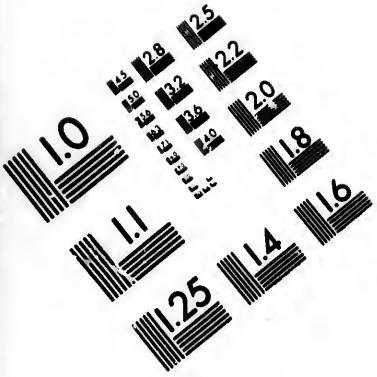

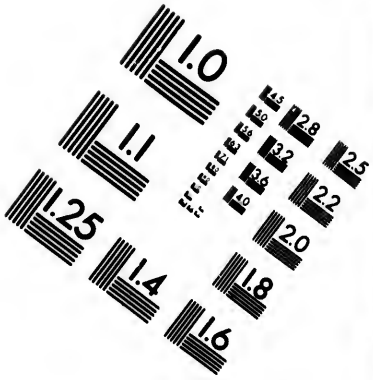

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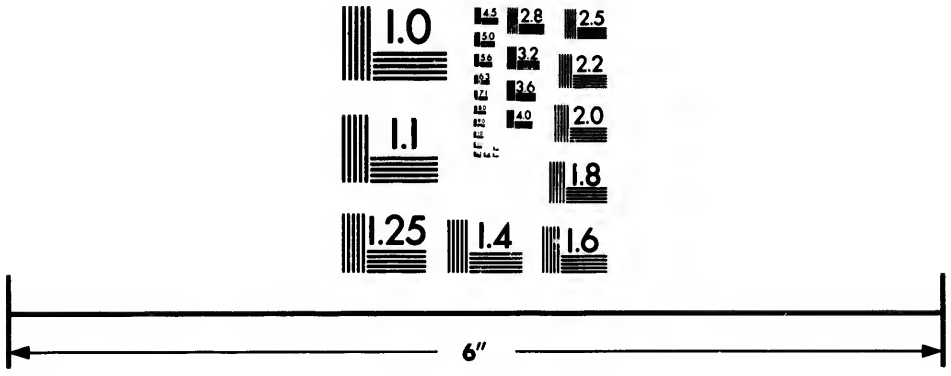

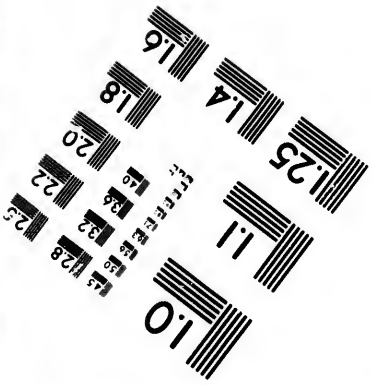

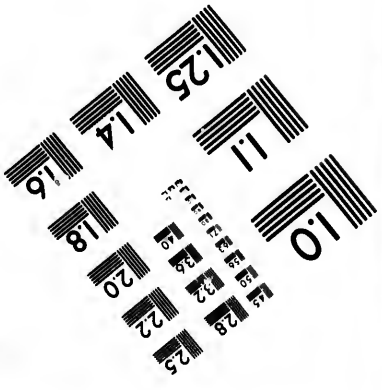

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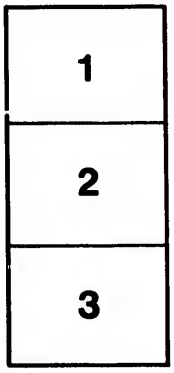

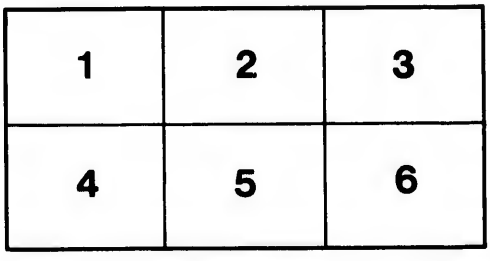

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MANUAL

ON THE

USE OF THE GLOBES;

IN TWO PARTS.

PART I.

ON THE TERRESTRIAL GLOBE.

BY

JAMES PATERSON,

PRINCIPAL OF THE SAINT JOHN GRAMMAR SCHOOL.

"Ere half of the school authors are read," says Milton, "it "will be seasonable for youth to learn the use of the Globes."

"A Terrestrial Globe ought to be considered an indispen- "sable article of apparatus in every school."

SAINT JOHN, N. B:

PRINTED BY HENRY CHUBB, MARKET-SQUARE;

AND

SOLD BY W. REYNOLDS, D. M'MILLAN, AND W. L. AVERY.

1838.

PREFACE.

The Author of the following Manual has been directed in drawing it up by what appeared to him necessary for the Seminary over which he presides; but he hopes, that it will not be unacceptable to other Teachers in this flourishing colony.

Nothing is introduced foreign to a simple course of instruction on the Use of the Globes, and nothing omitted that appeared to be absolutely necessary.

The Explanations and Problems are made to follow each other in an easy and natural order, like the propositions in Euclid, every one forming a preparation for those that follow; so that even the youngest pupil may be easily initiated into a knowledge of this elegant branch of youthful study.

For two reasons, it has been thought proper to publish this Manual in two parts; first, because in some schools the Terrestrial forms a subject of study to the exclusion of the Celestial Globe; and next, because the greater number of young people take so little care of their books, that before their course of study is finished they require more than one copy of a book.

Should a second edition be called for, any improvement which may be suggested by others, or which the Author's own further experience may find necessary, will be introduced.

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A

MANUAL

ON THE

USE OF THE GLOBES.

PART I.

OF THE TERRESTRIAL GLOBE.

THE terrestrial Globe represents the Earth in its form, its division into land and water, and into countries, kingdoms, oceans and seas.

The first thing that strikes the youthful eye is its roundness, or spherical shape. That the earth is spherical, or nearly so, the pupil may be told, is demonstrated by the shadow it projects upon the disc* of the Moon, when that luminary is eclipsed, a phenomenon which is occasioned by the Earth intervening between it and the Sun, the great source of the light by which it is illuminated. Without

* The disc of a heavenly body is its face, which appears flat on account of its immense distance.

going so high for a proof, he may ascertain the correctness of the doctrine, by being led to consider that the part of a ship which appears first when approaching the land, and the part which appears longest when going out to sea, is the top of the masts;—the convexity of the earth concealing from view the hull, which, on account of its largeness, would, were the earth not spherical, be seen first and longest. To which might be added the testimony of navigators, who have sailed round the world.

On a further inspection of the Globe, the pupil discovers a number of lines, circles and appendages, which it will be necessary for him to understand, before an attempt can be made to solve any problem.

EXPLANATION OF CIRCLES, &c.

The Circles* on the Globe are either great or small. Great Circles are such as divide the Globe into two equal parts, and whose centre is the centre of the Globe. Small Circles are such as divide the Globe into two unequal parts. All circles are divided into 360 equal parts, called degrees, but the de-

* A Circle is defined in geometry to be a figure contained by one line, every part of which is equi-distant from a point which is called the centre.

grees vary in magnitude with the circle. A degree of a great circle is divided into 60 minutes; and a minute into 60 seconds. Degrees are generally denoted by a small cipher over the figures, minutes by a small dash sloping from right to left, and seconds by two such dashes. For example, twenty-five degrees, fifteen minutes and thirty-seven seconds, will be written thus, 25° 15′ 37″.

The rod or spindle, by the extremities of which the Globe is suspended, and on which it freely moves, represents the axis of the Earth, or polar diameter.* The Globe, revolving on this from West to East, shews the diurnal rotation of the Earth, which causes the phenomena of day and night, and the apparent daily rising of the Sun and Stars in the East and setting in the West.

The ends of the axis are called the Poles, (from the Greek Poleo, to turn,) because on them the world is supposed to revolve. They are distinguished by the names Northern and Southern, or Arctic† and Antarctic.

The great circle, equi-distant from the Poles, is called the Equator, (from the Latin Æquo, to equal,) either because it divides the Globe into two equal parts, called the Northern and

* Diameter (from the Greek *dia*, through, and *metron*, measure,) means that line which passes through the centre and is terminated, both ways, by the circumference.

† Arctic (from the Greek *Arctos*, a bear,) is applied to the Northern Pole, from Ursa Major, the Greater Bear, a constellation in the heavens near the North Pole. Antarctic means opposite to the Arctic.

Southern Hemispheres,* or, more probably, because when the Sun in his annual course comes upon it, which occurs twice in the year, the day and night are equal in every part of the world.

The Circles that meet in and pass through the Poles are called Meridians (from the Latin Meridies, mid-day,) because the Sun, in his daily course, is on them at mid-day. There are generally twenty-four of these on the Globe, to represent the twenty-four hours of the day, 15° apart from each other. But every place has a meridian, and the Brazen Circle, in which the Globe is suspended, is employed to represent them all. This Brazen Meridian is graduated or divided into degrees, measuring 90° from the Equator Northward to the N. Pole, and 90° from the Equator Southward to the S. Pole, on the upper semicircle, and 90° from the North Pole to the Equator, and 90° from the South Pole to the Equator, on the lower semicircle.

The great Circle which intersects the Equator obliquely at two opposite points, is called the Ecliptic, (from the Greek Ekleipsis, a waning or eclipse,) because Eclipses of the Sun and Moon take place only when these two bodies and the Earth are all in the plane of that circle and in a direct line with respect to each other. It represents the Sun's orbit, or

* Hemisphere (from the Greek *hemi*, half, and *sphaira*, a sphere,) means half of the globe.

apparent path in the heavens, which he describes in 365 days and nearly six hours. It is divided not only into 360 degrees, like other circles, but also into twelve equal parts, called Signs, each occupying 30°, which derive their names from the Constellations with which they correspond on the celestial Globe, and are as follow,

Aries, the Ram,	♈
Taurus, the Bull,	♉
Gemini, the Twins,	♊
Cancer, the Crab,	♋
Leo, the Lion,	♌
Virgo, the Virgin,	♍
Libra, the Balance,	♎
Scorpio, the Scorpion,	♏
Sagittarius, the Archer,	♐
Capricornus, the Goat,	♑
Aquarius, the Water Bearer,	♒
Pisces, the Fishes,	♓

The first six are sometimes called the Northern Signs, because they embrace the Northern half of the Ecliptic, and the last six the Southern Signs, because they embrace the Southern half of that circle. They are also divided according to the seasons of the year, thus, Aries, Taurus, Gemini, are called the Vernal Signs; Cancer, Leo, Virgo, the Summer Signs; Libra, Scorpio, Sagittarius, the Autumnal Signs; and Capricornus, Aquarius, Pisces, the Winter Signs. Another division, which should not be omitted, is into Ascend-

ing and Descending Signs. The Ascending Signs are Capricornus, Aquarius, Pisces, Aries, Taurus, Gemini; and the Descending Signs are Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius.

Four points in the Ecliptic require particular notice,—the first degrees of Aries, Libra, Cancer and Capricornus. The first degrees of Aries and Libra are called the Equinoctial points,—Aries, the Vernal Equinox, and Libra the Autumnal Equinox, (from the Latin Æquus, equal, and Nox, night,)—because the Sun, when in these points, causes equal day and night.* The first degrees of Cancer and Capricornus are called the Solstitial Points,—Cancer, the Summer Solstice, and Capricornus the Winter Solstice, (from the Latin Sol, the Sun, and Sto, to stand,) the Sun appearing to stand still at these points, on account of some days together being of equal length at these periods.

The two Meridional circles that pass through these four points are called sometimes Colures, (from the Greek Kolos, cut, and Oura, a tail,) curtailed, because they are never seen above the horizon at once, and appear on that account to be cut or divided. They mark out the four seasons of the year.

The upper flat surface of the wooden frame, in which the Globe is supported, is called the Horizon, (from the Greek Horidzo, to bound

---

* Hence also the Equator is sometimes called the Equinoctial.

or limit,) and represents the natural boundary of our vision, when the eye casts itself over and around the whole expanse that lies before it, or rather a circle parallel to that natural boundary dividing the Globe into two equal parts. As every part of the Globe has a meridian, so has every part a horizon, and these intersect one another at right angles.

On the Horizon the pupil will observe several concentric* circles, which are indispensably necessary in the solution of some problems.

Two of these circles exhibit the twelve Signs of the Ecliptic and the months with which they correspond. The next, which in some Globes is within, and in others without these, is a delineation of the Points† of the Mariner's Compass, in their proper position in regard to the Globe. The remaining cir-

---

* Concentric means having the same centre, which is, in this case, the centre of the globe.

† These points are thirty-two in number, and are each denominated by means of the initials of the four first points, North, East, South, and West, viz:—

North	East	South	West
N. by E.	E. by S.	S. by W.	W. by N.
N. N. E.	E. S. E.	S. S. W.	W. N. W.
N. E. by N.	S. E. by E.	S. W. by S.	N. W. by W.
N. E	S. E.	S. W.	N. W.
N. E. by E.	S. E. by E.	S. W. by W.	N. W. by N.
E. N. E.	S. S. E.	W. S. W.	N. N. W.
E. by N.	S. by E.	W. by S.	N. by W.

The four principal points, North, East, South and West, are called the Cardinal Points, (from the Latin *cardo*, a hinge) as if all the other points hung upon them as upon hinges. So we speak of Cardinal virtues.

cle is divided into degrees, which are numbered both ways, from the East and West, until they end at 90° in the North and South Points.

The two dotted circles, which are drawn parallel to the Equator and through the Solstitial Points, are called the Tropics, (from a Greek word, Trepo, to turn,) because the Sun, when in his progress through the ascending signs he comes to the Summer Solstice, *turns* into the descending signs, and again when in his progress he comes to the Winter Solstice, he *turns* into the ascending signs. The Northern Tropic is called the Tropic of Cancer, because then the Sun is in the first degree of Cancer, and the Southern is called the Tropic of Capricorn, because then the Sun is in the first degree of Capricorn. These circles are just 23° 28′ from the Equator.

At the same distance from the Poles that these circles are from the Equator, the pupil will discover two other dotted circles. These are called the Polar Circles, the Northern the Arctic and the Southern the Antartic. Being 23° 28′ from the Poles, they are consequently 66° 32′ from the Equator.

The Polar Circles and the Tropics divide the surface of the Globe into five broad spaces, which receive the name of Zones, (from a Greek word *Zonē*, signifying a broad belt or girdle.) These are distinguished by names derived from the different degrees of heat and

cold to which they are subjected by their situation. That between the two Tropics is called the Torrid Zone. Those between the Tropics and the Polar Circles are called the Temperate Zones. And those between the Polar Circles and the Poles, the Frigid Zones.

Attached to the North Pole, and on some Globes also to the South, is a brass moveable circle, divided into twice twelve, denoting the hours of the day and night. It is called the Horary or Hour Circle. On some Globes it is not moveable, but is furnished with a moveable index or pointer.

The Table of Equation of Time, which appears delineated on the surface of the Globe, together with its use, will be explained under one of the Problems.

There is an appendage of the Globe, which is not attached to it, consisting of a flexible slip of brass, the length of one fourth of a great circle, and divided into 90°, called the Quadrant of Altitude, because invented for the purpose of ascertaining the altitude or height of the Sun and other heavenly bodies. It serves other useful purposes also, which the pupil will find in the course of the problems.

Note.—In solving problems it is necessary to adjust the Globe so as to have the graduated side of the Brazen Meridian on the right hand.

PROBLEMS

ON THE

TERRESTRIAL GLOBE.

PROBLEM I.

To find the Latitude of a place.

DEFINITION.—The Latitude of a place (from the Latin, *latitudo*, breadth), is its distance from the Equator measured on the brazen meridian. When North, it is called North Latitude; when South, South Latitude.

RULE.—Revolve the Globe till the place comes under the brazen meridian, the degree then above it shows the Latitude.

Examples.—What is the Latitude of Saint John, N. B.?—*Ans.* 45° 15′ N.

What is the Latitude of the Cape of Good Hope?—*Ans.* Nearly 35° S.

Required the Latitude of the following places:—London, Paris, Bagdad, Canton, Saint Helena, Quebec, Rio Janeiro, Cape Horn, Mexico, Fredericton, Halifax, the Sandwich Islands, the extremes of Madagascar?

PROBLEM II.

To find those places which have the same Latitude as a given place.

RULE.—When the place given is brought to the brazen meridian, and the Latitude of it ascertained, make the globe perform one revolution, and observe all the places that come under the same point of the meridian; these have the same Latitude.

Examples.—What places have the same Latitude as Petersburgh?—*Ans.* Stockholm, Cape Farewell, Polym.

What places have the same Latitude as Cape St. Roque?—*Ans.* Loango, Macassar, Southern extremity of new Ireland, and Borja, on the Amazon.

Required the places whose latitude is the same as that of St. John, N. B., Philadelphia, Barbados, Archangel, Vienna, the Isle of Man, Buenos Ayres, Ascension Island, the Maelstrom, Mount Ætna.

PROBLEM III.

To find the difference of the Latitudes of two places.

RULE.—As the difference of Latitude is the Arc* of the Meridian intercepted between the points of latitude, if the places are both in the Northern, or both in the Southern Hemisphere, subtract the less latitude from

* An Arc (from the Latin *Arcus*, a bow), is a part of a curve line; as of a circle, &c.

the greater, but if the one is North and the other South, add them together.

Examples.—What is the difference of Latitude between Madrid and Petersburg?—*Ans.* 60°—40°=20° *

What is the difference of Latitude between St. John, N. B., and St. Salvador?—*Ans.* 45° 15′ + 13°=58° 15′

Required the difference of Latitude between Halifax and New-York, Montreal and Boston, Edinburgh and Lisbon, Pekin and Calcutta, Icy Cape and Cape Horn, St. Helena and Gallipagos, Dublin and Sierra Leone, Tunis and New Zealand, Botany Bay and Constantinople, St. John and London, Frederickton and Boston.

PROBLEM IV.

To rectify the Globe for the Latitude of a place.

By rectifying is meant, adjusting the Globe so that the place, when brought to the brazen meridian, will be in the zenith,† or as it were at the top.

RULE.—If the place is in the Northern Hemisphere, raise the North Pole as many

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* A small horizontal line — is used to denote subtraction; a horizontal line crossed by a perpendicular, + to denote addition; and two horizontal lines = to denote equality.

† Zenith (a corruption of an Arabic word, signifying the vertical point), is the highest point on the Globe, or, when referred to the heavens, the point exactly over our heads. The point directly opposite is called the *Nadir*, (also a corruption of an Arabic word.)

degrees as the Latitude is—if it is in the Southern Hemisphere, raise the South Pole.

Note.—The pupil will see from this Problem a reason for the graduation of the under semicircle of the Meridian beginning from the Poles.

Examples.—Rectify the Globe for London. As the latitude of London is 51° 30′ you raise the North Pole until 51° 30′ on the lower limb of the meridian coincide with the horizon.

Rectify the Globe for St. John, Toronto, Savannah, Cape Saint Roque, Otaheite, the Cape of Good Hope, Van Diemen's Land, Prince William's Sound, Cape Farewell, Bourbon Island, Trinidad, Straits of Magellan.

PROBLEM V.

To find the Longitude of a place.

Def.—Longitude (from the Latin, *Longitudo*, length), is the distance of a place from the first meridian, or meridian of Greenwich,* measured on the Equator. When East from

* The *first Meridian* is that from which all the others are reckoned, and is quite arbitrary. Different Meridians have been chosen for the First at different periods, and by different Geographers. Hipparchus who died 125 years B. C., fixed the first meridian at Ferro, one of the Canary Isles. Ptolemy chose the most Westerly Isle, some the Peak of Teneriffe, and others Cape Verd. In modern times Geographers have generally chosen the meridians of their respective capitals, as, the French, that of Paris, the Spanish, that of Madrid, and the English that of London, or the Observatory at Greenwich.

the first meridian, it is called East Longitude, and when West, it is called West Longitude. The terms Latitude and Longitude were adopted by the ancients in the infancy of geographical knowledge. They applied the term longitude or length to the extent East and West, because they knew more in that direction than in the extent North and South, which in contradistinction they called Latitude or breadth.

Rule.—Bring the given place to the meridian, and observe what degree of the Equator is intersected by the meridian, that is the Longitude.

Example.—What is the Longitude of Vienna?—*Ans.* 16° E. What is the Longitude of Port Royal, Jamaica?—*Ans.* 76° 45½′ W.

Required the Longitude of the following places:—Saint John, Charleston, Trinidad, Cape Finisterre, Calcutta, Bombay, Bergen, Rome, Tripoli, Alexandria.

PROBLEM VI.

To find the places that have the same longitude as a given place.

Rule.—Bring the given place to the meridian, and all the places that are under the upper side of the meridian from the North to the South Pole, have the same Longitude.

Examples.—What places have the same longitude as St. John, N. B.?—*Ans.* Middle of Porto Rico, Ciudad Real, La Plata.

What places have the same longitude as Buenos Ayres?—*Ans.* The Caribbee Islands, the S. W. part of the Island of Newfoundland, and Cape Breton.

Required the places whose Longitude is the same as that of Genoa, Madras, Lisbon, the Society Islands, Bombay, Amboyna, Petersburg.

PROBLEM VII.

To find the difference of longitude between two places.

Rule.—As the difference of Longitude is an Arc of the Equator intercepted between the points of Longitude, subtract the less from the greater if they are both East or both West, but if the one is East and the other West, add them.

Examples.—What is the difference of longitude between St. John and New-York?—*Ans.* 74°—66°=8°

What is the difference of longitude between Rome and Pekin? *Ans.* ~~119°—13°=106°~~ $116\frac{1}{2} - 12\frac{1}{2} = 104$

What is the difference of longitude between New-York and Constantinople? *Ans.* 74° + 29° 30′=103° 30′

Required the difference of longitude between Cork and Calcutta, Vera Cruz and Cape Comorin, Boston and Borneo, Mount Hecla and Mount Ætna, Philadelphia and Siam.

PROBLEM VIII.

To find a place when its Longitude and Latitude are given.

RULE.—Bring the point of the Equator which marks the Longitude to the meridian, and under the point on the meridian which marks the Latitude, the place will be found.

Examples.—What place has 60 degrees of North Latitude, and 31 degrees of East Longitude?—*Ans.* Petersburg.

What place has 18° of North Latitude and 76° 45½′ W. Longitude?—*Ans.* Port Royal.

Required the places whose Longitudes and Latitudes are as follow:

4°	23′	E.	long.	51°	13′	N.	lat.
151°	21′	E.	long.	34°	0′	S.	lat.
58°	31′	W.	long.	34°	35′	S.	lat.
88°	30′	E.	long.	22°	35′	N.	lat.
18°	38′	E.	long.	54°	21′	N.	lat.
0°	0′		long.	51°	29′	N.	lat.
9°	0′	W.	long.	37°	0′	N.	lat.
6°	0′	W.	long.	15°	0′	S.	lat.
155°	0′	W.	long.	19°	0′	N.	lat.

PROBLEM IX.

To find the distance between any two places on the Globe.

RULE.—If both places are on the same meridian, their difference of Latitude multiplied by 60 will give the distance in geographical miles, by 69½ in English miles. But

if they are not on the same meridian, lay the Quadrant of altitude between them, and the number of degrees intercepted, multiplied as above, will give the difference.

NOTE.—In the absence of a quadrant of altitude, the intercepted distance may be taken by a pair of compasses or a piece of small cord and applied to the equator or any other great circle which is divided into degrees.

Examples.—What is the distance between St. John, N. B. and London? *Ans.* 44° or 2640 geographical miles, or 3068 English miles. What is the distance between London and Mecca. *Ans.* 42° 45′ or 2645 geographical miles, or 9971 English miles.

Required the distance between Lisbon and Mexico, between New-York and Halifax, between Toronto and Madrid, between Dublin and Calcutta, between Cape Sable and Cape of Good Hope, between Cape of Good Hope and Canton.

PROBLEM X.

To find the angle of position of two places.

Observe, the Angle of Position is the angle made by a great circle passing through the two places with the meridian of one of them, and may be denominated the geographical bearing the one place has to the other.

RULE.—Rectify the Globe for the latitude of one of the places by Problem IV—bring

the place to the Zenith, fix the Quadrant of Altitude over it and extend it over the other place, the end of the quadrant will shew on the Mariner's Compass on the horizon the angle of position or geographical bearing.

Examples.—What angle of position does a great circle passing through London and Jerusalem make with the meridian of London? or what is the bearing of Jerusalem from London in a geographical sense? *Ans.* 68 deg. south-easterly or 22 deg. from the east towards the south: E. S. E. point of the Compass.

What is the Angle of Position made by the following places with the meridian of Saint John, N. B.? Mexico, Toronto, Washington, Sierra Leone, Halifax, London, Paris.

PROBLEM XI.

To find how many miles make a degree of Longitude on any parallel of Latitude.

Observe, that the circles parallel to the Equator, are called parallels of latitude, because they shew the latitude of places by their intersection with the meridian, and that every place, not on the Equator, has such a parallel, though there are only eight of them from the Equator to the Pole, set down on the Globe, at the distance of ten degrees from each other. Observe also, that the definitions formerly given of small and great circles require particular attention.

RULE.—With a pair of Compasses take off the distance between two meridians on the given parallel, and apply it to the Equator to see how many degrees of a great circle it makes, and then say, as the number of degrees between the same two meridians on the Equator is to the number ascertained on the given parallel, so is 60, the number of miles in a degree of longitude on the Equator, to the required answer.

Examples.—In the parallel of London, lat. $51\frac{1}{2}$, the space between the two meridian lines drawn at the distance of 15 degrees on the Equator, when taken with a pair of compasses and applied to the Equator, is found to contain $9\frac{1}{4}$ degrees. Then, as $15°:9\frac{1}{4}°::60:37$ geographical, or $69\frac{1}{2}$ to nearly 43 Eng. miles.

Required the number of geographical and English miles in the parallels of latitude in which the following places are situated—North Cape, Cape Farewell, St. John, N. B. New-York, Trinidad, Havanna, Tripoli, Mauritius, Icy Cape, the Marquesas Isles, Boston, London.

PROBLEM XII.

To find the Antœcians or Antœci of any place.

Observe, the Antœci of any people, (from the Greek *Anti*, opposite, and *oikos*, a house,) are those inhabitants of the earth who live in the opposite hemisphere, having the same longitude and latitude, being as far south as the other are north.

RULE.—Bring the given place to the brazen meridian, and having noticed its latitude, seek the same number of degrees in the opposite hemisphere, and that will show the situation of the Antœci required.

Examples.—What are the Antœci to the inhabitants of St. John, N. B. *Ans.* River Camarones, in South America. What are the Antœci to the inhabitants of the Colony of the Cape in Africa? *Ans.* The part of the Mediterranean Sea, North of Barca.

Required the Antœci of Edinburgh, Rome, Constantinople, Sardinia, Smyrna, Moscow, Morocco, Charleston, New Orleans.

What inhabitants have no Antœci?

PROBLEM XIII.

To find the Periœci or Periœcians of a place.

NOTE.—The Periœci (from the Greek *peri*, about, and *oikos*, a house,) are those who live in the same parallel of latitude, but in opposite points of Longitude.

RULES.—1*st.* Bring the given place to the meridian, bring XII on the hour circle, also to the meridian, and turn the Globe half a revolution; the Periœci will then be found under the same degree of latitude on the meridian; or

2*d.*—Subtract the Longitude of the given place from 180°, and the remainder will give the longitude of the Periœci in the opposite

hemisphere, which bring to the meridian, then under the latitude will be found the place.

Examples.—What are the Periœci of Saint John, N. B.? *Ans.*—A part of Chinese Tartary $5\frac{1}{2}°$ North of Pekin. What are the Periœci of London? *Ans.*—A spot 1° South of the Islands of the Northern Archipelago.

Required the Periœci of Halifax, Cape Breton, Berlin, Naples, Cairo, New Zealand, Van Diemen's Land, North Cape.

What spot on the Globe has no Periœci?

PROBLEM XIV.

To find the Antipodes of any proposed place.

NOTE.—The Antipodes, (from the Greek, *Anti*, opposite, and *podes*, feet,) are the inhabitants of two places on the earth, diametrically opposed to each other, and who therefore walk feet to feet.

RULES.—1*st.* Find the Antæci of the given place, and the Periœci of these will be the Antipodes; or

2*d.* Bring the given place to the meridian and observe its latitude; turn the globe half a revolution, then under the same degree of latitude in the opposite hemisphere, the Antipodal place will be found; or

3*d.* Bring the proposed place to the horizon; then the opposite point of the horizon will give the Antipodes; or

4*th.* Subtract the longitude of the given

place from 180° and it will give the longitude of the Antipodes—East, if the given place is West—and West, if the given place is East—which turn to the meridian, and under the latitude of the place, but in the opposite hemisphere, the Antipodes will be found.

Examples.—What place is Antipodal to London? *Ans.* A spot a little South of New Zealand.

What are the Antipodes to the inhabitants of St. John, N. B.? *Ans.* A portion of the Indian Ocean 10° South of the South Cape of New Holland.

Required the Antipodes of the following places—The Friendly Isles, Cape Comorin, Jerusalem, Santa Fe de Bogota, Quito, Delos, Cape Guardafui, Cape Horn, Icy Cape.

PROBLEM XV.

To find the Sun's place in the Ecliptic.

RULE.—Seek the day of the Month on the wooden horizon, and against it in the adjoining circle are the sign and degree in which the Sun is for that day, which, referred to the Ecliptic, will give the Sun's place required.

Examples.—What is the situation of the Sun at the Autumnal Equinox? *Ans.* 1° of Libra. What is the Sun's place on the 19th June. *Ans.* ♊ 28°

Required the Sun's place on the first day of each month.

PROBLEM XVI.

To find the day of the year, when the Sun's place is given.

RULE.—Look for the sign and degree of the Sun's place on the wooden horizon, and in the calendar contiguous to it will be found the day of the year.

On what day of the year is the Sun in the 10th of Taurus? *Ans.* 30th April.

Required the days in which the Sun enters respectively the twelve signs of the Ecliptic, or first degrees of ♈, ♉, ♊, ♋, ♌, ♍, ♎, ♏, ♐, ♑, ♒, ♓.

PROBLEM XVII.

To adjust the Globe for the Sun's place and Noon at any place on any given day.*

RULE.—Rectify the globe first for the Latitude of the place, then, finding the Sun's place in the Ecliptic for the given day, bring it to the brazen meridian and set the Index to XII, or, if the Horary Circle is moveable, move it till XII comes under the meridian.

Examples.—Adjust the globe for noon at Saint John on the 22d February. First rectify the globe for the latitude of Saint John,

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* NOON.—From the Latin *nona hora*, meal-time; literally the ninth hour, or three o'clock; the Romans reckoning the hours from 6 A. M.; and because the term was applied by succeeding nations to their dinner time, which was usually about the middle of the day, noon came to signify 12 o'clock.

which is 45° 15′, then bring the 4th degree of Pisces, which is the Sun's place for the 22d of February, to the meridian, and, keeping the globe in this position, bring XII on the hour circle to coincide also with the meridian.

Adjust the globe for Noon at Halifax, on June 30,—at Cadiz, 12th May,—at Cuba, 7th October,—at Paris, December 25,—at Morocco, January 1,—at Surinam, February 20,—at Fredericton, March 18,—at London, October 25,—at Quiloa, April 17,—at Ochotsk, July 19,—at Cape Voltas, Dec. 20.

PROBLEM XVIII.

The place and day being given, to find the Sun's Meridional Altitude.

NOTE 1*st*.—By Altitude (from the Latin *altitudo*, height,) is meant an arc of a great circle intercepted between the body, whose altitude is required, and the horizon. The meridional altitude is the height of the sun at mid-day.

2*d*. At places in the North Temperate, and North Frigid Zones, the Sun's meridional altitude is always a Southern Arc of the meridian; and at places in the South Temperate and South Frigid Zones, it is always a Northern Arc. But at places in the Torrid Zone, or within the Tropics, it is during a part of the year a Northern Arc, and during another part, a Southern Arc.

RULE.—Adjust the globe for the Sun's

place, and count the number of degrees on the meridian between the sun's place and the horizon; that will be the Altitude.

Examples.—What is the sun's meridional altitude at Saint John on the 1st of January? *Ans.* 20°

What is it on the same day at London.—*Ans.* 15°

Required the sun's meridional altitude at London on March 10, June 11, August 24; at Seville on May 12, July 19 and September 18; at Cairo on January 1 and July 1; at Botany Bay on September 14; at Fredericton on February 23; at Benguela on November 18.

PROBLEM XIX.

Given the Sun's Meridional Altitude on any day to find the Latitude of the Place.

RULE.—Bring the sun's place in the ecliptic to the brazen meridian, and adjust the globe by moving the meridian, till the distance between the sun's place and the horizon agree with the given altitude,—then observe the elevation of the pole; that will shew the Latitude.

That the Elevation of the Pole and the Latitude of a Place are equal, the young pupil will easily discover, when he considers, that, as the distance from the Equator to the Pole, and the distance from the Zenith to the Horizon, are, each a quadrant or 90°, it follows that whatever distance the Latitude removes

the Equator from the Zenith, it raises the Pole the same distance above the Horizon; or in other words, it makes the elevation of the Pole equal to the Latitude.

Examples.—The sun's meridional altitude on the 18th of May being 42° south, what is the Latitude? *Ans.* 67° north.

The sun's meridional altitude on the 5th of August being 74° north, what is the Latitude? *Ans.* 2° north.

Required the Latitudes corresponding with the following Meridional Altitudes of the Sun, on the annexed days:—Meridian Altitude, 38° south, January 13; 18°, March 11; 30° April 24; 64°, May 17; 35°, June 4; 25°, July 29; 48°, August 6; 18°, October 21; 50°, November 19; 45°, December 10.

NOTE.—The Sun's Altitude may be easily taken by any quadrant having sights and a plumb line: for holding it in such a position that its rays may pass through both sights, the plumb line will then intersect that degree on the limb of the quadrant which is equal to the height of the sun.

PROBLEM XX.

To find the Day of the Year, when the sun's meridional altitude at any place is known.

RULE.—Rectify the Globe for the latitude of the place, count the degrees of altitude on the meridian upwards from the horizon—then revolving the Globe, observe what degree of the Ecliptic comes in contact with the degree

of Altitude, and that will shew the Sun's place, which, referred to the calendar on the wooden horizon, will give the required day.

NOTE.—Two different answers may be obtained to questions on this Problem, according as the ascending or descending signs are employed.

Examples.—On what days of the year is the Sun's Meridional altitude at London, 59°? *Ans.* May 24, and July 18.

On what days is the meridional altitude at St. John 68°? *Ans.* June 7, and July 5.

Required the days in which the Sun's meridional altitude at Fredericton is 35°, 27°, and 49°—at London, 43°, 24°, and 29°—at St. Jago, 84°, 73°, 40°—at Quito, 84°, 65°, 49°—at Spitzbergen, 22°, 36°.

PROBLEM XXI.

The place, or latitude, and any hour of the day being given, to find the Sun's altitude.

RULE.—Adjust the Globe for noon, (by Problem XVII.) and if the hour is in the forenoon, turn the Globe Eastward, if in the afternoon, turn it Westward, till the given hour on the horary coincide with the Brazen Meridian; then fix the Quadrant of Altitude over the Zenith or latitude, and extend it to the horizon over the sun's place in the Ecliptic—the Arc of the Quadrant intercepted between the Sun's place and the horizon will give the required altitude.

NOTE.—Turning the Globe Eastward or Westward is to give the Sun's true position in the heavens at the given latitude—for rising in the East, he is eastward of the meridian till Noon, after which he is Westward.

Examples.—What is the altitude of the Sun at St. John, at the Vernal and Autumnal Equinoxes, at 6 o'clock, A. M.* and 6 P. M. *Ans.* 0°.

Required the Sun's altitude at London, at 8 A. M., July 16, and May 2; and at 4 P. M. December 1, and July 24; at Fredericton, at 6 A. M. May 1, and September 10; at Buenos Ayres, at 10 A. M. March 9; at Glasgow, at 7 A. M. August 22; at Stockholm, at 9 A. M. February 20; at Paris, at 10 A. M. September 4, and at 4 P. M. August 20; at Tristan D' Acunha, at $7\frac{1}{2}$ A. M. August 7, and 2 P. M. December 25; at Anticosti Island, at 9 A. M. September 10, and 1 P. M. January 1.

PROBLEM XXII.

Given the Sun's altitude, the day, and the place or latitude, to find the hour.

RULE.—First adjust the Globe for Noon, (by Problem XVII.) and fix the Quadrant of Altitude over the Zenith, then move the Qua-

* A. M. and P. M., so frequently used in common intercourse with regard to the hours of the day, are the initials or first letters of Latin words: the former *Ante Meridiem*, signifying before mid-day, and the latter *Post Meridiem*, after mid-day.

drant and the Globe at the same time, till the Sun's place on the Ecliptic for the given day be brought to coincide with the given degree of Altitude on the Quadrant, when the hour on the horary that coincides with the meridian will be the hour required.

NOTE.—To the questions on this Problem two answers may be obtained, according as the Eastern or Western side of the meridian is adopted, the Sun's altitude being the same, twice a day, once in the forenoon, and again in the afternoon.

Examples.—What is the hour at London on the 19th of May, when the Sun's altitude is about $43\frac{1}{2}°$? *Ans.* 9 A. M. or 3 P. M.

What is the hour at Saint John, February 21, when the Sun's altitude is 20°?

Required the hour at St. Helena, January 1, the sun's altitude 16°; at Petersburg, February 14, the sun's altitude 25°; at Prince William's Sound, June 29, sun's altitude 34°; at the Marquesas, December 16, the sun's altitude 50°; at the Pelew Islands, October 9, sun's altitude 27°; at Babylon, April 21, sun's altitude 30°; at Paris, January 21, sun's altitude 6°?

PROBLEM XXIII.

To find at what hour the Sun rises or sets on a given day in any given latitude, or at any proposed place.

RULE.—First adjust the Globe for Noon on the proposed day, then bring the Sun's place

to the Eastern edge of the horizon, the hour on the horary under the meridian will give the time of rising; bring it to the Western edge, it will give the time of setting.

Examples.—At what hour does the Sun rise at London, January 1? *Ans.* A quarter past eight. At the same place, June 21? *Ans.* Twenty minutes before four, nearly. At St. John, March 1? *Ans.* About half past six.

At what hour does the Sun set at St. John, 24th August? *Ans.* About three quarters past six.

Required the hours of the Sun's rising and setting on the first day of every month in the year at St. John?

Required the hours of the sun's rising and setting at London on the days in which he enters the twelve signs of the Ecliptic.

PROBLEM XXIV.

To find the length of any day or night of the year at any place.

RULES.—1*st.* Find the time of the Sun's rising and setting (by Problem 23,) and count the hours between them for the length of the day, which subtracted from twenty-four will give the length of the night; or

2*d.*—Double the hour of sun-setting for the length of the day, and double the hour of sun rising for the length of the night; or

3*d.*—After rectifying the Globe for the latitude, take the sun's place in the Ecliptic to the Eastern verge of the horizon, and adjust

the horary for XII. then turn the sun's place to the western verge, the horary will shew the length of the day, if it is less than twelve hours; but if more than twelve, add the hour shewn by the horary to twelve, for the length of the day. In like manner if the length of the night is required, bring the sun's place to the Western verge, adjust the horary for XII. and revolve the Globe Westward till the sun's place come up to the Eastern verge, the length of the night will then be found by the horary, if it is less than twelve hours, but if more than twelve, add the hour on the horary to twelve for the length of the night.

Examples.—What is the length of the day at London, at the summer and winter solstices? *Ans.* Sixteen and a half hours at the former period, and seven and a half at the latter.

What is the length of the day at St. John at the same periods? *Ans.* At the summer solstice, fifteen and a half hours long, at the winter, eight and a half hours long.

Required the length of January 1, at Quebec; of Feb'y 15, at New-York; of March 10 at Madrid; of April 20, at Savannah; of May 25. at Chiloe; of June 25, at Gibraltar.

PROBLEM XXV.

To find the length of the longest day at any place within the Temperate and Torrid Zones.

RULE.—1*st*. Rectify the Globe for the latitude of the place, and according as it is

North or South, bring the first degree of Cancer or Capricorn to the Meridian, and adjust the horary for XII,* then turn it to the Eastern edge of the horizon, and the horary will shew the time of sunrise, and take it to the western verge, the horary will shew the time of sunset; the intervening hours will give the length of the longest day. Or,

2*d*. Having rectified the Globe for the latitude, bring the first degree of Cancer or Capricorn, as the case may require, to the Eastern verge of the horizon, and adjust the horary for XII. and then revolve the Globe till the same degree come in contact with the Western edge; the hour shewn by the horary added to twelve, will give the length of the longest day.

NOTE.—To find the length of the shortest night, subtract the length of the longest day from twenty-four, and the difference will give the answer.

Examples.—What is the length of the longest day at St. John? As St. John is in the Northern hemisphere, employ the first degree of Cancer, and the longest day is found to be fifteen and a half hours.

What is the length of the longest day at Port Jackson? As Port Jackson is in the

* Teachers will remember that when the hour circle is furnished with a moveable index or pointer, the expression "set the index to twelve," is to be employed, in place of the one here used, wherever it occurs.

Southern hemisphere, employ the first degree of Capricorn, and the longest day will be found to be fourteen and a half hours.

Required the length of the longest day at the following places—Bristol, Terra del Fuego, Lisbon, Truxillo, Medina, Rio Janeiro, Seringapatam, Nankin, New Caledonia, Jeddo, Cape Denbigh, Bay of Camarones.

PROBLEM XXVI.

To find the length of the shortest day at any place in the Temperate and Torrid Zones.

RULE.—Rectify the Globe for the latitude of the place, and if it is in the Northern hemisphere, bring the first degree of Capricorn, if in the Southern, the first degree of Cancer to the Eastern verge of the horizon, and adjust the horary for XII.; then revolve the Globe till the first degree of Capricorn, or the first degree of Cancer, as the case may require, come to the Western verge, and the horary will give the length of the shortest day.

Examples.—What is the length of the shortest day at Fredericton? *Ans.* As Fredericton is in the Northern hemisphere, employ the first degree of Capricorn, and the length of the shortest day will be found to be about eight hours and twenty minutes.

What is the length of the shortest day at Cape Saint Mary, the southern extremity of Madagascar? *Ans.* As Cape St. Mary is in the Southern hemisphere, employ the first

degree of Cancer, and the shortest day will be found to be ten and a half hours.

Required the length of the shortest day at Philadelphia, Lima, Abo, Mozambique, Cape Comorin, Isle St. Juan, Straits of Perouse, the Friendly Isles, Owhyhee, Cape Clear.

PROBLEM XXVII.

The length of the longest day being given, to find the latitude of the place.

RULE.—Bring the first degree of Cancer or the first degree of Capricorn, according as the latitude sought is North or South, to the brazen meridian—adjust the horary to XII, and revolve the Globe Westward till the horary shews half the given number of hours; then, keeping the Globe fixed, move the meridian up or down, till the first degree of Cancer, or the first degree of Capricorn, as the case may require, coincides with the Western verge of the horizon; then observe what degree of the meridian is cut by the horizon under the elevated Pole, that gives the latitude sought.

Examples.—What is the latitude of a place, where the longest day is sixteen and a half hours? *Ans.* $51\frac{1}{2}°$.

Required the latitude of places, where the longest days are as follows:—12 hours; $12\frac{1}{2}$ hours; 14 hours; $14\frac{1}{2}$ hours; 16 hours; $17\frac{1}{2}$ hours; 18 hours; $19\frac{1}{2}$ hours; 20 hours; $21\frac{1}{2}$ hours; 23 hours; $23\frac{1}{2}$ hours.

PROBLEM XXVIII.

To find those places whose longest days correspond with a given length.

RULE.—Find the Latitude corresponding with the given length (by Problem XXVII.) and revolve the Globe; all the places that come under the degree of latitude on the meridian have their longest day of the same length.

Examples.—What places have their longest day sixteen and a half hours long? *Ans.* London, Brussels, Dresden, Leipsick, Warsaw, Nootka Sound, Cape Saint James, and Belle Isle.

Required those places where the day is twenty hours long? where it is fifteen hours long? where twenty-two and a half hours long? and where twenty-four hours long?

PROBLEM XXIX.

To find in what climate any place, not in the frigid Zones, is situated, the latitude being given.

NOTE.—Climate, in its more common use, denotes the character of the weather peculiar to every country, as respects heat and cold, humidity and dryness, fertility, and the alterations of the seasons. But in this Problem we use it in its ancient geographical sense, (which is more agreeable to its derivation from the Greek *Klima*, a region.) Climate, in this sense

of the term, is a part of the surface of the earth, bounded by two lesser circles parallel to the Equator; and of such a breadth that the longest day in the parallel nearest the Pole exceeds the longest day in that next the Equator by some certain space, as half an hour. Between the Equator and each Polar Circle are twenty-four half hour climates; and between each Polar Circle and its respective Pole, are six month climates, making sixty climates in all; thirty on each side of the Equator.

RULE.—Find the length of the longest day (by Problem XXV.) from which subtract twelve; the remainder reduced to half hours will give the climate.

Examples.—In what climate is Saint John, whose latitude is 45° 15′. *Ans.* The longest day at Saint John is fifteen and a half hours; from which twelve being subtracted, the remainder is three and a half hours or seven half hours, making Saint John to be in the seventh climate.

Required the climate in which London, Leipsic, Warsaw, Cork, Ghent, Cologne, Breslau, and Belle-Isle are, the latitude being about 51½°.

Required the climate in which Siam, Madras, Pondicherry, Tobago, St. Vincent, and Barbados are situated, the latitude being about 16°?

Required the climate of Jamaica, latitude about 23°; of the Canaries, latitude about 30°;

of Ispahan, latitude about 36° ; of Samarcand, latitude about 41° ; Cape Breton, latitude about 48°.

PROBLEM XXX.

To find what other day of the year will be of the same length with any given day.

RULE.—Bring the Sun's place in the Ecliptic for the given day to the meridian, and observe what degree of the meridian it intersects ; revolve the Globe till another degree of the Ecliptic intersect the meridian in the same point ; the day of the year that corresponds with that degree, found upon the horizon, is the day required.

Examples.—What day is of the same length as March 1 ? *Ans.* October 11.

Required the day which is of the same length as January 10, February 28, March 30, April 15, May 24, June 12, July 4, August 21, September 1, October 30, November 25, December 16.

PROBLEM XXXI.

To find upon what point of the Compass the Sun will rise and set, at any place, upon a particular day.

RULE.—Rectify the Globe for the latitude of the place, and bring the Sun's place in the Ecliptic to the Eastern edge of the horizon, the point of the horizon intersected by it is the point required for the sun's rising ; bring

it to the Western edge, the point of the horizon there intersected by it, is the point required for the sun's setting.

Examples.—On what points of the Compass will the sun rise and set at St. John on March 20? *Ans.* Due East and West. On March 1? *Ans.* It rises East by South, and it sets West by South. On April 20? *Ans.* It rises East North East 5° East, and sets West North West 5° West.

Required the points of the Compass on which the Sun rises and sets at London on June 21 and December 22; at New-York, January 1 and June 1; at Aberdeen, February 5 and July 8; at Berlin, March 9 and August 15; at Cape Horn, April 20 and November 6; at Cape Ambro, the Northern extremity of Madagascar, May 16 and December 5.

PROBLEM XXXII.

To find at what hours the sun will be due East or West at any place on any given day.

RULE.—Adjust the Globe for Noon, (by Problem 17,) fix the Quadrant of Altitude in the Zenith, and extend it to the Eastern point of the horizon; then turn the Globe till the sun's place touch the graduated edge of the quadrant, the hour which then coincides with the meridian is the time when the Sun is due East; bring the quadrant to the Western point of the horizon, and turn the Globe till

the sun's place touch its graduated edge, the hour which then coincides with the meridian, is the time when the sun is due West.

NOTE.—To places North of the Equator the sun is at no time of the day either due East or due West, from the Autumnal to the Vernal Equinox:—and to places South of the Equator the sun is never due East or West from the Vernal to the Autumnal Equinox. The questions on this Problem must therefore be regulated by this circumstance.

Examples.—At what hour is the sun due East at St. John on the 10th of May? *Ans.* Rectify the Globe for noon on the given day, extend the quadrant of altitude from the Zenith to the East point of the horizon, and move the Globe till the 20th degree of Taurus, the sun's place for the 10th of May, come in contact with the graduated edge of the quadrant; the hour then coinciding with the meridian is a quarter past seven, A. M., the hour required.

At what hour is the sun due West at St. John on the 21st August? *Ans.* A quarter past five, P. M.

At what time is the Sun due East at Edinburgh, April 15; at Stockholm, May 30; at Portsmouth, (England,) June 12; at Rome, July 24; at St. Augustin, (Florida,) August 18; at Algiers, September 5; at Cook's Straits, October 20; at Falkland Isles, No-

vember 14; at Guayaquil, December 25; at Paraiba, January 16; at Algoa Bay, February 29; ?

PROBLEM XXXIII.

To find the places that have the same hours of the day as a given place.

Those places that have the same longitude have the same hours, and therefore the Rule for Problem V. is to be adopted here.—To find the places that have contrary hours to a given place. Bring the given place to the meridian, and turn the Globe half a revolution, and places then under the meridian will be the places required.

Examples.—What places have the same hour of the day as Madras? *Ans.* Pondicherry, Tranquebar and Candy in the island of Ceylon.

What places have opposite hours of the day to St. John? *Ans.* The conjunction of the River Vitim with the Lena, the small islands in the middle of the China Sea, the Western part of Borneo, the middle of Java, and the Western lands of New Holland.

What places have the same hours as Astracan, Charleston, Formosa, Bougainville Straits, Cayenne, Lake Michigan, Belgrade, Cyprus?

What places have contrary hours to London, Tunis, Constantinople, Panama, Berne, Cairo, Batavia?

PROBLEM XXXIV.

The hour of the day at any place being given, to find what the hour is at any other place.

RULE.—Bring the given place to the meridian, and adjust the horary so that the given hour will also coincide with the meridian; then revolve the globe till the place for which the hour is required be brought to the meridian, the hour on the horary which then coincides with the meridian, will be the hour required.

NOTE.—The answer will be earlier in the day than the given time, if you have to revolve the globe eastward; but it will be later, if you have to revolve it westward.

Examples.—When it is noon at Saint John, what is the hour at London? *Ans.* About half past four o'clock P. M.

When it is three o'clock P. M. at London, what is the hour at New York? *Ans.* Ten o'clock A. M.

Required the hour at Constantinople when it is noon at London;—the hour at Vera Cruz when it is noon at Madras;—the hour at Rome, Port Royal, Bombay, Quebec, and New Britain, respectively, when it is noon at Saint John;—the hour at Saint John, Mexico, Saint Helena, New Zealand, Halifax, California, Saint Jago, and Comoro Isles, when it is six o'clock A. M. at London.

NOTE.—Time may be converted into longitude by multiplying the number of hours by

fifteen, because the Sun passes over fifteen degrees of the Equator every hour; and, *vice versa*, longitude may be converted into time by dividing the number of degrees by fifteen. Thus, if it is noon at St. John when it is half past four o'clock P. M. at London; by multiplying 15 by $4\frac{1}{2}$, we get 67° 30′, which is nearly the longitude of Saint John. And again, if the longitude of New-York is about 75° W. by dividing 75 by 15, we get five hours, the difference of time between New York and London.

PROBLEM XXXV.

The hour being given at any place, to find those places where it is any other given hour.

RULE.—Bring the given place to the brass Meridian and adjust the horary for the given hour at that place; then turn the globe till the other given hour coincide with the meridian: all the places which are then under that semicircle of the Meridian are the places sought.

Examples.—When it is 5 P. M. at London, where is it Noon? *Ans.* New York, Cape Mayze, Saint Martha, and all other places under the Meridian at the same time, or which have the same longitude.

When it is Noon at Saint John, where is it 6, 7, 8, 9, 10, and 11 o'clock A. M. and 1, 2, 3, 4, 5, 6, and 7 o'clock P. M.?

When it is 4 A. M. at London, where is it 9 P. M.?—7 P. M. at Hanover, where is it 11

A. M.?—half past 1 P. M. at the Pelew Islands, where is it half past 7 P. M.?—4 P. M. at Savannah, where is it 8 A. M.?—3 P. M. at Montreal, where is it 10 A. M.?—when it is midnight at Boston, where is it midday?

PROBLEM XXXVI.

To find the Sun's Declination for any given day.

DEFINITION.—Declination (from the Latin *Declino*, to bend from the straight course,) is the variation the Sun is continually making with regard to his distance from the Equator, and is measured on the Meridian.

RULE.—Bring the Sun's place for the given day to the Meridian,—the degree marked over it is the Declination.

Examples.—What is the Sun's Declination at the Solstices, June 21, and December 22? *Ans.* $23\frac{1}{2}°$, which is the greatest declination North or South.

Required the Sun's Declination on January 10, February 15, March 20, April 25, May 5, June 16, July 4, August 21, September 19, October 7, November 20, and December 1.

PROBLEM XXXVII.

The Sun's Declination being given, to find the Day of the Month.

RULE.—Turn the globe till some point of the Ecliptic intersect the degree of Declination on the brass meridian; that point refer-

red to the circle of Months on the wooden horizon will give the day required.

NOTE.—As the sun is twice in every degree of declination, except the most Northerly and the most Southerly, two answers may be given to questions under this Problem.

Examples.—On what days is the Sun's Declination 20° N.? *Ans.*—May 19 and July 23.

Required the days on which the Sun's Declination is 0°; 16° N.; 20° S.; 18° N.; 22° S.; 3° N.; 12° S.; 21° N.; 17° S.; 7° N.; 23½° S.

PROBLEM XXXVIII.

To find those places to which the Sun is vertical on any given day.

Observe, 1st. To be vertical (from *Vertex*, the top,) is to be in the Zenith, or directly over head.

2d. As the Sun never recedes from the Equator farther than 23½°, which distance is marked out by the Tropic of Cancer on the North, and by the Tropic of Capricorn on the South, the places given in answers to questions under this Problem, must be within the Torrid Zone.

RULE.—Find the Sun's Declination for the given day, by Problem XXXVI.; then, revolving the globe, observe the places that come under that degree of the meridian; these will have the Sun vertical on the given day.

Examples.—To what places is the Sun vertical on the 10th of May? *Ans.* Jamaica, Midland parts of Africa, Pegu, &c.

To what places is the Sun vertical at the Summer Solstice, or June 21? *Ans.* Canton, Calcutta, Mecca, and Havannah nearly.

What places have the Sun in their Zenith on January 17, February 10, March 20, April 14, May 20, July 11, September 12, November 18, and December 21.

PROBLEM XXXIX.

A place in the Torrid Zone being given, to find on what two days of the year the Sun will be vertical.

RULE.—Find the latitude of the place, and, revolving the Globe, observe what two points of the Ecliptic pass under the degree of latitude on the meridian, these shew the places of the Sun, which, compared with the calendar on the horizon, will give the days required.

Examples.—On what days of the year is the sun vertical to Goyaz, Sergippo del Rey, the Comoro Isles, and Rotte Island? *Ans.*—October 22, and February 17.

On what days of the year is the Sun vertical at St. Lucia, Kingston in Jamaica, Candia in Ceylon, Trinidad, St. Jago in Cuba, Cape Verd, Tobago, Congo, Straits of Babelmandeb, Cambodia.

PROBLEM XL.

The day and hour being given at any place, to find where the Sun is vertical at that time.

RULE.—Ascertain the sun's declination by Problem 36; then bring the given place to

the brazen meridian, and adjust the hour circle for the assigned hour. Next revolve the Globe till XII, at noon, on the horary coincide with the meridian;* the place which is then under the degree of declination is that required.

Examples.—Where is the sun vertical at twenty-three minutes after twelve at noon, at London, November 6. *Ans.* The sun's place on November 6, is the fourteenth degree of Virgo, which, brought to the meridian, shews the declination to be 15° 45′ S.; next bring London to the meridian, and adjust the horary so that twenty-three minutes after twelve will coincide at the same time with the meridian. Then revolve the Globe till XII. at noon coincides with the meridian, and the place under the degree of declination will be found to be St. Helena, the place required.

Where is the Sun vertical on the 1st of March, when it is 9 o'clock, A. M. at Saint John? On the 25th October, at 5 hours, 7 minutes, P. M. at London? On the 1st of March at 3 P. M. at Boston? On the 12th of May at mid-day at Washington? On the 26th of March at noon at Botany Bay? On the 8th of October, at three-quarters past 4 A. M. at Alderney? At the summer solstice, at 7 P. M. at Madeira?

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*Teachers will remember that when the globe is furnished with a moveable index, the expression "till the index points to XII, &c." is to be employed, in place of the one here used, wherever it occurs.

PROBLEM XLI.

The day and hour being given at any place, to find where the sun is rising, setting, or on the meridian, and what parts of the Globe are illuminated, and what in darkness.

RULE.—First find the place to which the Sun is vertical at the assigned hour, by Problem 39; next bring that place to the meridian, and rectify the Globe for its latitude; then to all those places in the western semicircle of the horizon, the sun is rising, to those in the eastern semicircle he is setting, to those under the meridian it is noon, to all the places above the horizon the Sun is present, and those under the horizon are deprived of his light.

Examples.—To what places is the sun rising, setting, and on the meridian, when it is 10 A. M. at Saint John, N. B. on the 1st of March?

Ans. At the proposed time the sun is found to be vertical at Paraiba in South America. Rectify the Globe for the latitude of Paraiba; then keeping the Globe fixed with Paraiba under the meridian, it is found that the enlightened part of the Globe consists of all South America, nearly all North America, all Africa, the island of Madagascar, all Europe, excepting the north-west part of Russia, and Arabia and Turkey in Asia; the sun is rising to Slave River, Port Saint Francis, and the places on the coast north of California; he is

setting to Bourbon Isle, the Almirante Isles, the Gulf of Persia, Bagdad, and Astracan. He is on the meridian of Bera Fyrth in Greenland, Cape Saint Roque, Paraiba and Olinda in South America, and the Island of Georgia in the South Atlantic Ocean.

To what places is the sun rising, setting, and on the meridian, on June 5, at seven P. M. at London? On August 21, at nine A. M. at Glasgow? On September 21, at one P. M. at New-York? On the 26th April, at three quarters past six A. M. at London?

PROBLEM XLII.

To put the Globe in positions representing a parallel sphere, a right sphere, and an oblique sphere.

RULE.—To represent a parallel sphere, elevate the pole to the Zenith, or make the Equator coincide with the horizon. To represent a right sphere, make the poles coincide with the horizon, or cause the Equator to move at right angles to the horizon. When the poles are neither in the horizon nor the Zenith, the sphere is in an oblique position.

PROBLEM XLIII.

To explain, in general, the alteration of the length of the days, and difference of the seasons, from a given latitude.

RULE.—Put several marks upon the Ecliptic; rectify the Globe for the given latitude,

turn it about, and it will be seen for a northern latitude that the nearer the marks are to the Tropic of Cancer, the corresponding diurnal arcs will increase; but as you approach the Tropic of Capricorn, the diurnal arcs of the marks will decrease; also the former arcs will be greater than a semicircle, and the latter less, and the marks in the Equator will describe a semicircle above the horizon.

Therefore, when the sun is in the Equator, the days and nights are equal; as he advances towards the tropic of Cancer, the days increase and the nights decrease; when he comes to the Tropic, the days are the longest and the nights the shortest. As the sun approaches the Equator, the length of the days diminishes and that of the nights increases; and when he comes to the Equator, the days and nights will again be equal. Then, as he advances towards the Tropic of Capricorn, the days diminish and the nights increase, till he reaches that Tropic, when the days will be the shortest and the nights the longest; and then, as he approaches the Equator, the days will increase and the nights decrease; and when at the Equator, it will again be equal day and night.

Whatever be the latitude of the place, when the sun is in the Equator, the days and nights are equal.

At the Poles, the Sun is half a year above the Horizon and half a year below it. At the Equator, the days and nights are equal during

the whole year; the sun being twelve hours above the horizon, and twelve below.

By rectifying the globe for the latitude of the Arctic Circle, or $66\frac{1}{2}°$, the longest day will be found to be twenty-four hours, and the longest night of the same length; and it will be readily seen, that all places enjoy equally the Sun in respect to time, and are equally deprived of it; the length of the days at one season of the year being exactly equal to that of the nights at the opposite.

Examples.—Illustrate the above facts by taking the Latitude of London. Rectify the globe for the latitude of London, and put marks upon the Ecliptic, say on the beginning of each sign. Then by bringing each mark successively, beginning with the first point of Aries, to the eastern and western horizon, and observing the time of its rising and setting, you will see, as follows, the increase and decrease of the days and nights:—

	He rises	He sets	Length of day.	Length of night.
When the sun enters ♈	6h 0′	6h 0′	12h 0′	12h 0
When the sun enters ♉	5 0	7 0	14 0	10 0
When the sun enters ♊	4 8	7 52	15 14	8 16
When the sun enters ♋	3 47	8 13	16 26	7 34
When the sun enters ♌	4 11	7 49	15 38	8 22
When the sun enters ♍	5 3	6 57	13 54	10 6
When the sun enters ♎	6 0	6 0	12 0	12 0
When the sun enters ♏	7 3	4 57	9 54	14 6
When the sun enters ♐	7 51	4 9	8 18	15 42
When the sun enters ♑	8 12	3 48	7 36	16 24
When the sun enters ♒	7 50	4 10	8 20	15 40
When the sun enters ♓	7 0	5 0	10 0	14 0

The Pupil may be exercised in finding from the globe, in the same manner as above, the increase and decrease of the days and nights for every 15° of the Sun's progress in the Ecliptic in the latitude of Saint John; the increase and decrease of the days and nights for every 20° of the Sun's progress in the Ecliptic, in the latitude of New York; the same for the first day of every month in the latitude of Archangel.

PROBLEM XLIV.

To find on what day the Sun begins to shine constantly, and how long, at any given place in either of the Frigid Zones.

RULE.—Observe the distance of the assigned place from the Pole, and reckon an equal number of degrees from the Equator towards the same Pole; revolve the globe, and mark the two points of the Ecliptic, which pass under that degree of the meridian; and then find on the Horizon on what days of the year the Sun is in those points of the Ecliptic; the day nearest the Vernal Equinox is the one on which the Sun begins to shine constantly in the Northern Frigid Zone, and the space of time between the two days is the duration of sunshine.

Examples.—On what day does the Sun begin to shine constantly, and what is the time of its duration at the North Pole? *Ans.*—The Vernal Equinox; duration six months.

When does the sun begin to shine without intermission, and what is the period of its duration at the following places:—Spitzbergen, North Cape, James's Sound, Icy Cape, Behring's Straights.

PROBLEM XLV.

To find the latitude of those places in the Frigid Zones where the Sun begins to shine constantly on any given day.

RULE.—Find the Sun's declination for the given day and subtract it from 90° the remainder will give the latitude required.

NOTE.—The same latitude in the opposite Hemisphere will show those places to which the Sun is beginning to disappear.

Examples.—In what latitude does the Sun begin to shine without intermission on the 20th of March? *Ans.*—Lat. 90°, or the North Pole.

Required the latitude of those places where the Sun begins to shine constantly at the Autumnal Equinox, April 15, May 20, June 18, August 24, October 29, November 1, and December 21.

PROBLEM XLVI.

To find in what parallel of Latitude in the Northern Frigid Zone the Sun does not set for any given number of days not exceeding 180.

RULE.—Count as many degrees on the Ecliptic, beginning at the first degree of Can-

cer, if in the Northern hemisphere, at the first degree of Capricorn, if in the Southern hemisphere, as amount to half the number of assigned days; bring the point, where the counting terminates, to the meridian; observe how many degrees are intercepted between it and the corresponding Pole; and then, reckon the same number of degrees on the meridian from the Equator towards the same Pole, and that will shew the required parallel of latitude.

Examples.—In what parallel of latitude does the sun not set for 20 days in the North Frigid Zone. *Answer.*—Counting ten from the first degree of Cancer, and bringing the tenth degree to the meridian, the arc intercepted between that and the Pole is 67°,—this number counted from the Equator towards the Pole gives 67° on the meridian for the parallel of latitude required.

Required the parallels of latitude in which the Sun does not set for 30, 40, 50, 60, 70, 80, 90, 100, 130, 150, 170 and 180 days.

PROBLEM XLVII.

A place and time being assigned, to find where it is twilight.

Eplanation.—Twilight, or crepusculum, is the time from the first dawn of the morning to the rising of the sun; and, again, between the setting of the sun and the last remains of day. Without this twilight, the sun's light would not appear till its rising and

would instantly disappear at its setting. The duration of twilight is different in different climates; and in the same place it varies at different periods of the year. It is longest in a parallel sphere, and shortest in a right sphere; and in an oblique sphere, the nearer the sphere approaches to a parallel, the longer is the twilight, because it commences and terminates when the Sun is about 18° below the horizon; for then the stars of the sixth magnitude, the smallest that appear to the naked eye, disappear in the morning and appear in the evening. Hence to solve Problems regarding the twilight, the Quadrant of Altitude is usually furnished with what is called a crepusculum graduation of 18 degrees.

RULE.—Rectify the globe for the place to which the sun is vertical on the given day (by Problems 40 and 4), fix the quadrant over the zenith, move it round the globe betwixt the Zenith and the Horizon, and observe what places the crepusculum part of it passes over in its course; these have twilight at the assigned time.

Examples.—Where is it twilight on the 4th of June, when it is half past eleven, a. m. at Saint John? *Ans.*—At Otaheite, and other Society Islands it is morning twilight. At the Cape of Good Hope, the Channel of Mozambique, the Eastern part of Africa, the Eastern past of Arabia, a great part of Tartary, and the South of Siberia, it is evening twilight.

Where is it twilight when it is noon at London, January 3? Nine A. M. at St. John, February 18? Nine A. M. at New-York, March 5? Three P. M. at London, April 17?

PROBLEM XLVIII.

On any proposed day, to find when morning twilight begins and evening twilight ends, at any assigned place.

RULE.—Adjust the Globe for noon; fix the quadrant over the zenith, and extend it to the eastern verge of the horizon; then turn the Globe till the sun's place comes in contact with the 18th degree of the crepusculum graduation on the quadrant, and the hour then coinciding with the meridian will be the hour at which the twilight begins at the proposed place on the given day.

The same operation performed on the western side of the horizon will shew when twilight ends.

When does twilight appear at Saint John, March 5? *Ans.* About three-quarters past Four, A. M.

When does twilight appear at London, January 15? at Paris, February 20? at Philadelphia, March 2? at Constantinople, April 25? When does twilight end at Edinburgh, May 6? at Cuba, June 1? at Tobago, July 30? at Cape Horn, August 15?

PROBLEM XLIX.

To find the duration of twilight at the North Pole, and likewise how long night continues there after the total cessation of twilight.

RULE.—Adjust the globe to represent a parallel sphere (by Problem 42), turn the globe till some part of the Ecliptic, counted from the first degree of Libra, falls directly under 18° of the meridian in south declination, which will be in 26° of Scorpio, the sun's place on the 12th November, the day when twilight ends; then turn the Globe till some other point of the Ecliptic meets the same degree of south declination, which will be 10° of Aquarius, the sun's place for January 29, till which time the sun's light is totally absent; from this time twilight begins again, and continues till the sun enters Aries, when a day of six months commences at the North Pole.

The pupil may exercise himself in finding in like manner the duration of twilight at the South Pole, and how long night continues there after twilight totally ends.

PROBLEM L.

To find in what Latitude the longest day is of any given length less than twenty-four hours.

RULE.—Bring the solstitial point to the meridian, and adjust the horary for XII., then turn the Globe westward half the given number of hours; keep the globe steady, and move

the meridian up or down, till the solstitial point comes to the horizon; the elevation of the Pole will then be the latitude sought.

Examples.—In what latitude is the longest day fifteen and a half hours? *Ans.* $45\frac{1}{2}°$.

Required the latitudes where the longest day is 12, 13, 14, 15, $15\frac{1}{2}$, 17, $18\frac{1}{2}$, 19, 20, $21\frac{1}{2}$, 23, and $23\frac{1}{2}$ hours.

PROBLEM LI.

To find all those places to which a Lunar Eclipse§ is visible at any instant.*

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* Lunar from *Luna* the Moon.

§ An Eclipse (from the Greek, *ekleipo*, to fail) is a privation of light of one of the luminaries by the interposition of some opaque body, either between it and the observer, or between it and the Sun. Eclipses of the Sun and Moon happen when the moon is near her nodes, or the points in which her orbit intersects the Ecliptic. Those of the Sun happen only at new moon, or when the moon is in conjunction with the Sun, that is, when she is between the Earth and the Sun: and those of the Moon happen at the time of full Moon, or when the Moon is in opposition to the Sun.

Eclipses, with respect to their circumstances are divided into total, partial, annular and central.

An Eclipse is *total*, when the body eclipsed is wholly out of view, a phenomenon that very seldom occurs with regard to the Sun. An Eclipse is *partial* when only part of a luminary is eclipsed.

An Eclipse is called *Central*, when the centres of the luminaries exactly coincide, and are directly in a line with the eye of the observer.

RULES.—1*st.* Find the place to which the sun is vertical at the given time, bring that place to the meridian, and rectify the globe for its latitude; then, as the moon must be directly opposite to the sun whenever she is eclipsed, the eclipse will be visible in all those places which are then under the horizon: or

2d. Bring the antipodes of the place, to which the Sun is vertical at the assigned time, to the brass meridian, and rectify the globe for their latitude; the parts of the earth then above the horizon will have the eclipse visible.

Annular (from the Latin *Annulus*, a ring), is a term applied to an eclipse of the sun, in which a ring of light appears around the dark body of the moon. There can be no *annular* eclipse of the moon, on account of its being a much smaller body than the earth, whose shadow causes its eclipses.

If the Moon's orbit were coincident with the plane of the Ecliptic, the Moon's shadow would fall upon the earth, and occasion a central eclipse of the Sun at every conjunction, or new Moon; whilst the Earth's shadow would fall on the Moon and occasion a total eclipse of that body at every opposition or full moon. For as the moon would then always move in the ecliptic, the centres of the Sun, Earth and Moon, would all be in the same straight line at both of these times. But the Moon's orbit is inclined to the Ecliptic, and forms with it an angle of about 5 deg. 10m.; and therefore the Moon is never in the Ecliptic except when she is in her nodes; hence, there may be a considerable number of conjunctions and oppositions of the Sun and Moon, without any Eclipse taking place.

Examples.—Suppose a lunar eclipse to take place at St. John, at 9 P. M. on April 9, to what places would it be visible? *Ans.* The sun is vertical on the 9th April at 9 P. M. to the most easterly of the Carolinas, lat. 8° N. The globe, rectified for the latitude of their Antipodes, gives all Africa, all Europe, excepting the north-east part of Russia, all South America, and all North America, excepting the north-west part of it, as the places to which the eclipse is visible.

Suppose Lunar eclipses to happen at the following times and places, to what parts of the earth will they be visible? At London, May 27, at 7 o'clock, P. M.; at Saint John, January 10½ P. M.; at London, February 18, at 7, P. M.; at St. John, May 3, at 10, A. M.?

PROBLEM LII.

To find those places to which a Solar Eclipse will be visible, a particular day and hour being given.*

NOTE.—This Problem cannot well be solved by a globe merely, as a Solar eclipse, on account of the vast distance and size of the sun compared with the moon, does not happen to the whole hemisphere of the earth next the sun, nor does it happen at the same time to those places where it is visible. But as it

* From the Latin *Sol*, the Sun.

is generally given in Books on the use of the Globes, we here insert the common

RULE.—Find the place to which the Sun is vertical at the given time; keep that spot under the brass meridian, and rectify the Globe for its latitude; then, if the Eclipse be large, it will be visible to almost all those parts which are then in the upper hemisphere.

Examples.—Suppose the Sun were eclipsed at Saint John on the 21st of June, at half-past one p. m. to what other places would the Eclipse be visible?—*Ans.* To all North and South America, almost all Europe, and the North-west part of Africa.

Suppose Solar Eclipses to take place at Saint John, on the following days and hours, to what parts of the earth would they be visible?

April 17, half-past seven, a. m.—May 21, half-past nine, a. m.—June 10, half-past ten, a. m.—August 8, half-past 12, p. m.—September 6, two p. m.

PROBLEM LIII.

To find the Right Ascension of the Sun for any day.

DEFINITION.—Right Ascension is that degree of the Equator which rises with the Sun in a *Right* Sphere, and which comes to the Meridian with the Sun in any position of the Sphere. It is reckoned from the first Point

of Aries, or the Vernal Equinox, all round the Equator.

RULE.—Bring the Sun's place in the Ecliptic for the given day to the Brazen Meridian, and that degree of the Equator which is cut by the Meridian is the Right Ascension.

NOTE.—The reason of thus referring it to the Meridian is, that *it* is *always* at right angles to the Equator, whereas the Horizon is so, only in a right sphere.

Examples.—What is the Right Ascension of the Sun on the 20th of March, and 21st of Sept.—*Ans.* 0 deg. and 180 deg.

Required the Right Ascension on the following days—

Jan. 15; Feb. 20; March 12; April 10.
May 16; June 19; July 22; Aug. 24.
Sept. 30; Oct. 7; Nov. 15; Dec. 25.

PROBLEM LIV.

To find the Sun's Oblique Ascension for any given place and day.

DEFINITION.—The Oblique Ascension is that point or degree of the Equator which rises at the same time with the Sun in an oblique Sphere. Oblique Descension is that point of the Equator which sets with the Sun.

RULE.—Rectify the Globe for the latitude of the place, find the Sun's situation in the Ecliptic for the given day, and bring it to the Eastern verge of the Horizon; the degree of

the Equator then coinciding with the Horizon is the Oblique Ascension required.

Examples.—What is the Sun's Oblique Ascension at Saint John on the 10th of March? *Ans.* 355°.

Required the Sun's Oblique Ascension at St. John, on the 20th of March and 21st of September? at London, Jan. 15, and June 20? at New-York, Feb. 10, and July 15? at Turk's Island, March 5, and Aug. 20? at Kong, April 19, and Sept. 25? at Cordova, May 27, and Oct. 9?

PROBLEM LV.

To find the Ascensional Difference, and, from it, the Time the Sun rises before or after Six.

DEFINITION.—The Ascensional Difference is the difference between the Right and Oblique Ascension.

RULE.—Find the Right and Oblique Ascensions for the given place and day, (by the two preceding Problems) and take their difference. This may be reduced to time by dividing by 15, the number of degrees corresponding with an hour.

NOTE.—In Northern Latitudes, when the Sun is in any of the northern signs, it rises before, and when in any of the southern signs, it rises after six o'clock.

Examples.—Required the Sun's Right Ascension, Oblique Ascension, Ascensional

Difference, and the time of his rising at St. John on the 1st of June.—*Ans.* Right Ascension, 69½ deg.; Oblique Ascension, 45 deg.; Ascensional Difference, 24½ deg.; which divided by 15, gives one hour and thirty-eight minutes for the time the Sun rises before six.

Required the Sun's Right Ascension, Oblique Ascension, Ascensional Difference, and time of Rising at London, on the 1st of May? at Edinburgh, on the 12th of July? at Lisbon on the 8th August? at New Orleans, on the 10th Sept? at Boston on the 17th Oct.? at Magellan's Straits on the 9th Nov.? at Mecca, on the 16th of Dec.? at the Straits of Sunda, on the 5th of Jan.? at Jesso, on the 25th of February?

PROBLEM LVI.

The day and Place being given to find the Sun's Amplitude.

Definition.—The Amplitude of the Sun (from the latin *Amplitudo*, extent) is an arc of the Horizon, measuring the extent of the distance of his rising or setting from the East or West Points, and is accordingly distinguished into *ortive* or *rising*, and *occasive** or *setting*.

Rule.—Adjust the Globe for the latitude

* Ortive from the Latin Ortus, Sun-rising, and Occasive from the Latin Occasus, Sun-set.

of the given place, and bring the Sun's place in the Ecliptic for the given day to the Eastern edge of the Horizon; the number of degrees then intercepted between the Sun's place and the East Point is the Rising Amplitude, which will be north or south according as the Sun is in north or south declination. Revolve the Globe till the Sun's place coincides with the Western verge of the Horizon, and the Setting Amplitude will be found in like manner.

Examples.—What is the Sun's Amplitude at Saint John on the 12th of March? *Ans.* The rising Amplitude is 5 deg. from the east, southerly, and the Setting Amplitude is 5 deg. from the west, southerly.

Required the Sun's Amplitude at London, March 12; at Vienna, Jan. 6; at New York, Feb. 10; at Philadelphia, April 17; at Fox Islands, May 21; at Surinam, June 25; at Morocco, July 29.

PROBLEM LVII.

The day of the Year and the Sun's Amplitude being given, to find the Latitude.

RULE.—Bring the Sun's Place in the Ecliptic for the given day to the eastern or western verge of the Horizon, according as the Ortive or Occasive Amplitude is given, and move the Brass Meridian up or down, till the Sun's place coincides with the given amplitude on the Horizon; the elevation of the Pole will give the Latitude required.

Examples.—If the Sun's Amplitude is 35 deg. from the east towards the north on the 21st of June—what is the latitude of the place? *Ans.* 45½ degrees.

Required the Latitude where the Sun's Amplitude is 30 deg. from the east, northerly on the 6th of June; where it is 20 deg. from the east, southerly, on the 25th Oct.; where it is 15 deg. from the west, northerly, on the 21st of April; where it is 40 deg. from the west, southerly, on the 4th of January.

PROBLEM LVIII.

The day, hour, and place being given, to find the Sun's Azimuth.

DEFINITION.—Azimuth (an Arabic term) is an arc of the Horizon intercepted between the Meridian of the place and an imaginary great circle,* passing through the Zenith and the Sun at right angles to the Horizon. In the forenoon it is east of the Meridian, and in the afternoon, west. The imaginary great circle is represented in the solutions of this Problem by the Quadrant of Altitude fixed to the Zenith.

RULE.—Adjust the Globe for noon on the given day, (by Problem 17,) fix the Quadrant of Altitude in the Zenith, move the Globe till it is adjusted for the given hour,

* Such circles are generally called Vertical or Azimuth circles.

then pass the quadrant over the Sun's place, and the point of its intersection with the Horizon will give the required Azimuth.

Examples.—What is the Sun's Azimuth at Saint John on the 22d of May, at 9 a. m.? *Ans.* About 71 deg. South Azimuth, that is, 71 deg. from the south-easterly; or 19 deg. from the east, southerly, or 109 deg. Azimuth from the north.

Required the Sun's Azimuth at the following places on the subjoined days and hours:—London, Jan. 1, 10, a. m.—Cork, Feb. 15, 11 a. m.—Madrid, March 7, 2, p. m.—Boston, April 1, 3, p. m.—Nicaragua, May 21, 4 p. m.—Tripoli, June 18, 6 a. m.—Samarcand, July 5, 7 a. m.—Aracan, Aug. 21, 9 a. m.

PROBLEM LIX.

The place, the day, and the Sun's Azimuth being given, to find the hour of the day.

RULE.—Adjust the Globe for noon, (by Problem XVII.) fix the Quadrant in the Zenith, and move its graduated edge to the given azimuth; then revolve the Globe till the Sun's place coincides with the edge of the Quadrant, and the hour required will then be that on the hour circle, which coincides with the meridian.

Examples.—What is the hour at London, July 22, the Sun's Azimuth being 66 deg. from the south, easterly?—*Ans.* 9 a. m.

Required the hour at the following places, on the annexed days, the Azimuth of the Sun being as subjoined.

St. John, May 22, Sun's Azimuth 71 deg. from the south, easterly; Edinburgh, Feb. 24, Sun's Azimuth 40 deg. from the south, easterly; Guadaloupe, April 20, Sun's Azimuth, 10 deg. from the east, northerly; Mexico, Nov. 1, Sun's Azimuth 25 deg. from the west, southerly; Calais, May 30, Sun's Azimuth 60 deg. from the north, easterly; Fredericton, Aug. 15, Sun's Azimuth, 56 deg. from the south, easterly; Halifax, Sept. 5, Sun's Azimuth 17 deg. from the south, easterly.

PROBLEM LX.

To find the Sun's Depression below the Horizon at any hour of a given night at any place.

RULE.—Rectify the globe for Noon at the given place (by Problem 17), turn it westward, till it is adjusted for the given hour; then, keeping it fixed, find the Altitude of the Degree of the Ecliptic exactly opposite to the Sun's place for the given day; that altitude will be equal to the Depression required.

Examples.—What is the Sun's depression at St. John on the 15th March, at 10 o'clock, p. m.? *Ans.*—The Sun on the 15th March is in the 25th of Pisces, the degree exactly opposite which is the 25th of Virgo. The globe having been adjusted according to the Rule, the altitude of the 25th of Virgo is found to

be 48°, which is the Depression of the 25th of Pisces required.

NOTE.—The Azimuth of the Sun when under the horizon may at the same time be found, by finding the azimuth of the degree of the Ecliptic of which the altitude is taken and referring it to the opposite point of the horizon. Thus the azimuth of the 25th of Virgo is found to be S. E. by S. 5° E. which referred to the opposite point of the Compass is found to be N. W. by N. 5° W. the azimuth of the 25th of Pisces at the specified time.

Required the Sun's depression below the horizon at London, November 1, at 10, p. m. —at Petersburg, February 20, at 7, p. m.— at Lima, June 26, at 11, p. m.—at Mexico, November 8, at 4, a. m.—at New York, January 7, at 7, p. m.—at Cape Horn, July 20, at 10, p. m.—at Quito, Feb. 15, at midnight.

PROBLEM LXI.

To find the Equation of Time, as far as it can be done by means of a Globe.

Explanation.—Were the Sun not to vary his Declination, but to move daily either coincident or parallel with the Equator, a degree of the Ecliptic would be described in neither more nor less time than a degree of the Equator, and solar time would always be coincident with the time of a well regulated clock. But this is not the case. The Sun is continually varying his declination, and

causing the well known obliquity of his path; the consequence of which is, that the time in which he describes a degree of the Ecliptic is seldom exactly coincident with a degree of the Equator. This may be easily illustrated by placing patches on the Ecliptic and Equator at every tenth or fifteenth degree, and turning the globe slowly on its axis. By doing this, it will be seen that the patches pass under the brazen meridian at different times. Hence arises the Equation of Time*, which is greatest about February 6, May 5, August 8, and November 8, and is nothing about March 21, June 21, September 23, and December 21.

RULE.—Bring the Sun's place in the Ecliptic to the brass meridian, count the number of degrees from the first point of Aries to the brass meridian on the Equator and on the Ecliptic; the Difference, reduced to time, reckoning four minutes to a degree, is the Equation of Time. If the number of degrees

* One part of it, only, however; for the unequal motion of the Sun in the Ecliptic, is another circumstance which enters into the Equation of Time, but which cannot, in any manner, be illustrated by an artificial Globe. This part of the Equation is greatest about March 30th and October 3d, and least or nothing on July 1st and December 31st, when the Sun is in his Apsides, or those points of his orbit which are nearest and most distant. As the Sun moves from the Apogee, or point most distant from the Earth, where he is on the 1st of July, to the Perigee, or point nearest the Earth, where he is on the 31st of December, the time shewn by the Sun, or apparent time, precedes that shewn by a well regulated clock, or mean time; but whilst it moves from the Perigee to the Apogee, the mean time precedes the apparent time.

on the Ecliptic exceed those on the Equator, the Sun is faster than the clock, but if the number of degrees on the Equator exceed those on the Ecliptic, the Sun is slower than the clock.

Examples.—What is the Equation of Time on the 27th of June? *Ans.*—The degrees on the Equator exceed those on the Ecliptic by One, hence the Sun is four minutes slower than the clock.

Required the Equation of Time on the first day of every month, and on the days on which the Sun enters the different Signs.

NOTE.—The Equation of Time is set down on the horizon of some globes, so that it can easily be obtained by reference.—On other globes an Analemma* is inserted on a vacant part of the torrid zone, constructed somewhat in the form of the figure 8, extending from tropic to tropic, so as to embrace every degree of declination. The months and days of the year are inserted in it, in such a manner as to come under the degrees of declination on the meridian, that correspond with them. On some globes, through the point of this figure, where the opposite parts cross each other, a small line is drawn parallel to the Equator and divided as a scale, for the purpose of giv-

*An Analemma (from the Greek *analambano*, to take backwards,) is properly a planisphere, or projection of the sphere on the plane of the meridian. But here it is nothing else but a scale of Declination combined with a scale of the Equation of Time.

ing the Equation of Time; extending to 20 minutes on one side, showing the slowness of the clock, and to 20 minutes on the other, showing the fastness of the clock, when compared with the solar time.

To find the Equation of Time by the Analemma; bring the day of the month on the Analemma to the graduated edge of the brass meridian, and observe what point of the scale of time simultaneously coincides with it; that gives the Equation desired.

Several other Problems may be solved with the greatest ease by the Analemma; as—

1st. *To find the Sun's Declination.* Bring the day of the month on the analemma to the brass meridian, and observe what degree it intersects.

2d. *To find those two days in the year in which the Sun's Declination is the same.* Let the analemma pass under the meridian, and the two days on the analemma which pass under the given degree of declination are those required.

3d. *To find the Sun's place in the Ecliptic.* Revolve the globe till some point of the Ecliptic pass under the degree of declination on the meridian, which has been previously ascertained by bringing the day of the month on the analemma to the meridian; that will be the Sun's place required. If the day is on the decreasing scale, then the descending side of the Ecliptic must be taken, but if on the in-

creasing scale, the ascending side must be taken.

4th. *To find where the Sun is vertical.* Pass the analemma to the meridian to find the declination, and, revolving the globe, observe all the places that come under that degree of the meridian.

5th. *To find those two days of the year to which the Sun will be vertical to any place within the torrid zone.* Find the latitude of the place and bring the analemma under it.

6th. *To find what other day of the year will be equal to a given day.* Find the given day on the analemma, and adjoining it will be found the required day.

PROBLEM LXII.

To draw a Meridian Line.

NOTE.—A Meridian, or North and South Line, is of the greatest importance in all cases relating to Astronomy, Geography, and Dialling, because on the exact determination of it, all the other parts have their chief dependence. The following Rule is perhaps one of the most simple for young pupils:—

RULE.—On a flat board describe several concentric circles or arcs of circles, and on the centre fix a style or pin, about half a foot long, perpendicular to the plane of the board, having a little hole drilled in its top, which should be made flat. Place the board in a true ho-

rizontal position, and about the 21st of June between the hours of nine and eleven in the forenoon, and one and three in the afternoon, observe the points, wherein the lucid spot, projected by the hole, touches the several arcs. Divide the spaces between them in the several arcs into two equal parts, and draw a line through the points of bisection; that line will be the meridian line required.

PROBLEM LXIII.

To find the Angular distances of the hour lines on a horizontal dial for any latitude.

Definition.—Dial (from *dies*, a day), is an instrument serving to measure time by means of the shadow of the sun, on which account it was also called by the ancients, *Sciatheracum*, the shadow-hunter, (from the Greek *skia*, a shadow, *theraō*, to hunt). A horizontal dial is one drawn on a plane parallel to the horizon, having its gnomon or style elevated according to the latitude of the place, or pointing to the pole.

Rule.—Rectify the globe for the given latitude; bring any one of the twenty-four meridian lines to the brass meridian, and at the same time adjust the hour circle for XII. keeping the Globe in this position, mark off the distances in degrees from the brass meridian, at which the different meridians intersect the horizon, these will give the angular distances of the hour lines required.

Example.—Find the angular distances for a horizontal dial at St. John, New-Brunswick? *Ans.* Having prepared the globe according to the Rule, the angular distances of 1 P. M. and 11 A. M. are found to be $10\frac{1}{4}°$; of 2 P. M. and 10 A. M. $21\frac{3}{4}°$; of 3 P. M. and 9 A. M. 35°; of 4 P. M. and 8 A. M. $50\frac{1}{2}°$; of 5 P. M. and 7 A. M. 69°; of 6, both morning and evening, 90°; of 7 P. M. and 5 A. M. 110°; of 8 P. M. and 4 A. M. $128\frac{1}{2}$.° As the gnomon does not cast a shadow strong enough on the dial to tell the hour before 4 A. M. or after 8 P. M. it is not necessary to proceed further in drawing the hour-lines.

Find the hour-angles for horizontal dials at London and New-York?

PROBLEM LXIV.

To find the Angular distances of the hour lines for an Erect Direct Dial for a given place.

Definition.—An Erect Dial is one that stands perpendicular to the horizon, and when it faces one of the Cardinal points, it is called Direct, otherwise, Declining.

Note.—As a tangent to a circle is parallel to a diameter drawn at the distance of 90 degrees, so the plane of a horizontal dial must be parallel to the plane of an Erect dial for a place whose difference of latitude is 90 deg.

Rule.—Rectify the globe for a latitude 90 degrees from the given latitude, and determine (by Problem LXIII.) the hour angles

for a horizontal dial at that latitude; the diagram will furnish an erect dial for the given place. The gnomon of this dial must make an angle with its plane equal to the latitude of the place where it is a horizontal dial.

Examples.—Find the hour angles for an Erect Direct South Dial at London?

Ans. Having rectified the globe for $38\frac{1}{2}°$ south, which is 90 degrees south of the latitude of London, and prepared the Globe as in the preceding Problem, it is found that the hour angles of a horizontal dial for that latitude are as follows: for 1 and 11, $9\frac{1}{4}°$—for 2 and 10, $19\frac{1}{2}°$—for 3 and 9, $31\frac{1}{2}°$—for 4 and 8, 47°—for 5 and 7, $66\frac{1}{2}°$—for 6, both morning and evening, 90°—for 7 and 5, $112\frac{1}{2}°$—for 8 and 4, $132\frac{1}{2}°$.

This Dial will constitute an Erect Direct South Dial at London.

Find the Hour angles of an erect direct South Dial in the Latitude of Saint John, in the latitude of Paris, and in the latitude of Jamaica.

NOTE.—When the Dial is in its true position, the morning hours will be on the West side of the gnomon, and the afternoon hours on the East side. The line on which the gnomon stands is called the substile line.

PROBLEM LXV.

To find the Hour-lines of a Declining Dial for any given place.

Definition—A Declining Dial is an erect

one that does not face any of the Cardinal Points, but stands inclined to some one of them at a greater or less angle.

RULE.—Bring the given place to the Meridian and rectify the Globe for its latitude. Note its longitude—find that place which is in the Horizon at a distance from the Meridian equal to the declination of the required Dial, bring it to the Meridian, and note its latitude and longitude. Rectify the Globe then for that latitude, and bring Aries to the Meridian—then turn the Globe, till that degree of longitude, which is equal to the difference of the longitude of the given place, and the longitude of the place found on the Horizon come under the Meridian, and fix the Globe. Then the Meridians, passing through every fifteen degrees of the Equator, cut the Horizon in the respective distances of all the hours from the Substile, or the line on which the gnomon is erected.

Example.—Find the angles which the hour lines make with the Substile of a vertical Dial, in the latitude of St. John, that declines from the South, towards the East, fifty degrees.

Solution.—Rectify the Globe for the latitude of St. John, bring Saint John to the Meridian and mark its longitude, 66°; observe that place on the Globe which is 50° from the South towards the East, bring it to the Meridian and observe its latitude and longitude, the former of which is 26½° South

and the latter 9° West. The difference of which and that of Saint John is 57°.

Next rectify the Globe for 26½° South, and bring Aries to the Meridian: turn the Globe till 57° East longitude comes under the brass Meridian and fix the Globe. The Equinoctial colure will then cut the Horizon at 33° from the Substile line, which will be the hour line of XII; the Meridian nearer the brass Meridian or substile makes an angle of 21° with the substile, and is the hour line of XI; the next makes an angle of 12° and is the hour line of X; the next makes an angle of 5°, the hour line of IX; the next makes an angle of 1¾° to the West of the Substile line and is the hour line of VIII; the next is 9° the hour line of VII: the next 17° the hour line of VI; the next 28½° the hour line of V; the next 44°½ the hour line of IV. Going Eastward to the next Meridian beyond the Equinoctial colure, we find it cuts the horizon at 52° from the brazen Meridian, which gives the hour line of I; the next is 78½° the hour line of II.

Note.—If an Erect Dial Decline towards the East from the South, the Substile line will fall among the morning hours, as in the above example; but if it decline Westward, the Substile will fall among the afternoon hours.

MISCELLANEOUS QUESTIONS

FOR THE

EXERCISE OF THE LEARNER.

What is the latitude, and what the longitude of that place where Bonaparte died?

What is the difference of the latitude of that great city which is unrivalled in its pursuit after every improvement and the amelioration of mankind, and the latitude of that other great city, which is as much distinguished for its antiquated customs, and its hatred of that book which is the source of all improvement among men?

Whether is Europe or Africa the longest from North to South? and what is the difference of the longitudes of their extreme East and West points?

How much longer is America than Asia? and how much broader is Asia than America?

How much time would a balloon occupy in passing from Saint John to London, at the rate of eight and a half miles an hour?

What place is that which lies in the parallel of St. John as far East from London as St. John is West?

How far would a ship travel in circumnavigating the Globe, if it should set out from London, touch at Bermuda, Trinidad, Buenos Ayes, Terra del Fuego, Chiloe, Truxillo, the Gallipagoes, the Marquesas, New Caledonia, Van Diemen's Land, Kerguelen's Land, Cape of Good Hope, St. Helena, Sierra Leone, the Madeiras, and thence to London?

In what latitude and longitude is that point from which a circle described would pass through St. John, London, and Paris?

What place has neither latitude nor longitude? and what place has no latitude, and yet the greatest degree of longitude?

What are the Antipodes of the Periœci of St. John?

What are the Periœci of the Antœci of London?

What is the distance in geographical miles of the Antœci, and thence to the Periœci, and thence to the Antipodes of Saint John?

What are those places of the earth where the shadow of the people go completely round them in the twenty-four hours?

What people have no shadow?

What people have their shadow pointing always Northward? who have their shadow pointing always Southward? and who have their shadow pointing Northward one half of the year, and Southward the other half?

What is the distance of the Southern extremity of the Andes from the Northern extremity of the Rocky Mountains?

What is the difference of the longitudes of the highest mountains in America and Asia?

If a Steam Vessel should cross from London to New-York in 12 days, at what rate per day would she sail?

What is the difference of the Sun's lowest Meridian Altitude, and his highest Meridian Altitude at Saint John?—and what is the difference of his rising amplitudes at those times?

At what hour are the Sun's Azimuth and Altitude equal, on the 1st April, at St. John?

To what place must a person travel South from Saint John, to make his distance from Saint John equal to the distance of St. John from London?

On what day of the year is the Sun's Altitude 35° due East at Saint John?

If London were made the centre of a circle whose radius would reach from London to the North Pole, through what places would the circle pass?

If two ships sail from the same point on the

globe, in opposite directions, the one East and the other West; supposing them to sail equally, at the rate of ten miles per hour, on a great circle; how many days would each of them count after having returned to the port whence they set out?

On what point of the Compass does the Sun set at Fredericton, when he rises at 7, A. M?

What is the Equation of time, as far as it depends upon the obliquity of the Ecliptic, on the 1st of May?

At what hour will the Sun's Altitude be equal to his amplitude on the 10th of May at Saint John?

Would a ship, in setting out from a Port, describe what is called the angle of position by keeping her head always towards one point of the Compass? And if not, what constitutes the difference between Geographical bearing and Nautical bearing?

Describe a Horizontal Dial for the latitude of Cape Horn?

At what hour does the Sun first make his appearance at Saint John on the 1st of June, and what o'clock is it then in London?

How many miles are the Inhabitants of St. John carried per hour by the Earth's rotation on its axis?

How much longer is the 1st of May at St. John than at New-York?

When the clock is ten minutes slower than

the Sun, what is the sun's place in the Ecliptic, and the day of the year?

Describe the phenomena that attend a Parallel Sphere?

Describe the phenomena that attend a Right Sphere?

What day of the year at London is equal to the longest day at St. John?

When the Sun's depression below the horizon at St. John is 25° on the 15th of May, what is the hour of the night?

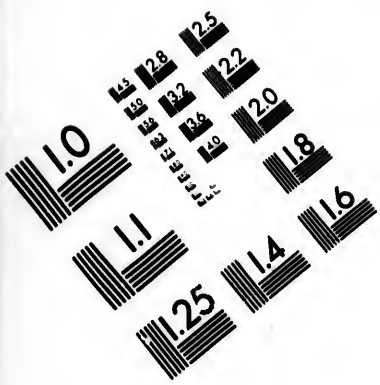
When the sun's altitude is equal to his amplitude on the 1st of June at St. John, what is his Azimuth?

If a steamer, sailing from Liverpool to New York, proceeds at the rate of 11½ miles per hour, in what time will she reach her destination?

How often will a coach wheel, whose circumference measures ten feet, go round, in describing the parallel of latitude on which St. John is situated?

If two steamers should start the same instant of time, the one from Boston, bound to Cork, sailing at the rate of ten miles per hour, and the other from Cork bound to Boston, sailing at the rate of twelve miles per hour, in what latitude and longitude might they be expected to meet?

How many geographical miles from the first meridian is that place whose longitude is 69° W. and latitude 57° N.?



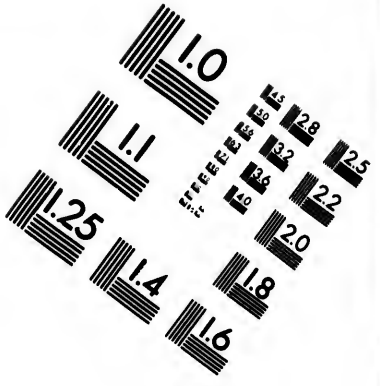
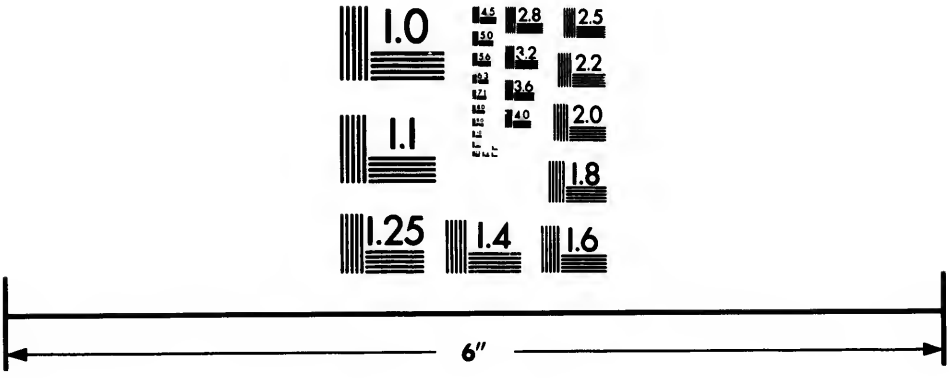
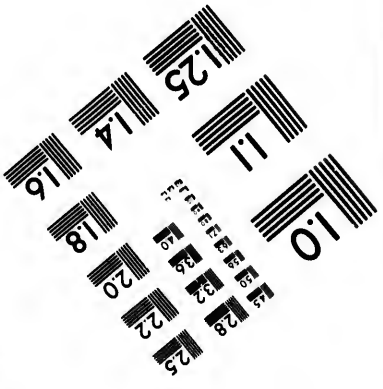


IMAGE EVALUATION TEST TARGET (MT-3)





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Find the longitude of that place in 50° of latitude, which measures on its parallel of latitude 5000 miles West from the meridian of Greenwich.

What is the meridian altitude of the sun at St. John, when the day is eighteen hours long at the Arctic circle?

Required the hour angles of a vertical dial facing the South for New-York?

When the sun's right ascension is 56°, what is his oblique ascension at St. John, and what is the length of the day?

For what latitude is a horizontal dial constructed, the angular distance of whose XII. and I. is 14°.

EASY RULES

FOR THE

CONSTRUCTION OF MAPS.

1st. Draw marginal lines to contain the numbers expressing the latitude and longitude.

2d Draw a line up and down through the middle of the Map, to represent a meridian, and divide it into as many parts as there are to be degrees of latitude.

3d. Take a line equal to one of these degrees, and subdivide it into any number of small spaces to measure minutes.

4th. Find from the subjoined table, the length of a degree of longitude on the parallel of latitude which is to pass through the top of the map; and to the right and left of the meridian, drawn through the middle of the map, divide the line along the top into degrees of the length found in the table.

5th. Find the length of a degree of longitude on the parallel which is to pass through

the bottom of the Map; and on each side of the Central Meridian, divide the line along the bottom of the Map, into degrees of the length found in the table.

6th. Draw meridians from the degrees marked along the bottom to those marked along the top.

7th. Produce the Central Meridian and any two of the others at an equal distance on each side of it, till they meet in a point; from which as a centre, describe lines from one side of the Map to the other, passing through the degrees marked on the Central Meridian.

8th. Number the degrees along the sides, and the top, and bottom, and subdivide them into such parts as the scale of the map will admit.

9th. From an accurate Map, or a table of latitudes and longitudes, lay down the capes, towns, and other prominent places in their proper situations, and then trace the boundaries, rivers, mountains, &c.

TABLE

Showing the length of a Degree of Longitude on any parallel of Latitude, from the Equator to the Pole.

Degree of Latitude.	Deg. of Long. Geog. Miles.	Degree of Latitude.	Deg. of Long. Geog. Miles.	Degree of Latitude.	Deg. of Long. Geog. Miles.
1	59.99	31	51.43	61	29.09
2	59 96	32	50 88	62	28.17
3	59.92	33	50.32	63	27.24
4	59.85	34	49.74	64	26.30
5	59.77	35	49.15	65	25.36
6	59.67	36	48.54	66	24.40
7	59.55	37	47.92	67	23.44
8	59.42	38	47 28	68	22.48
9	59.26	39	46 63	69	21.50
10	59 09	40	45.96	70	20.52
11	58.90	41	45.28	71	19.53
12	58.69	42	44.59	72	18.54
13	58.46	43	43.88	73	17.54
14	58.22	44	43.16	74	16.54
15	57 96	45	42.34	75	15.53
16	57.67	46	41.68	76	14.52
17	57.38	47	40.92	77	13.50
18	57.06	48	40.15	78	12 47
19	56.73	49	39.36	79	11.45
20	56.38	50	38.57	80	10.42
21	56 01	51	37.76	81	9.39
22	55 63	52	36.94	82	8 35
23	55.23	53	36.11	83	7.31
24	54.81	54	35.27	84	6 27
25	54.38	55	34.41	85	5.23
26	53.93	56	33 55	86	4.19
27	53.46	57	32.68	87	3.14
28	52 98	58	31.80	88	2.09
29	52.48	59	30.90	89	1.05
30	51.96	60	30.00	90	0.00

Part II. on the Celestial Globe will appear in a short time.

ppear in