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GAS TUBE CIRCUIT

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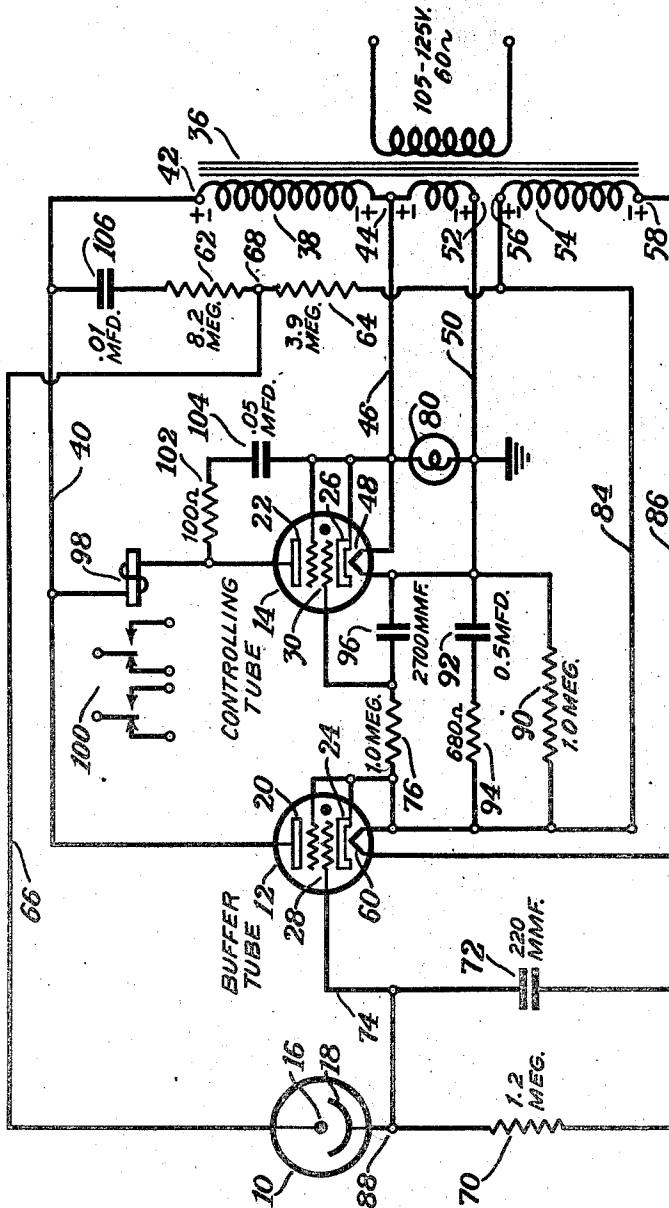


Fig. 1

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GAS TUBE CIRCUIT

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6 Claims. (Cl. 315-152)

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This invention relates to circuits for gaseous discharge tubes and, more particularly, to time delay circuits for controlling the operation of such tubes.

In many applications, time delay combinations are employed to delay the firing of a gas tube or to delay the extinguishment of space current in a gas tube already fired. Where alternating currents are applied to the electrodes of the gas tube, space current therein is extinguished on each negative half cycle of the anode voltage; to delay extinguishment of current in a tube so operated, it is necessary to delay firing thereof during the subsequent positive half cycle or cycles. It is frequently important to control the duration of that delay with accuracy and to make it independent of extraneous factors tending to vary the duration of the period of delay.

By way of example, reference may be made to the control system shown and described in the co-pending application of J. H. Reynolds, Serial No. 526,524, filed March 15, 1944, entitled "Photo-electric relay," and assigned to the same assignee as the instant application. The present invention, while constituting an improvement on the circuit of the control system described in that application, is not limited in scope to that circuit but may be employed whenever it is desired to delay the operation of a gas tube with accuracy.

In the control system of the application referred to, a beam of light is directed to a photo-tube and current from the photo-tube fires a gas tube, which in turn energizes a relay; the latter controls the operation of a conveyor along which objects are moved in spaced relation. These objects intermittently interrupt the light passing to the photo-tube. This would ordinarily extinguish current in the gas tube, except that a time delay circuit, connected between the grid and the cathode of the gas tube, delays such extinguishment for a period at least equal to the time taken by an object to traverse the beam. When, however, objects become jammed on the conveyor and the light passing to the photo-tube is interrupted for more than a predetermined period, current in the gas tube is extinguished, the relay opens and the operation of the conveyor ceases.

Among the factors which tend to cause variation in the period of delay in this and similar applications are the following:

1. *Variation in supply voltage.*—This will affect the filament and anode voltages of the gas tube and, therefore, its sensitivity; it will also affect the anode voltage of the photo-tube and, therefore, the voltage impressed by that tube on

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the capacitor of the time delay circuit. If there are other tubes in the circuit, their electrode voltages will also be affected by variation in supply voltage and this, in turn, will affect the delay period.

2. *Variation in the intensity of light.*—Variations in supply voltage will affect the intensity of light and, therefore, the delay period; but light variations may be due to other causes.

3. *Variations in the characteristics of tubes.*—Since no two tubes are constructed precisely alike, there may on replacement of tubes be a difference in the characteristics of the two tubes due to such difference in construction, and, hence, a further variation in delay. Moreover, the critical grid voltage which will cause the tube to fire may vary in any one tube, depending on its age, by as much as one volt. Both these factors will affect the period of delay.

It is, therefore, an object of the invention to provide an improved circuit for a gas tube, including a time delay combination wherein the period of delay will be substantially constant and independent of factors tending to vary it.

A further object of the invention is to provide an improved circuit of the character described, wherein the period of delay will be independent of variations in supply voltage.

A still further object is the provision of an improved circuit for a gas tube, which includes a light-responsive element and a time delay combination, and in which the delay will be independent of variations in the intensity of light passing to that element.

Another object is to provide a time delay circuit for a gas tube which will have a delay independent of the characteristics of the particular tube employed therein.

According to the invention, these objects are achieved by providing in the grid circuit of the gas tube, in addition to the time delay combination, a resistor and capacitor in parallel therewith, so connected and of such values as to produce a variation in the bias applied to the grid, which counterbalances the effects caused by variations of the character described.

The invention may be better understood from a consideration of the following description of a preferred embodiment thereof, when read in conjunction with the accompanying drawing, the single figure of which is a schematic diagram of a circuit embodying the principles of the invention which may be used in a photo-electric control system.

Referring to the drawing, the circuit includes

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a photo-tube 10 and two gas tubes 12 and 14. The photo-tube, which may be an RCA type 868, has an anode 16 and a cathode 18. Each gas tube has an anode 20, 22, a cathode 24, 26 and a control grid 28, 30, respectively. The two gas tubes may be an RCA type 2051.

All three tubes are connected in cascade, the cathode 18 of the photo-tube being connected to the control grid 28 by a conductor 74, and the cathode 24 of the first or buffer gas tube to the control grid 30 by a resistor 76. The first gas tube isolates or buffers the second or controlling gas tube from the photo-tube and makes it independent of variations in the intensity of light passing to the photo-tube.

Alternating potentials for the electrodes of the three tubes are obtained from any appropriate source of alternating voltage (not shown) through a transformer 36. The voltage supply may have a frequency of 60 cycles per second and an output which varies between 105 volts and 125 volts. The transformer 36 has a secondary winding 38, one end 42 of which is connected by a conductor 40 to the anodes 20 and 22 of the two gas tubes. The anode potentials of the gas tubes of the preferred embodiment should not exceed 350 volts. The anode 16 of the photo-tube, on the other hand, requires only 90 volts and for this purpose a voltage divider, consisting of resistors 62 and 64, is connected across the secondary winding 38; a resistor 90 and a capacitor 106 are also connected across this winding for purposes hereinafter explained. The anode of the photo-tube is connected by a conductor 66 to a terminal 68 between the two resistors 62 and 64. By way of example, the values of all the resistors and capacitors in the circuit are marked on the drawing.

The gas tubes 12 and 14 have filaments 60 and 48, respectively. Voltage for the filament 48 is derived from a portion of the secondary winding 38 between a tap 44 thereon and an end 52. Current is applied to the filament by conductors 46 and 50. The filament circuit so formed also provides voltage for an exciter lamp 80. Voltage for the filament 60 is derived from an auxiliary secondary winding 54 of the transformer 36. Current is applied to the filament through conductors 84 and 86.

The cathode 18 of the photo-tube is connected to one end 58 of the auxiliary secondary winding 54 by the conductor 86 and a resistor 70; in parallel with this resistor is a capacitor 72. The terminals of the resistor and capacitor adjacent the photo-tube are connected to the conductor 74 (and, therefore, to the control grid 28) at the junction 88 of the conductor 74 and the cathode 18. By this means, an alternating bias derived from the voltage on the filament 60 is applied to the control grid 28. The bias prevents gas tube 12 from firing in the absence of a firing potential derived from the photo-tube. In a similar fashion, an alternating bias is derived from the voltage on the filament 48 and applied to the control grid 30 through a capacitor 92, connected to the conductor 50 (in the filament circuit of tube 14) and the resistor 76, which connects the cathode 24 to the control grid 30. The bias prevents the tube 14 from firing unless a positive potential is derived from the cathode circuit of the tube 12.

In parallel with the capacitor 92, in the grid circuit of the tube 14, is the resistor 90. The resistor and capacitor together constitute a time delay combination, their values being selected to

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provide the delay desired. In this embodiment, the product of resistance and capacitance provides a time constant of .5 second, but other values may be chosen as desired. The resistor 76 also has some effect on the time delay. A resistor 94 connects the capacitor 92 to the cathode 24 of the tube 12. The resistor 94 must be large enough to limit current flowing through tube 12 to a safe value, and yet small enough to charge the capacitor 92 quickly when tube 12 fires, the charging time being determined substantially by the time constant of the combination of resistor 94 and capacitor 92. In the preferred embodiment, a value of 680 ohms was found satisfactory for resistor 94.

A capacitor 96 is also contained in the grid circuit of tube 14, being connected at one terminal to the end of the resistor 76 adjacent the grid 30, and at the other terminal to the filament 48. This capacitor and the resistor 76 determine the magnitude of the bias applied to grid 30 and thereby automatically compensate for the effects on the tube 14 caused by variations in the supply voltage, as hereinafter explained.

A relay 98, in operative connection with a switch 100, is connected in the anode circuit of the tube 14 between the anode 22 and the end 42 of the secondary winding 38. In order to damp out sharp, transient impulses caused by voltage which may be built up in the energizing coil of the relay when current in the tube 14 is extinguished, a resistor 102 and capacitor 104 are connected between the relay and the cathode 26. The capacitor 106 in the anode circuit of the photo-tube prevents the charge built up on the capacitor 92 from reaching the anode of the photo-tube.

The operation of the circuit may be explained as follows: When the photo-tube is not excited, the two gas tubes 12 and 14 are prevented from firing by the alternating bias applied to their grids and derived from their respective filament circuits. The respective instantaneous polarities of the ends of the two sections of the secondary winding 38 and auxiliary secondary winding 54 are shown on the drawing. When the anodes of the two gas tubes are most positive, their grids are most negative, and vice versa. When each anode is about to commence on its positive half cycle, each grid commences on its negative half cycle. In the case of tube 12, the capacitor 72 shifts the phase of the bias slightly. Moreover, the combination of the resistor 70 and capacitor 72 acts as a slight filter of the pulsating voltage appearing across the resistor when grid current is drawn on the positive swing of the bias.

Both of these effects make the grid 28 somewhat more negative when the anode potential is zero and is about to commence on its positive half cycle. This contributes to prompt and accurate extinguishment of the tube 12, which is important if the period of delay is to be accurately controlled. The combination of the resistor 76 and the capacitor 96 in the grid circuit of the tube 14 has a similar effect in helping to extinguish that tube. The action of the resistor 102 and capacitor 104, tending in the same direction, has already been explained.

When light from the lamp 80 is permitted to pass to the cathode 18 of the photo-tube, current passes from that cathode to the control grid 28 of the buffer tube 12. The voltage built up on the grid overcomes its bias and fires the tube. Space current then flows in the cathode circuit and passes along at least two paths; one path is

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through the resistor 94 and, therefore, builds up a charge on the capacitor 92. As previously explained, the resistance of the resistor 94 is low and the charging time is, therefore, small. The other path is through the resistor 76 to the control grid 30, whose bias is overcome in the same fashion as in the case of the other gas tube. The controlling tube 14 is thus fired, the relay 98 energized and the switch 100 closed.

When the passage of light to the photo-tube is interrupted, the positive voltage derived therefrom is removed from the control grid 28 and the space current of the tube 12 is extinguished. The capacitor 92 is then discharged mainly through the resistors 90, 94 and 76. Since the resistor 94 is small by comparison with the two resistors 90 and 76, it has very little effect in this connection. The desired time delay is, in general, dependent on the time constant of the resistor-capacitor combination 90-92. When the potential of the grid 30 falls sufficiently, the controlling tube 14 is extinguished and switch 100 is opened.

For the consistent extinguishment of space current in the tube 14, the grid 30 must not be permitted to rise to a value which will fire the tube on the positive half cycle of the anode voltage. That value will, however, vary inversely with the anode voltage which, in turn, is a function of the supply voltage. The voltage on the grid 30 (after extinguishment of space current in the tube 12) is the algebraic sum of the charge on the capacitor 92 and the bias derived from the filament circuit of the tube 14. The function, therefore, of the resistor-capacitor combination 76, 96 is to so vary the grid voltage as to offset changes caused by variations in the supply voltage. If the supply voltage increases, for example, the combination of the resistor 76 and the capacitor 96 increases the bias and alters its phase, and, therefore, the tube 14 is not affected by the variation in supply voltage. A decrease in supply voltage has an opposite effect. The delay is, therefore, constant and independent of variations tending to affect it.

At 60 cycles per second (the frequency of the current flowing in the filament circuit of the controlling tube 14), the impedance of the capacitor 92 and the resistor 94 may be regarded as negligible, and the resistor 76 is, therefore, effectively in parallel with the capacitor 96.

The resistor 76 must be large enough to prevent the capacitor 92 from discharging through it too rapidly. Since grid current passes through the resistor, a large resistance would emphasize differences in characteristics between individual tubes. The greater the value of the capacitor 96, the greater is the bias on the grid 30. In the embodiment described, it was found that with a value of 1 megohm for the resistor 76 and 2700 micro-microfarads for the capacitor 96, any change in anode and filament voltages and in the voltage across the capacitor 92, was balanced by a change in the bias applied to the grid 30. The delay in extinguishment of the tube 14 was maintained constant within limits of ± 5 per cent, notwithstanding variations in supply voltage, light intensity and tube characteristics.

Since the discharge curve of the capacitor 92 is an exponential one, it was found desirable to maintain the charge on the capacitor high, so that any variation in the firing potential of the grid 30 caused minimum variation in delay.

There has thus been described a circuit for a gas tube, including a time delay circuit in which

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a resistor and capacitor in parallel therewith in the grid circuit of the gas tube create changes in the bias of the grid, which counterbalance changes due to variations in supply voltage, light intensity and tube characteristics. The time delay of the time delay combination is, therefore, enabled to remain substantially constant.

I claim as my invention:

1. In combination, a gas tube having a control grid, a source of firing potential for said grid, a resistor connecting said source to said grid, terminal means for connecting a source of alternating electrical energy to said tube to apply alternating potentials to the anode and filament of said tube and an alternating bias to said grid to prevent conduction of said tube, a time delay circuit connected to said grid to delay extinguishment of space current in said tube during positive half cycles of the alternating potential applied to said anode on interruption of said source of firing potential, and a capacitor effectively in parallel with said resistor for varying said bias as a function of any variation in the voltage output of said source of alternating electrical energy, whereby to make said delay independent of said variation.

2. In combination, a gas tube having a control grid, a source of firing potential for said grid including an element adapted to have an alternating potential applied thereto, a resistor connecting said source to said grid, terminal means for connecting a source of alternating electrical energy to said element and said tube to apply alternating potentials to said element and to the anode and filament of said tube, and an alternating bias to said grid to prevent conduction of said tube, a time delay circuit connected to said grid to delay extinguishment of space current in said tube during positive half cycles of the alternating potential applied to said anode on interruption of said source of firing potential, and a capacitor effectively in parallel therewith for varying said bias as a function of any variation in the voltage output of said source of alternating electrical energy, whereby to make said delay independent of said variation.

3. In combination, a controlling gas tube having a control grid, a source of firing potential for said grid including a light-responsive element, a buffer gas tube connected between said element and said grid, a resistor connecting said buffer tube to said grid, terminal means for connecting a source of alternating energy to said tubes to apply alternating potential to the anodes and filaments of said tubes, respectively, and an alternating bias to said grid to prevent conduction of said controlling tube, a time delay circuit connected to said grid to delay extinguishment of space current in said controlling tube during positive half cycles of the alternating potential applied to the anode of said controlling tube on interruption of said source of firing potential, and a capacitor effectively in parallel with said resistor for varying said bias as a function of any variation in the voltage output of said source of alternating electrical energy, whereby to make said delay independent of said variation and of any variation in the intensity of light passing to said element.

4. In combination, a light-responsive device having an anode and a cathode, a source of light passing to said cathode, a controlling gas tube, a buffer gas tube, each of said tubes having a control grid, terminal means for connecting a source of alternating electrical energy to said device and

said tubes to apply alternating potentials to the anode of said device and the respective anodes and filaments of said tubes, and alternating biases to the grids of said tubes to prevent conduction of said tubes, said device, said controlling tube and said buffer tube being connected successively in cascade with said device whereby to fire said tubes on the passage of light to the cathode of said device, a time delay circuit connected to the grid of said controlling tube to delay extinguishment of space current in said controlling tube during positive half cycles of the alternating potential applied to the anode thereof on interruption of light passing to the cathode of said device, and a resistor connecting the cathode of said buffer tube to the grid of said controlling tube and a capacitor effectively in parallel with said resistor for varying the bias of said controlling tube as a function of any variation in the voltage output of said source of alternating electrical energy, whereby to make said delay independent of said variation and independent of any variation in the intensity of the light passing to the cathode of said device.

5. In combination, a gas tube having a control grid, a source of firing potential for said grid, a first resistor connecting said source to said grid, terminal means for connecting a source of alternating electrical energy to said tube to apply alternating potentials to the anode and filament of said tube and an alternating bias to said grid to prevent conduction of said tube, a time delay circuit connected to said grid to delay extinguish-

ment of space current in said tube during positive half cycles of the alternating potential applied to said anode on interruption of said source of firing potential, said circuit including a second resistor and a first capacitor in parallel therewith, a third resistor of low resistance connecting said source of firing potential to said first capacitor, whereby on cessation of said interruption said first capacitor will charge quickly by comparison with said delay, and a second capacitor effectively in parallel with said first resistor for varying said bias as a function of any variation in the voltage output of said source of alternating electrical energy, whereby to make said delay independent of said variation.

6. In a gas tube which has (a) at least one control electrode in addition to a cathode and an anode, (b) a circuit connecting said control electrode to said cathode and including a time delay combination and (c) connections to a source of alternating voltage for applying an alternating potential to said anode and an alternating bias to said control electrode to prevent conduction of said tube, the improvement which consists in including in said circuit in addition to said time delay combination a resistor and a capacitor effectively connected in parallel with said resistor whereby to vary said bias as a function of any variation in the voltage of said source and thereby to make the delay created by said time delay combination independent of the variation in said source.

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