2 Sheets—Sheet 1.

S. HAYFORD.

Solar-Time Instrument.

No. 219,469. Patented Sept. 9, 1879.

Fig. 1.

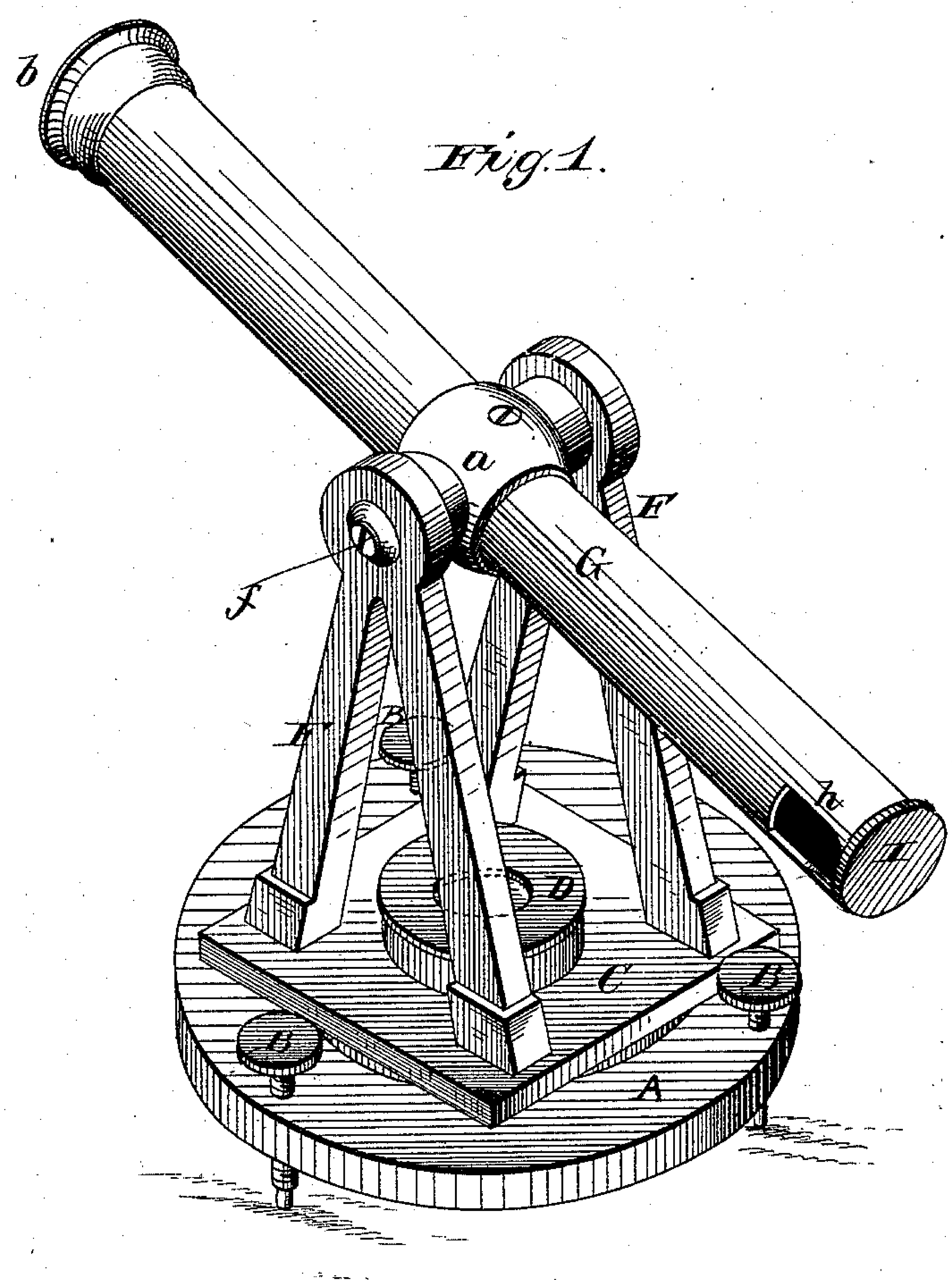
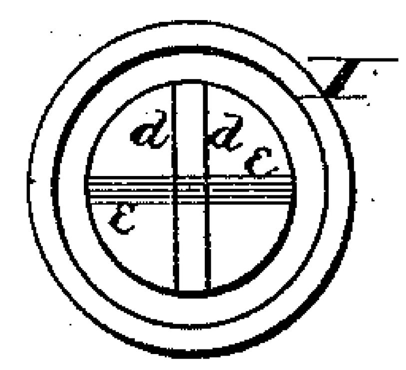


Fig. 2.

Fig. 3.



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2 Sheets—Sheet 2.

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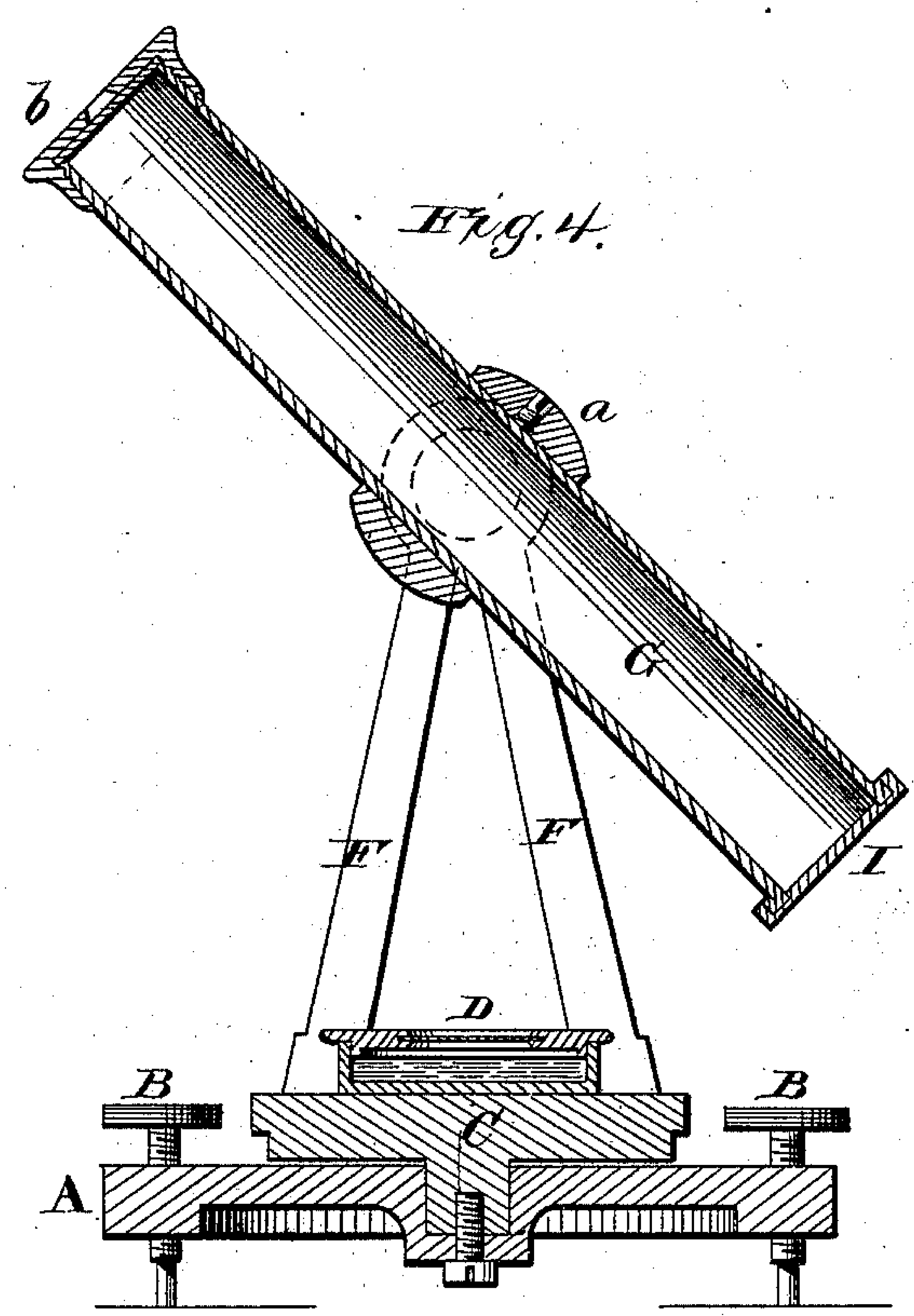
Fig. 4.



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UNITED STATES PATENT OFFICE.

SAMUEL HAYFORD, OF AUSTIN, TEXAS.

IMPROVEMENT IN SOLAR-TIME INSTRUMENTS.

Specification forming part of Letters Patent No. **219,469**, dated September 9, 1879; application filed March 28, 1879.

To all whom it may concern:

Be it known that I, SAMUEL HAYFORD, of Austin, in the county of Travis and State of Texas, have invented certain new and useful Improvements in Solar-Time Instruments; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

The nature of my invention consists in the construction and arrangement of a solar-time instrument, as will be hereinafter more fully set forth.

In the annexed drawings, Figure 1 is a perspective view of the entire instrument. Fig. 2 is a longitudinal section of one end of the telescopic tube. Fig. 3 shows the face of the diaphragm with its horizontal and vertical lines. Fig. 4 is a central vertical section of the instrument.

A represents a base or leveling plate, resting on and operated by three leveling-screws, B. On this, and concentric with it, rests another and smaller plate, C, called the "azimuth-plate," on which are mounted a circular level, D, and a pair of uprights, F F, each upright supporting one end of a horizontal axis, *a*. This axis is perforated by and supports a telescopic tube, G, one end of which holds a lens, *b*, the focus whereof is on the surface of a diaphragm, I, of any suitable material, attached to the other end of the tube.

The diaphragm I has on its surface facing the lens two systems of lines cut in the surface, one consisting of two parallel lines, *d d*, in vertical planes, intended as a guide to assist in retaining the sun's image in nearly the same place on the diaphragm during the time covered by the observations. The other system of lines is horizontal, and consists of three, five, or any other desirable number of equidistant parallel lines, *e*, placed at such distance that the sun's image focused by the lens shall more than cover the width of the space occupied by the lines.

The axis of the telescopic tube is movable on its own centers in altitude, and in azimuth by the revolution of the azimuth-plate on which its supports rest, so that its optical axis may be set at any angle with the meridian and the horizon.

By means of screws *f* at the ends of the axis the telescopic tube may be firmly clamped in any position.

An aperture, *h*, is made in the side of the tube next the diaphragm, through which the contacts of the sun's image with the horizontal lines may be noted, either with or without the aid of a magnifying-glass; if with the magnifier, it may be either held in the hand or attached permanently as a reading glass to the instrument.

To use the instrument, place it in the sunshine on any tolerably firm support, such as a window-sill, and the nearer on the level of the eye the better, and bring the bubble to the center by means of the leveling-screws. Revolve the upper plate, C, and the telescopic tube G on its axis until the image of the sun is seen just above the horizontal lines *e*.

Suppose the time to be about 9 o'clock a. m.; see that the bubble is in the center of the level, and clamp the axis of the telescope; watch the image of the sun as it descends until its lower edge comes in contact with the first line, and note the time by a watch; do the same with the other lines as the image moves across the diaphragm. If great accuracy be required the contacts of the upper edge of the image may also be observed and the times noted. The instrument is then to be put away carefully, being particular not to move the telescopic tube on its axis in the least, as the absolute rigidity of the tube in its position until the afternoon observations have been taken is the one condition of accurate results.

A little before 3 o'clock p. m. the instrument is to be set again in the sunshine. By means of the leveling-screws the bubble is to be brought to the center, and then the tube directed toward the sun by revolving the upper horizontal or azimuth plate, but without moving the tube on its axis. By continually directing the tube in this way toward the sun as it moves westward, the sun's image will soon be seen entering on the lower edge of the diaphragm and approaching the horizontal lines *e*. Now see that the bubble is still in the center of the level, and observe the contacts as before, noting the times carefully, and remembering that if the lower edge of the image was observed in the morning the same edge must be observed in the evening, and if both edges were observed in the morning the same should be done in the evening, and in this latter case the first set of contacts of the morning and the second set of the evening correspond and belong together, and the same of the other two sets.

To calculate the time from one set of observations each before and after noon, add together the times of the morning contacts, and divide the sum by the number of contacts observed. Do the same by the times of the evening contacts, remembering to call 1 o'clock 13 hours, 2 o'clock 14 hours, and so on. Add together the two average times, and divide the sum by two. The result will be the time of apparent noon by the time-piece used. This time will need a slight correction, due to the change of the sun's declination in the interval of time between the morning and evening observations. This correction is given for every tenth day of the year, and for each degree of latitude from 28 to 49, in a table of equations to equal altitudes, a copy of which is to go with every instrument. The equation of time applied to the corrected time of apparent noon gives the time of mean noon by the time-piece used.

I will here give an example of the above. On the 27th of February, 1879, at the city of Austin, Texas, about latitude 30° north, the following observations were taken for time:

MORNING.				EVENING.		
9h	07m	38s	lower limb	15h	41m	08s
9	08	08		15	40	39
9	08	40		15	40	11
9	09	09		15	39	39
9	09	39		15	39	09
45	43	14		78	20	46
These divided by 5 give						
9	08	33.8	and	15	40	09.2
Which added together make				24	48	48
And this sum divided by 2 gives				12	24	24

By referring to the table of equations to equal altitudes it is found that the correction for an interval of six hours on the 1st of March in latitude 30° is a little over eleven seconds, or, say, 11″ for 27th of February, subtractive.

Thus,	12h	24m	24s
Less correction,			11
Time of apparent noon,	12	24	13
Add equation of time,		12	58
Gives time of mean noon,	12	37	11

So that the time-piece used was 37 minutes 11 seconds too fast for mean time at Austin.

On the same occasion the upper limb of the image was observed with the following results:

MORNING.				EVENING.		
9h	10m	35s	upper limb	15h	36m	05s
9	11	05		15	36	37
9	11	36		15	37	10
9	12	09		15	37	40
9	12	37		15	38	12
45	58	02		78	05	44
Divided by 5 give						
9	11	36		15	37	08.8
These added make				24	48	45.2
And divided by 2 gives				12	22	22.6
Less correction,						11
				12	22	11.6
Add equation of time,					12	58
Time of mean noon,				12	37	09.6

The two results differ by the amount of 1.4 seconds. Taking the average or mean result by adding and dividing by 2 gives the true time of mean noon, 12 37 10.3 by the time-piece used.

Some of the advantages of this instrument are, that it is extremely simple in construction and cannot get out of order by any means short of absolute breakage. Its construction is such that it requires absolutely no adjustments previous to being used. Only a few seconds of time are required to set it up for use.

Setting up for use consists simply in placing it where the direct rays of the sun can strike it, and bringing the bubble to the center of the level by means of the leveling-screws, and only the simplest possible calculations are required to derive the true time from the observations.

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

In a solar-time instrument, the telescopic tube provided at one end with a lens, and at the other end with a removable diaphragm having horizontal and vertical lines marked thereon, in combination with the axis and clamping device, the azimuth-plate with level and upright supports, and the base or bed plate provided with leveling-screws, all constructed substantially as and for the purposes herein set forth.

In testimony that I claim the foregoing I have hereunto set my hand.

SAMUEL HAYFORD.

Witnesses:
C. W. DANIEL,
W. O. SHANDS.