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GAS-FILLED TUBE CIRCUITS

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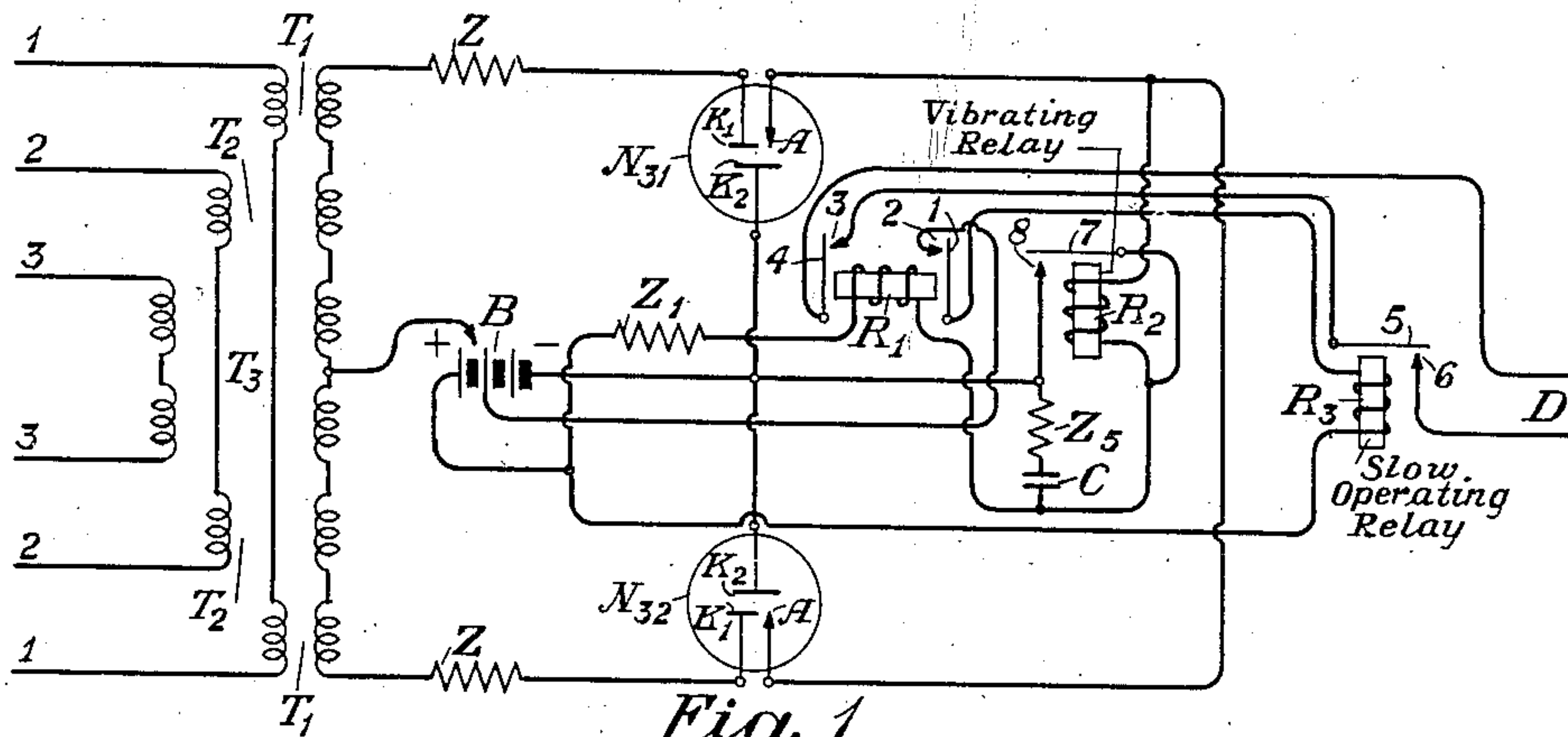


Fig. 1

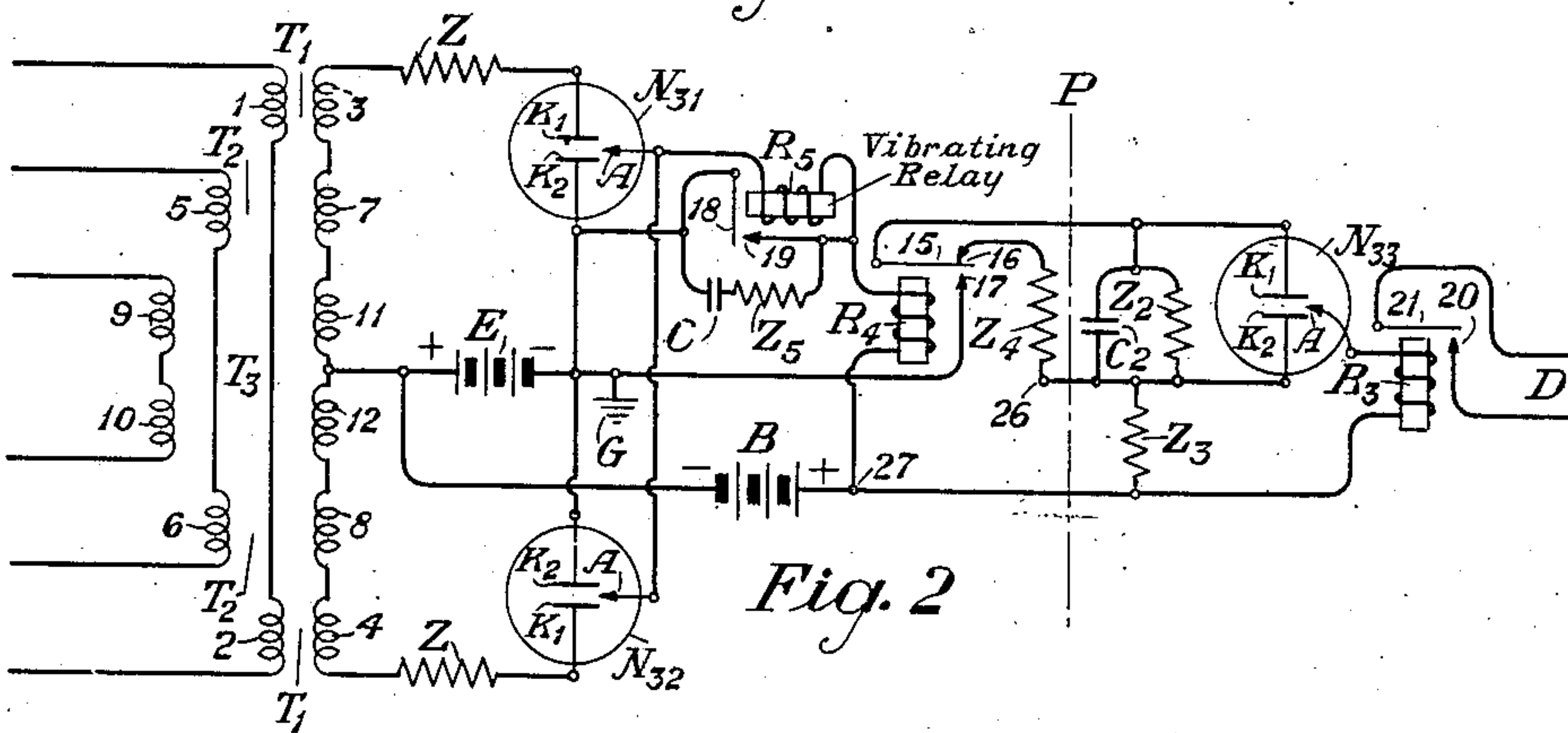
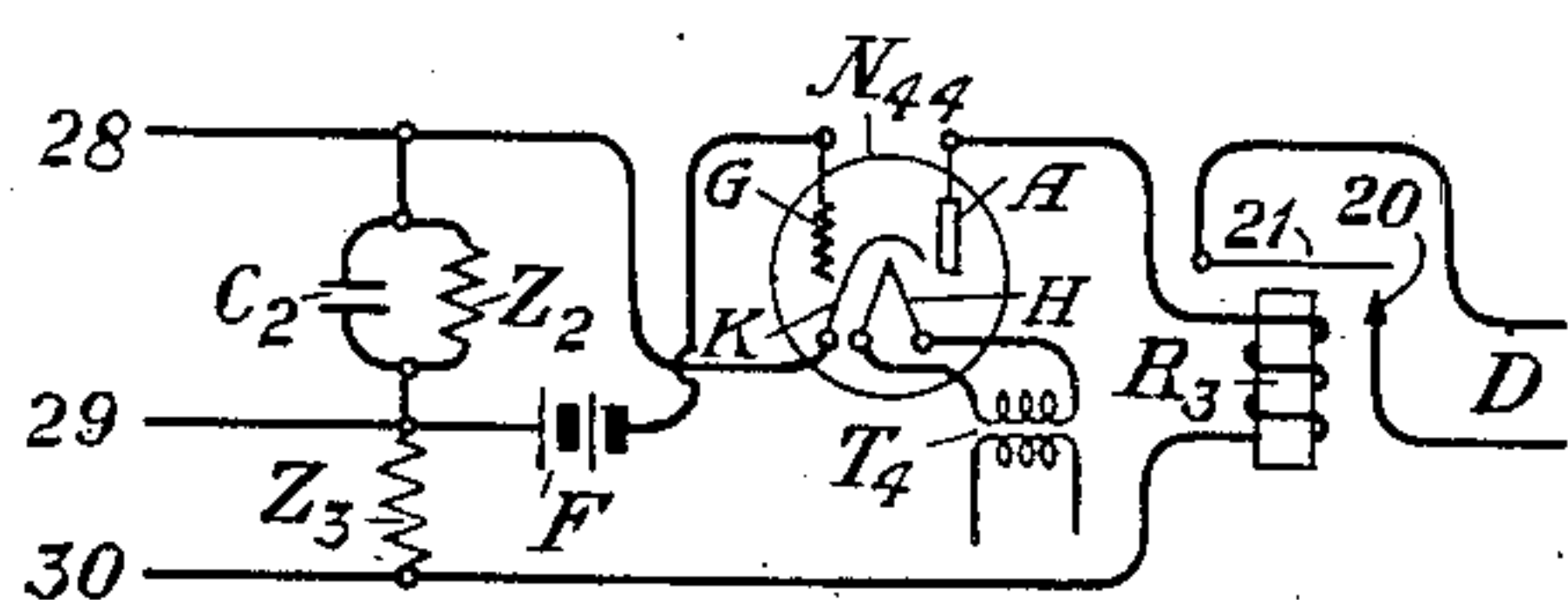


Fig. 2



UNITED STATES PATENT OFFICE

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GAS-FILLED TUBE CIRCUITS

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This invention relates to novel methods and apparatus for actuating relay systems or working circuits or the like. More particularly, this invention relates to arrangements for operating a relay system or work circuit or the like only when the voltage in an associated circuit equals or exceeds a predetermined value and persists for a period of time in excess of a prescribed duration.

There may be occasions when it is undesirable to have a given work circuit operate from impulses of very short duration, as, for example, where it is desired that oscillograms record impulses of long duration and not record impulses of very short duration such as static or lightning. In certain locations, a fairly large percentage of the operations of a recording oscillograph may be found to be from static or lightning, which, as far as data obtained are concerned, may be of little or no value. In accordance with this invention, therefore, a delay arrangement may be incorporated into a proper recording system for the purpose of selecting the type of impulses desired and to exclude the undesired impulses which may, for example, interfere with and to some extent nullify the effect of the desired impulses.

This invention will be better understood from the following description when read in connection with the accompanying drawing in which Figures 1 and 2 show two embodiments of the invention each of which includes novel apparatus associated with cold-cathode gas-filled tube systems; Fig. 3 shows an arrangement including a hot cathode gas-filled tube system; Figs. 4 and 5 show different types of arrangements employing two cold-cathode gas-filled tubes.

In Fig. 1 there is shown a method of initiating operation of some such device, as, for example, an oscillograph, after a predetermined time delay. The work circuit to be actuated, for example, the oscillograph, may be connected to terminals D. This single work circuit may be actuated from any one of a multiplicity of circuits connected to terminals 1—1 of transformer T₁, terminals 2—2 of transformer T₂, or terminals 3—3 of transformer T₃, each transformer being associated with a given actuating circuit. Gas tubes N₃₁ and N₃₂ are ionized from potentials in excess of a predetermined value, applied through transformers T₁, T₂ or T₃. Each of these gas tubes may, for example, include three electrodes K₁, K₂ and A, two of which—electrodes K₁ and K₂—may be considered as the input electrodes and two of which—electrodes K₂ and A—may be considered as the output electrodes. The electrodes K₁ and K₂ of each tube N₃₁ and N₃₂ are connected to the sec-

ondary windings of transformers T₁, T₂ and T₃ through a common biasing battery B, the voltage of which may be varied, as shown, and through a resistor Z employed for the purpose of limiting the flow of current in these input circuits. The output electrodes designated K₂ and A of the gas tubes N₃₁ and N₃₂ are associated with the output or work circuit of the system.

In the output or the work circuit there is a vibrating relay R₂ which performs, among other things, the function of resetting the gas tubes, i. e., deionizing the gas in the tubes, at high speed, the armature of relay R₂ vibrating during the period of persistence of voltage of sufficient amplitude between electrodes K₁ and K₂ of either gas tube.

A resistance Z₁ and the winding of a relay R₁ are connected in series with the winding of the vibrating relay R₂. The relay R₁ controls the operation of a slow operating relay R₃. The latter relay R₃ in turn causes operation of any desired apparatus connected at D after there has elapsed the predetermined interval required to operate relay R₁ in tandem with relay R₃. In order that the work circuit may be operated, it is necessary that both relays R₁ and R₃ be simultaneously brought into their operated positions.

The operation of the device is as follows: Voltage applied between terminals 1—1 or between terminals 2—2 or between terminals 3—3, etc., of transformers T₁, T₂ or T₃, respectively, or between the terminals of any or all of these transformers, if of sufficient amplitude will cause ionization of the gas between electrodes K₁ and K₂ of either or both of gas tubes N₃₁ or N₃₂. This will result in the flow of current from anode A to cathode K₂ of either or both of said tubes to the negative terminal of the battery B, this current flowing then from the positive terminal of battery B through resistance Z₁, the winding of relay R₁, the winding of relay R₂, and thence returning to electrodes A of the gas tubes N₃₁ and N₃₂. This current causes operation of the relays R₁ and R₂. The latter relays jointly operate even if the gas within one of the tubes N₃₁ and N₃₂ has become ionized. Armatures 1 and 4 of relay R₁ are then simultaneously attracted to contacts 2 and 3, respectively.

The closure of the circuit at armature 1 and contact 2 of relay R₁ starts operation of the slow operate relay R₃ by virtue of potential derived from the portion of the battery B between its positive terminal and its lower contact. The relay R₃ being of the slow operate type, requires a predetermined interval of time for its armature

5 to close its contact 6. When armature 5 closes contact 6 and if the relay R_1 is still operated so that its armature 4 remains closed against contact 3, a circuit will be established to bring about operation of such device or devices as are connected at D. If, for any reason, relay R_1 has lost sufficient current in its winding during the interval that armature 5 is closed against contact 6 of the slow operate relay R_3 , the circuit at D will not be closed and the apparatus connected thereto then will not be operated.

In order to prevent the closure of the circuit at D during the interval required for the joint operation of relay R_1 and relay R_3 , it merely becomes necessary to restore relay R_1 to its unoperated position. This may be accomplished by the cessation of operation of the vibrating relay R_2 and by the deionization of the gas within the gas tubes N_{31} and N_{32} . The stoppage of current through either or both of these tubes can be brought about in a few thousandths of a second by or upon the withdrawal of voltage from terminals, 1—1, 2—2 and 3—3 of the transformers T_1 , T_2 or T_3 , respectively. Moreover, the deionization of the gas within tubes N_{31} and N_{32} may be brought about by the closure of armature 7 against contact 8 of relay R_2 , resulting in a prompt withdrawal of the potential of battery B from the anodes A of both gas tubes. The closure of armature 7 against contact 8 practically eliminates all potential from between the anodes A and the cathodes K_2 of each of the gas tubes. The potential between these electrodes is thereby reduced to a value below that required to sustain ionization between these electrodes. This will promptly restore the tubes to normal as far as the work circuit, i. e., the output circuit, of the tubes is concerned. If, however, the gas within these tubes is nevertheless ionized by virtue of voltage applied between their input electrodes through anyone or all of the transformers T_1 , T_2 and T_3 , current will be again supplied to the windings of relays R_1 and R_2 , resulting in re-vibration of the armature of relay R_2 . Relay R_1 continuously remains in its operated position during the period of vibration of the armature 7 of the relay R_2 because of the flow of current through the gas tubes even while the armature 7 is not in contact with 8. If, when armature 7 leaves contact 8, the gas within the tube or tubes remains in ionized condition due to the presence of voltage at the input electrodes K_1 and K_2 , the winding of relay R_1 will still receive current over the circuit including the winding of relay R_2 and the electrodes K_2 and A of the gas tubes. Hence, relay R_1 can not restore to normal until the gas within both tubes has become deionized and the relay R_2 ceases to vibrate its armature.

During the period of ionization of the gas between electrodes K_1 and K_2 on account of voltages transmitted through transformers T_1 , T_2 and T_3 , relay R_2 continuously vibrates and holds the relay R_1 in continuous operation for the duration of the vibration. Relay R_2 , however, ceases vibration immediately upon the withdrawal of potential from the input electrodes K_1 and K_2 of either gas tube, thence restoring relay R_1 to normal. If the relay R_1 remains operated for a period of time in excess of that required to operate relay R_3 the closed circuit is completed to terminals D as already explained. This closed circuit will be maintained at D for a period of time dependent upon the duration of the applied voltage at the input of anyone or all of the transformers T_1 , T_2 or T_3 .

The resistance Z_5 and condenser C bridge the armature 7 and contact 8 of the vibrating relay R_2 . They are so arranged for the purpose of substantially reducing the effect of sparking as this armature is caused to vibrate at high speed.

It will be observed that the tubes N_{31} and N_{32} are arranged so that the gas therein is ionized alternately in accordance with opposite halves of each alternating current cycle applied through any or more of the transformers T_1 , T_2 or T_3 . Actuating voltages are alternately applied during each cycle to the electrodes K_1 and K_2 of the tubes N_{31} and N_{32} and these tubes fire intermittently but continually if the alternating potential is continuous and consequently the arrangement is well adapted for full-wave operation.

In Fig. 2 transformers T_1 , T_2 and T_3 are connected to the actuating circuits extending to the electrodes K_1 and K_2 of tubes N_{31} and N_{32} , as in Fig. 1, except that battery E provides the biasing potential for these circuits. Voltage applied to any one of the three transformers T_1 , T_2 and T_3 , if of sufficient amplitude, will produce glow between cathodes K_1 and K_2 of either tube if of the proper polarity. Once the glow is established between any pair of cathodes, or indeed between both pairs of cathodes, current will flow from the anode A to cathode K_2 , the interconnected circuit including the biasing battery E, the battery B, the winding of relay R_4 , and the winding of relay R_5 . This current causes the armature 15 of relay R_4 to be momentarily withdrawn from contact 16 to close contact 17, thereby applying the negative potential of both batteries E and B, arranged in series relationship, to the cathode K_1 of the gas tube N_{33} , the interconnected circuit including the resistance Z_3 . There will then be a potential drop across resistance Z_2 and across condenser C_2 , both of which bridge the electrodes K_1 and K_2 of the tube N_{33} . The charge on the condenser C_2 will build up to such a point that the voltage drop across the resistance Z_2 and the condenser C_2 will approximate the ionizing potential between cathodes K_1 and K_2 of the gas tube N_{33} . The potential of the batteries E and B, together with the values of resistances Z_2 , Z_3 and condenser C_2 determine the length of time required for the resistance Z_2 and condenser C_2 to become impressed with the ionizing potential required for producing glow between the cathodes K_1 and K_2 of tube N_{33} after closure of the armature 15 and contact 17 has taken place. This time interval can of course be varied from a few thousandths of a second to practically any desired period of time, depending upon the value of the constants chosen. After the prescribed time interval required to sufficiently charge condenser C_2 and to set up a corresponding voltage across resistance Z_2 ample to breakdown the gas between cathodes K_1 and K_2 of tube N_{33} has elapsed, current will flow in the work circuit of the gas tube N_{33} which includes the electrode K_2 and anode A of the tube, the resistance Z_3 and the winding of relay R_3 .

This will cause the operation of the relay R_3 and its armature 21 will be attracted to contact 20. This in turn will produce a closed circuit to operate an oscillograph or any other equipment connected or coupled to the terminals D.

The current set up in the work circuits of gas tubes N_{31} and N_{32} not only operates the relay R_4 , but also causes the operation of relay R_5 , resulting in a closure of the armature 18 against the contact 19 of the latter relay. The closure of contact 19 results in the flow of additional current

through the winding of relay R₄, this additional current being supplied by batteries B and E. This additional current will assist in holding the armature 15 against contact 17 of relay R₄. However, when armature 18 rests against contact 19, the potential applied between the cathode K₂ and the anode A of both tubes N₃₁ and N₃₂ through the winding of relay R₅ is reduced practically to a nullity. This extinguishes the glow between the electrodes of the tubes and restores the gas within these tubes to the normal deionized condition, assuming of course the absence of further sufficient potential between their cathodes K₁ and K₂. The withdrawal of current from the winding of relay R₅ upon the closure of armature 18 to contact 19, causes the armature 18 to fall away from contact 19. This brings about a restoration of the application of the potentials of series batteries B and E through the windings of relays R₄ and R₅ to the anodes A of the gas tubes N₃₁ and N₃₂. If glow persists between cathodes K₁ and K₂ because of sufficient potential applied between these electrodes from transformers T₁, T₂ or T₃, current will again flow between anodes A to cathodes K₂ and re-establish the flow of current through the gas tubes and through the relays R₄ and R₅. Armature 15 will therefore be maintained continuously against contact 17 during all periods in which the gas within the tubes is ionized, and for such brief intervals of time thereafter as the armature 18 of relay R₅ is held against its contact 19.

It will thus be noted that the armature 18 of relay R₅ will vibrate periodically as long as glow persists between cathodes K₁ and K₂ of either or both of the tubes N₃₁ and N₃₂ which are in general arranged for full-wave operation. If, however, the armature 18 leaves contact 19 and at the same time the gas within the tubes is in a non-ionized condition due to absence of potential between cathodes K₁ and K₂, the armature 18 will remain in the non-operated position and hence spaced from its contact 19. No current will then flow through the winding of relay R₄. Upon the restoration of the gas within the tubes N₃₁ and N₃₂ to the deionized condition, current will also cease flowing through the path provided by the anodes and the cathodes of the gas tubes. Armature 15, therefore, of the relay R₄ will leave contact 17 and return to contact 16 and this will result in the short-circuiting of the condenser C₂ and resistance Z₂, the short-circuiting path being provided by the resistor Z₄ and the armature 15 and contact 16 of relay R₄. Condenser C₂ then will be almost immediately discharged through resistance Z₄, which is preferably a resistance of small magnitude.

When the armature 15 leaves contact 17, current is also withdrawn from the winding of relay R₃ and from the anode circuit of gas tube N₃₃. Consequently the relay R₃ will be restored to normal. Armature 21 of relay R₃ will then leave its contact 20 and hence open the circuit D which may extend to an oscillograph or any other apparatus or load. Relay R₃ will not be again operated unless the relay R₄ has repeated its operation and remained operated long enough to build up sufficient potential across condenser C₂ to cause a glow discharge to occur in the tube N₃₃. Relay R₄ will remain in the operated condition only as long as glow persists between cathodes K₁ and K₂ of the glass tubes N₃₁ and N₃₂ and this can occur only when sufficient potentials are transmitted through transformers T₁, T₂ or T₃ to the actuating circuits of tubes N₃₁ and N₃₂.

Fig. 3 shows an arrangement which employs in

the timing circuit a hot cathode type of tube N₄₄ containing a grid G, an anode A, a heater H and a cathode K. This tube may be employed to replace the cold cathode tube N₃₃ of Fig. 2. Conductor 28 of Fig. 3 may be connected to the armature 15 of the relay R₄ of Fig. 2. Conductor 29 of Fig. 3 may be connected to terminal 26 of Fig. 2, while conductor 30 of Fig. 3 may be connected to terminal 27 of Fig. 2. Thus the arrangement of Fig. 3 may be employed to replace the resistances Z₂ and Z₃, condenser C₂, gas tube N₃₃ and the relay R₃ shown at P of Fig. 2. The operation of the arrangement employing the hot cathode type of tube in Fig. 3 is in general the same as that obtained by the cold-cathode tube N₃₃, provision having been made for a source of biasing potential F and a source of heating current for the heater H which may be connected to the primary winding of the transformer T₄ shown in Fig. 3.

It will be understood that, although this invention has been disclosed in certain arrangements which employ three transformers, the invention may be readily practiced with arrangements which have but one transformer. One or more current sources may be connected to the primary winding of a single transformer, or if more than one source is required, each such source may be connected to the primary winding of a separate transformer, the secondaries of which may be connected in series with each other as shown in Figs. 1 and 2 of the drawing. Furthermore the circuits may be modified to eliminate all transformers.

Fig. 4 shows another type of circuit for delaying the operation of a load or work circuit. In this arrangement the condenser C₁₁ is normally discharged. The cathodes K₁ and K₂ of the tube N₁ are connected to the input circuit through the current-limiting resistor Z₁₀ and the battery B₁₀. The anode A of the tube N₁ is connected to the cathode K₂ of that tube through a circuit which includes the battery B₁₁, the variable resistor Z₁₁ and the resistor Z₁₂. The condenser C₁₁ is bridged across the resistor Z₁₁ as well as across the gap formed by the cathodes K₁ and K₂ of the tube N₂. The anode A of the tube N₂ is connected to the cathode K₁ through the circuit formed by the winding of the relay R₁₂ and the battery B₁₁.

The condenser C₁₁ is normally discharged and it cannot receive a charge until a sufficiently high voltage has been applied to the input circuit of the system. After such a voltage has become applied to the input circuit, the gas within the gaps K₁-K₂ and A-K₂ of the tube N₁ will become ionized and current will promptly flow through the circuit which includes the battery B₁₁, the anode A and cathode K₂ of the tube N₁ and the resistors Z₁₂ and Z₁₁. The impedance between the latter electrodes of the tube N₁ during ionization is very low. The condenser C₁₁ at the same time becomes charged by the flow of current from the battery B₁₁. When the voltage across the condenser C₁₁ equals or exceeds the value required to ionize the gas between the cathodes K₁ and K₂ of the tube N₂, current will then flow from the battery B₁₁ through the winding of the relay R₁₂ and operate this relay. The relay R₁₂ will remain operated as long as sufficiently high voltage remains applied to the cathodes K₁ and K₂ of the tube N₁. Any surge which is of but brief duration and insufficient to allow the condenser C₁₁ to become sufficiently charged will be ineffective in bringing about the operation of the relay R₁₂. Although deionization circuits have not

been shown in connection with the circuits of the tubes N_1 and N_2 merely for the purpose of eliminating unnecessary details, such circuits will, of course, be employed in the normal operation of these circuits. Suitable deionization circuits for this purpose are shown and described in Patent No. 1,977,256, dated October 16, 1934.

Fig. 5 shows a delay circuit interposed between two cold-cathode gas-filled tubes N_1 and N_2 . The cathodes K_1 and K_2 are shunted by a large resistor Z_{20} which bridges the input circuit of the system. The anode A of the tube N_1 is connected to the cathode K_2 by means of a circuit which includes the winding of the vibrating relay R_{20} , the winding of the relay R_{21} , the resistor Z_{21} and the battery B_1 . The armature and contact of the vibrating relay R_{20} are shunted by a spark suppression circuit including condenser C and resistor Z_5 as shown in Fig. 2. The relay R_{21} is normally unoperated and its armature and back contact are connected through a resistor Z_{22} across the variable condenser C_{20} . This condenser may also be shunted by a variable resistor Z_{23} , if desired, and the condenser will also shunt the circuit of the cathodes K_1 and K_2 of the tube N_2 . The anode A of tube N_2 is connected to the cathode K_1 through a circuit which includes the winding of a relay R_{22} , the battery B_1 and the front contact and armature of the relay R_{21} .

As long as the relay R_{21} is unoperated, the condenser C_{20} will remain discharged. But after the relay operates, the condenser will be charged by the battery B_1 , the charging circuit including the resistor Z_{24} and the armature and front contact of the relay R_{21} .

In response to the application of sufficiently high voltage to the input circuit of the system of Fig. 5, the gas between the cathodes K_1 and K_2 of the tube N_1 will become ionized and current will flow from battery B_1 through the windings of relays R_{20} and R_{21} . The relay R_{20} will vibrate its armature as long as sufficient voltage remains impressed upon the input circuit but the relay R_{21} will remain continuously operated during that interval. The operation of the relay R_{21} will immediately remove the short-circuit around the condenser C_{20} and around the cathode circuit of the tube N_2 and the battery B_1 will supply current for charging the condenser C_{20} . As the voltage across the condenser C_{20} exceeds the value required to ionize the gas between the cathodes K_1 and K_2 of the tube N_2 , battery B_1 will supply current to the winding of the relay R_{22} and cause this relay to operate.

In one arrangement set up in accordance with the diagram of Fig. 5, the battery B_1 had a terminal voltage of 135 volts, the resistors Z_{22} , Z_{23} and Z_{24} were of the order of 10, 200,000 and 20,000 ohms, respectively, and the operation of the relay R_{22} was brought about only after sustained application of voltage to the input circuit and lightning surges or the like were unable to operate this relay. The relay R_{22} was part of recording equipment for recording the occurrence of applied voltages. The amount of delay introduced by this circuit was determined by the magnitudes of the resistors and battery just specified as well as of the condenser C_{20} .

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

What is claimed is:

1. The combination of first and second gas discharge tubes, a source of potential, a condenser, means for connecting said condenser in series with said source, a resistor shunting said condenser and said second tube, means for ionizing the gas within the first tube and for charging said condenser, means responsive to a predetermined charge on said condenser for ionizing the gas of the second tube, and a load circuit operated in response to gaseous ionization within the second tube.

2. The combination of a gas discharge tube having an input circuit and an output circuit, a work circuit connected to said output circuit and including a first relay, a second relay which is a vibrating relay, a third relay of slow operate type controlled by the first relay, a load circuit operated in response to the simultaneous operation of the first and third relays, and means including the second relay for periodically deionizing the gas of the tube.

3. The combination of a gas discharge tube having three electrodes, means for ionizing the gas of said tube, a work circuit connected to said tube including a relay and means for periodically deionizing the gas within said tube, a slow operate relay controlled by the first mentioned relay, and a load circuit operated in response to the conjoint operation of both relays.

4. An arrangement for recording voltage effects persisting longer than a predetermined time interval comprising a gas discharge tube having an input circuit to which said voltage effects are transmitted and an output circuit from which the voltage effects are rendered available, a relay having a winding connected to said output circuit and operated by the voltage effects in said output circuit, a slow operate relay controlled by the armature of the first-mentioned relay, and a main circuit closed only upon the operation of the slow operate relay and said first-mentioned relay.

5. The combination of a full wave translating circuit of two equal gas filled discharge tubes each having three electrodes, two of the electrodes of each of said tubes being actuating electrodes between which a glow discharge occurs on opposite halves of each applied alternating current cycle, a relay having a winding connected between the third electrodes and one of the other electrodes of each tube, and operated in response to gaseous ionization in either tube, a delay device operated by said relay, and a main circuit controlled and operated only when said relay and said device have both operated.

6. The combination of first and second gas discharge tubes, a source of potential, a condenser, a resistor, means for ionizing the gas of the first tube, means responsive to the ionization of the gas of the first tube for connecting said condenser to said source of potential through said resistor to charge said condenser at a rate controlled by said resistor, a second resistor, said second resistor shunting said condenser, said condenser shunting said second tube so that the gas of said second tube may become ionized when the voltage to which said condenser is charged reaches a predetermined value, and a load circuit operated in response to gaseous ionization within said second tube.

7. The combination of first and second gas discharge tubes, a source of potential, first and second resistors, a condenser continuously shunt-

ing said first resistor and said second tube, means responsive to the ionization of the gas within the first tube to apply the potential of said source to said condenser through said second resistor to charge said condenser to a voltage exceeding that required to initiate gaseous ionization within the second tube, and a load circuit operated in response to gaseous ionization within the second tube.

10 8. The combination of first and second gas discharge tubes, three resistors, a condenser shunting the second of said tubes, means responsive to the ionization of the gas within the first tube

to charge said condenser through one of said resistors to a voltage sufficient to ionize the gas of the second tube, another of said resistors being connected permanently in shunt with said condenser, means for connecting the third resistor across said condenser and for disconnecting said third resistor from said condenser as the gas of the first tube becomes deionized or ionized respectively, and a load circuit operated in response to gaseous ionization within the second tube. 10

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