Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 1

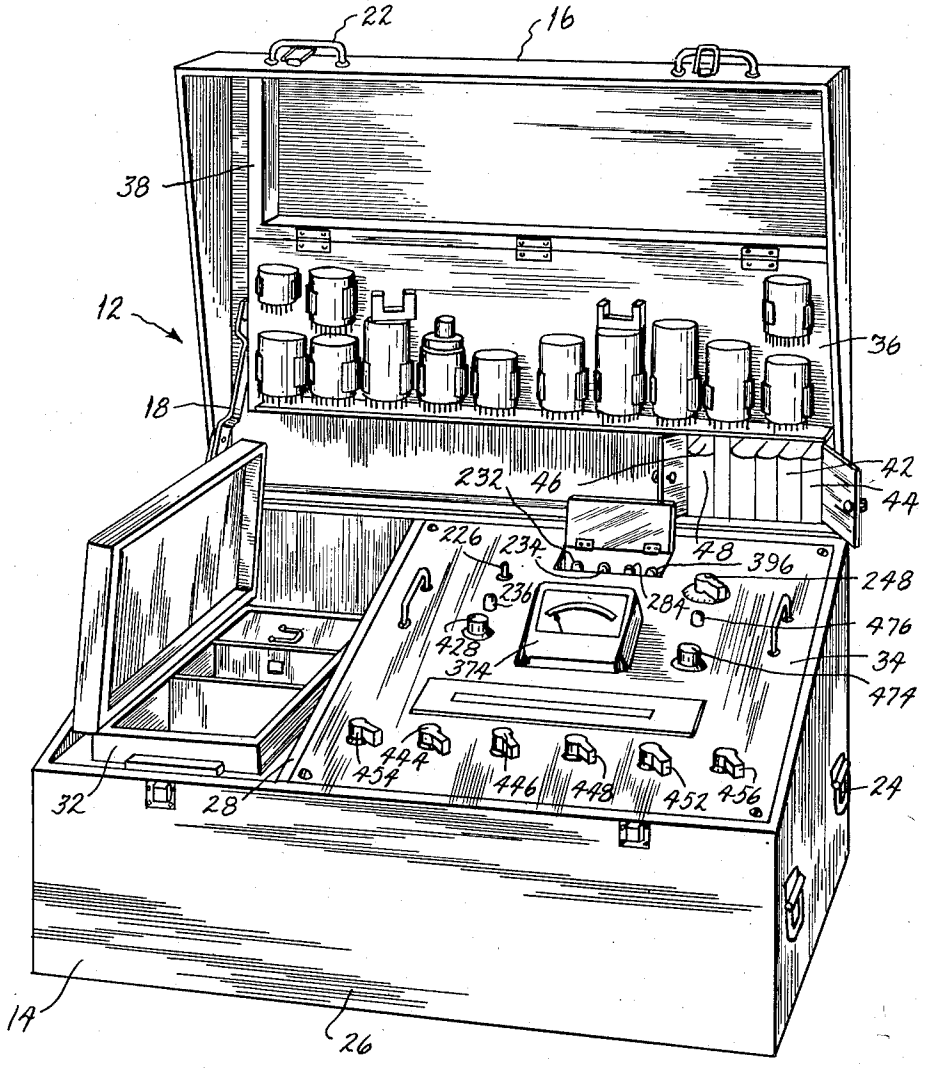

Fig. 1

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee S. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 2

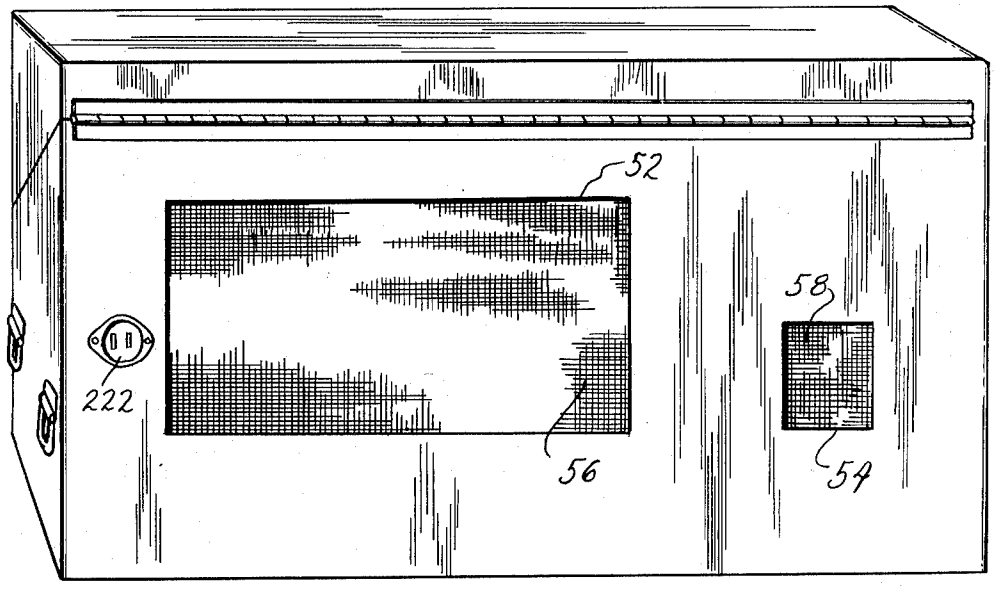

Fig. 2

TUBE TYPE	SWITCH 454 POSITIONS	SWITCH 456 POSITIONS	FIG. NO.
2 ELEMENT PHOTOTUBE (GENERAL)	2	3-8	13
PHOTOMULTIPLIER	2	1, 2	14
TWIN PHOTOTUBE (920)	1 2	8 7	15 16
CATHODE CAP (919)	3	3	17
ANODE CAP (917, 935)	4	3	18
2 ELEMENT PHOTOTUBE EITHER ELEMENT CATHODE OR ANODE (5652)	2 5	3 3	19 20

Fig. 20

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
BY REUBEN J. LEIBOWITZ
George Sipkin
Lee J. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 3

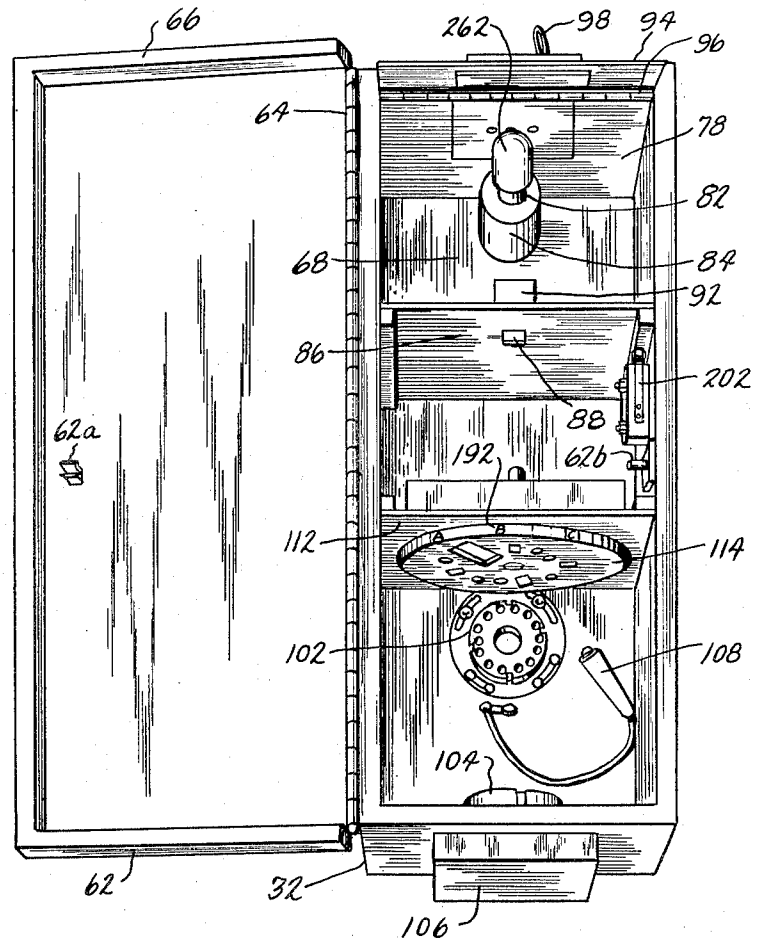

Fig. 3

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
BY REUBEN J. LEIBOWITZ
George Sipkin
Lee I. Shuttleworth
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 4

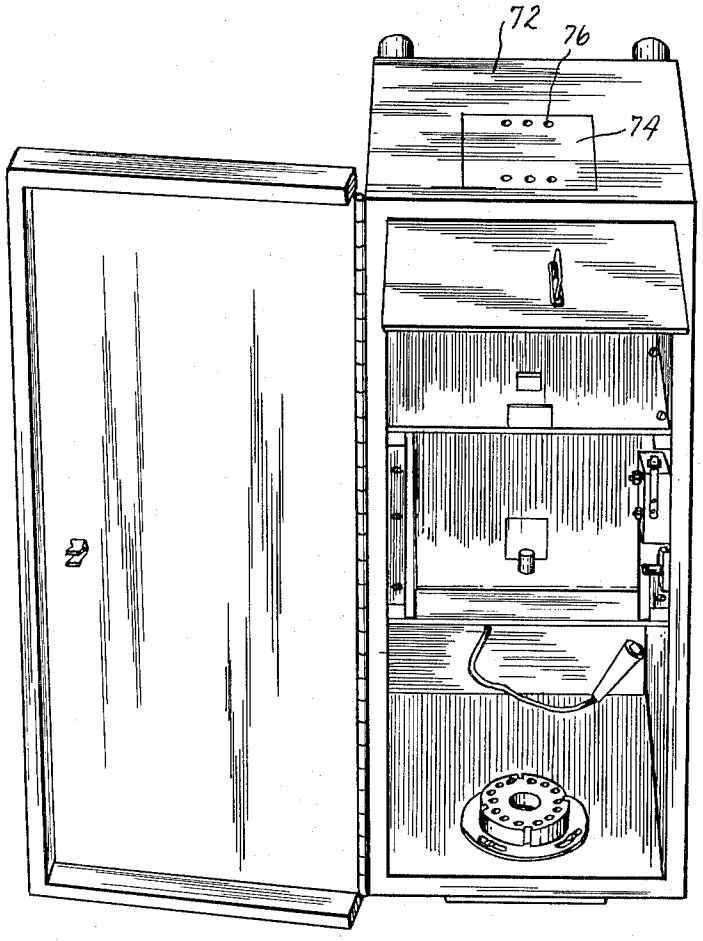

Fig. 4

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
BY REUBEN J. LEIBOWITZ
George Lipkin
Lee J. Strittberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 5

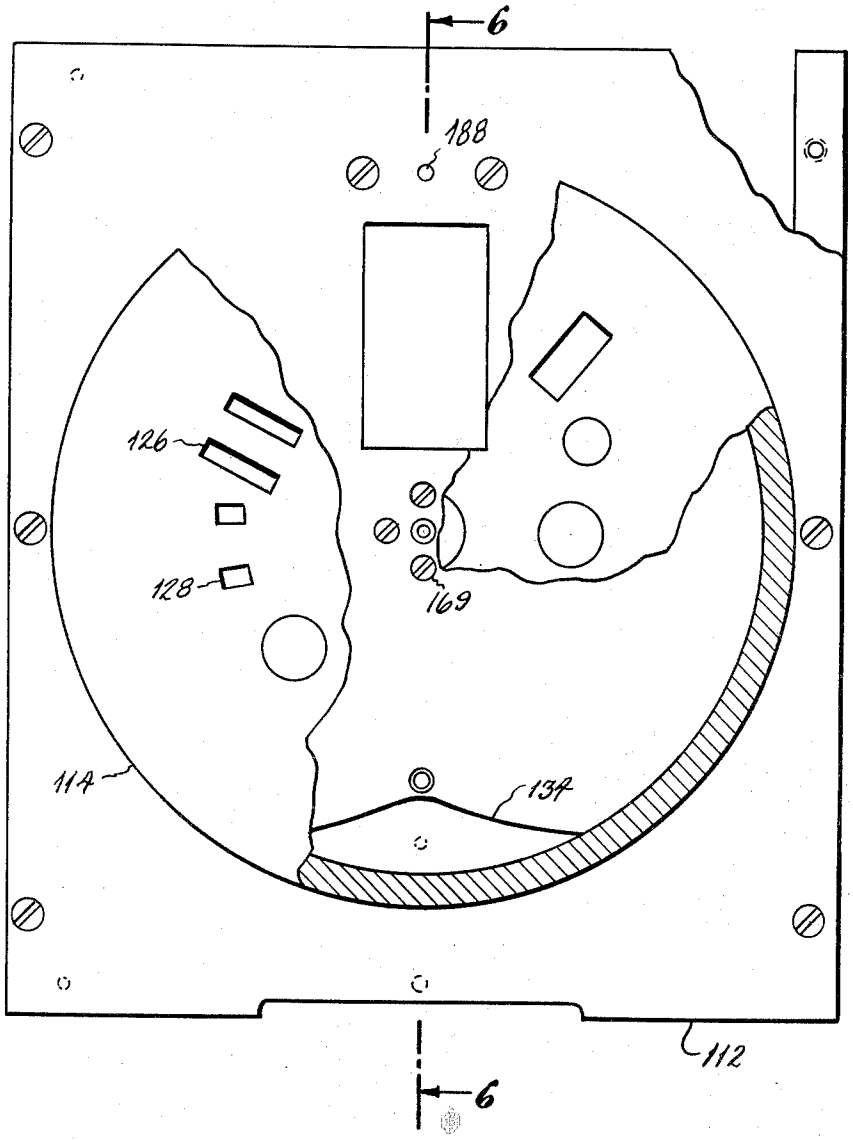

Fig. 5

INVENTORS
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee I. Shuntberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 6

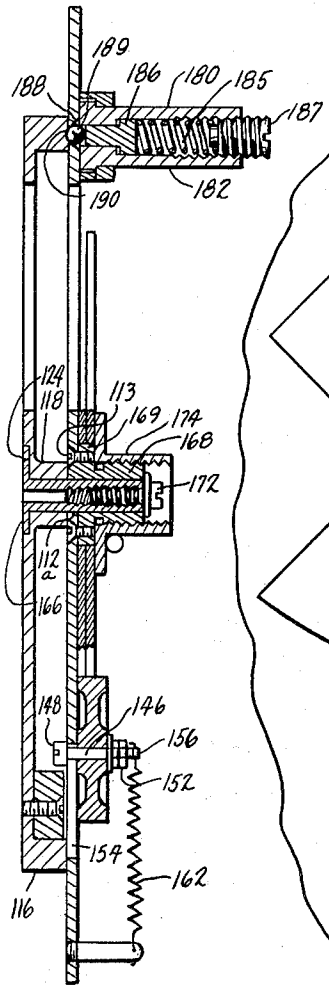

Fig. 6

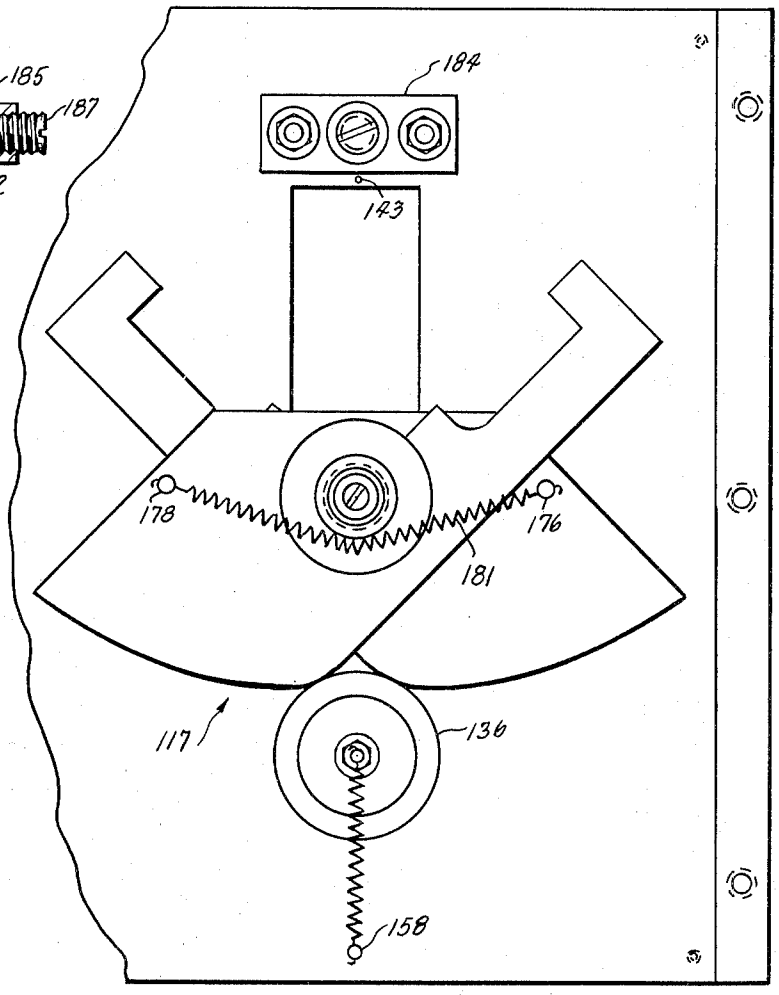

Fig. 7

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee I. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 7

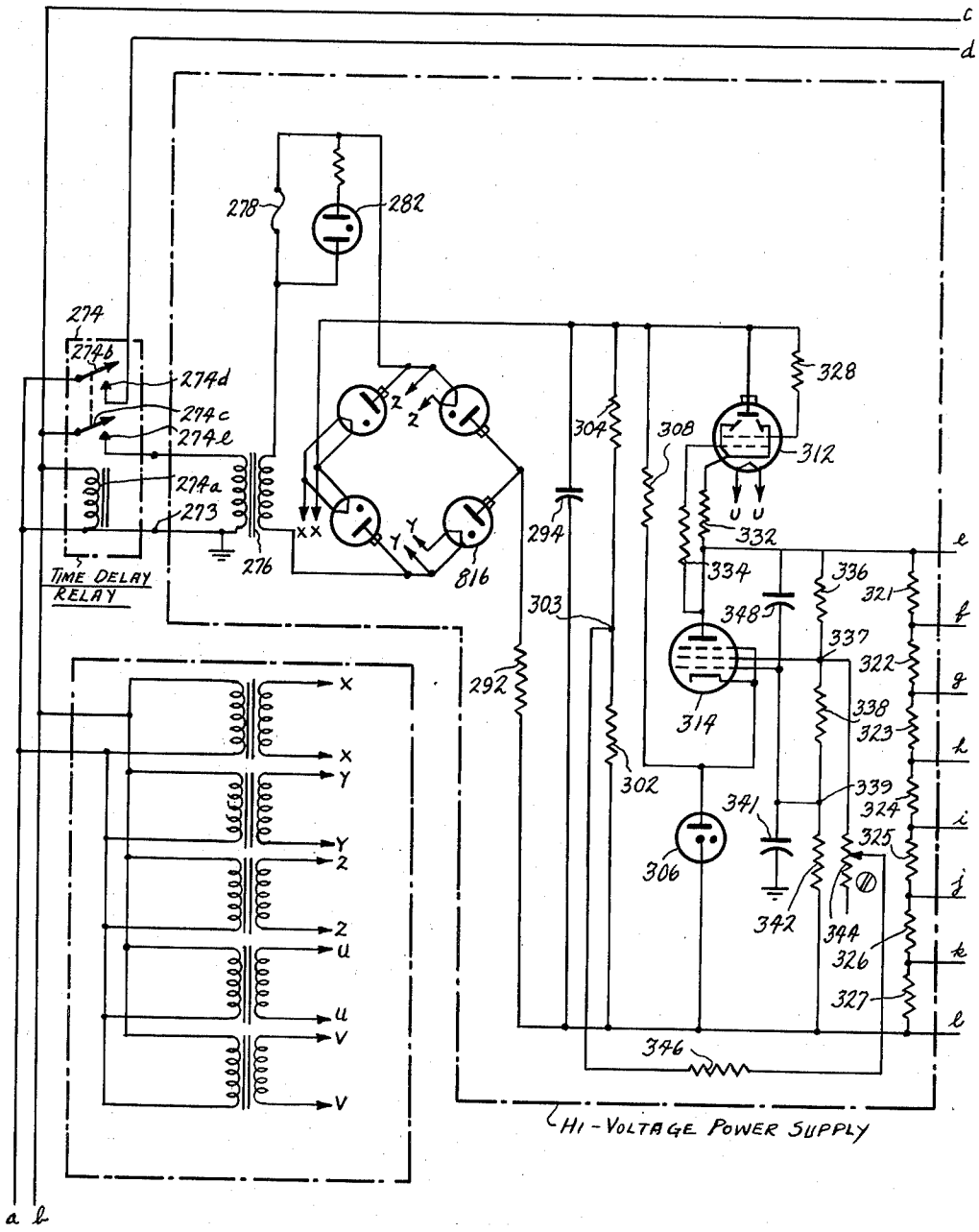

Fig. 8

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee I. Schlumberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 8

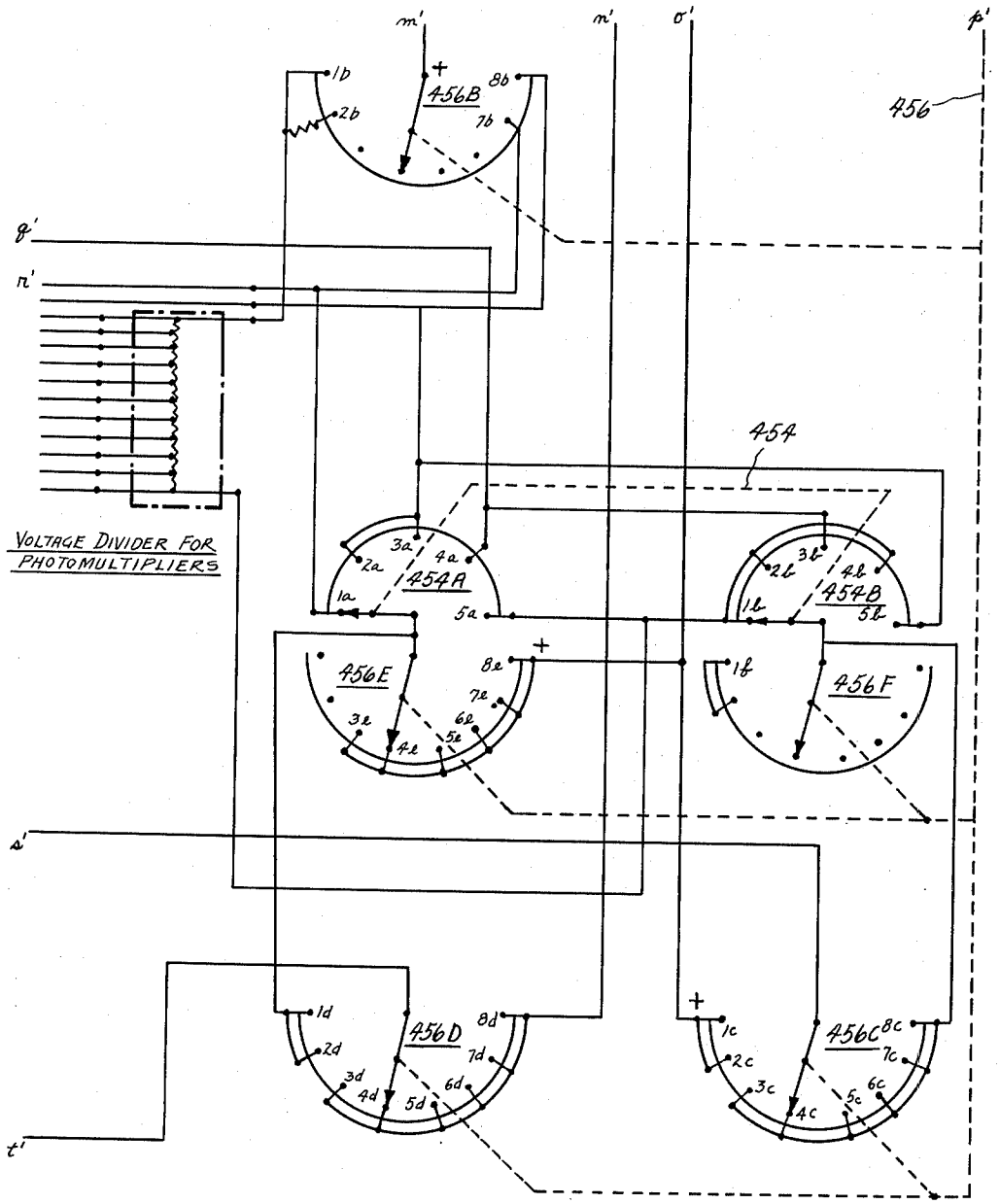

Fig. 9

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ

BY George Sipkin
Lee J. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 9

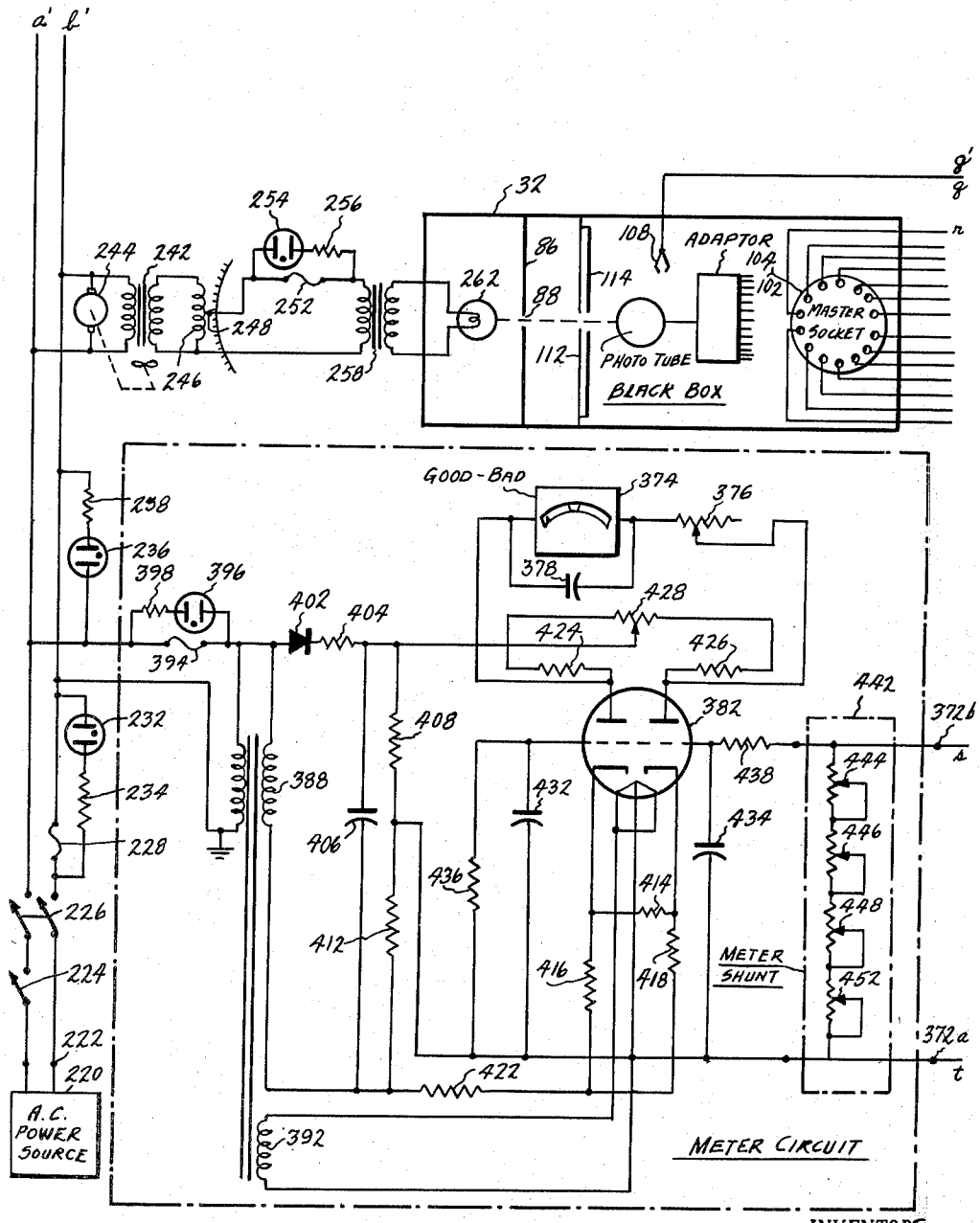

Fig. 10

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee T. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 10

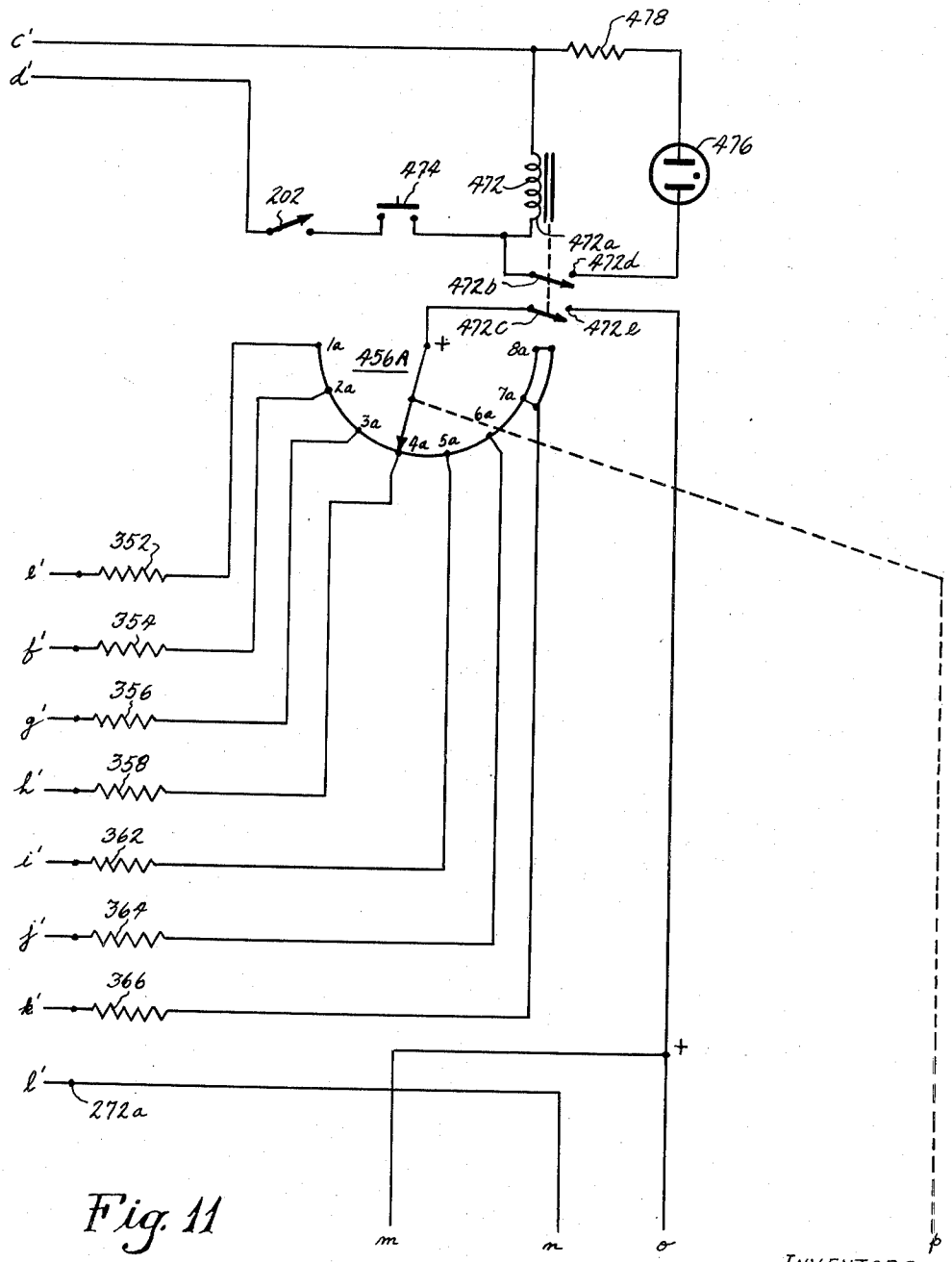

Fig. 11

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee S. Huntzberger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 11

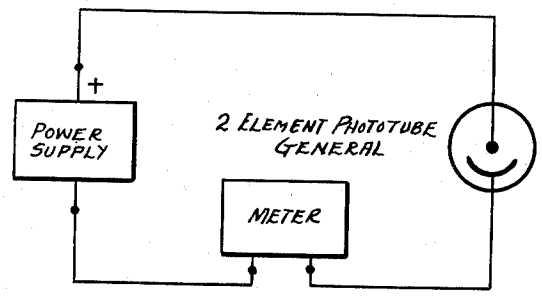

Fig. 12

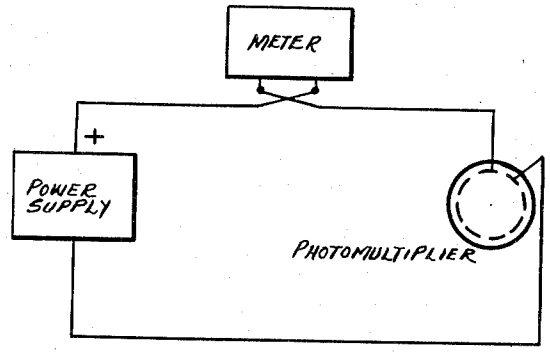

Fig. 13

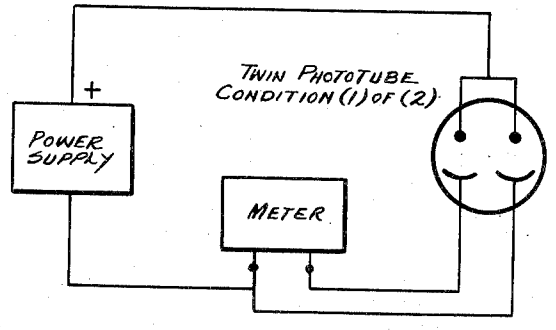

Fig. 14

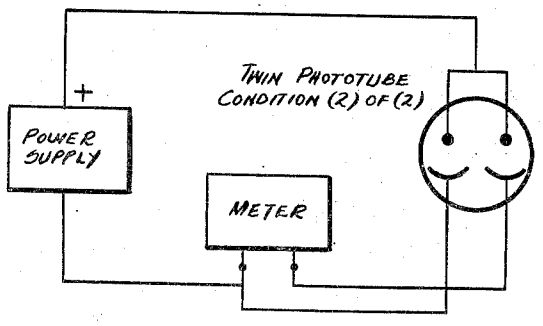

Fig. 15

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee J. Strunzburger
ATTORNEYS

Oct. 2, 1956 M. ADELMAN ET AL 2,765,440

PHOTOEMISSIVE TUBE TESTER

Filed June 10, 1954 12 Sheets-Sheet 12

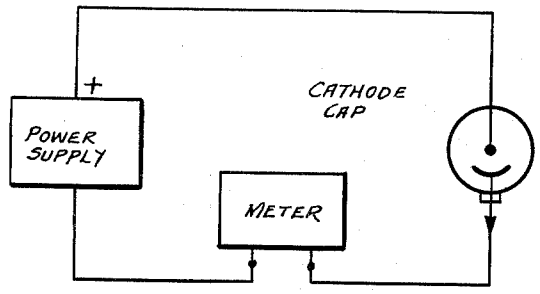

Fig. 16

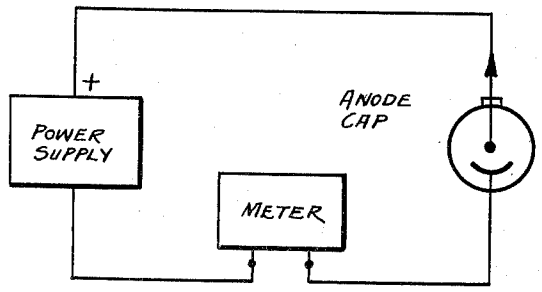

Fig. 17

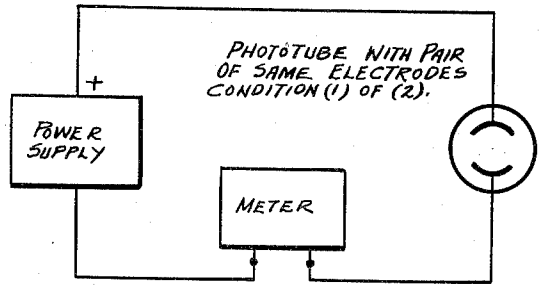

Fig. 18

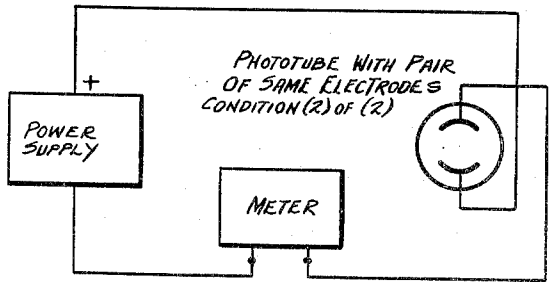

Fig. 19

INVENTORS.
MILTON ADELMAN
ROBERT W. BURKE
REUBEN J. LEIBOWITZ
BY George Sipkin
Lee I. Huntsberger
ATTORNEYS

United States Patent Office 2,765,440 Patented Oct. 2, 1956

2,765,440

PHOTOEMISSIVE TUBE TESTER

Milton Adelman, Robert W. Burke, and Reuben Leibowitz, New York, N. Y.

Application June 10, 1954, Serial No. 435,948

9 Claims. (Cl. 324—20)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention is directed to a photoemissive tube tester and more particularly to a portable universal photoemissive tube tester operable by a non-technical operator.

There is no universal photoemissive tube tester in the prior art. In the past, separate setups for each tube type have been used for testing photoemissive tubes in the factory, warehouse and service shop.

The term phototube is hereinafter substituted for photoemissive tube.

This invention is adapted either for testing different types of phototubes at discontinuous intervals, or for continuous mass testing of tubes off a production line, or for mass testing of tube stocks in a warehouse, to determine whether or not there are any tubes in the warehouse that have been so adversely affected by shelf life as to no longer be capable of functioning properly. Of the several measurable phototube characteristics, the anode current is the sole criterion for determining the end of useful life for all vacuum and phototubes except for photomultiplier tubes. Even in the case of photomultiplier tubes where the amplification characteristic is important, the anode current furnishes a reliable indication of the end of useful photomultiplier tube life. The effects of shelf life are manifest in a decreased anode current. A measurement of this characteristic is a basic method for determining the life stage of all phototubes. In other words, when anode current level of a phototube operating under recommended conditions drops below a predetermined reference value the phototube will not function properly for the prescribed length of time. Its effective life is too short and therefore is unacceptable. This minimum current is ascertainable from published Government and commercial specifications and empirical data and is not discussed herein since it is not germane to this invention. As for other parameters, life-test studies conducted independently by scientific personnel at phototube and optical companies produced concurring results in that spectral response does not vary significantly with age. Though results are inconclusive concerning the effect of age upon dark current, experimentation in Material Laboratory, New York Naval Shipyard, under cognizance of inventors, has shown that shelf life causes no prohibitive increase in dark current in phototubes.

The tester includes a black box for housing a standard lamp and the phototube under test. The standard lamp is the light source. It operates at a fixed color temperature and generates a known amount of light flux.

A partition having an aperture is mounted in the black box between the standard lamp and the phototube under test. The partition serves as a baffle. A mounting plate having an aperture is mounted in the black box between the partition and the phototube under test. A disk having a series of apertures some of which are covered by

neutral density filters is mounted on the mounting plate. Selected apertures in the disk are adapted to be aligned with the aperture in the mounting plate by rotation of the disk relative to the mounting plate. The sizes and the shapes of the apertures in the mounting disk correspond in each case to the portion of the cathode of the respective phototube type that is normally excited by luminous flux under recommended operation conditions. The radial distance between each of the apertures in the disk and the center of rotation of the disk, is directly related to the position of the cathode of the corresponding phototube under test when the latter is seated in the black box. Neutral density filters are included in some of the apertures of the disk for reducing the luminous flux for certain phototube types. The black box further includes master sockets connected in a test circuit. The phototube under test is adapted to be mounted in proper position in the black box through the use of corresponding adaptors which properly connect the phototubes with selected terminals of the master sockets and correctly position the various types of phototubes in the black box relative to the appropriate aperture and standard lamp. The tester further includes a circuit for applying the operating potentials to the phototube under test and a meter circuit for indicating the level of anode current. Since the range of anode currents for phototubes extends from about .2 microampere to about 200 microamperes, the anode current cannot be measured directly by a D'Arsonval galvanometer. The meter circuit includes a self compensating direct current amplifier with a variable input shunt. The tester further includes a phototube power supply. The power supply has to operate with good regulation since the anode current of gas phototubes and the anode current of multiplier phototubes change greatly with a slight change in operating potentials. The power supply included in the tester is a series regulated power supply which regulates with respect to line and load variation. A control panel is associated with the tester circuitry for conditioning the circuit to test each of the different types of phototubes. The setting of a minimum number of controls according to a chart provided right on the test panel, conditions the circuit for testing a particular phototube. The chart gives the disk position and designates the appropriate adaptor. The adaptors are stocked in the tester. Indicator bulbs strategically connected advise as to the operability of the circuit. A galvanometer in the meter circuit and mounted on the panel gives the results.

An object of this invention is to provide a phototube tester.

A further object is to provide a universal phototube tester.

A further object is to provide a universal phototube tester which translates test results directly and decisively.

A further object is to provide a universal phototube tester which is operable by non-technical personnel.

A further object is to provide a universal phototube tester which is portable.

A further object is to provide a universal phototube tester in a single self-contained unit.

A further object is to provide a universal phototube tester which is operable by non-technical personnel which is absolutely safe for operating personnel.

A further object is to provide a black box for use in testing phototubes.

A further object is to provide a black box for use in testing a variety of types of phototubes.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a perspective view of a preferred embodiment of this invention with its various closures in open position,

Fig. 2 is a rear view of the embodiment of the invention shown in Fig. 1 with the closures in closed position,

Fig. 3 and Fig. 4 are perspective views of the preferred embodiment of black box included in this invention,

Fig. 5 is a plan view with portions broken away of the disk arrangement used in the black box of Figs. 3 and 4,

Fig. 6 is a cross-sectional view taken along the line 6—6 of Fig. 5,

Fig. 7 is a plan view of the shutter and cam arrangement used in the black box of Figs. 3 and 4 and is taken from the rear of Fig. 5,

Figs. 8–11 are portions of composite schematic wiring diagram of the test circuit included in a preferred embodiment of this invention,

Figs. 12–19 are simplified schematic wiring diagrams showing the resultant circuit connections for various test conditions, and

Fig. 20 is a chart showing relationship between the tube type under test, the positions of the switches in the disclosed embodiment of the invention, and the figure numbers corresponding to the switch positions.

The tester **12** is a single self-contained unit mounted in a housing **14**. The housing **14** includes a hinged closure **16** supported when in open position by a folding bracket **18**. Handles **22** and **24** are provided on the closure and sides of the housing **14**, respectively. The body **26** of the housing **14** is subdivided into two portions by a partition **28**. On one side of the partition **28** is mounted a removable black box **32**. The circuitry portion of the tester is mounted on the other portion and is covered by an operator's panel **34**. In the hinged cover **16** of the housing **14** is provided another compartment **38** for housing a variety of adaptors. A hinged cover **36** is adapted to close the compartment **38**. Also included in the cover are two other compartments **42** and **46** for storing standard lamps **44** and for storing a standard phototube **48**, respectively. The rear of the housing **14** (Fig. 2) is cut out at **52** and **54**. Perforated screens **56** and **58** are secured in the cut-out portions. The screens permit air to circulate through the tester portions to limit the temperature rise.

The black box **32** is preferably made of wood. A cover **62** is fastened to the black box **32** by means of a piano hinge **64**. A piano hinge is used because it is important that the cover **62** close the black box **32** accurately and therefore completely to afford a light tight enclosure. Latching means for the cover **62** includes a spring clip **62A** fixed to the cover **62** and a pin **62B** fixed to the black box **32** for cooperation with the spring clip **62A**. A rim **66** appends from three sides of the cover **62** and when the cover is closed the rim **66** embraces the sides of the black box **32**. All inside surfaces are painted dull black with a matte finish. One end of the black box **32** is partitioned to provide a lamp compartment **68**. The end wall **72** of the black box which is also the end wall of the lamp compartment **68**, is cut out at **74** (Fig. 4). The cut-out **74** is closed by a ventilating screen which comprises a pair of spaced plates **76** and **78** (Fig. 4 and Fig. 3), each of which has apertures for circulating air. The apertures in the spaced plates **76** and **78** are staggered to prevent light from leaking into the black box. Both plates **76** and **78** are painted black. A lamp socket **82** is mounted on a pedestal **84** adjacent the end wall of the box **72**. The opposite end of the lamp compartment **68** is bordered by the partition **86** formed with an aperture **88**. Both the partition **86** and the pedestal **84** are designed so that the lamp filament is in alignment with the aperture **88** relative to the bottom of the black box. A lug **92** is fastened to the top of the partition **86**. A cover **94** is pivotally secured to the end wall **72** of the black box **32** by means of a piano hinge **96**. The cover **94** is

adapted to rest on the lug **92**. A finger grip **98** for the cover **94** is secured to the cover **94** through heat insulating material. This permits an operator to open the cover **94** even after the lamp has been lighted for a period of time sufficient to cause the compartment **68** to become hot.

The metal partition **86** and the metal cover **94** uniformly dissipate the heat given off by the lamp. Additional heat is dissipated through the two metal plates **76** and **78** containing the ventilating holes which are staggered to provide sufficient circulation of air while retaining the light-tight qualities of the box. The metal cover **94** serves to protect the operator's eyes from the glare of the lamp when the cover **62** of the black box **32** is raised. The metal partition **86** of the lamp compartment **68** serves as a light baffle and permits only direct rays from the lamp to pass on to the phototube under test.

A pair of master diheptal sockets **102** and **104** are secured toward the opposite end of the black box **32**. The master socket **104** is axially aligned with the aperture **88** in the metal partition **86** and the filament of the lamp mounted in the lamp socket **82**. The axis of the master socket **102** is perpendicular to the axis through the master socket **104** and is coplanar therewith. The master socket **102** is adapted to be used for all phototubes except end-on phototubes. End-on phototubes are adapted to be mounted in the black box by means of master socket **104**. The master sockets **102** and **104** are wired in parallel. The wiring from the master socket **104** extends to the underside of the box by means of an enclosed channel **106**. An alligator clip **108** is fastened in the black box **32** adjacent to master socket **102** for completing connections to phototubes having either anode or cathode caps. A transverse mounting plate is secured in the black box between the lamp compartment **68** and the master sockets **102** and **104**. A rotatable disk **114** is mounted on one side of the mounting plate **112**. A shutter and cam arrangement **117** is mounted on the opposite side of the mounting plate **112** (Figs. 5–7). The disk **114** is formed with an outer flange **116**. It is centrally formed with boss **118** terminating in substantially the same plane as that defined by the end of the outer flange **116**. The disk **114** is centrally formed with an opening **122** extending through the boss **118**. The surface of the disk opposite the boss **118** is recessed at **124**. A plurality of apertures, some rectangular and some circular, are formed in the disk **114**. The apertures differ in area and radial position. Twin rectangular openings **126** and **128** are for phototubes having twin cathodes. The mounting plate **112** includes a single rectangular aperture **132**. The aperture **132** in the mounting plate **112** is axially aligned with the aperture **88** in the partition **86** and with the filament of the standard lamp in the lamp compartment **68**. A cam **134** having a single high point is mounted on the inside of the flange **116** of the disk **114**. The high point of the cam is aligned along a diameter of the disk with the center of the largest rectangular opening of the disk **114** (Fig. 3). The disk **114** is mounted on the mounting plate **112** in combination with a shutter and cam arrangement **117**; it includes a wheel-like cam **136**. The wheel-like cam **136** operates in combination with a pair of similar shutter members **142** and **144**. The wheel-like cam **136** is mounted for rotation relative to a supporting pin **146**; the pin **146** terminates at one end in a head **148** and at its opposite end in a threaded portion **152**. The very end of the threaded portion **152** of the supporting pin **146** is formed with a spring receiving opening. A slot **154** is formed in the mounting plate **112** for permitting reciprocal movement of the pin **146** and its wheel-like cam relative to the mounting plate **112**. Wheel-like cam **136** is retained on the pin **146** by means of nuts **156**. A spring post **158** is secured to the bottom of the mounting plate **112** in alignment with the slot **154** formed in the mounting plate **112**. A tension spring **162** extends between the

supporting pin 146 and the spring post 158 for biasing the wheel-like cam 136 toward the bottom of the supporting plate 112. The head 148 of the pin 146 is adapted to bear against the inside perimeter of the flange 116 of disk 114. Reciprocal movement of pin 146 is obtained when brass cam 134, which is fastened to the inside of flange 116, slides under pin 146 and lifts it. Both the shutter members 142, 144, and the disk 114 are mounted for rotary movement about a single axis. The mounting means for both the disk 114 and the shutter members 142 and 144 include a flanged bushing 166, an externally threaded member 168 having a bearing flange 169 fastened to mounting plate 112 by screws 113 for supporting the shutter members 142 and 144, a screw 172 threaded into the flanged bushing 166 for retaining the disk 114 and flanged bushing 166 in assembled relationship relative to the mounting plate 112, and a flanged nut 174 having a knurled surface for retaining the shutter members 142 and 144 on the periphery of the bearing flange 169 of the externally threaded member 168 without clamping the shutter members against rotation. The flange of the bushing 166 seats in the recess 124 in the outer surface of the disk 114. The bushing 166 extends through an opening 112*a* formed in the mounting plate 112. The flanged bushing 166 is internally threaded at the end of the bushing opposite the flange. The externally threaded member 168 which is screw-fastened to the mounting plate 112 provides a clamping surface for screw 172 threaded into the end of the bushing 166 for retaining the disk 114 and flanged bushing 166 assembled to the mounting plate 112. The periphery of bearing flange 169 of the externally threaded member 168 is formed with a finished surface and is located against the surface of the mounting plate 112. It supports for rotation the shutter members 142 and 144. The bearing flange of the externally threaded member 168 is slightly wider than the combined thickness of the shutter members 142 and 144. The shutter members 142 and 144 are retained on the bearing flange 169 of externally threaded member 168 by the knurled nut 174 threaded on to the threaded portion of the externally threaded member 168 until it abuts the bearing flange. The shutter members 142 and 144 are provided with spring-supporting posts 176 and 178, respectively. A tension spring 182 extends between the spring supporting posts 176 and 178 for biasing the shutter members toward aperture restricting position.

Indexing detent means 180 is secured to the mounting plate 112 for cooperation with the disk 114. The indexing detent means 180 includes a spring housing 182 internally threaded at one end and internally reduced at the opposite end. The spring housing end is internally reduced and is formed with an external flange whereby it is adapted to be clamped to the mounting plate 112. The mounting means for indexing detent means 180 includes a bar 184 drilled and counterbored to seat the flange of the spring housing 182. The bar 184 is screw fastened to the mounting plate 112. A compression coil spring 185 and plunger 186 are retained in the spring housing 182 by a set screw 187. A countersunk opening 188 is formed in the mounting plate to be in axial alignment with the indexing detent means 180 at assembly. At assembly, a steel ball 189 is included between the spring-biased plunger 186 and the mounting plate 112. The end surface of the flange 116 of the disk 114 is formed with a series of spaced recesses 190 for seating the spring-biased steel ball of the indexing detent means 180. The recesses in the flange 116 are correlated with the openings formed in the disk 114 so that a selected opening in the disk 114 is positioned in registration with the rectangular aperture 132 of the mounting plate 112. Indicia 192 (Fig. 3) are etched into the surface of the flange 116 of disk 114. The indicia 192 in combination with indexing detent means 180 affords a convenient means for setting the disk 114. The outer surface of the flange 116 is knurled to afford a finger grip for rotating the disk from one indexed position to another index position. The openings formed in the disk 114 correspond to those recommended by the manufacturer for actual operating conditions.

In the black box 32, the candle power of the standard lamp 82 is fixed. Likewise, the distance from the standard lamp to the aperture or opening in the disk 114 is fixed. Therefore, the luminous flux measured at the disk aperture is a constant. The areas of the various openings in the disk 114 which are not covered by a filter determine the amount of luminous flux incident upon the cathode of the phototube under test. All the luminous flux passing through a disk opening impinges upon the cathode of the phototube under test. As previously stated, the design of the openings in the disk 114 correspond to manufacturer's recommendations as to actual operating conditions. It is further noteworthy that most phototubes operate with substantially the same luminous flux, which is generally 0.1 lumen. Furthermore, the luminous flux of 0.1 lumen is generally the upper limit for all phototubes. Therefore with the aperture's size fixed and the desired luminous flux fixed, it is a matter of design, based on practical considerations, as to the candle power of the standard lamp and the distance of the standard lamp from the disk opening. Overall blackbox size determines the practical upper limit of the distance between the standard lamp and the disk openings. Heat dissipation problems determine the upper limit of the intensity of the standard lamp. One satisfactory practical embodiment determined from actual laboratory test has been found to involve the use of a coiled-tungsten, lime-glass envelope lamp operating at a color temperature of 2870 degrees Kelvin to provide a 50 candle power source at a distance of 9.9 inches away from the apertures in the disk 114. This luminous intensity of the standard lamp source and this short distance between the standard lamp source and the phototube under test permits the use of a small light-tight box while at the same time securing essentially parallel rays by means of the baffling afforded by the partition 86 and the mounting plate 112. Because the recommended luminous flux values for the remaining small percentage of types of phototubes range downwardly from 0.1 lumen to 0.00001 lumen some of the apertures in the disk are covered by neutral density filters as described below. Generally, all the apertures in the disk 114 are formed symmetrically with respect to a single circle about the axis of rotation of the disk 114. The exception, that is, those apertures that are at a smaller radial distance from the axis of rotation are so located for practical considerations in order to limit the necessary number of adaptors while at the same time causing the luminous flux to impinge upon the central portion of the cathode of the phototube under test.

The rectangular aperture 132 formed in the mounting plate 112 is at least as large as the largest aperture formed in the disk 114. A difficulty is encountered when the disk is positioned so that the smaller or smallest aperture in disk 114 is aligned with the rectangular aperture 132 of the mounting plate 112. Luminous flux from the standard lamp leaks through apertures to either side the smallest aperture since the rectangular aperture 132 of the mounting plate 112 is so much larger than the smaller or smallest aperture in the disk 114. To avoid inaccuracy resulting from luminous flux leaking through non-selected apertures of disk 114, the shutter members 142 and 144 act to limit the size of the rectangular aperture 132 of the mounting plate 112 for all disk positions except that which aligns the largest disk aperture with the rectangular aperture 132. The shutter members 142 and 144 are held normally closed by the tension spring 181 extending between the posts 176 and 178 on the shutter members. A pin 143 on the mounting plate 112 cooperates with shutter member 142, acts as

a stop to define the closed position of the shutter members. When the disk is positioned so that its largest aperture is in operative position, the cam 134 on the disk 114 forces the supporting pin 146 for the wheel-like cam 136 upward causing the latter to force the shutter members 142 and 144 apart (Fig. 7).

Where the recommended luminous flux for the phototube under test is lower as described previously, a neutral density filter is mounted the aperture of the disk 114. By using neutral density filters secured in particular disk apertures the tester operation is simplified because there is no need for changing the candlepower of the standard lamp or for varying the distance between the standard lamp and the phototube under test. The filtering characteristics of commercially available neutral density filters vary markedly over the spectral range of the phototubes. A satisfactory type of neutral density filter for use in this invention may be formed from several sheets of fresh photographic film exposed to light for short periods of varied duration. The transmission factors of the exposed film can be determined at a precision of plus or minus 1% using a galvanometer and a photronic cell. Since neutral density filters formed and calibrated accurately in this manner may still show slight differences in percent transmission at different portions of the spectrum the anode current of phototubes such as sensitive photomultipliers having diverse spectral responses could be affected. Variations in the anode current due to the spectral response of the neutral density filter may be measured in the laboratory and may be compensated for in the metering circuit.

The design of the disk 114 with its various apertures, some of which have neutral density filters, is determined by the requirements of the tester. For example, the disk may be made larger to include a larger variety of apertures or it may be made smaller to include a lesser variety of apertures depending upon the operating requirements of the tester. In any case, departure from the basic description is only a matter of design and lies within the purview of those skilled in the art.

The adaptors stored on the hinged cover 36 of the housing 38 are illustrative of the different types needed for correctly positioning the cathodes of respective phototubes in proper test position in the black box 32. Besides properly positioning the respective phototubes the adaptors also transfer the proper operating voltages from the test circuit to the phototubes tested. The adaptors are mounted in the diheptal master sockets 102 and 104. For special tubes having anode caps, or cathode caps, the operating potential is obtained through the use of an alligator clip 108 in the black box 32.

An interlock switch 202 is mounted in the black box for cooperation with its cover 62. The interlock switch operates to prevent injury to personnel and damage to any phototube under test. When the cover 62 is opened the interlock switch 202 is adapted to cut off the operating voltage(s) from the phototube under test. The interlock switch 202 serves the additional purpose of insuring against light leakage into the black box 32 during a test by preventing operating potentials from being applied to the phototube under test until the cover 62 is completely closed. This is accomplished by using a sensitive snap-acting switch accurately positioned within the black box 32. The black box 32 is seated in the housing 14 of the tester 12 in the manner shown in Fig. 1. The black box 32 may be modified by elongating it to include a succeeding mounting plate 12 with its associating elements and a succeeding master socket. By this arrangement, the distance between the source and the phototube under test need not be limited to one fixed value. In such a modification, intervening mounting plates could serve as baffles.

The test circuit of the phototube tester 12 is included in the right-hand portion of housing 14 and is controllable from the operator's panel 34. The test circuit is adapted to be connected to an alternating current power supply 220 by way of the terminal 222 at the back of the housing 14 (Fig. 2). An interlock switch 224 is connected in series with one input terminal 222 and is physically positioned within the housing 14 so that if the operator's panel 34 is opened for access to the circuitry, the power supply to the test circuit is interrupted. A double-pole single-throw switch 226 is connected immediately beyond the interlock switch 224 in the input power supply circuit. The switch 226 is an on-off switch for the test circuit and is located on the operator's panel 34. A line fuse 228 is connected in one of the input power supply leads immediately beyond the switch 226. The line fuse 228 is shunted by a neon indicator bulb 232 in series with a current limiting resistor 234. The neon indicator bulb 232 glows when there is a short circuit in the test circuit that causes the line fuse 228 to open. The indicator bulb 232 is located in the little chamber at the top of the operator's panel 34 (Fig. 1). The associated fuse 228 (not seen in Fig. 1) is located in the same chamber adjacent the indicator bulb 232 and allows for easy replacement. An additional neon indicator bulb 236 in series with a current limiting resistor 238 is connected directly across the input power supply leads immediately beyond the line fuse 228. When the neon indicator bulb 236 glows, it serves to indicate that power is being supplied to the test circuit. The neon indicator bulb 236 is located near the top of the operator's panel 34 immediately adjacent the switch 226. If both indicator bulbs do not glow when switch 226 is closed the power supply 220 is at fault; if both glow, the test circuit is at fault. The primary winding of a line regulating transformer 242 is connected directly to the fused input supply line. The line regulating transformer 242 is in the lamp power supply. Because it handles considerable power, it generates a great deal of heat in continuous operation. A cooling source, such as a fan 244, for the transformer 242 is connected in parallel with the primary winding of the transformer 242. An air stream is directed across the transformer 242 by means of fan 244. Circulating cooling air is forced by the fan 244 to flow through the perforated screen 56 (Fig. 2) at the back of the housing 14 of the phototube tester to protect the transformer insulation from damage. A variable autotransformer 246 is connected across the secondary winding of the line regulating transformer 242. The variable autotransformer 246 has a knob; the knob has a pointer which cooperates with calibration indicia 248. The knob is accessible on the operator's panel 34 (Fig. 1). A fuse 252 shunted by a neon indicator bulb 254 in series with a current limiting resistor 256 is connected in series with the variable tap of autotransformer 246. The neon indicator bulb 254 indicates trouble beyond the variable autotransformer 246; it is mounted in the chamber at the top of the operator's panel 34. A step-down transformer 258 such as a filament transformer is connected across the output side of the variable autotransformer 246. A standard lamp 262 normally stored in the lamp compartment 42 of the housing 14 when not in use is adapted to be energized by the secondary of the step-down transformer 258. The standard lamp 262 is laboratory calibrated to afford the necessary high order of accuracy. Calibration of a standard lamp 262 for use in the phototube tester 12 is correlated with the calibration markings associated with knob 248 of the variable autotransformer 246 whereby the lamp 262 operates at the correct color temperature. When a standard lamp is mounted in the lamp socket 82 of the tester, the knob of the variable autotransformer is set so that it is aligned with the calibration mark which sets the operating voltage applied to the standard lamp to that required for use in obtaining the proper color temperature and candlepower from the lamp 262. Replacement standard lamps

44 are stocked in the phototube tester as shown in the compartment 42 of the housing 14 and are all labeled with the calibration markings for correctly setting the variable autotransformer 246.

The test circuit further includes a high voltage power supply 272. A time delay relay 274 is connected in circuit between the input end of the high voltage power supply 272 and the fused input power line. The time delay relay 274 includes a coil 274a adapted to be connected across the fused input power line after a predetermined time delay by conventional means, not shown. The relay includes a pair of contactors 274b and 274c and corresponding fixed contacts 274d and 274e. When the coil 274a is energized the input terminals 273 are connected to the fused input power line through the contactor 274c and contact 274e of the time delay relay 274. The contactor 274b and the fixed contact 274b are in the circuit which supplies the anode voltage to the tube under test and is more completely desscribed in succeeding paragraphs.

The high voltage power supply 272 includes a step-up transformer 276 providing an output voltage on the order of 1600 volts to provide operating potentials up to at least 1000 volts required by photomultipliers. The primary winding of the step-up transformer 276 is grounded to the chassis of the test circuit. A fuse 278 is connected in series with the secondary of the step-up transformer 276. The fuse 278 is shunted by a neon indicator bulb 282 in series with a current limiting resistor 284 for advising when there is trouble in high-voltage power supply 272. The neon indicator bulb 282 and the fuse are located in the chamber at the back of the operator's panel 34 (Fig. 1). A bridge rectifier 286 is connected to the secondary of transformer 276; it comprises gas-filled rectifier tubes (e. g. 816) because of current level and inverse voltage requirements. Four separate filament transformers generally shown at 288 are provided for the four gas diodes of the bridge rectifier 286. An RC filter is connected across the output of the rectifier; it comprises a resistor 292 (e. g. 5,000 ohms) and a condenser 294 (e. g. 4 microfarads). A voltage divider comprising series-connected resistors 302 (e. g. 2,000 ohms) and 304 (e. g. 2 megohms) are connected in series across condenser 294. The junction between resistors 302 and 304 affords a tap 303. Resistors 304 and 302 are at a ratio of 100 :1. A voltage regulator tube 306 (e. g. VR 150) in series with a current limiting resistor 308 is connected across the filter condenser 294. The output power is derived at the cathode of a beam power amplifier 312 (e. g. 807). The power output of the beam power amplifier 312 is applied across a multi-sectional voltage divider comprising series connected resistors 321, 322, 323, 324, 325, 326, and 327 (e. g. 18,000 1,000, 3,000, 14,000, 14,000, 138,500, 11,500 ohms respectively). The high voltage power supply 272 is connected as a series regulated power supply with the output voltage regulated with respect to line and load variations. Regulation is accomplished by automatically controlling the bias between the control grid and cathode of the beam power amplifier 312. The screen grid of the beam power amplifier 312 is retained at a substantially constant potential through a screen dropping resistor 328 (e. g. 35,000 ohms). The bias between the control grid and cathode of the beam power amplifier 312 is dependent upon the amount of current flow through the plate load resistor 332 (e. g. 1 megohm) of the pentode control tube 314 (e. g. 7C7). The control grid of the beam power amplifier 312 is connected to the plate of the pentode control tube 314 through a parasitic suppressor resistor 334 (e. g. 5,000 ohms). The suppressor grid and the cathode of the pentode control tube 314 are held at a constant potential by the voltage regulator tube 306. The bias on the control grid and the screen grid of the pentode control tube 314 are dependent upon the line voltage and the load voltage. The bias of both the control grid and the screen grid of the pentode control tube 314 is obtained through a voltage divider including resistors 336 338, and 342 (350K, 500K and 1.5M ohms, respectively). The bias on both grids varies directly with the current flow through the series connected resistors 338 and 342 of the voltage divider. The current through these resistors 338 and 342 varies as a function of the potential at the cathode of the beam power amplifier 312 and also as a function of the potential at the tap 303 of the voltage divider connected across the filter condenser 294. The tap 303 of the voltage divider on the line side of the high voltage power supply 272 is connected to the tap 337 of the voltage divider across the load side of the high voltage power supply 272. The connecting means between these two taps include a chassis adjustable rheostat 344 in series with a resistor 346 (e. g. 24,000 ohms) for limiting the range of adjustment of rheostat 344. The rheostat 344 is adapted to be adjusted so that the potential at the taps 303 and 337 are proportional for a particular level of line and load voltages. If either the line voltage or the load voltage decreases the potential on both the screen and the control grids of the pentode control tube 314 goes in negative direction. Conversely, if the line voltage or the load voltage increases the potential on the control and screen grids goes in a positive direction. In either case, there is a coincident but opposite reverse change in the bias of the beam power amplifier 312 due to the change in the current flow through the plate load resistor 332. As a result, the load voltage is kept constant. A condenser 348 (e. g. .15 microfarad) for neutralizing ripple voltage is connected between the control grid of the pentode control tube 314 and the cathode of the beam power amplifier 312. A high degree of regulation is essential for proper operation of the test circuit since in the case of gas phototubes and in the case of photomultiplier tubes, a slight change in the anode voltage causes a considerable percentage change in anode current. Resistors used in the high voltage power supply are necessarily accurate.

Each of the taps of the voltage divider connected across the output of the high voltage power supply 272 are connected in series with resistors 352, 354, 356, 358, 362, 364, and 366, respectively, corresponding to recommended load resistors for the different types of phototubes. The common output terminal at the low end of the high voltage power supply is not connected in series with any resistor. Each of the aforementioned resistors act as limiting resistors in the same manner as under actual operating conditions. Under operating conditions the limiting resistors generally serve as a means for limiting current flow in the event that the electrodes of the phototube become shorted.

A meter circuit 372 is provided for indicating the level of anode current in the phototube under test. The meter circuit 372 includes a galvanometer 374. For test purposes the galvanometer 374 is provided with a scale having three arcuate color segments. The arcuate segment at the low end of the scale is labeled "bad"; the arcuate segment at the high end of the scale is labeled "good," and the very small arcuate segment between the two is adapted to be used checking the test circuit with standard phototube 48. The galvanometer 374 is calibrated with the aid of a rheostat 376 connected in series with the galvanometer 374. If the test circuit is operating properly when checked with standard phototube 48, the pointer of the galvanometer 374 moves into registration with the central arcuate segment of the scale of the galvanometer 374. If this does not occur the rheostat 376 is adjusted to give full scale deflection of the galvanometer 374 when a potential of exactly 1.5 volts is applied to the meter shunt 442. The galvanometer 374 is shunted by a bypass condenser 378. Since the current level to be measured is in the range extending from a fraction of a microampere up to several hundred microamperes, an amplifier is combined with the galvanometer 374. The amplifier used is a conventional direct current push-pull bridge circuit.

The amplifier includes a twin triode 382 (e. g. 12AU7). The plate and filament power for the twin triode 382 is obtained from a transformer 384. The transformer 384 includes a primary winding 386 and secondary windings 388 and 392. A fuse 394, shunted by a neon indicator bulb 396 and current limiting resistor 398, is connected in series with one side of the primary winding 386. The neon indicator bulb and face are located in the chamber at the back of the operator's panel 34. The combination of primary winding 386 and its fuse and indicator bulb are connected across the fused input power line. The centertap of the filament of the twin triode 382 is connected to one side of the secondary winding 392 and the opposite ends of the filament of the twin triode 382 are connected to the other end of the secondary winding 392 of the transformer 384. The plate voltage for the twin triode 382 is obtained from the secondary winding 388. A half wave rectifier 402 in series with an RC filter including resistor 404 and condenser 406, is connected across the secondary winding 388. A voltage divider including series-connected resistors 408 and 412 is connected across the filter condenser 406. The cathodes of the twin triode are coupled through a resistor 414. Cathode resistors 416 and 418 are provided for respective sections of the twin triode 382. Corresponding ends of the cathode resistors 416 and 418 are joined and connected in series with the resistor 422 to the low potential end of the filter condenser 406. Plate load resistors 424 and 426 are provided for respective sections of the twin triode 382. Balance is obtained at zero input by means of a potentiometer 428. The resistance winding of the potentiometer 428 is connected between the ends of plate-load resistors 424 and 426. Plate voltage is applied to the twin triode 382 through the tap of the potentiometer 428. By adjusting the tap of the potentiometer 428 until the plates of the twin triode 382 are at the same potential, a pointer of the galvanometer 374 is zeroed in. The knob of the potentiometer 428 is on the operator's panel 34. The tap between resistors 408 and 412 of the voltage divider provides the operating bias. Stray pick-up bypass condenser 432 and 434 are connected in circuit with the respective grids of the twin triode 382. A grid resistor 436 is connected in circuit with the grid of the reference section of the twin triode 382. The resistor connected in circuit with the input section of the twin triode 382 includes a fixed resistor 438 and a variable resistance 442 (e. g. decade box). Variable resistor 442 serves as a meter shunt for adjusting the range of the meter circuit. The meter shunt 442 includes four separately adjustable knobs 444, 446, 448, and 452 on the operator's panel 34. By adjusting the resistance of the meter shunt 442 for the different phototubes so that 2/5 scale deflection is obtained for the minimum acceptable anode currents encountered in the different phototubes, the result of the qualitative reading may be taken off the single galvanometer 374. Meter circuit 372 is adapted to be connected in series with the cathode of the phototube under test in all cases except when multiplier phototubes are tested. By connecting the meter circuit 372 in the cathode side, the circuit is subject to less stray effect. Furthermore, it is preferable to have operating components at the lowest possible potential. However, in the case of multiplier phototubes, cathode current is not identical with the anode current because of dynode currents. Therefore, it is necessary to connect the meter circuit 372 in series with the anode of multiplier phototubes. Plural switch means as described below serve to perform this function.

A pair of plural switches, 454 and 456, serve to properly condition the test circuit in accordance with the phototube to be tested. Generally these plural switches 454 and 456 serve two primary functions. One of the functions is to select among the range of voltages obtainable from the high voltage power supply 272 for application to the anode of the phototube under test. The other function is to connect the meter circuit 372 in series with either the anode or the cathode of the phototube under test in accordance with whether or not the phototube under test is a multiplier phototube, as described above. The switches 454 and 456 control the application of the proper voltage to the phototube under test by controlling the potential applied to the terminals of the master socket 102 or 104. A properly designed adaptor selected from those stocked in the hinged cover 16 of tester 12 mounts the phototube under test in the master socket. It supports the phototube in correct position relative to the disk opening and also transfers the operating potential to the phototube.

The plural switch 456 is an eight position, six deck switch. The plural switch 454 is a five position, two deck switch. Two positions of the eight position switch are devoted to multiplier phototubes having two different numbers of dynodes. Two other positions of the eight position switch are devoted to twin phototubes whereby both sections of the twin phototubes are excited at the same time while the anode current of each is metered separately. By switching the contactors of switch 456 into positions 1, and 2, the meter circuit 372 is connected in series with the anode of a phototube under test; in this case the phototube under test is a photomultiplier (Fig. 13). In all other cases the meter circuit 372 is connected in series with the cathode of the phototube under test. Large currents are measured in the case of photomultiplier tubes and therefore the leakage currents are only a negligible percentage of the total current.

The switch 454 applies the voltage selected by the switch 456 to the proper pin(s) of the master socket, and the plate/cathode alligator clip 108 in the black box 32.

When testing twin phototubes (Figs. 14 and 15) the anodes are connected in common to the high side of the power supply. The cathode current is measured separately for each.

Switch deck 456A selects the proper anode potential from among the seven levels of potential made available by the high voltage power supply 272. The remainder of the switch decks 456B—456F in combination with the switch decks 454A and 454B of the other plural switch 454 serve to connect the meter circuit 372, the phototube under test in the black box and the selected tap of the high voltage power supply 272 in proper circuit relationship for the various types of phototubes being tested as shown in Figs. 12–19.

Fig. 20 shows a generalized chart listing six basic breakdowns of phototube types and the positions of switches 454 and 456 corresponding to each of the six tube types. More particularized information is obtainable from a tube chart mounted on the operator's panel 34. The tube chart on the operator's panel 34 lists for each of the particular tubes adapted to be tested by the phototube tester 12 the position of the disk 114 in the black box 32 as indicated by the indicia 192, the particular adaptor to be selected from the adaptor compartment 36 for properly positioning the phototube and completing the necessary electrical connections between the phototube and the master socket 102 or 104 in the black box 32. The particular master socket to be used (102 or 104) is also indicated by the chart. The proper setting of the meter shunt 442 is obtainable from the chart where the chart indicates the positions of each of the knobs 444, 446, 448, and 452. The positions for switches 454 and 456 are likewise indicated on the chart. By means of this information it is a simple matter to condition the tester for testing any particular tube within the range adapted to be handled by the tester. A standard phototube 48 is provided for checking the phototube tester 12 and the standard lamp 44. With the proper settings of the several variables the pointer of the galvanometer 374 comes into registration with the central arcuate portion of the galvanometer scale if the tester and the standard lamp are operating properly. If such is not the case, the standard lamp is changed and the tester 12 is again tested with the

standard phototube 48. By this arrangement, it is possible to constantly keep check of the accuracy of the phototube tester 12.

The tester is constructed and arranged so that anode voltage is not applied to the tube under test until the black box is closed and a positive switching operation is performed by an operator. This affords the necessary measure of safety both to the operator and to the phototube under test. This function is performed in part by means of a relay 472 including relay coil 472*a*, contactors 472*b* and 472*c* and fixed contacts 472*b* and 472*e*. The relay coil 472*a* is adapted to be energized from the fused input power line. Assuming the conditions are such that the interlock switch 224 on the chassis is closed, the on-off switch 226 on the operator's panel is in closed position and the time delay relay 274 has had time to become energized so that the contactor 274*b* is in engagement with the fixed contact 274*d*, the circuit is conditioned so that the relay coil 472*a* may be energized. However, before the relay coil 472*a* can be energized, it is necessary to close the cover 62 of the black box 32 so as to close the interlock switch 202 in series with the relay coil 472*a*. The only condition remaining to be satisfied before the relay coil 472 becomes energized, is that the push-button switch be actuated by the test operator. The switch 474 is operated from the operator's panel 34. When the push-button switch is pressed to closed position, if all the positions precedent outlined above are satisfied, the relay coil 472*a* becomes energized causing the contactor 472*b* to engage the fixed contact 472*d* and the contactor 472*c* to engage the fixed contact 472*e*. In order that the test operator may know whether or not anode voltage is being applied to the phototube under test when the push-button switch 474 is actuated, an indicator bulb 476 in series with a current limiting resistor 478 is connected across the fused input power line when the contactor 472*c* engages the fixed contact 472*e* to apply anode voltage to the phototube under test. The neon indicator bulb 476 is located on the operator's panel 34 immediately above the push-button switch 474.

In operation, the phototube tester 12 is brought to the site of the test and is seated on a bench so that the cabinet is horizontal. A line-cord, not shown, is adapted to connect the input line terminal 222 of the phototube tester 12 to a source of alternating current power 220 such as an ordinary lighting circuit. The hinged cover 16 of the tester 12 is swung into open position and braced by a folding bracket 18. The phototube test circuit is conditioned for operation by throwing the operating member of the switch 226 to "on" position. The neon indicator bulb 236 glows if power is being supplied to the circuit. As soon as the switch 226 is actuated, fan 244 is caused to rotate to circulate cooling air through the perforated screen 56 at the back of the housing 14. A standard lamp is selected from the compartment 42 in the hinged cover 16 of the housing 14. The lamp is inserted into the lamp socket 82 in the lamp compartment 68 of the black box 32. The lamp power supply is properly adjusted by setting the pointer knob of the variable auto-transformer 246 to that calibration marking on the panel 34 corresponding to the number indicated on the container of the standard lamp selected for use. With the lamp supply properly adjusted, the lamp is energized to the proper color temperature and candlepower for which the tester 12 is designed. The cover 94 of the lamp compartment 68 serves to keep light from the lamp out of the test operator's eyes since the lamp is energized as soon as the switch 226 is actuated. A standard phototube 48 is available in the compartment 46 for determining whether or not the tester 12 is operating properly. Information for setting up the circuit and the black box for use with the standard phototube 48 is determined from the tube chart at the front of the operator's panel. An adaptor for the standard phototube is selected from the adaptor compartment 36 and is inserted into a master socket 102 of the black box 32. The standard phototube is the inserted into the adaptor. The disk 114 in the black box is turned to proper position when the indicia 192 on its flange is in accordance with the tube chart. The black box is then in condition for operation. The cover 62 of the black box 32 is then closed which further acts to condition the remainder of the test circuit for operation by actuating the interlock switch 201 which permits application of anode voltage to the phototube in the black box 32. The meter shunt is adjusted by setting the knobs 444, 446, 448, and 452 on the operator's panel to the proper value of meter shunt resistance. The switches 454 and 456 are likewise positioned to the respective settings for applying the proper anode voltage to the phototube in the black box 32. It is necessary to zero the galvanometer 374 prior to any test. With no current input, the meter is zeroed by adjusting the knob of the potentiometer 428 in the meter amplifier circuit so that the plate potentials of the two triode sections of the double triode 382 are made equal. The test circuit is then ready for operation. The only thing remaining for the operator to do is to press the button on the push-button switch 474. If the circuit is operating properly, as soon as the push-button switch 474 is operated, the indicator bulb 476 immediately above the push-button glows. With the circuit set up for a standard phototube, the pointer of the galvanometer 374 moves to the center arcuate portion of the scale if the standard lamp and the remainder of the circuit is operating properly. The six indicator bulbs on the operator's panel 34 advise as to whether there is any trouble in the test circuit and precisely in which portion of the test circuit the trouble exists. If any of the indicator bulbs 232, 254, 284, and 396, located in the chamber at the back of the operator's panel 34 being to glow, the operator is notified that the fuse located in the particular associated circuit has become inoperative. Fuse replacement is simplified because the fuse associated with each particular indicator bulb is mounted in the chamber at the top of the panel 34 adjacent the indicator bulbs. If replacement of the fuse does not solve the particular trouble, the trouble is localized and it is possible to quickly determine which of the elements is the source of the trouble. When the push-button 474 is pressed, indication is afforded by the galvanometer 374 as to the condition of the phototube under test. The procedure for any phototube is similar to that described in connection with the standard phototube. All the needed information is determined from the tube chart. Interlocks both in the black box 32 and the chassis proper afford needed protection to the operating personnel from high voltage generated within the circuit.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

We claim:

1. A black box for use in testing any of a plurality of types and sizes of electrical elements which are responsive to radiant energy in and about the frequency range of visible light, said black box comprising an elongated rectangular box having a hingedly connected closure forming one of the elongated sides of said box, a black non-reflecting material coating the inside surfaces of said box, a pedestal-mounted socket fixedly secured at one end of said rectangular box for supporting a source of the radiant energy in a predetermined position in said rectangular box and for transferring operating power to a source of radiant energy supported therein, a pair of master sockets secured at the opposite end of said rectangular box, the axis of one of said master sockets being parallel to the axis of said first-mentioned socket and the axis of the other of said master sockets being perpendicular to the axis of said first-mentioned socket, the axes of both master sockets and of said first-mentioned socket being coplanar, a partition secured transversely in said rectan-

gular box and formed with an aperture for permitting a predetermined amount of the radiant energy flux emitted by a source of radiant energy mounted in first-mentioned socket to pass through, a mounting plate formed with an aperture secured in said rectangular box between said partition and said master sockets, the aperture in said mounting plate being aligned with the aperture in said partition, a disk mounted on one side of said mounting plate, said disk being cut out to provide arcuately spaced apertures of various configurations and areas, a neutral density filter mounted in at least one of the apertures of said disk, means associated with said disk and said mounting plate whereby said disk is rotatable into any one of a plurality of positions for bringing selected apertures therein into registration with the aperture in said mounting plate, shutter means mounted on the side of said mounting plate opposite said disk, cam means mounted on said mounting plate and associated with said disk and said shutter means whereby said shutter means is caused to effectively reduce the size of the aperture in said mounting plate when smaller disk apertures are aligned therewith so as to prevent radiant energy flux leakage through apertures in said disk not aligned with the aperture in said mounting plate and adaptor means for mounting a phototube in one of said master sockets.

2. A black box as described in claim 1 wherein said shutter means includes a spring for biasing said shutter means toward aperture reducing position, said disk being constructed and arranged to cause said cam means to automatically move said shutter means out of aperture reducing position for at least one position of said disk.

3. A phototube tester comprising a black box having a closure, a standard lamp mounted in said black box, said black box including means for mounting and transferring selected operating potentials to a phototube under test, an interlock switch mounted in said black box in cooperative relationship with said closure whereby said interlock switch is closed when said closure is in closed position on said black box, an adjustable lamp power supply connected to said standard lamp, a high voltage power supply providing a plurality of operating potentials, a meter circuit including a galvanometer and adjustable input means for selectively varying the range of said galvanometer, said meter circuit adapted to be connected in series with a phototube under test and with said high voltage power supply for indicating resultant phototube anode current, selector means for selecting a particular one of the operating potentials afforded by said high voltage power supply for application to a series combination of a phototube under test and said meter circuit and for further connecting said meter circuit in series either with the anode or with the cathode of a phototube under test, said interlock switch being connected in circuit with said selector means and adapted to prevent application of operating potential to a phototube under test until said black box is closed by said closure.

4. A phototube tester comprising; a black box having a closure, a standard lamp mounted in said black box; means mounted in said black box for mounting and transferring selected operating potentials to a phototube under test; an adjustable lamp power supply connected in circuit with said standard lamp; a high voltage power supply providing a plurality of operating potentials; a meter circuit including a meter connected to a direct current push-pull bridge circuit amplifier having an adjustable input means, said adjustable input means of said meter circuit being adapted for selectively varying the range of said meter, said meter circuit adapted to be connected in series with a phototube under test and with said high voltage power supply for indicating resultant phototube anode current; selector means for selecting a particular one of the operating potentials afforded by said high voltage power supply for application to a series circuit of a phototube under test and said meter circuit, and further for connecting said meter circuit in series either with the anode or with the cathode of a phototube under test.

5. A universal phototube tester comprising a black box having a closure, a standard lamp mounted in said black box, master socket means secured inside said black box remote from said standard lamp for use in mounting and transferring selected operating potentials through an adaptor to a phototube under test, luminous flux baffling means secured within said black box between said standard lamp and said master socket means and including means for affording any of a plurality of selected apertures for passage of luminous flux from said standard lamp to a phototube under test, an interlock switch mounted in said black box in cooperative relationship with said black box in cooperative relationship with said closure whereby said interlock switch is closed when said closure is in closed position on said black box, an adjustable lamp power supply connected to said standard lamp, a regulated high voltage power supply providing a plurality of operating potentials, a meter circuit including a galvanometer and adjustable input means for selectively varying the range of said galvanometer, said meter circuit adapted to be connected in series with a phototube under test and with said high voltage power supply for indicating phototube anode current, a pair of independently operable switches for selecting a particular one of the operating potentials afforded by said high voltage power supply for application to a series combination of a phototube under test and said meter circuit and for further connecting said meter circuit in series either with the anode or with the cathode of a phototube under test, said interlock switch being connected in circuit with one of said independently operable switches for preventing application of operating potential to a phototube under test until said black box is closed by said closure, a normally open push-button switch in series with said interlock switch and adapted to be actuated when said tester is readied for operation, and a plurality of indicator means for giving notice as to the operating condition of said tester.

6. A universal phototube tester as described in claim 5 wherein said light baffling means includes a multiposition disk having a plurality of apertures, a neutral density filter in at least one of the disk apertures, a mounting plate having an aperture, means for supporting said disk on said mounting plate whereby selected apertures of said disk are moved into registration with the aperture in said mounting plate, said light baffling means further including shutter means secured to said mounting plate for effectively reducing the size of the aperture in said mounting plate in accordance with particular positions of said disk.

7. Means for use in testing elements responsive to radiant energy, said means comprising, a box having a closure, a mounting plate, said mounting plate having an aperture, said mounting plate secured in said box intermediate the ends thereof to prevent radiant energy from transferring from the portion of said box on one side of said mounting plate to the portion of said box on the other side of said mounting plate except through the aperture, a disk mounted on one side of said mounting plate, said disk being cut out to provide arcuately spaced apertures of various configurations and areas, means associated with said disk and said mounting plate whereby said disk is rotatable into any one of a plurality of positions for bringing selected apertures therein into registration with the aperture in said mounting plate, shutter means mounted on the side of said mounting plate opposite said disk, means mounted on said mounting plate and associated with said disk and said shutter means whereby said shutter means is caused to effectively reduce the size of the aperture in said mounting plate when a small disk aperture is aligned therewith so as to pre-

vent radiant energy flux leakage through apertures in said disk not aligned with the aperture in said mounting plate.

8. A variable-aperture radiant energy barrier for use in performing tests on elements responsive to radiant energy, said barrier comprising a mounting plate having an aperture, a disk mounted on one side of said mounting plate, said disk being cut out to provide a plurality of arcuately spaced apertures of various configurations and areas, means associated with said disk and said mounting plate whereby said disk is rotatable into any one of a plurality of positions for bringing selected apertures in said disk into registration with the aperture in said mounting plate, shutter means mounted on the side of said mounting plate opposite said disk, means mounted on said mounting plate and associated with said disk and said shutter means whereby said shutter means is caused to effectively reduce the size of the aperture in said mounting plate when a small aperture of said disk is aligned therewith so as to prevent radiant energy flux leakage through apertures in said disk not aligned with the aperture in said mounting plate.

9. A variable-aperture radiant energy barrier for use in performing tests on elements responsive to radiant energy, said barrier comprising, a mounting plate having an aperture, a disk rotatably mounted on one side of said mounting plate, said disk being cut out to provide arcuately spaced apertures of various configurations and areas, indexing means associated with said disk and said mounting plate whereby said disk is rotatable into any one of a plurality of positions for bringing selected apertures therein into registration with the aperture in said mounting plate, a pair of shutter elements pivotally

mounted on the side of said mounting plate opposite said disk, said shutter elements being pivotable between a first position wherein the shutter elements effectively reduce the size of the aperture in said mounting plate and another position wherein said shutter elements do not interfere with radiant energy passing through the aperture in said mounting plate, a spring connected to said shutter elements for biasing said shutter elements toward aperture reducing position, first means slidably mounted on said mounting plate for engaging said disk adjacent the rim thereof, second means urging said first means into engagement with said disk, camming means on said disk for forcing said first means to move to a particular position against the urging of said second means for at least one indexed position of said disk, said first means engaging said shutter elements and forcing them away from aperture reducing position against the bias of said spring when said first means is engaged by said camming means on said disk, whereby said shutter means is effective to reduce the size of the aperture in said mounting plate when a small aperture in said disk is aligned therewith so as to prevent radiant energy flux leakage through apertures in said disk not aligned with the aperture in said mounting plate.

References Cited in the file of this patent

UNITED STATES PATENTS

2,460,471	Schade	Feb. 1, 1949
2,463,321	Scott	Mar. 1, 1949
2,632,358	Ehat	Mar. 24, 1953
2,699,086	Finch	Jan. 11, 1955