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AUTOMATIC HEADLAMP CONTROL SYSTEM

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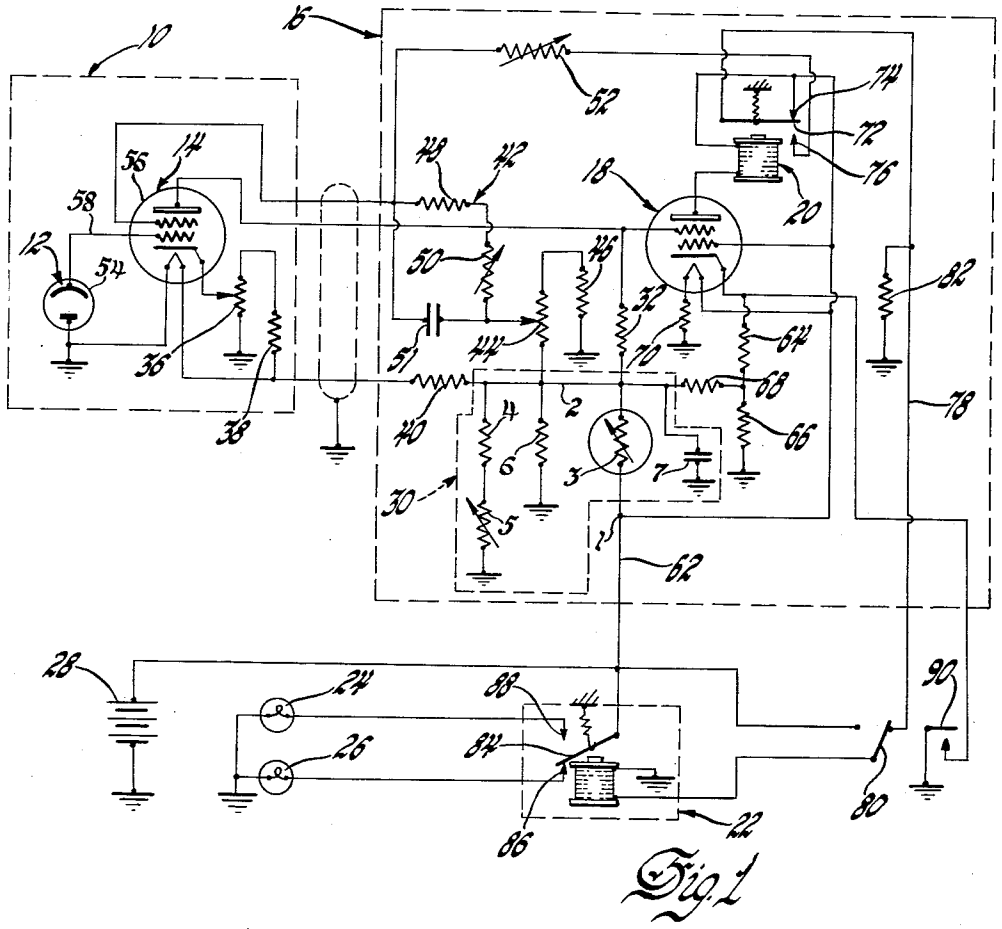


Fig. 1

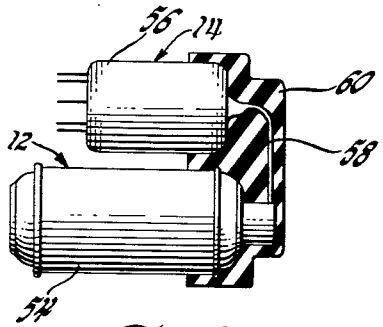


Fig. 2

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AUTOMATIC HEADLAMP CONTROL SYSTEM

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This invention relates to light responsive control systems and more particularly to automatic control systems for vehicle headlamps.

In accordance with this invention there is provided an automatic headlamp control system which may be energized directly at the low voltage level of the vehicle battery and avoids the need for voltage transforming arrangements. This is accomplished by using amplifier circuits incorporating low plate potential electron tubes with a preamplifier connected as an electrometer circuit for developing a signal voltage for a direct coupled current amplifier.

It is a principal object of this invention to provide an automatic headlamp control system with improved response time so that the headlamps are immediately returned to the upper beam circuit after an oncoming vehicle passes by. This is accomplished by a speed up circuit which causes the sensitivity of the preamplifier to be maintained momentarily at a reduced level after exposure to a high value of light intensity. In a preamplifier of the type using a screen grid electron tube, the sensitivity reduction is accomplished by use of a time constant circuit interposed in the screen grid circuit. In this arrangement, the system sensitivity after the lower beam headlamp circuit is selected is determined by a potentiometer also connected in the screen grid circuit, and the system sensitivity after the upper beam circuit is selected is determined by a variable resistor connected across the potentiometer through a relay actuated switch. The overall sensitivity of the system is subject to manual control of the operator by means of a potentiometer bias connection in the cathode circuit of the preamplifier. Additionally, means are provided for voltage stabilization of the system and to cause the preamplifier and current amplifier to become operative in the proper sequence. A more complete understanding of this invention may be had from the detailed description which follows taken with the accompanying drawings in which:

FIGURE 1 is a schematic diagram of the automatic control system; and

FIGURE 2 shows the assembly of a preamplifier tube and a photocell.

Referring now to the drawings, there is shown an illustrative embodiment of the invention in a system which comprises a pick-up unit **10** including a light responsive device or photocell **12** and a preamplifier **14** for developing a signal voltage corresponding to incident light intensity. The pick up unit **10** is mounted on the vehicle in a well known manner so that the photocell **12** intercepts the light rays from the headlamps of an oncoming vehicle. A control unit **16** includes a current amplifier which controls the energization of a control relay **20** in accordance with the signal voltage. The relay **20** controls the energization of a power relay **22** which in turn selectively connects the upper beam circuit **24** and the lower beam circuit **26** of the headlamps with the vehicle battery **28**. The preamplifier **14** and the current amplifier **18** are supplied with operating voltages from a voltage regulator **30** and the vehicle battery.

The voltage regulator **30** has an input terminal **1** and an output conductor **2** with a ballast resistor **3** connected therebetween in series with the battery **28** through a voltage dividing network, which includes a fixed resistor

4 and variable resistor **5** in series and a fixed resistor **6** and filter capacitor **7** in parallel. Thus a regulated supply voltage is derived from the conductor **2** for use in certain parts of the system and an unregulated supply voltage is derived directly from the battery on conductor **62** for use in other parts of the system, as will appear hereinafter.

In the pick-up unit **10** the photocell **12** and the preamplifier **14** are connected as an electrometer circuit. The photocell is a high vacuum photo-emissive diode and has its cathode connected with the control grid of the preamplifier **14** and its anode connected to ground. The preamplifier **14** comprises a low plate potential electron tube and has its plate connected through resistor **32** to the voltage regulator **30**. The cathode of the preamplifier is connected to ground through the movable contact of a potentiometer **36** which is connected through voltage dropping resistors **38** and **40** to the voltage regulator. The cathode heater filament is connected between the voltage regulator and ground through the resistor **40**. The screen grid of the preamplifier is connected through the time constant "speed up" circuit **42**, which will be described subsequently, and to the movable contact of a potentiometer **44** which is connected between the voltage regulator and ground through a voltage dropping resistor **46**. The potentiometer **44** provides an adjustable screen grid voltage for the hold sensitivity control, i.e. the sensitivity of the system when the lower beam circuit has been selected. The time constant circuit **42** comprises a fixed resistor **48** and a variable resistor **50** connected in series across a condenser **51**. The variable resistor **50** and the potentiometer **44** are mechanically connected, as indicated, to provide concurrent adjustment as will be explained more fully hereinafter. A variable resistor **52** is connectible across the time constant circuit **42** and the hold control potentiometer **44** by the relay **20** for the dim sensitivity control, i.e. the sensitivity of the system when the upper beam circuit has been selected.

The grid circuit of the preamplifier presents a resistance of several million megohms and is subject to resistance change from variations of atmospheric humidity. Unless special precautions are taken such humidity will cause current leakage across the glass of the photocell envelope **54** and the preamplifier envelope **56** and such current leakage will produce the same result as light upon the photocell. To avoid this effect, the preamplifier grid lead and the photocell cathode terminal, which are connected by a conductor **58**, and the adjacent ends of the envelope are potted. The potting compound, suitably an epoxy resin, is of low moisture absorption and high resistivity and is molded and heat cured in place on the envelopes to form an encapsulation **60**.

The current amplifier **18** comprises a low plate potential electron tube of the space charge grid type. The control grid is connected directly to the plate of the preamplifier **14** to derive the signal voltage therefrom and the load resistor **32** serves as a grid return path. The plate is connected through the energizing coil of the control relay **20** and conductor **62** to the battery and the space charge grid is connected directly to the battery through conductor **62**. The cathode of the current amplifier is connected through cathode resistor **64** and voltage divider resistor **66** to ground. Resistor **66** is connected through voltage divider resistor **68** to the voltage regulator to develop a fixed bias in the cathode circuit. The cathode heater filament of the current amplifier is connected across the battery through conductor **62** in series with a current limiting resistor **70** which delays the warm-up of the current amplifier until after the preamplifier has become operative.

The control relay **20** includes a switch with a movable contact **72** which is spring biased into engagement with a

back contact 74 and actuable by relay energization into engagement with the front contact 76. The movable contact 72 is connected to ground through conductor 78, a selector switch 80 and the energizing coil of the power relay 22. The front contact 76 is connected with the dim sensitivity control resistor 52 and thus when the relay 20 is energized, or pulled in, the resistor 52 is connected across the time constant circuit 42 and potentiometer 44, as previously mentioned. The back contact 74 is connected directly with the battery through the conductor 62 and thus when the control relay 20 is deenergized, or dropped out, the ground connection to resistor 52 is interrupted and the power relay 22 is energized. A resistor 82 is connected across the control relay contacts to minimize the destructive effect of current interruption.

The power relay 22 includes a movable switch contact 84 which is spring biased into engagement with a back contact 88 and is connected directly to the battery 28 for energization of the upper beam circuit 24 when the power relay is dropped out. When the power relay is pulled in, the movable contact 84 engages a front contact 86 to energize the lower beam circuit 26. The system includes a manually actuable override switch 90 connected between the cathode current amplifier and ground to cause control relay 20 to be pulled in for selection of the upper beam circuit at the will of the operator. The selector switch 80 permits manual selection of the lower beam circuit and disconnection of the automatic control system. In the position shown, the switch connects the power relay with the control relay 20 to provide for automatic control. In the alternate position, it connects the power relay energizing coil across the battery and provides for manual selection of the lower beam headlamp circuit.

In operation, when there is a low value of light intensity impinging upon the photocell 12, the photocell presents a very high resistance in the grid to cathode circuit of the preamplifier 14. The potentiometer 36 is adjusted to maintain the cathode at a small potential above ground and the plate is maintained at a somewhat higher potential by its connection through the load resistor 32 to the voltage regulator. This plate voltage is limited by the clamping action of the control grid current in the current amplifier 18. Accordingly, in preamplifier 14, electrons accumulate on the control grid and maintain it at cut-off. The gain of the preamplifier 14 is adjusted by the screen grid voltage as determined by the potentiometer 44 and the dim sensitivity resistor 52 in parallel therewith. The plate voltage of the preamplifier 14 is applied to the control grid of the current amplifier 18 and causes sufficient conduction to pull-in the relay 20 which closes the movable contact 72 against the front contact 76. The current amplifier 18 has a fixed cathode bias voltage from voltage divider resistor 66 and a self-bias voltage developed by cathode resistor 64 which produces good voltage stabilization. With the control relay 20 pulled in, the energizing circuit for the power relay 22 is interrupted and the power relay is dropped out causing the movable contact 84 to engage back control 88 to energize the upper beam circuit 24.

Upon an increase of light intensity impinging photocell 12, it becomes more conductive and acts as a variable grid leak resistor permitting the control grid of the preamplifier to become more positive. Consequently, preamplifier conduction increases and the plate voltage becomes less positive causing the conduction through current amplifier 18 to decrease. At a predetermined value of light intensity, determined by the adjustment of the dim sensitivity resistor 52, the conduction through current amplifier 18 decreases sufficiently to permit the control relay 20 to drop out. The movable contact 72 engages the back contact 74 and connects the battery across the energizing coil of power relay 22. The power relay is pulled in and the movable contact 84 engages front contact 86 to energize the lower beam circuit 86. When the control relay 20 drops out, it also interrupts the ground return circuit for the dim sensitivity resistor 52, disconnecting it from across the time constant circuit 42 and the potentiometer 44. Thus, the screen grid voltage in the preamplifier 14 becomes more positive and increases the sensitivity to permit the preamplifier to maintain the current amplifier cut-off at a lower value of light intensity. The sensitivity of the system under this condition is determined by the setting of the hold sensitivity control potentiometer 44. This increased sensitivity prevents instability or oscillation of the system when the headlamps of the oncoming vehicle are switched to lower beam.

As the oncoming vehicle approaches, and the light intensity increases far beyond the dimming level, the preamplifier current increases. The preamplifier screen grid draws an increasing current and a voltage drop is developed across the variable resistor 50 and fixed resistor 48. A corresponding voltage is developed across the condenser 51 and the potential of the screen grid of the preamplifier becomes less positive, decreasing the sensitivity. When the light on the photocell is suddenly removed, the decreased voltage on the screen grid is maintained by the condenser 51 permitting the control grid to cut-off conduction immediately. The reduced screen grid voltage is maintained for a time interval determined by the time constant of the resistance-capacitance network of the speed-up circuit and is suitably of the order of one-half second. It has been found that the speed of return to upper beam varies somewhat with the sensitivity of the preamplifier and photocell combination. To account for this variation, the time constant of the speed-up circuit is varied concurrently with the hold sensitivity adjustment by the mechanical inter-connection of the variable resistor 50 and the potentiometer 44. The systems with higher sensitivity require a lower screen grid voltage and thus the resistor 50 is decreased as the hold control voltage is decreased.

It has been found that the slow response time of a conventional preamplifier electrometer circuit with the photocell results from the extremely high grid return resistance in combination with the interelectrode capacitance of the preamplifier. By reducing the interelectrode capacitance sufficiently in the preamplifier, an acceptable response time in returning the system to the upper beam circuit has been attained without the need for the condenser 51 in the time constant speed-up circuit to hold the preamplifier at reduced sensitivity after the sudden decrease of incident light intensity.

Although the invention has been described with respect to a particular embodiment, such description is not to be construed in a limiting sense. Numerous modifications and variations within the spirit and scope of the invention will now occur to those skilled in the art. For a definition of the invention, reference is made to the appended claims.

We claim:

1. An automatic control system for vehicle headlamps comprising upper and lower beam circuits, a light responsive device, an amplifier including an electron tube having a cathode, a plate, a control grid and a screen grid, said light responsive device being connected between the control grid and cathode, an output circuit extending between the plate and cathode for developing a signal voltage corresponding to incident light intensity, relay means connected with said output circuit and including a switch for actuation thereby at predetermined values of light intensity, said switch being adapted for selection of the upper beam circuit when the signal voltage reaches a first predetermined value and for selection of the lower beam circuit when the signal voltage reaches a second predetermined value, a sensitivity controlling circuit connected between said screen grid and said cathode and including a potentiometer for determining the light intensity required to develop the first predetermined value of signal

voltage when the lower beam circuit is selected, and a resistor and condenser in parallel connected between said screen grid and potentiometer whereby screen grid current reduces the sensitivity as the light intensity increases and the reduced sensitivity is maintained during a decrease of light intensity and whereby the signal voltage quickly reaches the first predetermined value for selection of the upper beam circuit.

2. An automatic control system for vehicle headlamps comprising upper and lower beam circuits, a light responsive device, an amplifier including an electron tube having a cathode, a plate, a control grid and a screen grid, said light responsive device being connected between the control grid and cathode, an output circuit extending between the plate and cathode for developing a signal voltage corresponding to incident light intensity, relay means connected with said output circuit and including a switch for actuation thereby at predetermined values of light intensity, said switch being adapted for selection of the upper beam circuit when the signal voltage reaches a first predetermined value and for selection of the lower beam circuit when the signal voltage reaches a second predetermined value, a sensitivity controlling circuit connected between said screen grid and said cathode and including a potentiometer for determining the light intensity required to develop the first predetermined value of signal voltage when the lower beam circuit is selected, and a resistor and condenser in parallel connected between said screen grid and potentiometer whereby scren grid current reduces the sensitivity as the light intensity increases and the reduced sensitivity is maintained during a decrease of light intensity and whereby the signal voltage quickly reaches the first predetermined value for selection of the upper beam circuit, said resistor being variable and mechanically coupled with said potentiometer for concurrent adjustment therewith.

3. An automatic control system for vehicle headlamps comprising upper and lower beam circuits, a light responsive device, an amplifier including an electron tube having a cathode, a plate, a control grid and a screen grid, said light responsive device being connected between the control grid and cathode, an output circuit extending between the plate and cathode for developing a signal voltage corresponding to incident light intensity, relay means connected with said output circuit and including a switch for actuation thereby at predetermined values of light intensity, said switch being adapted for selection of the upper beam circuit when the signal voltage reaches a first predetermined value and for selection of the lower beam circuit when the signal voltage reaches a second predetermined value, a sensitivity controlling circuit connected between said screen grid and said cathode and including a potentiometer for determining the light intensity required to develop the first predetermined value of signal voltage when the lower beam circuit is selected, a variable resistor connected across said potentiometer through said switch when the upper beam is selected for determining the light intensity required to develop the second predetermined value of signal voltage, and a resistor and condenser in parallel connected between said screen grid and potentiometer whereby screen grid current reduces the sensitivity as the light intensity increases and reduced sensitivity is maintained during a decrease of light intensity and whereby the signal voltage quickly reaches the first predetermined value for selection of the upper beam circuit.

4. An automatic control system for vehicle headlamps comprising upper and lower beam circuits, a light responsive device, an amplifier including an electron tube having a cathode, a plate, a control grid and a screen grid, said light responsive device being connected between the control grid and cathode, an output circuit extending between the plate and cathode for developing a signal voltage corresponding to incident light intensity, relay means connected with said output circuit and including a switch for actuation thereby at predetermined values of light intensity, said switch being adapted for selection of the upper beam circuit when the signal voltage reaches a first predetermined value and for selection of the lower beam circuit when the signal voltage reaches a second predetermined value, a sensitivity controlling circuit connected between said screen grid and said cathode and including a potentiometer for determining the light intensity required to develop the first predetermined value of signal voltage when the lower beam circuit is selected, and a variable resistor connected across said potentiometer through said switch when the upper beam is selected for determining the light intensity required to develop the second predetermined value of signal voltage, and a potentiometer connected between said cathode and a point of reference potential for manual adjustment of the overall sensitivity of the system.

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