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PARALLEL OPERATED GAS FILLED TUBE

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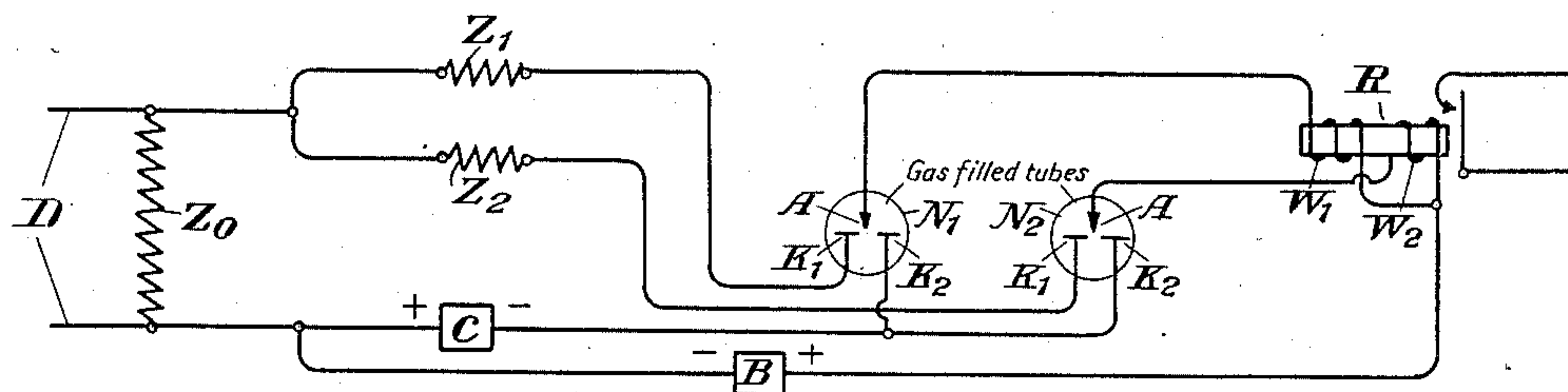


Fig. 1

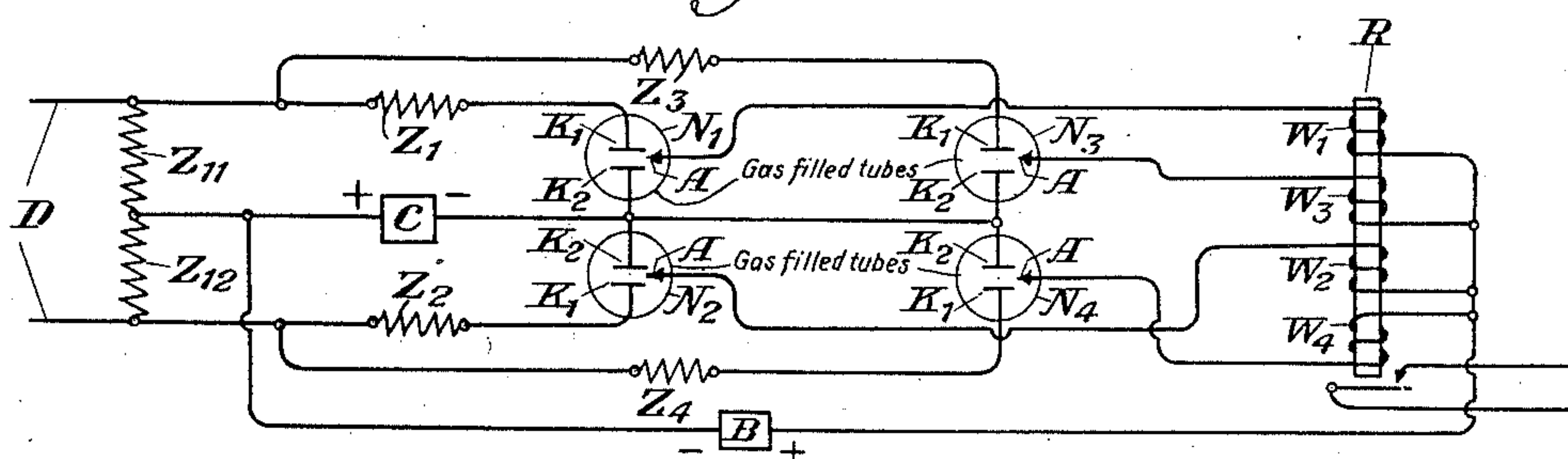


Fig. 2

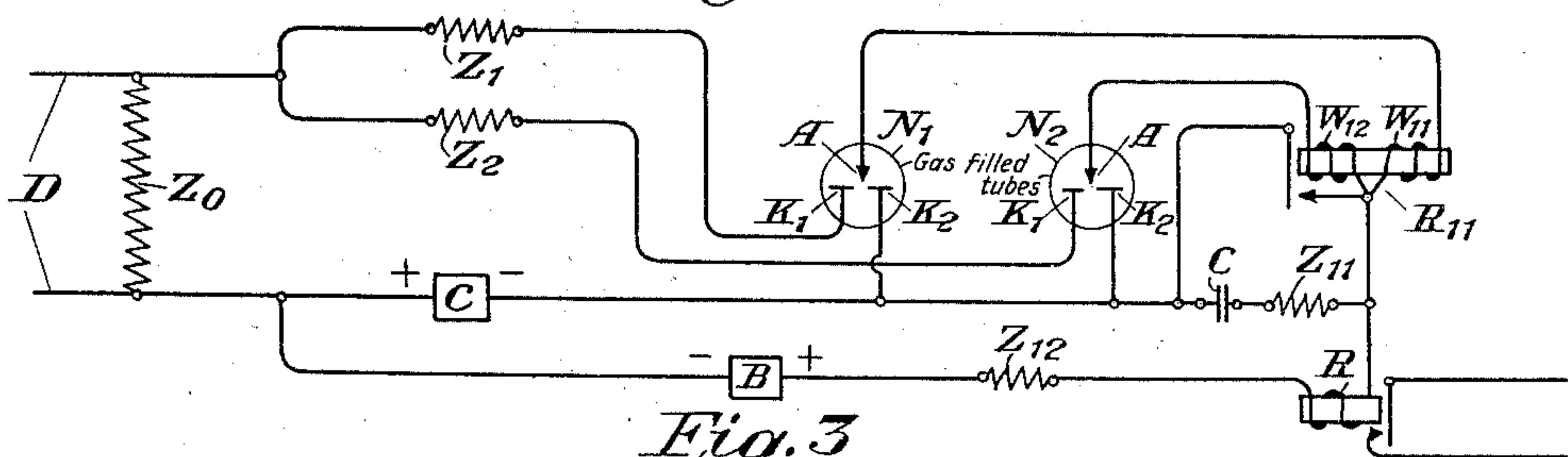


Fig. 3

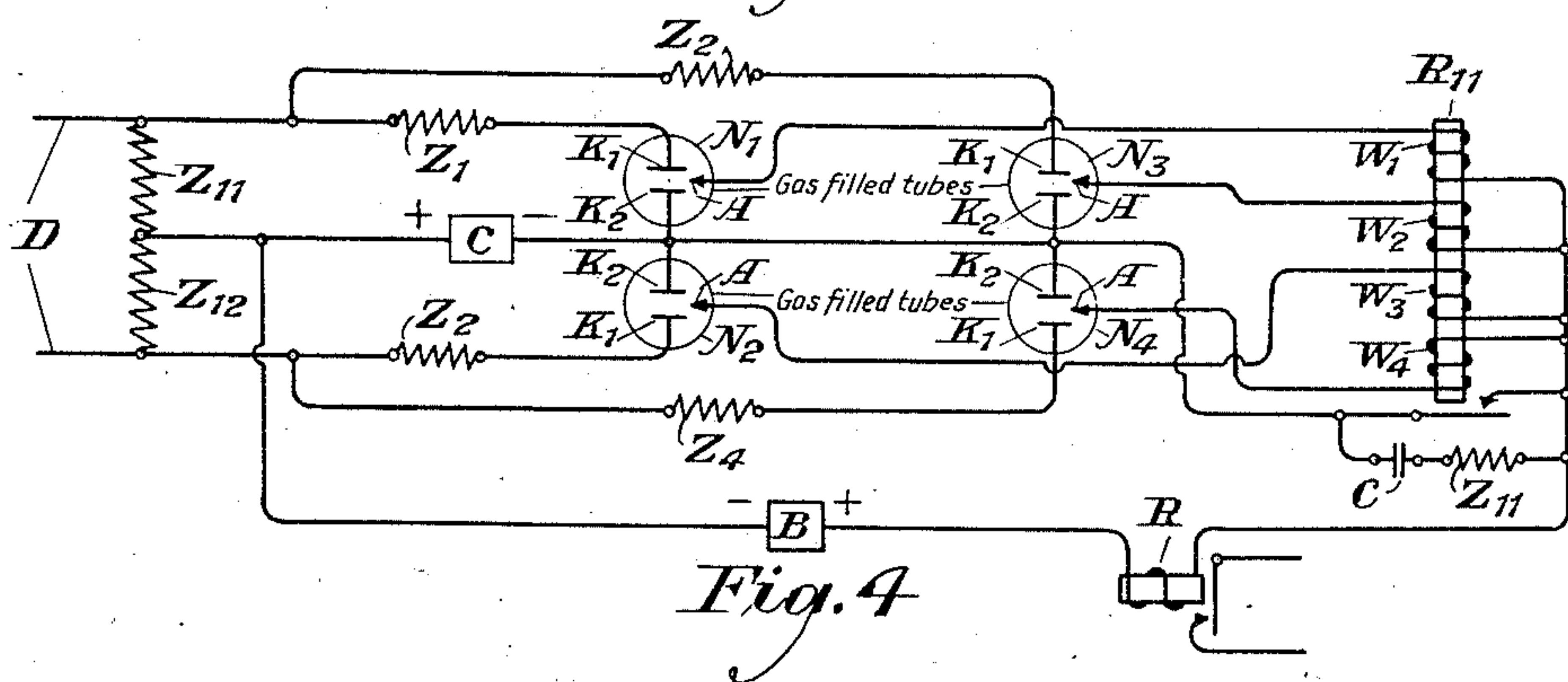


Fig. 4

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PARALLEL OPERATED GAS FILLED TUBE

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8 Claims. (Cl. 250—27)

This invention relates to electrical circuits and systems. More particularly, this invention relates to electrical circuits and systems employing gas filled tubes. Still more particularly, this invention relates to electrical circuits and systems employing gas filled tubes operated in parallel relationship.

It is well known that a tube having two spaced electrodes which are enclosed within an envelope filled with a gaseous medium such as neon, argon, helium or krypton gas or a combination of these gases or a combination of these gases and mercury vapor or hydrogen gas or the like will exhibit special characteristics when the voltage impressed across the electrodes exceeds a predetermined value. When this predetermined value of voltage is exceeded, the gas within the tube will become ionized and a discharge will occur between the electrodes of the tube. This will result in a substantial drop in impedance within the tube, the impedance before ionization being extremely high and almost infinite and after ionization very low and almost negligible. It is also well known that after discharge occurs between the electrodes of such a tube, the voltage required to sustain the discharge between the electrodes will be of substantially lower value.

The voltage characteristics of two such tubes, although intended to be precisely the same, will differ slightly due primarily to minute variations in their dimensions. It will be found that the discharge gaps of these tubes will be broken down at slightly different voltages. When the voltage in a line to which two such tubes are connected in parallel relationship exceeds that required to break down the gap of one of these tubes, for instance, the tube of slightly lower breakdown voltage, the impedance across the latter tube will become greatly reduced. If the voltage in the line tends to rise above that required to breakdown the gap of the second tube, the tube which has broken down will receive practically all of the current transmitted by the line and this tube will prevent the discharge gap of the second tube from being broken down. It follows, therefore, that when two or more of such tubes are connected in parallel relationship, immediately after the gap of one of the tubes has become broken down, it will be practically impossible to break down the gap of any of the other of the tubes without damage to the first mentioned tube.

One of the objects of this invention is to provide an arrangement for interconnecting two or more gas filled tubes in parallel relationship so that

the discharge gaps of all of these tubes may be simultaneously broken down.

Another of the objects of this invention is to provide an arrangement including a plurality of impedances which may be connected in series with a plurality of gas filled tubes, one impedance being connected in series with each tube, so that all of these tubes may become simultaneously discharged.

Another object of this invention is to connect a plurality of gas filled tubes in parallel relationship and simultaneously discharge the gaps of all of said tubes so that each will carry a predetermined portion of the total load intended to be carried by said tubes.

This invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing in which Figure 1 shows one arrangement for carrying out the principles of this invention; Fig. 2 shows another arrangement which is intended to be operated from both halves of each impressed alternating cycle; and Figs. 3 and 4 are modifications of Figs. 1 and 2, respectively, these modifications including apparatus for resetting all of the tubes to their normal conditions immediately after they have become operated.

Referring to Fig. 1 of the drawing, the reference character D designates a circuit transmitting voltages which may vary over a wide range of values. The circuit D is connected to an impedance Z_0 and the voltage across this impedance will correspond to that impressed thereon by the circuit D.

The reference characters N_1 and N_2 represent two gas filled tubes each of which includes two cathodes designated K_1 and K_2 and an anode designated A. Each of these tubes is filled with a gaseous medium of the composition described hereinabove.

The cathode K_1 of the tube N_1 is connected to the upper terminal of the impedance Z_0 through an impedance Z_1 . The cathode K_1 of the tube N_2 is connected to the upper terminal of the impedance Z_0 through an impedance Z_2 . The impedances Z_1 and Z_2 are preferably substantially equal and, moreover, their magnitudes are very large when compared to the impedances between the cathodes K_1 and K_2 of either of the tubes N_1 or N_2 .

An operating relay designated R includes two windings W_1 and W_2 , the upper terminal of winding W_1 being connected to the anode A of the tube N_1 and the upper terminal of the winding W_2 being connected to the anode A of the tube N_2 .

The lower terminals of the windings W_1 and W_2 are connected to each other and the conductor common to them is connected to the lower terminal of the impedance Z_0 through a source of potential designated B which is preferably a source of direct current potential but which may, if desired, be one of alternating potential, as will be described hereinafter.

The cathode K_2 of the tube N_1 and the cathode K_2 of the tube N_2 are connected to each other and the conductor common thereto is connected to the lower terminal of the impedance Z_0 through a source of potential designated C. This source C may be either a direct current potential or an alternating current potential and it is employed primarily for biasing the cathodes K_1 of both tubes N_1 and N_2 to a predetermined potential with respect to the cathodes K_2 of these tubes.

When a voltage is impressed by the circuit D upon the impedance Z_0 , that voltage will also be impressed through the impedance Z_1 between the cathodes K_1 and K_2 of the tube N_1 . The same voltage will also be impressed through the impedance Z_2 between the cathodes K_1 and K_2 of the tube N_2 . If the voltage impressed between the cathodes K_1 and K_2 of the tube N_1 is sufficient not only to ionize the gas within that tube but also to break down the gap between these electrodes, then this same voltage will generally be sufficient to ionize the gas within the tube N_2 and break down the gap between the cathodes K_1 and K_2 of the latter tube. Inasmuch as both tubes have substantially the same breakdown voltages between their cathodes K_1 and K_2 , and because the impedances Z_1 and Z_2 in series with the cathodes K_1 and K_2 of the tubes N_1 and N_2 , respectively, have magnitudes substantially higher than the impedances between these cathodes, the gaps between these cathodes will be discharged virtually simultaneously. The impedance between the cathodes K_1 and K_2 of the tube N_1 will represent a small portion of the total impedance in the circuit in series with these cathodes and the impedance between the similar cathodes K_1 and K_2 of the tube N_2 will represent a correspondingly small portion of the total impedance in the circuit in series with the latter cathodes. By virtue of this condition, it will almost invariably happen that the discharge gaps of both tubes will be simultaneously broken down if only the voltage impressed between the cathodes of these tubes is sufficient to ionize the gas within the tube having the higher breakdown voltage.

It will be noted that the winding W_1 of the relay R is in a circuit in series with the anode A and the cathode K_2 of the tube N_1 and that the winding W_2 of the relay R is in a circuit in series with the anode A and the cathode K_2 of the tube N_2 , both circuits being in parallel relationship, the elements in common with both parallel circuits including the sources B and C, as shown. Inasmuch as both tubes N_1 and N_2 have substantially the same characteristics, there will be substantially equal discharges between the cathode K_1 and the anode A of both tubes N_1 and N_2 after the gaps between cathodes K_1 and K_2 of both tubes have been broken down. Inasmuch as the tubes N_1 and N_2 are of similar construction, substantially equal currents will flow from the source B through the windings W_1 and W_2 of the relay R. Hence these windings will produce substantially equal effects in attracting the armature of the relay which is employed for closing a circuit controlled by this armature.

One of the features of this invention lies in the

employment of a winding or an impedance in series with the anode of each of the tubes N_1 and N_2 . By including substantially high impedances in the windings W_1 and W_2 , i. e., impedances which are much greater than the impedances between the anode A and cathode K_2 of the corresponding tube, substantially equal currents will be transmitted through the circuits formed by the anode A and the cathode K_2 of these tubes. In other words, the anode or output circuits of both tubes will carry substantially equal portions of the total current flowing from source B through the two windings of the relay R.

Fig. 2 shows an arrangement for operating with considerable efficiency during both halves of each cycle of alternating potential transmitted by the circuit D. Fig. 2 includes four gas filled tubes N_1 , N_2 , N_3 and N_4 , two of which are caused to operate from the one-half cycle of an applied alternating current cycle and the other two of which will be caused to operate from the other half of the alternating current cycle.

The source D is connected in series with impedances Z_{11} and Z_{12} . The impedance Z_{11} is connected to the cathodes K_1 and K_2 of the tube N_1 through the impedance Z_1 and the source of potential C. The impedance Z_{12} is connected to the cathodes K_1 and K_2 of the tube N_2 through the impedance Z_2 and the source of potential C. The impedance Z_{11} is connected to the cathodes K_1 and K_2 of the tube N_3 through the impedance Z_3 and the source of potential C. The impedance Z_{12} is connected to the cathodes K_1 and K_2 of the tube N_4 through the impedance Z_4 and the source of potential C. It will be evident that the source of potential C is employed to bias one of the cathodes of each of the tubes N_1 , N_2 , N_3 and N_4 to a predetermined potential with respect to the other cathode of each of these tubes. It will also be evident that the impedances Z_1 , Z_2 , Z_3 and Z_4 are connected in series with the two cathodes of each corresponding tube so that the gaps between the cathodes of all of the tubes will be practically simultaneously broken down immediately after the circuit D transmits a sufficiently high direct or alternating voltage.

The relay R includes four windings W_1 , W_2 , W_3 and W_4 and one terminal of each of these windings is connected to the anode A of the corresponding tube N_1 , N_2 , N_3 or N_4 , as shown. The other terminals of these windings are connected to each other and their common conductor is connected through the source of potential B to the terminal common to the impedances Z_{11} and Z_{12} .

During the first half of each alternating current cycle, a voltage will be impressed across the impedances Z_{11} and Z_{12} which will be in only one direction and this voltage, if large enough, will break down the gaps between the cathodes K_1 and K_2 of two of the tubes which will at that time be operated in parallel relationship. Thus, during the first half of each alternating current cycle the voltage impressed across the impedance Z_{12} may, for instance, be poled so as to cause the gaps between the cathodes K_1 and K_2 of the tubes N_1 and N_3 to be simultaneously broken down. During the succeeding half of each alternating current cycle, the voltage impressed across the impedance Z_{12} will be so poled as to cause the discharge gaps between the cathodes K_1 and K_2 of the tubes N_2 and N_4 , which are also operated in parallel relationship, to become simultaneously broken down.

For one half of an applied alternating current

cycle, the windings W_1 and W_3 will be supplied with current from the source B and the conjoint effect of these windings will cause the armature of relay R to become attracted so as to close the circuit connected thereto. For the other half of the alternating current cycle, the windings W_2 and W_4 of the relay R will be supplied with current from the source B and the conjoint magnetic effects of these windings will add to that produced in windings W_1 and W_3 . It follows therefore that the armature of the relay R will be caused to operate from the first half of an applied alternating current cycle impressed upon the circuit D, provided the voltage of the alternating current is sufficient to bring about a breakdown of the gaps of any of the various tubes.

Fig. 3 shows an arrangement for returning the gas filled tubes to their original condition after their gaps have been broken down by the transmission of a voltage exceeding a predetermined value. Without some form of arrangement for resetting the gas filled tubes to their initial condition in which the gaps are free to become again discharged when impressed with further voltages exceeding the predetermined value, it will be impossible to continuously discriminate between the application of voltage or the absence of voltage applied to the input circuit.

Fig. 3 shows an arrangement somewhat similar to the one shown in Fig. 1. Fig. 3 includes, however, a vibrating relay, the armature of which is capable of vibrating at an extremely high speed and it also includes a circuit for resetting the gas filled tubes to their initial condition immediately after their gaps have become discharged by applied voltage.

The vibrating relay is designated R_{11} and it has two windings W_{11} and W_{12} . The winding W_{11} is connected between the anode A of the gas filled tube N_1 and the cathode K_2 of the tube N_1 through a circuit which includes impedance Z_{11} , which may be a resistance of low magnitude, and a condenser C which is of large capacity. The other winding W_{12} of the vibrating relay R_{11} is connected between the anode A of the tube N_2 and the cathode K_2 of that tube through the same circuit of impedance Z_{11} and condenser C. The sources B and C are preferably direct current sources, such as storage batteries, and they are connected in series relationship so that their voltage effects are additive, the series circuit including an impedance Z_{12} , the winding of an operating relay R, the impedance Z_{11} and the condenser C. It will be noted that the armature and contact of the vibratory relay R_{11} are bridged across the series elements of impedance Z_{11} and capacity C.

It will be apparent that when the circuit D transmits a voltage above a predetermined value, the gas within the tubes N_1 and N_2 will become ionized, the gaps between the cathodes K_1 and K_2 of these tubes will become broken down and current will flow simultaneously between the anodes A and the cathodes K_2 of both tubes N_1 and N_2 . The current emanating from sources B and C will flow through impedance Z_{12} , the operating winding of the relay R and it will divide substantially equally between the windings W_{11} and W_{12} , respectively. The flow of current through the circuit just described will attract the armature of the operating relay R, closing the circuit controlled by this armature.

After the vibrating relay R_{11} has become operated, as will be the case immediately after a high voltage has become impressed upon the line D,

the armature of the vibrating relay will close a circuit which will completely shunt out the current flowing through the windings W_{11} and W_{12} of the vibrating relay and between the anodes A and cathodes K_2 of the tubes N_1 and N_2 , respectively. This will cause a substantial increase in the flow of current through the winding of the operating relay R, current then flowing from batteries C and B through the impedance Z_{12} , the operating winding of the relay R and the armature and contact of the vibrating relay R_{11} . At the same time, any charge upon the condenser C will tend to become dissipated through the impedance Z_{11} . Furthermore, the flow of current through the armature and contact of the vibrating relay R_{11} will reduce the current tending to flow through the windings W_{11} and W_{12} and between the anodes A and the cathodes K_2 of the tubes N_1 and N_2 , respectively, to a practically negligible value and thereby transform the gas within these tubes to its initial de-ionized condition, provided that the voltage transmitted by the circuit D remains insufficient to cause ionization between the cathodes K_1 and K_2 of these tubes. After the current through the parallel circuit just described has become reduced to a negligible value, the magneto-motive force of the windings of the vibrating relay R_{11} will be insufficient to hold the armature closed against its contact, and consequently, the circuit formed by this armature and its contact will become opened. Hence current may thereafter flow from batteries C and B through impedance Z_{12} , the operating winding of the relay R and through the parallel paths formed by the windings W_{11} and W_{12} of the vibrating relay R_{11} and the corresponding paths formed by the anodes A and cathodes K_2 of the tubes N_1 and N_2 , respectively, only if the voltage transmitted by the circuit D is sufficiently great to continue the ionization of the gas within the tubes N_1 and N_2 and break down the gaps between the cathodes of these tubes.

So it will be seen that as long as a sufficiently high voltage is transmitted by the circuit D, the gas within the tubes N_1 and N_2 will become ionized and remain ionized and the impedance of all of the gaps of both tubes will be reduced to a practically negligible value and it will be noted that the relay R_{11} , which is of the vibrating type, will cause the continuous opening and closing of the contact of that relay by its armature at a high speed. Moreover, the vibration of the armature of relay R_{11} will cease almost instantly after the voltage transmitted by the circuit D becomes reduced below that required to produce ionization within the tubes N_1 and N_2 .

Immediately upon the opening of the contact of the vibrating relay R_{11} , the winding of the operating relay R will produce a substantial voltage "kick" which may of itself produce ionization of the gas within tubes N_1 and N_2 , if this voltage is allowed to become transmitted through the winding W_{11} and W_{12} of the vibrating relay R_{11} . In order to reduce this possibility of de-ionization of these tubes in the absence of a sufficiently high voltage in the circuit D, the condenser C and impedance Z_{11} of small resistance are connected in series with the operating winding of the relay R, thereby causing the voltage produced by the very high inductance of the operating winding of the relay R to be shunted through the impedance Z_{11} and condenser C. In fact, the condenser C becomes charged by the inductive "kick" of the winding of the operating relay R. The armature of the operating relay R

will close its contact and the circuit controlled by the armature of this relay will remain closed as long as the armature of the vibrating relay R_{11} continues in vibration in response to sufficiently high voltages transmitted by the circuit D.

Fig. 4 shows an arrangement somewhat similar to the one shown in Fig. 2 but incorporating the reset circuit just described hereinabove in connection with Fig. 3. The vibrating relay includes four windings W_1 , W_2 , W_3 and W_4 which are connected in series with the anodes A of tubes N_1 , N_2 , N_3 and N_4 , respectively, the operating winding of the relay R, the battery B, the battery C, and the cathodes K_2 of the tubes N_1 , N_2 , N_3 and N_4 , respectively, as shown. It will be noted that the armature and contact of the vibrating relay R_{11} are connected in shunt across the circuit which includes the impedance Z_{11} and the condenser C. In this arrangement, the vibrating relay R_{11} will produce a continuous vibration of its armature as long as the voltage transmitted by the circuit D is sufficiently great to bring about the breaking of the gaps between cathodes K_1 and K_2 of the various tubes N_1 , N_2 , N_3 and N_4 . It will be further noted that the armature of the operating relay R will close its contact and that this contact will remain closed as long as the relay R_{11} continues to vibrate its armature. The circuit shown will bring about the de-ionization of each of the various tubes almost immediately after the voltage transmitted by the circuit D becomes insufficient to ionize the gas within any one of the various tubes and produce a discharge between its electrodes.

It will be understood that the tubes designated N_1 , N_2 , N_3 and N_4 may be either of the hot cathode gaseous type or cold cathode gaseous type, both of which are well known.

It will be further understood that the various tubes may have electrodes so spaced and their gaseous pressures so adjusted that current will not be divided equally between the output electrodes of these tubes; the currents transmitted through the output circuits of these tubes may, if desired, be divided therebetween in any other predetermined relationship, all of which is within the scope of this invention.

It will also be understood that the impedances designated Z_1 , Z_2 , Z_3 and Z_4 may be any type of impedance, that is, inductance or capacitance, and need not necessarily be simple resistance.

It will be further understood that the operating relay may be replaced by any form of translating device or circuit or, if desired, the relay may be employed to control any well-known translating device or circuit.

And it will be further understood that the source designated C may be of the direct current type, the alternating current type or of the interrupted direct current type. In the arrangements shown in Figs. 1 and 2, the source designated B may be of the alternating current type or of the interrupted direct current type.

While this invention has been shown and described in one particular embodiment merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of two gas filled tubes each having three electrodes, two impedances, each of said impedances being connected in series with two of the electrodes of one of the gas filled tubes,

means for impressing voltages through said impedances upon the two electrodes of both tubes which are in series with said impedances, and means interconnected between the third electrode of each tube and either of the other electrodes of each tube which responds to the ionization of the gas within both tubes.

2. The combination of two gas filled tubes each having three electrodes, means responsive to a voltage exceeding a predetermined value impressed upon two of the electrodes of both tubes to simultaneously ionize the gas within both tubes and substantially reduce the impedance between all of the gaps within both tubes, and means connected between the third electrodes of both tubes and one of the other electrodes of both tubes which becomes responsive to the change in the impedance of the gaps of both tubes.

3. The combination of a plurality of gas filled tubes each having an input circuit terminating in electrodes within each tube and forming a gap and an output circuit also terminating in electrodes within each tube and forming another gap, means for simultaneously breaking the gaps between the input circuit electrodes of all of said tubes, a relay having a plurality of windings each of which is connected to one of the output circuit electrodes of each of said tubes, the output circuit electrodes of all of said tubes being arranged in parallel relationship, and means for vibrating the armature of said relay continuously as long as the gaps terminating the input circuit electrodes of said tubes are broken down.

4. The combination of a plurality of gas filled tubes each having at least two gaps between its electrodes, means responsive to a voltage exceeding a predetermined value for simultaneously breaking one of the gaps of each of said tubes, and a translating circuit connected in common to one of the remaining gaps of each of said tubes, the latter gaps being arranged in parallel relationship.

5. The combination of a plurality of gas filled tubes each having electrodes forming a first gap and a second gap, the first gap of one of said tubes being connected in parallel relationship with the first gap of each of the other of said tubes, means responsive to a voltage exceeding a predetermined value for simultaneously breaking all of said first gaps, a relay having a plurality of windings each of which is connected in parallel relationship with the second gap of one of said tubes, and a circuit controlled by the armature of said relay.

6. The combination of a plurality of gas filled tubes each having a plurality of electrodes forming gaps, means responsive to a voltage exceeding a predetermined value for simultaneously breaking the gaps of all of said tubes, a relay having a fast vibrating armature, and means responsive to the breaking of the gaps of said tubes for vibrating the armature of said relay and for maintaining the armature in continuous vibration as long as said gaps are broken.

7. The combination of two gas filled tubes each having a plurality of electrodes forming gaps, means responsive to a voltage exceeding a predetermined value for simultaneously breaking the gaps of all of said tubes, a translating circuit, means interposed between the translating circuit and the various tubes for operating the translating circuit when the gaps of the tubes are broken down, and means for restoring the tubes to their initial condition after the voltage which

caused their breakdown has become reduced below a second predetermined value.

ting voltages through said impedances to the electrodes in series with said impedances and for simultaneously breaking down the gaps between said electrodes when the transmitted voltage exceeds a predetermined value, and a translating circuit connected in common with the third electrode and one of the other electrodes of each of said tubes.

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8. The combination of two gas filled tubes each having three electrodes, two impedances, each of said impedances being connected in series with two of the electrodes of one of said tubes, said impedances being large as compared with the impedance between the electrodes to which they are serially connected, means for transmit-

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