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June 3, 1947. H. BELAR ET AL 2,421,476

PHOTOELECTRIC CONTROL APPARATUS FOR DIAPHRAGMS

Filed June 18, 1943 2 Sheets-Sheet 1

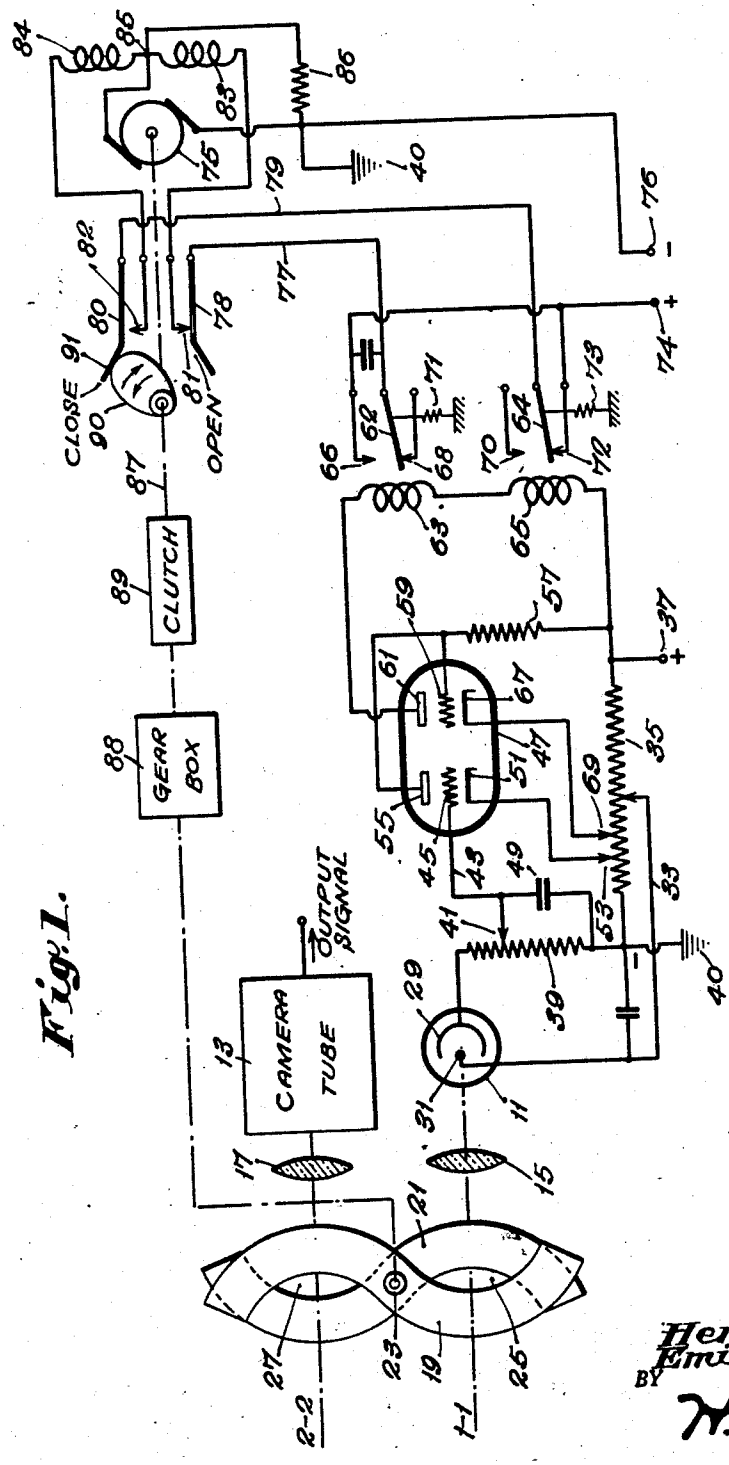


Fig. 1.

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Filed June 18, 1943 2 Sheets-Sheet 2

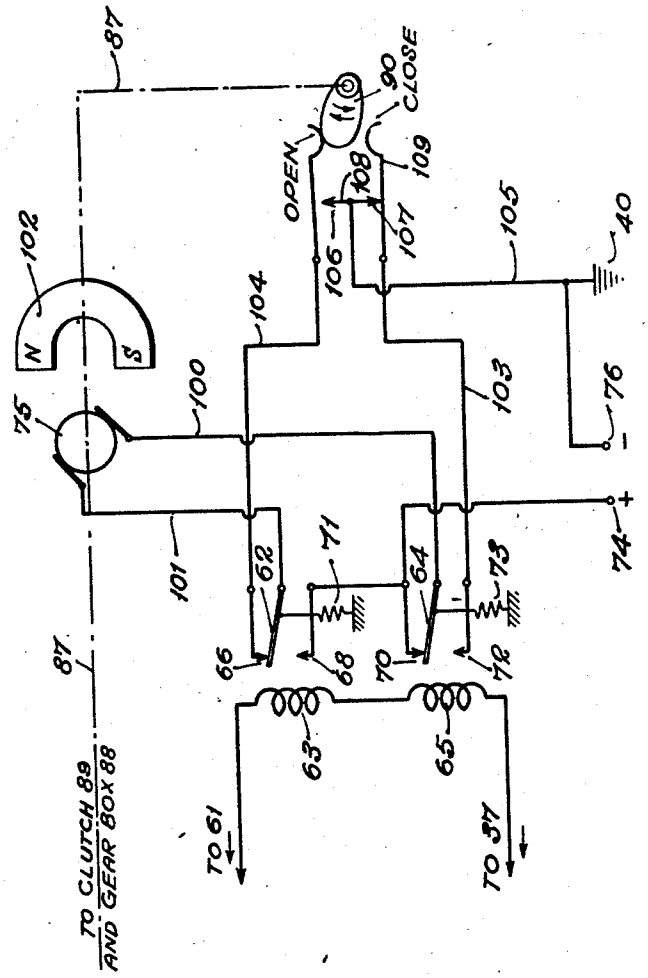


Fig. 2.

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UNITED STATES PATENT OFFICE

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PHOTOELECTRIC CONTROL APPARATUS FOR DIAPHRAGMS

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Application June 18, 1943, Serial No. 491,344

2 Claims. (Cl. 95—64)

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This invention relates to light control apparatus and is particularly concerned with apparatus and controlling circuits for regulating the amount of light which is permitted to fall upon a light sensitive device.

For purposes of illustration, the invention will be particularly related to and described in connection with television apparatus wherein there is included a light sensitive tube of the so-called camera type upon which an optical image is focused. In apparatus of this type, and especially in television apparatus wherein the so-called storage types of scanning or camera tubes are utilized, an optical image is suitably focused upon a light sensitive electrode member, commonly known as the mosaic element of the camera tube. This mosaic element in the camera tube, such as the type generally known as the "Iconoscope" and the "Orthicon," builds up an electrostatic charge image or replica of the impinging optical image, and the resultant electrical charge image is appropriately scanned by a scanning cathode ray beam to release signal energy output to a suitable load circuit for actuating electro-optical image reproducing apparatus.

In camera tubes of the general types above named, wherein the sensitivity is relatively high, it becomes apparent that while it is extremely important to insure adequate and proper exposure of the mosaic element to the impinging light image, it is extremely dangerous to over-expose the mosaic. It is particularly desirable that adequate, and yet proper, exposure be had for several reasons, among which are, that the scene lighting may vary within wide limits, and frequently may be much brighter than is required for proper exposure. Also, the camera or scanning tube equipment may, in some instances, be directed almost directly toward the sun, as would be particularly evident in cases of automatic gunfire control apparatus, where the camera equipment is mounted in an airplane and enemy aircraft are kept within the field of view of the scanning tube, and such attacking aircraft very frequently endeavor to make attacks so as to be between the attacked plane and the sun.

Under such circumstances, without suitable control of the light entering into the camera tube, it will be apparent that the television tube may be rendered practically useless if subjected to too much light because, with such great sensitivity of the tube, saturation effects result and it becomes impossible to resolve between high lights and low lights or bright spots and shadows.

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Further than this, too much light upon the mosaic is apt to result in the permanent injury, or at least impairment, thereof.

The invention herein to be disclosed provides for ways and means by which the camera tube may be appropriately protected, and whereby, for conditions of extreme bright light, the amount of light which is permitted to enter into the camera tube is reduced but, for conditions of reduced illumination, the amount of light which is permitted to enter upon or influence the camera tube is increased.

To this end, an appropriate iris control is provided by way of a shutter element which opens and closes under the control of an electrical circuit operating in accordance with reductions and increases in the amount of light available to influence the camera tube. For accomplishing this objective, provision is made for the use of a separate light sensitive element which is arranged to receive a light image which is a substantial duplicate of that directed into the camera tube and of substantially equal brilliance. A light sensitive tube of this character is then connected appropriately with a suitable form of amplifier and relay tube which provides for actuating a control motor which automatically serves to control the iris opening.

To this end, the motor is provided with a plurality of relay controls operated in such a way that for increases in light on the light sensitive tube, the motor turns or operates, for instance, in a clockwise direction, while for decreases in the amount of light the motor may turn or operate in a counter-clockwise direction. The rotation of the motor is arranged thus to control the diaphragm opening by simultaneously varying the opening through which the light on the light sensitive control tube is projected, and simultaneously varying the opening through which the light of the same image is able to pass to influence the scanning tube.

In the arrangement disclosed, provision is also made whereby when the motor has been operated in one direction of motion for a predetermined time (or angle) an appropriate instrumentality stops the rotations in that particular direction, but in no way affects the control in the reverse direction. When the light conditions change to the other extreme, exactly the reverse conditions take place and the iris or diaphragm is altered from one extreme to another in the opposite direction.

Provision is also made whereby, for a predetermined intermediate range of light chosen be-

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tween a minimum opening and a maximum opening of the diaphragm or iris, for instance, the motor and its controls will remain ineffective and yet, for a change in the impinging light at one of the two directions, the control shall be effective in one or the other above described ways.

It, accordingly, becomes an object of this invention to provide ways and means by which a light sensitive camera tube may have the amount of impinging light automatically set and controlled thereby to establish a predetermined signal level output for preestablished conditions of illumination.

A further object of the invention is that of providing a television scanning system and control wherein the scanning tube is protected against extreme conditions of illumination which would tend either to destroy the tube or to destroy its efficiency of operation.

A further object of the invention is that of providing a control of the light input to a scanning camera tube and to maintain a pre-established output level.

A further object of the invention is that of providing a light control for use with a light sensitive device which shall be capable of varying the amount of entering light in accordance with external conditions, and in which the time within which the control from one extreme to the other takes effect is reduced substantially to a minimum.

Another object of the invention is that of providing ways and means by which a proper exposure of a light responsive film is made possible, irrespective of the brilliance of illumination of the scene being viewed.

Another object of the invention is that of providing a control system in which the camera tube is automatically protected against excess light in the event of failure of the amplifying circuits associated with it.

Other objects of the invention are those of providing a system whereby any desired or predetermined characteristic of light input against scene lighting can be obtained for television or photographic systems through the use of suitably controlled diaphragm and iris elements.

Other objects of the invention are those of providing ways and means by which existing defects and disadvantages of prior art arrangements are overcome, while, at the same time, the control apparatus for achieving these results is extremely simple and substantially foolproof in its control.

Other objects of the invention will become apparent and at once suggest themselves to those skilled in the art to which the invention is directed, when the following description is read in connection with the accompanying drawings, wherein:

Fig. 1 shows conventionally one form of control system with the electrical circuit controlling a two-blade iris; and,

Fig. 2 shows a modification of a portion of the circuit of Fig. 1.

Referring now to the drawings, and first to Fig. 1, it will be assumed that light rays reflected from some suitable image area (not shown) pass along the substantially parallel paths conventionally designated as 1—1 and 2—2, of which the former light path is in the direction of a light responsive photo-electrically active tube 11, and the latter light path is in the direction of a camera tube 13 which, for illustrative purposes, may be considered as either an "Orthicon" or

"Iconoscope" located within a conventionally represented camera tube housing. It is to be understood, in this connection, that the same, or substantially the same, light image is projected along each of the paths 1—1 and 2—2, and that, where desired, appropriate correction for parallax distortion may be provided.

Many and various ways and means to accomplish the parallax correction in order to assure that substantially the same optical image is projected upon tubes 11 and 13 are known, but, as illustration of one of such forms, reference may be had to U. S. Patent No. 1,931,890, granted to Burns on October 24, 1933.

Under such circumstances, the light of the optical image passing along the path 1—1 enters the light sensitive phototube 11 through the lens or other suitable optical element 15 while light rays, representative of the same optical image, enter into and affect the camera tube within housing 13 by being focused along a path 2—2 and directed upon the light sensitive mosaic element of the camera by way of the lens or other suitable optical system 17.

Interposed in each of the light paths 1—1 and 2—2 are the blades 19 and 21 of a shutter instrumentality which is pivoted at the pivot point 23 in such a manner that two distinct openings, indicated by the area 25 in the optical path to phototube 11 and the area 27 in the optical path to the camera tube 13, are provided. It is apparent that, in the event the blades 19 and 21 move relative to one another about a pivot point 23, the openings 25 and 27 shall be made larger or smaller in accordance with the direction of motion of the two blades.

To this end, and for the purpose of providing a control of such a nature that the final control of the system approaches the action of a limiter, the output current from the phototube 11 is caused to control, in a manner later to be explained, the operation of a drive mechanism of appropriate form to vary the area of the openings 25 and 27 and to maintain the said openings of like size, or at least predetermined proportional size, at all times, in order that the amount or brilliance or effect of the impinging light on each of the light sensitive elements shall be suitably controlled.

Where the openings are of like size, the optical systems or lens elements 15 and 17 are preferably of the same size and the same aperture and focal length, so that the resulting control, which is exercised by way of the phototube control 11, shall be an exact measure of the effect produced upon the camera tube within the housing 13.

With the arrangement as it is constituted and shown, the phototube 11 includes the usual photo-electrically responsive cathode element 29 and the associated anode element 31. In accordance with the form of arrangement illustrated, the anode element is maintained positive relative to the cathode 29 by way of a suitable connection through conductor 33 to an appropriately chosen point on the voltage divider 35, between the outer terminals of which a suitable source of positive voltage is connected at 37 and the negative terminal of the voltage supply source is connected to ground at 40. The voltage supply source may be of any desired type and either constituted by the suitable voltage divider output from a suitable alternating current rectifier or may be an appropriately chosen battery.

The cathode element 29 of the phototube 11 connects to the voltage supply source (not shown)

at ground 40 by way of the load resistor 39. This load resistor is suitably tapped at a desired point 41, for instance, and supplies a control potential upon the grid or control electrode 45 of an amplifying tube 47 by way of the direct connection through conductor 43. In order that the control voltage applied may be appropriately smoothed, a condenser 49 connects between control electrode 45 and ground 40 in known manner. The cathode element 51 of the amplifier tube 47 connects to the voltage divider 35 at any appropriate point, such as 53, to provide the appropriate potential on the cathode relative to the anode 55, which connects through the load resistor 57 to the high potential terminal 37 of the applied voltage source, as connected across the voltage divider element 35.

In order that further amplification of the resulting energy output of the first half of tube 47 may be had, there is direct connection from the anode element 55 to the grid or control electrode of the second half of the tube. This second half of the tube has voltage supplied to the plate or anode element 61 through the serially connected relay coils 63 and 65, which connect between plate or anode 61 and the terminal point 37, where the positive end of the voltage supply source is connected. The cathode element 67 of the second half of the tube is appropriately biased by way of the connection to some suitable point on the voltage divider 35, such as the point 69.

From what has been disclosed, it thus becomes apparent that two stages of amplification of the output current from the phototube 11 have been provided which, for purposes of illustration, are shown as having been embodied within the single tube element 47. A tube of this character may, for instance, be one of the type known in the art as 12SN7, or other appropriate type provided for amplification purposes may be relied upon; or, still further, the two stages of amplification may be provided by two completely separate tube instrumentalities.

When current flows through the output of the second half of tube 47, for instance, it flows through the relay actuating coils 63 and 65 which serve to control the operation of the relay armatures 62 and 64, respectively, which are moved between the contact points 68 and 66 on the one hand, and 72 and 70 on the other hand. The armatures 62 and 64 are normally set, as indicated, by the resilient or spring elements, so that, in the state of deenergization of the relay coils 63 and 65, they rest against contact points 68 and 72, respectively.

Under conditions of energization of the coils, the relay armatures 62 and 64 move respectively to contact against contact points 66 and 70. It will be noted that the contact points 68 and 70 each lead, respecively, to blind or unused terminal points, so that, in such positions of the relay armatures, no resulting control effects take place.

It also will be appreciated that, in the arrangement as it is herein disclosed for illustrative purposes, the relay armature 62 may be considered to be brought into operation when the current flowing through the relay winding 63 is of the order of 6 milliamperes, while the relay armature 64 may be considered to be energized by way of the control winding 65 when the current flowing through the winding 65 is of the order of approximately 4 milliamperes.

Thus, relay armature 62 (as well as armature 64) functions for conditions of high output current from the second half of tube 47, and relay armature 64 alone functions for conditions of lower output current from this tube.

Under these circumstances, it will be seen that a suitable source of control voltage for operating a motor element, conventionally represented at 75, may be connected at terminal points 74 and 76, with the positive terminal of the supply or control source (not shown) being connected, for instance, at terminal point 74, and the negative connected at point 76, or connected at ground 40. A connection is made from the terminal point 74 to each of the contact points 72 and 66, with the armatures 62 and 64 connecting respectively by way of conductors 77 and 79 to the switch contact elements 78 and 80.

Under normal conditions, and in the absence of anything to break the contact, these contact elements 78 and 80, respectively, make contact with the contact points 81 and 82, of which the former connects through the field winding 83 of the motor 75, and the latter to the field winding 84 of the same motor, with the two windings 83 and 84 being connected from the common junction point by way of the low resistor 86 to ground 40 and to negative terminal of supply voltage source 76.

It thus becomes apparent that with the relays in the position shown by the diagram, current will flow from the positive terminal of the source connected between points 74 and 76, through the relay contact 72, the armature 64, the conductor 79, the contact armature 80, contact point 82 and winding 84, and thence from the point 85 through the motor armature back to the negative terminal 76, or ground 40, so that the motor 75 is rotated in one direction of rotation. The armature may be shunted by a resistor, such as 86. This then causes the motor shaft, conventionally represented as 87, to rotate in a corresponding direction and drive a gear train (not shown) contained within the gear box 88 through a clutch mechanism conventionally represented at 89. When so driven, the gear train within the gear box 88 is adapted to rotate (in an appropriate manner) the blades of the iris member about the pivot point 23 by means of gear elements so that one blade turns clockwise and the other counter-clockwise.

At the same time, due to the rotation of the motor in the direction named, a limit switch control element 90 is driven from the shaft 87, so that as it contacts the overhanging edge 91 of the contact strip 80 it causes the contact between the contact member 80 and contact point 82 to be broken, whereby the motor stops its rotation.

For the conditions above described, it will be appreciated that these are circumstances representing the operational conditions when bright lights influence the phototube 11, in that the current output under such circumstances from the second half of the tube 47 is reduced and, therefore, it is desirable to close further the opening 25 through which light affects the phototube 11 and reduce still further the output current to retain the equilibrium value.

However, suppose that this condition is maintained and the motor 75 turns in the direction chosen, it can be seen that the contact limit switch element 90 soon rotates far enough to break the contact between the contact strip 80 and contact point 82 so that the voltage supply to the motor is broken and the motor thus must stop running. At the same time, contact is maintained between contact member 81 and the contact strip 78, so that if the output energy from

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the second half of tube 47 increases above a value required to overcome the effect of the resilient means normally holding armatures 62 and 64 against contact points 68 and 72, it can be appreciated that the armature 62 will close on contact 66 and armature 64 will close on contact 70.

Whether or not contact between point 82 and strip 80 is broken, current to drive the motor in the opposite direction will flow from terminal point 74 through the contact point 66 and armature 62, conductor 77, contact strip 78, contact point 81, motor winding 83, point 85 and back through the motor armature to negative terminal 76, or ground 40, until the current flowing in the second half of tube 47 is reduced to release armature 62. Also, as the motor turns in the opposite direction to that first assumed at times when armature 62 contacts the point 66, it is apparent that the limit switch element 90 moves in such a direction that contact is again restored between the point 82 and the strip 80.

Thus, it can be seen that the opening of the limit switch, due to rotation of the motor in one direction, does not in any way affect the ability or the possibility of driving the motor in the opposite direction should conditions of light change in such a direction as to make the opposite type of aperture desirable.

From what has been stated above, it will be appreciated that if the light falling upon the phototube 11 is of a value or intensity greater than that required to reduce the current flow in the second half of the tube 47 to a value less than that required to overcome the force of the spring member 71 which holds the armature 62 in contact with terminal 68, whereby the armature 62 remains in contact with terminal point 68, and if this light is less in intensity than that required to reduce the current in the second half of the tube 47 to a value which is required to maintain the armature 64 in contact with the terminal 70 against the force of the spring member 73 normally holding it in contact with the terminal 72, then the circuit starting at the terminal point 74, whereat the positive voltage is applied, is open and the motor 75 cannot run. In other words, it becomes apparent that for predetermined light intensity and corresponding output currents from the second half of the tube 47, which are between the limits of the current flows required to actuate the relay armatures 62 and 64, the motor 75 will not operate. In this way, the iris members 19 and 21 will maintain the light impinging upon the phototube 11, and also upon the camera tube 13, between set limits during any change in scene lighting, but where there is a momentary change in the light intensity which tends to fall upon the camera tube, the motor will operate in one direction or the other to maintain the iris opening within the desired limited values.

Now, referring to the circuit modification shown by Fig. 2, the control arrangement for applying a control voltage upon the grid or control electrodes of the tube 47 is essentially the same as shown and described in connection with Fig. 1, and, accordingly, Fig. 2 shows only that portion of the circuit beginning with the relay windings 63 and 65. In the modified arrangement of Fig. 2, the output current from the second half of the tube 47 flows through the relay windings 63 and 65, as described in connection with Fig. 1, and, depending upon the current flowing, the armatures 62 and 64, respectively, will be actuated.

It was explained, in connection with Fig. 1, that where extremely bright lights or high intensities

of illumination fell upon the phototube 11, lower current output in the second half of the tube 47 would result. In this way, for high lights, the current flowing through the output of the second half of tube 47 would be insufficient to actuate the relay armature 62 against the force of the resilient means 73 over toward contact point 70.

In the de-energized state, the armatures 62 and 64, respectively, rest against contact points 68 and 72. While in the energized state (as shown by Fig. 2) the armatures 62 and 64, respectively, contact the contact points 66 and 70, respectively. Normally the contact points 70 and 68 are connected, and the contact points 72 and 66, respectively, connect by way of conductors 103 and 104 to ground 40, or to the negative terminal 76 by way of connection through the contact point 107 and the contact arm 109, or contact point 106 and contact arm 108, with a connection being made from the negative terminal 76 of the supply source (not shown) to ground by way of conductors 105. The armature members 62 and 64 connect by way of conductors 101 and 100, respectively, to the brushes of the motor 75, which has a permanent field developed in the manner shown conventionally by the magnet 102. As the motor 75 rotates, it causes the limit switch element 90 also to rotate in either a clockwise or counter-clockwise manner, depending upon the direction of current flowing through the motor.

As was explained in connection with Fig. 1, the rotation of the limit switch element 90 will cause the contact established between contact point 106 and the contact strip or arm 108 to be broken when limit switch element 90 rotates in one direction, which may be assumed to cause an opening of the iris elements, whereas, if the limit switch element 90 rotates in the opposite direction, contact will be broken between contact point 107 and the contact arm or strip 109 in such a way that the iris element will tend to close and reduce the light reaching each of the phototube 11 and the camera tube 13.

From the way in which Fig. 2 has been shown, it will be seen that a condition of low light on the phototube 11 and the camera tube 13 is assumed, so that a maximum current output of the current flows from the second half of the tube 47, which provides maximum current through the relay windings 63 and 65. Thus, each of the relay armatures 62 and 64 is actuated and, in the arrangement shown, current will now flow from the positive terminal 74 through the contact point 70 to the armature 64, and thence through the conductor 100, through the motor 75 and out through the conductor 101 and thence to contact point 66 and the armature 62, from which the circuit follows through the conductor 104, the contact strip 108 and contact point 106 back to the negative terminal 76 via the conductor 105 or to ground 40 from the contact point 106.

Under these circumstances, the limit switch 90 is rotated in a clockwise direction, as long as the relay actuating current stays unchanged, until the iris opens to a maximum degree, and contact is finally broken between contact point 106 and the contact strip or arm 108. Under these conditions, it can be seen that for reduction in current output of the tube 47, which is insufficient to actuate armature 62 but which maintains armature 64 in position shown, the condition of brightness control will remain fixed at its previous state, because there is now an open circuit formed, in that the positive terminal of the source (not shown) connected at 74 connects to both

conductors 100 and 101 by virtue of the connection established between the armature 64 and the contact point 70, and also between the armature 62 and contact point 68, which connects to contact point 70, thus no current would flow through the motor.

However, let it be assumed that conditions change still further so that the light becomes very bright on the phototube 11 and the camera tube 13, in which condition the current output from the second half of tube 47 becomes less and less, so that finally the current flowing through the relay winding 65 is insufficient to overcome the effect of the resilient means 73, whereupon the armature 64 now contacts point 72, and armature 62 is upon contact point 68. Under these circumstances, it can be seen that the motor will run in the opposite direction from that above described, because current now flows from the positive terminal of the source (not shown), connecting at contact point 72 through contact point 68, and the armature 62 and conductor 101, and thence back through the motor 75 and conductor 100 to the armature 64 and contact point 72, from which a connection is established by way of conductor 103 and the contact strip or member 109 and contact point 107 back to negative terminal 76 and ground 40 by way of conductor 105.

In this way, it can be seen that the current flowing through the motor flows in the opposite direction from that direction in which it flowed for relatively low intensity of illumination. The result is that the limit switch element 90 now turns in a counter-clockwise direction and, if the conditions of high light persist, then it becomes apparent that the connection between the contact strip or member 109 and the contact point 107 is broken and the iris elements are closed to the maximum degree, so that the opening provided at the iris elements 25 and 27 (Fig. 1) is a minimum. However, for intermediate values of current flow or for conditions where the current flow is just sufficient to actuate armature 64 but insufficient to actuate armature 62, conditions of intermediate opening are obtained.

As explained in the arrangement of Fig. 1, the modification of Fig. 2 also so provides that for conditions where the apertures or openings 25 or 27 have been closed to a limiting amount by way of the counter-clockwise rotation of the limit switch element 90, such closure in no way precludes operation of the motor in the reverse direction if the light intensity is reduced, and, consequently, the iris opening may be made greater even though there is, at the start of the reduced light intensity condition, an open connection between contact strip 109 and the contact point 107. However, under such conditions, since the motor rotates in a direction to rotate limit switch 90 in a clockwise direction, contact is again established between contact strip or member 109 and contact point 107, and likewise, until the limit switch rotates to a predetermined degree in the clockwise direction, contact will be maintained between contact strip 108 and contact point 106.

It thus becomes apparent that the modification of Fig. 2, in some senses, simplifies the arrangement shown by Fig. 1. Furthermore, from the circuit hereinabove described, it can be appreciated that if a failure of power supply for tube 47 should occur, the output current flow will be reduced to a minimum, and consequently the system is protected at all times, because minimum current output results for conditions of high light, and, therefore, if the power supply should fail, it will be appreciated that the relay armatures 62 and 64 occupy such a position relative to the contact points 68 and 72, respectively, that the motor 75 tends to rotate in a direction such as to close the iris opening and, at the same time, turn the limit switch in a counter-clockwise direction. In this way, the camera tube contained within the housing 13 is at all times protected.

Although the particular construction of the iris elements themselves forms the subject matter of a separate application, it is to be noted that it is especially desirable that these elements, from a mechanical standpoint, be carefully balanced with regard to each other, so that considerable ease of operation is obtained.

While the invention has been described herein as applicable and related to a television tube particularly, it will be appreciated that the system is likewise applicable to the ordinary type of camera equipment, such as a motion picture camera, wherein the camera tube, or the like, receives its light through the optical system 13 and the entering light, in contrast to its influence on the mosaic element of the television tube, influences a light sensitive photographic element to produce thereon a latent image of the viewed subject, and, accordingly, it is to be appreciated that the application of the invention, in its disclosed form, may have wide and varied uses, all of which fall fully within the sphere and scope of what is herein set forth.

Having described the invention, what is claimed is:

1. An optical system for television apparatus and the like for use in regulating the quantity of light directed to each of an optical image responsive target and a controlling photo-electric tube by way of an optical system arranged to direct substantially like and equally brilliant optical images simultaneously upon each of the target and the photoelectric tube along adjacent optical paths comprising, in combination, a single rotatable multiple section diaphragm element having a plurality of openings with one opening interposed in each of the optical paths for controlling the amount of light impinging upon each of the said image responsive target and photoelectric tube, a reversible motor element, a source of energy connected to said motor to drive the same, means to connect the diaphragm with the motor element to so operate the said diaphragm as to move it in the direction toward a maximum opening to pass greater light along each optical path with one direction of motor rotation and to move it toward the direction of the minimum opening to reduce the light along each optical path with motor rotation in the opposite direction, a pair of serially connected relay elements connected to respond to the current flow through the photoelectric control tube, one of said relays being connected to respond to current output levels to the photoelectric tube above a predetermined minimum value and the other of said relays being set to respond, jointly with the first-named relay, to current output levels exceeding a selected maximum value, electrical connections between the source and the motor through said relays so that current output levels from the photoelectric tube below the selected minimum response level of one of the relays causes the current to be supplied from the source to the motor to rotate it in a direction to open the diaphragm to admit a greater quantity of light upon each of the target and the photo-

electric control tube and for current output levels from the photoelectric control tube greater than the selected maximum relay response level of the other relay a current is supplied from the source to the motor in a direction to so rotate it as to move the diaphragm in the direction of closure and to reduce the light reaching the target and the photoelectric tube and further electrical connections provided by the said relays and effected at time periods when the photoelectric control tube output currents are of a value intermediate the selected maximum and minimum relay response levels to interrupt and break the connection between the energy source and the motor to arrest motor rotation.

2. An optical system for television apparatus and the like for use in regulating the quantity of light directed to each of an optical image responsive target and a controlling photoelectric tube by way of an optical system arranged to direct substantially like and equally brilliant optical images simultaneously upon each of the target and the photoelectric tube along adjacent optical paths comprising, in combination, a single rotatable multiple section diaphragm element having a plurality of openings with one opening interposed in each of the optical paths for controlling the amount of light impinging upon each of the said image responsive target and photoelectric tube, a reversible motor element, a source of energy connected to said motor to drive the same, means to connect the diaphragm with the motor element to so operate the diaphragm as to move it in the direction toward a maximum opening to pass greater light along each optical path with one direction of motor rotation and to move it toward the direction of the minimum opening to reduce the light along each optical path with motor rotation in the opposite direction, a pair of serially connected relay elements connected to respond to the current flow through the photoelectric control tube, one of said relays being connected to respond to current output levels to the photoelectric tube above a predetermined minimum value and the other of said relays being set to respond, jointly with the first-named relay, to current output levels exceeding a selected maximum value, electrical connections between the source and the motor through said relays so that current output levels from the photoelectric tube below the selected minimum response level of one of the relays causes the current to be supplied from the source to the motor to rotate it in a direction to open the diaphragm to admit a greater quantity of light upon each of the target and the photoelectric control tube and for current output levels from the photoelectric control tube greater than the selected maximum relay response level of the other relay a current is supplied from the source to the motor in a direction to so rotate it as to move the diaphragm in the direction of closure and to reduce the light reaching the target and the photoelectric tube, further electrical connections provided by the said relays and effected at time periods when the photoelectric control tube output currents are of a value intermediate the selected maximum and minimum relay response levels to interrupt and break the connection between the energy source and the motor to arrest motor rotation, and a switching means connected with the motor to open the established connection between the energy source and the said motor upon the attainment of selected degrees of rotation of the motor coinciding with selected maximum and minimum diaphragm opening positions.

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