No. 864,102. PATENTED AUG. 20, 1907.

J. T. MARSHALL.

LUMINOMETER.

APPLICATION FILED JULY 26, 1906.

2 SHEETS—SHEET 1.

Fig. 1.

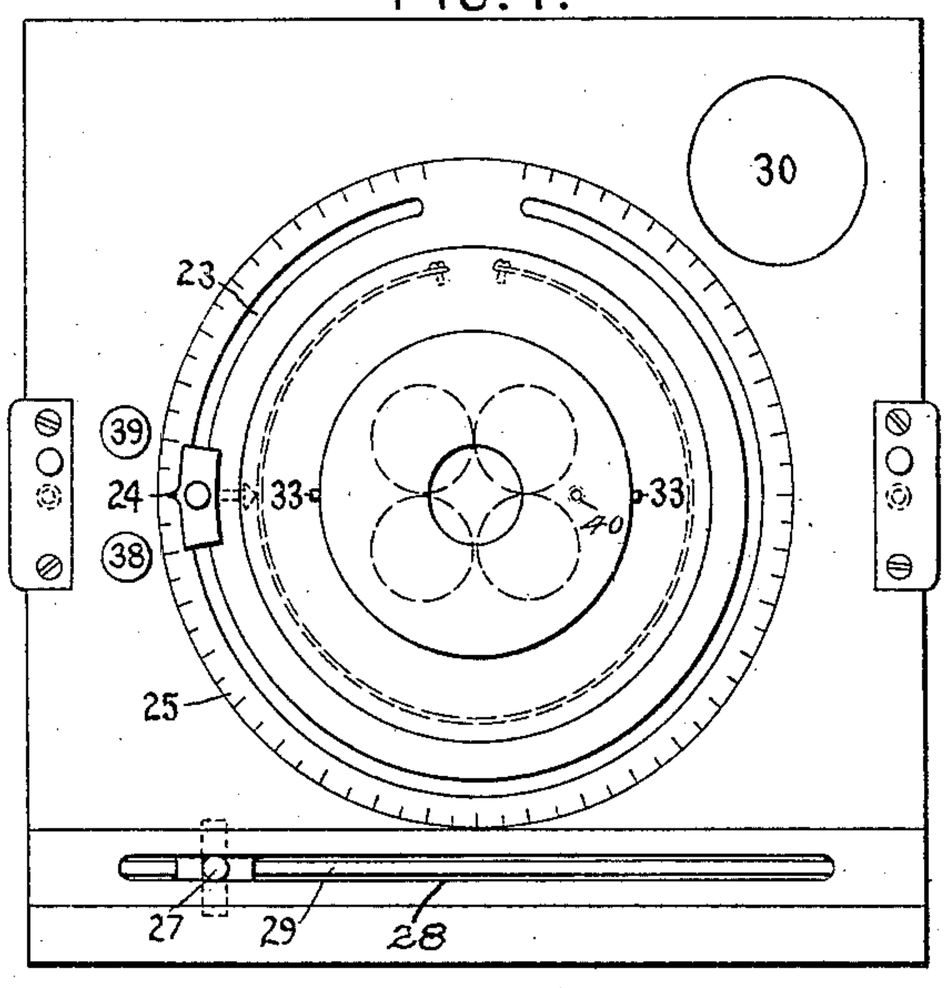


Fig. 2.

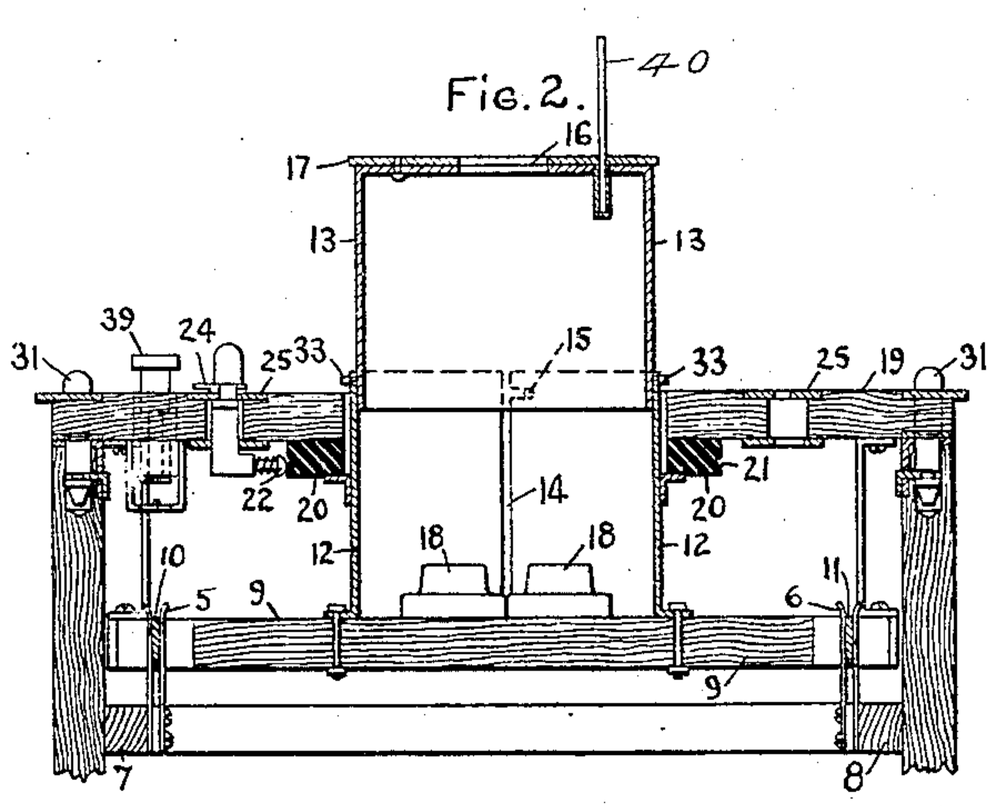
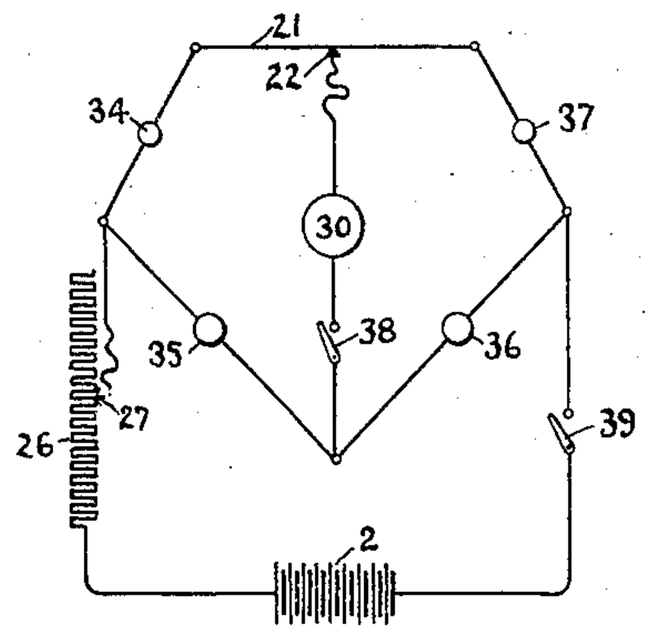


Fig. 5.



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2 SHEETS—SHEET 2.

Fig. 3.

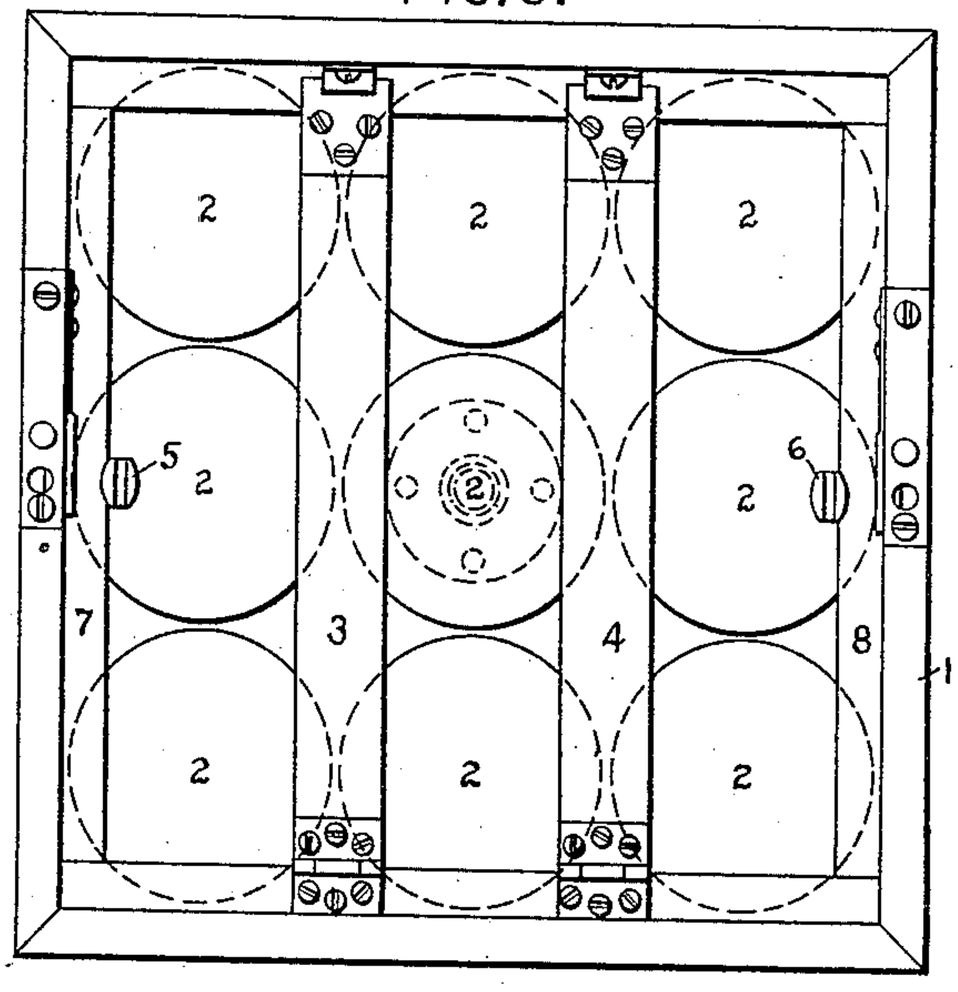
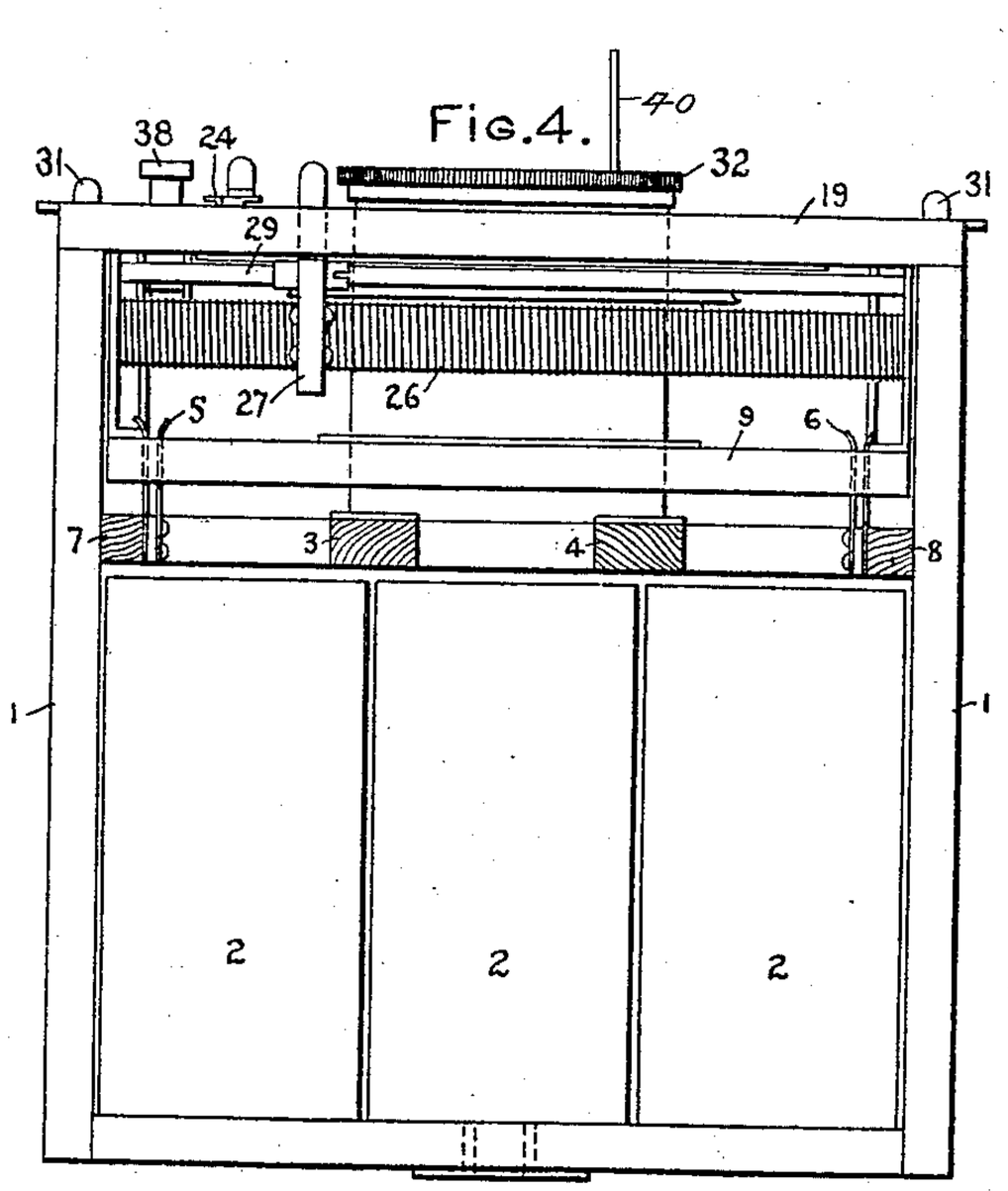


Fig. 4.



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UNITED STATES PATENT OFFICE.

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LUMINOMETER.

No. 864,102. Specification of Letters Patent. Patented Aug. 20, 1907.

Application filed July 26, 1906. Serial No. 327,814.

To all whom it may concern:

Be it known that I, JOHN T. MARSHALL, a citizen of the United States, residing at the borough of Metuchen, county of Middlesex, State of New Jersey, have invented certain new and useful Improvements in Luminometers, of which the following is a specification.

This invention relates to the class of instruments known as luminometers, the function of which is to measure illumination.

The object of the invention is to provide a portable instrument capable of accurately measuring the foot candles of illumination falling on any surface.

My invention involves the provision of a luminometer embodying the principle of balancing the illumination to be measured against that from an electric lamp which is included in one arm of the Wheatstone bridge.

It is a well-known fact that a change of current through a carbon filament lamp produces coördinately a change of candle power and a change of resistance. This change of resistance may be shown by a change of balance of the Wheatstone bridge, and the change of candle power may be shown by a change in the photometer screen. The Wheatstone bridge and the photometer screen in combination permit the construction of a simple, compact, portable instrument for the measuring of illumination, which is independent of the voltage and character of the current in which it is connected. The arms of the bridge may be of incandescent lamps, or some of them may be metallic resistance. If all four arms are incandescent lamps, at least one of the lamps should have its change of resistance by change of current affected to a different degree than the others. While changes of current produce changes of resistance in all incandescent lamps, this change is not the same for untreated filaments, treated filaments, and metallized filaments. The former have their highest resistance at temperatures lower than the atmospheric temperatures, and the resistance decreases with the increase of temperature, even up to the highest temperature to which filaments can be raised. Treated filaments have their highest resistance at temperatures below atmospheric temperatures and decrease in resistance more rapidly than do untreated filaments with increase of temperature down to the point when the resistance reaches the minimum, after which the resistance increases with increase of temperature up to the highest temperature to which the filament can be raised. Metallized filaments, on the other hand, if rather thickly treated, may be made to have their lowest resistance below atmospheric temperatures and their resistance will increase with the increase of temperature to the highest temperature to which they can be raised. A large number of combinations of lamps and metallic resistances in the arms of the bridge may, therefore, be made, the essential condition being that there shall be a concurrent change of balance with the change of candle power. Perhaps the most sensitive combination, or the one that will give the greatest change of balance for a given change of candle power, will be an untreated filament run below incandescence and a metallized treated filament run at incandescence on each side of the bridge but in reverse order.

My invention possesses the further advantage of dispensing with the use of electric measuring instruments which are apt to introduce errors and which require frequent calibration, making the instrument more convenient to use and more accurate.

In accordance with my invention I provide an opaque box inclosing an electric illuminating unit or units, preferably incandescent lamps, and having in one of its faces a photometer screen. The lamp or lamps are included in one or more arms of the Wheatstone bridge, the other arms of which include other resistances, either metallic or made of carbon filament lamps, and an indicating instrument, such as a telephone or galvanometer, is arranged for connection across the bridge. Adjustable resistance is connected in series with the bridge, so that the movable contact of this resistance may be adjusted to regulate the illuminating power of the lamp or lamps within the opaque box and cause it to illuminate the photometer screen equally with the illumination to be measured. The resistances in the arms of the bridge being such that a change of current affects them differently, the balance of the bridge will be disturbed. When this has been done, one of the connections to the indicating instruments may be adjusted along one side of the bridge to find the point at which the bridge is balanced, and a scale, reading in foot candles, may be arranged adjacent to this portion of the side of the bridge, so that direct readings can be made. The incandescent lamp or lamps with whose light the illumination to be measured is compared, should be operated at low efficiency; *i. e.*, enough below normal incandescence so that there will be practically no fixed change in the resistance of their filaments over a long period of use. When I wish to adapt the instrument for use over a wide range, I provide a supplementary resistance in any one of the arms of the bridge, which resistance may be metallic or a carbon filament lamp, or I may substitute another lamp for any one of the lamps, any one or all of which lamps may be mounted within the opaque box, as desired. Supposing that with a given arrangement of lamps and resistances the scale can be calibrated only from 1/10 of a foot candle, to two foot candles, and it is desired to read a still higher foot candle, then such an addition of supplementary resistances or substitution

of lamps may be made that the two foot candle mark on the scale will come where the 1/10 foot candle mark came with the previous arrangement, and the instrument may be recalibrated to read considerably above two candles. This expedient should only be resorted to in case the light-giving lamp can safely be operated to a sufficiently high candle power. If it can not be so operated, it should be replaced by another suitable lamp, or a reflector may be placed behind it to increase its apparent light, with which change there must, of course, be a recalibration. In practice, I find that I can make one combination produce a sufficiently wide range to meausre all ordinary illumination. However, by calibrating the instrument successively with two or more light-giving lamps, each one can be used in practice as a check on the others, and as long as the measurements made with each are in agreement it is safe to assume that all calibrations have remained unchanged and are correct. By changing the size and length of the scale wire, I can give to the scale any desired degree of openness.

When the instrument is adapted for use over a wide range, or for several scales, by use of supplementary resistances with the substitution of lamps, I prefer not to calibrate the scale of the instrument in foot candles, but instead, to mark off the sub-divisions numerically in sequence and to employ a table or curve to which the numbers on the scale can be referred to give the foot candles of the measurement. In this way the instrument can be arranged for use with several combinations, each giving the instrument a different range, using with each combination a table or curve which was previously prepared in calibrating the instrument for that combination.

In the accompanying drawings I have shown one embodiment of my invention, but it should be understood that this is merely for purposes of illustration and that many changes may be made therein without departing from the spirit of my invention.

In the drawings, Figure 1 is a plan view of a device embodying my improvements; Fig. 2 is a sectional view of the upper portion of the same; Fig. 3 is a plan view of the case with the cover and upper portion, including the lamps and resistances, removed; Fig. 4 is a sectional view through the entire device; and Fig. 5 is a diagram of circuits.

Referring to the drawings, 1 indicates a box or case in the bottom of which are placed a number of dry cells 2, in this case nine such cells being shown. The box extends considerably above the top of the cells, and a cover is arranged to hold the battery in place in case the instrument is inverted, consisting of hinged bars 3 and 4, which may be swung open to remove the battery cells, and a pair of metallic clips 5 and 6, forming terminals for the battery cells, are arranged on bars 7 and 8 secured to the box in the plane of the bars 3 and 4. A base 9, provided with metallic blades 10 and 11 for fitting into the clips 5 and 6, is supported just above the bars 3 and 4. At the upper end of this base is an opaque box made of two portions 12 and 13 which are arranged to telescope within each other by means of slots 14 in the lower portion and a pin 15 in the upper portion. In the upper end of the portion 13 is a screen comprising a paraffined portion 16 and an opaque portion 17. Within the opaque box and mounted on the base 9 are sockets 18 for lamps. The cover of the box 19 is cut away to fit over the opaque box and has secured to its inner side and concentric with the opaque box a strip of insulating material 20 and a resistance wire 21 secured in the edge of this strip. Coöperating with this resistance wire is a spring contact 22, adapted to slide in a slot 23 and having a pointer 24 coöperating with a scale 25 in the outside of the cover. A resistance 26 is arranged along the side of the upper portion of the box and contactor 27 adapted to slide through the slot 28 along the rod 29. The galvanometer 30 is arranged in a convenient position on the cover, which cover is made easily removable by pressing the pins 31 to unlock the same. When the device is not in operation the upper portion 13 of the opaque box is turned until the pin 15 engages the slot 14 and allows the upper portion to drop. The lowering of the screen likewise affords another range of calibration. A cover 32 is then placed over the screen and secured by pins 33.

The instrument as thus constructed is connected in circuit as shown in Fig. 5. Any one or all of the four resistances 34, 35, 36 and 37, may be incandescent lamps and placed in the sockets 18. As before stated, some of these lamps may run below incandescence and a sensitive arrangement would be to have the lamps 34 and 36 of untreated filament run below incandescence, and lamps 35 and 37 of metallized, treated filament run at incandescence. The galvanometer 30 is connected across the bridge, having a switch 38 included in the circuit and the adjustable contact 22 arranged for balancing the bridge. The battery 2 is then connected in series with the resistance 26 and switch 39, as shown in Fig. 5. To use the device, the resistance 26 is varied by means of the brush 27 until the illumination of the paraffined portion 16 of the screen is equal to the illumination at the point where it is to be measured. When the illumination on both sides of the screen is equal, the contactor 22 is slid along the resistance wire 21 until the bridge is balanced, which balance is indicated by there being no deflection of the galvanometer. The illumination falling on the screen may then be indicated in foot candles upon the scale 25, or the divisions of this scale may be made to correspond with points on a curve which has previously been plotted, and thereby indicates the illumination. The spot should always be viewed at the same angle and for this reason I have arranged a rod 40 on the cover, and the spot should be viewed with the eye in line with the top of this rod. With many types of photometer spots there is difficulty in making comparisons of lights that vary greatly in color, and our light standard used, as it is, over a wide range of C. P. is very different in color at low C. P. than it is at high C. P. I find that I can very satisfactorily overcome this difficulty by employing a spot of the compound type, using for the more opaque of the two papers one of a pinkish color, and for the more transparent paper, ordinary tracing cloth preferably with the tracing cloth on top and with the rough surface up. With this device, I can make a good comparison with my luminometer even for the measurements of daylight.

It will be seen that the instrument is small and the parts thereof compactly arranged so that it is well adapted for portable use. Moreover, no electric measuring instruments are required and a knowledge of the

voltage supplying the instrument is not necessary in order to obtain correct readings.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. A luminometer comprising a source of electric light, a photometer screen in coöperative relation therewith, means for varying the candle power of said light, and an instrument for measuring said variation.

2. A luminometer comprising an electric circuit and resistance devices arranged to cause equi-potential points therein, an indicating instrument connected across said points, a source of electric light in said circuit, a photometer screen in coöperative relation therewith, and means for varying the candle power of said light.

3. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, an indicating instrument arranged for connection across the bridge, and a photometer screen in coöperative relation to said lamp.

4. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, an adjustable resistance in series with the bridge, an indicating instrument arranged for connection across the bridge, and a photometer screen in coöperative relation to said lamp.

5. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, an indicating instrument arranged for connection across the bridge, means for adjusting the point of connection of the indicating instrument to one side of the bridge, and a photometer screen in coöperative relation to said lamp.

6. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, a resistance in series with said lamp in its arm of the bridge, an indicating instrument arranged for connection across the bridge, and a photometer screen in cooperative relation to said electric lamp.

7. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, an adjustable resistance in series with the bridge, an indicating instrument arranged for connection across the bridge, means for adjusting the point of connection of the indicating instrument to one side of the bridge, and a photometer screen in coöperative relation to said lamp.

8. A luminometer comprising an electric lamp and resistances connected to form arms of a Wheatstone bridge, an indicating instrument arranged for connection across the bridge, means for adjusting the point of connection of said instrument to one side of the bridge, a scale adjacent to the path of adjustment of said point of connection, and a photometer screen in coöperative relation to said lamp.

9. A luminometer comprising an electric lamp and resistances connected to form the arms of a Wheatstone bridge, a resistance in series with said lamp in its arm of the bridge, an indicating instrument arranged for connection across the bridge, an adjustable resistance in series with the bridge, and a photometer screen in coöperative relation to said electric lamp.

10. A luminometer comprising a base having mounted thereon an electric lamp and an opaque box over the lamp, a photometer screen in one of the faces of the box, resistances mounted on said base, means connecting said lamp and resistances to form the arms of a Wheatstone bridge, means on said base for supporting a resistance and connecting it in series with said electric lamp in its side of the bridge, an indicating instrument arranged for connection across said bridge, a scale adjacent to the point of connection of said instrument to one side of the bridge, and an adjustable resistance mounted on said base and connected in series with the bridge.

In witness whereof, I have hereunto set my hand this twenty third day of July, 1906.

JOHN T. MARSHALL.

Witnesses:
S. N. WHITEHEAD,
GEO. V. DELANEY.