance of the flanks of the next bastions, will very well defend one another, and also the entering angle: but should the angle exceed 120 degrees, then put against that angle a work like a bastion, if it can be; or if there is not room for the projection of the flanked angle, make but one face, observing that it be raked from one of the adjacent flanks.

167. A town that has been fortified in the ancient manner, and has already a good rampart and foss, may be put into a good state of defence against the modern methods of attack, by adding outworks so disposed as to cover the town wall, be mutually defended by one another, and commanded from the ramparts of the town. Such a place, with the outworks judiciously disposed, may hold out as many days as a place formed on a regular plan, which has been evinced from the good defence made by several towns fortified in this manner.

168. There is a multitude of other things that might be said on the business of irregular fortification, which, on account of the designed brevity of this tract, must be omitted; but after all, the best notions are acquired in these matters from studying the plans of the fortified towns in several parts of the world. Collections of these plans may be met with at most print-shops.

Digitized by Google

PART II.

Of Marine Fortifications.

SECTION I.

Of the kinds and properties of Harbours.

169. A HARBOUR or PORT is an opening or inlet into the land, into which the sea runs with a depth of water sufficient to float ships, and where such vessels may lie secure from tempests and the sea.

As harbours may be of very different forms, so there may be a multitude of ways proposed for their defence; but here the business will be confined to a few of the more common situations.

Harbours in general may be distinguished into two kinds, namely, artificial and natural.

170. *Artificial harbours* are such inlets of the coast, as are rendered safe for shipping to ride there, by building about its entrance certain works called MOLES or PIERS, which defend the ships within from the surges of the sea without. When the *moles* or *piers* can be brought so close, as to be shut up by *sluices* or *gates*, the harbour is then called a BASON; but the inner part of a harbour, where the ships ride in still water, is usually called the *bason*.

All artificial ports of these kinds are easily fortified by building on the moles or piers, batteries, redoubts, or forts, which command the entrance into the harbour; but as these works are usually done at the time when the moles are made, there need be no more said of them in this work.

171. *Natural harbours* are those where the natural figure of the land forming them is such as contributes to the safety of the shipping, by sheltering the vessels from the fury of the sea; and this happens in various manners, as by a shoal lying off the harbour's entrance, which breaks the waves, and keeps the water still within; or by the points of land which form the harbour's mouth, stretching themselves so far into the sea, and coming so near one another, that the surges are broken at their entrance; or by a narrow inlet that runs into the land for a considerable way, where the shores near the entrance receive the shock of the waves, and render the upper parts smooth enough to anchor in, of which kind are navigable rivers; or by a large deep bay, where islands, or other obstructions, contribute to render a part secure for the riding of ships at anchor, &c. &c.

172. The properties of a good harbour are, a sufficient depth of water for large ships to enter at any time, whether the tide be in or out; good offing, and an easy access out of all danger from the winds; free entrance, without rock or sand-bank; the entrance not too wide to be easily barred and defended upon occasion; not subject to overflow, and where ships may lay close to the keys; where the vessels are sheltered from all winds by the high mountains surrounding the harbour, and from which there is an extended view of the sea; lastly, that the shipping there be in no danger of being set on fire, bombarded or cannonaded from sea by the ships of an enemy.

173. There

Digitized by Google

173. There are many places in which ſhips anchor, that lie open to the ſea, and are ſafe to ride in only when the weather is calm, or when particular winds blow; ſuch anchoring places are called *roads*.

SECTION II.

Of the fortifying of Roads and Harbours.

174. First Sort. *When a town lies open to the ſea upon a curved or ſtraight bold ſhore, and has before it a ſufficient depth of water and good anchorage, within gun-ſhot of the ſhore.* As ſuch places can afford ſhelter for ſhipping only at certain times of the year, when they are generally ſure to have calm weather, or gentle gales, in which veſſels may ſafely ride at anchor, they cannot ſo well be ſecured from the attack of an enemy, as places more incloſed. However, the ſhipping lying there during the ſeaſon of trade, may be well defended by forts built near the water's edge on each ſide of the anchoring place; ſuch forts being ſo contrived as to have two or three batteries, one higher than the other, furniſhed with many cannon, carrying ſhot from 24 to 48 pounds, will awe the ſhips of an enemy in general from undertaking any thing againſt the veſſels that are lying in that road.

175. But in order to defend the town itſelf, there ſhould be a rampart or wall, well flanked, built along the ſhore, beſide the fortifications on the land ſide. The works along the ſhore ſhould be carried ſo near to the water's edge, that were any troops to land under the cannon of a fleet, they might not find any ground to entrench themſelves on.

176. Forts built on a bold ſhore, to which ſhips of war can come within muſket-ſhot, are in general liable to be eaſily taken, unleſs ſome precautions are uſed. For as the batteries on ſhore are ſeldom raiſed much above the water's level, in order to be more certain of their mark; the troops poſted at the guns are liable to be commanded by the marines quartered in the round-tops, and other elevated parts of the ſhips. However, this may be prevented, either by driving ſeveral rows of piles (which are long pieces of timber, or the bodies of trees, pointed, and ſhod with iron at one end when neceſſary) in the water before the fort; or by fixing along the battery a kind of *ſhed* made with planks of muſket-proof, and covered with raw hides or earth, that they may not be ſet on fire by combuſtibles thrown from the ſhips. Theſe ſheds are convenient not only to preſerve the troops poſted at the guns from muſket-ſhot, during the time of an attack; but they would alſo preſerve the cannon and carriages from the weather at all times; for the expence of a few rough planks, uſed now and then to repair ſuch ſheds, added to the firſt coſt, might, perhaps, in a length of time, be found of leſs expence than the gun-carriages they would preſerve; and ſhould it turn out otherwiſe, the framing and planks might be prepared in time of peace, and ſet up only when there are apprehenſions of an attack; but care ſhould be taken to fix them ſo, as to be leaſt expoſed to the cannon from the ſhips. In ſuch ſheds, as they would be open behind, the ſmoke would be ſoon diſſipated, and might be ſooner thrown off by making

Digitized by Google

holes in the ſhed over every gun; which holes may be covered by a ſhort plank raiſed before them.

177. SECOND SORT. *When a harbour, being a bay, has a ſhoal or ſmall iſland lying before its entrance:* Such a place is fortified by building a ſtrong fort on the iſland, in a place where it can command the entrance on both ſides, when the ſize of this iſland is not too large for this purpoſe; but when the mouth of the harbour, and the extent of the iſland is too large for one fort on the iſland to guard the entrance, then two or more forts ſhould be raiſed in the moſt commodious places that command the avenues to the bay.

178. Beſide the forts raiſed on ſuch an iſland or ſhoal before a harbour's entrance, there ſhould be others raiſed on the moſt convenient points of land forming the mouth of the bay; which will make the defence of the paſſage more ſecure, ſhould the ſhips of an enemy paſs the advanced defences.

179. When forts are thus built, it is not enough to contrive them in ſuch a manner, that their batteries may annoy the ſhipping which attempt a forcible paſſage; but they ſhould be alſo carefully fortified to reſiſt attempts from an enemy aſhore; for ſhould this be neglected, a body of marines, or ſeamen, landing on the iſland or place where the battery or fort is, would fruſtrate the intention of ſuch fortifications or defences, of which there are many inſtances to be met with in hiſtory.

180. As there may be ſeveral ſpots or points proper to erect the defences on, and which may command the entrance of the harbour in the manner deſcribed above, it is of importance to know which will have moſt advantages and feweſt diſadvantages; for both circumſtances are to be brought into the account, and that choſen which has moſt of the former and feweſt of the latter. Thus the ſoil ſhould be the firmeſt and moſt capable to bear the cannon and building to be erected. The ground of a height ſufficient to be out of the reach of tides and floods, and not much higher than is barely neceſſary to avoid thoſe inconveniences; for the cannon commands beſt when near the water's level. The place ſhould be difficult for an enemy to land in its neighbourhood; and if landed, where they may be moſt incommoded in their march to the fort—where ſuccours may eaſily approach—where the troops on duty may without much trouble obtain the neceſſaries of life—and where there are the feweſt noxious exhalations.

When the moſt convenient place for a fort or battery is choſen, the next thing to conſider is, whether the work is to be temporary or perpetual; that is, whether the work is to ſerve only for a preſent emergency, or to be kept in repair under a probability of its being frequently attacked; and whether the work be temporary or perpetual, it is neceſſary that it be ſuited to the materials at hand, or that can be procured with the leaſt trouble and expence.

181. It may frequently happen, that in ſuch ſituations the paſſage between the iſland and main is rather too wide for cannon to command acroſs; therefore, if the place is of ſufficient importance, there may be many ways contrived to remedy this defect, when it is poſſible to be avoided. The beſt are thoſe which oblige ſhipping to keep in one tract or channel; and when this can be accompliſhed, either by ſinking old ſhipping, running out moles, or contriving to form ſand-

6 banks

Digitized by Google

banks or ſhoals, or by any other means that the ſituation of the place can furniſh; forts alſo or batteries may be advanced ſo far into the water, as to command that channel; or if the paſſage cannot be reduced to leſs than two channels, then a fort ſhould be erected, if poſſible, between them.

182. In the building of theſe works great care ſhould be taken, that the foundations are laid ſufficiently firm to ſupport the ſuperſtructure; and as theſe places are generally low, either in marſhy or ſandy ſituations, a great number of piles ſhould be driven into the ſoil, to the depth of 10, 20, 30, or more feet, according as they drive with more or leſs difficulty. If a quantity of ſuch piles be driven, at the diſtance of 12 or 18 inches from one another, over the place intended for the foundation, and the tops of them be cut level ſome feet below the ſurface, a floor of timber may be laid over the tops of the piles, and the building raiſed on it.

183. Third Sort. *When the harbour is in a bay, and the points which form the entrance ſtretch into the ſea, and approach one another within cannon-ſhot:* Such a harbour is fortified by building on both ſides of its entrance one or more forts; and if it is poſſible, let a fort be alſo built within the harbour's mouth, in ſuch a manner, that its cannon can rake the ſhipping fore and aft as they come in; for this would be a good reſerve, ſhould an enemy's fleet force their way between the forts which command the entrance. If there is no proper ſpot for ſuch a fort, let others be erected on the moſt convenient points, that command the turning to the right and left within the mouth of the bay; for by theſe means an enemy will be obliged to endure a kind of running fire, which, if the forts be well conſtructed, he will ſcarcely be able to ſuſtain.

184. Fourth Sort. *When a harbour is formed by a cluſter of iſlands:* Such a harbour is not difficult to fortify, when the channel between the iſlands is not too wide for the command of cannon from one or both ſhores, the directions how to place the forts in the foregoing caſes being equally applicable to this. And in places where the channel is more than cannot-ſhot from either ſhore, the ſhipping that can ride there muſt depend upon the batteries aſhore, as in the firſt caſe, when the ſhore is bold enough for the ſhips to run under the cannon.

185. Fifth Sort. *When the harbour lies in an inlet or river ſome miles above its mouth:* If the paſſage to the port lies ſtraight, and can be commanded from ſide to ſide, a fort built at each point of the entrance, and two others between them and the harbour, but not oppoſite to one another, unleſs the width of the channel requires it, will, in moſt caſes, be a proper ſecurity for the ſhipping in ſuch a harbour. And when the channel or river is winding, the forts ſhould be built where they can command a *reach* at leaſt; or be ſo placed at the bends, as to command two adjacent reaches; for as veſſels muſt tack near the forts ſo placed, they will at thoſe times be more under the command of the batteries, than they would be when ſailing by them on a direct courſe.

In the directions for placing forts in this, and the other caſes, there has been no mention of the figure, in which it would be moſt proper to conſtruct them; for the engineer, who has the charge of ſuch works, generally does, or ſhould take care to adapt the figure to the ſpot; but for the ſake of the mariner, it was judged proper to point out the methods uſually taken on ſuch occaſions.

186. *Of*

Digitized by Google

186. *Of the Figure and Size of Forts.*

Beside the forts described as redoubts (Art. 68, 70), there are many others, such as squares, pentagons, hexagons, or the halves of these figures, which are fortified with entire bastions, by nearly the same kinds of constructions as are the polygons in the table, Art. 89; only the measures of the *exterior side*, *normal*, and *face*, are much less than those for a town, and usually near the following numbers:

Make the side or front about 180 yards; the normal one-seventh, or one-sixth of the side; and the face about twice the normal, or a little less; with a ditch, if necessary, about 20 yards broad; a rampart broad enough for a platform, and a parapet about 12 feet thick.

The exterior sides of forts may be considerably less or greater than 180 yards, even between the limits of 60 yards to 200, according to the size of the spot on which it is to be built, and the importance of the place it is to defend; for it would be a great absurdity to build a large expensive fort to secure a harbour or port of little more use than as a shelter to a few fishing-boats; or, on the contrary, to build a small trifling work to guard a haven, where many ships of the utmost importance are laid up, or riding at anchor.

It is not always necessary, or even convenient, to make these forts on figures perfectly regular; for the situation may require some of its sides to be shorter than others: neither is it necessary that the figures should be fortified with bastions, or half-bastions, at the angles; for there are many cases, in which it will answer the purpose equally well, or even better, to make a bastion on the side of a figure toward the middle; but then the faces of the bastion should be so drawn, that they may be raked from the extremities of that side, by a defence of at least 10 or 12 yards.

In many cases there needs no other than a direct defence from one, two, or three contiguous batteries, making one, two, or three sides of the figure given to the fort, suitable to the shore.

187. *Of proper Forts, and their Disposition.*

If the place on which the fort is to be built is a spot surrounded with water, forming a channel on both sides, the figure is to be disposed so as to have one or two of its fronts turned toward each channel, by which means the batteries in the flanks will scour both up and down the stream, while those in the faces and curtins command the passage directly before them. That part to seaward may either have a front extended along it, or have one of the points of the figure directed that way, according as it may be judged most convenient; and if before these fronts there is any place at which an enemy can land, then one or more batteries should be so formed, that their guns may be brought to bear on that landing place; and if this be thought not sufficient, a small outwork should be built near that place, to make the landing more dangerous; and on account of the convenience of landing, the fort should be furnished with a ditch, covered way, and glacis: the part next the harbour will be sufficiently secured by a line thrown up properly flanked. Should the situation be on a rock, where there is no danger of an enemy's landing, a good line, capable of covering the troops and cannon, will suffice. *If there is only*

 a chan-

Digitized by Google

a channel on one side fit for shipping to pass through, that side should be fortified as in the former case; and lest the enemy's boats should get through on the other side, it should be also put in a state of defence: but here a slight redan, furnished with a few pieces of small cannon, may be found a sufficient defence against the boats.

188. When a fort is built on a point of the main, the kind of disposition used in the foregoing case, next to the channel, will also obtain in this: but it is necessary to take proper care of the land side, which in this case is more liable to be attacked than in the former. In the fortifying of the land side, the works should be proportioned to the strength of the enemy that may probably appear before it. For there are many places where there is no likelihood of ever seeing an enemy with a stronger force than can be exerted by a fleet of three or four ships of war; and as these cannot be furnished sufficiently for undertaking a regular land-siege, a well-flanked line, with a ditch, if properly defended, will secure the place against the attacks of sailors or marines unprovided with artillery: or should a few pieces be brought against the place, their passage to it will be very dangerous, unless they can be brought near enough to act under cover; and to leave such a cover, would be an unpardonable oversight in those who had the care of constructing that fort. But when the importance of a place may bring before it a large fleet, and a land army properly appointed, then the fortifications on the land side should be put in a state capable of sustaining a vigorous siege.

There are many low points on which batteries may be raised for the defence of a channel, over which a lofty ship may have a considerable command: in such ports, proper traverses should be placed, that the line of the battery be not raked by the ship's guns.

189. In the constructions of all forts it should be remembered, that a figure of the fewest sides and bastions that can probably answer the proposed defence, is ever to be preferred, as the works on such plans are sooner executed, and with less expence; besides, fewer troops will serve, and they are more readily brought together in cases of necessity. And with regard to the executive part of such works, enough has been already said, only let it be observed that where stone and brick are scarce, and there is plenty of wood, then timber works are to be most used; and, on the contrary, stone or brick earth being plenty, and wood scarce, masonry is to be preferred: and let care be taken never to use sea-water in the lime, nor to make the parapet entirely of stone; for the splinters driven about by the enemy's cannon, will make it dangerous for the defendants to continue on their posts.

SECTION

Digitized by Google

SECTION III.

190. *Of fortifying Harbours by Booms.*

Notwithstanding the forts built for the security of a harbour, or passage, there are many instances that might be produced to shew that such forts alone are not sufficient. The great Sir Walter Raleigh says, " In " this age, a valiant and judicious *man of war* will not fear to pass by the " best appointed fort of Europe, with the help of a good tide and a " leading gale of wind; no, though forty pieces of great artillery open " their mouths against him, and threaten to tear him in pieces.

" In the beginning of Queen Elizabeth's reign, when Denmark and " Sweden were at war, our Eastland fleet, bound for Liefland, was for" bidden by the king of Denmark to trade with the subjects of his ene" mies, and he threatened to sink their ships if they came through the " streights of Elsineur. Notwithstanding this, our merchants, having " a ship of her majesty's, called the Minion, to defend them, made the " adventure, and sustaining some vollies of shot, kept on their course. " The king made all the provision he could to stop them on their re" turn. But the Minion, commanded (as I take it) by William Bur" rough, leading the way, did not only pass with little loss, but did beat " down with artillery a great part of the fort of Elsineur, which at that " time was not so well rampar'd, as perhaps now it is; and the fleet of " merchants that followed him, went through without any wound re" ceived. Neither was it long since, that the duke of *Parma*, besieging " *Antwerp*, and finding no possibility to master it otherwise than by " famine, laid his cannon on the bank of the river so well to purpose, " that he thought it impossible for the least boat to pass by. Yet the " Hollanders and Zealanders, not blown up by any wind of glory, but " coming to find a good market for their butter and cheese, even the " poor men attending their profit, when all things were extreme dear at " Antwerp, passed in boats of ten or twelve ton, by the mouth of the " duke's cannon, in despight of them, when a strong westerly wind and " tide of flood favoured them; as also with a contrary wind, and ebbing " tide, they returned back again: so as he was forced in the end to build " his *stockado* overthwart the river, to his marvellous trouble and charge. " The fort of St. Philip terrified us not in the year 1596, when we en" tered the port at *Cadiz*; neither did the port at *Puntal*, when we were " entered, beat us from our anchoring by it, though it played upon us " with four demi-cannon, within point-blank from six in the morning " till twelve at noon. The siege of *Ostend*, and of many other places, " may be given for proof, how hard a matter it is to stop the passage of a " good ship, without another to encounter it. Yet it is true, that where a " fort is so set as that of *Angra* in *Tercera*, that there is no passing along " beside it, or that ships are driven to turn upon a bow-line toward it, " wanting all help of wind and tide; there, and in such places, it is of " great use and fearful: Otherwise not."

Since Sir Walter's time, the Sound has been better fortified, yet in 1700 Sir George Rook passed it, notwithstanding the Danish fleet lay to impede his passage. The actions at Londonderry, Vigo, Porto Bello, Carthagena, and at many other places, are all sufficient proofs, that neither

Digitized by Google

ther forts nor caſtles can ſtop the enterprizes of the brave; and therefore it has been judged proper on many occaſions, beſides forts and batteries, to lay booms and other obſtructions in a ſtream, to ſecure the ſhipping there from the attacks of a powerful enemy.

191. *To lay a Boom.*

Provide a great number of wooden battlings or ſpars of about 20, 30, or 40 feet long, more or leſs, and between 5 and 10 inches diameter. Then moor two boats, having a ſheet-anchor in each, in the place near one ſide of the river where it is intended the boom ſhall begin; bend two cables to theſe anchors, and round them place the ſpars or poles, frapping on each with rattling ſtuff, or better with four-inch rope, until the boom is 7, 8, 9, 10, or more feet diameter (according to the hands employed), the cables being in the middle; next, with iron hoops rivetted together, worm the boom, and drive through the hoop a nail into almoſt every ſpar. After having wrought a good birth for the anchors, drop them, and continue the work till it is brought near the other edge of the river, and there drop two anchors more, with the cables bent to them. Then over all laſh the ſpare yards and top-maſts with the top-chains, ſo far as the channel goes.

To that part of the cable within the boom, over the channel, let two or more cables be faſtened, and bent to anchors laid down the ſtream; over the clinch of theſe cables let battlings or ſpars be wrought for near ten fathoms down the ſtream, that the enemy may not cut theſe cables. Theſe will be ſerviceable when the enemy's ſhips come *ſtemlings* againſt the boom; for if he force it in one place, the whole will not be opened by that fracture.

In places where wood is ſcarce, and proper ſpars are not to be readily had, or in caſes where there is not time ſufficient to prepare them, it may be found ſufficient to woold two cables together with old ropes, laſhing to them the oars, top-maſts, and yards, and worming the whole about with iron hoops: and let every part be well *payed* with pitch, and ſmall gravel ſtrewed on it while the pitch is warm. A boom ſo prepared cannot be eaſily cut.

It is in moſt caſes convenient to have the boom ſo contrived, as to open at one end for the paſſage of veſſels; and this may be done ſeveral ways, one is to let one end of the cable be clinched to an end of a large mooring-chain, the other end floating with a buoy, and this end fixed to the ring of the anchor by a ſhackle. Now the chain being looſed from the anchor at the ebb with a ſlack hawſer fixed to it, the boom will ſwing down the ſtream during the ebb, and upon the flood the boom may be relaid, if the enemy appear in ſight, which he muſt do the firſt of the tide, for upon the ebb there is no danger of his coming; becauſe, if the wind be right in, a prudent enemy will not adventure againſt the tide, a ſhip then making ſuch wild ſteerage; and ſhould ſhe ground, ſhe muſt lie there till flood, which may prove fatal to her from the batteries aſhore; and againſt both wind and tide the enemy cannot come in. On the contrary, ſhould the boom be carried up the flood, and the enemy appear at the beginning of the next flood, the boom cannot be relaid till the ebb, and before that time the enemy may have accompliſhed his deſign.

192. If

Digitized by Google

192. If there be good ſtore of timber at hand, a *ſtockado* may be made by driving ſeveral rows of piles in the channel before the boom; or ſhould the depth of water be too great for this work, the trees may be uſefully applied in making a raft to ride before the boom by good anchors, ſo that the cables be made too faſt for the enemy to cut them. Theſe rafts may be of ſingular uſe, by making fires on them, when the enemy appears, which will put him into ſome conſternation, and perhaps may cauſe him to chop to anchor, and loſe time or his tide; and this may be done each flood, obſerving not to have the ſmoke drive into the works, which might give the enemy too great an advantage.

193. *To lay a Boom in a ſtraight Channel.*

Suppoſe the wind for the moſt part to blow obliquely acroſs the river or channel on the ſtarboard quarter going up the river, if the boom be laid directly athwart the channel, the ſhips coming with the tide of flood, and a leading gale will run ſtemlings againſt it, and poſſibly break it by ſtriking with a force that comes direct; whereas, could the boom be laid obliquely athwart the river, nearly in a line with the wind, ſo that the ſhip muſt take it with her bow, the blow would be diverted by the ſhip's caſting: becauſe in this poſition the enemy cannot run ſtemlings againſt it; for in ſailing up the river, the ſhip muſt be near before the helm; and to bring her head to a boom laid obliquely, the helm muſt be put down, and then it is ten to one whether ſhe come to ſo nicely as to take the boom: not to mention the miſtakes which in the confuſion may be committed by the man at the *helm*, and him upon the *cond*, nor the ſmoke; for excluſive of all theſe, it may be taken for granted, that the ſhip would caſt along-ſide the boom; and then the batteries at the end of the boom on the larboard ſide would rake him fore and aft, while the oppoſite batteries on the ſtarboard ſide playing on his broadſide with *double-round* and *partridge*, muſt make a great ſlaughter among his men cutting at the *boom*. And ſhould he not ſwing along-ſide the boom, but lie ſtemlings againſt it, the batteries on the ſtarboard ſide of the river, which are to be made above the weather end of the boom, will rake him fore and aft, while thoſe on the larboard ſide play on his quarter or broadſide.

194. The ſhips within the boom, which it is to protect, ſhould be moored in a kind of half-moon with their broadſides flanking the boom. And ſeveral old ſhips, or thoſe which are the leaſt uſeful, may be ſunk as ſoon as a ſignal is given from one of the forts, ſignifying that the boom will be cut. For this purpoſe, thoſe ſhips ſhould have large ſcuttles ready cut: and for a farther ſecurity it would be very proper to have a ſmall boom to divert the enemy, that the ſhips may be ſunk in the channel before he boards them.

As to the reſt of the ſhips, they are left to the judgment of their commanders: and if there is no other remedy, the people may get aſhore to windward if they can, and there make the beſt defence in their power againſt the enemy's boats and fire-ſhips. From duly weighing the whole of theſe circumſtances it will be found, that the chief ſtrength is in the boom;

Digitized by Google

boom; therefore if a double, triple, or fourfold boom were laid, if the materials could be procured, and the value of the ſhipping and cargoes were of ſufficient importance, it would make the place ſo much the ſtronger, and the enterpriſe of the enemy more hazardous. In ſtretching theſe booms, the trouble of many anchors may be ſpared by making all the cables faſt to the firſt, and ſo let them float in a bight, and by a ſmall anchor ride upon the ebb, to keep clear of one another.

195. *To lay a Boom in the Bend of a River.*

From the point formed by a bend ſtretched two booms acroſs the channel, one toward the middle of the oppoſite bight, and the other ſo much higher, as to lie directly athwart the channel, leaving a kind of angular ſpace between them.

Next the point from whence the two booms ſtretch, erect a proper fort or battery to command the channel below and above the bend.

On the other ſide of the river erect another fort or battery againſt the bight a little above the end of the lower boom, and ſo diſpoſed, that its cannon may rake the channel coming up, as well as command both the booms.

From ſuch a diſpoſition, it is a great chance if a ſhip anſwer her helm ſo timely in *bearing* or *loofing* about the point, as to take the boom ſtemlings, and if ſhe ſmite it with her bow, ſhe caſts; and in either caſe ſhe will be raked fore and aft by one fort, and have her broadſide battered by the other.

Let ſome old veſſels be fitted up for fire-ſhips, and placed between the two booms; from each ſhip let two hawſers be carried aſhore, one on each ſide, and fixed to crabs or capſtans ſet up; ſo that as ſoon as the enemy has paſſed the firſt boom, theſe ſhips being ſet on fire, and heaved in their way, nothing can hinder the enemy's deſtruction. As ſoon as fire is ſet to the train, the boat may pull aſhore under covert of the ſhip without any apparent danger; for ſuch will be the enemy's conſternation, that they will ſoon leave firing. The hawſers may be faſtened to clamps below the water-line, that they be not burnt, nor in ſight of the enemy to cut them. If the fire-ſhip is clapt aboard the weathermoſt ſhip, they may be both heaved together aboard another to leeward.

The ſhips to be defended, may be moored in a half-moon, with their broadſides ſo laid, as to batter the enemy when he attempts the boom: and if other works than what are here directed be judged neceſſary, they muſt be adapted to the ſituation of the place.

196. When no ſtrong attacks by land are to be feared, the mooring of ſhips behind a point is beſt on account of laying the boom. Now ſhould the boom be forced, which muſt be upon the flood, a fire-ſhip, inſtead of falling on board a ſhip thus moored, will, by the tide, be hurried beyond her; and if the place be any ways favourable to the ſhips moored there, it will be found impracticable to board a ſhip thus moored, with ſuch a wind and tide as the enemy muſt have to break the boom, unleſs he expoſe his boats in carrying out an anchor to *warp* over, which will be a very dangerous attempt; or ſome unaccountable accident intervene.

197. It

Digitized by Google

197. It may be objected that ships thus moored cannot bring their broadsides to bear upon the enemy when coming to force the boom; and that they may be battered by the enemy over the point. To this it may be answered, first, It is no matter whether the broadsides do bear or not, for perhaps it might be the best way to get the guns ashore, if there is time, to be there used; and to put the smaller sort only on the lower deck, and turned to flank the boom. Secondly, The enemy will have but an uncomfortable *birth* in lying to batter the ships over the point, as they will have to deal with the fire from the fortifications ashore. What is here said, is only to be understood when five or six ships are to be defended; for the wake of a point would not hold any considerable fleet.

198. *Maxims to be observed in fortifying a harbour and mooring the shipping in it.*

I. Let all the land-marks be removed that may direct the enemy's steerage into, or up the river or harbour, when there is a probability of an attack.

II. Choose such a place, if possible, for erecting the works on, as cannot be laid under water, either by hasty rains, or by any art of the enemy.

III. Let the eminences which command the works within cannon-shot, be secured by erecting small forts on them, furnished with small cannon.

IV. All woods within cannon-shot of the fortifications are to be cut down, and the timber employed about the works.

V. Secure a spring of fresh water by a fort and proper guard.

VI. Take all the buoys from the anchors that ride the booms, that the enemy may not trip them.

VII. Let the powder and other munitions be separated and kept in different places, that if an accident happens, the whole may not be destroyed.

VIII. The ships should not be posted near any town or village, unless they are intended to cover that place, or the thing be unavoidable; lest the shot and bombs which miss the ships destroy the town.

IX. The ships should never be moored before the fortification.

X. Moor the ships so as to rake the enemy fore and aft when he batters the works.

XI. Let not the ships when moored touch one another, that the enemy may be obliged to burn each ship singly.

XII. Unrig the ships, and strip the shrouds from the mast-head, that the grapplings of fire-ships may have no hold.

XIII. Let the sails be carried ashore for tents, and most of the gunner's stores; that if the worst happen to the ships, there may be store of ammunition for the forts.

XIV. Unless the cargo be ashore, let not the chests nor clothes of any person, from the captain to the swabber, be carried out of the ship; that every man may have some inducement to exert himself in the defence.

XV. Let outguards and centinels be placed upon and near the banks of the river or harbour; and let some hands in nimble boats, armed, pass down the stream each night to watch the motions of the enemy.

SECTION

Digitized by Google

SECTION IV.

199. *Of the mooring of ſhips in fortified harbours.*

Before the boom is laid, it will be neceſſary to appoint the place where to moor the veſſels, that they may be beſt ſecured from the enemy's fire-ſhips, and yet annoy their men of war; and as this can be only done either in the ſtream or out of it, the advantages and diſadvantages in both caſes will be here conſidered.

200. *Conſiderations in mooring with regard to the ſtream.*

FIRST. *The advantages an enemy has of a ſhip moored in the ſtream.* A ſhip moored in the ſtream will find ſome difficulty in bringing her broadſide to gall an enemy in his approach, who always comes with the ſtream; and if the tide runs too ſwift for one to lie athwart, it certainly does ſo for the other; both having ground tackle equally good.

2d. In this ſituation there is no hindering a fire-ſhip, that has paſſed the boom, from being aboard you, as none but the chaſe-guns can be brought to bear on it; and ſhould you heave athwart, the enemy will be the ſurer of grappling you, unleſs by bringing your whole broadſide to bear you ſink him; for if the officer, through want of courage, ſhould forſake the fire-ſhip, yet the tide will bring it aboard; beſides, in ſuch a poſition the enemy's ſhips of war may board you, and then your batteries aſhore are uſeleſs.

3d. In riding in the ſtream the cables are expoſed to the enemy; which being hit by a chance ſhot, the ſhip will ſwing upon the tide, and the enemy have the opportunity of raking you fore and aft; and if the enemy has any conduct, he may lay his anchors ſo, that his cables ſhall be ſecured from your ſhot.

4th. Should you moor athwart the ſtream, the enemy may drop a ſmall anchor out aftern, veer athwart your hawſe, and ſo conſtrain you to alter your poſition, or rake you fore and aft.

5th. In riding athwart the ſtream, the cables by bearing a more than ordinary ſtrain, are apt to break, or ſtart an anchor; then the ſhip ſwinging on the tide, it is a great chance but the other anchor ſtarts, and ſhe ſwings to leeward. But theſe advantages are on the enemy's ſide only while the tide ſets in; for the defendants have them when the tide ſets out: therefore, in ſuch places where the ſtream runs continually out, the beſt way is to moor in it, if the wind does not blow always in.

201. SECONDLY. *The advantages a ſhip moored in a ſtream has over an enemy.*

1ſt. A ſhip moored athwart the tide lies convenient to rake an enemy fore and aft in his approach, and ſo may do him a conſiderable damage before he is athwart the ſtream to batter.

2d. In riding thus in the ſtream, according to the common ſituation of rivers, the enemy cannot batter you under covert.

202. THIRDLY. *A ſhip moored out of the ſtream has theſe diſadvantages.*

1ſt. That ſhe cannot rake the enemy fore and aft ſo well as while ſhe lies in the ſtream, unleſs by ſome particular ſituation of the place.

2d. The

Digitized by Google

2d. The enemy's men are not much exposed in mooring; for he needs only to drop his anchor, and he may veer along your side; or, if you lie athwart the river, across your hawse: but this may be prevented by riding in the wake of a point; for should the enemy drop anchor before he is about the point, he cannot veer along-side; and if he let go his anchor after he is about the point, he may be astern before he is brought up.

203. FOURTHLY. *A ship moored out of the stream has these advantages.*

1st. There is no danger of the fire-ships driving aboard her, unless directed by a strong wind. And for the same reason, the enemy cannot be athwart your hawse, unless he tows there with his boats, and then they and their crews are exposed to your cannon.

2d. A ship thus moored is in less danger of driving, should her cables be shot.

Considerations in mooring with regard to the wind.

204. FIRST. *With regard to windward.*

Besides the advantage of being free from the smoke, you may cause the enemy to drive to leeward should you hit his moorings; and if he tries to heave off by carrying an anchor to windward, his boats will be exposed to your cannon; and if the boats *lay to pass* his ship, while he heaves, will be raked fore and aft, which must do great execution among his men while they stand thick at the capstan: but it is highly probable, a ship so grounded could not be got off.

When to windward, the cables are covered from the enemy by the ship, and may be *seized* to *clamps* and *cleats* nailed to the side, and so the mooring secured from random-shot. And this ought to be carefully done for preventing the only disadvantage that attends ships moored to windward, which is, that if their cables are shot, they drive out upon the enemy, or swing head to the wind; if the former, they may be boarded by the enemy's fire-ships, or ships of war, and then your precautions are rendered fruitless; if the latter, they may be raked fore and aft by the enemy; and if neither of these happen, the ship may drive to leeward and be grounded.

205. SECONDLY. *With regard to leeward.*

A ship so moored cannot prevent the enemy's being sent on board, unless a shoal or stockado lie between them.

In this position, should you shoot the enemy's cables, through his carelessness in covering them with his hull; yet as he drives ashore, or upon you, his boats are covered with his hull, while they carry an anchor to windward to heave off.

Besides, your moorings lying to windward are exposed to the enemy; and should they be cut, you will swing head at wind, and in that position be raked fore and aft; if you attempt to carry out an anchor to heave your broadside against the enemy, your boats will be too much under his command; indeed, instead of carrying out an anchor it may be best to clap a spring upon the cable, but this will fail if the ship is too near the shore.

Upon the whole, it appears best to moor to the windward in the wake of a low point, when such a situation can be obtained; but the circumstances being so various, it must be left to the judgment of the commander, who, if he rightly considers what has been said, will chuse the best.

SECTION

Digitized by Google

SECTION V.

206. *Of some remarkable actions concerning the attacks of ships in fortified harbours.*

Having shewn the methods that have been directed by experienced men, to be used in the defence of harbours, we shall now think of closing this work with the accounts of some of the most remarkable actions recorded within the last 100 years, in which the English have had any share. This was thought useful on two accounts; first, as examples to the preceding precepts; and, secondly, to point out to the young mariner the means by which many have acquired great reputation and honour.

207. *The battle of Santa Cruz, in the year* 1657.

Santa Cruz is a town and bay on the west side of the island of Teneriff, one of the Canary islands. The bay, which lies rather open than inclosed, has deep water near in shore; but the best anchoring is about half a mile from shore, in 30, 40, or 50 fathoms water, black slimy ground: if there be many ships, they must ride close one by another. The shore is in general high land, and in most places is steep to the water.

Admiral Blake lying with some ships near Cadiz to watch for the return of the Spanish plate fleet, had intelligence they were in the bay of Santa Cruz, in the island of Teneriff; he broke ground the 13th of April, and on the 20th arrived at Santa Cruz, where he found the Spanish fleet, to the number of sixteen, moored in the bay in a half-moon. Near the mouth of the bay was a castle well furnished with near 40 heavy cannon; and besides that, there were seven forts round the bay, with 6, 4, or 3 great guns in each, all united by a line of communication from fort to fort, and well lined with musketeers. *Don Diego Diagues*, the Spanish general of the fleet, upon sight of the English fleet, caused the ten smaller ships to be moored close to the shore, and set six great galleons, well manned, farther out at anchor, with their broadsides to sea: In this posture the Spanish admiral vainly thought himself so secure, that a Dutch merchant ship going out of the harbour, he sent a message by him to *Blake, that he might now come if he durst.*

The English admiral, having well viewed their posture, saw it would be impossible to bring off the galleons; however, he resolved to burn them, and to that end sent in Captain *Stayner*, commander of the *Speaker frigate*, with a squadron to attack them. He soon forced his passage into the bay, whilst other frigates entertained the *forts* and *lines* with continual broadsides; these were presently supported by *Blake* himself, with the whole fleet, who placing some of his ships to batter the castles and other forts, he with *Stayner* continued to engage the galleons; over which, in six hours, he gained (notwithstanding they had reinforcements of men several times from the shore) a complete victory. The Vice-admiral and Admiral were blown up in the engagement, and the rest driven ashore; where, notwithstanding the fire from the forts, they were all set on fire by the English, and every one of them was burnt to the water's edge. They had no sooner done this, than the wind luckily turned, and carried the fleet, without the loss of one ship, out of the bay, and put them safe to sea again.

208. *The action of Londonderry, in the year* 1689.

Londonderry is a ſmall but pretty ſtrong town in the north of Ireland: it ſtands on the weſt ſide of the river *Loughfoyle*, about three miles from a lake of the ſame name; which is about ten miles broad and fifteen miles long, communicating with the ſea by a ſtreight of about a mile in breadth, ſo that the town ſtands about eighteen miles from the ſea. The river next the town is about ¼ of a mile over, and keeps this breadth nearly between the town and lake, where its mouth is defended by Culmore fort, which is a large ſquare with four baſtions.

This town was beſieged by the Iriſh and French in the year 1689, and the garriſon brought into great ſtraits for want of proviſions, the beſiegers having ſtrongly fortified the river. There was a boom framed of a chain of cables, covered with timbers, ſtretched acroſs the river about two miles below the town, from a point on the eaſt ſide: each end of the boom was defended by a fort. Between the boom and Culmore fort were two other forts, one on each ſide the river, and another fort above the boom oppoſite the town. The ſides of that narrow river were intrenched and lined with muſketeers, and ſeveral boats were ſunk, and ſtockadoes drove, armed with large iron ſpikes.

Notwithſtanding all theſe preparations the boom was forced, the town relieved, and the ſiege raiſed, by the aſſiſtance brought by three ſhips only, in the following manner: The *Montjoy of Derry*, commanded by Captain *Browning*, and the *Phœnix of Colrain*, by Captain *Douglas*, being both laden with proviſions, were ſent towards the town, under the convoy of the *Dartmouth* frigate, commanded by Captain *John Leake*. They were forced to ſtand a furious fire of the enemy from Culmore fort, and from the forts and intrenchments on both ſides of the river, which they received and returned with the greateſt bravery imaginable. The *Montjoy* made a little ſtop at the boom, occaſioned by her rebound, after ſtriking and breaking it, ſo that ſhe run a-ground. Upon this the enemy gave a loud and joyful ſhout (though a dreadful one to the beſieged), fired all their guns upon her, and were preparing their boats to board her. The trouble and concern of the beſieged, to ſee their laſt hopes diſappointed, is not to be expreſſed; but by great providence, firing a broadſide, the ſhock looſened the ſhip ſo, that ſhe got clear and paſſed the boom. Captain *Douglas* was engaged all the while, and the *Dartmouth* gave the enemy very warm entertainment, till at length the three ſhips, having overcome the great difficulty of breaking and paſſing the boom, got into the city, and brought unſpeakable joy and tranſport to a garriſon, which reckoned only upon two days life, having nothing left but nine lean horſes, and a pint of meal to each man. This brave and ſucceſsful undertaking ſo diſcouraged the enemy, that they raiſed the ſiege the next day, and retreated by night in the utmoſt confuſion; but made a moſt miſerable havock in the country, by robbing and burning all before them for ſeveral miles.

The boom appears to have been laid directly athwart the ſtream, and ſo was eaſier to force, than if it had been laid obliquely acroſs.

209. The

Digitized by Google

209. *The action of Gibraltar, in the year 1693.*

The English fleet, under the command of *Sir George Rooke* and *Sir Thomas Hobson*, were convoying a very large fleet of merchant ships toward the Mediterranean; but falling in with the French fleet, under the command of *Admiral Tourville*, the English admiral gave the signal for the merchantmen to shift for themselves. Among others, four heavy-laden Turkymen; namely, the *Shandois*, the *Italian Merchant*, the *Asia*, and the *Loyalty*, stood away for the Spanish ports, and put into the bay of Gibraltar; where the commanders of the Turky ships, being hindered from prosecuting their vogage by some dissension on board, and the fear of the French fleet, thought proper to fortify themselves.

For this purpose the commanders posted their four ships in a line within the new mole, which stretches to the NW., with their broadsides flanking toward the north, or entrance into the mole; the ships were unrigged, and consequently having no sails to manage, they turned all hands to the cannon, bringing as many as they conveniently could to bear on one side.

On the SE. end of the mole, or land-side, was a castle, in which were mounted ten small cannon, four pointing into the bay toward the west, three commanding the mole, and the rest flanking the NE. shore. Opposite to the mole-head was a kind of redent, very advantageously built to flank the entrance into the mole; but neither on this, nor the mole-head, had the Spaniards any cannon. From the castle there ran northward a line of communication, or a strong stone wall, to the south end of the town, where was a battery of cannon, but too far from the mole to be of any service in defending it.

The English stretched a cable from the mole-head to the redent, the ends being bent to two sheet anchors, and to this cable they lashed their *spare-yards* and *top-masts*. Upon the mole-head were planted six of the Shandois's guns to flank the boom, and this battery was committed to the care of some English seamen, who behaved themselves very well. The commanders intended to plant some guns at the other end of the boom upon the redent, but being obliged to go through the castle, the draw-bridge broke, and down went the first gun that came upon it into a ditch near forty feet deep, with some of the Shandois's men; by this it may be judged in what condition the Spanish works and garrison were.

In this posture things were, when the French came into the bay with fourteen or sixteen men of war and two bomb-ketches, and standing within shot of the castle, the Spaniards shewed their dexterity in managing their ordnance by firing about one shot in half an hour. The commanders perceiving their aukwardness, sent a quartermaster from on board the Shandois, and the gunner's mate of the Loyalty, to their assistance, and some dozens of cartouches; but through want of judgment in the Spaniards they were both blown up. All this time not a ship could bring a gun to bear, and so without any damage the enemy passed by into the bay, where they anchored.

In the afternoon they sent down two *men of war* to view in what posture the ships lay; as soon as they came within shot, the English fired briskly at them; but before many broadsides were returned, they stood away to

Digitized by Google

their ſquadron, and continued quiet that day. Next morning a ſhip of upwards of fifty guns came toward the boom, and it proving calm when ſhe came within ſhot, there was pretty briſk firing on both ſides, on which ſhe endeavoured to tow off, but her boats were ſunk from the battery on the mole-head, and had not boats come from the ſquadron to her aſſiſtance, ſhe had moſt certainly been ſunk, having above 100 cannon playing upon her from the Engliſh. The enemy finding ſuch entertainment provided for them before the boom, ſent off four *men of war* and the two *bomb-ketches*, which lying to the ſouthward of the mole, and firing over it, raked the Engliſh fore and aft; who, on account of their former diſpoſition, could not bring one gun to bear upon the enemy, either from the four ſhips, or from the mole; under theſe circumſtances, the commanders judged it beſt to ſink the ſhips. In the evening the French ſtood out of the bay; and next day ſtood in again; and having poſted ſome *men of war* and their two bomb-ketches againſt the caſtle and mole, they ſent in a ſtore-ſhip which they had turned into a fire-ſhip, and burnt the upper works of three ſinking ſhips; for the *Italian Merchant*'s forecaſtle being under water, ſaved the Shandois.

210. *Diſpoſition of the Engliſh fleet at Cadiz.*

The 16th of October *Sir George Rooke* arrived in the bay of Cadiz with the fleet under his command, and on the 21ſt it was reſolved in a council of war, that as there were but 30 ſhips of the line, which was not a force ſufficient to oppoſe the enemy, who were expected to be above double that number, all that could be propoſed till the fleet ſhould be reinforced from England, was to protect the trade. But leſt the French ſhould appear at Cadiz before this reinforcement arrived, it was agreed that the ſhips ſhould be removed within *Puntal* caſtle, and formed in three lines; which was all that could be done, the ſhips being in general but half manned, and the Dutch ſhips very foul.

Theſe three lines were to be as follows: the firſt to conſiſt of the largeſt Engliſh ſhips, to lie from *Pultal* thwart the channel to the creek's mouth called *Truccadero*, next within the north caſtle; the ſecond to be compoſed of the ſmalleſt Engliſh and Dutch ſhips, along the ſhoal on the ſouth ſide of the harbour; and the third to be of the largeſt Dutch ſhips, to begin from the upper end of the ſecond line, and to trench away thwart the channel, to the mouth of the upper creek, which goes to *Port Real*; and the ſmall frigates, bomb-veſſels, and fire-ſhips, were to be poſted to the beſt advantage, as the wind and other circumſtances might permit. However the fleet was not attacked, and about the middle of March Sir *George* put to ſea on his return to England, and arrived in the Channel on the 22d of April.

211. *Fortifications in the harbour of St. John in Newfoundland*, 1697.

Commodore *Norris* being ſent with a fleet to recover Hudſon's bay, put into the harbour of St. John in Newfoundland, upon hearing that a large French fleet were on the coaſt of North America; and not knowing the ſtrength of the enemy, he judged it prudent to ſecure his force, that it

Digitized by Google

it might be employed in the service he was sent on. He therefore put his squadron into a line of battle, which was composed of four fourth rates, two fifth, and two sixth rates, with two fire ships, two bomb-vessels, and a hag-boat. Two booms were laid across the harbour, and Colonel Gibson's regiment, that was carried by the squadron from England, was disembarked, and several guns mounted on the batteries ashore.

When the French squadron came in sight, the foregoing disposition was altered. All the *men of war* lay in a half-moon to the harbour's mouth; and each ship's broadside commanded the two booms: Colonel Gibson's regiment was posted at the two batteries, and about the harbour's mouth, and Captain Richards (who was the engineer for fortifying the harbour) was making such works as he judged necessary on this occasion; and that the squadron might be better able to do service, all the men were taken from the merchant ships and put on board them.

The French fleet made no attempt on the harbour; but, on the contrary, were glad to find that the English had been misinformed of their strength, and so shaped their course for Europe.

212. *The battle of Vigo, in the year* 1702.

Monsieur *Chateau-Renault* arriving early in September at Vigo in Gallicia, with the Spanish galleons under his convoy, received information of the English and Dutch fleets being before Cadiz; of which timely intelligence he made all the advantage he could in preparing for their reception.

In the upper end of *Vigo bay* is a river running into the bay; up this river is *Redondella* harbour, which is surrounded with hills in such a manner, as to be capable of being made very strong, the harbour's mouth not being above a musket-shot over. On the north side the entrance was a battery of eight brass, and twelve iron guns, and on the south side a platform with twenty stately brass guns, and twenty good iron guns, besides a stone fort, with a trench about it, mounted with ten guns, and defended by 500 men. A little above the battery on the right, from two points in a narrow gut, was stretched a cable, to which was lashed masts, yards, casks, &c. with their top chains, and frapped about with four-inch rope very thick. The bight of the boom was rid by three anchors down the stream, that if the English ships came stemling against it, they might not bring home the anchors upon the shelf at the end of the boom; or if they cut it in one place, the whole might not be open. To flank the boom, there was moored the L'Esperance, a ship of seventy guns, on the south side, and the Le Bourbon, a ship of seventy-six guns, on the north side; also five men of war, of sixty and seventy guns each, lay moored with their broadsides flanking the gut. The French admiral, to give him his due commendation, had taken all human precautions to secure his fleet.

When the confederate fleet came before the place, Sir George Rooke called a council of war, and it was resolved to attempt the forcing of the harbour the next morning. As soon as the land-forces were got on shore, the 12th of October in the morning, the admiral gave the signal to weigh, the line was formed, and the squadron was briskly bearing up to

Digitized by Google

the boom; but when the van was got within shot of the batteries, it fell calm, so that they were necessitated to come to anchor. A fresh gale springing up not long after, Vice-admiral *Hopson*, in the *Torbay*, being next the enemy, immediately cut his cables, clapt on all his sails, and bearing up directly against the boom, amidst all the enemy's fire, broke through it at once, cast anchor between the L'Esperance and Bourbon, and with unparalleled resolution received several broadsides from them. The rest of Vice-admiral *Hopson*'s division, and Vice-admiral *Vandergoe*'s, with his detachment, having weighed at the same time, sailed abreast toward the boom, to add the greater weight and force to the shock, but being becalmed, they all stuck, and were obliged to hack and cut their way through; but a fresh gale blowing again, the Dutch Vice-admiral made such good use of it, that having hit the passage which the valiant *Hopson* had made, he went boldly in, and made himself master of the *Bourbon*. All this while Admiral *Hopson* was in great danger, for being clapt on board by a French fire-ship, by which his rigging was presently set on fire, he expected every moment to be burnt; but it very fortunately fell out, that the French ship, which indeed was a merchantman laden with snuff, and fitted up in haste for a fireship, being blown up, the snuff in some measure extinguished the fire, and preserved *Hopson*'s ship from being consumed, which however received very considerable damage in this action. At the same time Captain *Bokenham*, in the *Association* of ninety guns, laid his broadside against a battery of seventeen guns on the left side the harbour, while Captain *Wyvell* in the *Barfleur*, a ship of like force, was sent to batter the fort on the other side. Thus for a long while there was a considerable firing of great and small shot on both sides, till the French admiral seeing the platform and fort in the hands of the English, his fire-ship spent in vain, the *Bourbon* taken, the boom broken, and the confederate fleet pouring in upon him, he set fire to his own ship, and ordered the rest of the captains under his command to follow his example, which was done in great confusion; yet could he not be so punctually obeyed, but that several men of war and galleons were taken by the *English* and *Dutch*.—In this action it should be observed, that the success of the fleet was in a great measure owing to the land-forces under the command of the Duke of *Ormond*, who not only drove away several bodies of troops destined for the defence of the shore, but also took the castle and platform on the south side, which might otherwise have done great damage to the fleet.

213. *The action of Carthagena, in the year* 1741.

Carthagena, one of the best towns the Spaniards have in South-America, lies on the Caribbean Sea, almost due south of the east end of Jamaica. An irregular shaped peninsula, running in the direction of the sea-coast, nearly north and south, forms a fine harbour of about ten miles long, and in some places about two miles broad: near the north end of this harbour stands the city, its NW. side being washed by the sea, which being very shoal and rocky to some distance from the shore, together with a great surf, hinders the town from being molested to sea-ward. On the south end of the harbour is an entrance called Boca-chica, of about one

Digitized by Google

one third of a mile broad, with sufficient water for the largest ships. The north side of this entrance is near a mile long, running east and west, and the south side not above half that length; just within this passage, on the south side, lies a small island, between which and the east end of the north side is about one fourth of a mile.

In the spring of the year 1741, England being at war with Spain, an expedition against Carthagena was undertaken by the English; the fleet was under the command of Admiral *Vernon*, and the land force was conducted by General *Wentworth:* the Spaniards, apprized of the design, made an excellent disposition for the reception of their enemies, who found the following impediments to their sailing into the harbour.

Near the east end of the north side of the entrance, stood a well-built regular square fort called Boca-chica castle, two of its bastions commanding the passage, the walls of stone, and mounted with 82 cannon and three mortars; and at the west end were the forts of St. Philip and St. Jago, serving as redoubts to the castle, and guarding a small bay where there was tolerable landing. On the western end of the south shore, called the Barradera, was a fascine battery of 15 heavy cannon, about five of which commanded to sea-ward, and the rest flanked the west shore of the other side, and even the castle itself. On the island stood St. Joseph's fort with 21 guns; between this fort and the castle was stretched a boom obliquely across the passage; and above this boom were moored, in a line commanding the boom, four men of war, each carrying from 60 to 70 guns.

Three English 80 gun ships, in about three hours cannonading, obliged the enemy to retire from the forts of St. Philip and St. Jago; and the army was landed, encamped, and formed the siege of the castle: eight days afterward, the camp having been much galled by the Barradera battery, it was attacked, burnt, and most of the guns spiked, by the boats of the fleet, under the command of Captain *Boscawen:* but the Spaniards, knowing the value of that battery, repaired it; and by its fire so much interrupted the progress of the army, that seven days after its first destruction, three ships were ordered to lie against it, and the boats of the fleet were again manned, under the command of Captain *Watson*, when they effectually destroyed the whole battery. Two days after, on the 25th of March, while Bocha-chica castle was storming by the army through the breach they had made, the Admiral sent the ships boats, under the command of Captain *Knowles*, to attack St. Joseph's fort, which he took possession of about ten o'clock at night, and also of the Gallicia, the Spanish admiral Don Blass's ship, the Spaniards, upon hearing the English huzzas at the castle, having abandoned the castle, St. Joseph's fort, and the four ships, which were already scuttled for sinking to barr up the passage; but the enemy, in the utmost panic, had not time to follow their orders, so that only two of their ships were sunk, and a third they set on fire. Captain *Knowles* immediately ordered the boom to be cut, and opened the passage, through which Admiral *Vernon* with the fleet sailed the next morning: and now the *English* having possession of the harbour, the necessary dispositions were made for gaining the town: but here they failed; and the officers thought it better to retire with their fleet and army, than to stay longer in a country, the unwholesome

Digitized by Google

wholesome climate of which was infinitely more to be dreaded than the utmost efforts of its timid inhabitants.

214. *The proceedings of the English in the river Hughley, in Bengal, in India,* 1757.

In the year 1756, the government of Bengal devolving on a nabob in the French interest, he, on a frivolous quarrel, dispossessed the English of most of their settlements on the river Hughley: but the governor of Calcutta, and many of the factory, secured themselves, and part of their effects, on ship-board, and fell down the river out of the nabob's reach. To regain these places, and to punish the nabob and the *French* for their perfidious dealings, Admiral Watson, commanding the fleet, and Colonel Clive the land-forces, entered the river Hughley. On the 15th of December the army was landed, and, in conjunction with the fleet, attacked and took every place of defence on the river up to Calcutta, which they retook on the 2d of January, 1757; and before the 11th they took the town of Hughley, which they plundered, and afterward destroyed.

On the 5th of February, Captain *Warwick*, at the head of a party of seamen, by the Admiral's order, joined Colonel Clive, and the same day they gained a victory over the nabob's army, which obliged him to make a peace, very advantageous to the English.

Afterward, Colonel Clive having taken all the French posts in the neighbourhood of Chandenagore, except one between the fort and the river, Admiral Watson, who was proceeding up the river to second the land operations, found himself obliged to come to anchor about two miles below the place; for the French had done every thing in their power to obstruct the passage of the English by sinking two ships, a ketch, a hulk, a snow, and a vessel without any masts, all directly in the channel, within gun-shot of the fort, and laying two booms, moored with chains, across the river.

The Admiral conceiving that a passage might be found between those sunken vessels without weighing any of them, sent by night some expert persons, under the direction of Mr. Delamot, master of the Kent, who, without being perceived by the French, found out a sufficient channel, and cut the booms; which being effected, and the boats on their return, Delamot * hung up a light at the mast-head of one of the sunken vessels, at which the enemy kept up a constant cannonade during the night. On the 24th the Admiral passed through this channel with three ships, and coming abreast of the fort, he anchored; and in less than three hours, after a very brisk firing, the enemy hung out a white flag, and capitulated, notwithstanding they were 1200 strong, had 183 cannon, and

* Perhaps Delamot, to cover his last operation, hung up the light at a distance from the place where he was at work, to draw the enemy's fire clear from the people employed.

three

Digitized by Google

three mortars. Captain Latham was ſent to receive the keys, and take poſſeſſion of the fort, and colonel Clive, with the king's troops, marched in about 5 o'clock.

215. *Of the ſiege of Louiſburg, in* 1758.

Louiſburg is a ſtrong town in the iſland of Cape Breton; it ſtands at the SW. end of a very fine bay, which extends NE. and SW. above two miles in length, and is about three quarters of a mile in breadth: the entrance, of about one quarter of a mile broad, is near the middle of the bay; its ſouthern ſide is formed by a cluſter of iſlands, in one of which ſtood a large battery, called the Iſland Battery, of 36 guns; and on the coaſt oppoſite the entrance ſtood the royal battery of 42 guns, with a covered way and glacis before it. In the harbour were 13 ſail of ſhips, moſt of them lying to the NW. of the town, ready to defend it on the harbour ſide, and to impede the approaches on the land ſide: the garriſon was about 4,000 ſtrong, had about 220 cannon, 18 mortars, and was well ſtored with proviſion and ammunition.

On the 28th of May, the fleet under Admiral *Boſcawen*, and the army under General *Amherſt*, aſſembled before Halifax, and on the 2d of June they anchored in Gabarus Bay, about two miles to the SW. of Louiſburg: but on account of the blowing weather, nothing toward landing could be done till the 8th, when ſeven frigates drew near ſhore, and for about a quarter of an hour cannonaded the French defences thrown up along ſhore; and then the boats landed the troops amidſt a very heavy fire, both of the French muſketry and cannon, and a moſt dreadful ſurf, which overſet and ſtaved ſeveral of the boats, and drowned many ſoldiers; and upon the whole there were above 100 boats loſt in landing the troops and proviſions.

On the 12th, Brigadier Wolfe was ſent round the harbour to the north ſide of the entrance, to conſtruct a battery near the light-houſe, and thence to ruin the iſland battery. He drove the enemy from all their defences on that ſide, took ſeveral cannon, and by the 20th had completed the light-houſe battery, which, with the fire from the ſhips, ſilenced the iſland battery by the 25th. The light-houſe battery being conſiderably ſtrengthened by ſhip-guns, and intrenched, Brigadier Wolfe was ordered round with his detachment and cannon, and to advance toward the weſt gate, and to try to deſtroy the ſhipping. He took poſt on the hills for that purpoſe on the 30th.

The 29th, the French ſunk four ſhips in the harbour's mouth with their maſts cut down; and on the 21ſt of July, one of their ſhips was ſet on fire by a ſhot from the marine battery; this fire communicating to two others, the three were burnt. On the night of July 25, Admiral Boſcawen detached the boats of the fleet in two ſquadrons, under the command of the Captains Lafory and Balfour, to take or burn the only two French ſhips then in the harbour. The boats going ſilently along the middle of the harbour, the noiſe of the oars was not heard at land, nor at the ſhips till the boats were nearly along-ſide; and then the courage and activity of the ſeamen rendered all reſiſtance uſeleſs; one of the ſhips,

Digitized by Google

ſhips, the Prudente of 74 guns, being aground, they ſet her on fire; and the other, the Bienfaiſant of 64 guns, they cut from her anchors, and towed into the NE. harbour amid the fire of the muſketry and cannon from the town and other places.

In fine, the batteries of the Engliſh being opened, well ſerved, and well directed; and the enemy's ſhips, and many of their defences being ruined; they thought proper to capitulate on the 26th of July, and the Engliſh took poſſeſſion of the town on the 27th.

216. *Of the taking of Quebec, in the year* 1759.

QUEBEC, the capital of the French dominions in North America, ſtands on the NE. bank of the great river St. Lawrence, about 360 miles from its mouth, and on the ſouth ſide of the river St. Charles; which falling into the river St. Lawrence on the north of the town, forms a fine baſon of about three miles in length and breadth; the eaſt and NE. parts are terminated by the iſle of Orleans, which is a moſt delightful and well cultivated ſpot about twenty miles long and ſeven broad, formed by the river St. Lawrence. The greateſt part of Quebec ſtands on a rocky hill, in ſome places near fifty feet above the river; and on a ſmall ſtrand at the foot of the hill is built the part called the Lower Town: the high land ſtretches up the river St. Charles, and alſo, with a ſteep front, for many leagues up the river St. Lawrence. The town was fortified and well defended by many batteries; and an army of about 10,000 men, under the brave and cautious General *Montcalm*, occupied poſts well intrenched, at every acceſſible ſpot, for an extent of near five miles on the ſide of the river St. Charles, which was imagined to be the only part where the town could be approached by an enemy: theſe poſts had in front a ſand-bank between them and the river, and thick woods in their rear.

The Engliſh army, of about 7,000, commanded by General *Wolfe*, was landed by Admiral Saunders, who commanded the fleet, on the 27th of June, on the iſle of Orleans; and on the 29th of June a detachment drove the enemy from Point Levi, a high promontory on the ſouth ſhore of St. Lawrence, which commanded the baſon, and even the town of Quebec, and from whence the Engliſh batteries conſiderably damaged the Upper Town, and entirely deſtroyed the Lower one: and about the ſame time a detachment took poſſeſſion of the weſtern point of the iſle of Orleans, which alſo commanded the baſon. Admiral Saunders, with his diviſion of the fleet, was poſted below the town in the north channel, and Admiral Holmes, with his diviſion, was ſtationed above the town, to divide the enemy's attention, and guard the batteries playing on the town and works.

On the 30th of June, about midnight, ſix fireſhips, well prepared for burning, their ſails being covered with a compoſition that burnt a conſiderable time, were almoſt in an inſtant lighted up, and made a moſt terrible appearance. They came down with a gentle breeze and a ſtrong tide toward the middle of the fleet, then riding in the north channel, pretty cloſe to one another; but this being expected by the Admiral, the boats were ordered out, and theſe dreadful machines towed aſhore on

Digitized by Google

on the Isle of Orleans, where they burnt quietly without doing any mischief. The enemy's next attack was by a raft of fire-stages composed of fir logs, each stage about the size of a long-boat; these were lashed together, filled with combustibles, loaded pistols, and gun-barrels, and turned adrift toward the ships, but with no better success than the other: the whole was about 200 feet long, and made a fine bonfire.

General Wolfe having encamped on the 9th of July at Montmorenci, on the continent below the town, and tried, during almost two months, several ways to bring the enemy to a battle, (all which were frustrated either by the difficulties of the place, or the vigilance of *Montcalm)*, determined to try what could be done above the town. He therefore removed the camp to Point Levi on the opposite shore, and Admiral Holmes's squadron made for several days some movements up the river, the English army advancing at the same time along the southern side; while M. Bouganville, with a body of 1,500 French troops, proceeded along the northern side to watch these motions. On the 12th of September, about midnight, the English were embarked in the flat-bottomed boats, and fell silently down the stream, the enemy being amused up the river by Admiral Holmes. The boats landed on the north side, not exactly where it was intended, and the troops were obliged to scramble up a woody precipice, which however they effected, dispersing a captain's guard posted there, and the army was formed by daylight.

While this was doing, in order to draw Montcalm's attention another way, as had been concerted, Admiral Saunders ordered all the boats of the men of war and transports, well filled with men, to feign an attempt on the French intrenchments below the town. The number of boats, and the manner in which this false attack was conducted, kept the French general too much alarmed to think what might be doing above the town, and which he could scarcely believe when informed of it; but being convinced, he assembled his troops and marched to attack the English. Both armies drew up with great circumspection; and the French advancing, began the engagement with a galling though irregular fire; which was received and borne with great patience, till they were come to the distance of 40 yards; then the English poured in such a well-aimed and dreadful fire, that the French army immediately staggered; and being pushed with a true British spirit, they broke and yielded up the victory. This decisive battle was followed by the surrender of Quebec, by capitulation, five days after; and the English troops took possession of that city and its neighbouring country.

217. The late wars, particularly the last, have furnished many examples of sea engagements, and of the attack of strong places on the sea-coasts; where both the sea and land officers have shewn themselves possessed of all the military knowledge, which good sense and experience could produce, besides that intrepidity so natural to Britons: the few examples here selected, chiefly to illustrate the laying of booms, are neither the most interesting, nor those where British valour

has

Digitized by Google

has ſhone in its greateſt ſplendor: there are many actions of equal importance, and accompanied with as ſtriking circumſtances, which may be found among the accounts publiſhed on thoſe occaſions. This ſubject cannot be better cloſed, than with a remark of Admiral Vernon; That where men of war can be brought to act at a ſmall diſtance, as about 100 yards, or leſs, no fort can withſtand their fire; but at a greater diſtance, as of half a cannon ſhot, a fort can receive very little damage from the fire of ſhip-guns.

FINIS.

James Macully's Book.

James Macully's Book.

Digitized by Google

Digitized by Google

NX 001 131 264

UNIVERSITY OF VIRGINIA LIBRARY
The return of this book is due on the date indicated below

DUE	DUE
11-30-91	
10-12-94	

MICHIE CO

Usually books are lent out for two weeks, but there are exceptions and the borrower should note carefully the date stamped above. Fines are charged for over-due books at the rate of ten cents a day; for reserved books the rate is twenty-five cents a day. (For detailed regulations please see folder on "Loan of Books.") Books must be presented at the desk if renewal is desired.

Digitized by Google

Digitized by Google