July 16, 1946. W. A. GIESEKE 2,404,131

PHOTOELECTRICALLY CONTROLLED AMPLIFYING CIRCUIT

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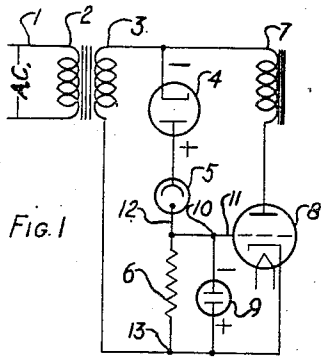


FIG. 1

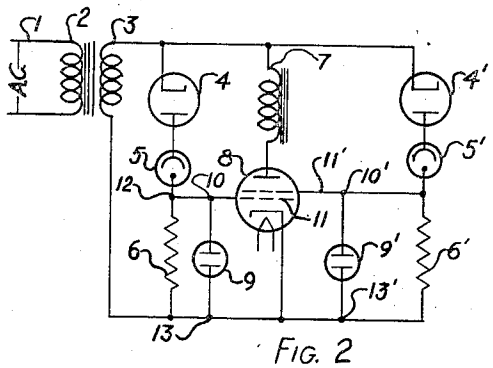


FIG. 2

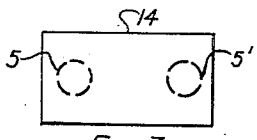


FIG. 3

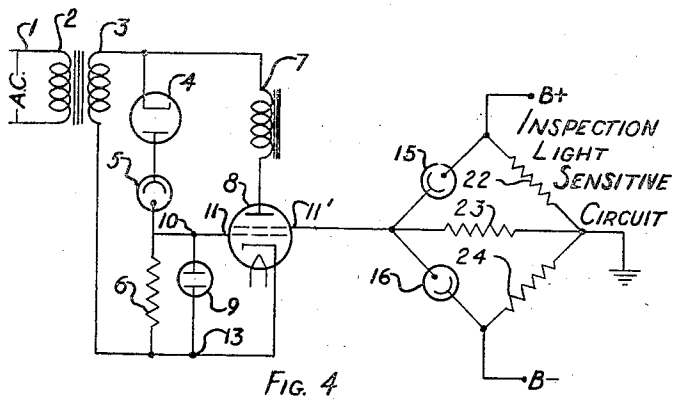


FIG. 4

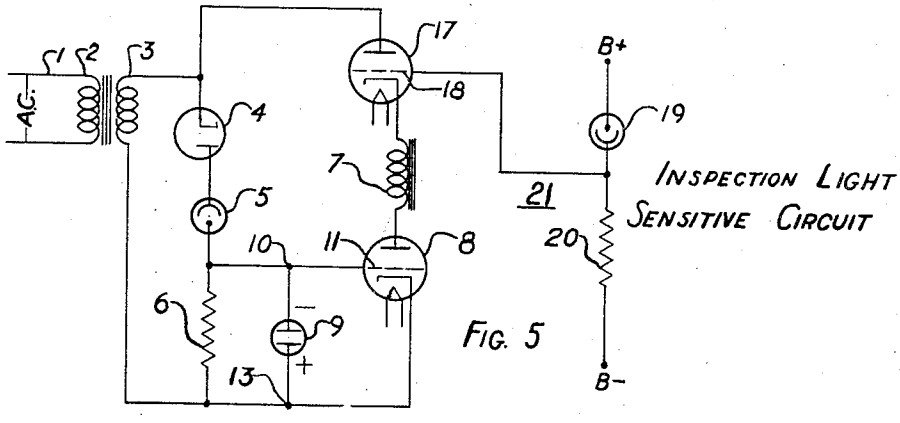


FIG. 5

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PHOTOELECTRICALLY CONTROLLED AMPLIFYING CIRCUIT

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1 Claim. (Cl. 250—41.5)

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This invention relates to a photoelectric amplifying circuit and particularly, to an amplifying circuit controlled by a light sensitive device wherein the maximum output can be obtained, or in other words, substantially the full line voltage can be employed to actuate an energy translation means.

In the ordinary amplifying circuit wherein the operating current and voltages are used in part to provide a proper bias on the amplifying tube for rendering the tube conducting or non-conducting, a portion of the power or the voltage is consumed by resistors or equivalent devices for obtaining such bias. By the use of my device in an alternating current amplifying circuit, I avoid the use of separate sources of power for providing the proper bias on the amplifying tube and at the same time, I am able to obtain substantially the full line voltage at the output of the amplifying tube. This has particular advantages where higher voltages at the source of alternating current are not obtainable and where heavy duty is required by the energy translation means or where the amplifier may control a motor or other heavy duty machine. My device also has the advantage of simplicity since it is not necessary to use a separate source of power such as a separate direct current source of power to supply the operating voltages for the amplifying tube.

In general, my invention comprises a source of alternating current with an amplifying tube and an energy translation means, such as a relay coil, connected in series across the source of the alternating current and connected in parallel with a light sensitive device such as a phototube connected in series with a resistor wherein the anode of the phototube is connected to the control electrode of the amplifying tube and to the resistor. In addition, a condenser is also connected between one side of the alternating current and the anode of the phototube as well as to the control electrode. By this arrangement, when the phototube is in shadow, the control electrode is at zero potential and the cathode of the amplifying tube is also at zero potential and the amplifier conducts a current. But when the phototube is in light, current will flow across the phototube when it receives a pulse from the alternating current and the condenser will be charged such that the end of the condenser connected to the control electrode discharges a negative potential and the condenser must be adapted and arranged to hold that charge for at least one-half a cycle of the alternating current which means with a 60 cycle per second of alternating current, the condenser

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must hold the charge for $1/120$ of the second in order to accomplish the objects of the invention which is to prevent the amplifying circuit from conducting when the phototube is in light. By the use of this device it is apparent that no loss in voltage occurs through any dividing resistor for obtaining the bias on the amplifying tube in order to render it conducting. Although it is not necessary, it is desirable to connect between the cathode side of the phototube and one side of the alternating current a rectifier which actuates as a check valve and prevents any current from flowing through the phototube during that half of the cycle of the alternating current when the anode of the phototube is subjected to the negative half of the cycle. This is an additional provision because some phototubes will conduct a very small amount of current from the anode to the cathode when the anode is subjected to the negative half of the cycle.

It is also within the scope of my invention to provide additional light sensitive circuits using additional light sensitive devices to control the electronic circuit which actuates the energy translation means and involving one or more amplifying tubes. In one modification, a second control electrode is provided in the amplifying tube controlled by a circuit identical with that described above or the control electrode may be controlled by a separate light sensitive circuit used for making another photoelectric inspection.

It is also within the scope of my invention to employ a second light sensitive circuit in combination with the circuit above described wherein the phototube of the first circuit is used to indicate when the article undergoing inspection is in the testing zone, the second light sensitive circuit used for actually making the photoelectric inspection.

In another embodiment of my invention, I may employ two or more amplifying tubes connected in series to the energy translation means and the control electrode of one of the amplifying tubes having its bias rendered negative when the phototube is conducting and the other control electrode in one of the other amplifying tubes controlled by an inspection light sensitive circuit for making the photoelectric inspection.

Other advantages, uses and objects of my invention will become apparent by referring to the drawing wherein

Figure 1 represents one of the more simple diagrams of my circuit illustrating how the maximum output from the amplifier can be obtained.

Figure 2 illustrates two such devices as shown

in Figure 1 for independently and simultaneously controlling two electrodes in one amplifying tube.

Figure 3 illustrates diagrammatically, one application of the device shown in Figure 2.

Figure 4 illustrates the control of one electrode in an amplifying tube by the device shown in Figure 1 and the control of another electrode of the amplifying tube by a separate light sensitive circuit which may be used for the photoelectric inspection.

Figure 5 illustrates another modification involving the use of two amplifying tubes wherein the controlled electrode of one of the amplifying tubes is controlled by a circuit similar to that shown in Figure 1 and the control electrode in another amplifying tube controlled by the inspection light sensitive circuit.

Referring to Figure 1, 1 indicates a source of alternating current having a primary coil 2 and a secondary coil 3. Connected in series across the source of alternating current is rectifier 4, a light sensitive device such as a phototube 5 and a resistor 6, wherein the rectifier and the phototube are connected such that the anode of the rectifier is connected to the cathode of the phototube and the anode of the phototube is connected to resistor 6. An energy translation means, such as relay coil 7 is connected in series with an amplifying tube 8 which may be a thermionic tube of either the vacuum type or the gas-filled arc discharge type. The amplifying tube is arranged so that its anode and cathode are reversed to the phototube in respect to their connections across the source of alternating current. A condenser 9 is connected to the side of the alternating current to which the resistor 6 is also directly connected at point 10 between the control electrode 11 and the anode 12 of the phototube 5. The operation of this device is as follows:

When phototube 5 is in shadow, the control electrode 11 is at the same potential as the cathode of tube 8 and the amplifying tube 8 conducts a current which actuates the energy translation means 7. When the phototube 5 is in light, current will flow across the phototube during each pulsation of the alternating current at the point 13 which charges the condenser 9 and maintains a negative charge at point 10 which drives the bias of the control grid 11 in a negative direction and prevents the power tube 8 from conducting. The power tube will remain non-conducting as long as the phototube 5 receives light provided that the condenser 9 receives a sufficient negative charge to maintain the bias negative on the control grid 11 for sufficient time to at least equal one-half of the cycle of the alternating current; otherwise, the bias will not remain negative even though the phototube 5 remained in light and the device would not function. It is apparent, therefore, that to enable the device to work, the charge on the condenser must be such as to maintain the negative bias on the control throughout the time the phototube 5 is in light.

It is also apparent by the use of my device, the condenser 9 can also function as a timer by providing and arranging the condenser 9 such that the negative charge will be maintained for longer time than one-half of a cycle of the alternating current which will prevent tube 8 from conducting for a given length of time depending on the amount of charge, even though phototube 5 should again be placed in shadow. Thus, while it is necessary to have a charge on the condenser equal to at least $\frac{1}{120}$ of a second for a 60 cycle per second alternating current depending upon the operation desired, any additional charge on the condenser maintains the power tube 8 non-conducting even after the phototube 5 is again placed in shadow.

The energy translation means 7, while it can be a relay coil 7 as shown, can also take any suitable form or it can be a motor or indicator or else the relay coil 7 can actuate an independent circuit for actuating an indicator means or a solenoid valve for accepting and rejecting an article or for actuating any type of selection circuit.

In order to make the drawing easier to follow, comparable parts which appear in the different figures are numbered the same.

Referring to Figure 2, the control grid 11 of the power tube 8 is controlled in the identical manner as described in Figure 1. In addition, a similar circuit in which I mark the comparable parts as shown in Figure 1 with prime numbers is used to control a second control electrode 11'. The second circuit is provided with rectifier 4', phototube 5', resistor 6' and condenser 9' and the bias on the control electrode 11' is controlled in the exact way that the bias on the control electrode 11 is controlled and functions in exactly the same manner. In this case, if either of the phototubes 5 or 5' are in light, the power tube 8 will not conduct. However, if both of the phototubes 5 or 5' are in shadow, the power tube 8 will conduct and the energy translation means 7 will be actuated.

This modification of my device is particularly applicable in checking articles for either a minimum size or a maximum size although it has many other uses. Referring to Figure 3, in checking the article 14 with the phototubes 5 and 5', the article meets the required specifications if it places both phototubes 5 and 5' in shadow. In this case, referring to Figure 2, both electrodes 11 and 11' have their bias such that the power tube 8 will conduct and the energy translation means 7 actuated.

Referring to Figure 4, the control 11 of the power tube 8 is controlled in the same manner as the control electrode 11 in Figure 1. Figure 4 differs from Figure 2 in that the control electrode 11' is controlled by a separate inspection light sensitive circuit involving a photoelectric bridge and provided with phototubes 15 and 16. In this setup, wherein the phototube 5 may be used to condition the power tube for the photoelectric inspection when the article undergoing the inspection places the phototube 5 in shadow, the phototubes 15 and 16 can be used to determine the photoelectric inspection and through bridge circuit, control the electrode 11'.

Similarly, in Figure 5, the electrode 11 in the power tube 8 is controlled in the same manner as control electrode 11 of Figure 1. In addition, this circuit provides a second power tube 17 connected in series with power tube 8 and the relay coil 7 is not actuated unless both of the power tubes 8 and 17 are conducting.

This circuit has applications similar to that described in Figure 4 wherein the control grid 18 of tube 17 is controlled by the inspection light sensitive circuit 21 containing the phototube 19 and the resistor 20 connected across a source of D. C. potential.

The above various modifications of my invention are not to be considered equivalent nor are they to be considered as limiting my invention which is only limited by the following claim.

I claim as my invention:

In an alternating current photoelectric amplifier, a source of alternating current; a power tube containing a control electrode and an energy translation means connected in series across said source of alternating current; a rectifier, a light sensitive device and a resistor connected in series across said source and parallel to said power tube circuit; said light sensitive device having its anode connected to said control grid and its cathode to said rectifier; a condenser connected to said control grid and to one side of said alternating current to which the resistor is also connected; said condenser connected in parallel with said

resistor; said energy translation means responsive to the flow of current through the power tube when the light sensitive device is in shadow and means for substantially preventing the flow of current through the power tube for a definite period of time when the light sensitive device is in light including charging the condenser with sufficient negative charge when current flows through the light sensitive device when in light to maintain the bias on the power tube negative for time equal to at least one-half of the cycle for the alternating current.

WERNER A. GIESEKE.