

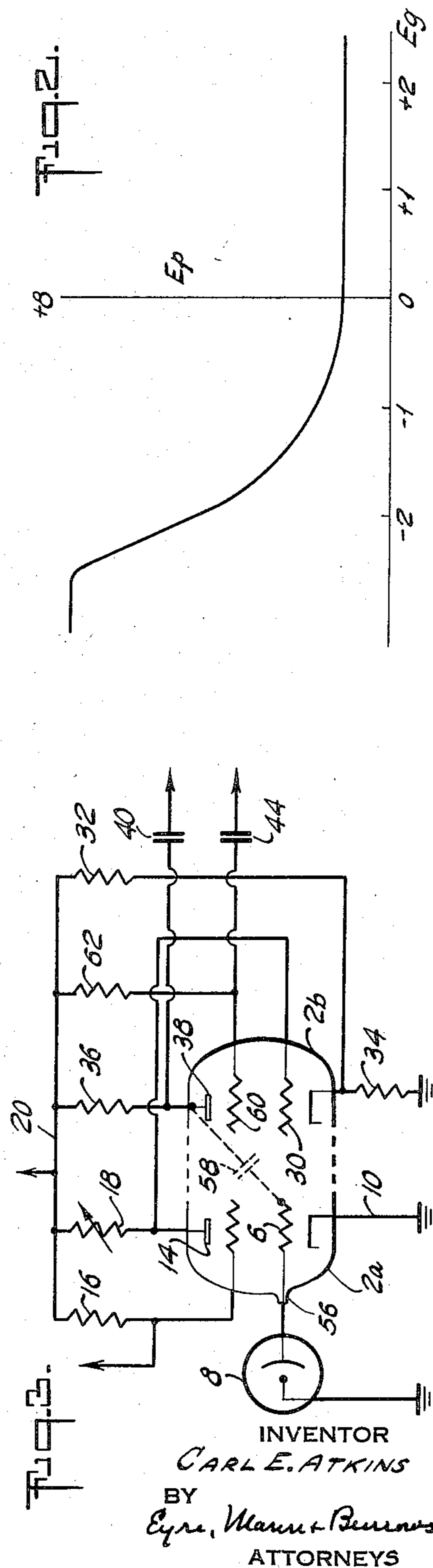
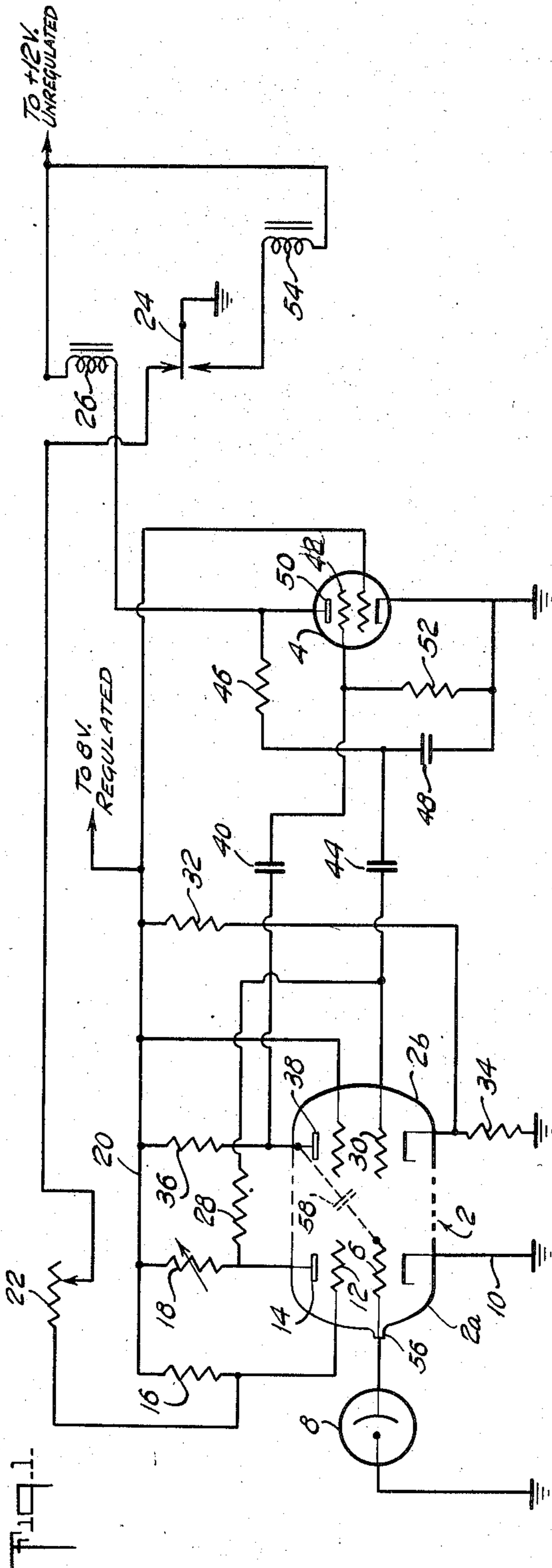
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LOW VOLTAGE OSCILLATORY CIRCUIT

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LOW VOLTAGE OSCILLATORY CIRCUIT

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10 Claims. (Cl. 317-130)

The present invention relates to a novel low voltage oscillatory circuit suitable for use as a multivibrator and to a light responsive circuit incorporating the new oscillatory circuit.

As the new oscillatory circuit, while of general application, is particularly adapted for use in the control of automobile headlamps in response to incidence of light, it will be described with reference to such application and particularly with reference to the type of light responsive system disclosed and claimed in my prior pending applications Serial No. 433,959, filed June 2, 1954, and Serial No. 547,508, filed November 17, 1955, over which the light responsive circuit of the present invention is an important improvement. Each of the circuits of the said prior applications comprises in general a photoelectric tube, preferably a diode, which when subjected to light causes increase in current through an electronic multi-element tube (called an electrometer tube), an oscillatory circuit coupled to the electrometer tube through a phase inverter and quiescent except when light is incident on the photocathode of the photoelectric tube and a relay control tube connected to the oscillatory circuit to receive controlling pulses therefrom when the photoelectric tube is subjected to light, the relay control tube being normally conducting to hold energized in its plate circuit a sensitive relay which, upon release of its armature, closes contacts controlling the circuit of a power relay. Five electronic tubes, or tube sections where double tubes are employed, are required in addition to the photoelectric tube, in each of the circuits of my said prior applications. These five comprise the electrometer tube or tube section, the phase inverting tube or tube section, two tube sections of a double triode connected as a multivibrator and the relay control tube.

In the new light responsive circuit incorporating the novel oscillatory circuit of the present invention only three electronic tubes or tube sections are required as contrasted to the five required in my prior circuits. The need for a phase inverter tube section has been obviated and the relay control tube serves not only to control the sensitive relay but also as one of the two tubes of the new oscillatory circuit.

In the new oscillatory circuit, unlike the usual multivibrator circuit, oscillations are initiated by application of negative potential to the control grid of the first of the two tubes or tube sections and quenched by application of positive potential to such grid. Hence in the light responsive circuit, the potential of the anode of the electrometer tube which decreases with increase in intensity of light incident on the photocathode and increases when the intensity of the incident light decreases, can be used directly as the control potential of the oscillatory circuit to initiate oscillation thereof when light of a predetermined intensity is incident on the photocathode and to quench the oscillation of the oscillatory circuit when the intensity of incident light reduces to a predetermined value.

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The new oscillatory circuit, as above indicated, includes two electronic tubes, preferably tetrodes each of which, in the quiescent state, are conducting. Relatively low operating potential of the order of 8 to 15 volts is applied to the anode of the first tube through a dropping resistor and to the anode of the second tube, preferably through an inductor. In the particular application of the circuit to the control of the dimming switch of an automobile the inductor is the sensitive relay hereinbefore mentioned in connection with the description of the circuits of the said prior applications and the source of voltage is the car carried battery of nominally 12 volts. When the oscillatory circuit is quiescent the control grid potential of the first tube is such that the tube passes maximum current and hence any increase in positive potential applied to the control grid can not increase the anode current. A decrease in control grid potential will, however, reduce the current through this tube and cause an increase in potential at the anode thereof. The anodes and control grids of the two tubes of the oscillatory circuit are so interconnected that increase in potential at the anode of the first tube will initiate oscillations of the circuit. Oscillations will cease when the control grid of the first tube is raised sufficiently to cause the tube to again become saturated.

Preferably the second tube of the oscillatory circuit, the relay control tube, is of the space charge grid type, the first grid being maintained at a positive potential of say 8 volts and the second grid serving as the control grid. A large bias resistor is provided for the control grid to cause the potential of the grid to be driven negative by the self-rectifying properties of the grid cathode circuit when positive pulses from the anode of the first tube are impressed upon the control grid of the second tube. Thus during oscillation of the steady current through the second tube is gradually reduced to release the sensitive relay whereas pulses of relatively large magnitude due to the inductive effect of the relay winding appear at the anode of the second tube to be transmitted back to the control grid of the first tube to maintain the circuit in oscillation.

For a better understanding of the oscillatory circuit and of the new light responsive circuit incorporating the same reference may be had to the accompanying drawing of which:

Fig. 1 is a circuit diagram of a light responsive circuit embodying the invention;

Fig. 2 is a graph explanatory of the operation of the first tube of the oscillatory circuit; and

Fig. 3 is a diagram illustrating an alternative arrangement for part of the circuit of Fig. 1.

In Fig. 1 the light responsive circuit of the invention is shown as including a double tetrode 2 the first half 2a of which operates as the electrometer portion of the circuit and the second half 2b of which operates as the first tube of the oscillatory circuit, and a relay control tube 4 which serves also as the second tube of the oscillatory circuit. The control grid 6 of the electrometer portion 2a of tube 2 is connected to the photocathode of a photoelectric tube 8, the anode of which is grounded. The cathode 10 of the electrometer portion 2a is grounded and the screen grid 12 and anode 14 thereof, are connected through respective dropping resistors 16 and 18 to a line 20 maintained at a regulated voltage of 8 volts. Resistor 18, as indicated in Fig. 1, is made adjustable to serve as the hold control. The screen grid 12 is also connected through an adjustable resistor 22, comprising the dim control, to a front contact associated with the grounded armature 24 of the sensitive relay 26 in the anode circuit of tube 4.

Anode 14 of section 2a is connected through a resistor 28 to the control grid 30 of section 2b. The cathode of

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section 2b is operated at above ground potential by virtue of a connection to the junction of a pair of resistors 32 and 34 connected in series between the 8 volt line 20 and ground. The 8 volt line 20 is connected directly to the screen grid of section 2b and, through a dropping resistor 36 to the anode 38 of that section.

Anode 38 of section 2b is also connected through a capacitor 40 to the second or control grid 42 of the output tube 4. The control grid 30 of section 2b is connected through a capacitor 44 to the junction between a resistor 46 and capacitor 48 series connected between the anode 50 of tube 4 and ground. The circuit comprising resistor 46 and capacitor 48 serves as a potential divider and phase shifter for pulses fed back from anode 50 to grid 30.

The cathode of tube 4 is grounded and the first or space charge grid thereof is connected directly to the 8 volt line 20. A grid bias resistor 52 of relatively large magnitude, say two megohms, is connected between the grid 42 and ground. A car battery (not shown) of the order of 12 or 13 volts is connected to the anode 50 through the relay 26 and is connected through the winding of a power relay 54 to the back contact associated with armature 24 of relay 26.

Any suitable means, as for example, a gas filled regulator tube of conventional construction may be employed for obtaining from the battery the regulated 8 volts for application to line 20. Such means have not been shown because forming no part of the present invention and because adequately disclosed in the pending applications to which reference has already been made.

The operation of the circuit of Fig. 1 will now be given with reference to that figure and also with reference to the graph of Fig. 2. Under conditions of low or no light on the photocathode of the photoelectric tube 8 electrons from the heated cathode of the electrometer portion of tube 2 will accumulate on the grid 6 and drive that grid sufficiently negative to maintain relatively low current through the electrometer portion 2a of the tube. When dropping resistor 18 is of say 100 K and resistor 28 of about 300 K then the potential at the anode 14 will be relatively high say 2 volts or higher and the potential of grid 30 will be at least about one and one-half volts above ground, or zero with respect to the cathode. Accordingly section 2b of tube 2 will be in its most conductive condition. The value of resistor 28 is so chosen that the potential of grid 30 under such conditions of low current through the electrometer portion 2a will be high enough to insure that the current through the second half of tube 2 is that corresponding to saturation at the operating voltages. In Fig. 2 wherein plate potential above ground is plotted against grid potential above cathode potential a grid voltage of zero volts corresponds to the operating point at which saturation occurs. Increase in positive potential of the grid beyond this value can not change the anode potential because the anode is already taking all the current it can draw. Decrease in grid potential below this operating point will however, reduce the current through the section 2b and thereby result in increase in anode potential.

Still assuming the no or low light conditions, the tube 4 will be conducting and will pass a steady current of the order of 15 milliamperes. Accordingly relay 26 is energized holding open the circuit of the power relay 54 at the back contact of armature 24 and holding closed the circuit through the dim control 22 to the screen grid 12 of the electrometer portion 2a of tube 2. No oscillation of the circuit including the second half of tube 2 and the relay control tube 4 will occur under these conditions of low or no light.

If now light of predetermined intensity, determined in part by the adjustment of resistor 22 in the circuit of the screen grid, falls on the photocathode of tube 8 the negative charge accumulated by control grid 6 will dissipate through the photoelectric tube thereby raising the poten-

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tial of grid 6 and causing increased current to flow through the electrometer portion 2a. The potential at anode 14 therefore decreases and that at grid 30 likewise decreases. When the potential at grid 30 is sufficiently below the operating point (zero with respect to the cathode), the current through section 2b will decrease raising the potential at anode 38 and applying a positive pulse through condenser 40 to control grid 42 of tube 4. This will result in a momentary increase in current through tube 4 which increase is reflected as a drop in potential at anode 50 and, through the phase shifting and potential dividing circuit comprising resistor 46 and capacitor 48, as a negative pulse applied to grid 30. This negative pulse on grid 30 causes a positive pulse to appear at anode 38 and at control grid 42 which in turn reinforces the negative pulse at anode 50. When tube section 2b reaches cut off, the potential at anode 38 can rise no further. Consequently when the pulse applied through condenser 44 dissipates, the anode potential falls and the reverse cycle is initiated. Thus the oscillatory circuit comprising the section 2b and the relay control tube 4 will break into oscillation and continue to oscillate so long as the current through the electrometer portion 2a is sufficient to maintain the grid 30 at an average potential below that of the operating point indicated in Fig. 2.

Because of the presence of the inductive winding of the sensitive relay in the anode circuit of tube 4 the pulses created at anode 50 will be strongly negatively peaked and of a magnitude more than sufficient to maintain the circuit in oscillation. The steady current through tube 4 which is effective to hold the relay energized will gradually decrease during oscillation of the system due partly to the decrease in the average potential of grid 42 resulting from the self-rectifying properties of the grid circuit including the high resistor 52 and capacitor 40 and to the fact that the inductive kick drives the anode potential so low during positive excursions of the grid voltage that average plate current is reduced.

The potential dividing circuit comprising resistor 46 and capacitor 48 serves to reduce the magnitude of the pulses applied from anode 50 through capacitor 44 to control grid 30 and at the same time to shift the phase of these pulses to insure that oscillation will be continued so long as a light signal is present.

When the relay 26 releases the circuit of the power relay 54 is closed through armature 24 and the dimming switch (not shown) will be actuated. The circuit through adjustable resistor 22 is opened at the front contact of armature 24 and consequently the potential of the screen grid 12 of the electrometer portion of tube 2 is increased to increase the sensitivity of the circuit and to thereby insure that dimming of the lights of an approaching car will not cause return of the circuit to high beam conditions.

The control grid 6 of the electrometer portion 2a is preferably taken out through a top cap as indicated diagrammatically in Fig. 1 by the bracket 56. Preferably also this portion of the double tube 2 is of the construction illustrated and described in my said copending application Serial No. 547,508 filed November 17, 1955, which construction insures that change in cathode emission will not appreciably affect anode current. The construction involves a grid pitch-grid cathode spacing ratio less than unity to avoid "island formation" as explained more fully in said copending application.

Also the internal lead from grid 6 to the top cap is preferably so disposed with respect to the anode 38 of section 2b that there will be a capacitive coupling between that anode and grid 6 and the parts conductively connected thereto such as the top cap 56. Such coupling, of the order of 0.1 micromicrofarad, which is symbolized in Fig. 1 by the condenser 58 shown in dotted lines, serves to increase the speed of response of the circuit to change in light intensity, as explained in the said copending application. When the negative charge on grid

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6 starts to dissipate as a result of increase in intensity of light, and current through section 2b consequently reduces, the increase in potential at anode 38, through its capacitive coupling to grid 6, causes the potential of that grid to rise more quickly and hence accelerates the response of the circuit.

In the construction of double tetrode described in the said copending application the heaters are provided with unequal thickness of insulation to insure that the first half of the tube will heat up more promptly and thereby insure that when the circuit is first put into operation the dimming switch will be operated irrespective of light intensity. In the present circuit this result is automatically obtained during the charging of grid 6 from the cathode. Hence unequal rate of heating of the sections of the double tube is unnecessary and undesired. Both heaters are therefore preferably fast acting.

In the circuit of Fig. 1 the control grid 30 of tube section 2b is connected both to anode 14 to receive control potential therefrom and through capacitor 44 to the potential dividing and phase shifting network to receive pulses therefrom during a light signal. An alternative arrangement, wherein the feedback pulses are applied to the screen grid, rather than to the control grid of tube section 2b is illustrated in Fig. 3.

In Fig. 3, control grid 30 of section 2b is shown connected only to anode 14 of the electrometer section 2a and the screen grid 60 is shown connected to capacitor 44. The resistor between anode 14 and grid 30 is omitted and a potential dropping resistor 62 is included in the connection between the 8 volt line 20 and grid 60. The remainder of the circuit, being identical with that of Fig. 1, is not shown in Fig. 3. The operation of the circuit of Fig. 3 does not differ in any material respect from that described with reference to Fig. 1. The feedback connection to the screen grid rather than to the control grid has the effect, however, of keeping oscillatory current out of the dropping resistor in the anode circuit of the electrometer portion of tube 2.

An illustrative set of specific values of the several electrical components of the new system are given in the following table. Electrical components having values different from those given in the table could be employed in a system operating in accordance with the invention, as will be obvious to those skilled in the art.

Table of illustrative values of circuit components

R16	680 ohms.
R18	100 kilohms—variable.
R22	10 kilohms.
R28	300 kilohms.
R32	5 kilohms.
R34	1 kilohm.
R36	100 kilohms.
R46	22 kilohms.
R52	2.2 megohms.
C40	.002 microfarad.
C44	.001 microfarad.
C48	.0005 microfarad.
Capacitive coupling 58	about .01 micromicrofarad.

The invention has now been described with specific reference to control of the dimming switch of automobile headlights in response to incident light. Obviously the utility of the new oscillatory circuit of the invention is not limited to such specific application.

The following is claimed:

1. An oscillatory circuit comprising a first and second electronic tube section each having an anode and a cathode and at least one grid, means capacitatively coupling the anode of each section with a grid of the other section, a first conductive impedance, means for impressing a potential difference across said impedance and said first section in series, grid biasing means for said first section, a second conductive impedance, means for impressing a potential difference across said second impedance and

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second tube section in series, said second impedance being of a magnitude selected with reference to the magnitude of the potential difference impressed across said second impedance and said second tube section and with reference to the characteristics of such tube section as to cause such section to be current saturated when the potential of a grid thereof with respect to the cathode thereof is at or above a predetermined value, and means for initiating oscillation of the circuit by depressing the potential of said last mentioned grid below said predetermined value and for quenching oscillation of said circuit by raising the potential of said last mentioned grid above said predetermined value, said last mentioned means comprising a separate energized circuit connected to said last mentioned grid and to the cathode of said second section and having means therein for varying the potential of said last mentioned grid.

2. The oscillatory circuit according to claim 1 wherein said first conductive impedance is an inductive impedance whereby during oscillation of said circuit the average current through said first tube section decreases.

3. The oscillatory circuit according to claim 2 including a resistor and capacitor connected in series across said first tube section to serve as a potential dividing and phase shifting network for pulses fed back to a grid of said second tube section, said means capacitatively coupling said last mentioned grid of said second tube section to the anode of said first tube section comprising a capacitor connected between said grid and the junction of the resistor and capacitor of said network.

4. The oscillatory circuit according to claim 3 wherein said inductive impedance comprises the winding of a sensitive relay energized by the steady current through said first tube section when the circuit is not oscillating and wherein said grid biasing means comprises a high bias resistor connected between the cathode and the grid of said first tube section that receives pulses from said second tube section when the circuit is oscillating, whereby during oscillation of the circuit the average current through said first tube section and relay winding decreases to release the relay because the grid is driven negative by virtue of the self-rectifying properties of the cathode grid circuit including said bias resistor and because the inductive kicks at the anode depress the anode potential during parts of the time that positive pulses are impressed upon the grid.

5. The oscillatory circuit according to claim 1 wherein said second conductive impedance comprises two resistors one connected to the anode of said second tube section and the other connected to the cathode of said second tube section and wherein said separate energized circuit comprises a third electronic tube section, a dropping resistor, means for impressing a potential difference across said dropping resistor and third electronic tube section in series, and a connection between a grid of said second tube section and the junction of said third tube section with said dropping resistor whereby the potential applied to the grid of said second tube section varies with the current through said third tube section.

6. The oscillatory circuit according to claim 5 including a resistor in said connection to reduce grid current of said second tube section and to minimize oscillatory current in the dropping resistor connected to the third tube section.

7. The oscillatory circuit according to claim 1 wherein said second tube section has both a control grid and a screen grid, said control grid being connected to said separate energized circuit and coupled to the first tube section for reception of voltage pulses therefrom when the circuit is oscillating, said screen grid being connected for operation at constant positive potential.

8. The oscillatory circuit according to claim 7 wherein said separate energized circuit comprises a third electronic tube section and dropping resistor, means for impressing a potential difference across said third electronic tube

section and dropping resistor in series and a resistor connected between the control grid of said second tube section and the junction of said third tube section with its dropping resistor.

9. The oscillatory circuit according to claim 1 wherein said second tube section has both a control grid and a screen grid, said control grid being connected to said separate energized circuit and said screen grid being connected through a dropping resistor to said means for impressing a potential difference across said second impedance and second tube section in series and being coupled to said first tube section for reception of voltage pulses therefrom when the circuit is oscillating.

10. The oscillatory circuit according to claim 1 wherein said second impedance comprises a dropping resistor connected to the anode of said second tube section and a cathode resistor connected to the cathode of said second tube section and wherein said separate energized circuit includes a third electronic tube section having a cathode, at least one grid and an anode, a third conductive impedance, means for impressing a potential difference across said third impedance and said third tube

section in series and a connection between the anode of said third tube section and the grid of said second tube section, said second and third tube sections having a common envelope provided with a top cap to which the grid of said third tube section is internally connected, the electrodes within said common envelope being so oriented and the internal connection to the top cap being so disposed that there will be an inherent small capacitative coupling between the anode of said second tube section and the grid of the third tube section which accelerates response of the circuit to change in potential of the grid of the third tube section.

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