No. 780,178. PATENTED JAN. 17, 1905.

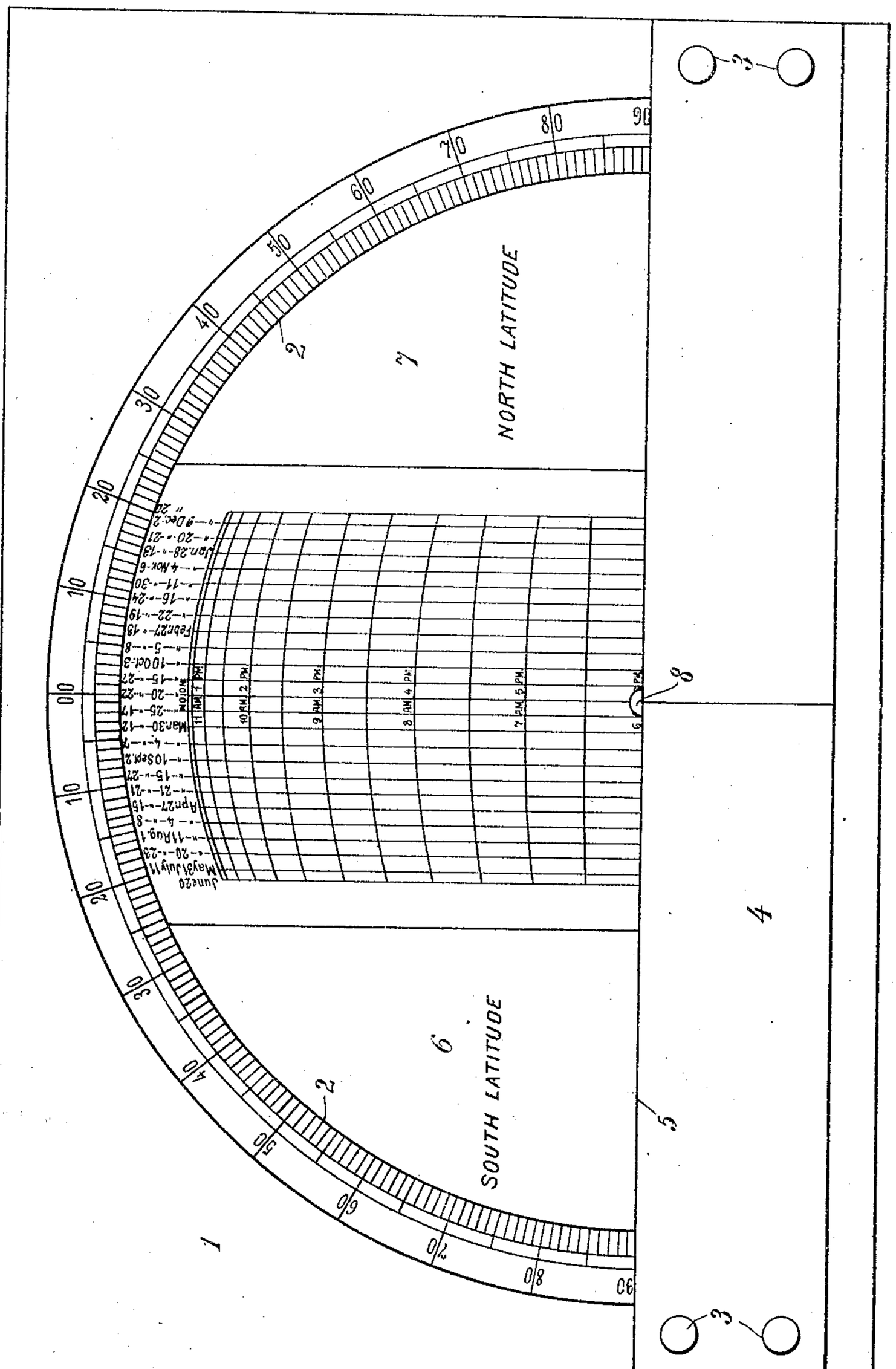
R. E. HENNING.

PHOTOGRAPHIC LIGHT VALUE SCALE.

APPLICATION FILED DEC. 26, 1903.

2 SHEETS—SHEET 1.

Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 3.

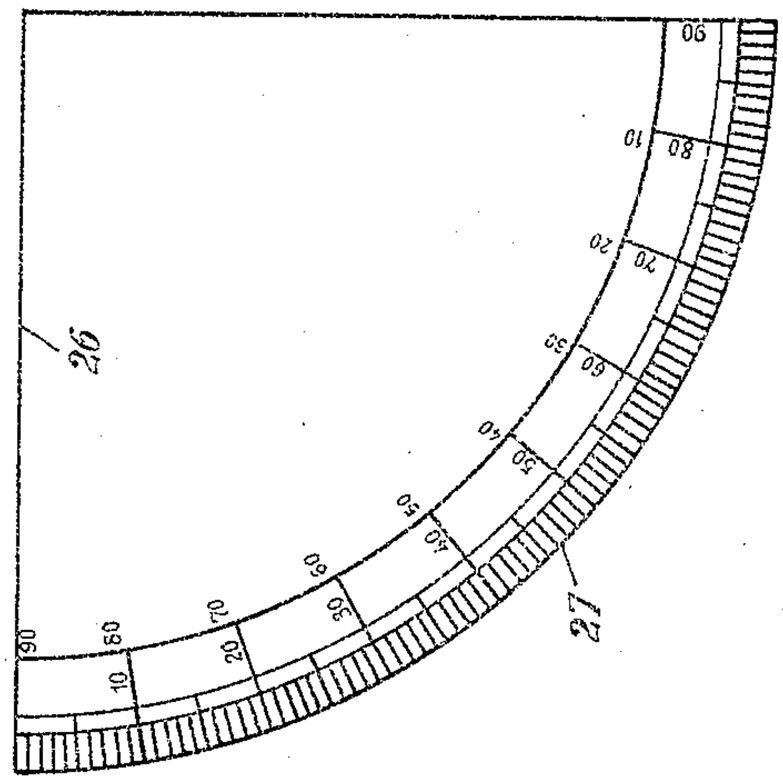

Fig. 2.

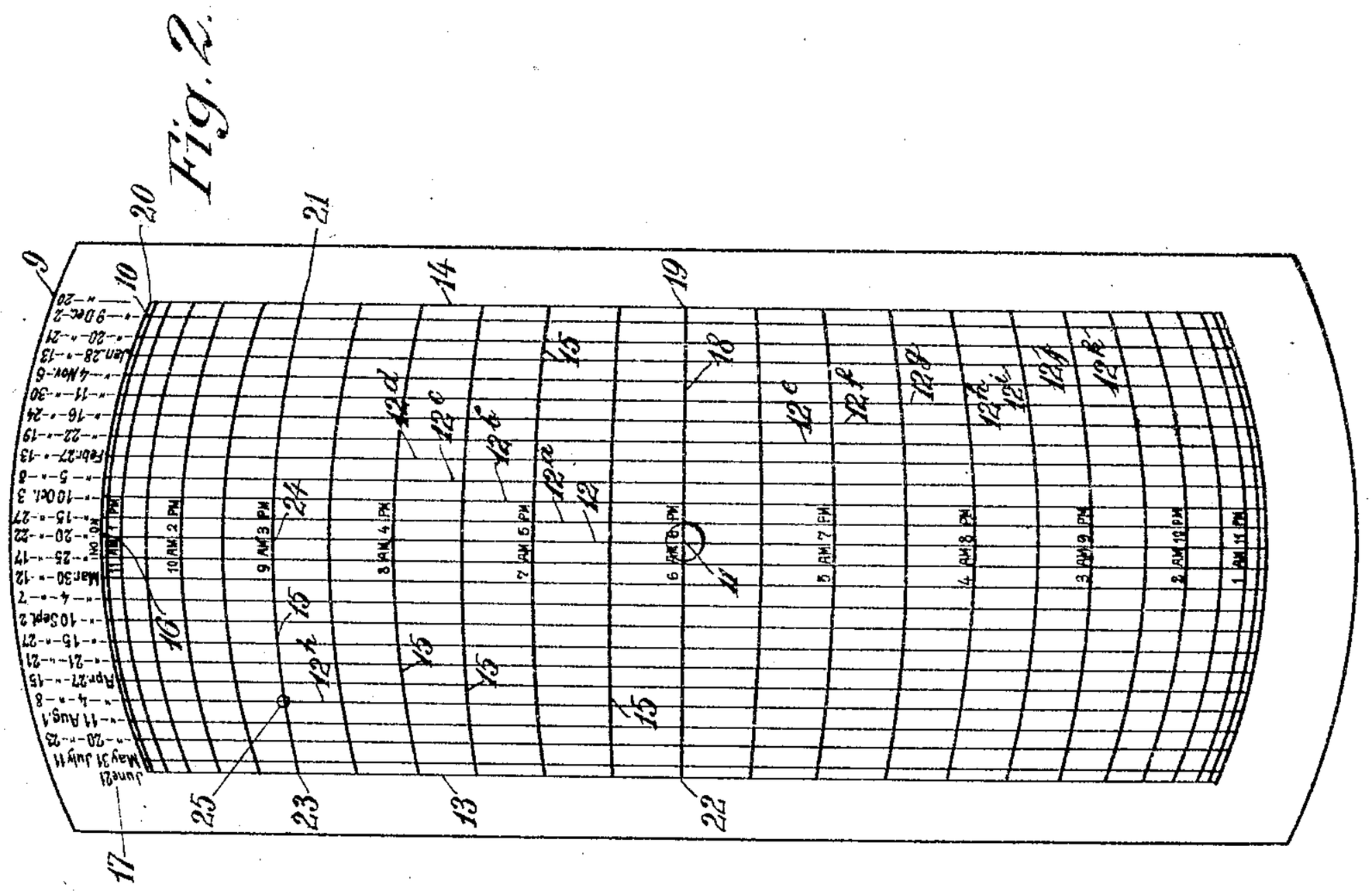

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PHOTO-LITHOGRAPHED BY SACKETT & WILHELMS LITHO. & PTG. CO. NEW YORK.

No. 780,178. Patented January 17, 1905.

UNITED STATES PATENT OFFICE.

ROBERT E. HENNING, OF CHERITON, VIRGINIA.

PHOTOGRAPHIC-LIGHT-VALUE SCALE.

SPECIFICATION forming part of Letters Patent No. 780,178, dated January 17, 1905.

Application filed December 26, 1903. Serial No. 186,659.

To all whom it may concern:

Be it known that I, ROBERT E. HENNING, a citizen of the United States, and a resident of Cheriton, Northampton county, Virginia, have invented certain new and useful Improvements in Photographic-Light-Value Scales, of which the following is a specification.

Heretofore, so far as known to me, the means employed to determine the length of exposures necessary for making photographs have been the various exposure-meters, depending on the darkening of small strips of sensitive paper when exposed to the light and then matching a certain shade and various exposure-tables. The defects of the exposure-meters are that they take considerable time to determine, and there is considerable difficulty in determining when the standard shade has been matched. The objection to the exposure-tables is that they are only applicable to one latitude and cannot, therefore, be used with any degree of certainty when the position of the place varies several degrees from the place for which they were determined.

The purpose of my invention is to provide an exact means of measuring the light value of the sun, and consequent determination of the length of photographic exposures, both for making negatives and positives.

My invention will be understood by reference to the accompanying drawings, in which—

Figure 1 is a top view of the base, showing a portion also of the light-value scale. Fig. 2 is a top view of the light-value scale, and Fig. 3 is a top view of the quadrant.

Referring to the drawings, the numeral 1 designates a base-piece made of any suitable material, such as cardboard or light metal, upon which is struck an arc 2 of one hundred and eighty degrees. Secured to the base 1 by pins 3 or other suitable means is a strip 4, which may be of the same material as base 1 and under which the light-value scale, Fig. 2, may be passed. The upper edge 5 of the strip 4 coincides with the chord of the arc 2 and serves as a horizon or base line from which is measured the height of the sun at any given place or time, as will be fully described hereinafter. The arc or semicircle 2 is divided into two quadrants 6 and 7, and each quadrant is divided into degrees, beginning with zero at the center of the arc, right and left to the horizon-line 5. The quadrant to the right is marked "North latitude," and the quadrant to the left is marked "South latitude." At the center of the chord of the semicircle 2 under the horizon-line 5 is a pivot 8, over which passes at its center the light-value scale, Fig. 2, said scale resting upon the base 1 under the strip 4 and freely rotatable about the pivot 8. Said pivot indicates the position of the sun at six a. m. and six p. m. at both equinoxes.

The light-value scale is made as follows: From the center 11 of the card or other material used an arc 9 is drawn with a radius equal to the radius of the semicircle 2, drawn on the base, Fig. 1. Inside of this is drawn another arc, 10, somewhat smaller than the arc 9, using the same center 11. A radius 12 is then drawn from the center 11 of both arcs to the outer arc. Such radius will then represent the horizontal projection of the path of the sun at the equinoxes. Parallel to the radius 12 on each side are drawn lines any convenient number of degrees apart as measured on the arc 10. These lines 12^a 12^b 12^c, &c., represent the degrees of declination of the sun to the celestial equator, the radius 12 representing the horizontal projection of the path of the sun at the equinoxes and the lines 12^a 12^b 12^c, &c., the horizontal projection of the paths of the sun at other times of the year, the lines to the left of the radius 12 representing north declination and to the right south declination. I have spaced the lines 12^a 12^b 12^c, &c., two degrees apart except the outermost lines 13 and 14, which represent, respectively, the summer and winter solstices, which are one and one-half degrees, (the whole space at each side of the equinoctial line 12 being equal to twenty-three and one-half degrees,) it being understood that the lines may be made to represent a greater or less number of degrees. These parallel lines 12^a 12^b 12^c, &c., represent the horizontal projections of the paths of the sun at the different dates indicated at any convenient place on the scale, and preferably at

one end thereof, as at 17, these dates being ascertained from any standard nautical almanac. If preferred, the dates may be replaced by numbers indicating the declination in degree. The scale, Fig. 2, is also divided by a series of transverse curved lines 15, which represent the hourly position of the sun on the lines 12 12^a 12^b, &c. The position of these curved lines is determined by the natural sines of the hour-angles. On the radius 12, at its crossing the arc 10, is the point 16, representing the position of the sun at noon of both equinoxes. The intersection of the arc 10 with any of the lines 12 12^a 12^b, &c., represents the sun's position at noon at the date given on the declination-lines 12 12^a 12^b, &c. As the sine of ninety degrees equal one, the radius 12, representing the equinoctial line, is taken as the base for computing the other arcs 15—for instance, to determine the curve for the hours nine a. m. and three p. m. The number of degrees the sun has passed through or will pass through from six a. m. to nine a. m. or from three p. m. to six p. m. is forty-five degrees, (the height of the sun above the horizon being practically the same at equal lengths of time before and after noon on the same date) The natural sine of forty-five degrees is .70711. Therefore the center of the arc for the hours nine a. m. and three p. m. is .70711 parts of the entire distance from the center 11 to the point 16. The line 18 through the center 11 and at right angles to the lines 12 12^a 12^b, &c., is a straight line and represents the six a. m. and six p. m. line. I then measure the distance from 19, the intersection of the lines 14 and 18, to 20 on the line 14 and take .70711 parts of that distance and lay it off on line 14 from 19, thus determining the point 21. The same distance is laid off on the line 13 from 22, thus determining the point 23. In the same way the point 24 is determined by laying off on the radius 12 from the center 11 .70711 parts of the distance from 11 to 16. From the points 21, 23, and 24 the center is determined in a well-known manner and the arc 15 is struck. In a similar manner all the transverse curves 15 are determined. These curves are not parallel; but the curvature of the arc becomes less and less as they near the straight line 18, which is the line for six a. m. and six p. m. The other half of the scale below the line 18 is laid off in like manner. The next line below will be five a. m. and seven p. m., and so on, or the half-hours and, if wanted, the quarter-hours and so on may be computed and laid out in the same manner. In use the light-value scale is centered on the pivot 8 under the strip 4, so as to be rotated about said pivot.

In Fig. 3 is shown a quadrant 27, divided into ninety degrees and numbered consecutively from both ends in reverse order.

To employ the scale to determine light values, incline the scale from the vertical to the right for north latitudes, to the left for south latitudes, a number of degrees equal to the latitude of the place where the light value is to be determined. This inclination is measured in degrees by the quadrants 6 or 7 on the base and by inclining the light-value scale until the line 12 coincides with the desired number of degrees on either of said quadrants. The scale is then clamped in position by a spring-clamp or other suitable means. The next step is to determine the position of the sun on the scale at the required time and date. This is determined by the intersection of the particular hour-curve 15 with the declination-lines 12 12^a 12^b, &c., of the nearest date and measuring the height of this intersection from the horizon-line 5 by means of the quadrant Fig. 3. To make this more clear, we may take as an example a place thirty-seven degrees north latitude, time three p. m. August 5. The quadrant 7 on base 1 to the right is used to incline the scale to the right thirty-seven degrees, and it is then clamped in position. Then the point 25 at the intersection of the hour-curve nine a. m. and three p. m. and the declination-line 12^h (the date nearest to August 5) gives the position of the sun (declination and height) at that particular time and place. The height of the sun above the horizon is measured by the quadrant 27, passing the edge 26 along the horizon-line 5 until the curved edge (which in this case is placed to the top and right side) passes through the point 25. The reading on the quadrant 27, counting from below up, gives the angular height of the sun above the horizon, which in this example is forty-five degrees. The position and consequent light value for any other time of day or latitude and date may be determined in a similar manner. Whenever the position of the sun on the scale is below the line 5 or horizon, the sun has either set or has not risen, and the light value for that particular place and time cannot be determined. It is well known that the actinic value of the sun's rays is proportional to its height above the horizon, being minimum at the horizon and gradually increasing to maximum at the zenith and then gradually decreasing to the horizon, being almost equal for the same period of time before and after noon. These examples are based on actual solar time and not on standard time, as generally used in the United States. Allowance must be made for this difference.

It will be found by actual experience that a certain subject at a given time, date, and latitude requires a certain exposure. Then the exposure necessary to be given to a like subject at any other time, date, or place (either or all) may be found by comparing the light values for the two times or localities. If the light value in the first place was forty-five or

the height of sun was forty-five degrees and in another case the height was only fifteen degrees or the light value was fifteen, then $45 \div 15 = 3$, and the exposure necessary for the latter place and time would be three times that necessary for the first place and time. Let us suppose, for example, we have found by experience that a certain landscape at a given time and place with a given-size diaphragm in the lens requires an exposure of one second and having measured the light value for this particular place and time and found it to be twenty and another similar subject at another place and time has a light value of forty-five, then the exposure for the second place and time would be twenty divided by forty-five, or .44 seconds. For convenience it might be assumed that the light value at forty-five degrees is equal to one and that any other light value is equal to forty-five divided by the number of degrees the sun is above the horizon. In this manner at an altitude of one degree the light value would be forty-five or forty-five times the exposure necessary at forty-five degrees. At an altitude of twenty degrees the exposure would be forty-five divided by twenty, or 2.25 times. At ninety degrees or at the zenith the exposure would be forty-five divided by ninety, or .5. In a like manner for all positions of the sun the light value may be computed. If the same sort of sensitive material is used in all cases the exposure will vary as above stated; but if different material is used allowance must be made for the variation in rapidity. Allowance must also be made if the sun is obscured by clouds, fog, or mist or if the subject is in the shade. This scale does not give the exposure in absolute numbers; but light values which when used as a multiplier in connection with a table of comparative exposures based on one given height of sun will give the proper length of exposure in absolute numbers.

If preferred, the quadrant 27 may be graduated directly in light values instead of degrees as follows: If the height of the sun at forty-five degrees is taken as a base, mark this (forty-five degrees) "1.0." Then the point ninety degrees from the horizon will be .5, one degree will be forty-five, three degrees will be fifteen, and so on throughout the whole scale, and then the readings will be directly in light values instead of degrees.

What I claim, and desire to secure by Letters Patent, is—

1. A device for determining photographic-light values comprising a scale divided longitudinally by parallel lines to indicate the horizontal projections of the paths of the sun at given times of the year, and also divided by transverse straight and curved lines to represent the hourly positions of the sun on the said longitudinal lines.

2. A device for determining photographic-light values comprising a scale divided longitudinally by parallel lines to indicate the horizontal projections of the paths of the sun at given times of the year, and also divided by transverse lines to represent the hourly positions of the sun on the said longitudinal lines, the positions of said hour-lines being determined by the natural sines of the hour-angles taking the equinoctial line as a base.

3. A device for determining photographic-light values comprising a scale divided by a central longitudinal line to represent the horizontal projection of the path of the sun at the equinoxes and by parallel lines on each side of said central line for a distance of twenty-three and one-half degrees to represent the horizontal projections of the paths of the sun at other given times of the year, said scale being also divided by transverse straight and curved lines to represent the hourly positions of the sun on the said longitudinal lines.

4. A device for determining photographic-light values consisting of a base having a quadrant and a horizontal line indicated thereon, a light-value scale pivoted at the center of said quadrant and horizon-line, said scale being divided longitudinally by parallel lines to indicate the horizontal projections of the paths of the sun at given times of the year and also divided by transverse straight and curved lines to represent the hourly positions of the sun on the said longitudinal lines, and a quadrant adapted to be moved along said horizon-line.

5. A device for determining photographic-light values consisting of a base divided into two quadrants indicating north and south latitudes and having a horizon-line thereon, a light-value scale pivoted at the center of said quadrant and horizon-line, said scale being divided longitudinally by parallel lines to indicate the horizontal projections of the paths of the sun at given times of the year and also divided by transverse straight and curved lines to represent the hourly positions of the sun on the said longitudinal lines, and a quadrant adapted to be moved along said horizon-line.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ROBERT E. HENNING.

Witnesses:
GRACE L. HEASLEY,
ANDREW W. SMITH.

Correction in Letters Patent No. 780,178.

It is hereby certified that in Letters Patent No. 780,178, granted January 17, 1905, upon the application of Robert E. Henning, of Cheriton, Virginia, for an improvement in "Photographic-Light-Value-Scales," an error appears in the printed specification requiring correction, as follows: In line 88, page 3, the word "horizontal" should read *horizon;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of February, A. D., 1905.

[SEAL.]

F. I. ALLEN,

Commissioner of Patents.