J. F. SARRATT.

Astronomical Clock or Cosmochronotrope.

No. 220,036. Patented Sept. 30, 1879.

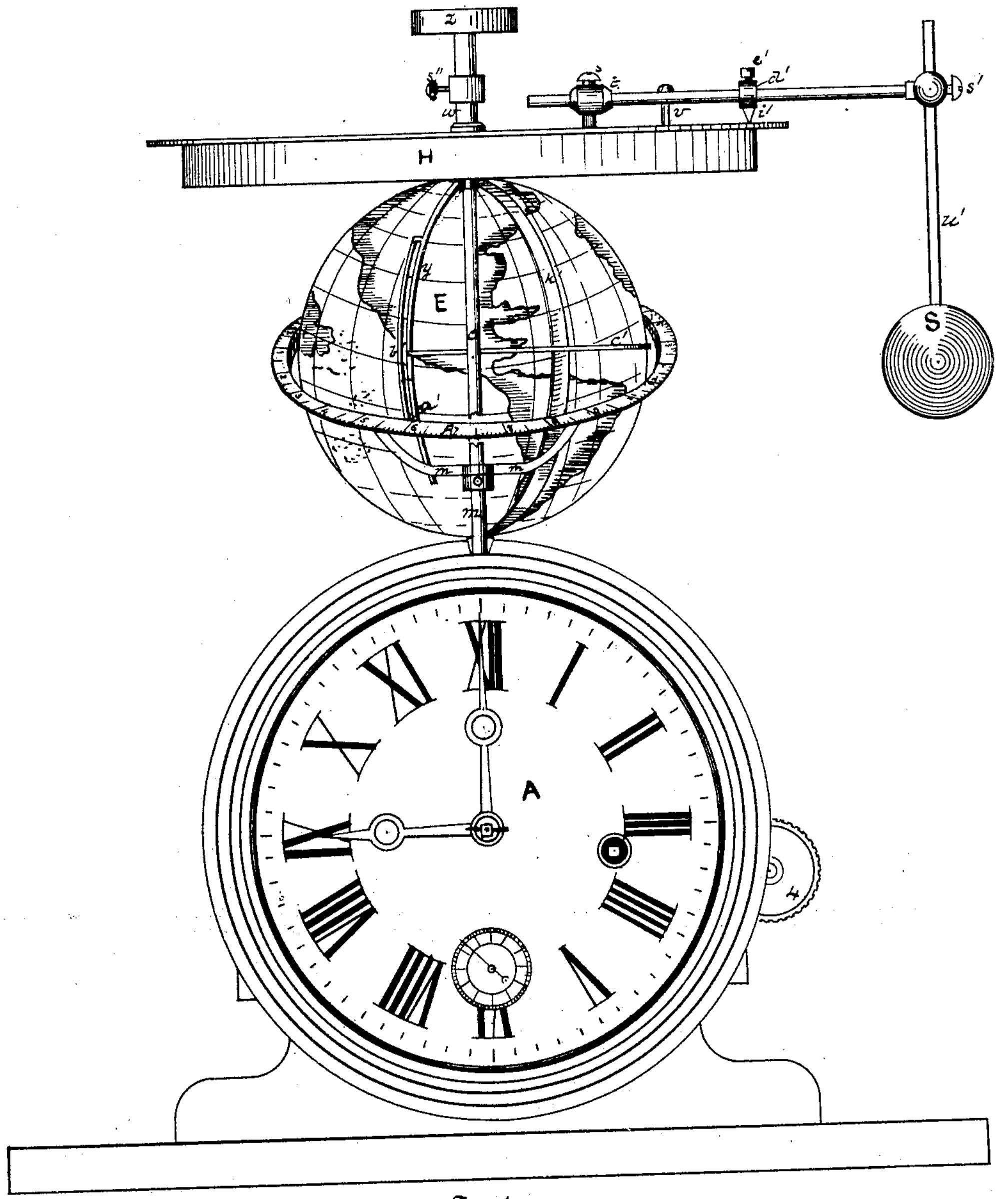

Fig. 1

Witnesses.

John K Smith

L. C. Fitter

Inventor

James F. Sarratt

by his attorneys

Bakewell & Kerr.

N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

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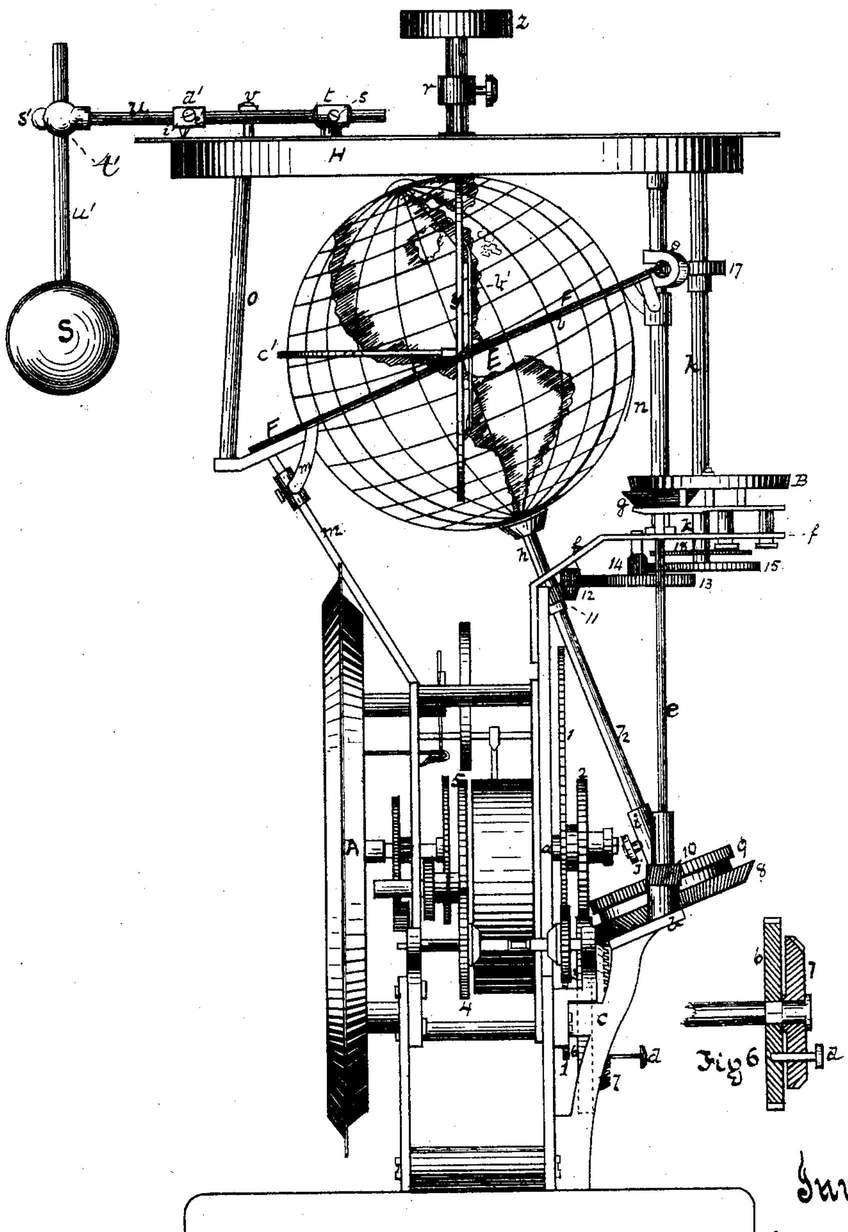

Fig. 2

Fig 6

Witnesses.
John K Smith
L. C. Fitler.

Inventor
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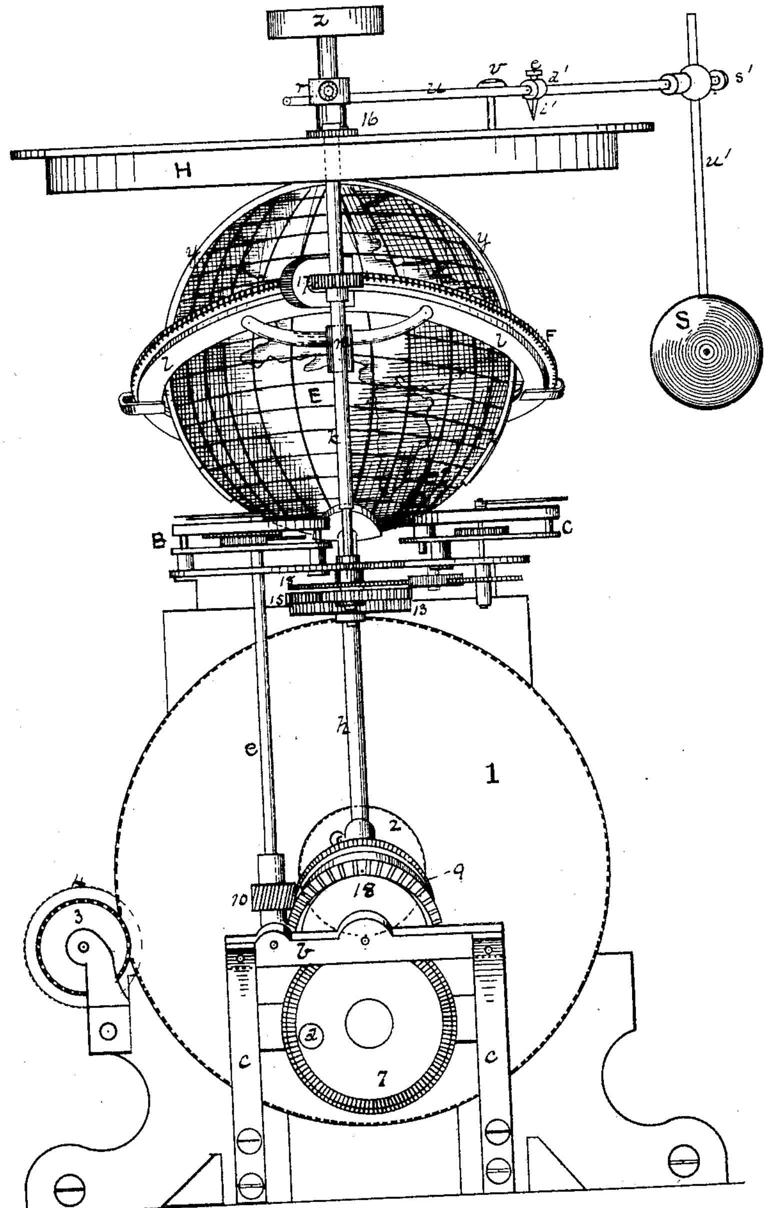

Fig 3.

Witnesses.

John K Smith

L. C. Fitler

Inventor.

James F. Sarratt

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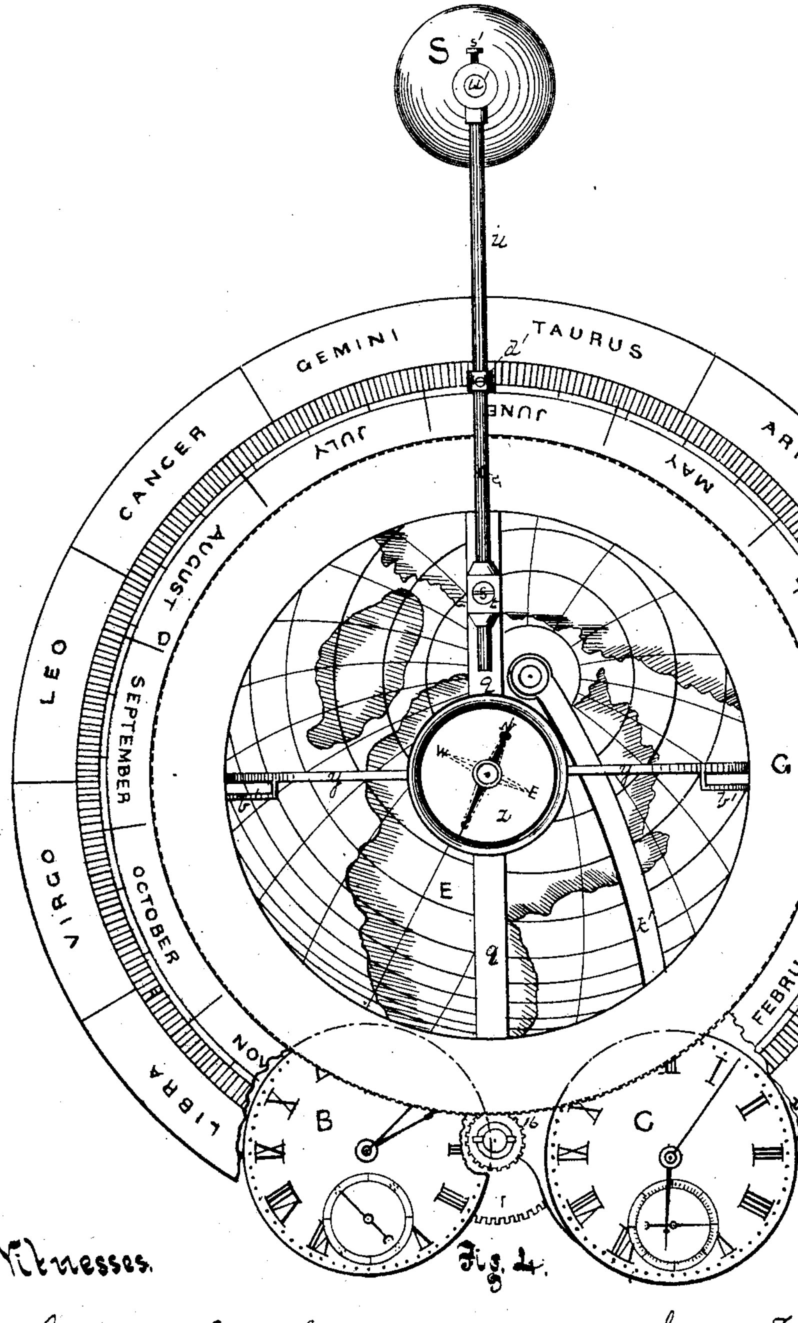

Fig. 4.

Witnesses.

John K. Smith

L. C. Fitler.

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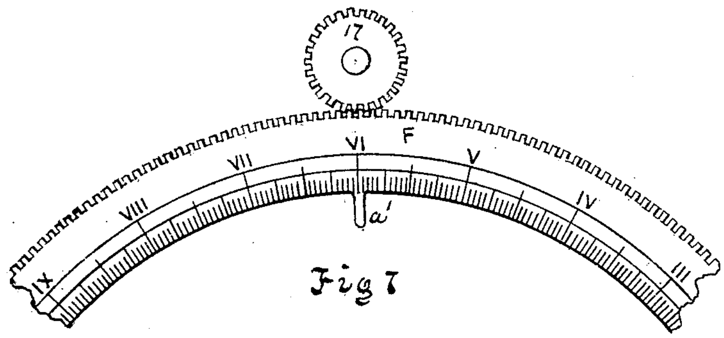

Fig 7

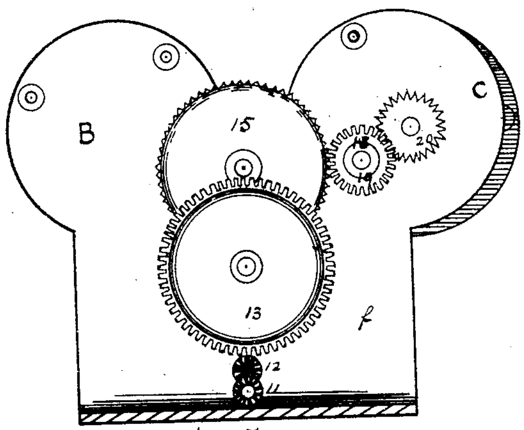

Fig. 5

Witnesses

John K Smith

L. C. Fitler.

Inventor.

James F. Sarratt

by his attorneys

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N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

JAMES F. SARRATT, OF STEUBENVILLE, OHIO.

IMPROVEMENT IN ASTRONOMICAL CLOCKS OR COSMOCHRONOTROPES.

Specification forming part of Letters Patent No. **220,036**, dated September 30, 1879; application filed July 23, 1879.

To all whom it may concern:

Be it known that I, JAMES F. SARRATT, of Steubenville, in the county of Jefferson and State of Ohio, have invented a new and useful Improvement in Astronomical Clocks or Cosmochronotropes; and I do hereby declare the following to be a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a front elevation of my improved heliotellus clock or cosmochronotrope. Fig. 2 is a side elevation. Fig. 3 is a rear elevation. Fig. 4 is a top view. Fig. 5 is a plan view from the under side of the gearing which operates two watch movements, indicating mean time and the sun's right ascension. Fig. 6 is a sectional drawing of the device by which the clock is detached from the rest of the apparatus. Fig. 7 shows a part of the equatorial circle.

In the several figures letters of reference denote the same parts.

My improved apparatus is a combination of astronomical clock and heliotellus, and is designed to illustrate and exhibit, first, the relative position of the sun and earth on each day of the year; second, the right ascension and declination of the sun on each day of the year; third, mean time at any two places on the earth's surface; fourth, the length of day and night at any place and on any day of the year; fifth, the equation of time for any day of the year; sixth, the portion of the earth's surface enlightened by the sun at any given time; and, seventh, the portion of time that the sun is north or south of the equator during the year.

Furthermore, my apparatus is so constructed that if kept wound up and allowed to run without interruption, it exhibits the relative position of the earth and sun at all times; or if it be required to use the apparatus for the purposes of illustration in teaching astronomy, the connection of the spheres representing the earth and sun, with the clock-work which gives them motion, may be severed, and then the apparatus may be set in any desired position so as to work the several problems before referred to.

It will be unnecessary in this specification to explain in detail the relative motions of the sun and earth, or to explain the difference between mean time, sidereal time, and apparent time, or the cause of the difference between mean solar time and apparent solar time, or why the earth's average velocity from the vernal to the autumnal equinox is slower than her average velocity from the autumnal equinox back to the vernal equinox, causing it to continue about eight days longer on the north side of the equator in summer than it does on the south side in winter, as these matters will be found explained in any treatise on astronomy. Suffice it therefore to say that these variations are exhibited in my apparatus, the construction of which I shall proceed to explain; and after doing so I shall give a few illustrations of its practical operation.

In the several drawings, A is a clock, of any desired construction, operated by spring or weights, as may be preferred, and regulated either by spring-balance or pendulum, to show true, mean, or clock time. This clock furnishes the motive power of the whole apparatus, and is provided with the necessary wheels and escapements so that the hour-hand shall perform one circuit around the dial in exactly twelve hours, and the minute-hand in exactly one hour of mean time. It may also be provided with a graduated circle and hand to indicate seconds of time. There being nothing peculiar about the clock itself, it needs no further description.

Attached to the rear of the clock-frame, and in line with the shaft of the minute-hand of the clock, is a stationary shaft, *a*, which serves as a bearing for the large cog-wheel, 1, of two hundred and nineteen cogs, turning freely thereon, and in rear of the cog-wheel 1, and turning on the same shaft *a*, is a smaller cog-wheel, 2, of fifty-four cogs, which is connected with the large cog-wheel, 1, so as to move with it and revolve in the same time. The large cog-wheel, 1, receives its motion directly from the gearing of the clock by means of two cog-wheels, 3 4, on the same shaft, and each having thirty-six cogs, one meshing into the large cog-wheel, 1, and the other into the cog-wheel 5 attached to the shaft which carries the spring or prime motor of the clock. Of course the relative number of cogs in the gear-wheels 1, 2, 3, and 4 will be such in relation to the cog-wheel 5 of the clock as to give the proper time of revolution of the large cog-wheel, 1; but the actual number of cog-wheels will depend upon the number of cogs and time of revolution of the clock-wheel 5, from which the motion is derived.

The number of cogs in the several wheels of my apparatus may be varied from that stated in this specification, but must be such as to give the relative speed of motion to the main parts of my apparatus, as is hereinafter stated.

The small cog-wheel, 2, gears into a larger cog-wheel, 6, of sixty-five cogs, which is attached to a bracket, *b*, connected by arms *c c* with the clock-frame.

On the same shaft as the cog-wheel 6, and in the rear of it, is another cog-wheel, 7, having seventy cogs, which revolves loosely on its shaft. This cog-wheel 7 may be connected or disconnected at pleasure with or from its companion wheel 6 by means of a pin, *d*, which is passed through the face of the cog-wheel 7 and enters a corresponding notch or hole in the face of the cog-wheel 6. When this pin *d* is drawn so far out as not to take into the cog wheel 6, as shown in Fig. 6, the clock-work is disconnected from the rest of the apparatus, which then ceases to have any automatic motion.

The cog-wheel 7 has beveled gearing, which meshes into another bevel-wheel, 8, having seventy cogs, which is supported on the upper part of the bracket *b* in an inclined position, at an angle of about twenty-three and a half degrees to a horizontal plane, being the angle of inclination of the axis of the earth to the plane of the ecliptic, my apparatus being constructed with the plane of ecliptic horizontal.

Attached to the inclined bevel-wheel 8, and above it, is a cog-wheel, 9, similarly inclined, and having seventy-two cogs, which meshes into a pinion, 10, rigidly attached to a vertical shaft, *e*, the lower end of which has its bearing in the bracket *b*, and the upper end its bearing by passing through the upper bracket *f*, which bracket is also attached to the clock-frame.

The pinion 10 has seventeen cogs, which are so inclined from a vertical line as to mesh into the teeth of the inclined cog-wheel 9.

The upper end of the shaft *e* of the pinion 10 passes up through the upper bracket, *f*, and is attached to one of the wheels *g* (say, the fusee-wheel) of the watch-movement B.

By means of the gearing already described the cog-wheels 8 and 9 (which are attached together and have the same movement) make one revolution in twenty-four hours, mean or clock time, and the vertical shaft *e*, which gives movement to the works of the watch B, causes the watch B to keep mean clock time. By means of this watch, which moves in unison with the works of the clock A, the mean time at two different places may be indicated—as, for instance, the clock A being set at mean time of the place where my instrument is used, the watch B may be set at Greenwich time, which is most commonly used in astronomical calculations.

The watch-movement B is of ordinary construction, excepting that there is no main-spring nor escapement, as these are rendered unnecessary by the fact that the watch receives its motion exclusively from the clock A by means of the shaft *e*, and is isochronous with it.

The shaft of the cog-wheel 9 is a hollow sleeve, *i*, which receives the shaft *h*, to which the globe E is rigidly attached.

The globe E represents the earth, and the shaft *h* its imaginary axis, entering the globe at its south pole, and is accordingly inclined at an angle of twenty-three and a half degrees from a vertical position, that being about the angle of inclination of the equator to the ecliptic.

The shaft *h* is secured to the sleeve *i* by a set-screw, *i'*, so that by tightening or loosening this set-screw the shaft *h* is attached to or detached from the cog-wheel 9. When so detached the shaft *h* may be freely rotated by hand and the apparatus set in any desired position.

The gearing connecting the cog-wheel 9 with the clock A is such, as before described, that the globe E (representing the earth) revolves from west to east once in every twenty-four hours of mean time. The earth-shaft *h* has its upper bearing in the upper bracket, *f*, through which it passes.

On the earth-shaft *h*, just below the upper bracket, *f*, is a pinion, 11, having ten cogs, which gears into a beveled idle-wheel, 12, also of ten cogs, which is supported by the bracket *f* on its under side. This idle-wheel 12 gears into a cog-wheel, 13, of sixty cogs, which has attached to its shaft a pinion, 14, of ten cogs, which gears into a cog-wheel, 15, of sixty cogs. This cog-wheel 15 is attached to the lower end of a vertical shaft, *k*, which passes through the bracket *f*, and has a shoulder bearing thereon.

The shaft *k* has two pinions, one, 16, at its upper end, (see Fig. 3,) having twenty-three cogs, and another, 17, lower down, having twenty-six cogs, both of said pinions being attached to and revolving with the vertical shaft *k*.

Surrounding the globe E, and in the exact plane of the equator, is an annulus or equatorial circle, F, which is graduated to indicate the twenty-four hours of the day, with subdivisions of the hours. At the outer periphery of this equatorial circle are cogs, two hundred and sixty-four in number, which gear into the pinion 17, of twenty-six cogs, and by which the equatorial circle is caused to rotate once for every three hundred and sixty-five and one-fourth revolutions of the globe E or earth, thus revolving around the earth once a year.

As is well known, the velocity of the earth is somewhat retarded when passing from her vernal equinox to her autumnal equinox, causing it to take eight days longer to accomplish that half of its orbit, which variation of motion also affects the equation of time, causing a variation between mean time or apparent or sun time.

In order to illustrate this variation in my apparatus, the two hundred and sixty-four cogs on the equatorial circle F are not quite uniformly distributed around the equatorial circle, one-half of that circle, between the points marked with the hour VI on opposite sides of the circle, having one hundred and thirty-four cogs, and the other half only one hundred and thirty cogs, the difference in size and distances of the cogs being so slight as not to interfere with the meshing of the pinion 17, but effecting a retardation of motion of the equatorial circle during half of its annual revolution, thus exhibiting the slower apparent motion of the sun round the earth from the vernal to the autumnal equinox.

By means of the graduation-marks on the equatorial circle, which indicate the twenty-four hours and their subdivisions, being uniformly spaced around the equatorial circle, while the cog-wheels at the periphery are not uniformly spaced, as just described, the equation of time is indicated, being the difference between apparent time and mean time on every day of the year, excepting on the four days when mean time and solar time are alike.

The equatorial circle F is supported in its inclined position coincident with the plane of the equator, and yet left free to be rotated, as before described, by resting loosely upon a fixed annulus, *l*, which is supported by a prop, *m*, attached to the clock-frame in front, and by a standard, *n*, rising from the bracket *f* in the rear.

The standard *n* extends upward to a point above the top of the globe E in the rear. Another standard, *o*, forming a vertical, or nearly vertical, extension of the inclined prop *m*, also rises to the same height in front. At the top of these standards *n* and *o*, and rigidly attached thereto, is an annulus, *p*, which is placed in a horizontal position, so as to preserve the proper relative angle to the axis of the earth. This annulus *p* has a circular depression all around, near, and extending to its periphery, in which rests the sun-wheel G, at the periphery of which are two hundred and thirty-four cogs, which mesh into the cogs of the pinion 16 at top of the upright shaft *k*, and cause it to revolve in a horizonal plane, its axis of rotation being at right angles to the plane of the ecliptic, and at an angle of twenty-three and a half degrees to the axis of rotation of the equatorial circle F. The pinion 16 having twenty-three cogs causes the sun-wheel to make one complete revolution in three hundred and sixty-five and one-fourth days, or once for every three hundred and sixty-five and one-fourth revolutions of the earth E on its axis.

As the sun-wheel G carries a sphere, S, representing the sun and its apparent motion around the earth, it is necessary that the motion of the wheel G should be such as to correspond to the varying time or velocity of motion of the earth around the sun, before referred to; and this is accomplished in the same manner as before described in relation to the revolution of the equatorial circle F—that is to say, the two hundred and thirty-four cogs or teeth on the sun-wheel G are unequally distributed around its periphery, one-half from the point marked *x* to the point marked *x'*, diametrically opposite, having one hundred and twenty cogs, and the other semi-circumference, from *x'* to *x*, having only one hundred and fourteen cogs. The half of the sun-wheel G having the larger number of cogs is placed so as to coincide with the half of the equatorial circle F which has the greater number of cogs, so that the revolutions of the sun-wheel G and equatorial circle F may be coincident in time and in relative position.

The sun-wheel G has a cross-piece, *q*, passing diametrically across it, to which is rigidly attached a sleeve, *r*, at the center of the wheel G. On top of the sleeve *r* is placed a magnetic compass, *z*.

To one side of the center of the sun-wheel G, on the cross-piece *q*, is fixed a sleeve, *t*, through which passes horizontally a rod, *u*, fastened to sleeve *t* by a set-screw, *s*. At the outer extremity of the rod *t* is another sleeve, *t'*, furnished with a set-screw, *s'*, through which sleeve *t'* passes a vertical rod, *u'*, at the lower extremity of which is a ball or sphere, S, representing the sun. When the apparatus is sufficiently large to enable me to do so, I use in place of the ball S a globe of glass, preferably frosted, containing a small lamp, to represent the sun.

The horizontal arm *u* is further held in its position, which is that of a radius of the circle of the sun-wheel G, by a pin, *v*, which passes through the arm *u* and enters the face of the sun-wheel G.

The length of the vertical rod *u'* is such that the center of the sphere S, or sun, is in the same horizontal plane as the center of the globe E, representing the earth. Thus, by means of the revolution of the sun-wheel G on its axis in three hundred and sixty-five and one-fourth days, or once for each three hundred and sixty-five and one-fourth revolutions of the earth on its axis, the sun-sphere S is caused to revolve around the earth E according to its apparent motion from east to west, which, for all the purposes of my apparatus, serves the same purpose as if the earth-globe E were caused to perform an annual revolution around the sun S.

A short rod, *w*, is inserted into the sleeve *r* at the center of the sun-wheel G, and attached thereto by a set-screw, s''. To the lower extremity of this rod w is attached a circular strip of metal, y, which extends nearly around the earth-globe E from the point near its north pole, and parallel to and nearly touching its surface, at right angles to the plane of the ecliptic, thus dividing the globe into two equal parts. Both arms of this circular strip y occupy a vertical plane at right angles to the horizontal arm u which carries the sun S, and as this circular strip y revolves around the globe E with the sun-wheel, it serves, in every position of the globe E, to indicate that part of the earth's surface which is enlightened by the rays of the sun, and to mark the line dividing day and night.

As it is necessary that this circular strip y should preserve at all times a vertical position in a plane at right angles to a line drawn from the center of the sun S to the center of the earth E, it is kept in such position by two pins, a' a', attached to and projecting inward from opposite sides of the equatorial circle F, and which pass into the narrow space between the circular strip y and guide-strips b', one of which is attached to each side of the circular strip y. The circular strip y is further kept in position by a semicircular arc of wire, c', which half surrounds the earth-globe E in the exact plane of the ecliptic on that side which is toward the sun S. This arc c' serves to indicate on the surface of the earth the apparent path of the sun between the tropics of Cancer and Capricorn, and shows at what points the sun is vertical at any given time.

The revolution of the sun-wheel G carries with it the sun S, which is thus caused to make an annual revolution around the globe E, representing its apparent motion around the earth, which, by the gearing already described, is completed, if the apparatus is run by the clock A, in an actual period of three hundred and sixty-five days and one-fourth; or if the apparatus is turned by hand the sun S revolves once round the earth E for each three hundred and sixty-five and one-fourth revolutions of the globe E on its own axis.

Supported on the annulus p, which projects slightly beyond the circumference of sun-wheel G for that purpose, is a graduated ecliptic-circle, D, which is stationary. This circle is divided into equal spaces for the days of the year, with larger divisions for the months, which are marked thereon. This circle is preferably made of metal of different color from the sun-wheel G and zodiac-circle H for the purpose of distinction. The zodiac circle H is also supported by the annulus p, and is placed immediately outside of the ecliptic-circle D, and, like it, is stationary. The zodiac-circle H is graduated into twelve spaces by radial lines, which, by their coincidence with the graduations on the ecliptic-circle D, indicate the day on which the sun enters each sign of the zodiac.

On the horizontal arm u, which carries the sun-sphere S, is attached a sleeve, d', by means of a set-screw, e', projecting from which sleeve d' is a pointer, i', which, as the sun-wheel G revolves, points to the days on the stationary ecliptic-circle D, and points to the day of the month, and gives the exact relative position of the earth and sun on each day of the year.

The watch-movement B, which indicates mean or clock time, is run, as before described, by the shaft e, which receives its motion from the clock A by intermediate gearing.

On the same bracket f, and alongside of the watch-movement B, is placed a second watch-movement, C, which indicates the right ascension of the sun, and receives the requisite motion for that purpose as follows: At the lower extremity of the vertical shaft k, and under the bracket f, is a cog-wheel, 15, before mentioned, of sixty cogs. Immediately above this cog-wheel 15, and secured to the same shaft k, so as to receive motion therefrom, is a cog-wheel, 18, of fifty-nine cogs, which gears through an idler, 19, having twenty-five cogs, with a cog-wheel, 20, also of twenty-five cogs, attached to the spindle of the minute-hand of the watch-movement C. This watch C has the usual wheels intermediate between the minute-hand wheel and the seconds-wheel and hour-wheel, so as to communicate the proper relative motion of the hour, minute, and seconds hands of the watch C.

The gearing which runs the watch-movement C is so proportioned, as before described, as to cause its minute-hand to traverse its dial once in the one twenty-fourth part of a year, while the hour-hand makes one complete revolution in one-half of a year, and the seconds-hand traverses its dial sixty times for each revolution of the minute-hand; or, in other words, this watch-movement runs so that its hour-hand traverses its dial twice for every complete revolution of the sun-sphere S around the earth-globe E. By this arrangement the hands of the watch-movement C show in hours, minutes, and seconds the right ascension of the sun on every day of the year.

In order to indicate the declination of the sun and as certain latitudes a thin metallic strip, k', is stretched from one pole to the other of the terrestrial globe E, so that one edge of the strip shall coincide with the meridian, and is pivoted to the axis of the globe at each pole, so as to be capable of being turned and set at any required position. The edge of this strip k' which lies in line of the meridian is graduated to indicate degrees and smaller divisions of the polar circumference of the earth, so that being turned around until the graduated edge touches any city or other point on the earth's surface, the latitude of such place may be read on the meridian-strip. The graduations run, of course, from zero at the equator to ninety degrees at each pole. The sun's declination is indicated by the graduation-marks between the tropical circles.

I have thus described the mechanism of my improved apparatus as shown in the drawings.

It is obvious that the utility of my machine is increased as its size is enlarged. In a large machine, where the terrestrial globe is of sufficient size to indicate with comparative accuracy the position of places on the earth's surface, and where the ecliptic-circle D, the equatorial circle F, and the meridian-strip k' can be minutely and accurately graduated, and where the teeth of the wheels can be made of smaller size and greater number than is indicated in this specification, the operation will be more correct and the results more accurate.

Owing to the necessary smallness of the figures in the drawings, I have not attempted in all cases to show the number of teeth in the cog-wheels, and, in some instances—as, for example, on the periphery of the equatorial circle—I have not shown any cog-teeth at all. It will be understood, however, from the specification which wheels are gear-wheels, as well as the required relative number of teeth in the several wheels.

The uses of this apparatus I have described will be obvious to all who are familiar with the elements of astronomical science; but in order to make the operation and utility of my machine more apparent, I will proceed to describe the manner of working it and some of the uses to which it is designed to be applied.

In order to use the clock, when it is designed to run automatically, it is necessary that it should be set and started correctly. In order to do this, first loosen the set-screw j, which connects the axis h of the terrestrial globe with the gearing which is intermediate between the shaft h and the clock A. Then, by revolving the shaft h, turn the sun-wheel G until the pointer i' on the arm u is over the mark on the ecliptic-circle D, indicating the 21st day of March, (the vernal equinox.) Then see that the zodiacal circle H is correctly placed, having the line between Aquarius and Pisces on the circle H corresponding with the date of 21st March on the ecliptic-circle D, because the sun enters Pisces (which is now the first constellation) at that time. Then set the hour, minute, and seconds hands of the watch-movement C at XII exactly. The apparatus thus adjusted is set for the 21st March, when the sun's apparent right ascension and declination are at zero. The hour XII on the equatorial circle should then correspond with the point where the semicircular ecliptic arc c' intersects the equator on the terrestrial globe E.

When thus set rotate the sun-wheel G by turning the axis or shaft h, as before, until the pointer i' on the arm u of the sun-wheel arrives at the graduation-mark on the ecliptic-circle D indicating the day on which or for which the instrument is to be started or set, bringing the terrestrial globe E to rest with the meridian-line of the place where the instrument is used, or for which it is set, exactly in line with the hour XII, noon, on the equatorial circle F and directly facing the sun S. Then tighten the set-screw j, thus connecting the terrestrial globe with the clock A, and set the clock A at XII o'clock, noon, plus or minus the equation of time, or the difference between apparent time and mean or clock time, as the sun may be slow or fast, and set the watch-movement B at mean Greenwich time, which will be faster or slower than the clock A, as the place where the instrument is set is east or west of the meridian of Greenwich, allowing four minutes of time for every degree of difference of longitude between the places. Then wind and start the clock A, and if it is regulated to keep true clock-time, and be allowed to run without interruption, it will indicate on each day the correct position of the earth in relation to the sun. The pointer i' will mark on the ecliptic-circle D the month and day of the month, and the position of the sun in relation to the zodiacal constellations, the time at which the sun rises and sets on that day at the place for which the apparatus is set, the equation of time or time by apparent sun-time, and also the apparent right ascension and declination of the sun.

If, however, it is desired to use my apparatus for ascertaining the sun's right ascension and declination, or the equation of time for any other day, the set-screw j must be loosened, and the shaft h, or earth's axis, rotated until the pointer i' indicates the day required on the ecliptic-circle F. Then the watch C will indicate in hours, minutes, and seconds the sun's right ascension—as, for instance, on 25th June the watch C will read 6 hours, 15 minutes, 15 seconds, and the declination indicated on the meridian-strip h' will read 23°, 44′, north, while the difference between the time indicated by the clock A and the point on the equatorial circle intersected between the meridian of the place for which the instrument is set will be two minutes and seventeen seconds, showing the sun to be that much slow.

If it is desired to ascertain what time the sun rises and sets on any day of the year at any given place, the apparatus must be set for that day and place, as before described. Then turn the terrestrial globe E until the place is brought directly under the circular strip w. Then follow the meridian of the place to the equator, and at the point coinciding therewith on the equatorial circle will be read the time at which the sun rises at that place.

To ascertain the time of sunset on the same day, the globe is then turned from west to east until the place of observation is brought directly under the strip w on the opposite side of the instrument, and then, by following the meridian of that place to the equator, we find, coinciding with that point on the equatorial circle, the hour of sunset.

It may be observed, however, that if the time of sunrise is ascertained, the time of sunset on the same day is readily learned by subtracting the time of sunrise from twelve hours, the remainder being the time of sunset.

Having thus described my improved apparatus, what I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination and arrangement of a clock-movement with a terrestrial globe and sun-sphere, and intermediate gearing, whereby the terrestrial globe is capable of a diurnal revolution on its axis, and the sun-sphere of an annual revolution around it, substantially as described.

2. The combination of a terrestrial globe capable of a diurnal movement on its axis with a graduated equatorial circle capable of an annual rotation around it in the plane of the equator of the globe, substantially as described.

3. In combination with a terrestrial globe capable of a diurnal movement on its axis, an equatorial circle capable of an annual revolution around the terrestrial globe in the plane of its equator by means of a cog-wheel having a uniform movement gearing into teeth so arranged around the periphery of the equatorial circle as to give it a slower movement during one half of its revolution than during the other half, substantially as and for the purpose described.

4. In combination with a terrestrial globe capable of a diurnal motion on its axis, and an equatorial circle capable of an annual revolution around the terrestrial globe in the plane of its equator, a circular strip nearly surrounding the globe at right angles to the plane of the ecliptic, with a semicircular arc attached to said strip and parallel to the surface of the globe in the plane of the ecliptic, and revolving with the equatorial circle by means of pins projecting therefrom, substantially as and for the purpose set forth.

5. In combination with a terrestrial globe capable of a diurnal revolution on its own axis, a sun-wheel having an annual rotation on its axis, and adapted to carry a sphere representing the sun, the axis of revolution of the sun-wheel being set at a suitable angle to the axis of the terrestrial globe, corresponding to the angle between the equator and the ecliptic, and also intersecting the center of the terrestrial globe, substantially as and for the purpose described.

6. In combination with a terrestrial globe capable of diurnal rotation on its axis, a sun-wheel capable of annual revolution, its axis by means of suitable intermediate gearing from the shaft of the axis of the globe meshing into teeth so arranged on the periphery of the sun-wheel as to cause it to move more slowly during one half of its revolution than it does during the other half, substantially as and for the purpose described.

7. In combination with a terrestrial globe capable of diurnal rotation on its own axis, and a sun-wheel capable of annual revolution on its axis in a plane parallel to that of the ecliptic, as hereinbefore described, a stationary ecliptic-circle graduated with the days of the year, and set in the same plane and with the same center as the sun-wheel, substantially as and for the purpose hereinbefore described.

8. In combination with the subject-matter of the preceding claim, a stationary zodiacal circle set in the same plane and with the same center as the sun-wheel, substantially as and for the purpose described.

9. In combination with a terrestrial globe capable of diurnal revolution on its axis, a watch-movement so connected, substantially as hereinbefore described, by suitable gearing with the shaft giving motion to the globe as to indicate on the watch-dial, in hours and their subdivisions, the sun's apparent right ascension, substantially as described.

10. The combination of a terrestrial globe capable of diurnal rotation on its axis, a graduated equatorial circle having coincident axis of rotation therewith, and capable of annual rotation around the globe, a sun-wheel having an axis of rotation parallel to the plane of the ecliptic and capable of annual rotation, a sun-sphere attached to the sun-wheel and revolving therewith, a stationary equatorial circle, graduated for the days of the year, having the same plane and center of revolution as the sun-wheel, and an index attached to the sun-wheel to indicate the days of the year, the whole being connected together by suitable gearing to give the proper relative motion to the parts, and detachably connected with the clock or prime motor, so as either to work automatically or to be set and rotated by hand at pleasure, substantially as and for the purposes hereinbefore described.

In testimony whereof I, the said JAMES F. SARRATT, have hereunto set my hand.

JAMES F. SARRATT.

Witnesses:

JNO. K. SMITH,

C. E. MILLIKEN.