Jan. 19, 1926. 1,570,029

S. W. BALCH

SUN DIAL

Filed April 18, 1922 3 Sheets-Sheet 1

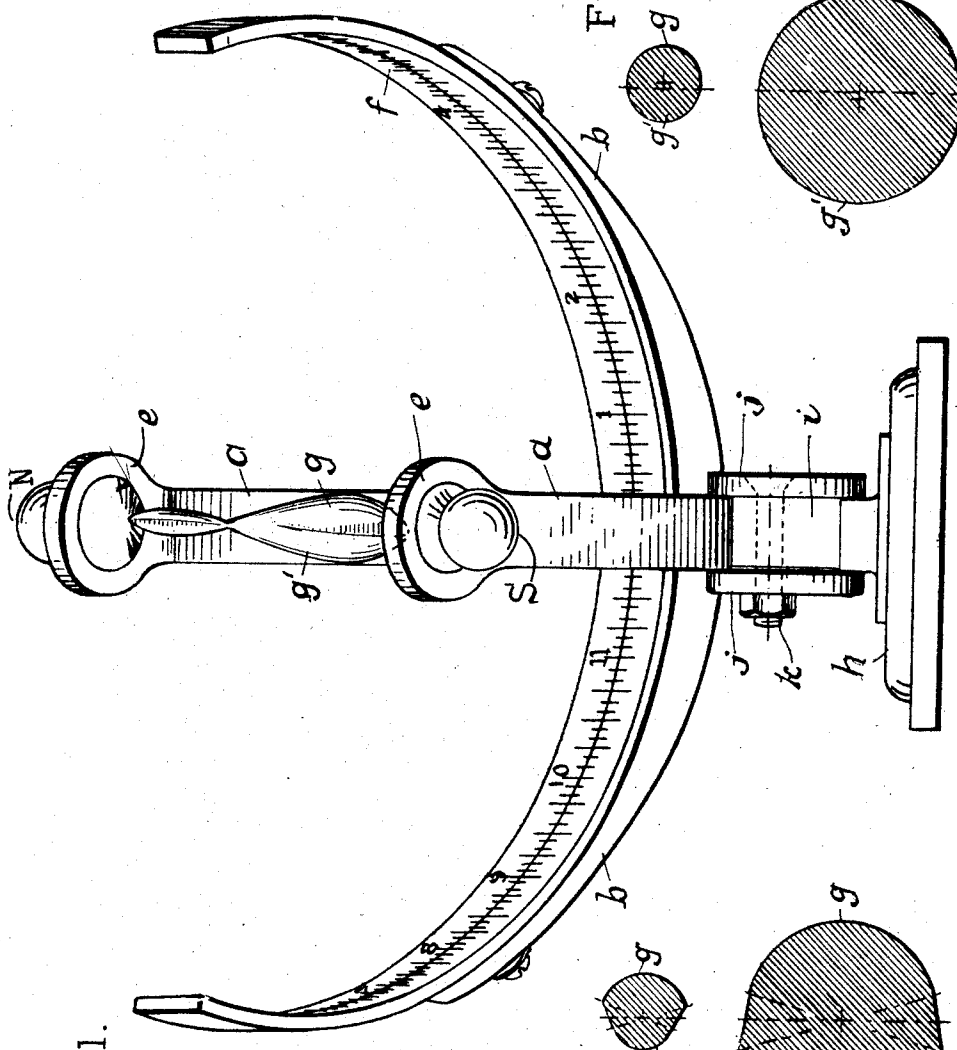


Fig. 1.

Fig. 7.

Fig. 8.

Fig. 5.

Fig. 6.

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Filed April 18, 1922 3 Sheets-Sheet 2

Fig. 4.

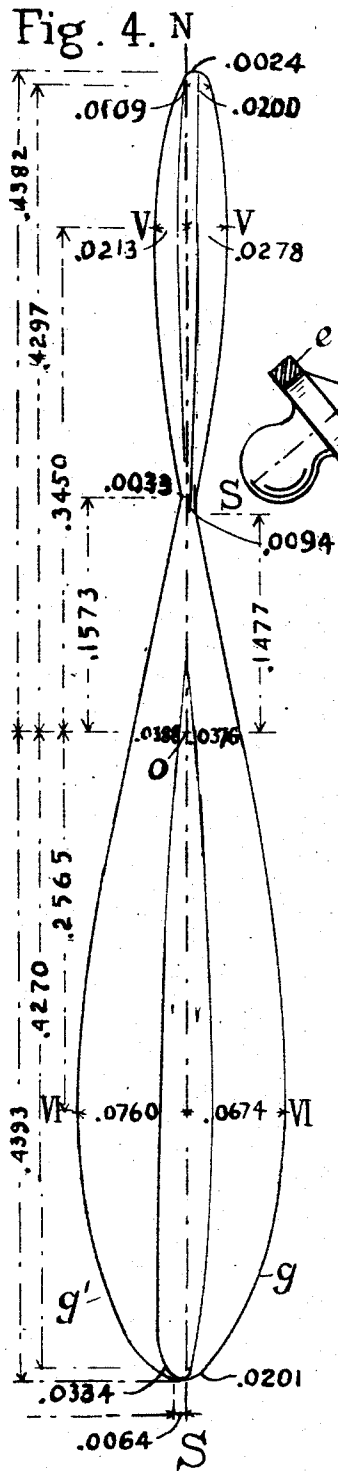
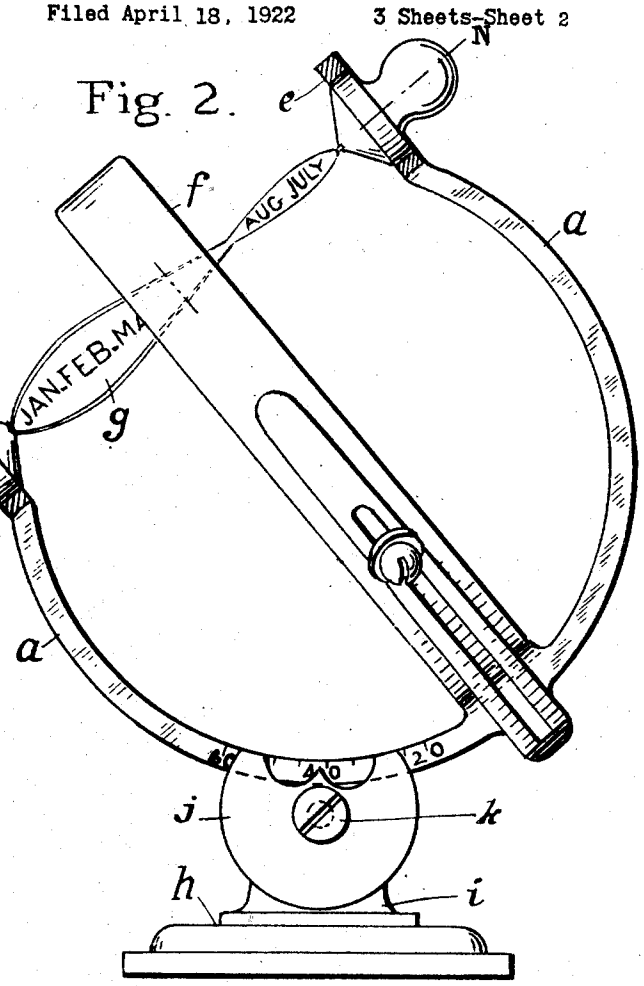


Fig. 2.



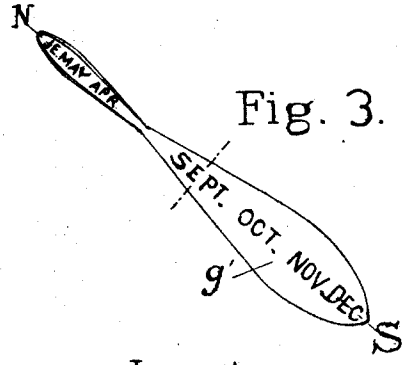


Fig. 3.

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SUN DIAL

Filed April 18, 1922 3 Sheets-Sheet 3

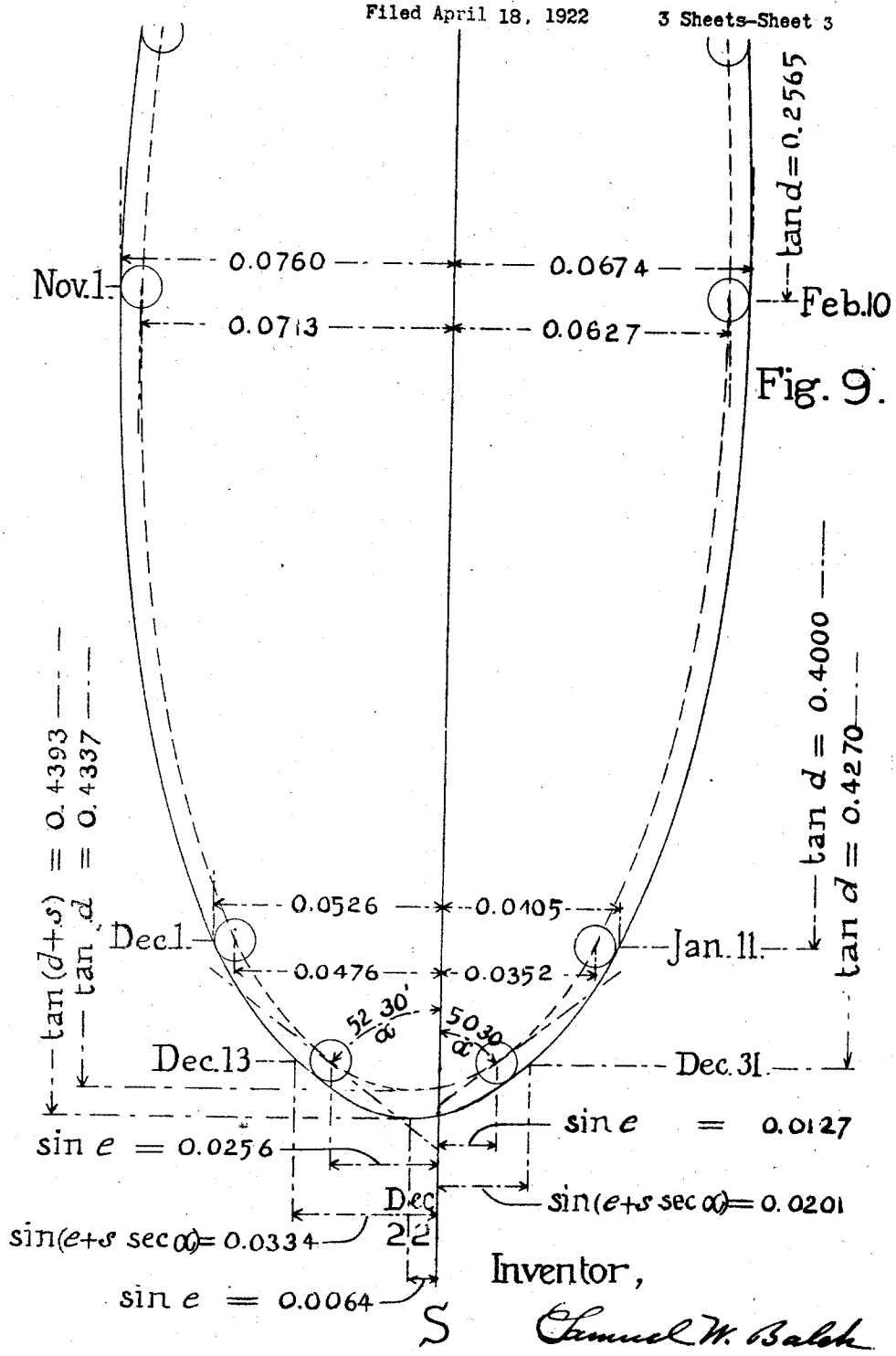


Fig. 9.

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UNITED STATES PATENT OFFICE.

SAMUEL W. BALCH, OF MONTCLAIR, NEW JERSEY.

SUN DIAL.

Application filed April 18, 1922. Serial No. 554,648.

To all whom it may concern:

Be it known that I, SAMUEL W. BALCH, a citizen of the United States of America, and a resident of Montclair, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Sun Dials, of which the following is a specification.

The object of this invention is to provide a sun-dial which will indicate standard mean time on any day between seven in the morning and five in the afternoon when the sun's rays can reach the dial, and with a degree of accuracy which is limited only by the closeness with which the shadow can be determined, and which will also indicate the time with small error before and after this period of the day. A further object is to provide a sun-dial which can be adjusted for any latitude and for any time meridian, the time of which may be used in the place where the sun-dial is located instead of the local time. A further object is to provide a sun-dial which while accurately indicating mean time, can be permanently adjusted when set up and requires no further alteration for different times of the year and which shows the true mean time directly and without requiring recourse to tables and calculation.

In the accompanying three sheets of drawings which form a part of this specification—

Figure 1 is an elevation of a sun-dial embodying this invention, looking north.

Fig. 2 is an elevation of the same, looking west, the eyes being shown in section.

Fig. 3 is an elevation of the gnomon, looking east.

Fig. 4 is a plan of the gnomon drawn to three times the scale of the preceding figures.

Figs. 5 and 6 are sections through the gnomon on the lines V—V and VI—VI respectively to the same scale as Fig. 4.

Figs. 7 and 8 are similar sections of a modified form of gnomon.

Fig. 9 is a plan of the outline of the southern end of the gnomon drawn to ten times the scale of Figs. 1 and 3.

The sun-dial comprises a main frame which is a casting with two arms a, a and two wings b, b. The arms have eyes e, e which are made sufficiently large to permit of a mandrel being passed through them for the support of a cutting tool for machining a cylindrical seat on the wings. A circular arc f with time graduations is fastened to the wings and the arms support the ends of a gnomon with positive and negative sides g and g' respectively. The main frame is supported from a base h which clamps the frame in any required adjustment for latitude. There is an upstanding tongue i on which one of the arms of the frame rests. The tongue is slightly narrower than the arms and jaws j, j are drawn together by a bolt k to clamp the frame.

Sun time varies from mean time throughout the year. The sun is on the meridian later than twelve by the clock from June 15 until September 1, and also from December 25 until April 15, and is on the meridian earlier than twelve by the clock during the two remaining periods of the year. These times are given in almanacs under the heading "Sun on the meridian." As the sun changes from day to day in declination, a different part of the gnomon casts its shadow across the time scale on each successive day, and it is therefore possible by using a gnomon of suitable form to displace the shadow on each day by the amount of correction required. By making the dial scale a part of a circle whose axis is parallel to the earth's axis and the gnomon a solid of revolution about this axis and of proper form either the positive or the negative corrections can be accurately made for all times of the day when the sun's rays can reach the dial, but not both. This is because it so happens that the sun is at each particular declination on two different days of the year, on one of which the correction is usually positive and on the other of which it is negative. As these are also usually of slightly different numerical values such a gnomon cannot be accurately shaped for all hours of both days. By restricting the surface of revolution to between 150 to 180 degrees the period of accurate marking on each day will be limited to from ten to twelve hours, and this is not objectionable as the interval during which a sharp shadow is cast is usually within this period. As the arc for the negative correction is on the opposite side of the gnomon from the arc for the positive correction both can be at the same declination part of the gnomon without materially interfering.

The curve of the gnomon is found by first drawing a curve on which each day is

represented by a point the absissa of which is the sine of the equation of time and the ordinate of which is the tangent of the sun's declination. As the sharp edge of the shadow is where the umbra joins the penumbra and not at the middle of the penumbra, the sun's semidiameter is laid off normal to this curve, and the true curve is calculated by making the absissa equal to the sine of the equation of time plus the product of the sun's semidiameter multiplied by the secant of the slope of the gnomon. On June 21 and December 22 the shadow is cast by the tips of the gnomon, and in calculating the position of these tips, the sun's semidiameter is added to the declination instead of to the equation of time. The sines and tangents are the dimensions of the gnomon on the basis of a scale according to which unity is the radius of the arc bearing the time graduations. Each function must be multiplied by the radius if any other length than unity is used. In the following table there is shown for selected dates the equation of time e, the sun's semidiameter s, the correction for the slope of the gnomon c, the sun's declination d, and the co-ordinates x, y computed therefrom.

	e	s	c	d	x	y
	° ′ ″	′ ″	′ ″	° ′ ″		
June 21	+0 08 15	+15 46	-------	+23 26 44	+.0024	+.4382
June 29	+0 47 00	+15 46	+0 37	+23 15 13	+.0200	+.4327
June 14	−0 01 15	−15 47	−2 04	+23 15 09	−.0109	+.4297
July 28	+1 19 45	+15 47	-------	+19 04 01	+.0278	+.3450
May 16	−0 57 15	−15 51	-------	+19 01 41	−.0213	+.3450
Sept. 1	+0 01 00	+15 53	+0 16	+ 8 24 05	+.0056	+.1573
Apr. 13	+0 09 30	−15 58	−0 29	+ 8 56 15	−.0033	+.1573
Apr. 12	+0 13 30	+15 58	+0 16	+ 8 24 23	+.0094	+.1477
Sept. 2	−0 13 45	−15 53	−0 29	+ 8 02 18	−.0071	+.1477
Mar. 21	+1 50 45	+16 05	+0 16	+ 0 07 22	+.0376	.0000
Sept. 23	−1 52 30	−15 58	−0 29	+ 0 03 05	−.0388	.0000
Feb. 10	+3 35 45	+16 14	-------	−14 26 01	+.0674	−.2565
Nov. 1	−4 05 15	−16 09	-------	−14 20 16	−.0760	−.2565
Dec. 31	+0 43 35	+16 18	+9 20	−23 07 22	+.0201	−.4270
Dec. 13	−1 28 00	−16 17	−10 28	−23 08 08	−.0334	−.4270
Dec. 22	−0 22 00	−16 17	-------	−23 26 47	−.0054	−.4393

In the case of each pair of dates of nearly the same declination the average ordinate is used for simplicity without introducing material error.

The equation of time is usually given in almanacs in minutes and seconds of time. The numerical values are multiplied by 15 to convert to minutes and seconds of arc as given in the above table. A preliminary curve is first drawn as shown in dotted line in Fig. 9 without introducing the correction for the sun's semidiameter. In this preliminary curve the absissæ are the sines of the equation of time and the ordinates are the tangents of the sun's declination for the same instants of time. From this curve the slope of the gnomon at each point is measured, and the sun's semidiameter is corrected by multiplying by the secant of the angle of the slope. Thus at December 31 the slope is found by measurement to be 50° 30′ and the sun's semidiameter, 16′ 18″ multiplied by the secant is 25′ 38″, an increase of 9′ 20″ as shown in column c of the table. The absissa for this date is the sine of the sum of the angles in the three columns e, s, and c, opposite the date.

A modification of the gnomon is shown in Figs. 7 and 8 by which it is made a single surface of revolution and its construction thereby simplified. At each point of declination its diameter is the numerical sum of the positive and negative absissæ. It would need to be set with its axis deviating fifty minutes of arc from the true north and south axis, the north end being to the east and the south end to the west.

As the gnomon casts a shadow with two edges crossing the line of time graduations, of which only one indicates the mean time, it is necessary to show from which edge the time is to be read. The names of the months are therefore inscribed on the sides of the gnomon. It is only necessary to touch one's finger to the month and its shadow will point to the side from which the time is to be read.

I claim—

1. In a sun-dial for indicating mean time, a dial bearing a circular arc with time graduations, and a gnomon shaped so that every day shall be represented by a point on the surface the absissa of which measured from the axis of the circular arc is the sine of the sum of the equation of time and the product of the sun's semidiameter with the secant of the slope at the point with respect to the axis of the circular arc, and the ordinate of which measured from the plane of the circular arc is the tangent of the sun's declination.

2. In a sun-dial for indicating mean time, a dial bearing a circular arc with time graduations, and a gnomon in which each of the two sides is bounded by approximately half of a surface of revolution about the axis of the circular arc, the two sides being dissimilar, one side being figured for the positive corrections to sun time and the other side being figured for the negative corrections to sun time.

SAMUEL W. BALCH.