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CIRCUIT FOR SPACE DISCHARGE DEVICES

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FIG. 1

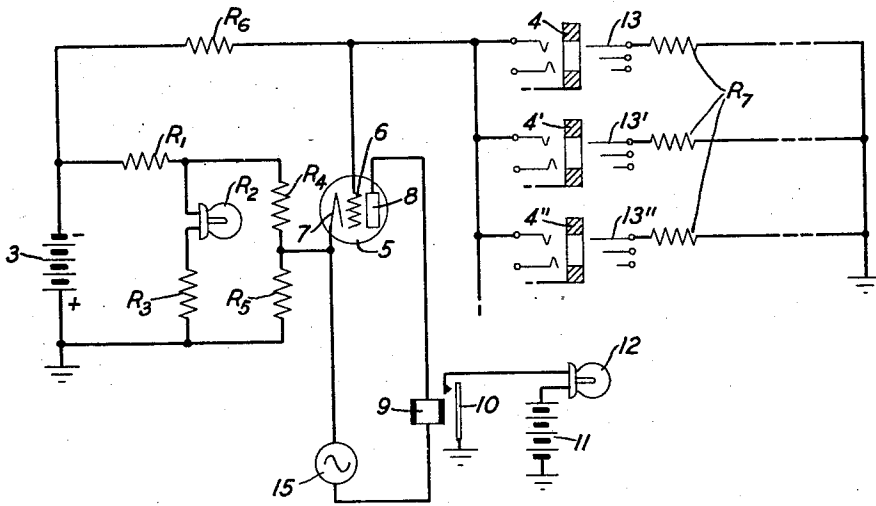
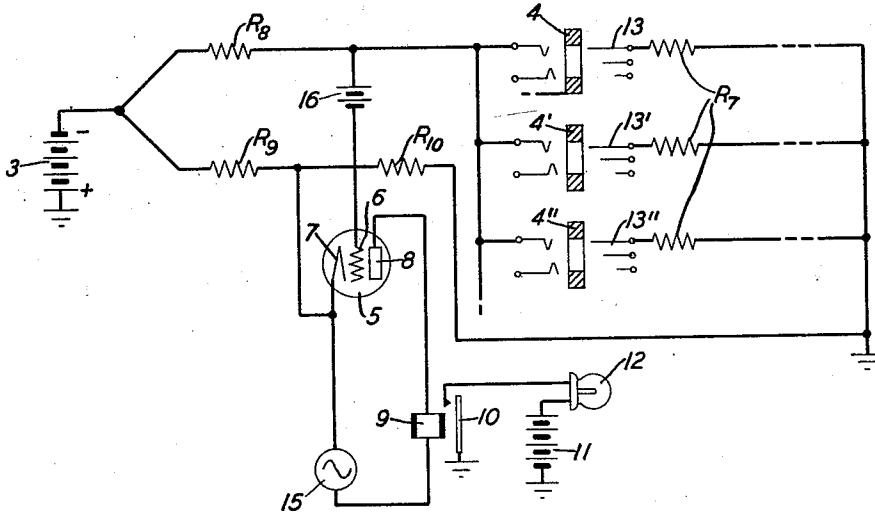


FIG. 2



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CIRCUIT FOR SPACE DISCHARGE DEVICES

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This invention relates to circuits for the control of the operation of space discharge devices. The invention is applicable to systems using any type of space discharge device but has more especial application to systems utilizing devices having that characteristic of operation known as "trigger action".

As is well known, space discharge devices have been constructed in which no space current will flow as long as the grid bias is more negative than a certain critical value, but when the critical value is passed in a positive direction by even a very small amount, plate current will flow a substantially its maximum rate.

Wherever this trigger action of space discharge devices is utilized to actuate signals, etc., it is of very great importance that the source from which the grid bias is obtained be substantially constant. Otherwise fluctuations of the voltage of the source may cause false operation.

The invention has as an object the prevention of false operation of trigger type space discharge devices.

Another object of the invention is to maintain the grid bias of a space discharge device substantially constant with a variable voltage source from which the bias is obtained.

These and other objects and features of the invention will be apparent and the invention more clearly understood from the following description together with the attached drawings illustrating in

Fig. 1 one form which the invention may take; and in

Fig. 2 a second form of the invention.

The invention, as illustrated in the drawings, has particular application to the overflow circuit in a telephone switchboard. In such an arrangement it is desirable that a signal be given when all of a given number of trunks have been put to use. This signal is controlled by the operation of a trigger type space discharge device, the grid bias of which is determined by the resistance associated with each trunk cord and the ordinary 24 volt central office battery. The voltage of

this battery, depending upon the degree of charge, may vary from 20 to 28 volts.

Referring now particularly to Fig. 1 the ordinary telephone central office battery 3 is represented as having its positive terminal connected to ground and its negative terminal connected through resistance R_6 to a contact of each of a series of jacks 4, 4', 4'', etc., mounted on a switchboard.

Space discharge device 5 having a grid 6, filament or cathode 7 and plate or anode 8 is of the type having the trigger action characteristic. Included in the plate circuit of device 5 is a relay 9 adapted upon energization by passage of plate current through its winding, to attract its armature 10, closing a circuit from battery 11 through signal lamp 12, whereupon lamp 12 is lighted for a purpose which will appear hereinafter.

The grid 6 of device 5 is connected to a point in the circuit between resistance R_6 and jacks 4, 4', 4'', etc., and the cathode 7 is connected to a point between two resistances R_4 and R_5 which are connected around the battery 3 in series with resistance R_1 . Also connected in parallel with resistances R_4 and R_5 and in series with resistance R_1 are ballast lamp R_2 and resistance R_3 .

Each cord and plug 13, 13', 13'', etc., associated with jacks 4, 4', 4'', etc., contains a part of a resistance the various units of which are indicated as R_7 . Therefore, R_7 is a variable resistance, the units of which are connected in parallel as the cords are plugged in, that is, under the operation of plugging in additional cords the value of resistance R_7 decreases.

As resistance R_7 decreases in value more current from battery 3 will flow therethrough and also through resistance R_6 . The IR drop through resistance R_6 , therefore, becomes greater, and the part of resistance R_6 remote from the battery becomes more positive as to potential. It is at this point that the grid 6 is connected and its potential therefore becomes more positive with respect to ground.

Assuming for the present no change in the voltage of battery 3, the potential of the cathode with respect to ground remains unchanged. The grid bias of the device, that is,

the potential difference between grid 6 and cathode 7 changes in a positive direction or the grid attains a potential less negative with respect to the cathode as additional cords are plugged in.

Resistance R_7 , R_6 , etc., are chosen as to values to correspond with the characteristics of device 5 and also in accordance with the number of cords which are to be placed in service. These values should be such that when the last cord is plugged in, the grid bias of the device will pass its critical value and plate current will flow energizing relay 9 thereby causing lamp 12 to light indicating that all cords are in use.

If the voltage of battery 3 were to remain constant, only resistances R_6 and R_7 would be required but in practice it is found that whereas battery 3 has a nominal voltage of 24, its voltage may vary from 20 to 28.

To maintain the grid bias substantially constant with variable voltage of battery 3 it is necessary to maintain the potential of the grid 6 with respect to cathode 7 the same despite battery voltage change, that is, the potentials of these elements must change at the same rate.

By inspection, it will be seen that the potential of grid 6 must vary with varying battery voltage because changing the resistance of the units R_7 changes the current flow through R_6 and this would occur with varying battery voltage. Varying the resistance R_7 is an essential part of the operation of the switchboard and signal arrangement. Hence it is necessary that the potential of cathode 7 change at the same rate and in the same direction as that of grid 6 with battery voltage change. The circuits involving resistances R_1 , R_2 , R_3 , R_4 and R_5 accomplish this result by maintaining the potential difference between grid and cathode substantially constant. The relation of the resistance values will be seen from the following:

Assume the battery voltage to be E at one time and E' at some other time; I , with a distinguishing subscript, the current at the time when the battery voltage is E ; and I' when the battery voltage is E' . The resistance values will be represented by their reference characters.

Then the grid potential when battery voltage is E is

$E_G = E - I_3 R_6$ where I_3 is the current through R_6 . The cathode potential at the same instant is

$E_C = E - I_1 R_1 - I_4 R_4$ where I_1 and I_4 are the currents through R_1 and R_4 , respectively.

The grid bias

$$E_{GC} = E_C - E_G = -I_1 R_1 - I_4 R_4 + I_3 R_6.$$

When battery voltage is E' ,

$$E'_{GC} = E'_C - E'_G = -I'_1 R_1 - I'_4 R_4 + I'_3 R_6$$

The change in grid bias due to change in battery voltage is

$$\Delta E_{GC} = E_{GC} - E'_{GC} = -R_4 (I_4 - I'_4) - R_1 (I_1 - I'_1) + R_6 (I_3 - I'_3) \quad (1)$$

The current through the ballast lamp R_2 is constant at I_2 regardless of battery voltage change.

$$\text{Hence } I_1 = I_2 + I_4$$

$$\text{and } I'_1 = I_2 + I'_4$$

$$\text{subtracting } I_1 - I'_1 = I_4 - I'_4 \quad (2)$$

$$\text{substituting (2) in (1) } \Delta E_{GC} =$$

$$-(R_1 + R_4) (I_4 - I'_4) + R_6 (I_3 - I'_3) \quad (3)$$

$$I_3 = \frac{E}{R_6 + R_7}$$

$$I'_3 = \frac{E'}{R_6 + R_7}$$

$$I_1 = I_2 + I_4 = \frac{E - (R_4 + R_5) I_4}{R_1}$$

$$I_2 R_1 + I_4 R_1 = E - (R_4 + R_5) I_4$$

$$\begin{aligned} I_2 R_1 &= E - I_4 R_1 - (R_4 + R_5) I_4 \\ &= E - (R_1 + R_4 + R_5) I_4 \end{aligned}$$

from which

$$I_4 = \frac{E - I_2 R_1}{R_1 + R_4 + R_5}$$

and since I_2 is constant (current through ballast lamp)

$$I'_4 = \frac{E' - I_2 R_1}{R_1 + R_4 + R_5}$$

$$I_4 - I'_4 = \frac{E - E'}{R_1 + R_4 + R_5}$$

substituting in (3)

$$\Delta E_{GC} = -(R_1 + R_4) \frac{E - E'}{R_1 + R_4 + R_5} + R_6 \frac{E - E'}{R_6 + R_7} \quad (4)$$

if

$$\Delta E_{GC} = 0 \text{ and } E - E' \neq 0$$

$$\frac{R_1 + R_4}{R_1 + R_4 + R_5} = \frac{R_6}{R_6 + R_7}$$

Inverting

$$\frac{R_1 + R_4 + R_5}{R_1 + R_4} = \frac{R_6 + R_7}{R_6}$$

or

$$1 + \frac{R_5}{R_1 + R_4} = 1 + \frac{R_7}{R_6}$$

$$\frac{R_5}{R_1 + R_4} = \frac{R_7}{R_6}$$

Inverting

$$\frac{R_1 + R_4}{R_5} = \frac{R_6}{R_7}$$

R_7 has a nominal value 800 Ω and knowing the tube characteristics the other resistance values may be approximated and by actual experiment the desirable values may be ob-

tained. In one embodiment of the invention the various resistance values were $R_1=16\omega$, $R_3=18\omega$, $R_4=1000\omega$, $R_5=2000\omega$, $R_6=350\omega$ and as noted $R_7=800\omega$.

Assuming a change in battery voltage of 8 volts equation (4) shows that for such change the grid bias as E_{GC} will be .256 volts which in the embodiment of the invention tested was not sufficiently large to cause false operation. However, it can be seen that with but slight variations in some of the resistances the grid bias change can be made substantially zero.

As is well known discharge devices which exhibit the trigger action tend to permit space current to flow, when once started, regardless of the subsequent grid potential. The space current flow can be stopped by opening the space current circuit. After the grid has again reached a potential more negative than its critical value for a sufficient time to deionize the space, the plate voltage may be again applied and the grid then has control of the space current as at first. Various arrangements may be devised for accomplishing the cessation of space current flow and the means about to be described is not the only way in which this can be done, hence applicant does not wish to be limited thereto.

The plate supply source 15 is alternating current of a low frequency, that is, of the order of power circuits, for example 60 cycles, and relay 9 is an alternating current relay. Therefore when the grid has passed its critical value in a positive direction and space current flows on the positive half cycle, relay 9 will be operated and will remain operated during the negative half cycle, maintaining the circuit of signal 12 closed.

When any one of the jacks 13, 13', etc., is removed from its associated plug the grid of device 5 will assume a potential more negative than its critical value. With an alternating current plate supply, plate current will cease to flow on the negative half cycle and will not flow due to the grid potential on the succeeding positive half cycle. With a source of approximately 60 cycle frequency there will be sufficient time during the negative half cycle for the device to be deionized. Plate current therefore will cease to flow and relay 9 will release, opening the circuit of signal 12.

Another circuit arrangement which will accomplish the same purpose is shown in Fig. 2. In this figure the features common to both figures have been given the same reference characters as in Fig. 1. Battery 3 is the standard central office battery with its positive pole grounded and with parallel circuits connecting its negative terminal to ground. One circuit includes resistance R_3 , jacks 4, 4', etc., and plugs and cords contain-

ing units of resistance R_7 while the other circuit includes resistances R_9 and R_{10} .

Resistances R_7 , R_8 , R_9 and R_{10} form a resistance bridge with battery 3 connected across diagonal corners and the grid 6 and cathode 7 of space discharge device 5 connected to the alternate corners.

In this arrangement the main requirement is that the values of resistances R_8 and R_9 be equal. Assuming a constant voltage for battery 3 it will be seen that with decreasing resistance at R_7 (as additional cords are plugged in) more current flows through this branch and hence the IR drop through R_8 increases. As the grid 6 of device 5 is connected to this branch at a point between R_7 and R_8 the change in the potential on grid 6 is in a positive direction. Since the cathode 7 is connected to a point between resistances R_9 and R_{10} and the current flowing through these resistances does not change with variation in R_7 the potential of the cathode remains constant. As in Fig. 1 the values are so chosen that when the last available cord is plugged in the potential of grid 6 is changed sufficiently to permit plate current to flow whereby relay 9 is energized and the corresponding signal given.

With a fixed value of resistance for R_7 and the values of resistances R_8 and R_9 equal, a change in voltage of battery 3 will cause a change in current flow through the branches of the bridge but no relative change. Hence, whereas the potentials of grid 6 and cathode 7 will change relative to ground, their potential difference (grid bias) remains unchanged and battery voltage change will not cause false operation of the system.

In the circuit of Fig. 2 a grid biasing battery 16 is shown. This battery may be used to insure a bias on the grid under certain conditions of resistance values. For example, if the resistance of R_7 is equal to that of R_{10} the potentials of the grid and filament will be equal and some means must be utilized to keep the grid at a potential more negative than its critical value until the value of resistance R_7 reaches that required to make the grid more positive than its critical value.

As in Fig. 1 the plate current source 15 is alternating current of a low frequency. The operation of relay 9 and the manner of deionizing space discharge device 5 is the same as that of Fig. 1.

It is to be understood that whereas the invention is illustrated in connection with one circuit of a telephone switchboard the invention itself is capable of being applied to any circuit involving the use of a space discharge device. The invention, therefore, is to be limited only to the scope of the appended claims.

What is claimed is:

1. In an electrical system involving a space discharge device having grid, cathode and plate electrodes, a battery, a divided circuit

of resistances connected across said battery; connections from said grid and cathode to different points on said resistances whereby current flow from said battery establishes a potential difference between said grid and said cathode and means including said resistances for maintaining this potential difference substantially constant, with change in the voltage of said battery.

2. In an electrical system involving a space discharge device having grid, cathode and plate electrodes, a battery, circuit means whereby current flow from said battery establishes a potential difference between said cathode and said grid, including means operating in response to change of voltage of said battery to cause a proportionate change in the potentials of each of said electrodes whereby their difference in potential remains substantially constant.

3. In an electrical system involving a space discharge device having grid, cathode and plate electrodes, a battery, parallel circuit branches through which current from said battery flows, said grid being connected to one of said branches and said cathode connected to another of said branches and resistance units in said branches so disposed that the potential difference between said grid and said cathode remains substantially constant with varying battery voltage.

4. In an electrical system involving a space discharge device having grid, cathode and plate electrodes, a battery, a plurality of circuits associated with said battery, the grid of said device being connected to one of said circuits at a point between two resistances included in said circuit, the cathode being connected between two resistances included in another of said circuits and a third circuit containing a ballast lamp in parallel to said second circuit.

5. In a telephone switchboard, fixed and movable contact members for connecting circuits through said switchboard, resistance means associated with said members, a space discharge device, a battery, connections whereby said battery and said resistance means cooperate to vary the grid bias of said space discharge device to cause anode current to flow therethrough to operate a signal device after a given number of said contact members are operated.

6. In a telephone switchboard in combination, a battery, a space discharge device, jacks in said switchboard, cord circuits including plugs to be inserted in said jacks for connecting circuits through said switchboard, resistance units included in said cord circuits, a circuit including said battery and said resistance units and to which the grid of said space discharge device is connected, means including said resistance units in said cord circuits whereby the current flow from said battery is varied to vary the grid potential

of said space discharge device whereby the anode current flow therethrough is varied causing the operation of a signal device.

7. In a telephone switchboard in combination, a space discharge device, a battery, a plurality of jacks, a plurality of cord circuits including plugs for insertion in said jacks, a resistance unit in each cord circuit, a circuit including said battery, said jacks and said cord circuits to which the grid of said space discharge device is connected, and other circuits associated with said battery and said space discharge device whereby the grid bias of said space discharge device is varied by said cord circuit resistance irrespective of said battery voltage to cause the operation of a signal device.

8. In a telephone switchboard, a signal means comprising, a space discharge device, a signal device included in the anode circuit of said space discharge device, a plurality of cord circuits, a resistance unit in each cord circuit, and means whereby said cord circuits as they are utilized cause a change in the grid bias of said space discharge device of such a degree that when the last available cord circuit is used the grid bias is such as to cause sufficient anode current to flow to operate said signal device.

In witness whereof, I hereunto subscribe my name this 12th day of May, 1931.

ALBERT E. BACHELET.