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L. K. SWART

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ELECTRICAL PROTECTIVE SYSTEM

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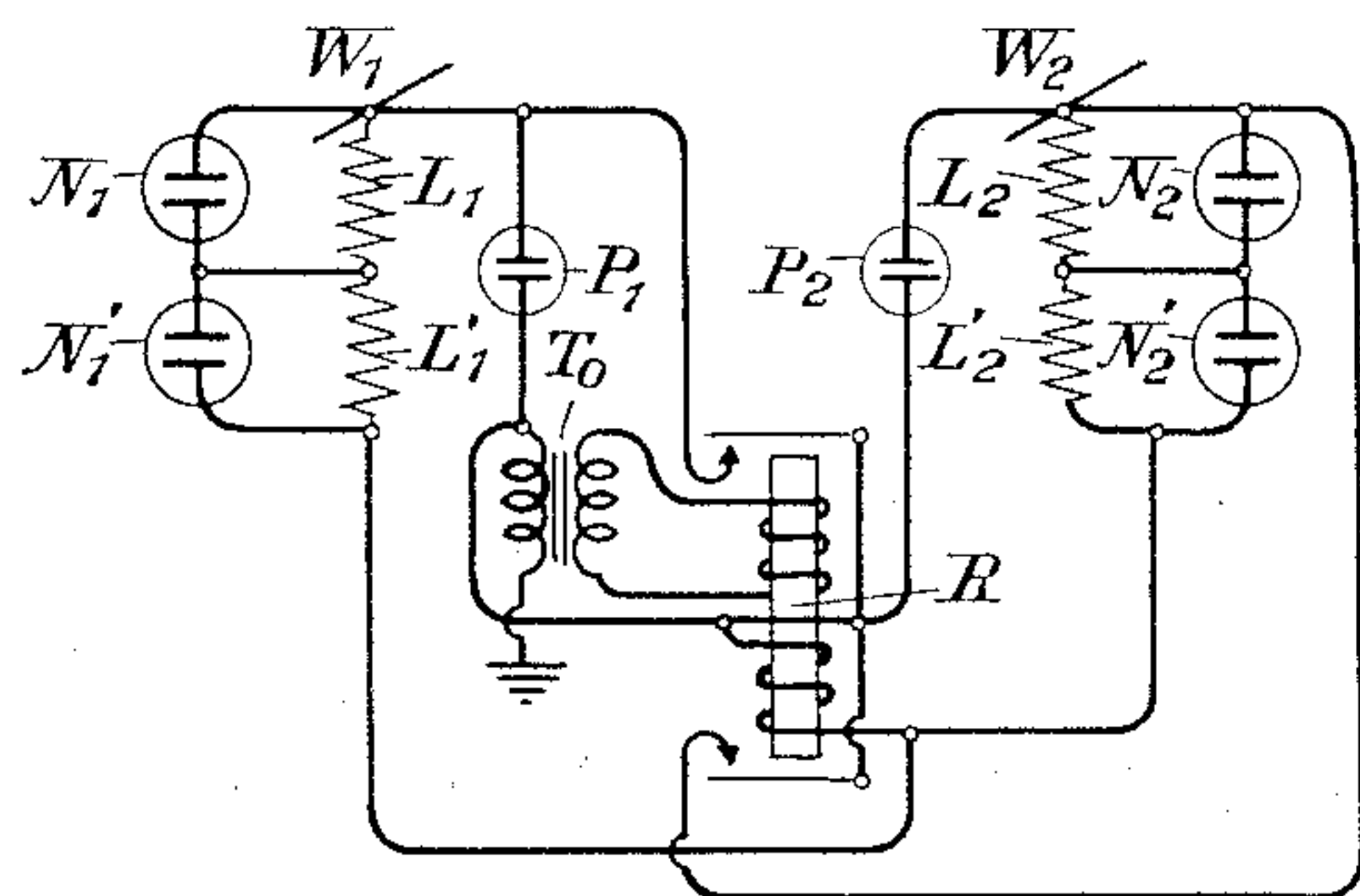


Fig. 1

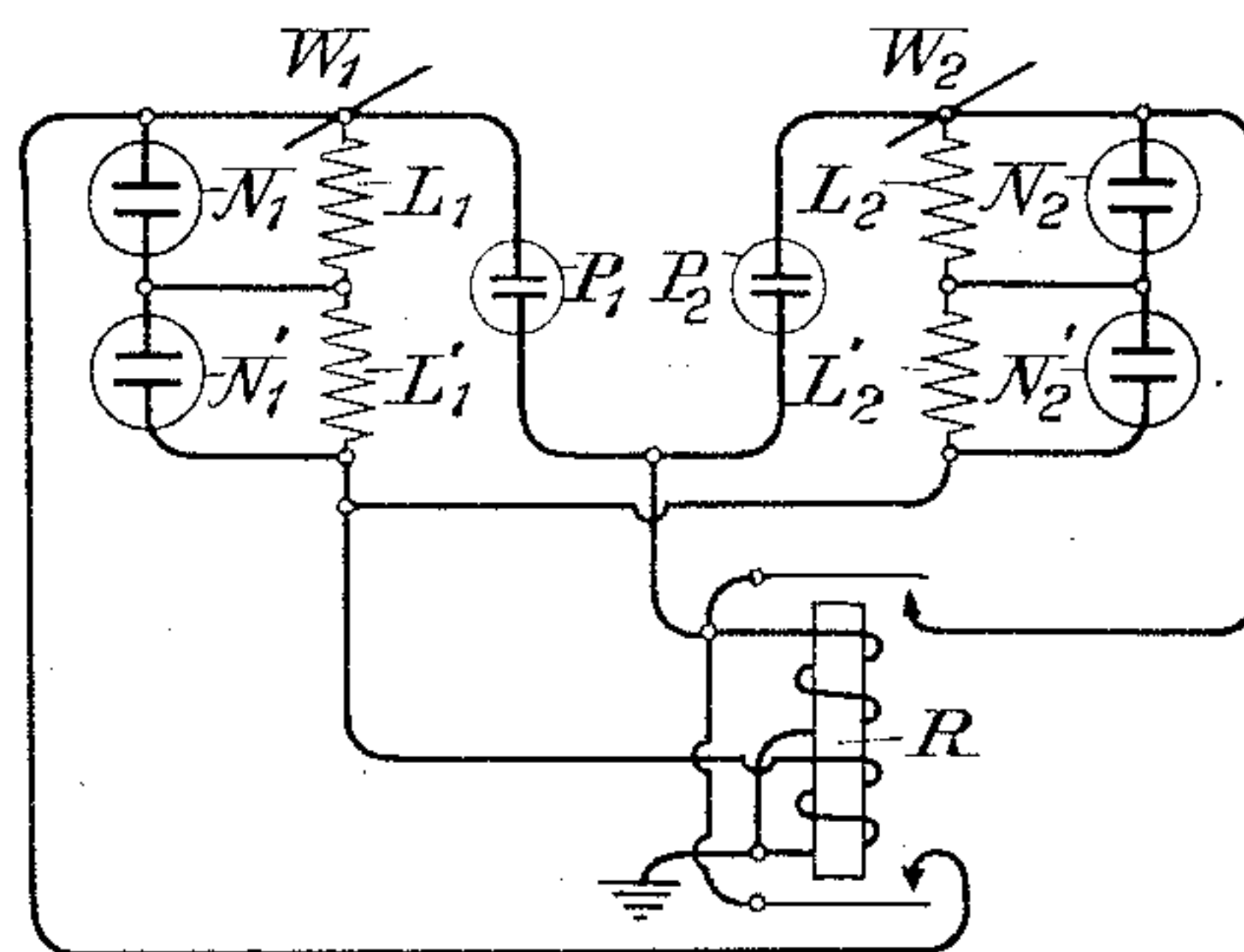


Fig. 2

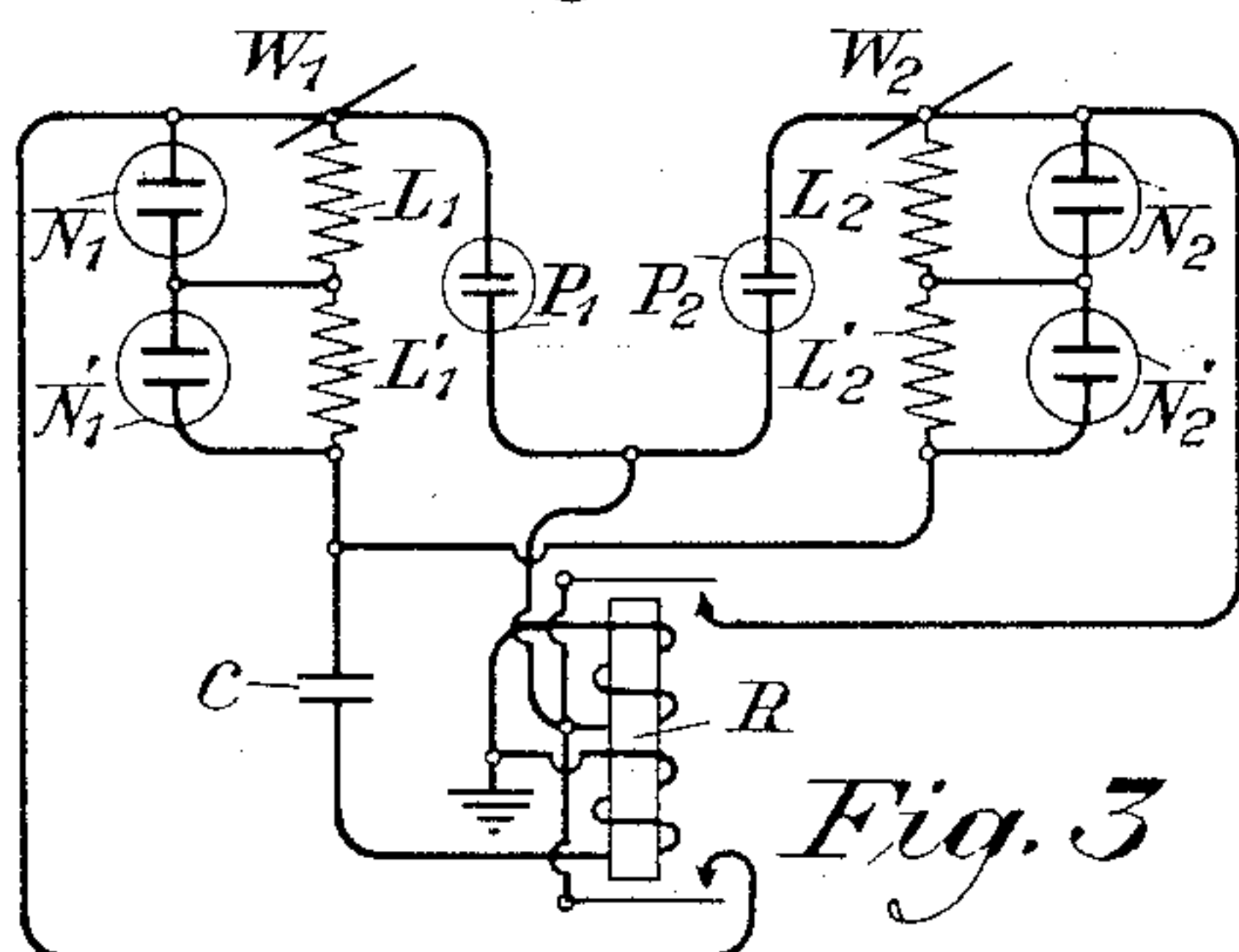


Fig. 3

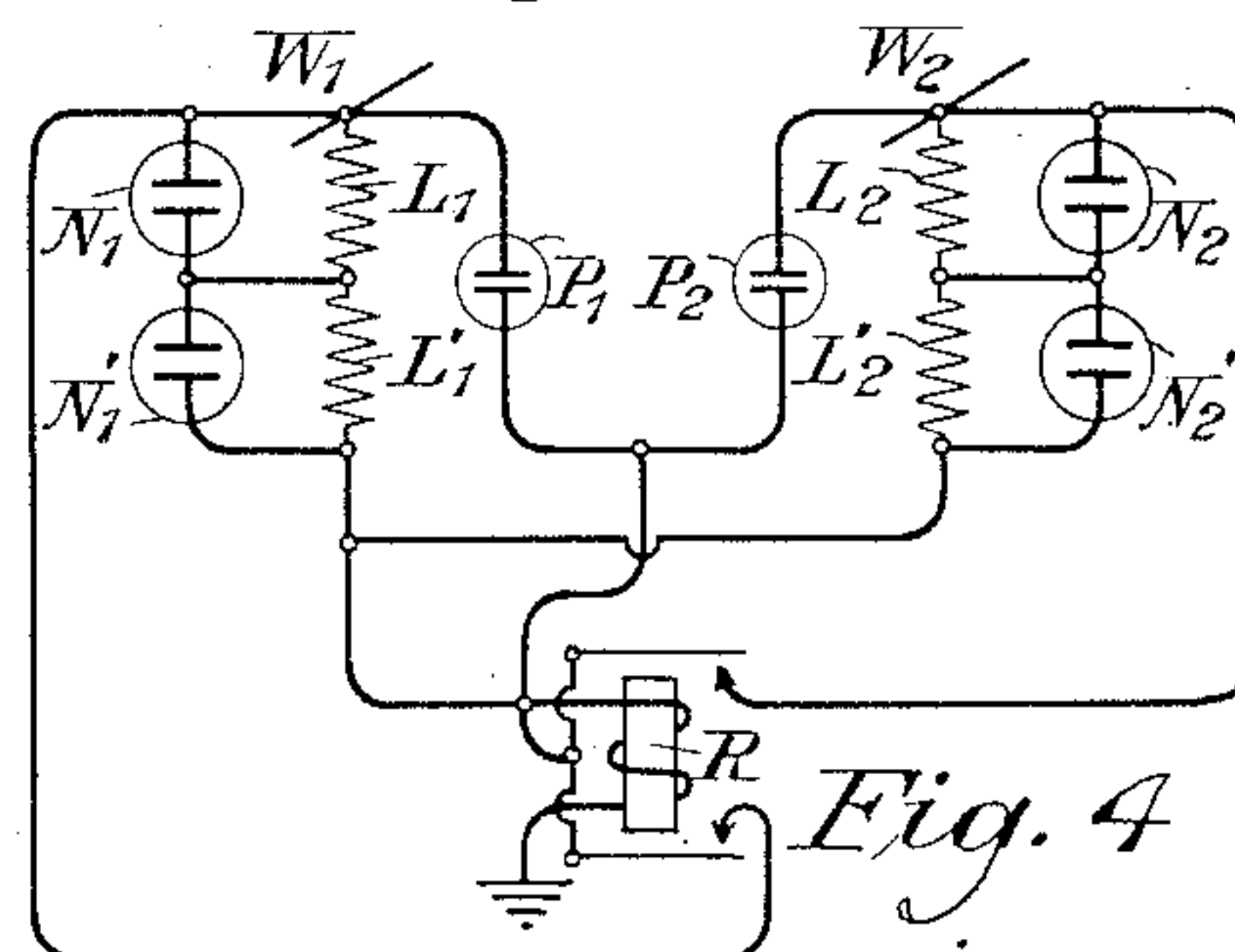


Fig. 4

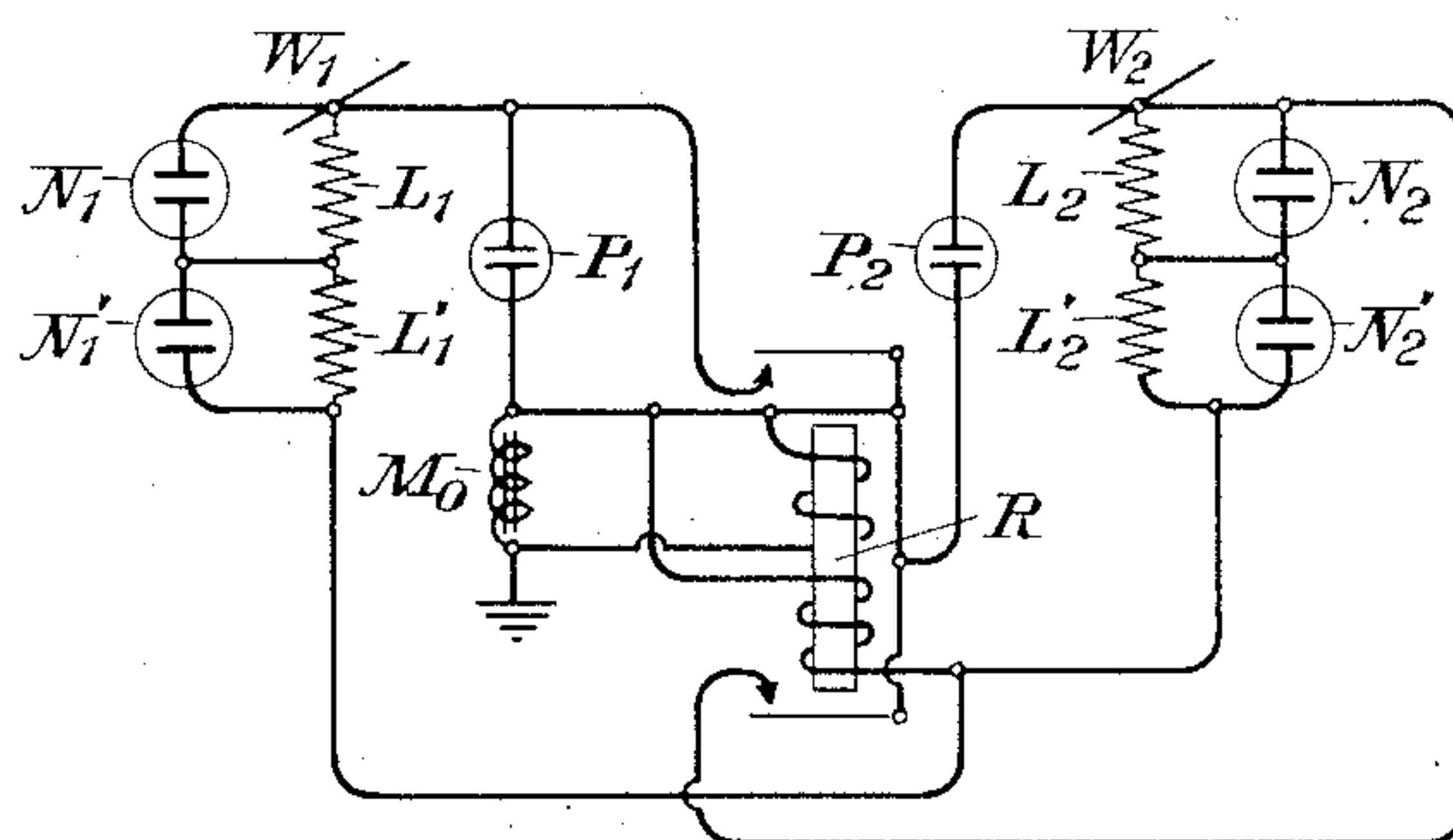


Fig. 5

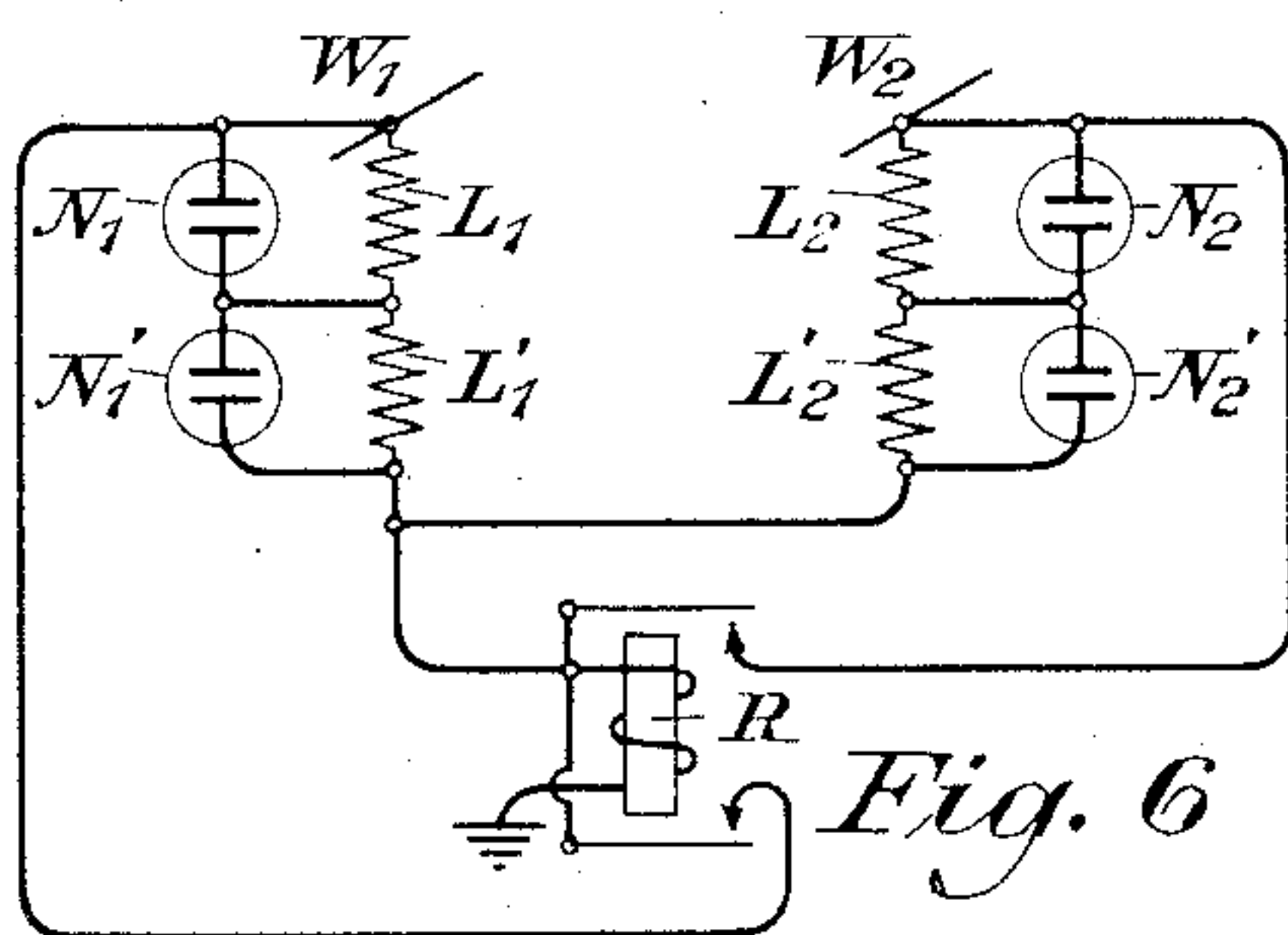


Fig. 6

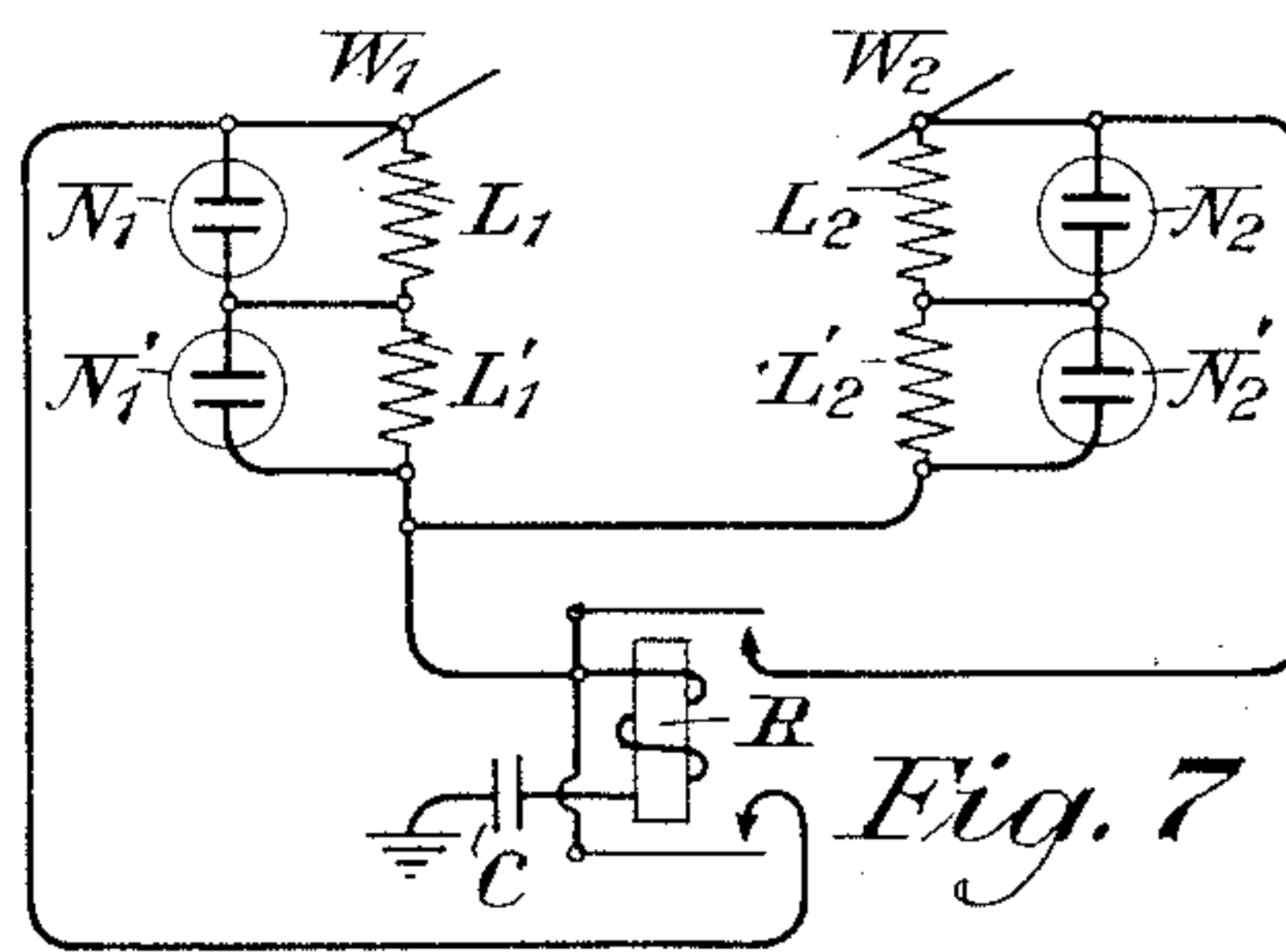


Fig. 7

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ELECTRICAL PROTECTIVE SYSTEM

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8 Claims. (Cl. 179—78)

This invention relates to electrical protective systems. More particularly, this invention relates to arrangements for simultaneously grounding a plurality of circuits when induced voltages above a predetermined value become impressed thereon. Still more particularly, this invention relates to arrangements for testing the apparatus employed in carrying out the principles of this invention.

Pairs of protector blocks, each having an air gap which breaks down at a predetermined potential, have recently been used in the telephone art for the protection of each of a number of telephone circuits from high voltages set up therein by one or more sources extraneous to the circuits themselves. In these arrangements a resistor, or saturating reactor, is interposed in the ground connection of each pair of protector blocks or in the common ground connection of all the protector blocks. This resistor or reactor, as the case may be, is designed to carry all of the operating current flowing through all of the protector blocks associated therewith.

In some of these arrangements the impedance drop across the resistor or reactor is rectified by a rectifier which may be, for example, of the copper oxide type. The rectified current is supplied to the winding of a relay which, when operated, shunts a pair of protector blocks. The rectified current is also supplied to a pilot relay which supplies local battery to a plurality of short-circuiting relays which are associated with the apparatus for the purpose of grounding all of the protector blocks against the currents which traverse these blocks during the period in which extraneous voltages are applied to one or more of the lines.

This application discloses an arrangement which employs no copper oxide rectifiers or a pilot relay. It does, however, employ a gas-filled tube which may be of the cold cathode type in which two or more electrodes, spaced from each other by a predetermined distance, are enclosed within an envelope which is filled with a gaseous medium such as neon, helium, krypton, argon or the like, or mixtures thereof. Each gas-filled tube is so designed that while it operates, its electrodes are maintained at a substantially low temperature. While each of the gas-filled tubes forming part of the arrangements set forth in this application are of the two-electrode type, it will be understood that each of these tubes may have more than two electrodes and that the electrodes need not be maintained at a substantially low temperature and that the temperature

of these electrodes may in fact be relatively high, as will be understood by those skilled in the art.

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 embodiment of this invention having a plurality of protector blocks and a plurality of gas-filled tubes and a saturating transformer; Figs. 2, 3 and 4 show modified arrangements in which the saturating choke coil or transformer has been eliminated; Fig. 5 shows an arrangement employing a saturating choke coil which is coupled to the windings of an alternating current relay; and Figs. 6 and 7 show still other arrangements which eliminate all of the various protector blocks as well as the saturating choke coils or transformers.

Referring to Fig. 1, the reference characters W_1 and W_2 represent two of a plurality of conductors which may be of the open-wire type and may be employed for transmitting signals from one place to another. The conductors W_1 and W_2 are connected to the upper terminals of protector blocks P_1 and P_2 , respectively, and the lower terminals of these protector blocks are connected to ground through the primary winding of a saturating transformer T_0 , as shown. The secondary winding of this transformer is connected to the terminals of the upper winding of a relay designated R , which may be of the alternating current type.

The conductor W_1 is connected to the upper terminal of a gas-filled tube designated N_1 , the lower terminal of which is connected in series with the electrodes of another gas-filled tube designated N_1' . Similarly, the gas-filled tubes N_2 and N_2' are connected in series with each other and to the conductor W_2 . Resistances L_1 and L_1' are connected in shunt respectively with the tubes N_1 and N_1' , while the resistances L_2 and L_2' respectively shunt the tubes N_2 and N_2' . The lower terminals of the resistances L_1' and L_2' are connected to each other and their common terminal is connected to the lower terminal of the lower winding of the relay R . The upper terminal of the lower winding of the relay R is connected to the upper terminal of the primary winding of the transformer T_0 as well as to the lower terminals of the protector blocks P_1 and P_2 .

When a voltage of sufficiently high magnitude is impressed between either of the conductors W_1 or W_2 and ground so as to cause the gas within the associated tubes to become ionized, the relay R will become operated, as will be ex-

plained hereinafter. The upper armature and contact of the relay R will then provide a circuit which will shunt the protector block P₁, and its lower armature and contact will provide a similar circuit in shunt with the protector block P₂ and therefore both of the conductors W₁ and W₂, as well as all other conductors, which are connected to similar apparatus, will be connected to ground through the primary winding of the saturating transformer T₀. The relay R will remain operated as long as any one of these conductors continues to be impressed with a voltage above the aforementioned predetermined value.

In considering the operation of this circuit, let it be assumed that a voltage is impressed between the conductor W₁ and ground which is greater than that required to break down the gaps of the series-connected tubes N₁ and N₁', but which is insufficient to break down the gap of the protector block P₁. Upon the application of the voltage just referred to, current will flow in the circuit including the conductor W₁ and the series-connected tubes N₁ and N₁', in shunt with which the series resistances L₁ and L₁' are connected, through the lower winding of the relay R, and through the primary winding of the transformer T₀ to ground. The flow of current through the primary winding of transformer T₀ will cause a substantial current to flow through its secondary winding which is connected in series with the upper winding of the relay R. The conjoint magnetizing action of the upper and lower windings of the relay R will operate this relay and cause its armatures to close their associated contacts and when this occurs, the protector blocks P₁ and P₂ and all other protector blocks connected to similarly exposed conductors, will be simultaneously shunted by circuits provided by the armatures and contacts of a plurality of relays similar to relay R. It will be understood, however, that all of the various protector blocks may be shunted by the contacts of a single relay such as relay R, which has a plurality of contacts.

Fig. 2 shows a modified arrangement which includes an alternating current relay similar to the one shown in Fig. 1, but no saturating coil or transformer is employed in this arrangement. The conductor common to the lower terminals of the protector blocks P₁ and P₂ is connected to ground through the upper winding of the relay R. The conductor common to the lower terminal of tube N₁' and resistance L₁' is connected to the conductor common to the lower terminal of tube N₂ and resistance L₂' and the conductor common to these common conductors is connected to the upper terminal of the lower winding of relay R. The lower terminal of the lower winding of relay R is also grounded.

When a voltage is impressed between one of the conductors, for example W₁, and ground, which is sufficient to ionize the gas within the associated tubes N₁ and N₁', a substantial current will flow through the lower winding of the relay R and this current will be sufficient to operate the relay R. When this occurs, the lower armature and contact of the relay R will shunt the protector block P₁, while its upper armature and contact will shunt the protector block P₂. The lower winding of the relay R will remain energized sufficiently to maintain its contacts closed as long as the voltage applied to the conductor W₁ is sufficient to ionize the gas within the tubes N₁ and N₁'.

In the arrangements of both Figs. 1 and 2, the relay R will be operated if the voltage applied to any one of the conductors, for example W₁ or W₂, is sufficient to break down the gap of any one of the associated protector blocks. In Fig. 1 the energization of the upper winding of the relay R will be sufficient to maintain that relay continuously operated as long as the induced voltage remains effective upon any one of the various exposed conductors. In Fig. 2, however, the breakdown of the gap of any one of the protector blocks such as P₁, will cause a large current to flow in the circuit which includes conductor W₁, the protector block P₁, the upper winding of the relay R and ground. This current will be sufficient to operate the relay R and therefore provide circuits for simultaneously shunting all of the various protector blocks such as P₁ and P₂.

Fig. 3 illustrates a further modification of this invention. Here the conductor common to the lower terminals of tubes N₁' and N₂' and resistances L₁' and L₂' is connected in series with a condenser C and the lower winding of the relay R. This arrangement operates in a manner similar to the manner in which the arrangement of Fig. 2 operates, and therefore the description of its operation need not be repeated. However, the condenser C is connected in series with the lower winding of the relay R for the purpose of preventing the operation of the relay R as a result of the application of direct current voltages to any one of the associated exposed conductors W₁ and W₂, these direct current voltages being normally applied to these various exposed conductors in the normal service thereover. Thus the gas within the tubes N₁, N₁', N₂ and N₂' will not remain ionized by virtue of the application of large direct current voltages to the conductors W₁, W₂, etc., and ground. Hence, due to the lack of persistence of ionization, the field of the lower winding of the relay R will be unable to attract the armatures of the relay R in response to the application of such direct current voltages to the various exposed conductors.

Fig. 4 illustrates a further modification of the arrangement of Fig. 2, which is one of the circuits illustrating the principles of this invention. Here the conductor common to the lower terminals of tubes N₁' and N₂' and resistances L₁' and L₂' is connected to the upper terminals of the winding of the relay R. The lower terminals of the protector blocks P₁ and P₂ are also connected to the same upper terminal of the winding of the relay R. It will be noted that the relay R has but a single winding, the lower terminal of which is grounded. It will be further noted that the lower armature and contact of the relay R provides a circuit for shunting the protector block P₁ while the upper armature and contact of this relay provide a circuit for shunting the protector block P₂.

When a voltage is impressed between any one of the conductors, for example W₁, and ground, which is sufficient to break down either the gaps of the two gas-filled tubes N₁ and N₁' or the gap between the electrodes of the protector block P₁, a large current will flow through the winding of the relay R, which is preferably of the saturating type. Its armatures will then close their associated contacts and therefore provide circuits which will simultaneously shunt all of the various associated protector blocks P₁, P₂, etc. It will be further understood that the relay R may

be of the multi-contact type, including a plurality of contacts each of which is associated with a circuit for shunting one of the various protector blocks, as will be understood by those skilled in the art.

Fig. 5 represents a modification of the arrangement shown in Fig. 1. In this arrangement the saturating transformer of Fig. 1 is replaced by a saturating coil M_0 , the lower terminal of which is grounded.

In the arrangement of Fig. 5 the upper terminal of the lower winding of relay R is connected to the upper terminal of the saturating coil M_0 . When any one of the various protector blocks, as for example P_1 , breaks down due to the application of a sufficiently high voltage to the exposed conductor W_1 , the flow of current through the coil M_0 will energize the upper coil of the relay R and cause its armatures to close their associated contacts. This will simultaneously produce circuits for shunting all of the protector blocks, as is now well understood. When the voltage applied between the exposed conductor W_1 and ground is insufficient to break down the gap of the protector block P_1 but is sufficient to break down the gaps of the two gas-filled tubes N_1 and N_1' , current will then flow through these tubes, through the lower winding of the relay R, and through the coil M_0 to ground. The potential impressed across the saturating coil M_0 will again provide a magnetizing force in the upper winding of the relay R. Therefore, the conjoint action of both coils of relay R will cause its armatures to close their associated contacts, and at the same time provide circuits in shunt with the various protector blocks.

In all of the circuits illustrated in Figs. 1 to 5 a protector block is associated with each of the various exposed conductors. This protector block may have a breakdown voltage which is different from that of the two associated gas-filled tubes. If the breakdown voltage of the protector block exceeds the voltage required to break down the combined arrangement of tubes, then it will be clear that the gaps of the gas-filled tubes may be broken down before the gaps of the protector blocks have broken down. Then the induced voltage may be sufficient to break down the gaps of the gas-filled tubes and insufficient to break down the gaps of any of the protector blocks. In all of these arrangements relay R will operate and provide circuits for shunting the various protector blocks even though the induced voltage fails to cause a breakdown in the gaps between the electrodes of any one of the protector blocks.

On the other hand, if the breakdown voltage of any one or all of the protector blocks is lower than the breakdown voltage of the associated gas-filled tubes, then it is possible to operate the relay R and simultaneously shunt all of the protector blocks even before the gaps of any of the gas-filled tubes have become broken down.

Fig. 6 is a modification of the arrangement shown, for example, in Fig. 2, but this arrangement includes no protector blocks whatever and the relay R has but one winding. The alternating current relay R will be operated as soon as the voltage applied to any one of the conductors W_1 or W_2 is sufficient to break down the gaps of the associated gas-filled tubes. The lower armature and contact of the relay R will provide a circuit for shunting the gas-filled tubes N_1 and N_1' as well as the resistances L_1 and L_1' which shunt these tubes. The principal arma-

ture and contact of the relay R will provide a circuit for shunting the gas-filled tubes N_2 and N_2' as well as the resistances L_2 and L_2' which bridge these tubes. The relay R will become continuously operated as long as the voltage applied to any one of the various exposed conductors remains applied to that conductor. Moreover, after the relay R has become operated, all of the various conductors will be connected to ground through the winding of the relay R.

Fig. 7 shows a modification of the arrangement shown in Fig. 6 but in Fig. 7 a condenser C is connected between the lower terminal of the winding of the relay R and ground. This circuit operates as does the one shown in Fig. 6, but the condenser C prevents the relay R from being operated from the direct current voltages which may be applied to any one or all of the exposed conductors.

In each of the arrangements shown in Figs. 1 to 7, two two-electrode gas-filled tubes, which may be of the cold-cathode type, have been connected in series with each other, each of which was shunted by a resistance. This arrangement is by no means necessary. The two tubes and their associated resistances may be replaced by a single two-electrode tube, without a shunt resistance. This single two-electrode tube, without any shunt resistance, may be connected in place of the two tubes and their resistances, in a manner which will be understood by those skilled in the art.

It will be further understood that the two two-electrode tubes and their associated parallel resistances may be replaced by three or more tubes which are connected either in series with each other, or in a series-parallel combination, as will be understood by those skilled in this art. In any of these arrangements a resistance of properly selected magnitude may be connected in shunt with any one or several of the various tubes.

The resistances L_1 and L_1' , which, for example, are connected in parallel with the tubes N_1 and N_1' , respectively, are preferably of comparatively large magnitude but low as compared to the leakage resistance between elements of the tubes which they parallel. These resistances are moreover proportioned to the open circuit breakdown voltage between the elements of the tubes which they shunt.

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 without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Apparatus for the protection of an exposed conductor comprising a gas-filled tube having two electrodes, a resistor in shunt with said tube, a relay having a winding permanently connected in series with the gas-filled tube between the exposed conductor and ground, and means responsive to the operation of said relay for providing a path in shunt with the gas-filled tube.

2. Apparatus for the protection of an exposed conductor against inductive effects, comprising a two-electrode gas-filled tube, an alternating current relay and a condenser which is connected in series with the winding of the relay and the gas-filled tube between the exposed conductor

and ground, the armature and contact of said relay providing a circuit in shunt with the gas-filled tube.

3. Apparatus for the protection of a plurality of exposed conductors comprising a plurality of gas-filled tubes, each of which is associated with one of the exposed conductors, an alternating current relay having a winding one terminal of which is connected in common with said gas-filled tubes and the other terminal of which is grounded, the armatures and contacts of said relay providing circuits which individually shunt each of said gas-filled tubes, and means for preventing the operation of said relay in response to direct currents.

4. Apparatus for the protection of an exposed conductor comprising an alternating current relay having two windings, one terminal of each of which is grounded, a protector block which is connected between the exposed conductor and the ungrounded terminal of one of the windings, and a gas-filled tube of the two-electrode type which is connected between the exposed conductor and the ungrounded terminal of the other winding of said relay.

5. Apparatus for the protection of a plurality of exposed conductors comprising a plurality of protector blocks, each of which is connected to one of the exposed conductors, a two-winding alternating current relay, one terminal of each of said windings being grounded, the ungrounded terminal of one of the windings being connected in common with all of the protector blocks and a gas-filled tube connected between one of the exposed conductors and the ungrounded terminal of the other winding of said relay, and means responsive to the operation of said relay for providing circuits for simultaneously shunting all of the protector blocks.

6. Apparatus for the protection of an exposed

conductor comprising an alternating current relay having two windings, one terminal of each of which is grounded, a gas-filled tube having two electrodes, a condenser connected in series with the gas-filled tube between the exposed conductor and the ungrounded terminal of one of the windings of said relay, and a protector block connected between the exposed conductor and the ungrounded terminal of the other winding of said relay, said relay having an armature and contact which provide a circuit for shunting the protector block.

7. Apparatus for the protection of an exposed conductor comprising an alternating current relay, one terminal of the winding of which is grounded, a pair of multi-electrode gas-filled tubes which are connected in series with each other between the exposed conductor and the ungrounded terminal of the winding of said relay, a pair of resistors each connected in shunt with each of said gas-filled tubes, and means responsive to the operation of said relay for connecting the exposed conductor to ground through the winding of said relay.

8. Apparatus for the protection of a plurality of exposed conductors comprising an alternating current relay, a condenser which is connected between ground and one of the terminals of the winding of said relay, a plurality of gas-filled tubes individual to each exposed conductor, said gas-filled tubes being connected in series with each other between each corresponding exposed conductor and the ungrounded terminal of the winding of said relay, and a resistance connected to each exposed conductor, each resistance shunting the corresponding gas-filled tubes, said relay having a plurality of contacts, each of which provides a circuit for shunting the gas-filled tubes associated with each of the various exposed conductors.

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