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L. K. SWART

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ELECTRICAL PROTECTIVE SYSTEM

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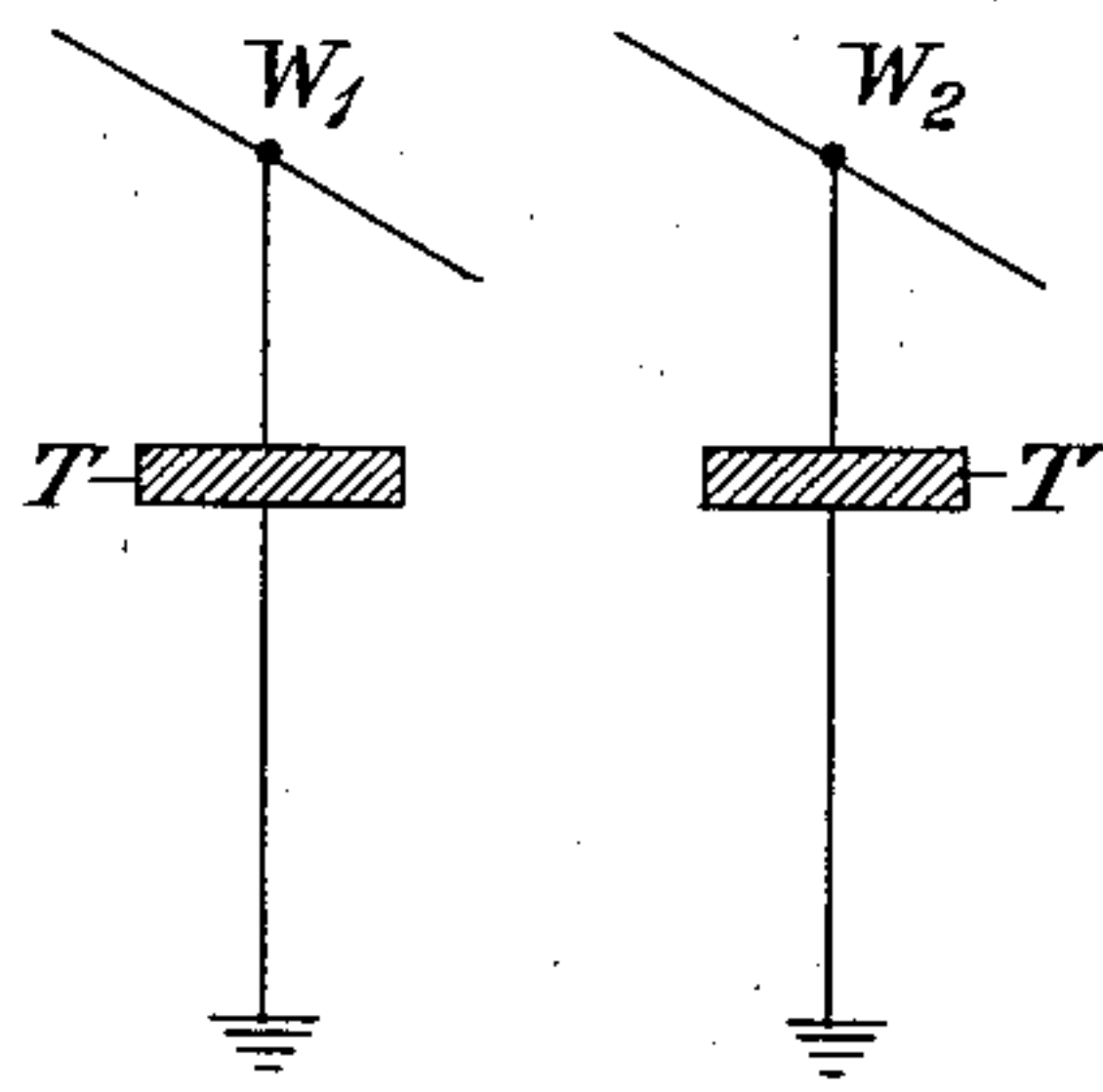


Fig. 1

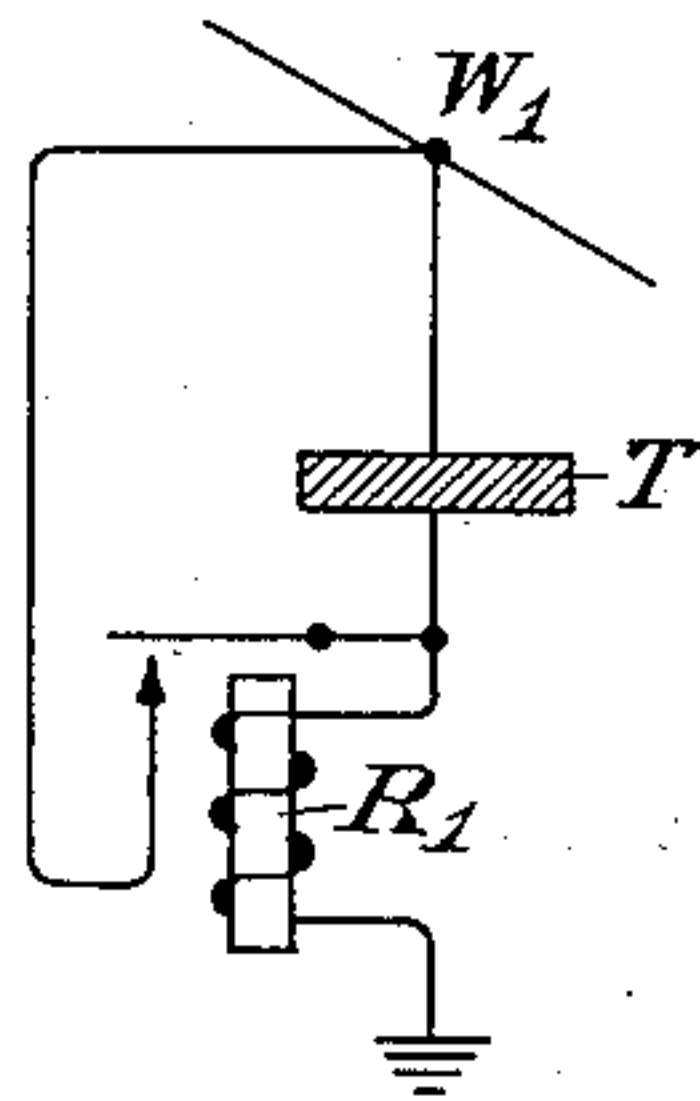


Fig. 2

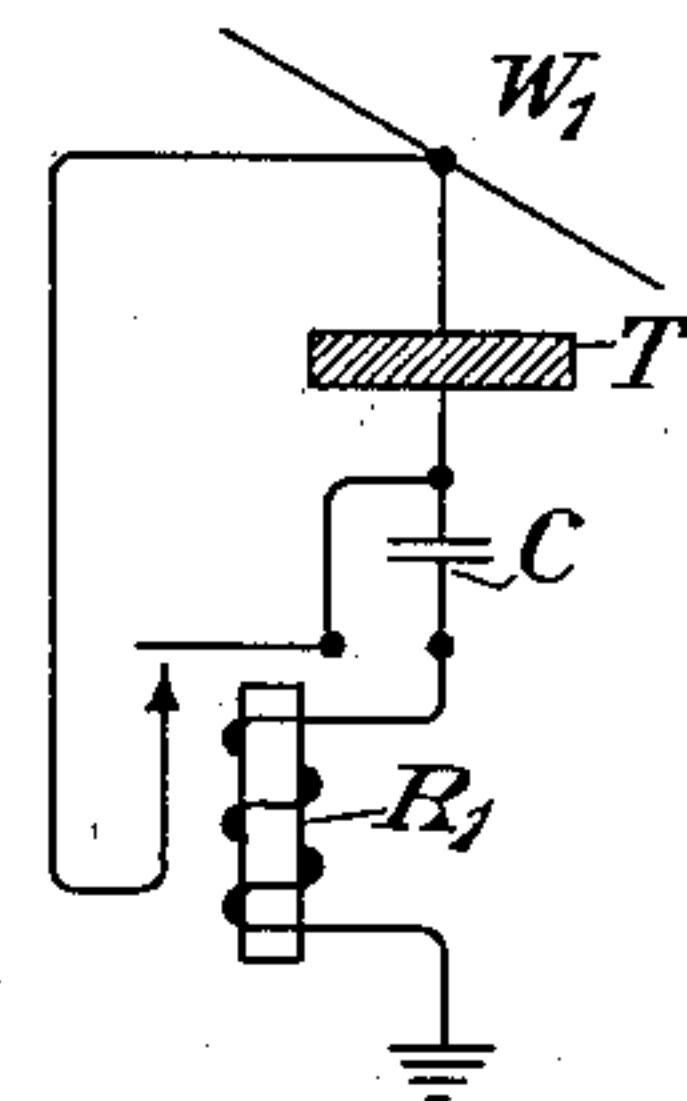


Fig. 3

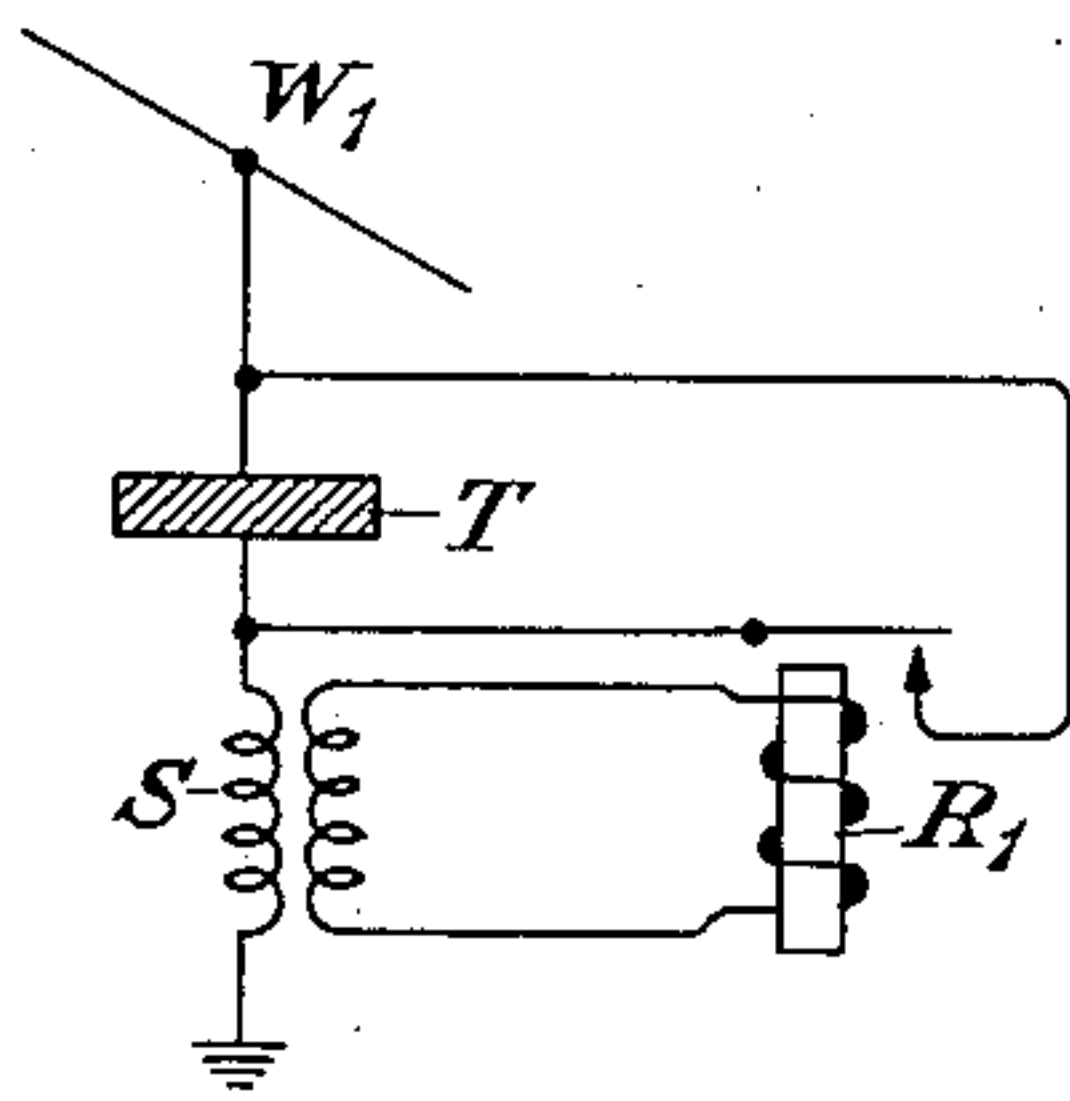


Fig. 4

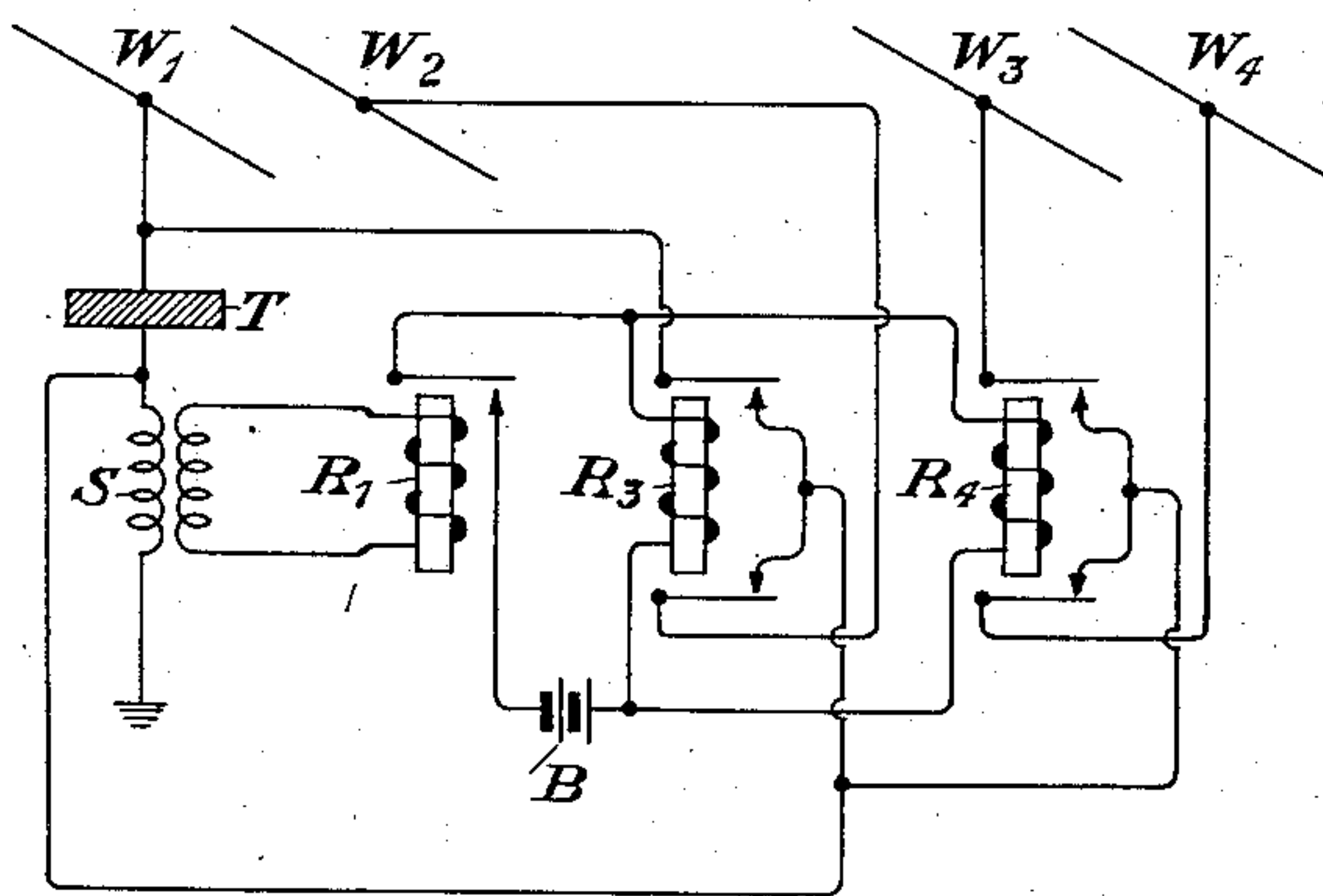


Fig. 5

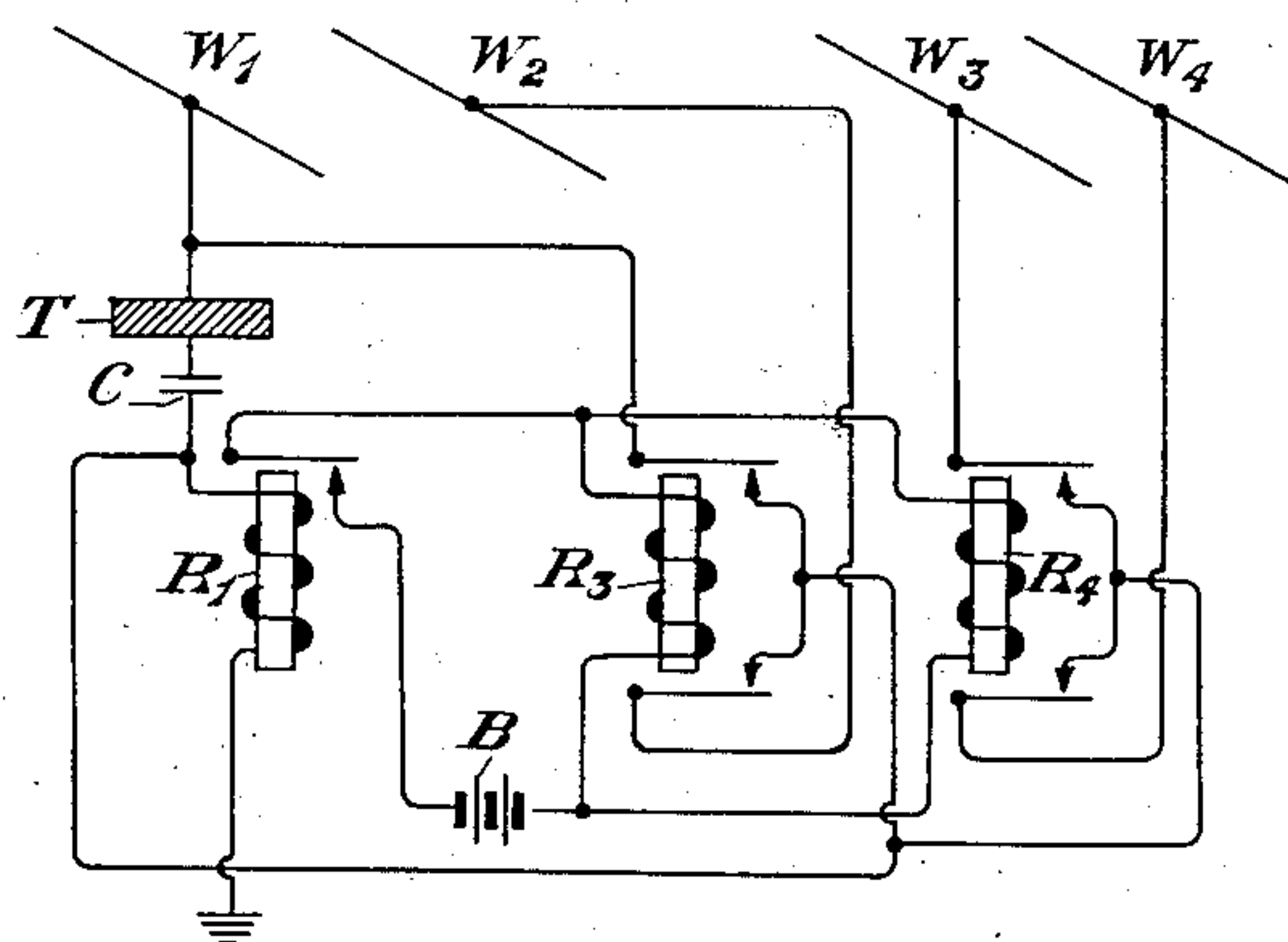


Fig. 6

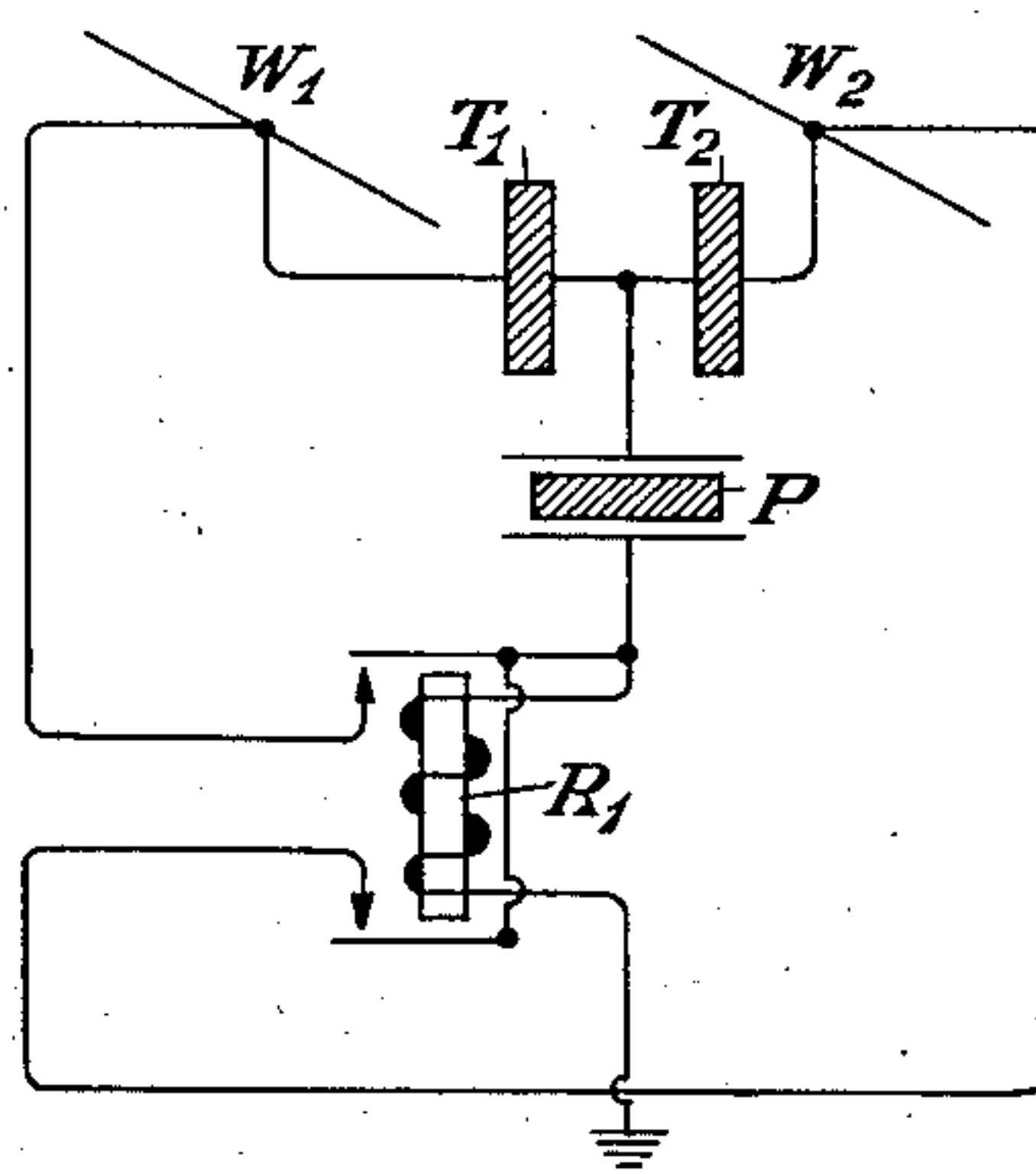


Fig. 7

INVENTOR
L. K. Swart
BY *g. y. for*
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRICAL PROTECTIVE SYSTEM

Leland Kasson Swart, Mountain Lakes, N. J.,
 assignor to American Telephone and Tele-
 graph Company, a corporation of New York

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9 Claims. (Cl. 179—78)

This invention relates to electric protection systems. More particularly, this invention relates to arrangements for reducing or eliminating the possibilities of acoustic shock on open-wire lines or other lines or circuits and for simultaneously grounding a plurality of lines or circuits when induced voltages become impressed thereon.

Previously, signal circuits have been protected by the use of protector blocks each having an air gap which breaks down approximately at a predetermined potential. In some cases these blocks have been protected by the use of relays which were designed to prevent a permanent closure of the air gap in each of the protector blocks. This was done for the reason that each protector block, if its air gap were closed, would temporarily destroy the usefulness of the associated signal circuits by grounding them.

However, where signal circuits are protected by protector blocks, several disadvantages have been found to occur. For instance, upon the breaking of the gaps of the protector blocks, unequal voltage drops were developed which in turn set up in the metallic circuits substantial voltages which appeared as acoustic shocks in the telephones or other translating devices associated therewith. Furthermore, carbon block protectors, and open space protectors of other designs, after being subjected to a number of break-down operations, built up surplusage material on one side of the protector block, which in due course reached the other side of protector block and thus closed the space therebetween, causing permanent grounding of the device and consequent outage of the circuit or circuits to which they were connected.

This invention is intended to provide a protective system for a plurality of conductors or circuits which will be of simple construction and free from the difficulties mentioned hereinabove. One of the features of this invention lies in the employment of a protective material of non-linear voltage-current characteristics such that voltages from signal circuits to ground may be reduced to a low value, the higher the potential existing between the signal circuits and ground the greater the current which will flow from the circuits to ground. The characteristic desired is a rapid reduction in impedance for a small increase in potential applied across the material. Materials which have been found to provide this desirable characteristic are thyrite, carborundum and certain other refractory materials.

The material commercially known as thyrite

has for some time been known in the electrical art. Its physical properties and some of its applications are described by T. Brownlee, General Electric Review, vol. 37, No. 4, April, 1934, pages 175 et seq. It is similar in appearance and in mechanical properties to porcelain but has the further property of rapidly changing in resistance inversely with the voltage applied thereto. The current through an element of thyrite has been found to increase very rapidly with increase in voltage, and vice versa. The existing relations may be expressed as follows:

$$I = KE^{3.57}$$

In this expression I represents the current, E the applied voltage and K a constant. From this expression, it will be seen that the impedance of the element will be reduced to approximately one-twelfth of its value for each doubling of the voltage and this range of impedance change is practically unlimited. The inherent property of this element, by which its impedance changes in accordance with the applied voltage, or any equal element or structure, may be employed for carrying out the principles of this invention which will be described hereinafter.

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 a plurality of lines each connected to ground through a thyrite element; Figs. 2, 3 and 4 show other arrangements for grounding individual lines through thyrite elements, each of these arrangements employing a quick-acting relay, and Figs. 5, 6 and 7 show other arrangements for simultaneously grounding a plurality of lines through thyrite elements.

In Fig. 1 of the drawing, the reference characters W_1 and W_2 represent a plurality of conductors, lines or circuits which are to be connected at suitable intervals to ground, or to each other, by means of a non-linear voltage-current characteristic material, such, for example, as thyrite, each such element being designated T. As voltages increase across the material or element T, currents passed to earth from either or both of the conductors W_1 or W_2 will be rapidly increased. A sample of thyrite, 3 inches in diameter and $\frac{1}{8}$ of an inch thick, with 2 volts applied between the signal circuits and ground, will present an impedance from each signal circuit to ground of approximately 10 megohms. For a potential of 10 volts, the impedance to ground will be approximately 120,000 ohms, for

a still higher voltage, as, for example, 100 volts, the impedance to ground will be about 224 ohms and for example an applied voltage of 1000 volts, the impedance to ground will be approximately one-half an ohm. Thus, it will be seen that where the signal circuits have induced voltages to ground of several hundred or more volts, the impedance to ground at the point of application of the thyrite protectors T will be very low. The impedance drop in the circuits W₁ and W₂, therefore, will be largely in the lines themselves, or in the grounds to which the thyrite elements are connected, instead of being applied to the apparatus to be protected. Thus, the apparatus to be protected will not be subjected to the effects of such induced voltages and these induced voltages will be unable to damage or destroy the apparatus. Furthermore, the personnel working on or maintaining the apparatus will not be shocked by these induced voltages.

Where the signal circuits W₁ and W₂ are of like impedance, as is generally the case, the current passed to earth through identically manufactured thyrite discs will be the same and the voltage induced in the metallic circuits will therefore be of small magnitude and hence the interference, to service or acoustic shock will be of small order and practically harmless to those who may be using the circuits at the time. Furthermore, since there is no gap which may be bridged by the building up of metal or other material, as is the case in arrangements employing open-spaced protector blocks, the circuits will not be rendered inoperative even after a very large and unlimited number of applications of voltage have occurred.

It has been found however, in work with thyrite, that when the material has been subjected to very high currents for any great length of time, such that substantial temperature changes take place in the material, its characteristics permanently change. In order to reduce this disadvantage to a minimum and enable thyrite to be used with constant and predetermined characteristics as a protective means for signal circuits, the arrangement of Fig. 2 has been devised. This arrangement discloses a method of protecting the protective material T by means of a quick-acting alternating current relay R₁, such that the current passing through the thyrite element to ground, when of sufficient magnitude, will cause the operation of the alternating current relay R₁. The armature and contact of relay R₁ short-circuit the thyrite element T in a very short period of time, thereby protecting the thyrite element against heavy currents except during the very brief space of time required to operate the relay R₁.

Where it is desired to avoid any possibility of the relay R₁ being held operated by direct current, voltages applied to the line W₁, a condenser C may be introduced in series with the thyrite element T and the winding of the alternating current relay R₁, as shown in Fig. 3. In this arrangement, the relay R₁ may, of course, be any form of quick-acting alternating current relay and the condenser C is preferably one of large capacity. In the arrangement shown in Fig. 3, the operation of relay R₁ will cause the armature and contact of that relay to shunt the thyrite element T. The presence of the condenser C in series with the winding of the relay R₁ will prevent direct current voltages from maintaining the relay R₁ in operated condition.

In Fig. 4, W₁ again represents the signal cir-

cuit or line, T the protective material having the desired non-linear voltage-current characteristic, S a transformer preferably of the saturating type and R₁ the alternating current relay, the armature and contact of which, when the relay is operated, short-circuit the protective material T. In Fig. 4, the presence of direct current voltages cannot cause the operation of relay R₁, nor can such voltage maintain that relay in operated condition even though the current required to operate relay R₁ be very small.

In some cases it is desirable that a multiplicity of signal circuits, such as W₁, W₂, W₃ and W₄ be protected, but that only one of the signal circuits be provided with the protective material and other apparatus, such as a transformer, etc., required for protection. One of the signal circuits, for example, W₁, will act as a pilot circuit to cause operation of a so-called master relay R₁, preferably of the alternating current type, which will cause operation of additional relays R₃ and R₄ to short-circuit all of the signal circuits to each other or to ground.

The current required to operate relays R₃ and R₄ will be supplied by battery B in parallel to the windings of the relays R₃ and R₄ through the armature and contact of relay R₁. It will be apparent that the contacts of the relays R₃ and R₄ respectively, short-circuit the signal circuits W₁ and W₂ and W₃ and W₄ to ground through the primary winding of the saturating transformers.

Fig. 6 shows another arrangement for simultaneously grounding a plurality of signal circuits such as W₁, W₂, W₃ and W₄ when an induced potential exceeding a predetermined value becomes impressed upon one of these circuits, such as W₁, which may, if desired, be considered a pilot circuit. The circuit W₁ is connected to ground through the thyrite element T, the condenser C, preferably one of large capacity, and the winding of the alternating current relay R₁. Immediately after relay R₁ becomes operated, its armature and contact close a circuit which allows current from battery B to flow through the windings of relays R₃ and R₄ which are connected in parallel relationship, and both of these relays operate simultaneously. The armatures and contacts of relays R₃ and R₄ respectively, connect to ground the circuits W₁ and W₂ and W₃ and W₄, the grounded path including the winding of the relay R₁. It is to be specially noted that the arrangement of Fig. 6 includes no saturating transformer.

To obtain sharper frequency discrimination for the protection of a plurality of signal circuits, piezo-electric crystals resonant at the frequency or frequencies of interference may be employed. In Fig. 7, the reference characters W₁ and W₂ again represent signal circuits in which high voltages may be induced, T₁ and T₂ designate two thyrite protectors having non-linear voltage-current characteristics, these protectors being associated with the circuits W₁ and W₂ respectively. P designates a piezo-electric crystal resonant at the interfering frequency and connected in series with the winding of the alternating current relay R₁, the armatures and contacts of which short-circuit the protectors T₁ and T₂ and the piezo-electric crystal P, as shown. It will be noted that the upper terminal of the piezo-electric crystal P is connected to the conductor common to the thyrite elements T₁ and T₂.

It is understood that the alternating current relay may be replaced by a saturating trans-

former S, as shown in Fig. 4, or by a saturating transformer S and a master relay R₂ for operating a multiplicity of short-circuiting relays such as relays R₃ and R₄ in order to short-circuit a multiplicity of signal circuits to ground, as shown in the arrangement of Fig. 5.

While this invention has been shown and described in 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 arrangements without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Protective apparatus for a circuit transmitting signals and exposed to extraneous inductive effects comprising an element of thyrite and an alternating current relay, the winding of which is connected in series with said element between said circuit and ground so that all current traversing said thyrite element will traverse the relay winding, the armature and contact of said relay shunting said element.
2. Protective apparatus for a circuit transmitting signals and exposed to extraneous inductive effects comprising an element of thyrite, a condenser of large capacity, an alternating current relay, the winding of which is connected in series with said condenser and said element of thyrite between said circuit and ground so that all current traversing said thyrite element will traverse the condenser and the relay winding, the armature and contact of said relay shunting said element of thyrite.
3. Apparatus for the protection of a circuit transmitting signals and exposed to extraneous inductive effects comprising an element of thyrite, a saturating transformer, and an alternating current relay, the primary winding of said transformer being connected in series with said element of thyrite between said circuit and ground so that all current traversing the thyrite element will traverse the primary winding of the transformer, the secondary winding of said transformer being connected to the winding of said relay, the armature and contact of said relay being connected in shunt with said element of thyrite.
4. Apparatus for the suppression of alternating current of a predetermined frequency comprising a piezo-electric crystal having a natural period corresponding to the frequency of the current to be suppressed, and means for protecting said crystal comprising a thyrite element.
5. Protective apparatus for a signaling circuit

which is exposed to an extraneous effect of a predetermined frequency comprising a piezo-electric crystal having a natural period corresponding to the frequency of the induced effect, and means for protecting said crystal comprising a thyrite element.

6. Protective apparatus for the signal conductor exposed to an extraneous effect of a predetermined frequency comprising an element of thyrite, a piezo-electric crystal having a natural frequency of vibration equal to that of the extraneous induced effect, and an alternating current relay, the winding of which is connected in series with said crystal and said element of thyrite between the signaling circuit and ground, the armature and contact of said relay being connected in shunt with said element of thyrite and said crystal.

7. Protective apparatus for two signaling circuits exposed to extraneous inductive effects comprising two elements of thyrite connected in series with each other between said signaling circuits, a piezo-electric crystal, and an alternating current relay having two armatures and two corresponding contacts, said crystal and the winding of said relay being connected in series with each other between the conductor common to said elements of thyrite and ground, each of the armatures of said relay and its associated contact shunting one of said elements of thyrite and said crystal.

8. Apparatus for protection of a signaling circuit against an induced effect of a predetermined frequency comprising a piezo-electric crystal having a natural frequency equal to that of the induced effect, and an element connected in series with said crystal between the signaling circuit and ground, said element varying in impedance inversely with respect to the voltage of the induced effect.

9. Apparatus for the protection of a signaling circuit exposed to an inductive effect of a predetermined frequency comprising an element of thyrite, a piezo-electric crystal having a frequency of vibration equal to that of the induced effect, said crystal being connected in series with said element of thyrite between the signaling circuit and ground, and means comprising a relay, the winding of which is connected to said element of thyrite for said crystal and preventing excessive current from flowing therethrough for a substantial period of time, the armature and contact of said relay shunting said element of thyrite and said crystal.

LELAND K. SWART.