

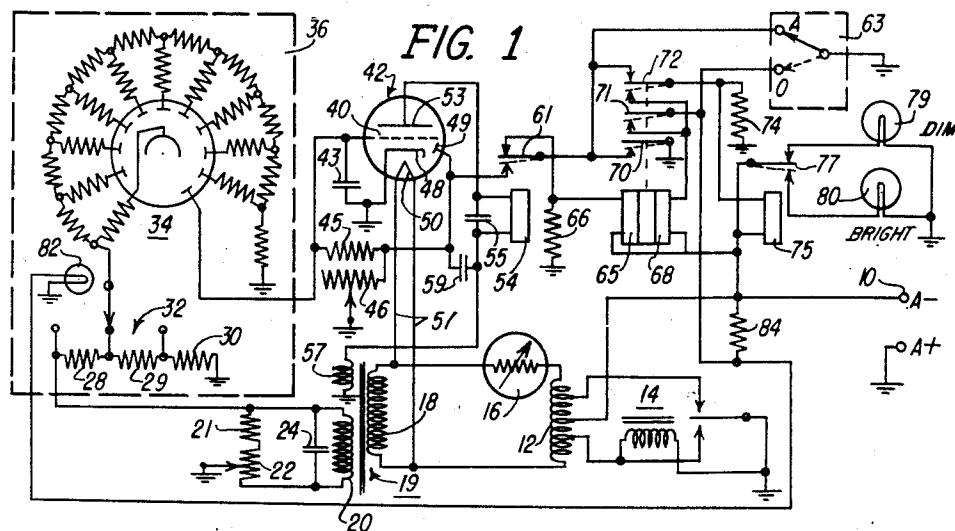
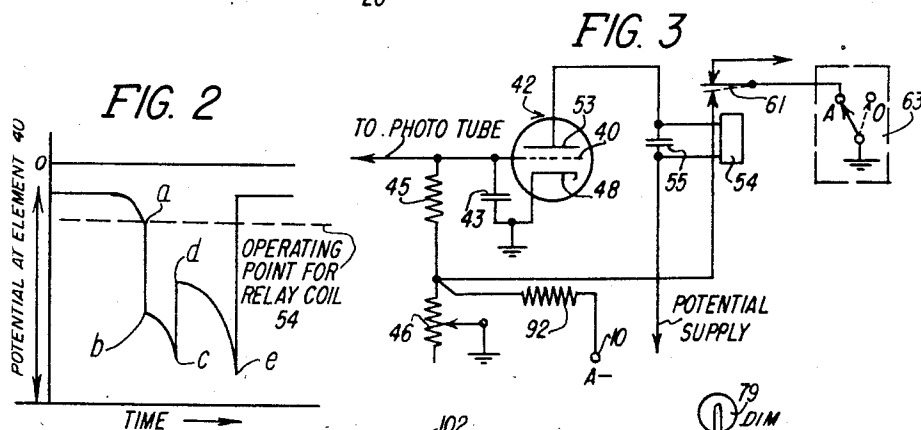
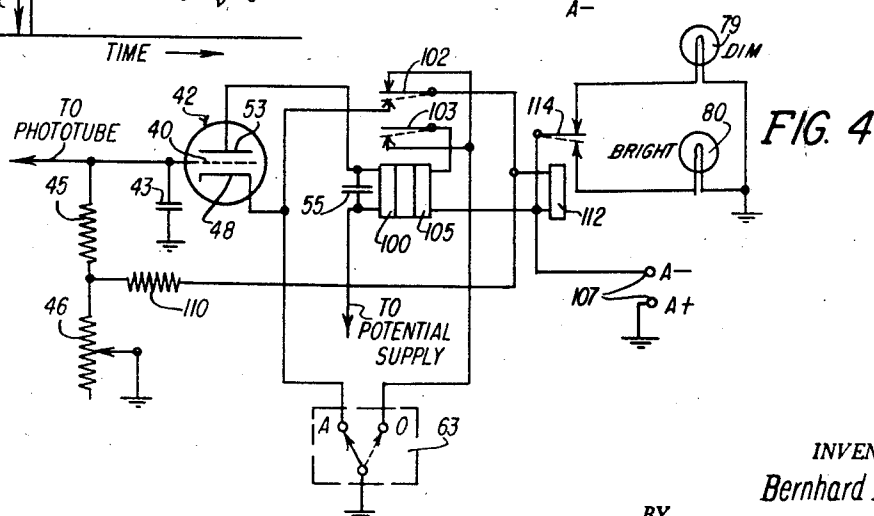
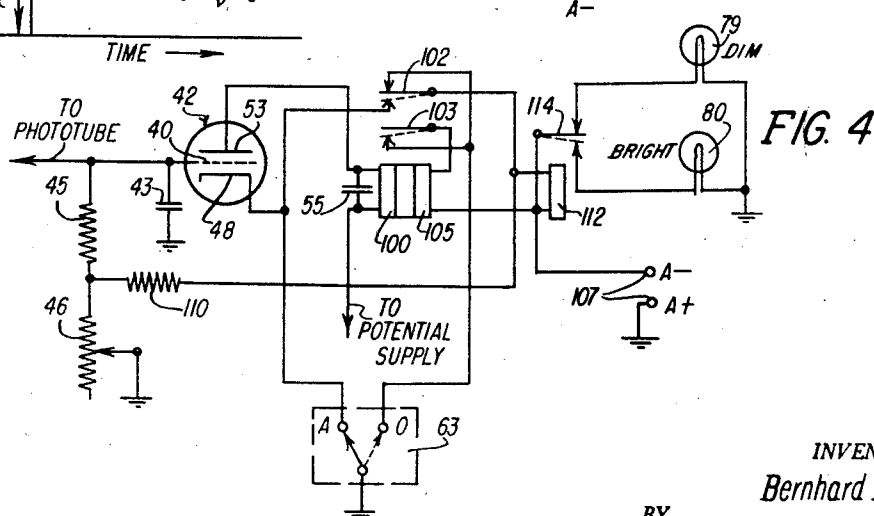
March 22, 1960

B. BIRKENES
CONTROL CIRCUIT

2,929,967

Filed Feb. 14, 1955

2 Sheets-Sheet 1



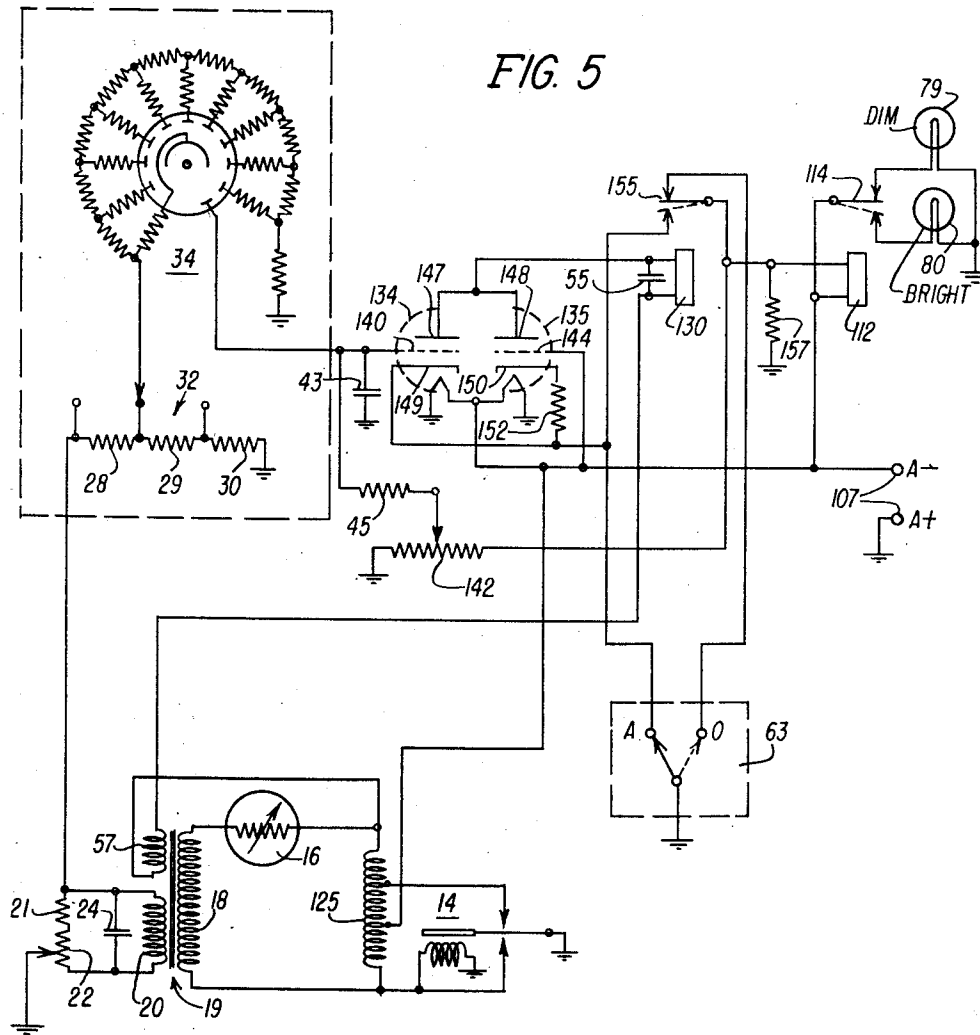
March 22, 1960

B. BIRKENES
CONTROL CIRCUIT

2,929,967

Filed Feb. 14, 1955

2 Sheets-Sheet 2



INVENTOR.

Bernhard Birkenes

BY

Mueller & Aichele

Attys.

1

2,929,967

CONTROL CIRCUIT

Bernhard Birkenes, Chicago, Ill., assignor to Motorola, Inc., Chicago, Ill., a corporation of Illinois

Application February 14, 1955, Serial No. 488,058

11 Claims. (Cl. 317—130)

This invention relates generally to electronic control circuits and more particularly to improved apparatus for automatically dimming vehicular headlamps in the presence of illumination from headlamps of oncoming vehicles.

The danger and inconvenience experienced when a vehicle on the highway maintains its headlamps in bright condition when meeting and passing other vehicles is well known. Various arrangements have been proposed to automatically dim headlamps when illumination of a certain amount exists in front of a driver. Among such dimmer circuits is the electronic type in which a light sensitive device responds to oncoming headlamps to operate a circuit which automatically dims the lights and then automatically reenergizes the bright lights when the actuating illumination is no longer present.

It has been proposed in such apparatus to make the device more sensitive to light once it has become actuated in order that the bright lights will not immediately be reenergized should the actuating illumination momentarily decrease somewhat. Thus, if the oncoming vehicle dims its lights after having actuated a dimmer circuit, the circuit will not then immediately reenergize the bright lights. There are also other instances in which an actuating illumination may decrease in intensity and in which it is desirable that the circuit maintain the lights in dim condition. While it has been found highly advantageous to have a circuit increasing in sensitivity once it has become actuated, such circuits have resulted in blocking of the dimmer circuit and/or have not given a satisfactory return to bright condition when the actuating illumination is no longer available. Furthermore, unstable and unsatisfactory operation of some dimmer circuits has stemmed from the fact that a very sensitive light responsive circuit is being energized by the electrical system of a vehicle in which the operating voltage is subject to considerable variation due to the varying speed of the generator supplying the power to the system.

Accordingly, it is an object of the present invention to provide an improved vehicular headlamp control circuit which operates in stable and reliable fashion from a power source subject to variations in voltage.

It is also an object to provide light actuated apparatus which incorporates an improved circuit for increasing the sensitivity thereof after operation is started while at the same time reducing the tendency of the circuit to block.

Still another object of the invention is to provide an improved voltage regulating circuit for providing steady operating potentials for a sensitive electronic control circuit.

Yet another object of the invention is to provide a simplified and improved headlamp control circuit having provision for overriding the automatic apparatus to permit selective manual operation of the bright or dim headlamps.

A feature of the invention is the provision of control apparatus with a power supply circuit energized from an interrupted low voltage, in which an auto transformer

2

energized by the interrupted voltage is coupled through a ballast tube to a high voltage transformer to provide regulated potentials for the apparatus.

A further feature is the provision of an electronic headlight control system for a vehicle having a power supply operating from the vehicle electrical system which provides regulated potentials for the heater, plate load and bias of a vacuum tube used in the system.

Another feature of the invention is the provision of headlamp control apparatus having an improved arrangement for switchably applying a fixed bias potential to a control tube in order to alter the sensitivity of the apparatus.

Still another feature of the invention is the provision of headlamp control apparatus utilizing a pair of electron discharge devices controlling relay apparatus to regulate the headlamps with one discharge device responsive to light sensitive apparatus and another adapted to hold a portion of the relay apparatus in readiness when a single switch is used for manual headlamp operation.

Further objects, features and the attending advantages of the invention will be apparent upon consideration of the following description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of the control apparatus of the invention; and

Fig. 2 is a graph useful in explaining the operation of the invention;

Figs. 3, 4 and 5 are schematic diagrams of alternate embodiments of the control apparatus.

In practicing the invention there is provided a control circuit for automatically dimming the vehicular headlamps in the presence of illumination from an oncoming vehicle. Power is applied to the apparatus from an interrupted low voltage source through an auto transformer and a ballast tube to a power transformer and tube filament circuit which supply regulated operational potentials for the light actuated circuit. Included in this circuit are a photoelectron tube and a vacuum tube amplifier which controls relays to place the headlamps in dim or bright condition. The amplifier tube is normally conducting and when sufficient illumination strikes the photoelectron tube, the current produced therein reduces the conduction of the amplifier tube to such an extent that the relay actuated thereby is released to energize the dim headlamps of the vehicle. Release of this relay also connects a bias source to the grid of the amplifier tube so that the tube will in effect be more sensitive and a lesser amount of light on the photoelectron tube will hold the conductivity of the amplifier tube to a point where the relay remains released. Therefore, the illumination striking the photoelectron tube must decrease to a point considerably below that which originally caused release of the relays to render the amplifier tube again conductive for changing the relays to reenergize the bright lights. By using the voltage regulated supply as previously described and the fixed source of grid bias, the circuit operates reliably and will promptly respond to illumination level in accordance with the sensitivity settings of the controls thereof.

Furthermore, the circuit is adapted to be connected to a simple foot switch so that the choice of bright or dim lights may be made by a driver while the automatically operated relays are temporarily held in readiness for subsequent automatic operation. Such manual "override" is accomplished by use of a hold coil on one of the relays or by an electron discharge device which is made conductive to hold such a relay in operated condition.

With reference to Fig. 1, a detailed description of the circuit construction will now be given. Low voltage direct current power is supplied between terminal 10

and ground, with either the positive or negative side of this power being connected to ground. A suitable source would be the vehicular storage battery and its associated generator. Terminal 10 is coupled to the center tap of auto transformer 12 and additional taps on this transformer on either side of the center tap are connected to the stationary contacts of the vibratory interrupter 14 so that by grounding the vibrating arm of this interrupter, a pulsating voltage will be induced in the auto transformer 12. The ends of the winding of transformer 12 are coupled through ballast tube 16 across the primary winding 18 of transformer 19. Transformer 19 has a secondary winding 20 across which a bleeder resistor circuit 21, 22 is coupled in parallel with capacitor 24. Between one side of secondary winding 20 and a tap on resistor 22 a voltage divider network including resistors 28, 29 and 30 is coupled. One end of resistor 30 is connected to ground while the various juncture points of the remaining resistors are connected by way of tap switch 32 to the photomultiplier tube 34 and its associated circuitry. A voltage divider network is connected between tap switch 32 and ground and this network supplies potential steps to the various dynodes of the photomultiplier tube 34 in order to provide the multiplying action. Resistors 28 to 30, switch 32 and photomultiplier tube 34 may all be housed in a suitable container 36 and placed in a position such as at the windshield of an automobile so that the desired actuating illumination may impinge upon the photomultiplier tube.

The control element 40 of electron discharge tube or device 42 is coupled to the output anode of the photomultiplier tube 34 and control element 40 is by-passed to ground by means of capacitor 43 and a resistor network including resistor 45 and variable resistor 46 is connected between element 40 and ground. Device 42 is shown as a combination diode-triode including a cathode 48 which is connected to ground and a diode anode element 49 which is coupled to the junction of resistors 45 and 46. A filament 50 in the device 42 is also connected by means of filament circuit 51 across the output of transformer 12 through ballast tube 16 which supplies the proper potential to filament 50.

Triode anode 53 of device 42 is connected through a parallel combination of relay coil 54 and filter capacitor 55 to the secondary winding 57 of transformer 19. The other side of winding 57 is connected to ground so that a suitable operating potential will be supplied to the discharge device 42 by means of this winding. Secondary winding 57 is also coupled through capacitor 59 to the anode 49 in order to supply a small portion of the secondary potential to this anode.

Switch arm 61 associated with relay coil 54 and actuated to its dotted position thereby is coupled to a first contact of switch 63 which may be conveniently positioned to be operated by the driver of a vehicle in which the circuit is used. Switch 63 also includes a second contact and an arm connected to ground in order to provide selective grounding of either of its two contacts. Switch arm 61 in its dotted position is connected to anode 49 and in its solid line position is connected to one side of relay winding 65. This side of the relay winding is also connected to ground through resistor 66. The other side of relay winding 65 is connected to the potential source at terminal 10 as well as to one side of the winding of the relay winding 68. Winding 68 serves as a holding coil for switch arms 70, 71 and 72 which are actuated to their respective dotted line positions by relay coil 65. In the solid line positions switch arm 70 makes no contact and in the dotted line positions thereof it makes contact with the first contact of switch 63. Switch arm 71 makes no contact in its solid line position but in the dotted line position thereof it connects to the relay holding coil 68 as well as to switch arm 72 in the dotted line position thereof. In the solid line position of switch arm 72 it is connected to switch

arm 61 associated with relay coil 54. Switch arm 70 is connected to ground and switch arm 71 is connected to the second contact of switch 63.

Switch arm 72 is connected to ground through resistor 74 as well as to one side of relay coil 75. The other side of relay coil 75 is coupled to the terminal 10 as well as to switch arm 77 associated with and actuated by this relay coil. In the solid line position of switch arm 77 it is connected through the dim lamp filaments 79 of the vehicle to ground. In the dotted line position of switch arm 77, to which this arm is moved by energization of relay winding 75, the arm is connected through the bright filaments 80 to ground. A pilot lamp 82 located in the housing 36 and visible to an operator of the vehicle is connected between ground and switch arm 71, while a resistor 84 is connected between terminal 10 and switch arm 71 to supply power to pilot lamp 82. When switch 63 is in the dotted line position, lamp 82 is shorted and it is lighted in the solid line position thereby indicating the position of switch 63.

Having thus described the wiring of the circuit, the operation thereof will now be explained. With a suitable direct current potential impressed between terminal 10 and ground, such as for example 6 volts in the case of some automobiles, the vibratory interrupter 14 may be rated at 6 volts and will vibrate to provide a pulsating potential in auto transformer 12. This potential is then impressed across the series combination of ballast tube 16 and primary winding 18. Auto transformer 12 is selected to provide a suitable potential for operation of the ballast tube, which may be of the 4 volt type, so that the proper potential at the primary winding 18 will remain substantially constant. In practice the voltage at terminal 10 will fluctuate through a range of voltage so that the voltage across the winding 12 will vary from 15 to 24 volts. The ballast tube will have an increasing resistance as the voltage increases so that the voltage across winding 18 will be held within relatively small limits of a value of the order of 12 volts.

It will be noted that the heater 50 of tube 42 is connected across the primary winding 18 so that regulation will be provided for the heater voltage as well as for the power applied to transformer 19. Accordingly, should variations of the supply potential occur, they will be largely accounted for by the ballast tube 16 and the operation of the dimmer circuit will not be impaired. Furthermore, by the use of auto transformer 12, it is possible to utilize a ballast tube and a vibrator of standard ratings. That is, without such a transformer the standard 4 volt ballast tube and the 6 volt vibrator could not be used satisfactorily together across a 6 volt battery the potential of which being too low to operate both satisfactorily.

By means of secondary winding 20 an alternating current potential will be supplied for operation of photomultiplier tube 34 and by means of secondary winding 57, a suitable operating potential for device 42 will be supplied. Variable resistor 22, in conjunction with tap switch 32, provides convenient adjustment of the magnitude of the voltage supplied for operation of the photomultiplier tube and will therefore permit adjustment of the signal developed thereby in accordance with a given illumination level. These controls are accordingly adjusted so that in the absence of actuating illumination the electron discharge device 42 is conducting to energize relay coil 54 so that switch arm 61 will be moved to its dotted line position. With switch arm 61 in its dotted line position, anode 49 will be grounded as will the bottom terminal of resistor 45, which is the grid leak resistor. With switch 63 in the solid line position, arm 61 will be connected to ground as will arm 72 so that relay coil 75 is energized. Therefore, switch 77 will move to its dotted line position energizing the bright filaments 80.

Assuming now an increase in the illumination falling upon photomultiplier tube 34, it may be seen that a nega-

5

ive voltage will be developed across resistor 45 causing control element 40 to become negative and thereby reduce conduction in the electron discharge device 42 so that relay coil 54 will not hold arm 61. Illumination from the headlamps of an oncoming vehicle falling upon the photomultiplier tube therefore causes switch arm 61 to move to its solid line position.

With the ground connection removed from resistor 45, the grid leak path is now through a portion of resistor 46. However, at the instant of operation of arm 61 a fixed negative bias is placed upon control element 40 through resistor 45. Such a bias is developed by coupling a portion of the alternating voltage of secondary winding 57 through capacitor 59 to the anode 49. Some of the alternating current voltage from winding 57 is therefore rectified and applied as a negative bias potential to the junction of resistors 45 and 46. Thus, with the switch arm 61 in the solid line position, the negative bias on control element 40 renders the device 42 more sensitive to a control voltage from the photomultiplier tube so that the relay 54 will remain released until a great reduction in illumination takes place. Accordingly, as explained previously, if the oncoming vehicle should dim its lights or if the illumination should decrease somewhat due to any cause, relay 54 will remain released until the illumination on photomultiplier tube 34 decreases to a point considerably below that which originally caused the relay to release. As will be apparent upon further consideration and explanation of the circuit, this will prevent the headlamps from flashing between bright and dim as the level of the actuating illumination changes about a point which produces a voltage at control element 40 which is close to that necessary for providing the actuating current of coil 54. Adjustment of the setting of variable resistor 46 provides a control for selecting the amount of the fixed bias which is coupled to control element 40 and in effect will permit selection of the amount of illumination necessary to cause operation of the relays.

With relay coil 54 deenergized and switch arm 61 released to its solid line position, relay coil 65 will become energized since its circuit is completed through the solid line position of switch 63. Ganged switch arms 70-72 will now move to their respective dotted line positions thus removing the energization potential from relay coil 75 and causing switch arm 77 to move to the solid line position which energizes the dim lamp filaments 79. It is apparent that when the actuating illumination has decreased sufficiently, that is, when the oncoming vehicle no longer shines headlamps upon photomultiplier tube 34, discharge device 42 will again energize relay coil 54 and deenergize relay coil 65 and energize relay coil 75 to again light the bright headlamp filaments 80.

The graph of Fig. 2 illustrates the voltage at element 40 when the lights of an oncoming vehicle impinge upon tube 34. It may be seen that the bias level is somewhat above the operating point for relay coil 54 when comparative darkness exists around the phototube. However, as a vehicle approaches and its lights strike the tube 34, element 40 becomes more negative as tube 34 conducts more. Eventually, conduction of device 42 is reduced to release relay 54 and cause arm 61 to move to the solid line position. The fixed bias is then connected and immediately causes the voltage on element 40 to fall to point *b*. The oncoming vehicle may continue to approach and then dim its lights at point *c*, but due to the fixed bias now on device 42, the signal level goes to point *d* which is still below the value for operating relay 54. Finally, the vehicle passes at point *e* and with comparative darkness again existing, device 42 may conduct sufficiently to energize coil 54.

Operation of foot switch 63 to the dotted line position serves to change the headlamp condition and lock the circuit in such changed condition so that the automatic control is no longer effective. With switch 63 in the solid

6

line position and the dim filaments 79 energized, that is, with relay coil 54 deenergized, operation of switch 63 to the dotted line position will cause bright filaments 80 to be energized. By such operation of switch 63, ground would be removed from switch arm 61 so that holding coil 68 and relay coil 75 are energized through dotted line positions of switches 71 and 72 causing bright filaments 80 to be energized.

It is apparent that with the ground connection removed from the first contact of switch 63, that is, in the dotted line position thereof, the deenergization of relay coil 54 will not cause relay coil 65 to be energized, therefore when switch 63 is moved to the dotted line position when bright filaments 80 are originally energized, the dim filaments 79 will become energized and remain so regardless of the condition of relay coil 54.

It may also be seen that if switch 63 is moved to the dotted line position when relay coil 54 is not energized, therefore when switch arm 61 is in the solid line position, a ground return will be completed for holding coil 68 through the dotted line position of switch arm 71 which will maintain switch arms 70-72 in the dotted line position. The ground return will also be completed for relay coil 75 through switch arms 71 and 72 so that switch arm 77 will be moved to the dotted line position thus energizing the bright filaments 80. Holding relay coil 68 will be self held through switch arm 71 in this position of switch 63 so that once again the condition of relay coil 54 will not affect the circuit. However, it is to be pointed out that when switch 63 is returned to the solid line position, the control circuit will again become automatic and responsive to the condition of switch arm 61 at that time. Switch arms 70, 71, and 72 may be slow to release so that they will not change condition during operation of switch 63. Thus, it is apparent that by operation of switch 63 the condition of the lights may be changed from whatever it was to the opposite condition and that by subsequent operation of switch 63 the system will again be automatically operative to respond to the illumination level impinging upon photomultiplier tube 34.

The circuits illustrated in Figs. 3 and 4 show different methods of producing the fixed grid bias supplied to the control electrode 40. The advantage, of course, of using the fixed bias to drive device 42 further into cut-off once sufficient actuating illumination has been intercepted by photomultiplier tube 34, is that grid-leak resistors 45 and 46 may be made of low enough value to permit a more rapid change in signal level at control electrode 40 to reduce the possibility of device 42 being blocked at large signal levels. Lower values of resistors 45 and 46 also provide a better discharge path for capacitor 43 than would large values of these resistors. Capacitor 43 is utilized to filter small fluctuations in the control voltage applied to electrode 40 and is particularly useful when the operating voltages for the discharge device 42 and the photomultiplier tube 34 are alternating as in the circuit shown in Fig. 1.

In the circuit illustrated in Fig. 3, rather than derive a portion of the anode voltage and rectify the same for use as a fixed bias, a fixed bias is applied from negative terminal 10 through resistor 92 to the junction of resistors 45 and 46 when switch arm 61 is in the solid line position. Therefore, at this time an additional bias will be applied to the control electrode 40 just as in the previously described circuit, and this bias will be ineffective when device 42 is conducting since the junction of resistors 45 and 46 will be grounded as in the previous circuit. The function of resistor 92 is, of course, to prevent short circuit of the potential supply when device 42 is conducting and switch arm 61 is in the dotted line position and switch 63 is in the automatic or solid line position. Adjustment of resistor 46 permits selection of the potential applied as bias through voltage divider action of resistors 46 and 92.

7

The circuit of Fig. 4 utilizes but two relays to accomplish the operations as described in connection with Fig. 1 and also uses a slightly different circuit for applying the fixed bias to the control element 40 when device 42 is non-conductive. It may be seen that anode 53 is coupled through relay coil 100 to a potential supply which may be the same as that shown in Fig. 1, and that switch arms 102 and 103 are moved from their respective solid line positions to dotted line positions when coil 100 is energized. Holding coil 105, also associated with switch arms 102 and 103, is coupled from the negative terminal of potential supply 107 to switch arm 103. In the dotted line position of switch arm 103 a connection is made to the second terminal of switch 63 which is connected to ground in the dotted line position of that switch. A connection is also made from this second terminal to switch arm 102 in the solid line position thereof. In the dotted line position of switch arm 102 a connection is made to the emission element 48 of device 42 and to the first terminal or automatic position of switch 63 which is grounded in the solid line position of that switch.

Switch arm 162 is connected through resistor 110 to the junction of resistors 45 and 46 as well as to one end of relay coil 112 which operates switch arm 114. The other side of relay coil 112 and switch arm 114 are both connected to the negative terminal 10. In the solid line position of switch arm 114 the dim filament 79 may be energized, and in the dotted line position of this switch arm the bright filament 80 may be energized.

The operation of the circuit of Fig. 4 will now be described. As in the circuit of Fig. 1, the photomultiplier circuit is adjusted to supply a signal which causes conduction of device 42 when little or no illumination impinges upon the tube 34. Therefore, device 42 will conduct and relay coil 100 will be energized, and relay coil 112 will be energized through the dotted line position of switch 102, assuming switch 63 to be in the automatic or solid line position. Therefore, switch arm 114 will be in the dotted line position and bright filaments 80 will be energized. It may also be seen that one side of resistor 110 will be grounded to provide a return for control element 40.

When sufficient illumination strikes the photomultiplier tube current through tube 42 will decrease so that the relay 100 will be released and switch arms 102 and 103 will move up as will switch arm 114, thus energizing dim filament 79. At this time, the return path for control element 40 will be through resistors 45 and 46. However, a voltage divider network will exist between ground, a portion of resistor 46, resistor 110, relay coil 112, and the negative terminal of potential source 107. The amount of current flow will not be sufficient to cause energization of relay coil 112, but will, however, be sufficient to apply a negative bias to the junction of resistors 45 and 46. The amount of this bias may be adjusted, of course, by varying the value of resistor 46. Therefore, as in the circuit shown in Fig. 1, device 42 will be biased considerably below the conduction level for release of arms 102 and 103 when illumination strikes tube 34. As previously, the signal developed by tube 34 will have to rise to a point considerably less negative than the level of the signal which initially released arms 102 and 103, thus preventing undesirable flashing of the lights as pointed out. However, the values of resistors 45 and 46 need not be so high as to prevent discharge of capacitor 43 and control element 40 from following the signal as developed by photomultiplier tube 34. Therefore, a precise action of discharge device 42 may be expected in response to the signal from the photomultiplier tube and this, in conjunction with the regulated power system, will provide a highly reliable dimmer circuit. It is also possible to use the fixed bias supply of Fig. 1 in the circuit of Fig. 4 by providing additional contacts associated with coils 100 and 105 to provide grounding of

8

the rectifier anode (such as anode 49) in the energized condition of coil 100.

When switch 63 (Fig. 4) is moved to its dotted line or override position, it will cause a change in the condition of relay coil 112. Thus, if the dim filaments 79 are energized and relay coil 100 is de-energized, movement of switch 63 to the dotted line position will place a ground return on relay coil 112 through the solid line position of switch arm 102 causing switch arm 114 to move to the dotted line position thus energizing the bright filaments 80. Signal level changes on control element 40 will have no effect on the device 42 since it is apparent that the cathode circuit is now open.

On the other hand, if relay coil 100 is energized and relay coil 112 is energized to cause filaments 80 to be lighted, movement of switch 63 to the dotted line position will remove the ground return from device 42 as well as from relay coil 112 thus causing switch arm 114 to move to the solid line position to energize filaments 79. At the same time, however, the return circuit for coil 105 will be completed through the dotted line position of switch 103 thus causing the relay to remain energized so that if switch 63 is again returned to its solid line position, the entire circuit will be again operated solely by the condition of electron discharge device 42. While the circuit to cathode 48 is still completed, self holding coil 105 will maintain arms 102 and 103 in the dotted position regardless of the condition of device 42. Switch arms 102 and 103 may be of the type which release slowly so that they will not be released during the time switch 63 moves between either of its positions.

The circuit of Fig. 4 provides, therefore, an improved grid biasing system in addition to providing the desirable override by operation of switch 63 as previously mentioned, however, the bias system of Fig. 1 may also be used in this circuit. But the circuit of Fig. 4 is advantageous in that it utilizes only a pair of relay devices to accomplish the result.

Fig. 5 illustrates another form of the dimmer circuit utilizing a pair of relays having single pole double throw contacts associated therewith in order to provide an inexpensive circuit but yet one which furnishes the desirable features referred to previously. The components corresponding to those shown in the previously described circuits are numbered the same and only the differences of the circuitry will be described here. In this circuit, the vibrator 14 is connected across the center tapped portion of the auto transformer 125 and the center tap is connected to the potential supply terminals 107 or A—. An additional section of the winding of transformer 125 is coupled in series with the ballast tube 16 and the primary winding 18 of transformer 19. One terminal of secondary winding 57 is coupled to the junction of ballast tube 16 and the additional portion of the winding of transformer 125 while the other terminal of winding 57 is connected to the relay coil 130.

The circuit also includes a pair of triode sections 134 and 135 which, by their conduction, serve to energize the relay winding 130. Triode section 134 includes a control element 140 which is coupled to the photomultiplier tube 34 and through resistor 45 to a tap point of resistor 142, an end terminal of which is grounded. Control element 144 associated with triode section 135, is connected directly to the potential supply or A—. The respective anodes 147 and 148 of the triodes are connected to the relay 130 and the cathodes 149 and 150 are connected together through resistor 152. Cathode 149 is coupled directly to a terminal on switch 63 so that it will be grounded in the solid line position of that switch.

Switch arm 155, associated with relay 130, is normally in the solid line position but is moved to the dotted line position when 130 is energized. Arm 155 is connected to one side of resistor 142 and to relay 112 as well as through resistor 157 to ground. The solid line position of switch arm 155 completes a connection to a terminal

of switch 63 which is connected to ground in a dotted line position of that switch. The dotted line position of switch 155 completes a circuit to cathode 149. Other portions of this circuit correspond to the circuits previously described.

When the circuit is in operation and there is comparative darkness existing around the photomultiplier tube 34 and switch 63 is in a solid line or automatic position, triode section 134 will be conducting which energizes relay 130 causing relay coil 112 to be energized through the dotted line position of switch arm 155 and the solid line position of switch 63. Thus, switch arm 114 will be moved to the dotted line position, thereby energizing the bright filaments 80. It may also be noted that both end terminals of resistor 142 are grounded so that there is zero grid bias on control element 140, thus maintaining conduction of triode section 134.

When a certain amount of illumination strikes the photomultiplier tube 34, current will be drawn through resistor 45 and a sufficient amount of illumination will reduce the conduction of triode section 134 sufficiently to cause deenergization of relay 130. This will move switch arm 155 to the solid line position which removes the ground return from relay coil 112 and causes energization of the dim filament 79. As in the previously described circuit when the controlling discharge device is cut off by, for example, the headlights of an oncoming auto, a fixed negative bias will be applied to the control device operating the relays. In Fig. 5, such additional fixed bias is applied by the tap point of resistor 142 to the control element 140. A small amount of current passing through resistor 142 and resistor 157 and relay coil 112 in parallel provide the necessary potential at this tap point. Such an amount of current will not, however, be sufficient to energize relay coil 112 although it will provide the desired bias potential which may be varied by adjustment of the tap point on resistor 142. This bias provides a circuit which will remain operated by lesser actuating light to prevent flashing of the controlled headlamp as previously pointed out.

It should be mentioned that with switch 63 in the solid line or automatic position, triode section 35 will not be conducting sufficiently to effect energization of relay 130. With control element 144 returned to a minus and the value of cathode resistor 152 properly chosen, the conduction of triode section 135 may be reduced to a point where it may not energize relay 130.

If the apparatus is in a comparatively dark area, that is, with the triode section 134 conducting and relay 130 energized, and it is desired to energize the dim filament 79, switch 63 may be moved to the dotted line position which will remove the ground return for relay coil 112 and permit establishment of the solid line position of switch 114 to effect the result. Such operation of switch 63 will also remove the ground return for cathode 149. However, with switch arm 155 initially in a dotted line position when switch 63 was moved to the dotted line position, triode section 135 may be rendered in a conducting condition so that relay 130 will remain energized. Triode section 135 will be conducting since the control element 144 and the cathode element 150 will be at substantially the same potential. The conducting path for the cathode element 150 is completed through the dotted line position of switch arm 155 and the parallel combination of resistor 157 and relay coil 112. Relay 130 may be slow acting so that it will not release as switch 63 is operated. Furthermore, it is apparent that relay coil 112 must be of the type which requires somewhat more current for its energization than that which is required for relay 130. Therefore, when at least a part of the current of triode section 135 is drawn through relay coil 112, energization of this coil will not occur.

If the entire apparatus is in a comparatively light area, that is with an actuating illumination impinging upon photomultiplier tube 34 and the dim lights energized, 75

switch 63 may be moved to the dotted line position to establish the ground return for relay coil 112, thereby energizing this coil and establishing the dotted line position of arm 114 to energize filament 80. At the same time, the cathode return for triode section 134 will be broken so that this tube may not conduct even though the illumination should be removed from the photomultiplier tube 34. Nor may triode section 135 conduct, since switch arm 155 is in the solid line position and there is no cathode return for this device. Therefore, it may be seen that a simple single pole double throw switch may provide automatic or override operation for the apparatus. Furthermore, this embodiment uses standard, inexpensive relays.

It may also be pointed out that provision is made for stabilizing the operation of triode section 134 in the event that the potential supply impressed upon terminals 107 should vary somewhat. It may be seen that when the apparatus is in an illuminated area and relay 130 is de-energized, the bias potential for control element 140 is supplied directly by voltage divider action of components across terminals 107. However, it may be seen that secondary winding 157 of transformer 19 which supplies the operating potential for anode 147 is series connected with a portion of the winding of auto transformer 125 so that as the "A" potential varies, the power supplied by secondary winding 57 will tend to follow the change through the transformer action of auto transformer 125, thus following any change in the bias potential applied to the control element 140. With the circuit connected in this manner, it is apparent that the potential supplied to the photomultiplier tube 34 will be regulated by bias tube 16 and, therefore, this potential will not tend to follow the changes in the A supply, thus promoting stability of the entire apparatus.

It may be also pointed out that during the initial warming up period of the apparatus shown in Figs. 1, 4 and 5, that is, before the electron valves are operative, the positioning of switch 63 permits selection of either the bright or dim headlamps. In Fig. 1, it may be seen that in the solid line position of switch 63 the circuit for relay coil 75 will be completed to the solid line position of switch arm 72 during the initial warming up period when relay coils 54, 65 and 68 are not energized. On the other hand, movement of switch 63 to the dotted line position will open this connection to energize to cause release of switch arm 77 thus energizing the dim filament 79.

In the circuit of Fig. 4, it may be seen that the bright filament 80 may be energized by operation of switch 63 to the dotted line position which completes the circuit for relay coil 112 through the solid line connection of arm 102 during the initial warming up period of the apparatus. On the other hand, movement of switch 63 to the solid line position would open this connection and cause release of switch arm 114, thus energizing the dim filament 79 during warm up.

Control of headlamps may also be manually effected during the warm up period of the circuit of Fig. 5. In the dotted line position of switch 63 the return for relay coil 112 will be established through the solid line position of switch arm 155 thus energizing coil 112 and causing operation of the bright filament 80. On the other hand, movement of switch 63 to the solid line position will open this connection and cause energization of filament 75 during the warm up period of the apparatus.

The invention provides, therefore, an improved dimmer circuit wherein stable and reliable operation is obtained. The circuit may be adjusted to a desired sensitive condition but yet it may be powered from a varying power source such as encountered in vehicular power systems. Furthermore, the apparatus will remain responsive and reliable at most signal levels without blocking since a fixed bias system is included in the circuit to establish the operating point of the incorporated amplifier. Addi-

tionally, a convenient override switch may be included in the circuit to provide manual change of the headlamps from any existing condition, and to permit immediate return to automatic operation when desired.

I claim:

1. Apparatus for automatically controlling headlamps of a vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination; light sensitive means for developing a signal in response to a certain light level; an electron discharge device coupled to said light sensitive means, said discharge device having a filament therein; relay means coupled to, and controlled by, said electron discharge device for controlling the headlamps; and regulated power supply means for said light sensitive means and said electron discharge device including power coupling means adapted to be connected to a voltage source in the vehicle to be energized thereby, auto transformer means, means coupled to said power coupling means and to said auto transformer means for providing an interrupted current therein, a ballast tube, transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said auto transformer means, a filament circuit connecting the aforesaid filament and said power coupling means, and said light sensitive means and said electron discharge device being coupled to said secondary winding for supplying regulated power thereto.

2. Apparatus adapted to operate from a vehicular electrical system for automatically controlling headlamps of the vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a control signal of given value in response to a certain light level, an electron discharge device having a control element coupled to and controlled by said light sensitive means, said discharge device further having a filament therein, relay means coupled to and controlled by said electron discharge device to control the headlamps in response to said control signal, regulated power supply means for said light sensitive means and said electron discharge device including power coupling means adapted to be connected to a source of operating potential in the vehicle, first transformer means, vibratory means coupled to said power coupling means and to said first transformer means for providing an interrupted current therein, a ballast tube, second transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said first transformer means, a filament circuit connecting said filament and said primary winding, means coupling said secondary winding to said light sensitive means and said electron discharge device for supply thereto of power regulated by said ballast tube and a source of bias coupled to said relay means and adapted to be controlled thereby to change the bias of said control element of said electron discharge device during control by said control signal to change the response of said discharge device to said light sensitive means.

3. Apparatus adapted to operate from a vehicular electrical system for automatically controlling headlamps of the vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a control signal varying with the light level, an electron discharge device having a control element coupled to said light sensitive means and controlled by said control signal, said discharge device further having a filament therein, relay means coupled to and controlled by said electron discharge device to control the headlamps, and regulated power supply means for said light sensitive means and said electron discharge device including a potential coupling circuit adapted to be coupled to the vehicular electrical system, first transformer means, means coupled to said potential coupling circuit and to said first transformer means for providing an interrupted current there-

in, a ballast tube, second transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said first transformer means, a filament circuit coupled between said filament and said primary winding, means coupling said secondary winding to said light sensitive means and said electron discharge device for supply of regulated potential thereto, and a rectifier circuit coupled to said secondary winding and to said relay means and adapted to develop a bias potential for application to said control element of said electron discharge device, said bias potential being altered by operation of said relay means to change the effective sensitivity of said discharge device so that said relay means is operated thereby in response to a control signal of different value.

4. Apparatus adapted to operate from a vehicular electrical system for automatically controlling headlamps of the vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a signal in response to a certain light level, an electron discharge device including a filament and having a control element coupled to said light sensitive means, first relay means controlled by said electron discharge device and having contacts operable to a plurality of conditions, second relay means controlled by said first relay means and connected to control the headlamps, switching means connected to said first relay means and operable to a position to maintain said first relay means in an existing condition and to change the condition of said second relay means, regulated power supply means for said light sensitive means and said electron discharge device including power coupling means adapted to be energized by the vehicular electrical system, first transformer means, vibratory means coupled to said power coupling means and to said first transformer means for providing an interrupted current therein, a ballast tube, second transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said first transformer means, a filament circuit coupled between said filament and said primary winding, means coupling said secondary winding to said light sensitive means and said electron discharge device for supply thereto of high voltage regulated by said ballast tube, a voltage divider network coupled across said power coupling means with a point thereon connected to said contacts of said first relay means and to said control element of said electron discharge device for changing a bias on said control element by operation of said first relay means.

5. A regulated voltage transforming system for an electronic control system including an amplifier valve with a filament therein, said system including in combination, direct current potential supply means, first transformer means, means coupled to said potential supply means and to said first transformer means for providing a pulsating current therein, a ballast tube, second transformer means having primary and secondary windings, said primary winding being connected in series with said ballast tube to said first transformer means, said secondary winding being coupled to said amplifier valve to energize the same, and means for connecting said filament across said primary winding whereby said ballast tube holds the potential across said primary winding and the filament substantially constant in response to variations in the potential applied by said potential supply means.

6. Apparatus adapted to operate from a vehicular electrical system for automatically controlling head lamps of the vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a signal in response to a certain light level, an electron discharge device having a control element coupled to said light sensitive means, first relay means including first and second windings and first and second sets of contacts operable to a plurality of conditions in response to energization of said windings, said first winding being connected to said

13

electron discharge device and being selectively energized thereby, said second winding being connected to said second set of contacts, second relay means controlled by said first set of contacts of said first relay means and connected to control the headlamps, switching means connected to said first and second sets of contacts and operable through said first set of contacts in one of said plurality of conditions of said sets of contacts to control said second relay means and operable through said second set of contacts in another of said plurality of conditions of said sets of contacts to energize said second winding, regulated power supply means for said light sensitive means and said electron discharge device including power coupling means adapted to be energized by the vehicular electrical system, first transformer means, vibratory means coupled to said power coupling means and to said first transformer means for providing an interrupted current therein, a ballast tube, second transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said first transformer means, and means coupling said secondary winding to said light sensitive means and said electron discharge device for supply thereto of power regulated by said ballast tube.

7. Apparatus adapted to operate from a vehicular electrical system for automatically controlling headlamps of the vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a signal in response to a certain light level, an electron discharge device having a control element coupled to said light sensitive means, first relay means including first and second windings and first and second sets of contacts operable to a plurality of conditions in response to energization of said windings, said first winding being connected to said electron discharge device and being selectively energized thereby, said second winding being connected to said second set of contacts, second relay means controlled by said first set of contacts of said first relay means and connected to control the headlamps, switching means connected to said first and second sets of contacts and operable through said first set of contacts in one of said plurality of conditions of said sets of contacts to control said second relay means and operable through said second set of contacts in another of said plurality of conditions of said sets of contacts to energize said second winding, and potential supply means coupled to said light sensitive means and to said electron discharge device and said relay means for energizing the same from the vehicular electrical system.

8. Apparatus for automatically controlling headlamps of a vehicle in response to the presence of the lights of an oncoming vehicle, said apparatus including in combination; light sensitive means for developing a signal in response to a certain light level; an electron discharge device coupled to and controlled by said light sensitive means, relay means coupled to, and controlled by, said electron discharge device for controlling the headlamps; and regulated power supply means for said light sensitive means and said electron discharge device including electric current supply means providing a direct current voltage subject to variations, auto transformer means, vibratory means coupled to said current supply means and to said auto transformer means for providing an interrupted current therein, a ballast tube, transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said auto transformer means, and said light sensitive means and said electron discharge device being coupled to said secondary winding for supplying regulated operating voltages thereto.

9. Apparatus for automatically controlling headlamps of a vehicle in response to the presence of a given level of surrounding illumination, said apparatus including in combination, light sensitive means for developing a signal

14

in response to the given illumination level, an electron discharge device coupled to said light sensitive means and controlled thereby, relay means coupled to and controlled by said electron discharge device for controlling the headlamps, and regulated power supply means for operating said apparatus including electric current supply means, auto transformer means, vibratory means coupled to said current supply means and to said auto transformer means for providing an interrupted current in said auto transformer means, a ballast tube, transformer means having a primary winding and first and second secondary windings, said primary winding being series connected with said ballast tube to said auto transformer means, said first secondary winding being series connected with at least a portion of said auto transformer means and said electron discharge device to energize the same, said second secondary winding being coupled to said light sensitive means to supply power therefrom, and a potentiometer system coupled across said current supply means and connected to said electron discharge device for supplying a bias thereto, whereby a variation of the potential supplied by said current supply means is accompanied by corresponding changes in the bias applied to said electron discharge device and the energization thereof by said first secondary winding of said transformer means.

10. Apparatus for automatically controlling headlamps of a vehicle in response to the presence of a light of an oncoming vehicle, said apparatus including in combination, light sensitive means for developing a signal in response to a certain light level, power supply means to supply a direct current potential with respect to a common point, an electron discharge device having a cathode and first and second control elements, said first control element being coupled to said light sensitive means and responsive to a signal therefrom, said second control element being coupled to said power supply means to be biased thereby, first relay means coupled to said electron discharge device and to said power supply means to be energized thereby, said first relay means having a switch arm and a first contact established in an energized condition thereof and a second contact established in a de-energized condition thereof, second relay means coupled to said switch arm and to said potential supply means and adapted to regulate head lamps in response to operation thereof, switch means coupled to said first and second contacts of said first relay means and to said common point to connect said first and second contacts selectively thereto, said cathode of said electron discharge device being coupled to said first contact of said first relay means, whereby connection of said first contact to said common point provides operation of said second relay means in response to control of said electron discharge device by said light sensitive means and connection of said second contact to said common point provides operation of said second relay means to regulate the headlamps with said first relay means being unresponsive to signals from said light sensitive means, and a voltage divider coupled to said switch arm of said first relay means and to said common point, said voltage divider having a tap point coupled to said first control element so that energization of said voltage divider through said second relay means provides bias for said first control element.

11. Apparatus for automatically controlling headlamps of a vehicle in response to the existence of a given level of illumination, said apparatus including in combination light sensitive means for developing a signal in response to the given illumination level, direct current supply means having a terminal negative with respect to a common point, an electron discharge device having anode means, cathode means, a first control element coupled to said light sensitive means, and a second control element coupled to said terminal of said supply means to provide a fixed bias therefor, power supply means for said apparatus including auto transformer means, vibrator means coupled to said current supply

15

means and to said auto transformer means for providing an interrupted current in said auto transformer means, a ballast tube, transformer means having primary and secondary windings, said primary winding being series connected with said ballast tube to said auto transformer means, first relay means coupled to said anode means and said secondary winding to be operated by said electron discharge device, second relay means having a terminal coupled to said terminal of said current supply means and contacts adapted to control the headlamps, a circuit for said cathode means coupled to said common point and including switch means having a first position adapted to close said circuit and a second position to open said circuit, said first relay means having a first contact established in an operated position thereof, and connected to said circuit for said cathode means, said first relay means further having a second contact established in the unoperated position thereof, said switch means having a contact adapted to operate said second relay means through said second contact of said first relay means in said second position thereof, and a voltage divider circuit with a

16

tap thereof coupled to said first control element, said voltage divider circuit being coupled through said second contact of said first relay means to said current supply means in the unoperated position of said first relay means and to said circuit for said cathode means in the operated position of said first relay means for negatively biasing said first control element in said second position of said first relay means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,938,367	Bedford	Dec. 5, 1933
2,128,051	Lowry	Aug. 23, 1938
2,338,079	Huge	Dec. 28, 1943
2,431,394	Friedman	Nov. 25, 1947
2,532,111	Longini	Nov. 28, 1950
2,560,748	Silva	July 17, 1951
2,718,612	Willis	Sept. 20, 1955
2,742,592	Miller	Apr. 17, 1956
2,763,809	Radin	Sept. 18, 1956
2,767,347	Miller	Oct. 16, 1956