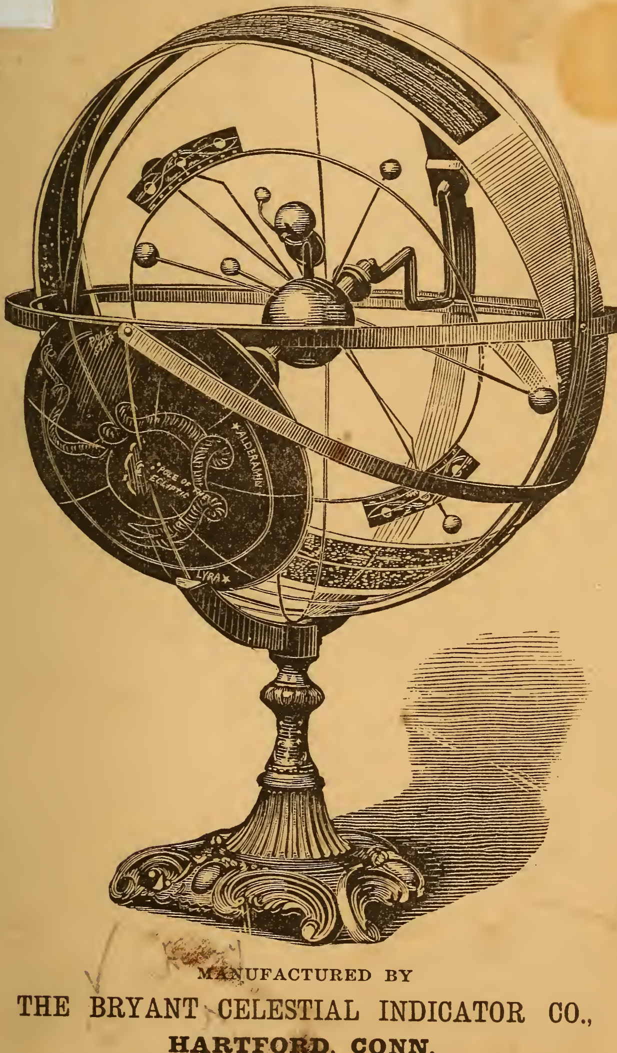
CELESTIAL INDICATOR.



MANUFACTURED BY

THE BRYANT CELESTIAL INDICATOR CO.,

HARTFORD, CONN.

Price 10 Cents.

A SYNOPSIS

OF THE

ELEMENTS OF ASTRONOMY,

AND A DESCRIPTION OF THE

CELESTIAL INDICATOR;

WRITTEN TO ACCOMPANY THE APPARATUS,

BY THE INVENTOR.

Henry Bryant

HARTFORD:
PRESS OF CASE, LOCKWOOD AND BRAINARD.
1871.

CELESTIAL INDICATOR.

Astronomy is the science which teaches the knowledge of the stars; a study that has "at once the beauty of poetry, and the exactness of Geometry." We look in all directions, on a clear evening, and we see a multitude of stars; were we to remain out all night, we should continue to see them coming up in the east, and going down in the west, until the dawn of morning obscured them from our sight. The sun rises; it is but a *star*, like those seen in the night; and were it as far away from us as the other stars, we should continue to see stars all the time under a clear sky; but, being comparatively near us, it looks large and gives us a flood of light that makes our day. Its distance is but 92,000,000 miles, and its light but eight minutes in reaching us, while the light from the next nearest fixed star, α Centauri, is more than three years in reaching us; and the light from some of the remoter fixed stars, that are seen with telescopes, would require a hundred thousand years to travel to us; yet their light is here, and the Beyond—a boundless space—yet filled with stars.

We live among the stars and amidst star-systems; yet we see less than 10,000, with our unaided vision; with the telescope, more than twenty millions.

But now we will confine our description to one star, and its planets moving eastward around it. To us it is a sun, yet it is one of the fixed stars belonging to the great group of the Milky Way, standing alone in space, and shining by its own light, billions of miles from any other fixed star; having near to it eight planets that shine not by their own light, but by the light they reflect from the sun — some of these also having satellites or moons. This group, the sun, its planets and their moons, is called our solar system.

The Celestial Indicator, which I now present to you, is constructed to illustrate the various phenomena of this system.

As I pass along, I will describe these phenomena, and the Indicator; using the instrument to illustrate and make clear to you those points that would be difficult for you to understand without its aid.

There is in the great star-system a star called Polaris, or Pole-star, otherwise called the north star, probably known to most people. You should all know its place in the heavens, for in the commencement of the study of astronomy, this is *the* important standpoint; from this direction we can look toward and easily comprehend our solar system. It is due north, standing quite alone, and elevated as much above the horizon in degrees, as our latitude is north of the equator.

Thus, in Hartford we are in 41° 36′ north latitude; consequently the star is above our northern horizon 41° 36′.

I will now describe to you a part of the Indicator.

I place it on the table with its polar map facing the north, for the reason that it has a polar star located in relation to its other parts, the same as the polar star in the Heavens stands in relation to the solar system; and I desire to have you comprehend the whole phenomenon that I am about to explain.

I now bring the revolving meridian over the top of the apparatus, and as you look at it, it is intended to represent the Sphere of the Heavens. I want you to imagine it so expanded as to reach the stars.

On the center of the northern part of this Indicator is the location of the north star. In the center of the apparatus is a large brass ball, that represents the sun, and the smaller balls surrounding it represent the planets. Their positions (except in size and distances) stand in relation to its north star the same as the position of the solar-system stands in relation to the north star in the Heavens.

Please fix this well in your minds.

First, I will point out the equator of the Indicator. It is a narrow strip of brass passing entirely around it east and west. A line from its north star through the center of this apparatus would represent its axis, and this equator and the axis represent the celestial equator and the axis of the heavens, as they are related, in position, to the north star of the Heavens.

This equatorial rim of brass is marked into 360 parts called degrees (°); just as the celestial equator is divided into the same number of degrees.

On the Indicator is another rim of brass, beginning at its north star, and passing horizontally around its central part, to its starting point; so is there an imaginary line passing entirely around the sphere of the celestial Heavens. The brass rim and this imaginary line around the Heavens are called the first meridian or equinoctial colure, (a great circle passing through the equinoxes.) At the vernal equinox, where the first meridian intersects the equator or equinoctial, I begin to place the degree-divisions before spoken of, and extend them eastward around the Indicator, ending with 360° at the point I started from, so that the first meridian again intersects the equator at the autumnal equinox half way around, or 180°. Just so is the imaginary first meridian placed, in relation to the celestial equator of the Heavens, and in like manner are the imaginary degrees placed on the great circle of the equator or equinoctial of the Heavens. We begin to count the longitude of the Heavens at the west side of the sphere on the first meridian, and as we go east, we call it right ascension.

Attached to the poles of the axis of the heavens on the Indicator, is a semi-circular rim of brass, called a revolving meridian, one edge of which is divided into 180°, beginning to count at the north pole going southward, and measures polar distance. The other edge is also divided into degrees, beginning at the middle and counting each way to 90°.

To indicate north and south declination, move the revolving meridian from 0°, the initial point of right ascension, along up the equator of the Heavens to 90° R. A.; it will then represent the solstitial colure, or the great circle running through the solstices. Follow the figures on it toward the north pole or polar star 30°, and you are at a point in the heavens called right ascension, (R. A.) 90°, and north declination 30°, (N. D.) In this way, you find any point of right ascension, and also of north or south declination. This revolving meridian is also used to locate the hour-circle of 15° R. A., and thus we make the divisions and count on the great imaginary circles of the celestial sphere.

The pupil should thoroughly understand this, and be able to apply it out of doors. To find the first meridian, step out of doors on a clear evening, say about the middle of November, and look at the north star, from which the first meridian of the heavens can be easily traced among the stars. Looking south of the pole-star about 31° you will see the bright star Caph: farther south 62° the bright star Alpheratz; then 15° south of Alpheratz the bright star Algenib. The two latter stars are on the east side of the great square of Pegasus, (a figure easily found and never forgotten.) The four stars pointed out are in a direct line, and it is along this line of stars that the first meridian lies.

To find the equator of the Heavens, take two straight sticks, cross and nail them together at right angles, then nail them to the side of a firm perpendicular post, letting one of the sticks point directly to the north star, the other stick will of course (as they cross at an angle of 90°) point out the equator of the heavens. Now as the earth revolves on its axis eastward, the stick that does not point to the north star is always describing the great circle of the equator of the Heavens, corresponding to the one on the Indicator, and any star on the line that the stick intersects will be on the celestial equator.

Looking along its length from time to time on the clear evenings you will soon know the stars that girdle the Heavens along the equator.

Looking again at the Indicator, you will observe a band of stars on a dark ground, 16° wide, encircling it and crossing its equator at an angle of about $23\frac{1}{2}°$. This is called the zodiac, and embraces within its limits *our solar system.* It is divided into twelve parts of 30° each, on which are placed the following signs—Aries ♈, Taurus ♉, Gemini ♊, Cancer ♋, Leo ♌, Virgo ♍, Libra ♎, Scorpio ♏, Sagittarius ♐, Capricornus ♑, Aquarius ♒, Pisces ♓. It also has twelve constellations of stars, bearing the same names, but located 30° in advance of the signs;—thus the constellation of Pisces is in the sign of Aries, and so on. The cause of this displacement will be told presently. Through the center of the zodiac is a line divided into degrees, and this line represents the *Ecliptic,* or pathway of the earth around the sun. You will see this line intersecting the Equator or Equinoctial at the 1° in Aries; and again at the 1° in Libra, or 180° R. A. These are the equinoctial points, and the equinoctial points are always where these two lines intersect. Suppose you could connect the opposite sides of the Ecliptic with something across, like a sheet of paper placed in that position on the indicator, you would call it the plane of the Ecliptic. The revolving meridian will give you the declination of the Ecliptic, so that you can find its position on the Indicator and apply it to its place in the Heavens at any time of the year, by having previously learned the position of the equator of the Heavens.

The large brass ball on the center of the shaft is intended to represent the sun. It is located in the center of the zodiac, and is stationary, as for all practical purposes it may be regarded, only it revolves eastwardly on its axis once in about 27 days. Around it on the Indicator are placed eight smaller balls to represent the eight planets, all within the limits of the zodiac. In nature they all revolve eastward in slightly elliptical orbits around the sun, having an axial motion eastward like the sun. Their orbital paths are nearly parallel to each other, crossing the Ecliptic at small and varied angles, and the planets vary of course in the length of their time of revolution, as well as in their axial motion, as their size, density and distances vary.

Those that are farthest off travel the slowest, and they gradually increase in speed, the nearer their orbits are to the sun. Mercury being the nearest to the sun is the swiftest in its motions. Its distance from the sun is 35,000,000 miles; its periodic time, 88 days; its diameter, about 3,000 miles.

The next is Venus, whose distance is 66,000,000 miles; periodic time, 224 days; diameter, 7,500 miles. These are called the inferior planets, because their orbits are within that of the earth.

Next in order is the Earth, on which we live, whose distance from the sun is about 92,000,000 miles; its periodic time 365¼ days; its diameter, about 8,000 miles. Of the superior planets (outside of the earth's orbit) the first is Mars, distant from the sun 139,000,000 miles; its periodic time being 686 days, and its diameter about 4,000 miles. The next in order are the asteroids, small planets; a large number (112) have been discovered, sweeping in vast orbits around the sun in a region between Mars and Jupiter; orbits somewhat more eccentric than those of the larger planets, and making greater angles with the Ecliptic. They are invisible except through the telescope. They are supposed to have once formed a large planet, which from some unknown cause was blown to atoms. A planet seems to be wanted in this region, in order to satisfy our conceptions of symmetry in the solar-system.

Next to the Asteroids is Jupiter, whose distance from the sun is 475,000,000 miles, its periodic time 4,332 days, and its diameter 88,000 miles.

Next to Jupiter is Saturn, its distance from the sun being 872,000,000 miles, its periodic time 10,769 days, and its diameter 72,000 miles.

Then comes Uranus, 1,753,000,000 miles from the sun, its periodic time 30,686 days, and its diameter 33,000 miles. And last and most remote of the eight is Neptune, at the enormous distance of 2,746,000,000 miles from the sun, its periodic time being 60,126 days, and its diameter 37,000 miles. And here, as far as we know, is the limit of our planetary system, though numerous comets sweep far beyond it.

What a vast circle this last or outside planet must describe in its circuit around the sun! too far away to be seen except with the telescope, while yet its relations with the sun are such as to bring it through its course in a given time with wonderful precision.

Some of these planets have moons. The earth has one; Jupiter four; Saturn eight; Uranus, four; and Neptune, one: all, except those of Uranus, going eastward around their respective planets.

All these planets and their moons have an axial motion eastward in the direction of their orbital motion. How is this? Did they once belong to the body of the sun? Modern science has located the sun in space, and called it a fixed star. Undoubtedly it is; and it is also supposed to to be a variable star. Its diameter is 852,000 miles. Now the distance to the moon being 238,000 miles, the sun's diameter would be nearly equal to four times the distance of the moon from the earth. The photograph and spectroscope have recently been called to our aid, and we know many of the component parts of the sun, such as sodium, calcium, barium, magnesium, iron, chromium, nickel, zinc, strontium, cadmium, cobalt, and hydrogen. We know it to be on fire, and white with heat. We also know it has an axial motion, and this too is eastward. Were the planets thrown from the sun by its axial motion? If so, and this occurring from time to time, the sun all the time retaining nearly its axial position, and the planet going off from near the sun's equatorial region, it would tend to form them in a line along the zodiac. The nutation of the sun's pole around a small ellipse of 14° diameter about the pole of the Ecliptic, in a long period might tend to break the parallel of their orbits a little, which is the fact; the tangential (or throwing-off) force, and the attractive power of the sun, would tend to give them an orbital motion; they, as parts of the parent body, would retain their axial motion. All this they have; and the inference is, that they once belonged to the body of the sun, and, when first thrown off, shone by their own light; but now, being crusted over, are seen by the reflected light of the sun.

The Indicator will show their position along the zodiac, and aid in the comprehension of this theory of their formation, called the "Nebulous Theory."

And what shall we say of the countless millions of stars, of which number our sun is but one, all with their respective solar-systems, and then all grouped again into star-systems, wheeling *probably* eastward around remote central points of their own groups, our system moving, perhaps, around Alcyone, (one of the Pleiades,) but in periodic times too great for our comprehension?

Then again, what if these groups are combined, and moving around other points in the universe, and this is only the threshold of the Great Universe! How vast, then, the creation, and how numberless the spirits may be in the spirit-world! And who can tell what countless glories in this science will yet be unfolded to us, in the new life, for endless ages to come?

The motion of the earth around the sun, and the changes of the seasons.

Tighten the shaft of the Indicator by turning the nut on the outside; then revolve the thumb slide (a part of the sun marked with an arrow) to the left and bring the earth around to the *vernal equinox.* Remember that the equinoctial points are always where the Equator of the Heavens intersects the Ecliptic.

Observe that, if the little ball, representing the earth, were lit up by a light from the large brass ball, representing the sun, the light would fall equally upon both hemispheres of the earth. In this position the earth is represented as being at the first point in Aries, on the first meridian at the vernal equinox, and the time about the 21st of September. The days and nights are of equal length. It is here that the earth's path crosses the equinoctial or Equator of the Heavens

We will now turn the slide and start the earth upward in its path along the Ecliptic, which now lies on the northern side of the Equator of the Heavens. It goes up (R. A.) eastward, a little inclining to the north pole of the Heavens, (N. D.) We pass through the latter part of September, October, November, and on to December 21st. The earth has now arrived at the winter solstice, 90° R. A., $23\frac{1}{2}$° N. D., its greatest point of N. D., and has entered the sign of Cancer, as seen in the zodiac.

If the light came now from the brass ball, it would fall obliqnely upon the earth's northern and directly upon its southern hemisphere, this being caused by the earth's passing up the northern part of the Ecliptic, at the same time keeping its axis parallel to the axis of the Heavens. It has departed, as you will see, 23½° from the Equator, N. D., thus causing the sunlight to fall obliquely on our northern hemisphere, making our days short and cold; while at the same time, the rays are direct on the southern hemisphere which makes its days long and warm.

We pass the earth along about ten days more, and it arrives at its perihelion December 31st, and is at its nearest point to the sun, the earth's orbit being a little elliptical. We move it again. It now proceeds in R. A., and is approaching the equinoctial line, passing on through January and February to the 21st of March, enters the sign of Libra at the Autumnal Equinox, R. A. 180°, and is again on the equinoctial line, declination 0°, having performed one-half of its journey around the sun. Again the days and nights are equal in length. Could we now look through the sun from the earth's position, our line of vision would carry us to our starting place; consequently the sun appears at that point, and we say the sun has entered the vernal equinox. But during all this time it has been stationary; remember that the appearance of the sun at this point is produced by our having traveled half around it. When the sun appears to us at this point in the Heavens, the year of the seasons commences.

We now move the earth along, crossing the Equator of the Heavens or equinoctial line, to the south side of it. The earth begins to veer a little toward the south pole of the Heavens, keeps along its path of R. A. through April, May, and to the 21st of June, entering the sign of Capricornus, when it is at the summer solstice, R. A. 270°, S. D. $23\frac{1}{2}$°.

The longest and warmest days of the year have come, and on the Indicator you will see the sunlight falling directly on the northern and obliquely on the southern hemisphere.

In 17 days more of the earth's journey we arrive at its aphelion, July 8th, this being its greatest distance from the sun, 3,000,000 miles greater than at its perihelion, December 31st.

The earth, having passed its greatest southern declination, is again approaching the Equinoctial. We move it along through July and August to the 21st of September, and it again intersects the Equinoctial at the 1st degree in Aries, or the vernal equinox, the point from which it started, having made a journey of 360° R. A., and completed a tropical year, keeping its axis parallel to the axis of the Heavens all the way around.

The earth's axial motion.

During this journey the earth revolves eastward on its axis $365\frac{1}{4}$ times, as you see the little ball representing the earth on the Indicator move on its axis, when I turn it over eastward. Observe the small brass plane indicating the horizon of its locality; it is now opposite to the sun. As I turn it, it begins to come into the sunlight; now it is sunrise. I move it a little more; it is next to the sun, midday. Now again it is leaving the sunlight, or it is sundown; now midnight. This is its daily axial motion.

So it is in nature. The earth is a vast globe 8,000 miles in diameter, suspended in space and moving through it by the laws of motion and magnetism; and travels with unvarying regularity and precision annually around the sun exactly in the course pointed out by the Indicator.

Thus you see why our seasons change, why we have warm and cold weather and the variation in the length of our days.

I am now about to speak of phenomena which it is very important to fully comprehend; and chiefly to aid in this, I have constructed the Celestial Indicator.

The Precession of the Equinoxes (or the receding of the Equinoctial points on the Ecliptic); the ever changing position of the Equator of the Heavens, showing the declination of the stars as well as their right ascension, and the motion of the axis of the heavens around the pole of the Ecliptic.

These phenomena are a unit; movements so combined as to be inseparable from each other; and so I have made them on the Indicator. They are caused by the earth being attracted by the sun and moon, the latter having far more influence than the sun, and the greatest when in that part of her orbit that diverges most from the earth's equator, having but little precessional effect in that part that leans toward the equator. While the sun exerts her influence most when the earth is at or near the solstices, both these influences acting together produce a displacement of the axis of the heavens, causing it to move westward around the pole of the Ecliptic. The Equator of the Heavens always keeping at right angles with its axis, of course it must move back on the Ecliptic, and the equinoxes, being the intersecting points of the Equator and Ecliptic, must gradually lose their places on the Ecliptic, and be constantly but slowly falling back, or westward about one degree in seventy-one years.

In the first place, let me describe that portion of the Indicator which illustrates this subject. Notice that the shaft has several angles in it. We will commence at the north, pole of the Ecliptic, which is the end of the crooked shaft and pass up to the second angle of it. Here the line of the shaft represents the axis of the Heavens. This point is $23\frac{1}{2}°$ from the pole of the Ecliptic; consequently it is inclined so much to its plane. Attached to this axis or shaft is a horizontal circle of wire, lying just within the first meridian, which it also represents. Crossing this wire at right angles to it, and just within the Equator of the Heavens, and representing it, is another circle of wire. These are made fast together and to the shaft.

At the intersecting points of these two wires are the equinoctial points, the *Vernal* on the *right*, the *Autumnal* on the *left*. In revolving the shaft, I also revolve these two wires, which form a sphere (a sphere within the outer one, the frame-work).

Remember that a sidereal year constitutes a *complete* revolution of the earth around the sun, from star around to the same star again.

A tropical year, or year of the seasons, varies in no way from it, except that it is about twenty minutes shorter, inasmuch as it begins and ends at the equinoctial points, and these are in a backward motion constantly, thus closing the year a little before the earth completes a revolution around the sun.

The new year always commences on the instant the old one closes, the Equinox always being precisely where the new year begins. It then follows that the Equinox must lose its place among the stars and go back a little on the Ecliptic, to meet the short-year point, or back as far as the earth would travel in twenty minutes. Thus the stars are made to appear as advancing eastward in R. A., and this is called the precession of the Equinoxes, whose periodic time is about 25,000 years.

2d. As the Equator of the Heavens must always intersect the Ecliptic at the Equinox, it follows that the Equator of the Heavens must change its position among the stars, and wind a little down on the Ecliptic to make the connection at the point where the year of the seasons ends. Consequently the declination of some of the stars is constantly changing, while others are gaining in polar distance. The amount of this variation is 47°. The periodic time is the same as that of the Equinoxes.

Connected again with these movements is that of the axis of the Heavens, which always keeps its place, at right angles with the plane of its Equator. And as the Equator winds down westward a little, marking the Equinox in a new place on the Ecliptic, so it must carry its axis along with it; and this axis always being 23½° from the pole of the Ecliptic, consequently in a long period it describes a circle of about 47° diameter around the pole of the Ecliptic. This has been observed to be a fact for some thousands of years, and its periodic time is the same as that of the other great motions just described, viz., 25,000 years, or about 1° in 71 years. Here are some of the grand and combined movements of our solar-system.

Now turn to the Indicator and revolve the shaft or axis of the Heavens, with the thumb piece on the outside, a little on its westward course around the pole of the Ecliptic, and you will see the whole operation as described, and as it occurs in nature.

Observe the position of Regulus, 14° N. D. As you move the axis, the Equator winds around toward it, causing it to lose its northern declination. While at the vernal equinox the stars gain in polar distance, at the same time you see the equinoctial points shift their places a little on the Ecliptic, and as they fall back give the appearance to all the stars as if they were moving eastward. Thus the constellations get in advance of their signs (the signs always keeping their places with the Equinoxes).

Carry the axis of the Heavens a little further along, and El Rea becomes the pole-star, and as you proceed with it around the pole of the Ecliptic, it points to all the stars that have been or will be pole-stars for all past or future time. In about 6,000 years hence, Alderamin will be the pole-star, the vernal equinox will have reached the point on the Ecliptic of the present summer-solstice. The axis of the Heavens, and the line of the Equinoxes will then coincide with the plane of the Milky Way, and this vast zone of stars becomes a grand hour-circle of the Heavens.

In about 11,500 years, the bright star Lyra will be the pole-star; and so the axis of the Heavens moves along from star to star in its course around the pole of the Ecliptic, coming again after the lapse of ages to α *Draconis*, which was the pole-star of the Egyptian, when he built the pyramids.

The Indicator will point this out, and you will see that the axis has moved back about 60° westward since that time. A degree of this motion indicates about 71 years, which, multiplied by 60, makes over 4,000 years since the pyramids were built. That they were erected while α *Draconis* was the pole star is proved by their latitude and the angle of the passage-way into them.

The vernal equinox then stood in the constellation of Gemini.

Did those people know of this motion of the axis of the Heavens, or was it a still more remote people that placed the figure of Draco in the northern Heavens, its head near to Lyra, coiled around the pole of the Ecliptic, with its open mouth and forked tongue, emblematically figured and seeming to say forever to the unborn nations, "This is the pathway of the axis of the Heavens."

The course of the Milky Way is represented on the Indicator by a thin wire running around the sphere, crossing the Equator at about 96° R. A., and again at 274° R. A., to show its location.

It is a great natural zone encircling the celestial sphere, composed of countless millions of stars "like glittering dust" on the dark vault of the Heavens, an unfathomable system of worlds, a unit and as a whole but an atom, compared to what is beyond in the great outlying nebulous regions, which embrace millions of like systems, that will yet be unfolded to us through great telescopes.

The Moon.

The moon is about 238,000 miles from the earth, and her diameter is 2,162 miles. She turns on her axis only as she moves around the earth. Her path is not precisely in the Ecliptic, but inclined to and crossing it, at an angle of a little over 5°, intersecting its plane at two opposite points, which are called the moon's nodes; the ascending one being that passing from the southern to the northern side of the Equinoctial, the descending node that passing from the northern to the southern side. The nodes are constantly retreating or falling back on the Ecliptic at the rate of about 19½° annually, performing a revolution in a little less than nineteen years. Eclipses can never take place except when the moon is at or near one of her nodes. If she is within 17° of a node at the time of her change she will partially obscure the sun, and if within 12° of a node at the time of her full, she will pass into the earth's shadow and be partially eclipsed. These are called solar and lunar ecliptic-limits ; while if she is at one of her nodes, the eclipse, whether solar or lunar, is total.

In a revolution of the moon around the sun, she completes 12 lunations and begins on the thirteenth, and when she has been around times enough to have completed 223 lunations, the sun, earth, and moon will return so nearly to the same relative positions, that in the next 223 lunations the same eclipses will occur again at the same times. This period was known to the Chaldeans, and by them was called the Saros. In it there are usually 41 eclipses of the sun, 29 of the moon, or 70 in all, so that, if we add 18 years, 11 days, 40 minutes, 38 seconds to any eclipse of the sun or moon, we predict the same eclipse again at the end of that time.

The ancients also knew another curious fact, that in exactly 19 tropical years there are exactly 235 new moons, and that at the end of this period they would repeat themselves again at precisely the same times, during the following 19 tropical years ; thus they could regulate their games and feasts, and this period was called the "Metonic Cycle." The places around the Ecliptic where eclipses occur vary as the nodes recede. Suppose an eclipse should occur when the node is in R. A. 30°, the next eclipse at the same node would be in R. A. 11°. You can illustrate this easily by the movable nodes and revolving meridian on the Indicator. Notice the month and day when the eclipse occurs, and add 173 days, and there will be an eclipse at the other node at the end of that period. Eclipses also occur in clusters at either node, in opposite seasons or months, which are called node-months. The semi-annual amount of the nodes' westward motion is marked on the disk that carries the nodes on the Indicator. The circle of wire on the Indicator, on which the moon's nodes are placed, represents the moon's path around the sun, showing the 5° 8′ angle it has to the plane of the ecliptic. (This circle also answers to illustrate the manner in which all the planets cross the Ecliptic, at small but different angles, having their node-points on the Ecliptic, but keeping within the limits of the zodiac.)

The nodes are constantly in motion westward, and cause a continual variation of the moon's path among the stars, so that in one revolution of her nodes, the moon would occult all the stars on the zodiac, that lie in the space of double the amount of the angle of her orbit's inclination, 10° 16′. The Indicator gives a beautiful illustration of this, as may be seen by revolving the nodes.

The moon, from conjunction ascending into the northern hemisphere of the heavens, until it is through half of its course, or fulled, begins to wane, goes down into the southern hemisphere to its conjunction again with the sun; and, passing through its different phases, completes a lunation and one revolution on its axis.

Place the moon in conjunction on the Indicator, and see the illustration. It now represents the old moon. Move it a little on its course. If it was now lit up by the ball representing the sun, the light would shine upon its lower half, and looking at it from the sundown point of the earth, you would see a little crescent of light on the lower limb precisely as you see it in nature. Passing the moon a little farther along on its eastward course (which is a little more than 12° per day around the earth,) we bring it to its first quarter with its face to us half lit up; we move it again and it is gibbous; then it becomes full and is in opposition, (opposite to the sun.) It has now completed one-half of its course; we move it along to its last quarter, passing into the southern hemisphere, and so along until it is near conjunction, when the little crescent of light would appear on the opposite side of where it was seen when it was new; and instead of seeing this just after sundown, we see it just before sunrise. All this while, remember, the moon has been traveling along in its orbit through nearly one sign or almost 30°. Hence you see that the moon in going around the earth cannot return again to its starting point in the heavens, but can complete its course and easily arrive at its conjunction again with the sun. You will also observe that during this revolution it has made just one rotation on its axis.

Nutation.

Besides the general effect of the sun and moon in causing the precession of the Equinoxes, is one due to the moon alone, which is called nutation. The moon's nodes performing a revolution in about nineteen years, during half of this time her orbit is inclined to the Ecliptic in the same way as the earth's equator; during the other half of the time it diverges greatly from the earth's equator. In the former position its precessional effect is small, but in the latter position its effect is much greater, thus causing the north pole of the earth to describe westwardly a small ellipse, exceedingly small, about the pole of the Heavens, during every period of nineteen years. To understand this backward motion, observe the right arm that supports the north pole of the earth on the Indicator in a revolution of the earth around the sun. You will see the arm attached to the cam move back westward, causing the north pole of the earth to move back with it, although the earth is on its eastward course around the sun, thus illustrating the motion of the earth's pole in relation to nutation.

The Tides.

The tides are the alternate rising and falling of the waters of the ocean. There are two high and two low tides each day, flood and ebb, day after day, year after year, and century after century. When it is flood-tide on one side of the earth, it is also flood-tide on its opposite side, and the same is true of ebb-tide. For an illustration, we will suppose the moon to be stationary, but all the while giving out her mysterious attraction, this influence exerting a lifting power on the waters of the earth, and also lifting the earth itself a little out of the waters under the earth, causing them to be ridged, or higher than they otherwise would be, so that the waters assume an ellipsoidal form, with the longer axis running through the highest point of the two high tides, and pointing to the moon. As the earth revolves on its axis fifteen degrees an hour, it would take one quarter, or 90° of its longitudinal surface, six hours, to pass by the direct influence of the moon. When the same section of 90° would be away from her influence, its middle point would be at low-tide. In six hours more this low-tide region will have revolved 90° further on to the high-tide point, or again into the line of the longest axis of the ellipsoid. The earth having now completed one-half of her revolution, and twelve hours gone by, in six hours more the same surface will be three-quarters round, and again out of the direct influence of the moon, and once more it is low-tide. Six hours more completes the day, and the same 90° of longitude occupies the place it started from, and, facing the moon, experiences high tide again.

Now had the moon been in motion, (as she always is.) she would have advanced a little in her orbit during this revolution of the earth, and consequently lengthened the time of the tides a little, inasmuch as the earth would have had to revolve about fifty minutes longer, in order to have placed the same surface under the moon's direct influence, thus making each tide of flood and ebb a few minutes over six hours in length. The tide remaining at its highest point but a few moments, then gradually subsides to its lowest point, then again rises, and so on forever. Thus the motion of the moon and the motions of the tides correspond.

Spring and Neap Tide.

We also have in each lunar month two high or spring tides, and two low or neap tides, caused by the increasing and diminishing of the above mentioned ellipsoidal form of the earth's waters. It must be remembered that the sun, though far away, has its attraction of the earth, and its tidal influence, though the latter small when compared to that of the moon. But when combined with the moon's attraction, it amounts to considerable, and this always happens either at conjunction or when the moon is full, for then the major axis of the ellipsoidal form of the earth's waters is in a line through the earth and moon to the sun, and the moon, thus aided by the sun's influence, lifts the waters higher than the usual flood-tides, and these are called spring-tides. Neap-tides occur when the moon is in quadrature, or at its first and last quarters, when the tides are uncommonly low, for now the attracting influences of the moon and the sun are working against each other, pulling or lifting at right angles to each other, and the consequence is that the waters of the earth are made to assume a more spheroidal form. Then the tides are very low, and are called neap-tides.

To illustrate, turn to the Indicator, and bring the earth for convenience to the winter-solstice; place the moon at her full. The little brass plane on the earth we will use as a starting place. As it now stands facing the moon, it represents a high-tide; opposite to this brass plane on the other side of the earth there would be a high-tide also. Now revolve the earth eastward and this point is leaving the face of the moon, in other words the tide is receding; bring it quarter round and it will stand at a low-tide point; continue it onward and the tide is beginning to rise, and when brought half round it will be at the high-tide place again, and the day is half finished. Move it round six hours more, and it is again at low-tide; carry it along, and from this point of its revolution the tide begins to rise, and is at its height when it comes around to its starting point. Now suppose the moon has meanwhile advanced a little in its orbit; you see that the duration of the tides will be increased somewhat.

Inferior and Superior Conjunctions.

When either Venus or Mercury are between the earth and the sun, they are said to be in inferior conjunction, and when the sun is between either of them and the earth, they are said to be in superior conjunction. The superior planets are in conjunction, when the sun is directly between them and the earth, and in opposition, when the earth is between them and the sun. They never pass between the earth and the sun; consequently they never have any inferior conjunction. This is illustrated on the Indicator, as the earth passes them in revolving around the sun.

A transit across the disk of the sun of either Venus or Mercury can happen only when the planet is at or very near one of her nodes, and in inferior conjunction. A transit may be illustrated in the same manner as a solar eclipse, by using for that purpose the ball which represents the moon.

To understand the retrograde motion of a planet, observe one as you pass the earth around the sun; you will see it in a certain sign of the zodiac. As the earth gets a little past it, observe again from the little ball representing the earth, and it will appear in another sign farther back on the zodiac. This gives the appearance of its having gone backwards, or in retrograde motion, though in nature the angle is much smaller. The planets can be placed in their respective signs, and then moved along from time to time, as they pass in their course around the sun.

Children once knowing the planets' positions in the signs or constellations of the zodiac, and their periodic times, will always be enabled to point out their places in the Heavens, and will be much interested in so doing, and may be able very soon to apply the knowledge they derive from the Indicator to the actual heavens, thereby enlarging their minds and enabling themselves to comprehend something more than the mere elements of the science.

In a synopsis of descriptive astronomy (and a short description of the Celestial Indicator,) but little can be said on so grand a subject. It is hoped and confidently believed that the Indicator will give a new impulse to the study by its capacity to elucidate, and that very much time can be saved, and the elements of the subject be better understood by its use. It was the intention of the inventor to compile a class-book to accompany the Indicator, but after looking over the numerous class-books on the elements of Astronomy and finding them so ably prepared, and so well adapted to illustrate the science, he abandoned the task. The writer would particularly recommend to teachers, the "Elements of Astronomy, by John Brocklesby, LL. D.," Professor of Mathematics and Natural Philosophy, in Trinity College, Hartford.

H. B.

HARTFORD, Dec. 15th, 1870.

The apparatus is made of brass; is simple, durable, and elegant in construction; not liable to get out of order, occupies about a cubic foot, and will be carefully boxed and directed to any part of the country.

PRICE $25.00.

TESTIMONIALS.

Among the many favorable opinions received, the following, from well-known gentlemen and teachers, are presented to the public:

The Celestial Indicator, invented and constructed by Mr. Henry Bryant, is a simple apparatus which illustrates with great clearness many important astronomical phenomena.

It is a celestial sphere within which the sun and planets are placed in their proper positions. All the parts have freedom of motion whenever motion is required for the elucidation of a truth. Without entering into detail, a few of the most striking illustrations are the following:

The subject of celestial measurements is made very clear, the meaning of *right ascension* and *declination* being seen at a glance.

The precession of the equinoxes is beautifully shown, also the changes consequent thereon of the places of the fixed stars, referred to the vernal equinox, the ecliptic, and celestial equator, and the varying positions of the poles of the heavens through thousands of years. The changes of the seasons, the phases of the moon, and eclipses, both solar and lunar, are all illustrated.

The conjunction, oppositions, and the direct and retrograde motions of the planets are also explained by means of this apparatus, and likewise the transits of Mercury and Venus.

From an examination of the Celestial Indicator, I am of opinion that it well deserves a place in our schools where the elements of astronomy are taught, and I know of no other similar apparatus now in use that contains such an amount of accurate illustration at so small a price.

JOHN BROCKLESBY,

Professor of Mathematics and Natural Philosophy in Trinity College.

HARTFORD, Oct. 21, 1870.

I have examined a Celestial Sphere recently invented by Mr. Henry Bryant, and desire to recommend it unhesitatingly to the attention of all interested in astronomy, particularly teachers. The last five years have been prolific in new and beautiful mechanical contrivances for illustrating the movements of the heavenly bodies. Nevertheless, Mr. Bryant's apparatus being quite unique and different from all others, deserves a place in every good collection of scientific apparatus on its own peculiar merits. By an ingenious contrivance, the inventor has so arranged miniature axes of the equator and ecliptic, that the one may be made to revolve about the other, illustrating with beautiful simplicity and clearness those problems of astronomy which it is usually extremely difficult for teachers to explain or scholars to comprehend. I refer to the precession of the equinoxes, and the various phenomena depending upon it, such as nutation, the change of the pole star, changes in the declination and right ascension of stars, the difference between the sidereal and tropical years, the retrogradation of the signs of the Zodiac, etc. If the instrument did nothing more than this, I should deem it invaluable for instruction in astronomy, as illustrating the very points which most need illustration. But I must add that other astronomical phenomena are explained by this apparatus, with sufficient clearness, particularly the revolution of the moon's nodes, the whole subject of lunar and solar eclipses, the lunar occulation of stars, the inclination of the planetary orbits to the ecliptic, the direction of the sun's axis of rotation, etc.

This apparatus does not, in my judgment, entirely supersede the necessity of a good celestial globe, but it forms an admirable supplement to the latter, and may be used with great profit wherever astronomy is studied.

S. M. CAPRON,

Principal of the H. P. H. S.

HARTFORD, Oct. 6, 1871.