June 21, 1949. P. W. STUTSMAN 2,473,832

ELECTRICAL SYSTEM

Filed April 14, 1944 2 Sheets-Sheet 1

FIG. 1.

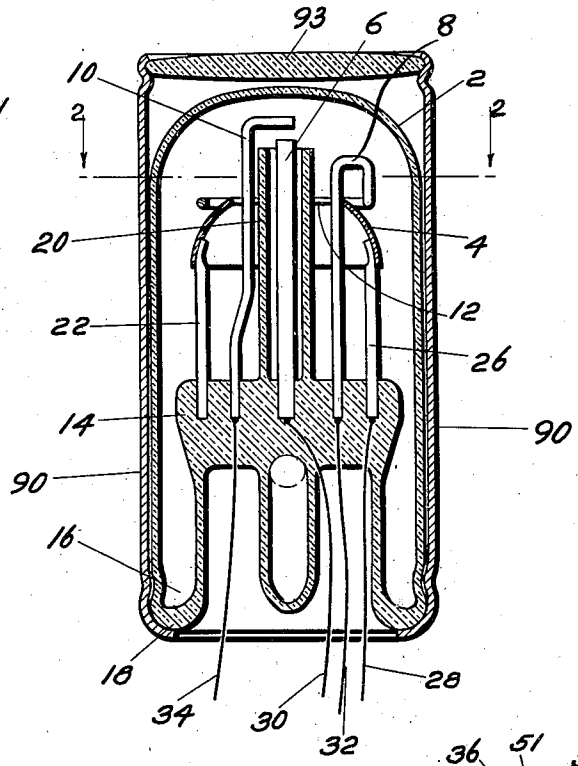


FIG. 2.

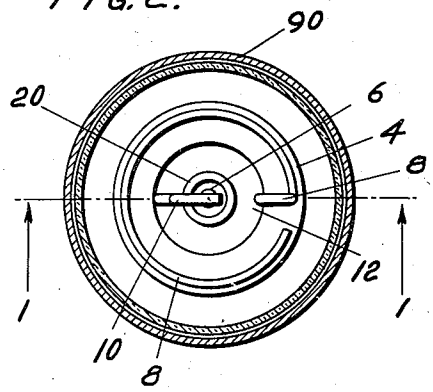
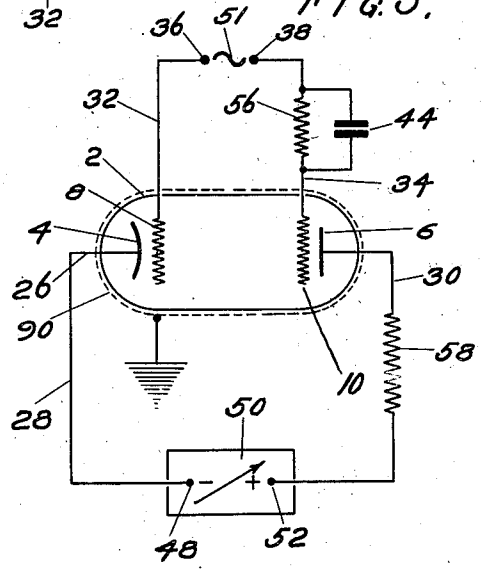


FIG. 3.



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FIG. 4.

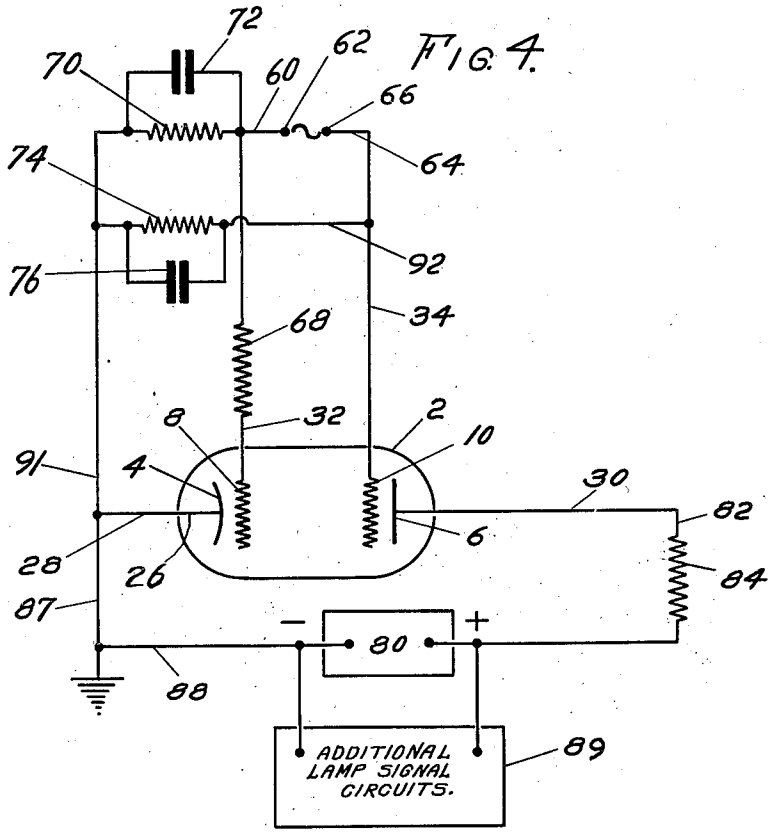
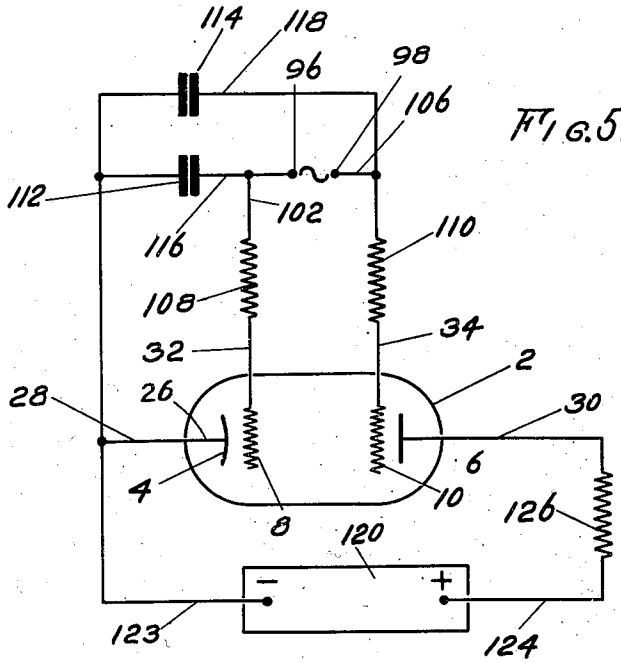


FIG. 5.



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ELECTRICAL SYSTEM

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Application April 14, 1944, Serial No. 531,067

7 Claims. (Cl. 315—275)

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This invention relates to electrical systems and more particularly to electrical signal systems for visible signalling.

Electrical signalling systems are known in which a relay and signal lamp are used to produce a visible signal. These systems, however, are objectionable, particularly in portable systems, on account of the weight of the relays.

One of the objects of the present invention is to provide an electrical signalling system in which this difficulty is overcome by substituting a novel tube that makes it possible to do away with the relay.

Electrical signalling systems heretofore used are also open to the objection, when it is desired to use a very small signal voltage, that they require the application of a relatively higher voltage in order to fire the tube. The present invention overcomes this objection by providing two auxiliary electrodes in addition to the anode and cathode, and so arranged that when a signal input voltage is applied between said two auxiliary electrodes and the anode and cathode respectively, the signal input voltage will be added to the cathode-anode voltage to raise the voltage across a gap within the tube to the breakdown point, the magnitude of the signal input voltage required to be added being relatively small, so that tubes embodying the present invention may be made to fire on a very low signal input voltage.

In such electrical signalling systems, transient voltage differences may occur between different circuits which may not only be disturbing but may even fire the tube.

Another object of the present invention, therefore, is to eliminate the effect of such transient voltage differences.

When devices of the above type are used in telephone systems comprising a plurality of signal circuits, there is a tendency to produce what is known as crosstalk, that is to say, conversation upon one line reproduced upon another. A further object of the present invention is to eliminate such crosstalk or to attenuate it sufficiently to render it unobjectionable.

A further object of the present invention is to provide an improved gaseous conduction tube.

These and such other aims and objects of the present invention as may hereinafter appear will be readily understood from the following description, taken in connection with the accompanying drawing, of embodiments of the invention herein presented for illustrative purposes.

In the drawing:

Fig. 1 is a vertical cross-section on line 1—1 of

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Fig. 2 of a tube embodying one illustrative embodiment of certain features of the invention;

Fig. 2 is a horizontal cross-section on line 2—2 of Fig. 1 but showing the tube elements in plan;

Fig. 3 shows an electrical signalling system embodying one illustrative embodiment of the invention;

Fig. 4 shows an electrical signalling system embodying another illustrative embodiment of the invention; and

Fig. 5 illustrates an electrical signalling system embodying a further illustrative embodiment of the invention.

Referring to Figs. 1 and 2, in the illustrative embodiment of the invention therein shown, the signal lamp comprises a glass envelope 2 containing a suitable ionizable gaseous medium and an electrode assembly comprising a cathode 4, an anode 6, and two grids or auxiliary electrodes 8 and 10. Said cathode may be relatively large and in this illustrative embodiment of the invention is shaped like an inverted bowl provided with a relatively large, central circular aperture 12 through which said anode 6 and the two auxiliary electrodes 8 and 10 extend upwardly. The lower ends of said anode and said two auxiliary electrodes are sealed in a press 14 formed upon the upper edge of the reentrant stem 16 of said envelope, the lower edge of said envelope 2 being hermetically sealed to the flare 18 of said stem 16. Above said cathode, said auxiliary electrode 8 is shown as bent horizontally away from the anode, then downwardly, and then circularly in a plane substantially parallel and in proximity to the upper surface of said cathode, this portion of said auxiliary electrode thus forming almost a complete circle and presenting an extended active area to the upper electron-emissive surface of said cathode. The auxiliary electrode 10 extends substantially parallel to the anode 6, its upper end being bent at right angles across the latter's upper end. Means may be provided to prevent premature ignition, such as a shield 20 surrounding the anode 6, and herein conveniently consisting of a glass cylinder integral with said stem 16. The cathode is supported by a post 22, the lower end of which is sealed in said press 14. A conductor 26 connects the cathode with a lead-in conductor 28, and the lower ends of said anode and of said two auxiliary electrodes 8 and 10 are joined to lead-in conductors 30, 32 and 34, respectively.

The signal lamp as above described, including the electrode assembly and other parts therein contained, may and preferably will be the same

for all embodiments of the present invention herein disclosed. In the description of Figs. 3, 4 and 5 therefore, such parts of the tube as may be referred to will be designated by the same reference numerals as in Figs. 1 and 2.

Referring to Fig. 3, auxiliary electrode 8 is connected by a conductor 32 to one terminal 36 of the signal input circuit, and auxiliary electrode 10 is connected to the other terminal 38 of said signal input circuit by conductor 34 through a resistance 56. It may be advantageous to use a voltage storage device, such as condenser 44, in this circuit as will be hereinafter more fully explained. The conductor 26, joined to the cathode 4, is connected by conductor 28 to one pole 48 of a battery or other suitable source 50 of D. C. voltage which may be adjustable and anode 6 is connected to the other pole 52 of said source by conductor 30. A current-limiting resistance 58 will preferably be included in said anode-cathode circuit.

In this embodiment of the invention when voltages of from 135 to 180 volts are available, neon gas may be used at a pressure of 40 mm. of mercury.

The signal discharge may be initiated in either one of two ways or both. It may be initiated directly between the two auxiliary electrodes 8 and 10 to produce sufficient ionization for the discharge to start between the cathode 4 and the anode 6. It is conceivable, however, that for some reason the initiation of the discharge might not take place between said two auxiliary electrodes. Such a condition might exist if the spacing of said two auxiliary electrodes were too great for the available signal voltage alone to break down, or the signal voltage might be too low to effect a breakdown even if the spacing of said two auxiliary electrodes were at the minimum breakdown distance. In such case it has been found that the discharge may be initiated between the auxiliary electrode 8 and the cathode 4, and between the auxiliary electrode 10 and the anode 6. It is believed that this may be due to the fact that the signal voltage may build up a potential on said auxiliary electrode 8, which is positive with respect to said auxiliary electrode 10, and the anode-cathode voltage makes the anode 6 positive with respect to the cathode 4. Under these conditions, the signal voltage will add to the anode-cathode voltage and thus the total voltage impressed across the gaps between the auxiliary electrode 8 and the cathode 4 and between the auxiliary electrode 10 and the anode 6 will be the sum of said signal and anode-cathode voltages. The voltages across these gaps may thus be raised to the breakdown point. If this theory is correct the magnitude of the signal input voltage required to produce breakdown becomes a function of the anode-cathode voltage, increasing and decreasing inversely to the increase or decrease of the anode-cathode voltage.

To illustrate, let us consider Fig. 3. As pointed out above, when the auxiliary electrode 8 is positive with respect to the auxiliary electrode 10, then voltage from the signal voltage 51 will be added to the anode-cathode voltage 50, across the gaps 4—8 and 10—6.

Let us suppose that the anode-cathode circuit voltage Ea is 180 volts D. C., that the voltage required for breakdown between cathode 4 and the auxiliary electrode 8 is 110 volts, and that the same voltage will be required for breakdown between anode 6 and auxiliary electrode 10. The necessary starting potential to break down both gaps 4—8 and 10—6 would therefore be 220 volts, which is made up of D. C. voltage, supplied by the anode-cathode circuit 50, and A. C. voltage supplied by the signal input circuit 51. If we designate by Es the R. M. S. A. C. voltage of the signal input circuit 51, then

$$Es=Eo \sin \omega t$$

where Eo designates the peak signal input circuit voltage. The tube will therefore fire when

(1) $$Ea+Eo \sin \omega t=220 \text{ volts}$$

Thus

(2) $$220 \text{ volts}-Ea=Eo \sin \omega t$$

But we know that

(3) $$Ea=180 \text{ volts}$$

therefore from (2)

(4) $$220 \text{ volts}-180 \text{ volts}=40 \text{ volts}$$

and

(5) $$Eo=40 \text{ volts}$$

when

$$\sin \omega t=1$$

The signal input circuit voltage required to be added to the 180 peak voltage of the anode-cathode circuit for starting the tube would be 40 volts peak, or, reduced to R. M. S. A. C., it would be equal to

$$\frac{40}{\sqrt{2}}=28 \text{ volts}$$

The signal input circuit voltage required to start the tube is therefore a function of the applied anode-cathode circuit voltage. Once initiated between the cathode and auxiliary electrode 8, the discharge will pass on through the signal input circuit to auxiliary electrode 10 and from the latter to the anode. Thereupon the discharge is finally initiated between said anode and cathode.

It has been stated above that the use of a condenser in the signal input circuit might be advantageous. It has been found in fact that under certain conditions the use of a condenser, shown at 44 in Fig. 3, reduces the starting voltage. Thus, with a condenser having a capacitance of .005 microfarad, the signal starting voltage was reduced from 65 volts R. M. S. to 50 volts R. M. S. and the peak from 91 volts to 70 volts.

When a plurality of devices as illustrated in Fig. 3 are utilized in a single telephone system where the voice signals also appear across the lines 32 and 34, there will be substantially no tendency to produce crosstalk since there is substantially infinite impedance between the signal input circuit and the anode-cathode circuit when the tube is not conducting as is the case during the period when speech is being transmitted, and thus no crosstalk can be transmitted. Referring to Fig. 3 it will be seen that as previously stated, in the illustrative embodiment of the invention therein shown, the auxiliary electrode 8 is directly connected to one terminal 36 of the signal input circuit by conductor 32 and that auxiliary electrode 10 is directly connected to the other terminal 38 of said circuit by conductor 34. The signal input circuit is therefore disconnected externally from the anode-cathode circuit, so that as above stated, when the tube is not conducting, there is substantially infinite impedance between the signal input circuit and the anode-cathode circuit and crosstalk is excluded.

In the embodiment of the invention illustrated in Fig. 3, the auxiliary electrodes 8 and 10 float

This is due at least in part to the favorable relative positions of said two auxiliary electrodes 8 and 10 to the other elements of the tube and the associated circuit. While the potential required for ignition has been reduced, premature ignition between the anode and the cathode, before a working voltage has been attained, is prevented by suitable means, such as a shield 20 (see Fig. 1), that encloses the anode throughout that part where such premature ignition might occur. The signal input voltage may be made as low as may be desirable.

Firing of the tube except when the desired and necessary signal input voltage is applied, and which was heretofore caused by transient disturbing voltage differences that may occur between circuits, has been eliminated and cross-talk in those systems wherein it is likely to occur has also been substantially eliminated or so attenuated that it is unobjectionable.

Systems embodying the present invention are also considerably lighter in weight where the lamps take the place of lamps and relays. Other advantages will suggest themselves to those skilled in the art.

I am aware that the present invention can be embodied in other specific forms without departing from the spirit or essential attributes thereof, and I therefore desire the present description to be considered in all respects as illustrative and not restrictive, reference being had to the appended claims rather than to the aforesaid description to indicate the scope of the invention.

What is claimed is:

1. In an electrical system, a gaseous conduction tube comprising an hermetically sealed envelope containing an electrode assembly comprising an electron-emissive cathode, an anode and two auxiliary electrodes; an anode-cathode circuit comprising said anode and said cathode; a signal input circuit comprising said two auxiliary electrodes; and means comprising a by-pass condenser, connected between said two circuits, for by-passing transient voltage differences that might occur between said two circuits thereby preventing said transient voltage differences from firing the tube.

2. In an electrical system, a gaseous conduction tube comprising an hermetically sealed envelope containing an electrode assembly comprising an electron-emissive cathode, an anode and two auxiliary electrodes; an anode-cathode circuit comprising said anode and said cathode; a signal input circuit comprising said two auxiliary electrodes; resistance means connected between said two circuits; and condenser means shunted around said resistance means.

3. In an electrical signal system, a gaseous conduction tube comprising an hermetically sealed envelope containing an electrode assembly comprising a glow discharge cathode, an anode and two auxiliary electrodes; an anode-cathode circuit comprising said anode and said cathode; a signal input circuit comprising said two auxiliary electrodes; and means comprising a by-pass condenser, connected between said two circuits, for by-passing transient voltage differences that might occur between said two circuits thereby preventing said transient voltage differences from firing the tube.

4. In an electrical signal system, a gaseous conduction tube comprising an hermetically sealed envelope containing an electrode assembly comprising a glow discharge cathode, an anode and two auxiliary electrodes; an anode-cathode circuit comprising said anode and said cathode; a signal input circuit comprising said two auxiliary electrodes; resistance means connected between said two circuits; and condenser means shunted around said resistance means.

5. In an electrical signal system, a gaseous conduction tube comprising an hermetically sealed envelope containing an electrode assembly comprising a glow discharge cathode, an anode and two auxiliary electrodes; an anode-cathode circuit comprising said anode and said cathode; a signal input circuit containing said two auxiliary electrodes and current-limiting resistance means; and condenser means connected between said two circuits.

6. A glow discharge lamp comprising a sealed envelope containing a light-producing gas at substantial pressure, said envelope having an insulating stem through which a plurality of conducting leads are sealed, an insulating sleeve projecting into said envelope from said stem and surrounding one of said leads, said sleeve being open at its inner end to permit the inner end of the lead which it surrounds to act as an anode, a cup-shaped cathode supported by another of said leads, said cathode having its convex surface facing away from said stem and having a central opening through which said sleeve projects, an auxiliary ring-shaped electrode supported by another of said leads and lying closely adjacent the convex surface of said cathode, and a second auxiliary electrode connected to another of said leads and overlying the open inner end of said sleeve in close juxtaposition to the anode.

7. A glow discharge lamp comprising a sealed envelope containing a light-producing gas at substantial pressure, said envelope having an insulating stem through which a plurality of conducting leads are sealed, an insulating sleeve projecting into said envelope from said stem and surrounding one of said leads, said sleeve being open at its inner end to permit the inner end of the lead which is surrounds to act as an anode, a cup-shaped cathode supported by another of said leads, said cathode having its convex surface facing away from said stem and having a central opening through which said sleeve projects, an auxiliary ring-shaped electrode supported by another of said leads and lying closely adjacent the convex surface of said cathode, a second auxiliary electrode connected to another of said leads and overlying the open inner end of said sleeve in close juxtaposition to the anode, and an opaque shield surrounding said envelope, said shield being provided with a window at one end whereby the light generated at the convex surface of said cathode may be observed through said window.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,144,596	Hewitt	June 29, 1915
1,506,468	White	Aug. 26, 1924
1,550,877	Chaffee	Aug. 25, 1925
1,838,871	Schmierer	Dec. 29, 1931
1,893,638	Schmierer	Jan. 10, 1933
1,947,774	Heany	Feb. 20, 1934
2,113,464	Hazeltine	Apr. 5, 1938

with respect to the anode and cathode. This has a tendency to render the tube somewhat unstable. To remedy this and to stabilize the tube it is preferable to provide stabilizing means, such as, for example, a grounded shield 90 of metal or other suitable electrically conductive material. (See Fig. 3.) If desired said shield may completely enclose the tube except at the top and bottom thereof so as to confine the light to what is emitted through the top of said shield. If desired the light from the tube may be further localized by insertion of a lens 93 in the top of the cylinder 90.

Stabilizing circuit arrangements may also be utilized such as shown in the illustrative embodiment of Fig. 4. In this embodiment the auxiliary electrode 8 is connected by conductors 32 and 60 to one terminal 62 of the signal input circuit and the auxiliary electrode 10 is connected by conductors 34 and 64 to the other terminal 66 of said circuit, a current-limiting resistance 68 being preferably inserted in said circuit. The anode 6 is connected to the positive pole of a source of D. C. voltage, battery 80, for example, for the anode-cathode circuit by conductors 30 and 82 through a resistance 84 for limiting the anode-cathode current to working value, and the cathode 4 is connected to the negative pole of said source of D. C. voltage by conductors 26, 28, 87 and 88. The auxiliary electrode 8 is also connected to the negative pole of said source of D. C. voltage 80 by conductors 32, 91, 87 and 88 through a relatively high resistance 70 and a current-limiting resistance 68, and the auxiliary electrode 10 is also connected to said negative pole of said source of D. C. voltage 80 by conductors 34, 92, 91, 87 and 88 through a relatively high resistance 74.

I have discovered that by using a discriminatory impedance network connected between the anode-cathode circuit and the signal input circuit and comprising for example, a by-pass condenser 72 shunted around said resistance 70, and a second by-pass condenser 76 shunted around said resistance 74, the benefits of circuit stabilization are secured without introducing difficulties, such as undesired firing and crosstalk.

I have found that the transient disturbances which tend to produce undesired firing are of relatively high frequency as compared to those voice frequencies which carry the intelligible portions of the voice signal and said voice frequencies are relatively high as compared to the signal frequencies. Due to said frequency differences, the impedance of the members 72, 70 and 76, 74 can be made sufficiently low, relative to the undesirable transient voltage differences that may exist between said anode-cathode circuit and said signal input circuit and which might otherwise fire the tube, to by-pass said transient voltage, and yet sufficiently high with respect to the signal frequencies so as to permit a sufficiently high signal voltage to be built up across said impedance to fire the tube. By a suitable adjustment of said impedance, crosstalk due to intercircuit coupling, when the invention is used in a telephone system, for example, having a plurality of lamp signal circuits, can be sufficiently attenuated to render it unobjectionable without in any way interfering with the regular signalling functions of the system. Additional lamp signal circuits are diagrammatically indicated at 89.

It has been found that by-pass condensers 72 and 74 of 200 micromicrofarads each and resistances 70 and 74 of 5 meg. each give very good results.

When an anode-cathode voltage from 90 to 135 volts is available, a gaseous medium composed of a mixture of neon and argon gases (about 34.4 mm. of neon to 0.6 mm. of argon) may be used in the embodiment of Fig. 4. If higher voltages were available and as a result a neon-filled tube were to be used in the arrangement of Fig. 4, a continuous small discharge may be present between the anode and auxiliary electrode 10 due to the connections afforded by the resistances 70 and 74. Should this be objectionable the embodiment of the invention illustrated either in Fig. 3 or in Fig. 5 is preferable.

In the illustrative embodiment of the invention shown in Fig. 5, auxiliary electrode 8 is connected through a current-limiting resistance 108 to terminal 96 of the signal input circuit by conductors 32, 102 and auxiliary electrode 10 is connected through a current-limiting resistance 110 to terminal 98 of said circuit by conductors 34, 106. In this embodiment of the invention condensers 112 and 114, like condensers 72 and 76 of the previously described embodiment of the invention disclosed in Fig. 4, can be adjusted to provide an impedance that is sufficiently low, relative to the undesirable transient voltage differences that may exist between the anode-cathode circuit and the signal input circuit and which might otherwise fire the tube to by-pass said transient voltage differences, and yet to provide a sufficiently high impedance with respect to the signal voltages as to insure the building up of a voltage across said impedance that will be sufficiently high to fire the tube. However, resistances across the condensers 114 and 112 such as are present in Fig. 4 are omitted. By such judicious adjustment of said condensers 112 and 114 it is possible to cause extraneous transient voltages to be by-passed and substantially eliminated, and crosstalk, due to intercircuit communication when the invention is used in a system where it tends to occur, to be so greatly attenuated that it becomes unobjectionable. These by-pass condensers 112 and 114 are connected to the signal input circuit by conductors 116 and 118, respectively. They are also connected to the anode-cathode circuit, being connected to the negative pole of a source of D. C. voltage, such as a battery 120 for example, by conductor 123, the cathode 4 being connected to the negative pole of said battery by conductors 26, 28 and 123. The positive pole of said battery is connected to the anode 6 by conductor 124 through a current-limiting resistance 126.

As stated above where the anode-cathode voltage exceeds 135 volts, the above described embodiment is preferable to that disclosed in Fig. 4, as the continuous small discharge between the anode and auxiliary electrode 10 that may be present in said embodiment of Fig. 4 is prevented by said condensers 112 and 114. The system disclosed in Fig. 5 is designed to operate at a higher voltage such as 135 to 180 volts. As pointed out above where such a higher voltage is used, the tube may contain neon gas at a pressure of approximately 4 cm. mercury.

The invention has been described by way of illustration in its application to electrical signalling systems for visible signalling. It should be understood, however, that the invention is in nowise limited to such particular application, certain of its features being equally applicable to other electrical systems.

The present invention is a distinct advance in the art. It has materially lowered the potential from the signal circuit required for ignition,

Certificate of Correction

Patent No. 2,473,832. June 21, 1949.

PAUL W. STUTSMAN

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 8, line 44, claim 7, for the words "which is" read *which it*;

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of November, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.