March 3, 1936.

L. K. SWART

2,032,513

ELECTRICAL PROTECTIVE SYSTEM

Filed March 14, 1935

2 Sheets-Sheet 1

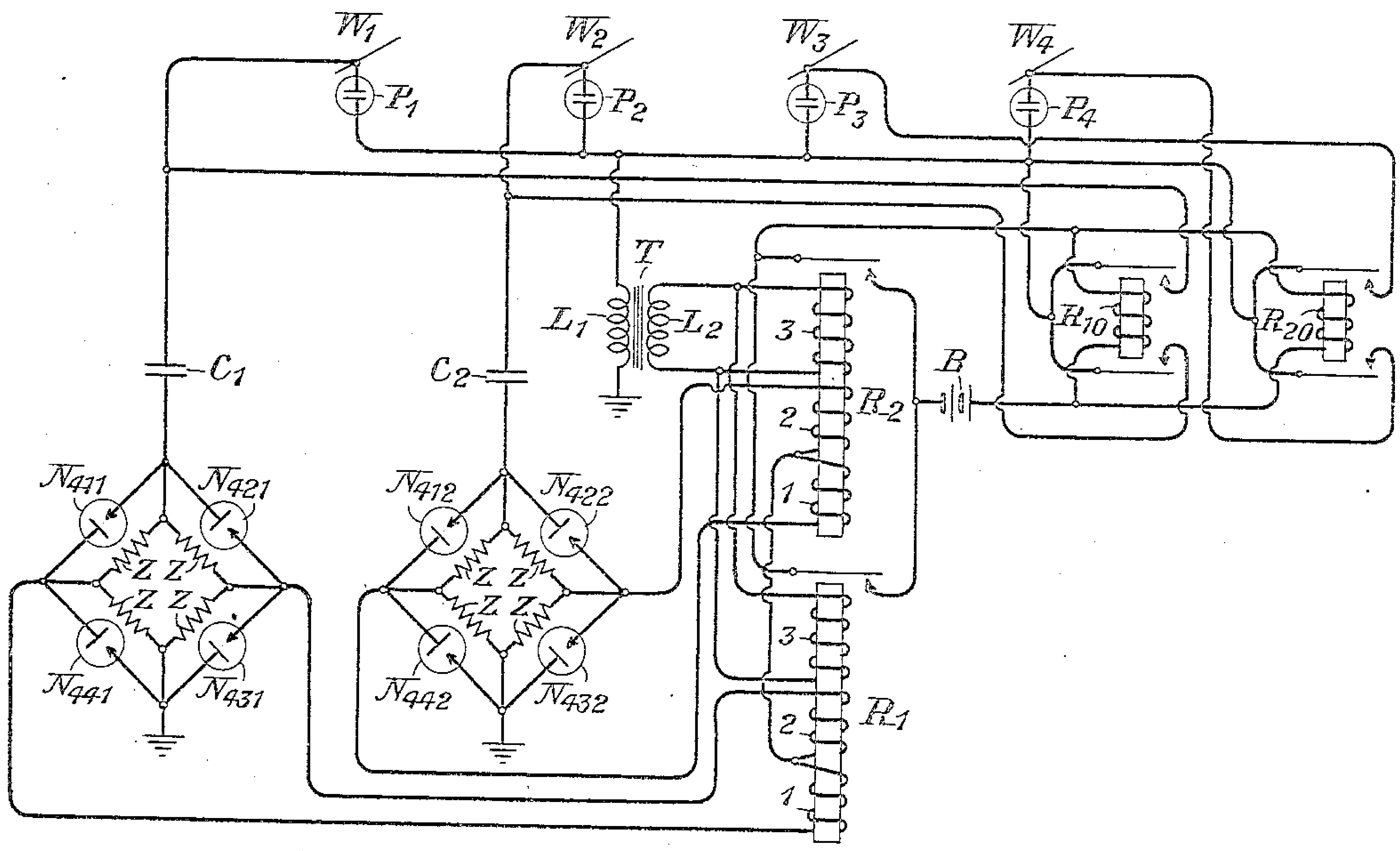

Fig. 1

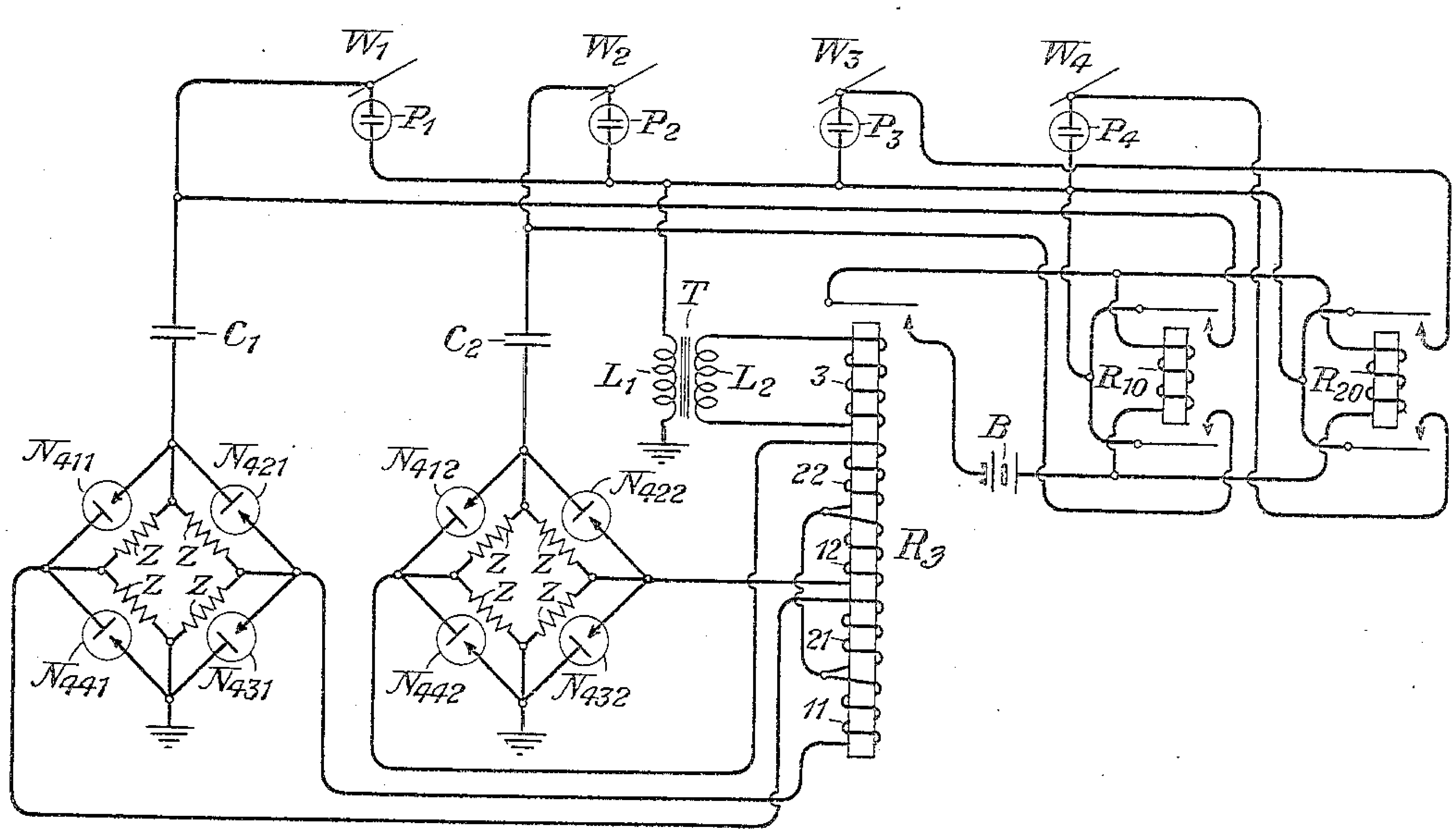

Fig. 2

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2 Sheets-Sheet 2

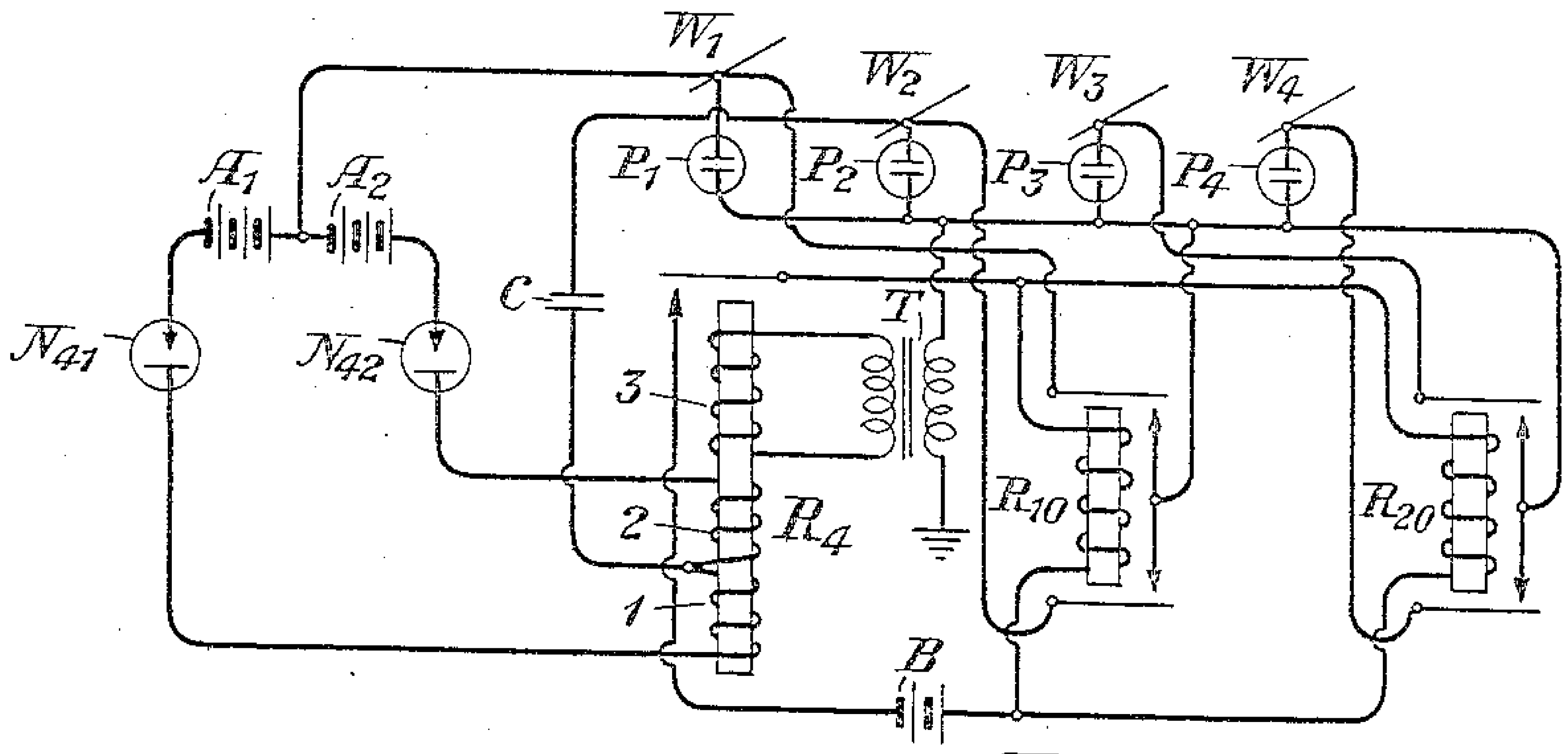

Fig. 3

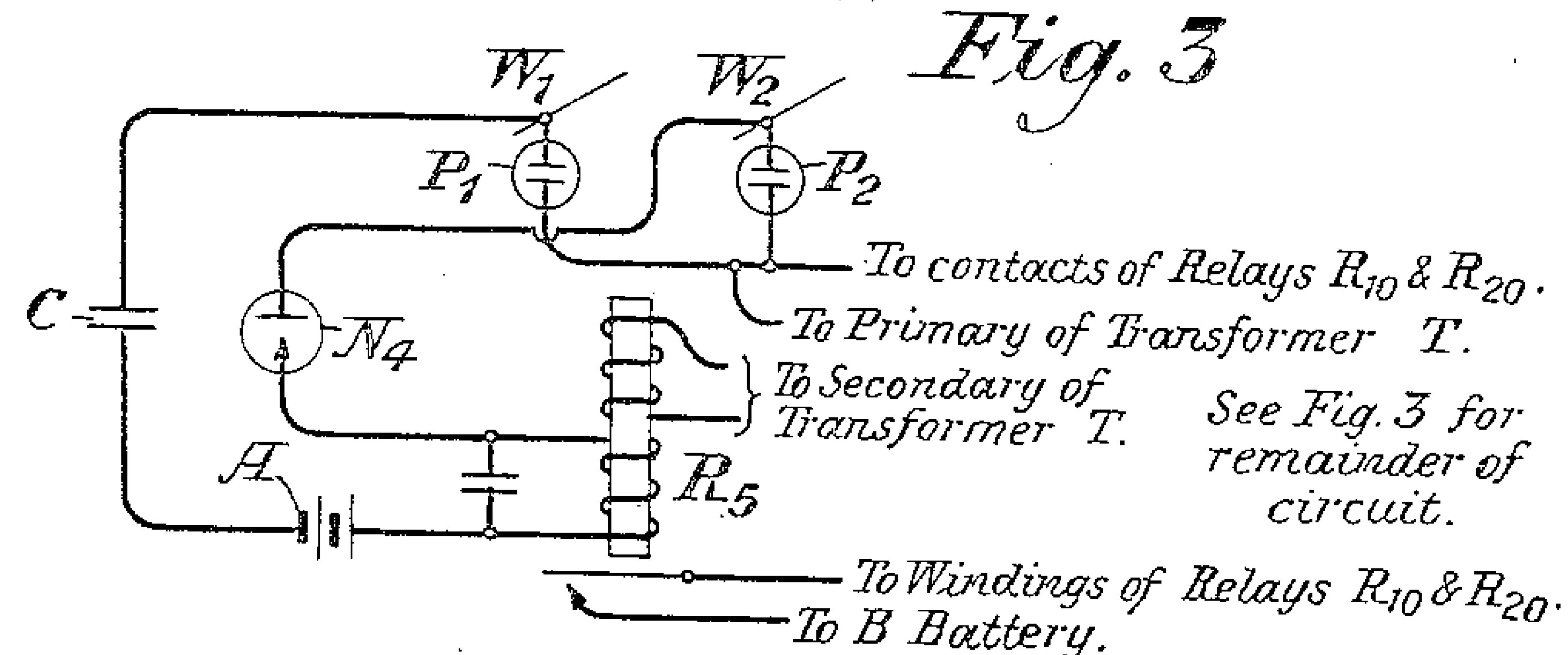

Fig. 4

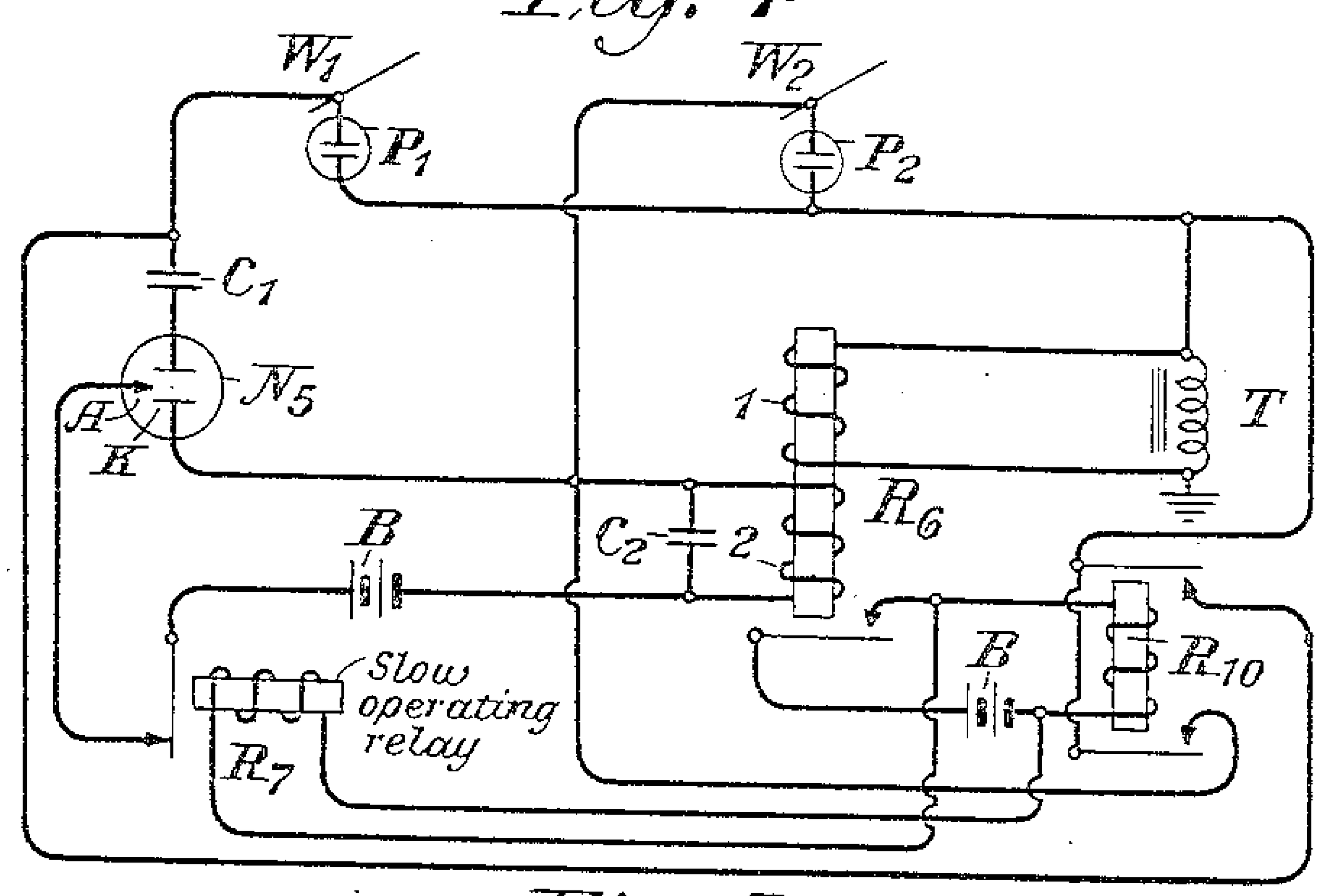

Fig. 5

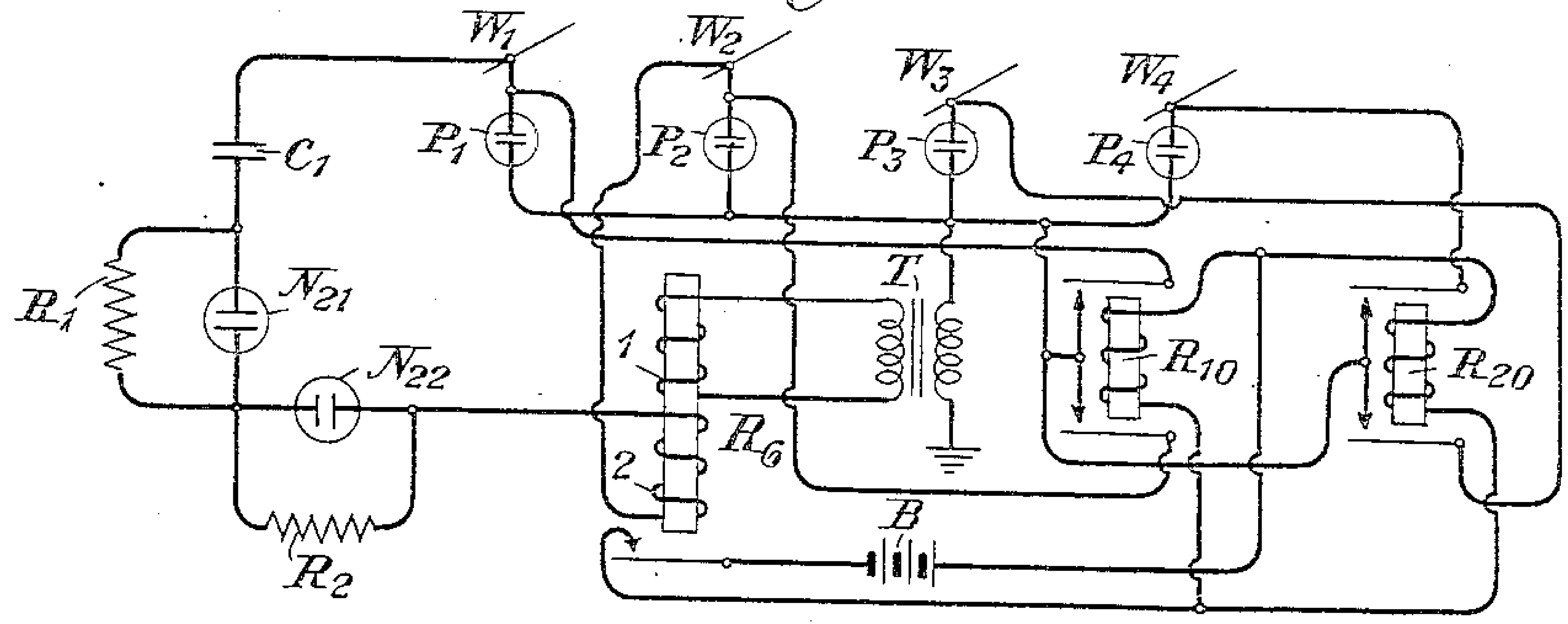

Fig. 6

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2,032,513

ELECTRICAL PROTECTIVE SYSTEM

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Application March 14, 1935, Serial No. 11,177

7 Claims. (Cl. 179—78)

This invention relates to electrical protective systems or more particularly to arrangements for simultaneously grounding a plurality of conductors when induced voltages above a fixed and predetermined value become impressed thereon. The arrangements of this invention also are adaptable for the purpose of testing the apparatus and in the testing operations potentials may be applied either to the various conductors and ground or to the conductors alone.

Pairs of protector blocks each having an air gap which breaks down at a predetermined potential are used in the telephone art to protect each of a number of telephone conductors from high voltages set up therein by one or more sources extraneous to the circuits themselves. In these arrangements a resistor, saturating reactor or transformer is interposed in the ground connection of each pair of protector blocks or in the common ground connection of all protector blocks. In some arrangements the current derived from the impedance drop across the resistor, reactor or transformer, is rectified by a copper-oxide type of rectifier. This rectified current is applied to a relay which when operated shunts a pair of protector blocks or, if desired, the rectified current may be caused to operate a relay which will apply local battery to a group of short circuiting relays, employed for short circuiting all the protector blocks during the period in which the extraneous voltage exists. In another type of relay protector arrangement the current traversing one or all of the protector blocks may be applied to a saturating reactor or transformer which operates an alternating current relay the contacts of which apply local battery to a multiplicity of short circuiting relays. The contacts of these relays short circuit all of the protector blocks, thus preventing permanent grounding of these blocks.

At present the commonly employed low voltage carbon protector blocks have a considerable variation in operating range depending upon the history of previous operation of the blocks, the impedance of the line, the humidity, etc. In order to provide operation of protective equipment at a predetermined fixed value of voltage, the carbon protector block alone can not be depended upon to give operation within a narrow margin of operating voltage. If a gas discharge device, however, is shunted around the protector block in series with a relay, condenser, etc., as will be described hereinafter, a fixed operating voltage, depending on the design of the tube may be obtained. This operating voltage can be made to lie slightly above the normal telegraph and ringing voltages applied to the line conductors and considerably below the 250-volt minimum of a carbon protector block. Furthermore, by the use of gas discharge devices it becomes practicable to operate the device from voltage applied to a line wire from a remote point. A particular protective device situated along an open-wire line can be selected for operation by knowing the conductors on which the various gas discharge devices are applied. Furthermore, remote testing may be carried out by applying voltages between wires equivalent to the voltage required to operate the device from a single conductor to ground. When testing by application of voltage between the conductors, the voltage to ground will be one-half of that required to operate the device from a single conductor to ground, as will be shown hereinafter. Thus, there will be a very wide margin in the operating voltage of the device. This is of decided advantage due to the very wide operating values to be expected of carbon protector blocks some of which as before stated, might operate at a very low voltage and ground in the process of testing. This results in lost service time and necessitates sending an attendant out to some remote point to replace the blocks before the circuits can be restored to normal.

At times it may be desirable to provide for remote testing and yet not employ the gas discharge devices to operate from voltages to ground but from voltages between line wires only. This is readily accomplished by the apparatus of this invention, as will be shown thereinafter.

This invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawings in which Figure 1 illustrates a plurality of adjacent conductors two of which are respectively connected to networks of gas-filled tubes and relays; Fig. 2 illustrates a modification in which the two relays of Fig. 1 are replaced by a single relay; Fig. 3 illustrates a biasing arrangement of batteries connected between two of the conductors, the arrangement also including two oppositely directed gas-filled tubes; Fig. 4 shows the two conductors connected by a single tube and a single biasing battery; Fig. 5 illustrates a modification which includes a trigger tube of the three-electrode type; and Fig. 6 shows another modification which includes two tubes and one of the windings of an associated relay connected in series with each other between the two parallel conductors.

In Figure 1 reference characters W_1 to W_4, inclusive, represent four of a plurality of conductors or circuits which may be supported by a common protector pole. Each of these conductors may be connected to ground through an individual protector block and a common reactor or saturating transformer T, as shown. The various protector blocks are designated P_1 to P_4, inclusive. The lower terminal of each of these blocks is connected to the upper terminal of the primary winding L_1 of the transformer T. Each upper terminal of these protector blocks is connected to conductors W_1 to W_4, as shown. Each of the various protector blocks may include two carbon electrodes spaced from each other by a gap of predetermined width.

The transformer T includes also a secondary winding L_2 which is connected to the respective upper windings of relays R_1 and R_2. Each of these connections may or may not include a series condenser. The condenser if desired can be used to tune the circuit of the upper winding of the relays R_1 and R_2 to some definite frequency such as that of some nearby source of extraneous induced potential.

The relays designated R_{10} and R_{20}, associated with the protector blocks P_1 to P_4, inclusive, are arranged so that their windings are connected in parallel, the parallel circuit being in series with a battery B and the armatures and contacts of the relays R_1 and R_2. When either or both of the relays R_1 and R_2 become operated, current will flow from the battery B over the armatures and contacts of these relays and through the windings of the relays R_{10} and R_{20}. The armatures of these latter relays will become simultaneously attracted to their contacts and will simultaneously shunt all the protector blocks. They will also shunt the gas tube devices connected thereto and extinguish the tubes, as will be shown hereinafter, and at the same time shunt the arc across all of the protector blocks P_1 to P_4.

In addition to the above described relay equipment a pair of conductors, such as W_1 and W_2, which traverse the entire exposure are chosen as pilot conductors to which are applied at a given protector point condensers, gas discharge tubes, resistances, etc., which will now be described. A condenser C_1 is connected to conductor W_1 and to the anode of rectifying gas tube N_{411} and to the cathode of rectifying gas tube N_{421}. The cathode of the gas tube N_{411} is connected to the cathode of the rectifying gas tube N_{441} and to lower terminal of winding 1 of the relay R_1. The upper terminal of the winding 1 of relays R_1 and R_2 and the lower terminal of winding 2 of these relays are connected to each other as shown. The upper terminal of winding 2 of relay R_1 is connected to the anodes of rectifying gas tubes N_{421} and N_{431}. The anode of gas tube N_{441} is connected to the cathode of gas tube N_{431} and to ground. Gas tubes N_{411}, N_{421}, N_{431} and N_{441} are shunted respectively by resistances Z and these are of equal value if these gas tubes have equal breakdown potentials. The values of each shunt resistance Z should be of the order of from 500,000 to 1,000,000 ohms or higher depending on the leakage between the elements of the gas tubes. The conductor W_2 is connected to a similar arrangement except that the relay R_2 is associated with this second arrangement. Windings 3 of both relays R_1 and R_2 are connected to the secondary winding L_2 of the transformer T.

The operation of the protective device from extraneous potentials is as follows: Assume that the polarity of the applied potential is such that conductors W_1 and W_2 are positive to ground. On one arrangement current will flow from conductor W_1 through condenser C_1 through the elements of gas tube N_{411} and its associated resistance to winding 1 of relay R_1, thence through winding 2 of that relay and through the elements of gas tube N_{431} and its associated shunt resistance to ground, resulting in operation of relay R_1, the contacts of which apply current to the short circuiting relays R_{10} and R_{20}. The operation of said latter relays results in a short circuit of all of the protector blocks P_1 to P_4 and the gas tube arrangements connected thereto, and current flowing from the various conductors W_1 to W_4 traverses the winding L_1 of the transformer T and passes to ground. Winding L_2 of transformer T, by virtue of its connection to windings 3 of relays R_1 and R_2 will, therefore, operate or hold operated both of these relays for the duration of the extraneous potential. The only potential existing across the gas tube arrangements and conductors W_1 to W_4 after operation of relays R_{10} and R_{20} will be that due to the voltage drop in primary winding L_1 of transformer T. This voltage will be but a few percent of that required to keep the glow present in the various gas discharge devices and hence these gas tubes will be extinguished.

For a potential between conductor W_1 and ground of the opposite polarity the operation will be as described with the exception that the current will pass from ground to the element of the gas tube N_{441} and its associated resistance, through windings 1 and 2 of the relay R_1, thence through gas tube N_{421} to the condenser C_1 and thence to conductor W_1. The operation as described with respect to the gas tube arrangement involving condenser C_1 applies equally well with respect to the gas tube arrangement associated with condenser C_2.

Where it is desired to test the relay protector equipment by applying potential at some remote point, potential may be applied between conductors W_1 and W_2, the mid-point of the source of potential being grounded. Operation of relays R_1 and R_2 is brought about as follows: Assuming the potential applied to conductor W_1 as positive and that applied to W_2 as negative, current will flow from conductor W_1 through condenser C_1 through gas tube N_{411} and its associated shunt resistance, through the winding 1 of relay R_1, through winding 2 of relay R_2 to gas tube N_{422}, condenser C_2 and thence to conductor W_2. Operation of the relays R_1 and R_2 is also brought about by reversing the potential applied between conductors W_1 and W_2 in which case current will pass from conductor W_2 through condenser C_2, gas tube N_{412}, winding 1 of relay R_2, winding 2 of relay R_1, through the gas tube N_{421} and its associated resistance, through condenser C_1 and thence to conductor W_1. This will ordinarily result in the operation of both relays R_1 and R_2. Thus, it will be noted that the voltage required to operate the gas tube arrangement by applying voltage between conductors W_1 and W_2 is equivalent to that required to operate the arrangement when that potential is applied between the conductor and ground. But the potential to ground applied between these conductors is only one-half of the potential between wires.

Fig. 2 shows an arrangement similar to the one described with respect to Fig. 1. The two relays R_1 and R_2 have been replaced by a single relay R_3. This relay has a winding 3 which is connected to the secondary winding of transformer

T and it also includes two pairs of windings numbered 11 and 21 and 12 and 22 which correspond to the windings 1 and 2 of relays R_1 and R_2 of Fig. 1. The operation, however, is identical to that as described with respect to Fig. 1.

In Fig. 3 operation of the relay protective device is brought about by the breakdown in the gaps of any one of the protector blocks or by voltages applied between two selected conductors such as W_1 and W_3 or by the voltage applied between any one of the conductors and ground. Biasing batteries A_1 and A_2, so poled as to increase or decrease the potential required to cause a discharge between the gaps of the tubes N_{41} or N_{42}, are connected respectively to the anode of tube N_{41} and the cathode of tube N_{42}, as shown. The mid-point or common terminus of these batteries is connected to the conductor W_1. The operation of the gas tube arrangement takes place as described previously and therefore need not be repeated. But one-quarter of the number of tubes are required however, and by means of the bias of batteries A_1 and A_2, the operating voltage of these tube devices can be altered as desired.

Fig. 4 shows another arrangement for accomplishing the same result using but a single gas tube which operates the relay R_5 when the potential applied to conductor W_2 is sufficiently positive and that applied to conductor W_1 is negative; or if conductor W_1 is rendered negative and the ground is rendered positive. The arrangement is biased by battery A which may be employed either to increase or to decrease the operating voltage of the gas tube N_4. A condenser may, if desired, be connected across the lower winding of relay R_5 for tuning its circuit for operation at a particular frequency.

Fig. 5 shows another arrangement for short circuiting conductors W_1 and W_2 upon the application of sufficiently high potentials to either or both of these conductors. This arrangement includes a gas discharge device operating on the trigger principle and it is actuated by potentials applied either between the conductors W_1 and W_2 or between conductor W_1 and ground. The relay protector device will of course also operate from currents through the protector blocks due to potentials applied between the conductors and ground.

Conductor W_1 is connected to condenser C_1, the other side of said condenser being connected to the auxiliary electrode of gas tube N_5. The cathode K of the gas tube N_5 is connected to the upper terminals of condenser C_2 and winding 2 of relay R_6. The other terminals of condenser C_2 and winding 2 of relay R_6 are connected to a source of potential B, the other side of which is connected to the armature of relay R_7. The contact of relay R_7 is connected to the anode A of gas tube N_5. The windings of the short circuiting relay R_{10} and of relay R_7 are both connected to the armature and contact of relay R_6 through local battery B.

The operation of the device is as follows: Voltage applied between conductors W_1 and W_2 or between conductor W_1 and ground through condenser C_1 if of sufficient amplitude to cause glow to take place between the electrodes of the gas tube N_5 causes current to flow in the circuit which includes the anode A and the cathode K of the tube N_5, winding 2 of the relay R_6, battery B, the armature and contact of relay R_7 and thence back to the anode A of the gas tube N_4. This current brings about operation of the relay R_6, causing its armature to be attracted to its contact. The closure of the latter contact causes operation of the relays R_{10} and relay R_7. The relay R_7 is of the slow operating type and therefore allows ample time for the operation of the relays R_6 and R_{10} before its own armature is withdrawn from its contact. The short circuiting of the protector blocks is of course brought about by the operation of the relay R_{10} and provides a low impedance path to ground through the winding or choke coil T. The low voltage potential applied between conductors W_1 and W_2 or between conductor W_1 and ground will hold relay R_6 in the operated condition. The armature of the relay R_7 will be held away from its back contact during the period in which the relay R_6 is operated. Upon withdrawal of potential from the conductors and ground, relay R_6 will restore to normal with the consequent restoration of the relays R_{10} and R_7 to normal. The latter relay R_7 will reapply battery potential to the anode A of the gas tube N_4.

It will be understood of course that the relay R_6 may be of the multi-contact type to provide short circuiting paths for protectors P_1 to P_2, if so desired, in which case the relay R_{10} may be dispensed with. The arrangement is described only for a pair of wires W_1 and W_2 but it is equally applicable to a multiplicity of conductors.

Another and varied arrangement for providing protector operation by application of potential between a pair of conductors is disclosed in Fig. 6. Conductor W_1 is connected to a condenser C_1 in series with a pair of gas tubes N_{21} and N_{22} which are shunted by resistances R_1 and R_2, respectively. These elements are in turn connected in series with winding 2 of the relay R_6 and with conductor W_2. Conductors W_1 to W_4, inclusive, are connected to protectors P_1 to P_4, a transformer T and the winding 1 of relay R_6. The short circuiting relays R_{10} and R_{20} are controlled by relay R_6 and battery B supplies the current necessary for their operation.

The operation of the arrangement for potentials applied to conductors W_1 and W_2 is as follows: Potential of sufficient amplitude to break down the gaps of both gas tubes N_{21} and N_{22} but of insufficient amplitude to operate protectors P_1 to P_4, inclusive, passes current through winding 2 of relay R_6 and brings about its operation. Relay R_6 operates relays R_{10} and R_{20}, the armatures and contacts of which short circuit protectors P_1 to P_4 in the normal manner.

The low impedance paths between the conductors and ground through the armatures and contacts of relay R_{10} and R_{20} and the primary winding of transformer T provides means for holding the relay R_6 in the operated condition by virtue of the connection of its winding 1 to the primary winding of transformer T. Relays R_6 and R_{10} and R_{20} will be held operated during the period in which sufficient potential exists between any one or all of the conductors and ground, but these relays will restore to normal immediately upon withdrawal of this potential. The gas tube discharge devices N_{21} and N_{22} are, therefore, required to carry current only for the period of time required to operate relay R_6 and relays R_{10} and R_{20}. Resistances R_1 and R_2 are applied to tubes N_{21} and N_{22} for the purpose of insuring a definite breakdown potential for these series connected gas tubes. If but one tube is required, resistances R_1 and R_2 may be omitted. It will also be understood that relay R_6 may be of the multi-contact type, thus performing the functions of relays R_{10} and R_{20}, etc., and, moreover, that the number of conductors so protected need not be restricted to four as indicated but may consist of a considerably greater number, if so desired.

In each of these arrangements where the circuit is tested by applying a voltage between two conductors, such as W_1 and W_2, the testing voltage should preferably be applied through a transformer, the secondary of which is connected to these conductors and the midpoint of which is grounded. If desired, the transformer may be replaced by a resistor or any other impedance or reactance the midpoint of which is grounded.

While this invention has been shown and described in certain particular arrangements 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 if departing from the spirit of the invention and the scope of the appending claims.

What is claimed is:

1. Apparatus for the protection of a plurality of signaling circuits, comprising a pair of gas-filled rectifier tubes connected in opposition between two of the signaling circuits so that alternate half cycles of voltage impressed between the said two signaling circuits will be transmitted through said tubes, and means responsive to the operation of both of said tubes for simultaneously grounding all of the signaling circuits.

2. Apparatus for the protection of a plurality of conductors, comprising a pair of gas-filled rectifier tubes, a pair of sources of potential, each of the tubes and each of the sources forming a series circuit bridging two of the conductors, and means responsive to the operation of said tubes for simultaneously grounding all of the conductors.

3. Apparatus for the protection of a plurality of exposed conductors comprising a pair of gas-filled rectifier tubes, a relay having two windings each of which is connected in series with one of the tubes across the same pair of exposed conductors, and means responsive to the operation of said relay for simultaneously grounding all of the exposed conductors.

4. Apparatus for the protection of a plurality of exposed conductors, comprising a plurality of protector blocks one terminal of each of which is connected to one of the exposed conductors, a saturating transformer the primary winding of which is connected between the other terminal of each of the protector blocks and ground, a relay having three windings one of which is connected to the secondary winding of said transformer, a pair of gas-filled rectifier tubes connected in mutual opposition across the same pair of exposed conductors, each of said tubes being connected to one of the remaining windings of said relay, and means responsive to the operation of said relay for simultaneously grounding all of the exposed conductors.

5. Apparatus for the protection of a plurality of exposed conductors comprising a gas-filled rectifier tube, a condenser, a relay having a winding connected in a circuit including said tube and said condenser, said circuit being connected across two of the exposed conductors, and means responsive to the operation of said relay for simultaneously grounding all of the exposed conductors.

6. Apparatus for the protection of a plurality of exposed conductors comprising a condenser, a relay, two gas-filled tubes connected in a circuit including the winding of said relay and said condenser and extending to two of the exposed conductors, a pair of resistors each of which is connected in shunt with one of said tubes, and means responsive to the operation of said relay for simultaneously grounding all of said conductors.

7. In an arrangement for the protection of a plurality of current carrying conductors, the combination of a plurality of protector blocks, a saturating reactor, each block being connected between one terminal of the reactor and one of the various conductors, the other terminal of the reactor being grounded, a relay having two windings one of which is connected to said reactor, a pair of gas-filled tubes connected in series with each other and with the other winding of said relay between two of said conductors, a pair of resistors each of which shunts one of said tubes, and means responsive to the operation of said relay for simultaneously grounding all of said conductors.

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