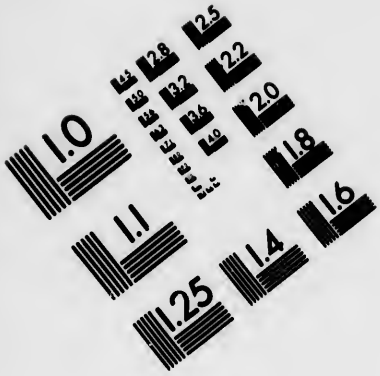


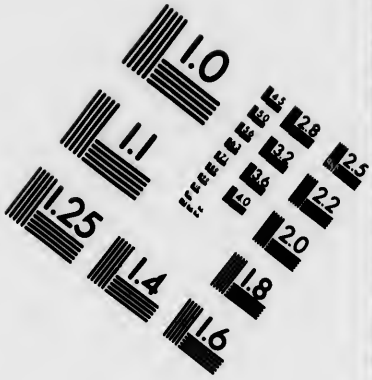
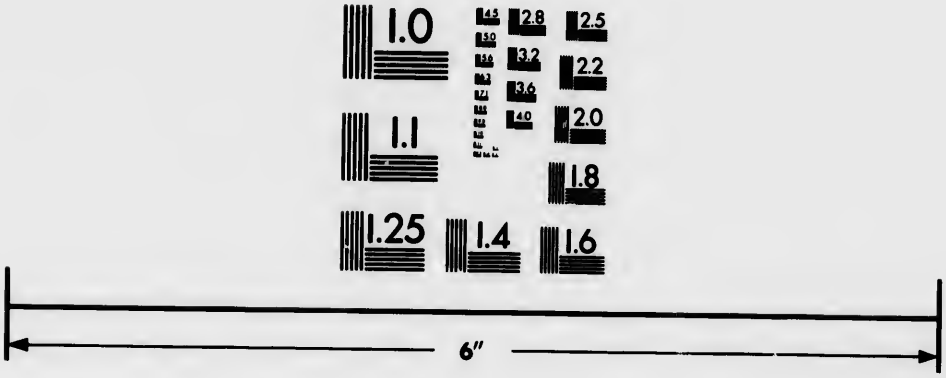
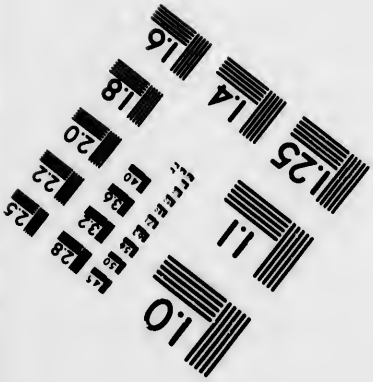
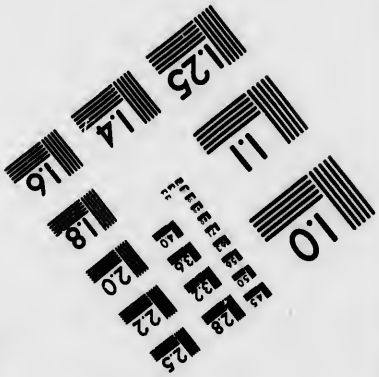


IMAGE EVALUATION
TEST TARGET (MT-3)







Photographic
Sciences
Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- [x] Coloured covers/ Couverture de couleur
- [ ] Covers damaged/ Couverture endommagée
- [ ] Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- [ ] Cover title missing/ Le titre de couverture manque
- [ ] Coloured maps/ Cartes géographiques en couleur
- [ ] Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- [ ] Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- [ ] Bound with other material/ Relié avec d'autres documents
- [ ] Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distortion le long de la marge intérieure
- [ ] Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- [ ] Additional comments:/ Commentaires supplémentaires:

- [ ] Coloured pages/ Pages de couleur
- [ ] Pages damaged/ Pages endommagées
- [ ] Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- [x] Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- [ ] Pages detached/ Pages détachées
- [x] Showthrough/ Transparence
- [ ] Quality of print varies/ Qualité inégale de l'impression
- [ ] Includes supplementary material/ Comprend du matériel supplémentaire
- [ ] Only edition available/ Seule édition disponible
- [ ] Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
				✓							

The copy filmed here has been reproduced thanks to the generosity of:

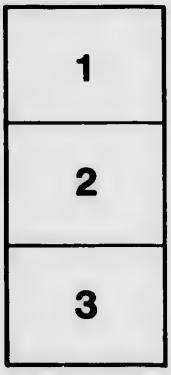
National Library of Canada

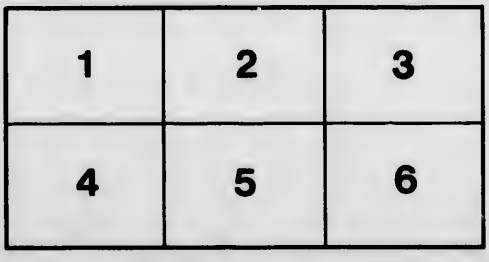
The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol → (meaning "CONTINUED"), or the symbol ▽ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:





L'exemplaire filmé fut reproduit grâce à la générosité de:

Bibliothèque nationale du Canada

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole → signifie "A SUIVRE", le symbole ▽ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.

32X

HAND BOOK

OF THE

IMPROVED

NEWTONIAN

OR,

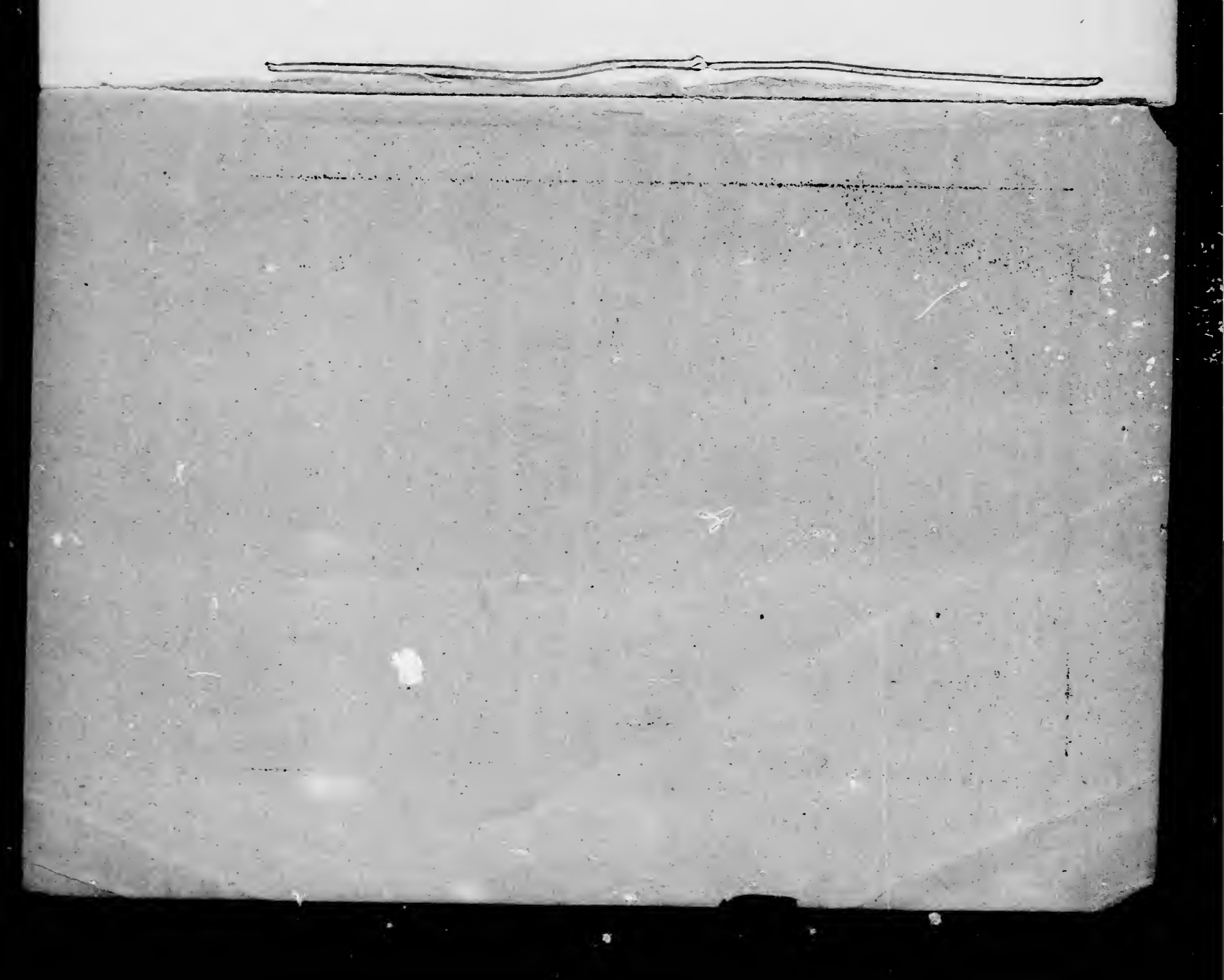
COMBINED ASTRONOMICAL

—AND—

TERRESTRIAL GLOBE.

BY M. TURNBULL.

WILLING & WILLIAMSON,
PUBLISHERS AND BOOKSELLERS, TORONTO, ONT.



HAND BOOK

OF THE

IMPROVED

NEWTONIAN:

OR,

COMBINED ASTRONOMICAL

AND

TERRESTRIAL GLOBE.

BY M. TURNBULL.

WILLING & WILLIAMSON,
PUBLISHERS AND BOOKSELLERS,
TORONTO.

1881.

INDEX.

HAND-BOOK

OF THE

NEWTONIAN: OR, COMBINED ASTRONOMICAL AND TERRESTRIAL GLOBE.

It has been observed by a distinguished educational authority, that "a terrestrial globe in a school-room is as essential as a black board or dictionary." Nevertheless, it is a remarkable fact that, from the first use of terrestrial globes to the present day, no improvement has been made in the mechanical appliances which, for educational purposes, have been fitted to them. The object of the new method of mounting is to effect a great improvement upon the old method, by means of original mechanical appliances, whereby the student will be enabled to solve a number of problems in what is commonly called astronomical geography, which are altogether insolvable by the ordinary methods of mounting at present in use.

It is a cardinal principle of astronomical geography, that, in viewing the earth as a member of the solar system, the eye is supposed to be situated in the sun; and the new method of mounting the terrestrial globe is simply an application of this principle. That the earth is a spherical body, slightly flattened at the poles, is a fact too well established to need proof here. According to the latest measurements, its polar diameter is about 7,899½ miles, and its mean equatorial diameter about 7,925½ miles. It may be noted here, as a fact not generally known, that the equatorial circumference is not a perfect circle, but an ellipse of very small eccentricity, the longer axis exceeding by about two miles and a half the shorter. The exact

figures are: larger axis, 7,926.84 miles; shorter, 7,924.234 miles. The mean equatorial diameter being about 26 miles longer than the polar diameter; whence it results that the equator is, on an average, about thirteen miles further from the earth's centre than are the poles.

Before detailing the various problems which the new globe is intended to solve, it will be desirable to give a clear description of all the mechanical appliances used. These are six in number, as follows:

1. The first is what may be called the great *datum circle* of the solar system. This is the large conspicuous circle in the model which rests upon the tripod stand. This represents the plane of the ecliptic, or the apparent annual path in the heavens described by the sun and the earth when viewed the one from the other. This circle of 360 degrees is divided into twelve constellations of thirty degrees each. On the circle is also marked the calendar of 365 days, so that each day of the year is coincident with the point in the circle of the constellation, or zodiac, where the sun's centre is situate on that particular day. Thus, the sun enters the constellation Aries in March and Taurus in April; and on examining the ecliptic circle of the model, we find the days of the month of March placed coincidently with Aries, those of April with Taurus, and so on throughout the entire circle. Another point to be noticed is that the ecliptic is divided into a northern and a southern portion, the former being the portion north of the equator, from Aries to Libra, and the latter being the portion south of the equator, from Libra to Aries. The ecliptic may also be divided geographically into an ascending and a descending portion; the first from the winter solstice, when the sun is at its greatest southern declination on the 21st December, to the 21st June, when it reaches its maximum northern declination; and the descending portion, from the 21st June to the 21st December.

It will be seen, then, that this appliance of the model exhibits the causes of the seasons.

2. The next mechanical appliance which may be noticed is the brass semicircle which extends from one pole to the other, representing the solar meridian. As the graduated edge of this semicircle always follows the sun's centre, and is regulated in position by the inclination of the axis of the globe, it is always in the true plane of the solar meridian. Thus, on moving the sun's place on the 21st December to its place on the 21st June, and onwards to the 21st December again, the meridian is inclined to the *right hand* from December to June, and to the *left hand* from June to December; the student being thus enabled to draw geometrically all the circles of latitude and the meridians in their true positions within the illuminated portion of the earth. It will be noticed, too, that as a consequence of the inclination of the axis of the globe, the graduated edge of this semicircle, in its motion over the sun's centre, rises above and sinks below the ecliptic plane, thereby reading off in degrees the declination from the equator, and illustrating the sun's northerly motion from December to June, and its southerly motion from June to December.

3. The third mechanical appliance is a double ring permanently fixed round the globe, on which the times of sunrise and sunset are marked. These rings divide the earth at all hours into two hemispheres of sunlight and total darkness respectively, the edge next the sun being the "*circle of illumination.*" The space between and including the breadth of the two rings represents the zone of twilight, and is eighteen degrees, or about 1,250 miles, in breadth on the earth's surface.

4. The fourth point to be noted with regard to the mounting of this globe, is that the axis of the earth is made to incline at an angle of 23° 28′ 10″ to the ecliptic, thus exhibiting the true

inclination, and at the same time the parallelism of the axis to itself throughout the year.

5. The fifth appliance is a semicircle of brass revolving round the sun's centre. It extends half way round the earth, 90° on each side of the sun, and is divided into degrees to measure the angular distance of any place from the zenith sun, thus furnishing a means of approximately measuring the relative intensity of the sun's heat at any place in sunlight, as deduced from the law that *heat diminishes* with the *square* of the *angular distance* from the *zenith sun.*

6. The sixth point to be noted is the introduction of an improved graduated hour circle, placed round the south polar axis. It is divided into 360 degrees, and also into hours of civil time. This circle, being carried round the globe by the solar meridian, will always be with the sun, and thus indicates the longitude east or west, and the hour of the day at any place on the earth's surface.

The mechanical appliances having thus been described, a number of the more important problems which they are adapted to serve, and their solutions, will now be given.

PROBLEM I.

TO FIND THE LATITUDE OF ANY GIVEN PLACE.

Rule.—Rotate the globe on its axis until the place is under the graduated solar meridian: the degree over the place is the required latitude.

Solve with the globe the latitude of the following places:

Q. Edinburgh?

A. 56° north.

Q. San Francisco?

A. 38° 15′ north.

PROBLEM II.

TO FIND ALL THOSE PLACES WHOSE LATITUDE IS THE SAME AS THAT OF ANY GIVEN PLACE.

Rule.—Rotate the globe, and all places passing under the degree of a given place have the same latitude.

Solve with the globe the following places:

Q. What places have the same approximate latitude as Edinburgh?

A. Copenhagen, Riga, and Omsk.

Q. What places have the same approximate latitude as Quebec?

A. St. John's, Jassy (Hungary), and Odessa.

PROBLEM III.

TO FIND THE LONGITUDE OF ANY GIVEN PLACE.

Rule.—Bring the prime meridian (that is, the meridian from which the longitude is calculated) to the solar meridian's place; then fix the vernier on the earth's axis to the prime meridian; rotate the globe till the given place comes beneath the graduated meridian; then, if the prime meridian has moved east, the arc passed over by the vernier will show the degrees of west longitude, and if it has moved west, the arc will show the degrees of east longitude.

Solve with the globe the longitude of the following places:

Q. What is the longitude of Washington?

A. 5h. 8 min. west of London.

Q. What is the longitude of Dublin?

A. 25 min. west of London.

PROBLEM IV.

THE LATITUDE AND LONGITUDE OF A PLACE BEING GIVEN, TO FIND THE PLACE.

Rule.—Work out as directed in the three previous Problems.

Solve with the globe the following:

Q. What island is situate 157° east longitude, 30° north latitude?

A. Lot's Wife.

Q. What city is 35° north latitude, and 16° east longitude?

A. Algiers.

PROBLEM V.

TO FIND THE TWO DAYS IN THE YEAR WHEN THE SUN WILL BE VERTICAL OVER ANY PLACE WITHIN THE TROPICS.

Rule.—Bring the sun's centre directly over the place given, and the day opposite to the sun's centre will be the day required.

Solve: When will the sun be vertical to the following places:

Q. Mexico?

A. May 11 and July 30.

Q. Tahiti?

A. January 28 and November 6.

PROBLEM VI.

TO FIND THE LENGTH OF ANY PARTICULAR DAY AT A GIVEN PLACE, AND THE TIMES OF SUNRISE AND SUNSET.

Rule.—Bring the given place to the solar meridian; screw the axial pointer to the same plane; rotate the globe till the place reaches the edge of the twilight zone in the forenoon, and

note the degree on the hour circle; then rotate the globe till the place reaches the edge of the twilight zone in the afternoon, and again note the degree on the hour circle. The two arcs indicate the time of sunrise and sunset respectively, and, added together, give the length of the solar day.

Solve with the globe the following:

Q. What time does the sun rise and set at Toronto, Dec. 25th, and how long is the day?

A. Sun rises at 7h. 40m. a.m., and sets at 4h. 44m. p.m. Length of day, 9h. 4m.

Q. When does the sun rise and set at Chicago, on January 1st, and how long is the day?

A. Sun rises at 7h. 20m. a.m., and sets at 4h. 32m. p.m. Length of day, 9h. 12m.

PROBLEM VII.

TO FIND THE LENGTH OF THE LONGEST DAY AND OF THE SHORTEST NIGHT, AT ANY GIVEN PLACE.

Rule.—For the Northern Hemisphere, bring the sun to the first of Cancer, and for the Southern Hemisphere, to the first of Capricorn; then work out as directed in Problem VI.

Solve with the globe the following:

Find the length of the longest day and shortest night, at the following places:*

Q. Edinburgh?

A. Day, 17h. 49m.; night, 6h. 11m.

Q. Boston. U.S.?

A. Day, 13h. 24m.; night, 10h. 36m.

---

* Day here is meant to be the time between sunrise and sunset.

PROBLEM VIII.

TO FIND THE DAY WHEN THE SUN BEGINS TO SHINE CONSTANTLY, HOW LONG IT CONTINUES TO SHINE CONSTANTLY, HOW MANY DAYS IT RISES AND SETS, AND HOW MANY DAYS IT NEVER RISES, AT ANY GIVEN PLACE IN THE NORTH FRIGID ZONE.

Rule.—Bring the place to touch, or right below, the edge next the sun, of the "twilight circle of illumination," and the day in the calendar when the sun commences to shine constantly will be found. Next move the sun to the day in the calendar where the given place again comes to the edge of the zone next the sun, and the interval in days will be the period of constant arctic sunshine.

Solve with the globe the following:

Q. When does the sun begin to shine constantly at the Island of Disco in the Arctic Circle; when does it disappear; how long is it absent; and on how many days does it rise and set?

A. The sun shines constantly at Disco from May 12th to July 28th; it is absent 154 days; and it rises and sets 99 times in the year.

Q. Dr. Kane, in 1854, spent that year at Rensselaer Bay, in the Arctic Circle, in latitude 78° 30′. When did the sun rise and set, and how long was the arctic day to him; how long was it absent; and how often did the sun rise and set to the place?

A. The sun shone constantly from April 19th to August 23rd. Length of arctic day, of constant sunshine: 127 axial rotations. The sun was absent from October 27th to February 14th, 110 axial rotations; and it regularly rose and set every 24 hours, from February 14th to April 19th=64 days; and again from August 23rd to October 27th=64 days.*

* The following abstract has been taken from Dr. Kane's notes, to enable the reader to compare the above globular solution with what he actually experienced at the place during the year—the reader being

PROBLEM IX.

TO FIND THE SUN'S MERIDIAN ALTITUDE ON ANY PARTICULAR DAY AT ANY GIVEN PLACE.

Rule.—Find the arc in degrees on the solar meridian, be-

expected, with the globe before him, to place the sun in the ecliptic to the days mentioned in the doctor's notes:

RENSSELAER BAY, *October 11th.*—The long staring day, which has clung to us for months past, to the exclusion of the stars, has begun to intermit its brightness; even Aldebaran, the red eye of the "bull," flared out into familiar recollection as early as ten o'clock, and the heavens, though still somewhat reddened by the gaudy tints of midnight, gave us Capella and Arcturus, and even that lesser light of home memories, the Pole Star.

November 7th.—The darkness is coming on with insidious steadiness, and its advances can only be perceived by comparing one day with its fellow of some time back. We still read the thermometer at noonday without a light, and the black masses of the hills are plain for about five hours, with their glaring patches of snow, but all the rest is darkness. The stars of the sixth magnitude shine out at noonday. Our darkness has ninety days to run before we shall get back again even to the contested twilight of to-day; altogether, our winter will be sunless for about one hundred and ten days.

November 19th.—Wishing to get on the south-west cape of our bay before the darkness set in thoroughly, I started in time to reach it with my Newfoundlanders at noonday, the thermometer indicating 23° below zero.

December 15th.—We have lost the last vestige of our midday twilight; we cannot see print, and hardly paper; the fingers cannot be counted a foot from the eye; noonday and midnight are alike; and except a faint glimmer in the sky that seems to define the hill outlines to the south on the meridian, we have nothing to tell us that this arctic world of ours has a sun.

January 21st.—First traces of returning light, the southern horizon having for a short time a distinct orange tinge.

February 21st.—We have had for some days the sun silvering the ice between the headlands of the bay; and to-day, towards noon, I started out to be the first of my party to welcome him back. I saw him once more, and upon a projecting crag, nestled in the sunshine, it was like bathing in perfumed waters.

tween the given place and the sun's centre on the given day; then subtract the value of the arc from 90°, and the remainder will give the southern altitude if the place be north of the sun's centre, and the northern altitude if the place be south of the sun's centre.

Solve with the globe the following:

Q. What is the altitude of sun at Ascension, April 18?

A. 77° 30′ north.

Q. What is the altitude of sun at Boston, May 23?

A. 64° south.

PROBLEM X.

TO FIND THE SUN'S PLACE IN THE ECLIPTIC ON ANY GIVEN DAY.

Rule.—Find the given day in the calendar circle, and directly opposite to it, on the outer graduated circle, will be found the sign and degree of the sun's place.

Solve with the globe the following:

What is the sun's place in the ecliptic for the following days:

Q. Where is it on December 22nd?

A. 1° Capricorn.

Q. Where is it on May 12th?

A. 22° Taurus.

PROBLEM XI.

THE SUN'S PLACE IN THE ECLIPTIC BEING GIVEN, TO FIND THE DAY OF THE MONTH.

Rule.—Find the sign and degree in the ecliptic, and directly opposite, on the inner circle of days, will be found the day of the month.

Solve with the globe the following:

Q. On what day is the sun in the 14° Aries?

A. April 4th.

Q. When is the sun in the 8° Virgo?

A. August 5th.

PROBLEM XII.

TO FIND WHEN TWILIGHT BEGINS AND ENDS AT ANY PARTICULAR PLACE ON ANY GIVEN DAY.

Rule.—Bring the sun's place over the given day in the calendar, and the particular place to the solar meridian; fix the hour pointer to noon; then bring the place given to the two edges of the twilight zone, and the pointer will show when twilight began and ended in the morning. Do the same for the evening portion of the zone, and the pointer will show when the evening twilight began and ended.

Solve with the globe the following:

Q. When did the twilight begin and end at Toronto, June 28th?

A. Twilight dawned at 2h. 16m. a.m., and ended at 4h. 24m. a.m.

Q. When did twilight begin and end at Venice, March 5th?

A. It began at 4h. 28m. a.m., and ended at 6h. 8m. a.m.

PROBLEM XIII.

TO FIND THE LONGITUDE BETWEEN ANY TWO GIVEN PLACES.

Rule.—Bring one of the places to the solar meridian, and set the axial pointer at noon; then rotate the globe till the other place is beneath the meridian, and the degrees of arc passed over by the pointer will show the difference of longitude.*

---

* To convert degrees of longitude into hours of time, divide by 15; to convert them into minutes of time, multiply by 4.

Solve with the globe the following:

Q. Find the difference of longitude between London (Eng.) and Toronto?

A. Toronto, 5h. 17m. west.

Q. New York and Toronto?

A. Toronto, 20m. west.

PROBLEM XIV.

GIVEN THE DAY AND HOUR AT ANY PLACE, TO FIND WHERE THE SUN IS THEN VERTICAL.

Rule.—Set the sun's place to the given day in the calendar, and also the given place to the solar meridian; fix the pointer to noon; then rotate the globe till the pointer on the hour circle is at the given time, and the place on the globe which is exactly beneath the sun's centre will have the sun vertical at the time.

Solve with the globe the following:

Q. Where is the sun vertical when it is 22 minutes to 8 a.m. at Toronto, on April 22nd?

A. Over the mouth of the River Gambia.

Q. Where is the sun vertical when it is 2h. 20m. p.m. at Montreal, Canada, on July 1st?

A. Cape St. Lucas, Old California.

PROBLEM XV.

TO FIND THE SUN'S NORTH OR SOUTH DECLINATION FOR ANY DAY IN THE YEAR.

Rule.—Bring the sun's centre to the required day in the calendar, and the degree on the graduated solar meridian, exactly beneath the sun's centre, is the declination sought.

Solve with the globe the following:

Q. What is the sun's declination on the following days in the year: Nov. 14th?

A. 18° 30′ south.

Q. March 20th?

A. On equator, or no declination.

PROBLEM XVI.

TO FIND HOW MANY EITHER GEOGRAPHICAL OR STATUTE MILES MAKE A DEGREE OF LONGITUDE ON ANY GIVEN PARALLEL OF LATITUDE.

Rule.—With a pair of compasses take the distance in degrees between two places on the given parallel of latitude, and note the number of degrees the points enclose on the equator; multiply this number by 60, or by 69.16, and divide the product by the number of degrees between the two places, and the result will give the number of geographical or statute miles respectively to a degree on the given latitude.

Solve with the globe the following:

Q. How many miles are there in a degree of longitude on the parallel of latitude of Toronto?

A. 44 geographical miles.

Q. How many miles on the parallel of London, England?

A. 36 geographical miles.

PROBLEM XVII.

FIND THE RATE PER HOUR AT WHICH THE INHABITANTS OF ANY GIVEN PLACE ARE CARRIED FROM WEST TO EAST BY THE ROTATION OF THE EARTH ON ITS AXIS.

Rule.—Find the latitude of the place under the solar meridian; then find by the last Problem the number of miles in one degree, and this number multiplied by 15 will give the required rate per hour.

Solve with the globe the following:

Q. At what rate per h Toronto carried from west to east?

A. 660 miles.

Q. At what rate per hour is London (Eng.) carried?

A. 540 miles.

PROBLEM XVIII.

GIVEN A PLACE WITHIN THE TROPICS TO FIND ALL THE PLACES WHICH HAVE THE SAME DISTANCE FROM IT WITHIN THE CIRCLE OF SOLAR ILLUMINATION.

Rule.—Bring the sun's place in the ecliptic directly over the given place, and the places required will be shown in degrees by the brass semicircle as it revolves round the sun's centre.

Solve with the globe the following:

Q. What places have the same distance from Calcutta as Pekin?

A. Singapore and Roumania.

Q. What places have the same distance from La Plata?

A. Congo (Guinea), Fernando Po, Timbuctoo, Morocco, Cadiz, San Francisco, and Oregon city.

PROBLEM XIX.

THE HOUR OF THE DAY AT ANY PLACE BEING GIVEN, TO FIND WHAT HOUR IT IS AT ANY OTHER PLACE.

Rule.—Find, by Problem XIII., the difference in longitude between the two places; divide the number of degrees representing this difference by 15, and the quotient will give the difference in time, in hours and minutes, between the two places.

Solve with the globe the following:

Q. When it is 12 at noon at London, what is the Toronto local time?

A. 6h. 43m. a.m.

Q. When it is noon at Cape Horn, what is the time at Cape Farewell?

A. 1h. 40m. p.m.

PROBLEM XX.

TO FIND THE PLACES WHICH HAVE THE SAME LONGITUDE AS ANY GIVEN PLACE.

Rule.—Bring the given place to the graduated edge of the apparent meridian, and all places from pole to pole under the same meridian have the same longitude.

Solve with the globe the following:

Q. What places have the same, or nearly the same, longitude as Chicago?

A. Mobile and New Orleans.

Q. As St. Petersburg?

A. Odessa, Cairo and Constantinople.

PROBLEM XXI.

TO FIND ALL THE PLACES OVER WHICH THE SUN WILL PASS VERTICALLY ON ANY GIVEN DAY.

Rule.—Bring the sun in the ecliptic to the given day in the calendar; then rotate the globe, and all the places over which the sun's centre will pass will have the sun vertical on the given day.

Solve with the globe the following:

Q. What places will the sun pass over vertically on the following days: January 25th?

A. Fiji Islands, Keppel's Islands, Society Islands, and Villa Rica.

Q. On April 5th?

A. Candia, Trincomalee, Barbadoes, Panama, and Sierra Leone.

PROBLEM XXII.

TO FIND BY THE GLOBE THE THREE CASES, VIZ.: THE ANTŒCI, PERIŒCI, AND ANTIPODES OF ANY GIVEN PLACE.

Rule.—Bring the place to the solar meridian, and note its latitude; then count the same number of degrees from the equator in the opposite hemisphere, and the ANTŒCI of the given place will be found. Next, the PERIŒCI being situate on the same latitude but on opposite meridians, set the hour pointer to the given meridian, and rotate the globe 180° in longitude; then the place on the globe below the same degree first assumed will be the PERIŒCI required. Again, as the ANTIPODES lie opposite upon the globe, with feet towards feet, on opposite meridians and parallels, the ANTIPODES will be found under the same degree of the opposite solar meridian where at first the ANTŒCI stood.

Solve with the globe the three above-mentioned cases;

Q. What place upon the globe is the ANTŒCI of Quebec?

A. Gulf of Penas, Patagonia.

Q. What place on the globe is the ANTŒCI of Tobolsk, Russia?

A. Kerguelen Land.

Q. What place on the globe is the PERIŒCI of Toronto?

A. Mouth of Onguan River, Mongolia.

Q. What place is the PERIŒCI of London, England?

A. Tanga Island, Kamtschatka.

Q. What place upon the globe is opposite to, or is the ANTIPODE of, Sydney, N.S.W.?

A. South of the Azores Islands.

Q. What place is the ANTIPODE of Cook's Straits, New Zealand?

A. Toledo, Spain.

PROBLEM XXIII.

TO FIND AT ANY PLACE THE SUN'S ELEVATION OR DISTANCE IN DEGREES FROM THE SOLAR TERMINATOR, OR POINT WHERE IT ROSE AND WILL SET, ON ANY DAY AND AT ANY GIVEN HOUR?

Rule.—Bring the sun's centre to the solar meridian for the given day, and fix the hour pointer to the above plane; rotate the globe on its axis till the pointer is at the required hour; then raise the brass semicircle which revolves round the sun's centre, and the degree above the given place will show the solar altitude at the time.

Solve with the globe the following:

Q. What is the altitude of the sun at Montreal on May 15, at 8h. 12m. a.m.?

A. 24°.

Q. What is the solar altitude at Detroit on Nov. 20, at 3h. 10m. p.m.?

A. 15° 30′.

PROBLEM XXIV.

THE TIME OF A LUNAR ECLIPSE BEING GIVEN, TO FIND ALL THE PLACES ON THE GLOBE WHERE IT WILL BE VISIBLE.

Rule.—Find by Problem XIV. where the sun will be vertical at the given time; bring the place to the solar meridian; then, as the sun will be visible to all parts of the earth above its horizon, the moon being at the time of an eclipse exactly opposite the sun, will be visible to the other, or dark hemisphere, at any point of which the different phases of the eclipse in local time can be pointed out.

Of the foregoing Problems, Nos. V., VI., VII., VIII., IX., X., XI., XII., XIV., XV., XVIII., XIX., XXI., XXII. and XXIV., cannot be solved correctly by any other terrestial globe now in use except the present Combined Astronomical and Terrestrial Globe.

PHENOMENA OF TWILIGHT.

The new method of mounting the terrestrial globe enables the student to solve a number of problems with respect to twilight; and a few preliminary remarks may here be useful. Twilight is due to the optical property of the earth's atmosphere, whereby, when the sun itself is below the horizon, its rays, by atmospheric reflection and refraction, are enabled to illuminate a portion of the atmosphere beyond the solar horizon. This illumination occurs as long as the sun is less than 18 degrees below the edge of twilight zone; as soon as it descends further than that angular distance, twilight ceases. Hence, viewed in perspective from the outside, from a point at right angles to the line joining the earth to the sun, the earth would present the following appearance: a full illuminated hemisphere towards the sun; then a band or zone of faint light, or twilight, 18 degrees, or about 1,250 miles, wide; and lastly, the larger portion of a hemisphere in total darkness; every portion of the earth, except the Frigid Zones, passing through the twilight phase twice in each twenty-four hours. Hence great differences occur in the duration of twilight, according as the place passes below the solar horizon perpendicularly or obliquely. It is obvious that when the place passes perpendicularly it will reach the angular distance of 18 degrees below the zone much sooner than where it passes very obliquely.

As illustrative of the foregoing remarks, the conditions of twilight at the two equinoxes and at the two solstices may be here detailed:

1. Vernal equinox: March 20th.

The edge of the twilight zone next the sun is concentric with and parallel to every meridian; so that the whole of each meridian, when it comes to the edge, passes from below it at the

same instant of time—an occurrence which takes place at no other time, except the two equinoxes. Hence at the two equinoxes every place on the earth has its shortest twilight, because every parallel of latitude moves through the zone at nearly *right angles*, which, of course, is the shortest path. It is also to be observed that, as a consequence of terrestrial curvature, the twilight lengthens as we proceed from the equator to the poles. At the equator, every degree of longitude being equal to four minutes of civil time, and the twilight zone being 18 degrees in breadth, it follows that the length of twilight will always be 18×4, or 72 minutes. At the parallel, 72° N. lat., every place north is below the zone of twilight after sunset, and consequently midnight darkness there entirely ceases, and there are 12 hours of sunlight and 12 hours of twilight. Thus, in both hemispheres, the twilight varies from 72 minutes at the equator to 12 hours at all latitudes north or south of 72 degrees—that is, within 18 degrees of the two poles.

2. Summer solstice: June 21st.

Bring the sun to the first of Cancer, when it will be seen that it has 23° 30′ north declination. Notwithstanding this obliquity, however, the twilight at the equator is practically the same as at the equinoxes, or about 72 minutes. At the parallel of Toronto, or about 44° N. lat., it will be found that the twilight is a little over two hours and twenty minutes; so that real midnight then only lasts for three hours and 40 minutes. At the edge of the twilight zone, next to the dark hemisphere, it will be seen that we have reached the parallel of 48° 30′, N. lat., and from this parallel up to that of 66° 30′, N. lat., or 18 degrees further north, twilight lasts throughout, from sunset to sunrise, and there is no real midnight. North of the latitude 66° 30′ N., the sun does not set during the 24 hours, so that there is neither night nor twilight. At the summer solstice the twilight phenomena of the Southern Hemisphere are the opposite to those

just described, and similar to those of the Northern Hemisphere at the winter solstice.

3. Autumnal equinox: Sept. 22nd.

Bring the sun to its place in the ecliptic on this day. The conditions as regards twilight are now identically the same as at the vernal equinox, except that the terrestrial axis, when viewed from the sun, now inclines to the left hand instead of to the right.

4. Winter solstice: Dec 21st.

Bring the sun to the first degree of Capricorn. It will be seen that the twilight zone is now concentric with the equinoctial colure, and that the other conditions are similar to those of the summer solstice, but reversed as regards the Northern and Southern Hemispheres. From the parallel 48° 30′ N. lat. to the pole, it is constant night; between 84° 30′ N. lat., and 66° 30′ N. lat., there is a zone of alternate night and twilight; and at all latitudes between 66° 30′ N. and the equator, there are alternations of day, twilight and night.

TWILIGHT PROBLEMS.

PROBLEM I.

TO FIND WHEN CONTINUOUS TWILIGHT TAKES PLACE AFTER SUNSET, AND HOW LONG IT CONTINUES, AT THE FOLLOWING PLACES IN ENGLAND, SCOTLAND AND IRELAND.

Rule.—Work as directed by the Rule given in Problem XII.

Solve with the globe the following:

Q. London?

A. Begins May 21st, and ends July 22nd.

Q. Bristol?

A. Begins May 22nd, and ends July 19th.

Q. Land's End?

A. Begins June 4th, and ends July 10th.

Q. Edinburgh?

A. Begins May 25th, and ends August 4th.

Q. Dublin?

A. Begins May 16th, and ends July 26th.

Q. Liverpool?

A. Begins May 14th, and ends July 27th.

PROBLEM II.

Q. What places in British America have continuous twilight during the open summer months?*

A. Every place within the parallels of latitude of 50° and 66° 30′ have continuous twilight after sunset, which includes a region in the Dominion of Canada, from the Lake of the Woods in the south, to the southern shores of the Great Bear Lake, besides the Copper Indian territory, in the north. Hence the

* By summer here is meant the time the sun takes to pass from the vernal to the autumnal equinox=184 days.

twilights are continuous over the whole of Hudson Bay and all the surrounding territories, from about the end of May to nearly the 10th of July; and during that period every lake north of the parallel of latitude of the mouth of the St. Lawrence has no midnight, which includes all the fishing lakes in the Dominion.

PROBLEM III.

TO FIND, FOR A GIVEN DAY, WHEN THE MORNING AND EVENING TWILIGHTS BEGIN AND END, AND HOW LONG THEY ARE, AT A GIVEN PLACE.

Rule.—Bring the place to the solar meridian of the day, and follow the directions given for twilight.

Solve with the globe the following:

Q. When is the beginning and end of twilight at Boston, July 12th?

A. Twilight begins at 2h. 28m. a.m., and ends at 4h. 45m. a.m.; duration, 1h. 56m.

Q. Quebec, July 7th?

A. Begins at 1h. 28m. a.m.; ends at 6h. 8m. a.m.

Q. Montreal, January 1st?

A. Begins at 3h. 56m. a.m.; ends at 6h. 40m. a.m.

Q. London (Ont.), May 5th?

A. Begins at 2h. 52m. a.m.; ends at 4h. 52m. a.m.

Q. Canton, September 12th?

A. Begins at 4h. 32m. a.m.; ends at 5h. 44m. a.m.

Q. Berlin, December 4th?

A. Begins at 3h. 40m. a.m.; ends at 5h. 36m. a.m.

Q. Venice, April 9th?

A. Begins at 3h. 52m. a.m.; ends at 5h. 24m. a.m.

In drawing to a close this part of the subject, the reader now may readily observe with what ease and accuracy the fore-

going new problems can be solved by the astronomical system of mounting; hence it is almost unnecessary to allude to its importance in the practical study of the earth's surface, whether it is viewed either as land or water, since you cannot reason or point out intelligently any particular place on the globe without its use. In fact, in a great measure the terrestrial globe, without all the astronomical appendages, is something like a man's body without the head, the intellectual part being wanting. In fine, in reviewing and tracing the causes of the distribution of light and heat upon the earth, and all the variations in the length of days and nights in a year, with the observed variable periods of light and darkness within the POLAR CIRCLES, the following conclusions may be safely come to as to whence they arise:

1st. To the orbital revolution of the earth round the sun in the ecliptic, and to the fact of the centres of the two bodies remaining always in the same plane.

2nd. To the inclination of the terrestrial axis to the earth's path in the solar system.

3rd. To the parallelism of the earth's axis to itself, combined with the rotation of the globe every twenty-four hours upon its imaginary axis.

In the study of this branch of knowledge with the astronomical mounting, it may now be added that all the GEOGRAPHICAL definitions should be firmly riveted in the memory, and in particular the mechanical details which the mounting is meant to represent; and these should be taken from the REAL MECHANISM, as exhibited in the appliance itself. Also, it should be observed that the full structure of terms used by geographers is of a mixed character, a portion being purely astronomical, or relating to the "Doctrine of the Sphere;" and the other portion strictly confined to describe the condition of the surface of the Earth. Hence the use and necessity of uniting the study of the two branches of knowledge in class instruction.

DEFINITIONS.

1st. The great imaginary AXIS of the EARTH is a straight line or diameter, around which the whole mass turns once in twenty-four hours.

2nd. The POLES of the EARTH are the two places on the surface at the very extremity of its axis, north and south.

3rd. The NORTH POLE determines the direction in which the axis points to in the heavens, and the SOUTH POLE determines the opposite extremity. In the present age no star happens to be exactly over the two points.

4. MERIDIANS on the globe's surface are hour circles, and when read on the equinoctial they are RIGHT ASCENSIONS; but when read on the ecliptic, they give the LONGITUDE.

5. The angles of RIGHT ASCENSIONS are at the POLES of the EARTH, and the angles of LONGITUDE are at the poles of the ecliptical axis.

6. The EQUATOR is a great circle, equidistant from the two poles. It divides the globe into two hemispheres, named after the poles, NORTHERN and SOUTHERN.

7. The PARALLELS OF LATITUDE are circles parallel to and diminishing in diameter on the globe, from the equator to the two poles.

8. THE LATITUDE of a place in degrees of arc is the distance of the place from the equator, north or south. Hence all places north have NORTH latitude, and places south have SOUTH latitude.

9. The LONGITUDE of a place on the globe is its distance EAST or WEST from a given assumed meridian, called the FIRST or PRIME MERIDIAN. Greenwich, England, is always used on globes in the British Empire, but the Americans often use the prime meridian of Washington.

10. The DECLINATION of the SUN is its distance in degrees of arc from the equator (often called the equinoctial). When it is north of this line it is named NORTH DECLINATION, and when it is south it is SOUTH DECLINATION.

11. The ECLIPTIC (or datum circle of the solar system) is the sun's apparent place among the stars, or the EARTH'S exact path or orbit.

In the manufacture of these new globes the greatest care is taken to insure excellence of workmanship and accuracy of adjustment; and the inventor is confident that any one who is desirous of procuring improved school or library apparatus will find that, in point of simplicity of construction, and for giving clear and precise exhibitions of terrestrial phenomena, his new astronomically mounted globe is far superior to any other now in use.

SELECT TESTIMONIALS.

MR. M. TURNBULL read a most interesting paper on Terrestrial Globe Mounting, illustrating his remarks upon one of his own patent instruments, which seemed to possess many features to recommend it, being a decided advance on the old unscientific mounting.—*Proceedings of Canadian Institute, Toronto, March 11, 1879.*

M. TURNBULL, Esq. TORONTO, Oct. 28th, 1879.

DEAR SIR,—I have no hesitation in stating that your "New Improved Terrestrial Globe" is the best I have ever seen.

Yours truly,

J. CARLYLE, M.A.,

Mathematical Master, Normal School, Toronto.

November 1st, 1880.

MR. TURNBULL, of Toronto, has arranged a form of Terrestrial Globe which is useful for showing the changes of the seasons, for finding the duration of twilight, and for solving various problems.

"THE OBSERVATORY,"

LONDON, ENGLAND.

Testimonial received by CHARLES BLOOMFIELD, Esq., Harrowgate, Yorkshire, who forwarded the New Mounted Globe for inspection to the Royal Geographical Society, London, England:

1 SAVILLE ROW, BURLINGTON GARDENS,

June 17th, 1880.

DEAR SIR,—I shall be obliged if you will kindly let me know the approximate price of the Globe which you sent here for inspection, as it is necessary to publish it, and any notice I publish must have some price named.

I like the Globe very much, and, if not too expensive, I should like to purchase one for my own private use in giving instructions in Astronomy, for which purpose it seems to be admirably adapted. I have, bowever, as yet been unable to give attention to more than the principle on which it is constructed.

Yours truly,

JOHN COLES, M.A.,

Curator and Lecturer on Practical Astronomy,

"Royal Geographical Society," London, England.

TORONTO, Dec. 17th, 1880.

I have carefully investigated the principles on which Mr. M. Turnbull, of this city, has constructed his Newtonian, or Combined Astronomical and Terrestrial Globe. These principles are at once natural, scientific and easy of comprehension. By this Globe, the study of geography, which was before a task for the young, will now become a pleasure. The apparatus presents a complete and visible explanation of the physical phenomena which characterise the earth as a member of the solar system.

From the time when globes first came into use for illustrating the science of Geography, down to the present day, no such invention as Mr. Turnbull's has been given to the world. His Globe will mark the beginning of a new era in the art of geographical and astronomical instruction. It is the work of a man who has been gifted with the rare faculty of translating great scientific knowledge into the shape of an apparatus which is a masterpiece of practical and beautiful mechanism.

S. J. WATSON,
Librarian, Ontario Parliament.

We confidently recommend the Turnbull Globe to the notice of teachers and students, and of all others interested in the study of astronomical geography. It should find a place in every well furnished library and school-room.—*The Canada Educational Monthly, Dec., 1880.*

Any improvement in the mechanical appliances for the use of the teacher must be a matter of deep interest to all who watch the progress of education, and therefore the invention of a new kind of astronomical globe, which bids fair to drive the old-fashioned terrestrial globe out of schools, is a matter of no small importance. It is impossible to draw a sharp line between geography and astronomy, because all the imaginary circles on the earth's surface are really astronomical and not terrestrial, and for this reason the inventor of the globe has preferred the title "astronomical" to the epithet "terrestrial."—*The Globe, Oct. 16, 1880.*

Mr. Turnbull's invention is a most ingenious yet simple mounting for terrestrial globes, and seems to be well adapted and calculated to exhibit to pupils the real causes of all those changes of light and heat which take place in different portions of the earth's surface.—*Toronto Evening Telegram, Oct. 16, 1880.*


PAT. NOV. 27/77