Oct. 31, 1933. F. W. SCHRAMM 1,932,606

GAS FILLED DISCHARGE TUBE CONTROL SYSTEM

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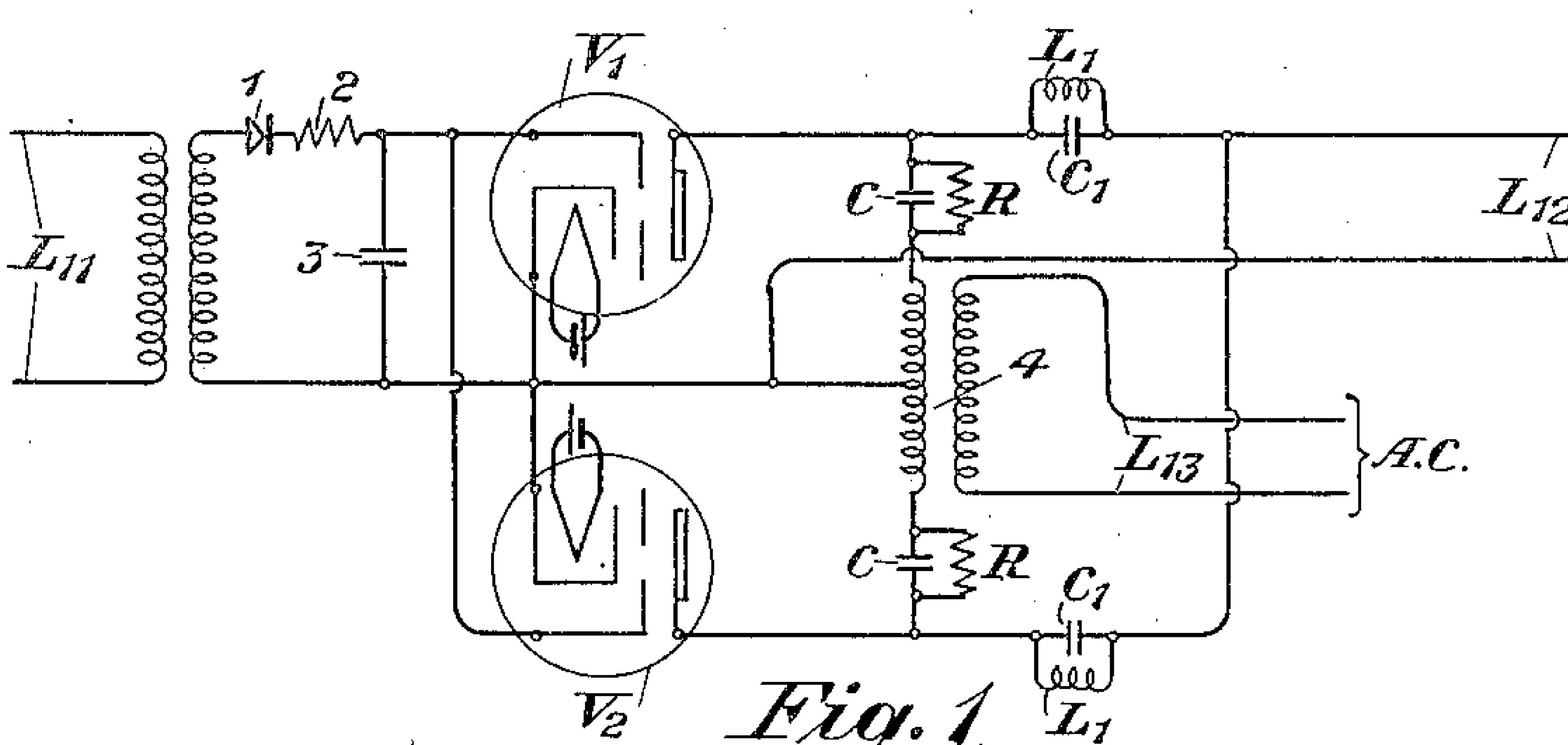

Fig. 1

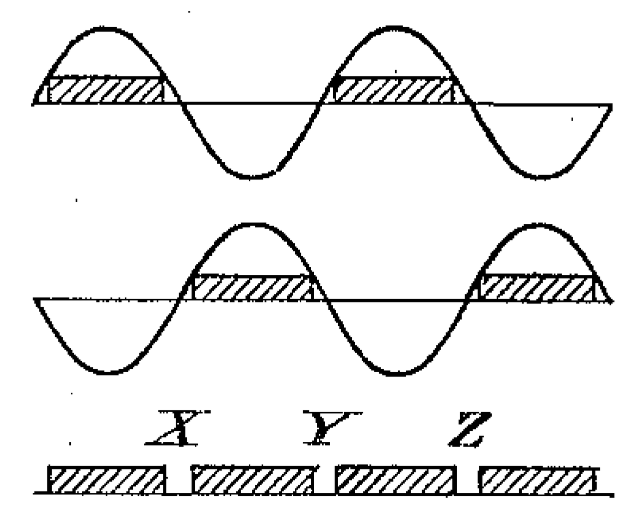

Fig. 2

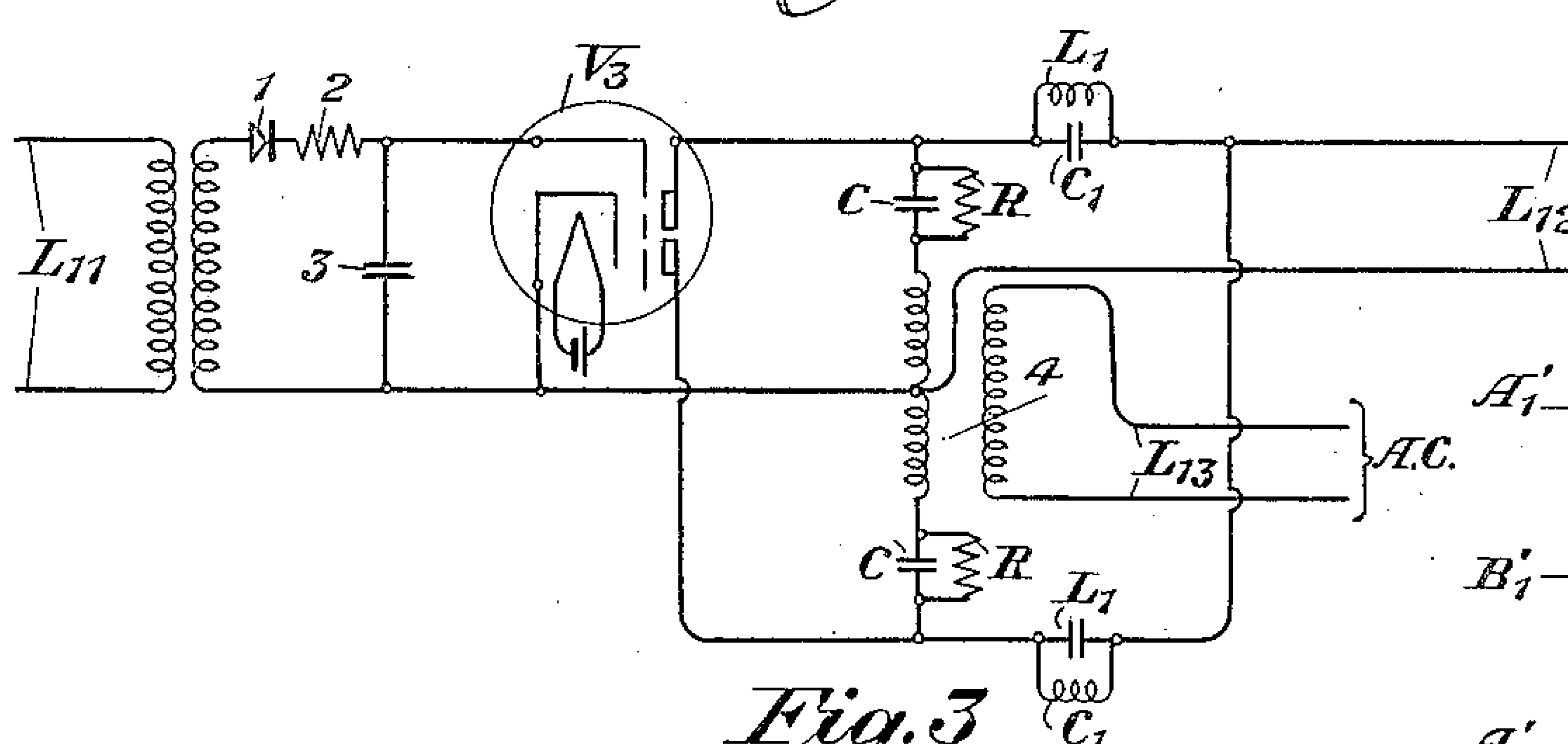

Fig. 3

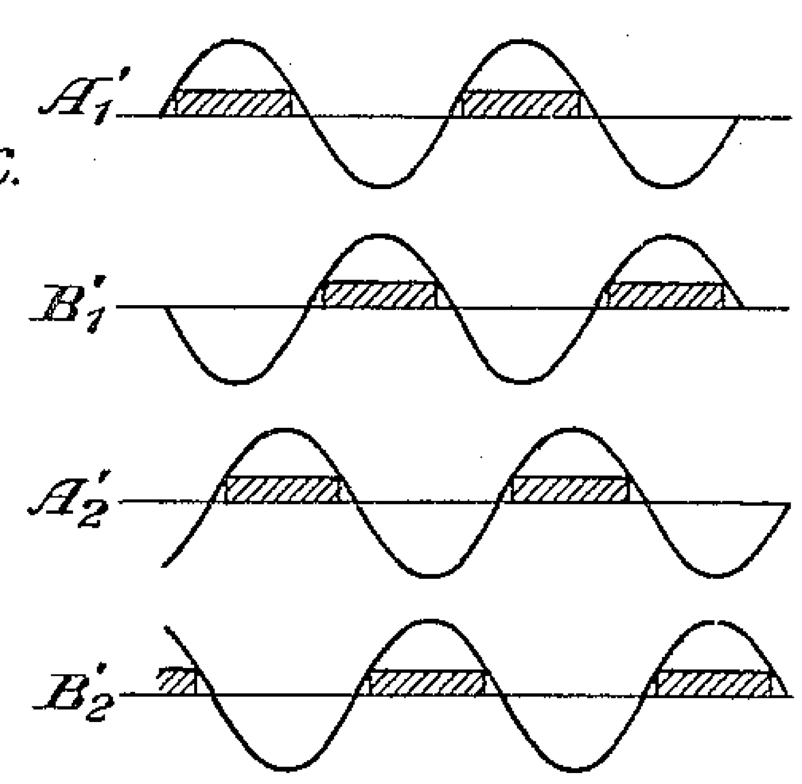

Fig. 5

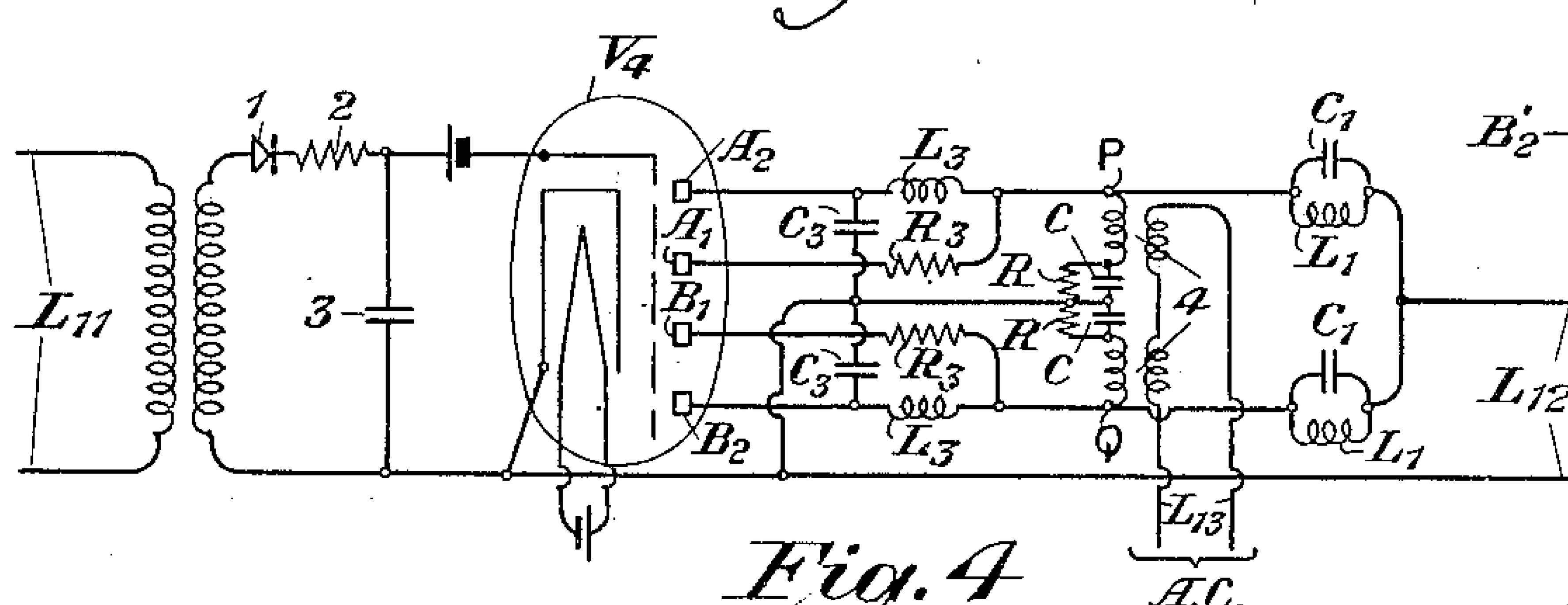

Fig. 4

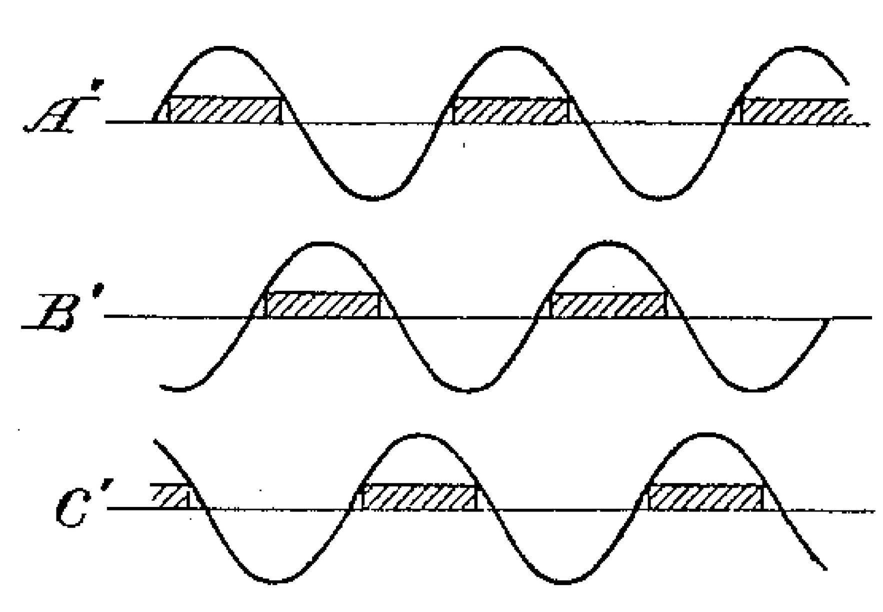

Fig. 7

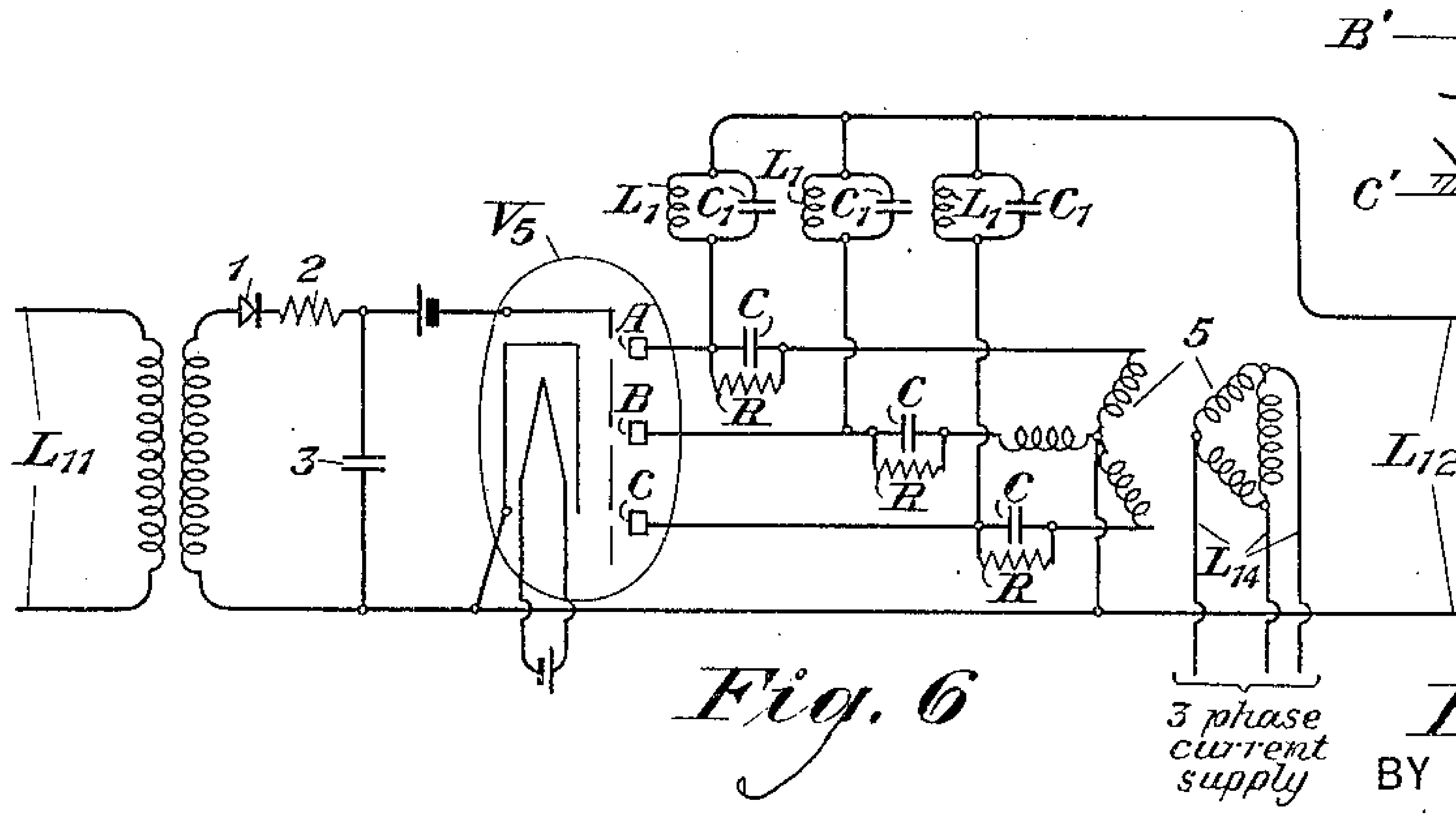

Fig. 6

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GAS FILLED DISCHARGE TUBE CONTROL SYSTEM

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10 Claims. (Cl. 175—320)

This invention relates to electrical circuits and more particularly to improved means whereby the current in one circuit may be utilized to control the impedance in another circuit connected to the first circuit by a gas filled tube, such for example, as a discharge tube filled with a gas such as neon.

Gas filled discharge tubes have the characteristic that the resistance between the cathode and anode elements may be changed from a high value to a comparatively low value when the gas is ionized and an arc is established therein by current applied thereto. Accordingly, a circuit completed over the cathode and anode elements of such a gas filled tube might have its impedance controlled by current applied to the tube over another circuit. Under such conditions the gas filled tube will perform many of the functions of an electromagnetic relay, such as effectively opening and closing the circuit to be controlled.

The arrangements of the invention are particularly applicable to systems of the above type in which alternating current is used to supply the voltage for the cathode-anode circuit of the gas filled tube and has for its primary object the provision of means for rendering the operation of the tube less intermittent and more steady in character than heretofore.

In systems utilizing gas filled discharge tubes to perform the functions of a switch or as a circuit controlling element the resistance of the path between cathode and anode is comparatively high when an arc is not established between said elements and drops to a few ohms during arcing periods. When direct current is used for the anode supply, this path remains at the low value during the whole time that the arc is established. However, when alternating current is used for the anode supply, as for example, to provide a self-quenching arrangement or for other reasons, the arc begins only when the anode is positive and the potential is somewhat higher than the arc-drop of the gas employed (in the neighborhood of 20 volts for the gases ordinarily used). The arc is quenched when the voltage again drops below this value and remains quenched during the entire negative half-cycle of the supply current. As a consequence, the average value of resistance of the cathode-anode path over a complete cycle of anode voltage is considerably higher than the value obtained when direct current anode supply is used. If the circuit to be controlled through the arc path is a direct current circuit, a condenser or filter must usually be provided to maintain the current flow during the quenched periods or, in other words, to prevent modulation at the supply frequency in the controlled circuit. The arrangements of the invention provide means whereby an alternating current anode supply may be used and the average value of resistance of the cathode-anode path over a complete cycle of anode voltage will be substantially as low as when direct current anode supply is used. The arrangements of the invention accomplish their objective by shortening or eliminating the quenched periods of the arc when alternating current anode supply is used. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

The invention may be more fully understood from the following description together with the accompanying drawing in the Figures 1 to 7 of which the invention is illustrated.

Fig. 1 is a circuit diagram embodying the invention. In Fig. 2 are shown curves illustrating principles of operation of the invention as shown in Fig. 1. Fig. 3 shows a modification of Fig. 1. Fig. 4 is a circuit diagram embodying a modification of the invention. In Fig. 5 are shown curves illustrating principles of operation of the invention as shown in Fig. 4. Fig. 6 is a circuit diagram embodying a further modification of the invention. In Fig. 7 are shown curves illustrating principles of operation of the invention as shown in Fig. 6. Similar reference characters have been utilized to denote like parts in all of the figures.

In Fig. 1 is shown a circuit L_{11} connected to the grids of the gas filled discharge tubes V_1 and V_2. The gaseous content of these tubes may, for example, be neon or some similar gas. These tubes have the characteristic that the gas will ionize and current will flow from anode to cathode at a certain grid voltage, and when in this condition will have a very low resistance between cathode and anode instead of a very high resistance, as when unoperated. A circuit L_{12} is shown connected to the anodes and cathodes of the tubes. The impedance of circuit L_{12} may be controlled by the operation of the tubes by the current applied over line L_{11}. The grids of the tubes V_1 and V_2 are connected in parallel in circuit L_{11} and the anodes thereof are connected in parallel in the circuit L_{12}. Alternating current is utilized to supply the potential for the anodes by means of the circuit L_{13} and the transformer 4. It will be noted that by means of the arrangement of the secondary windings of transformer 4 a push-pull connection is provided for the alternating current anode supply. In other words, during one half-cycle of the current a positive potential will be applied to the anode of one of the tubes and during the other half-cycle a positive potential will be applied to the anode of the other of the tubes. In such an arrangement an arc is established in one of the tubes for each half-cycle of the alternating current supply. The arc in each tube during the positive half-cycle will exist for all of the positive half-cycle except for the short periods at the beginning and end of the half-cycle when the potential (depending on the gas employed) is less than that required to maintain the arc. The above described operation is indicated in greater detail in Fig. 2. In the two upper portions of Fig. 2 the curves show the potentials applied to the anodes of tubes V_1 and V_2. These potentials would be 180° out of phase. The shaded areas indicate the periods during which arcs are established in each of the tubes. As indicated by the shaded areas in the lower portion of Fig. 2, a path will be closed by the tubes V_1 and V_2 for circuit L_{12}, except during the very short intervals X, Y and Z. With such an arrangement the cathode-anode resistance in series with circuit L_{12} would very closely approach the value which could be obtained by using direct current anode supply.

The control circuit connected to the grids of the tubes V_1 and V_2 is shown in Fig. 1 as including a transformer and a rectifying unit comprising the rectifier 1, resistance 2, and condenser 3, to apply a direct current potential to the grids. However, alternating grid potentials may be used if a frequency sufficiently higher than the anode supply is used to prevent "beats." With a control frequency at or near the anode supply frequency, complete quenching will be obtained if the grid is negative at the time the anode is positive and vice versa. The networks comprising condensers C_1 and inductances L_1 are provided as shown and are anti-resonant circuits at the anode supply frequency. This prevents short circuiting the transformer 4 while permitting the two anodes to be connected together for the external circuits. The networks comprising L_1 and C_1 would accordingly prevent alternating currents of the anode supply frequency from flowing in circuit L_{12} but would permit direct currents to flow therein. The networks comprising condensers C and resistances R are provided as shown. Resistances R are chosen to be high enough to effectively open the external circuit through the transformer center tap to the cathode. Condensers C provide a low impedance path around resistances R for the alternating current anode supply. Since the condensers C receive a charging current during the arcing interval, the resistances R also aid in dissipating the charges thereon during the quenched interval.

In Fig. 3 is shown a single tube V_3 having but a single grid and cathode but with two anodes. This tube would provide the same features as the two tubes of Fig. 1 and the circuit arrangements in other respects are substantially similar.

In order to provide a constant arc-path over the whole alternating supply current cycle the arrangement shown in Fig. 4 might be used. In this arrangement a single gas filled discharged tube V_4 would be provided having four anodes A_1, A_2, B_1 and B_2. Current from the alternating source would be transmitted over circuit L_{13} to the winding of transformer 4. Due to the arrangement of the secondary windings of the transformer with respect to the anodes during each half-cycle of the current the potentials applied at points such as P and Q would be 180° out of phase. This would cause the voltages on anodes A_1 and B_1 to be 180° out of phase. In Fig. 5 the curves A'_1 and B'_1 show the voltages on the anodes A_1 and B_1. The shaded areas indicate the periods during which an arc would exist in the respective anode circuits. If only anodes A_1 and B_1 were provided, the effect would be substantially the same as in the arrangements of Figs. 1 and 3 and a series of small gaps would exist in the arc. For this reason the additional anodes A_2 and B_2 are provided. The voltages on these anodes would for each half-cycle of the supply current be 180° out of phase. However, the potentials applied to the auxiliary anodes A_2 and B_2 will, by virtue of the phase displacement provided by L_3 and C_3, lag in phase behind the potentials applied to anodes A_1 and B_1, respectively, so that the arcs established through the circuits of anodes A_2 and B_2 will be maintained for a sufficient period after the extinguishment of the arcs through the circuits of anodes A_1 and B_1 to prevent the existence of any gaps in the arc, such as shown in Fig. 2. Curves A'_2 and B'_2 of Fig. 5 illustrate the above principles of operation of anode circuits A_2 and B_2. An examination of the shaded areas of all the curves of Fig. 5 will show that no gaps will exist between arcs in the various anode circuits and that a constant arc-path for circuit L_{12} will be provided. The anodes A_1, A_2, B_1 and B_2 are all connected in parallel with each other in circuit L_{12}. The networks comprising inductances L_1 and condensers C_1 and the networks comprising resistances R and condensers C are provided, as in the previous figures, to separate the alternating and direct current paths and to prevent the short circuiting of transformer 4. As heretofore pointed out the inductances L_3 and condensers C_3 each form a circuit which provides a voltage drop across C_3 lagging behind the voltage applied to anode A_1 or anode B_1. Resistances R_3 are provided to simulate the resistances of L_3 so that the resistance in the external circuit is the same through any arc-path.

In Fig. 6 is shown a further modification of the arrangements of the invention. In this arrangement a single gas filled discharge tube V_5 is provided with three anodes A, B and C. A source of alternating current is connected to circuit L_{14} and transformer 5 which will supply three-phase current to the anodes. The curves and shaded areas of Fig. 7 show the resulting overlapping of the arcing intervals in such an arrangement. The networks L_1 and C_1 and RC are provided as shown for the same purposes as in the other figures. By increasing the number of anode circuits of tube V_5 other polyphase currents might be used for the anode supply, if desired.

In the arrangements of the invention the gas filled discharge tubes may either be hot-cathode tubes, cold-cathode tubes, or tubes employing auxiliary elements, such as "collectors," in their operation. Accordingly, while the invention has been disclosed as embodied in certain specific forms which are deemed desirable, it is understood that it is capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having two anodes connected in said controlled circuit, an alternating current source connected to said anodes so that when a positive potential is applied to one anode a negative potential will be applied to the other anode, and vice versa, and means in said controlling circuit for applying a direct current voltage to the grid of said tube.

2. A controlling circuit, a circuit controlled thereby, gas filled discharge tubes interconnecting said circuits, the anodes of said tubes being connected in parallel in said controlled circuit, an alternating current source so connected to said anodes that when the applied grid voltages in said tubes are identical and of a certain polarity an arc will be established in one of said tubes for every half-cycle of current applied from said source, and means in said controlling circuit for applying identical voltages of a certain polarity to the grids of said tubes.

3. A controlling circuit, a circuit controlled thereby, gas filled discharge tubes interconnecting said circuits, the anodes of said tubes being connected in parallel in said controlled circuit, an alternating current source for supplying voltages for said anodes, said source being connected in push-pull relationship to said anodes whereby when the applied grid voltages in said tubes are identical and of a certain polarity said tubes will discharge alternately, one tube discharging for each half-cycle of current from said source, and means in said controlling circuit for applying identical voltages of a certain polarity to the grids of said tubes.

4. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a plurality of anodes connected in said controlled circuit, an alternating current source so connected to said anodes that voltages 180° out of phase with each other will be simultaneously applied to said anodes, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

5. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a plurality of anodes connected in said controlled circuit, means for simultaneously applying to said anodes voltages having opposing phase relationships, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

6. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a plurality of sets of anodes connected in said controlled circuit, means for simultaneously applying to the anodes of one of said sets equal voltages opposite in phase with respect to each other, means for simultaneously applying to the anodes of another of said sets equal voltages opposite in phase with respect to each other but lagging behind in phase relationship with respect to said first mentioned voltages, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

7. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having three anodes connected in said controlled circuit, a source of polyphase current for simultaneously supplying voltages to said anodes, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

8. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a plurality of anodes connected in parallel in said controlled circuit, an alternating current source for supplying voltages for said anodes, a transformer for connecting said source in push-pull relationship to said anodes whereby voltages opposite in phase will simultaneously be applied to said anodes, networks associated with the anode circuits of said tube for preventing direct currents from said controlled line from being transmitted through said transformer circuit and for preventing alternating currents from said source from being transmitted out over said controlled line, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

9. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a cathode and a plurality of anodes connected in said controlled circuit, an alternating current source, means for so associating said source with said anodes that at any instant at least one of said anodes is always at a positive potential with respect to said cathode, and means in said controlling circuit for applying to the grid of said tube a direct current voltage of a certain polarity.

10. A controlling circuit, a circuit controlled thereby, a gas filled discharge tube interconnecting said circuits, said tube having a grid and a cathode and a plurality of anodes connected in said controlled circuit, an alternating current source, and means for so applying said source to said controlled circuit that for a certain condition of grid voltage a continuous arc-path will be established in said tube and for another condition of grid voltage the arc-path in said tube will be extinguished.

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