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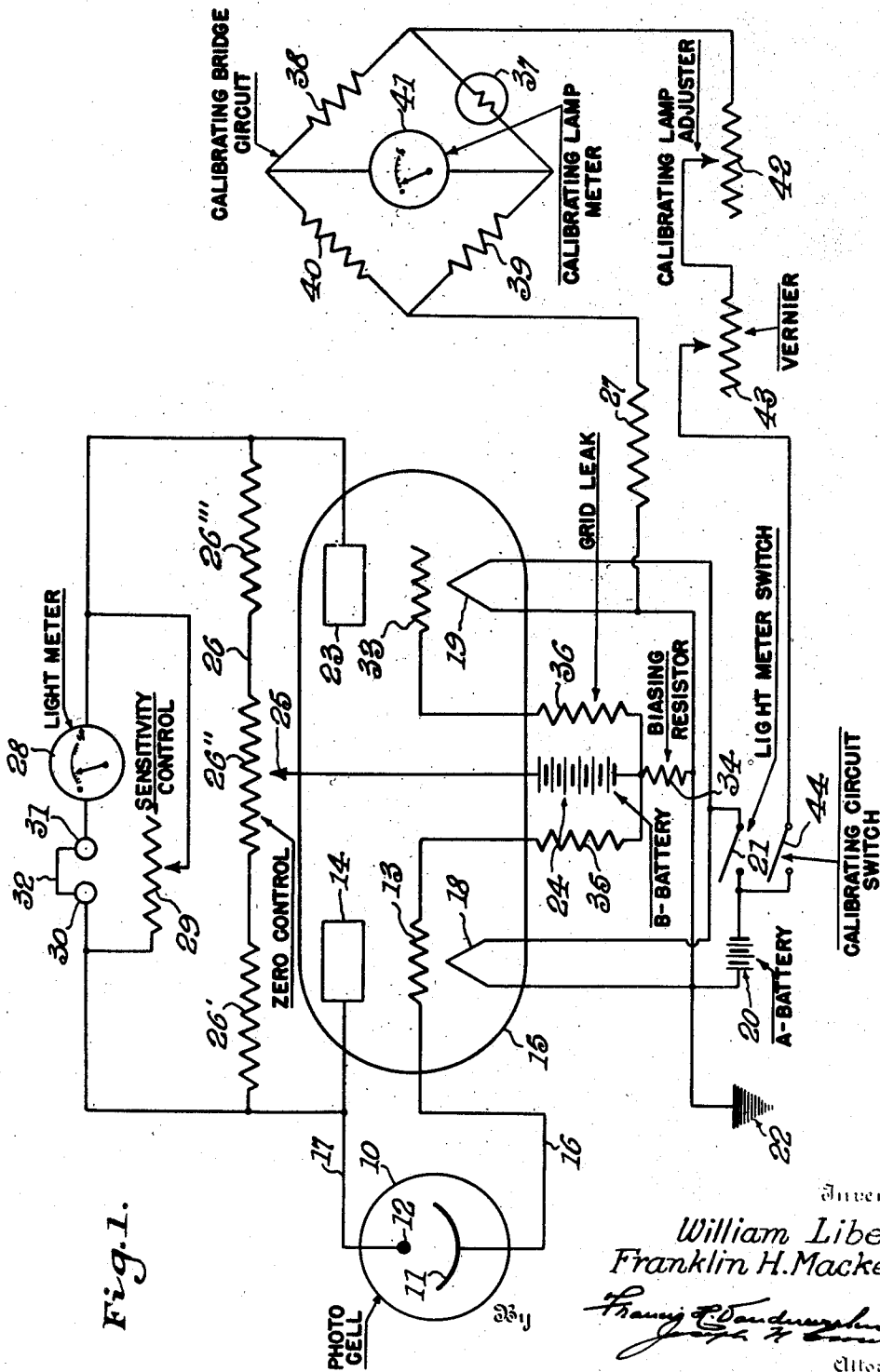
W. LIBEN ET AL

2,428,806

PHOTOELECTRIC PHOTOMETER

Filed Sept. 26, 1944

3 Sheets-Sheet 1



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Fig. 2.

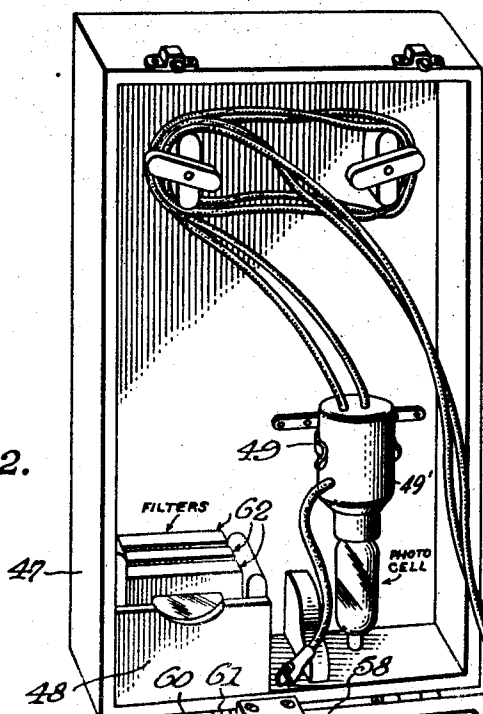


Fig. 6.

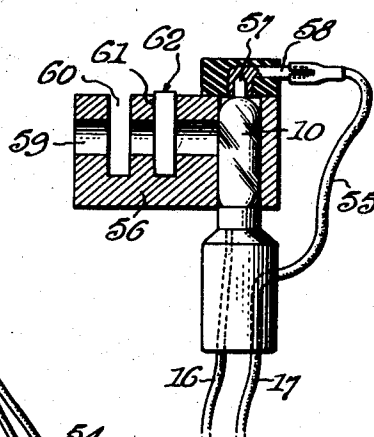
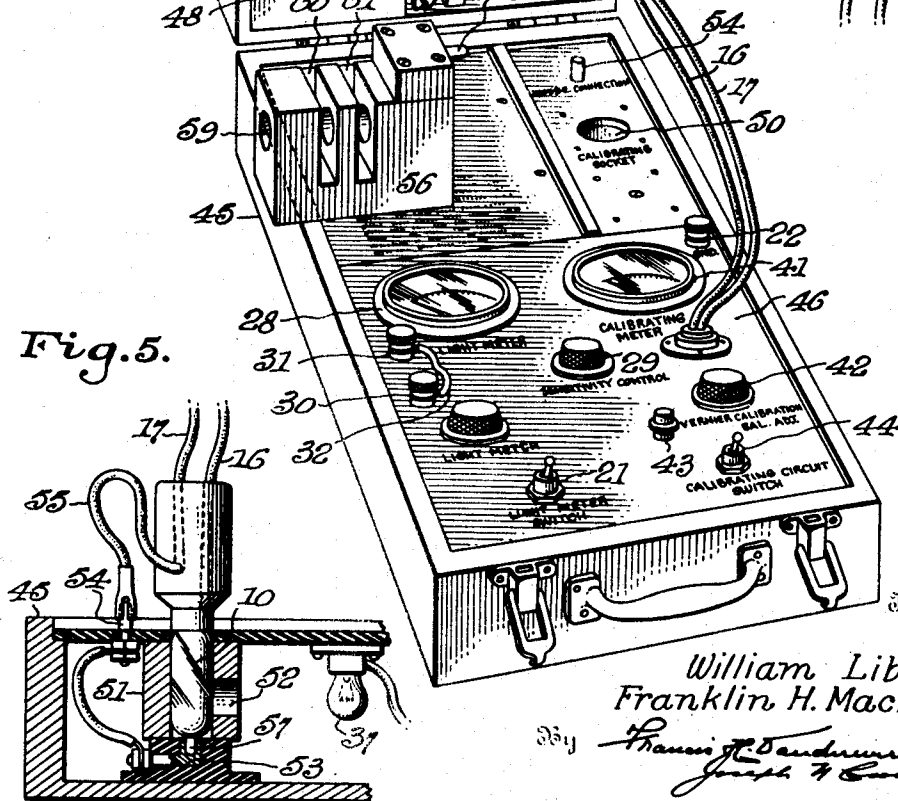


Fig. 5.



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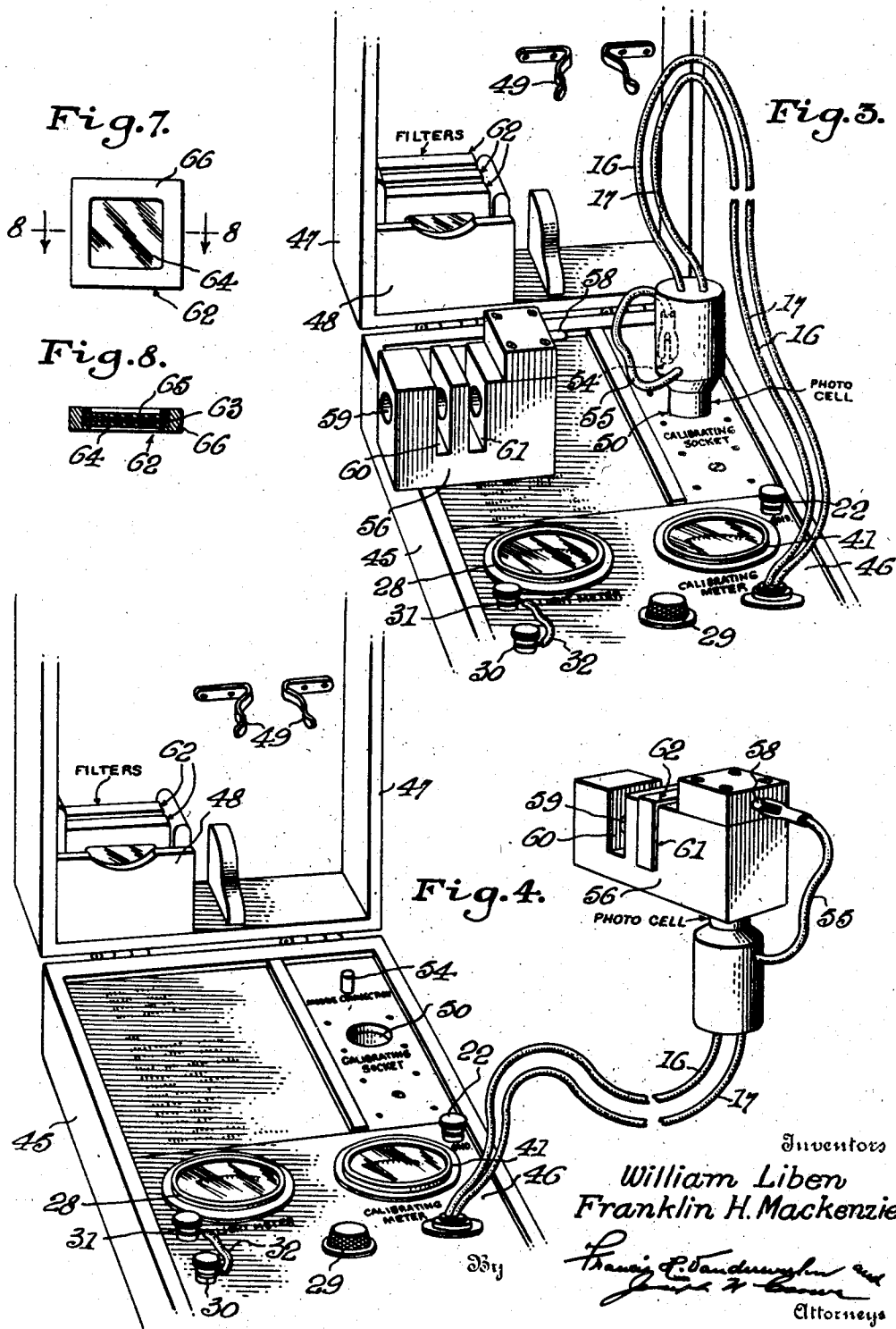
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UNITED STATES PATENT OFFICE

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PHOTOELECTRIC PHOTOMETER

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4 Claims. (Cl. 88—23)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without payment to us of any royalty thereon.

The present invention relates to a photoelectric photometer and more particularly to a portable photometer capable of measuring light intensities of a wide range.

An object of the invention is to provide a portable photometer by means of which accurate, direct readings of light intensities may be made in the field, for example to test the illumination of search lights or to determine illumination under blackout conditions. Another object of the invention is to provide a portable photometer combined with means for calibrating the photometer without disturbing the circuit connections of the photometer. Other objects and advantages of the invention will appear from the following description and the accompanying drawings in which:

Figure 1 diagrammatically illustrates a circuit of a photometer incorporating the invention;

Figure 2 is a perspective view of a portable photometer incorporating the invention illustrating the arrangement of various elements for transportation;

Figure 3 is a partial view in perspective of the portable photometer with the photoelectric cell inserted in the calibrating socket;

Figure 4 is a partial perspective view of the portable photometer as assembled for use in the field;

Figure 5 is a vertical section of a portion of the photometer containing the calibrating socket with the photoelectric cell inserted as illustrated in Figure 3;

Figure 6 is a vertical section of the combined photoelectric cell housing and filter holder with the photoelectric cell inserted as illustrated in Figure 4;

Figure 7 illustrates a filter for use with the photometer; and

Figure 8 is a sectional view taken along the line 8—8 of Figure 7.

Referring to the drawings in detail, in the circuit illustrated in Fig. 1, there is a photoelectric cell 10 connected to a single amplifying stage. The photoelectric cell 10 should be a vacuum type cell having a linear output characteristic in the low light level range. An example of a satisfactory type of photoelectric cell is one commonly designated by the trade as a 917. Other photoelectric cells may be used to increase sensitivity or to make the instrument more adaptable to lights of different wave lengths.

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A cathode 11 and an anode 12 of the photoelectric cell 10 are connected, respectively, to a grid 13 and a plate 14 of an amplifying tube 15 through shielded leads 16 and 17. Soldered connections are made between the leads 16 and 17 and the base of photoelectric cell 10 to avoid variations in the electrical characteristics of the circuit during the use of the photometer.

The amplifying tube 15 illustrated is of the duplex triode type commonly known as a 1G6GT having a dual set of elements. There are two plates 14 and 23, two grids 13 and 33 and two filaments 18 and 19. A pair of triode amplifying tubes may be used in place of the 1G6GT tube. The filaments 18 and 19 of the amplifying tube 15 are connected to a 1.5 volt A battery 20. One side of each of the filaments 18 and 19 is connected through a switch 21 to the positive side of the battery 20 and the other side of each of the filaments is connected to the negative side of the battery 20 and to ground 22.

The plates 14 and 23 of the duplex triode tube 15 and the photoelectric cell 10 are supplied with operating voltages from a 90 volt B battery 24. The positive side of the battery 24 is connected to a variable center tap 25 of a potentiometer 26 shunted across the plates 14 and 23 of the amplifying tube. The potentiometer 26 consists of three 500 ohm resistors 26', 26'' and 26''' connected in series. The variable center tap 25 connects with the central resistor 26''. The resistors of the potentiometer 26 and the dual sets of elements in the amplifying tube form a bridge circuit that may be balanced by adjusting the center tap 25 of the potentiometer in a manner described hereinafter. A microammeter 28 having a scale reading from zero to fifty is also connected across the plates 14 and 23 of the tube 15. The sensitivity of the microammeter 28 may be regulated by adjustment of a 2500 ohm variable resistance 29 connected across the meter. Binding posts 30 and 31 are connected in series with the meter 28 and are normally shunted by a connecting link 32. If it is necessary to use a meter of greater sensitivity than the meter 28, the connecting link 32 is removed and the more sensitive meter is connected to the binding posts 30 and 31.

A common biasing potential is applied to the grids 13 and 33 of the tube 15 by the drop across a 1000 ohm resistance 34 connecting the grids 13 and 33 through 50 megohm grid leaks 35 and 36, respectively, to the negative side of the B battery 24 and to ground 22.

Under conditions where no light falls on the photoelectric cell 10 and consequently no poten-

tial is impressed on the grid 13 of the amplifier tube. The variable center tap 25 of potentiometer 26" is adjusted so that the voltage drop between contact tap 25 and plate 14 equals the voltage drop between tap 25 and plate 23. In consequence of this adjustment no current will flow in the meter arm of the bridge circuit and the reading of the microammeter 28 will be zero. When light falls on the photoelectric cell 10, a potential is applied to the grid 13 of the tube 15, thus changing the bias of the grid 13 and causing a corresponding change in the output of the plate 14 associated with it. This change in output unbalances the bridge circuit and causes current to flow through the microammeter 28.

The values of the resistors given above were selected so that the 917 photoelectric cell 10 and the 1G6GT tube will operate on the straight line portions of their respective characteristic operating curves. This arrangement permits use of a straight line calibration for the microammeter 28 which can then be read directly in foot candles. Other types of photoelectric cells and amplifying tubes may be substituted in the instrument with appropriate changes being made in the circuit.

A calibrating bridge circuit is provided for calibrating the photoelectric cell 10 and the readings of the meter 28. This circuit is a Wheatstone bridge having a 3.8 volt flashlight bulb 37 and a 3.33 ohm resistance 38 connected in series as two arms of the bridge opposite two 6 ohm resistances 39 and 40 connected in series and forming the other two arms of the bridge. A calibrating milliammeter 41 having a scale reading from zero to five is connected to the detector terminals of the bridge. The terminal of the bridge between the two 6 ohm resistances 39 and 40 is connected through a .027 ohm resistance 27 to the negative side of the A battery 20 and ground. The terminal of the bridge between the 3.33 ohm resistance 38 and the flashlight bulb 37 is connected through a one ohm rheostat 42, a .035 ohm vernier rheostat 43 and a switch 44 to the positive side of the A battery 20. By this arrangement the sensitivity of the calibrating meter 41 may be raised so that a null point adjustment may be accomplished with a sensitivity that matches the photometer.

By adjusting the resistances of the rheostats 42 and 43 which are external to the bridge circuit itself, the resistance of the filament of the lamp 37 may be varied to balance the bridge circuit. The change in the resistance of the lamp filament is a function of its thermal coefficient so that when the resistances of the rheostats 42 and 43 are decreased, the resistance of the lamp filament is increased. When the bridge circuit is balanced in the manner described, the illumination of the lamp 37 is fixed at a known value.

The components of the circuit described above with the exception of the photoelectric cell 10 are assembled in a portable carrying case 45 that is completely metal shielded. The various meters and controls are mounted on a panel 46 and there is a hinged cover 47. The cover 47 is provided with a compartment 48 to hold a set of filters and a spring clamp 49 to hold an adapter 49' to which is detachably connected the above referred to photoelectric cell 10.

A calibrating socket 50 is located in the carrying case 45. This socket 50 consists of a housing 51 to receive the photoelectric cell 10. The housing 51 has an aperture 52 extending through one side in line with the calibrating lamp 37 so

that light from the lamp 37 will strike the photoelectric cell 10 when it is inserted in the socket. A contact 53 to receive the anode of the photoelectric cell 10 is located in the base of the socket 50 and is wired to a terminal 54 located on the front panel 46. Connection between the terminal 54 and the lead 17 is made by a flexible lead 55 which extends from the adapter 49' as clearly shown in Fig. 5 of the drawings.

When the photoelectric cell 10 is placed in the calibrating socket 50, the light from the lamp 37, which has a fixed value of illumination, falls on the cell 10. This results in a reading on the microammeter 28. By adjusting the sensitivity resistance 29 the reading on the ammeter 28 may be made to correspond to the known value of the illumination from the lamp 37. As previously described the photoelectric cell 10 and the amplifying tube 15 are operated within the linear limits of their operating curves so that when the photoelectric cell has been calibrated in conjunction with the microammeter 28 for a known value of illumination, the ammeter may be read directly in foot candles for other values of illumination.

The provisions described above permit accurate calibration of the photometer immediately prior to its actual use and under the actual conditions to which the instrument is subjected without disturbing the electrical circuits of the photometer and without establishing any additional circuits in the field. This is of great importance inasmuch as variations in the electrical circuits will greatly affect the operation of such a sensitive instrument.

After the photometer has been calibrated the calibrating circuit is disconnected by opening the switch 44 and the photoelectric cell 10 is removed from the calibrating socket 50 and is placed in a movable housing 56 for use at points remote from the instrument.

The housing 56 has a socket to receive the photoelectric cell 10 and a contact 57 to receive the anode connection of the photoelectric cell 10. The contact 57 has a terminal 58 located on exterior of the housing 56 to which the lead 55 is connected. The housing 56 has an elongated portion through which an oval shaped opening 59 extends to the socket portion. The opening 59 permits light rays to strike the photoelectric cell when the cell is in the socket and the area of the opening 59 is approximately equal to the flat plane area of the cathode 11 on which it is focused.

The elongated portion of the housing 56 is provided with two slots 60 and 61 in each of which a light filter 62 may be placed. The slots 60 and 61 extend across the opening 59 so that the filters will be interposed between the photoelectric cell 10 and the source of light.

The filters 62 are constructed by placing a photographic negative 63 between two sheets of glass 64 and 65 and mounting them in a Bakelite frame 66.

A set of three filters of various light transmitting powers is provided. Filter No. 1 includes a negative having a light transmission of ten per cent; filter No. 2 includes a negative having a light transmission of one per cent; and filter No. 3 includes two negatives each having a light transmission of one per cent so that the total light transmitting power of this filter is one hundredth of one per cent.

By using the various filters and combinations thereof in conjunction with the photoelectric cell 10, the full scale reading of the microammeter

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may be made to read directly over a range from .05 to 50,000 foot candles. The full scale reading of the meter with various filters being as follows:

Filter	Full Scale Reading of Meter
	Foot candles
No Filter	.05
Filter No. 1	0.50
Filter No. 2	5.00
Filter No. 1 and No. 2	50.00
Filter No. 3	500.00
Filter No. 1 and No. 3	5,000.00
Filter No. 2 and No. 3	50,000.00

While a particular embodiment of the invention has been described in detail it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention.

Having thus described our invention, what we claim as new and wish to secure by Letters Patent is:

1. In a photometric apparatus, the combination with a portable casing provided with an instrument panel, a light-responsive cell, an adapter for said cell, said adapter being removably associated with said casing; of a light metering system within said casing adapted to coact with said light-responsive cell to indicate the light response thereof, said system including a panel-mounted light meter and a pair of electrically shielded flexible cables extending from said panel, said cables constituting input and output leads for said system and terminating in said adapter, means in connection with said system for determining the intensity of a light source located at a distance from said casing, said means including a portable light receiver formed with a light opening and provided with means for seating said light-responsive cell in operative relation with respect to said light opening, and coacting means in connection with said light receiver, light-responsive cell and adapter for establishing an electrical relation between said light-responsive device and said light-metering system through said adapter and the cables terminating therein, and means for calibrating said light meter in terms of units of illumination, said means including a light calibrating housing formed with a light opening, and a seat communicating with said opening and adapted to receive said light-responsive cell, a light source, means for adjusting said light source so that its illuminating effect corresponds to a predetermined unit of illumination, and coacting means between said calibrating housing, said light-responsive cell, and said adapter for establishing an electrical relation between said cell and said system through said adapter and the cables attached thereto.

2. In a photometric apparatus, the combination with a portable casing provided with an instrument panel, a photoelectric cell and adapter therefor, said adapter being removably associated with the casing; of a light metering system within said casing adapted to coact with said cell to indicate the response thereof, said system including a panel-mounted light meter and a pair of electrically shielded cables extending from said panel, said cables constituting input and output leads for said system and terminating at their free ends in said adapter, means within said casing for calibrating said light meter in terms of units of illumination, said means including a calibrat-

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ing housing disposed adjacent said panel, and formed with a seat adapted to receive said photoelectric cell, a light source within said housing in operative relation with respect to said cell, means

for regulating said light source to provide an illuminating effect corresponding to a unit of illumination, means exterior of the casing for determining the intensity of a light source located at a distance from said casing and including a portable light receiver formed with a light opening and a socket for said photoelectric cell in communication with said opening, and coacting means in connection with said adapter, cell, light calibrating housing and light receiver for placing said cell in electrical relation with said cables when said cell is successively seated in said calibrating housing and said light receiver.

3. In a photometric apparatus, the combination with a portable casing provided with an instrument panel, a photoelectric cell and adapter therefor, said adapter being removably associated with the casing; of a light metering system within said casing adapted to coact with said cell to indicate the response thereof, said system including a panel-mounted light meter and a pair of electrically shielded cables extending from said panel, said cables constituting input and output leads for said system and terminating at their free ends in said adapter, means within said casing for calibrating said light meter in terms of units of illumination, said means including a calibrating housing disposed adjacent said panel and formed with a seat adapted to receive said photoelectric cell, a light source within said housing in operative relation with respect to said cell, means for regulating said light source to provide the illuminating effect of a unit of illumination, said means including a Wheatstone bridge network disposed within said casing and having said light source in one leg thereof, a panel-mounted calibrating meter across said bridge, a source of electrical energy, and means for balancing said bridge, the balancing of said bridge regulating the intensity of the light source to provide a unit of illumination, means exterior of the casing for determining the intensity of a light source located at a distance from said casing and including a portable light receiver formed with a light opening and a socket for said photoelectric cell in communication with said opening, and coacting means in connection with said adapter, cell, light calibrating housing and light receiver for placing said cell in electrical relation with said cables when said cell is successively seated in said calibrating housing and said light receiver.

4. In a photometric apparatus, the combination with a portable casing provided with an instrument panel, a photoelectric cell and adapter therefor, said adapter being removably associated with the casing; of a light metering system within said casing adapted to coact with said cell to indicate the response thereof, said system including a panel-mounted light meter and a pair of electrically shielded cables extending from said panel, said cables constituting input and output leads for said system and terminating at their free ends in said adapter, means within said casing for calibrating said light meter in terms of units of illumination, said means including a calibrating housing disposed adjacent said panel and formed with a seat adapted to receive said photoelectric cell, a light source within said housing in operative relation with respect to said cell, means for regulating said light source to provide the illuminating effect of a unit of illumination,

said means including a Wheatstone bridge network disposed within said casing and having said light source in one leg thereof, a panel-mounted calibrating meter across said bridge, a source of electrical energy, and means for balancing said bridge, the balancing of said bridge regulating the intensity of the light source to provide a unit of illumination, means exterior of the casing for determining the intensity of a light source located at a distance from said casing, said means including a portable light receiver formed with a light passage extending longitudinally of said receiver, one end of said passage opening to the exterior of said receiver, the other terminating in a seat adapted to receive said photoelectric cell, light filtering means detachably associated with said receiver in intercepting relation with respect to its light passage, and coacting means in connection with said adapter, cell, light calibrating housing and light receiver for placing said cell in electrical relation with said cables when said cell is successively seated in said calibrating housing and said light receiver.

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FRANKLIN H. MACKENZIE.

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