Oct. 19, 1937. L. K. SWART 2,096,143

ELECTRICAL PROTECTIVE SYSTEM

Filed Aug. 1, 1936

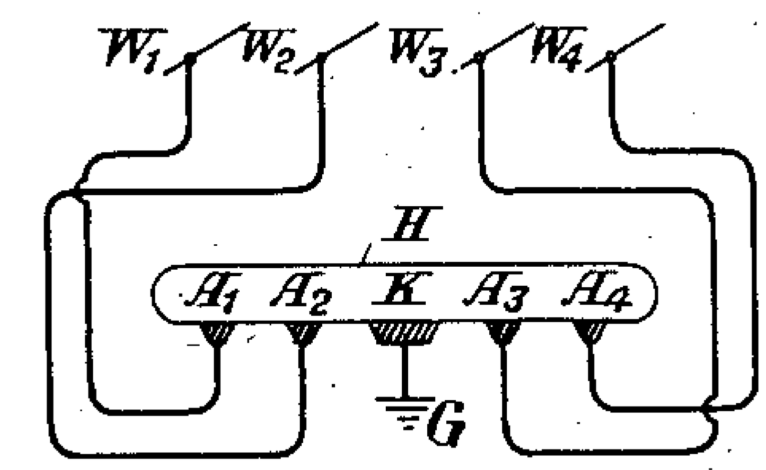

Fig. 1

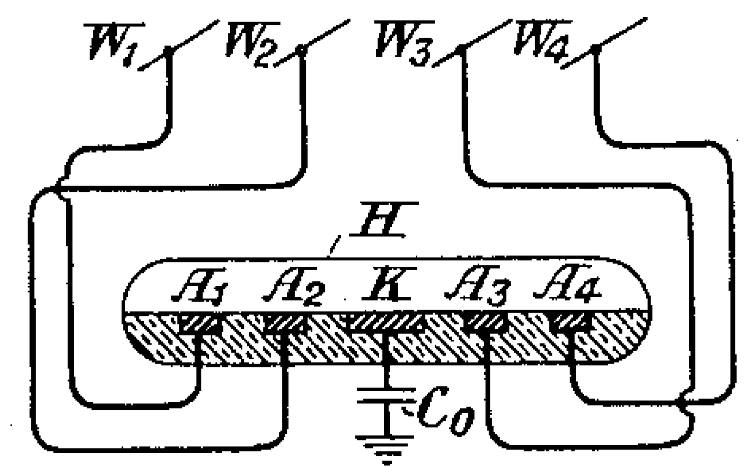

Fig. 2

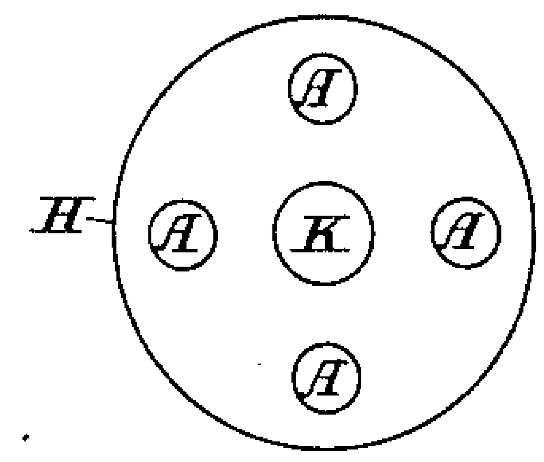

Fig. 3

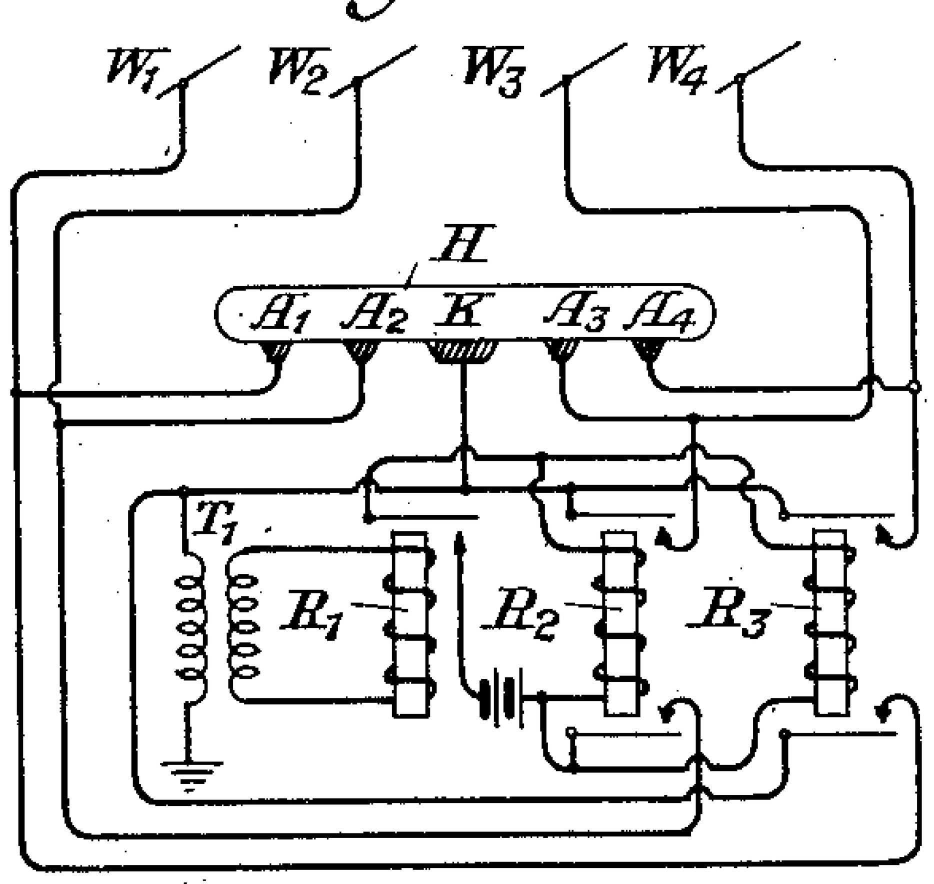

Fig. 4

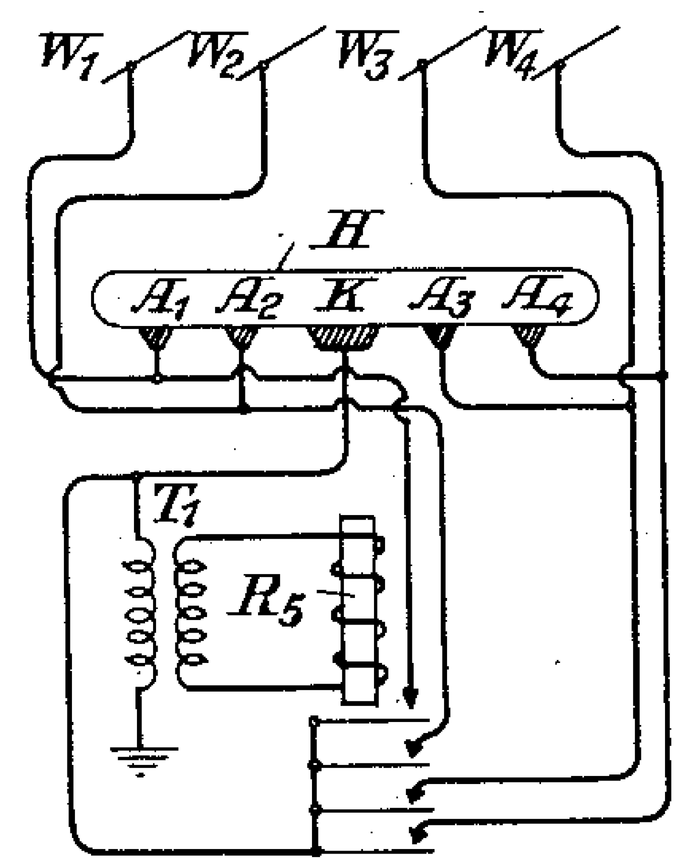

Fig. 5

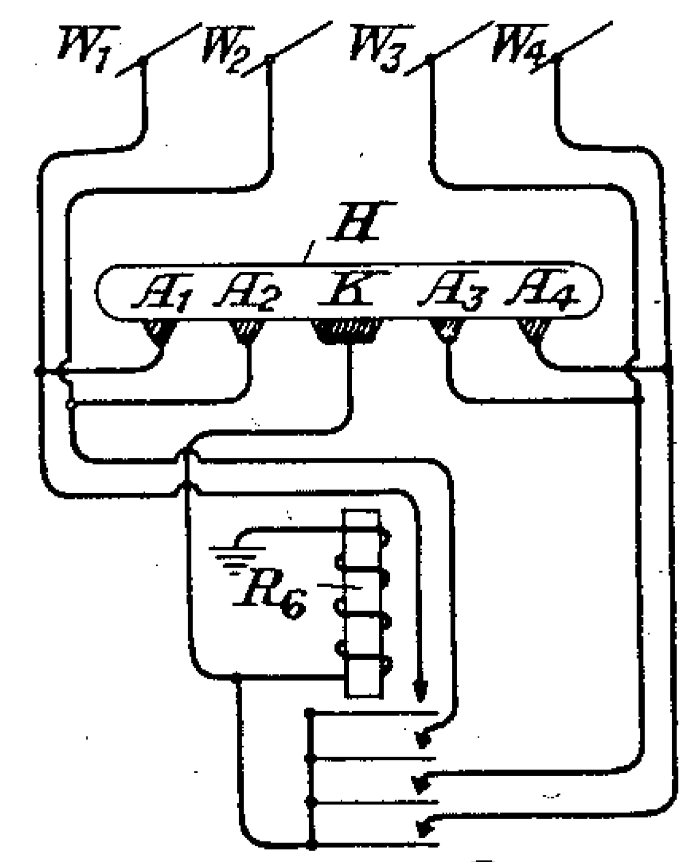

Fig. 6

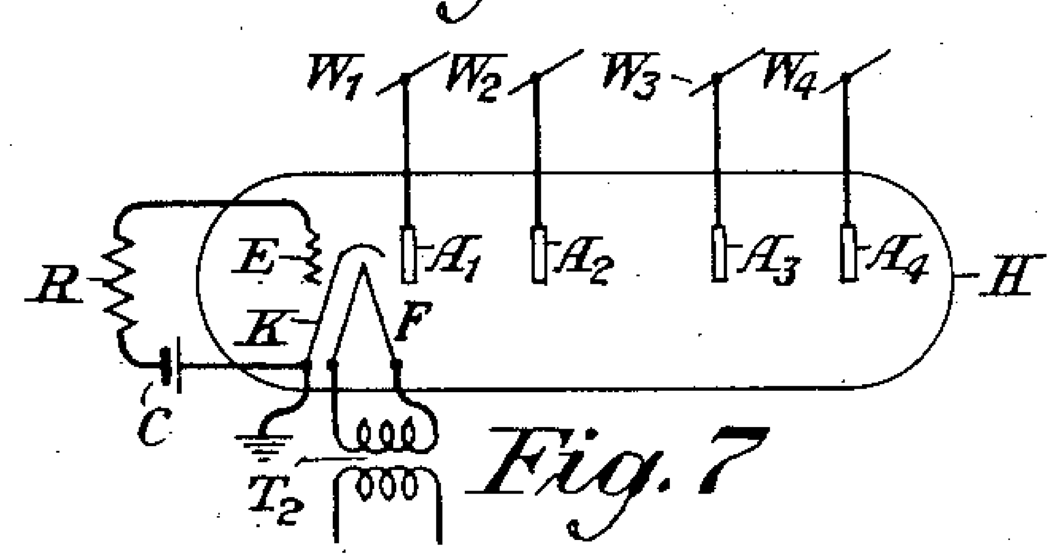

Fig. 7

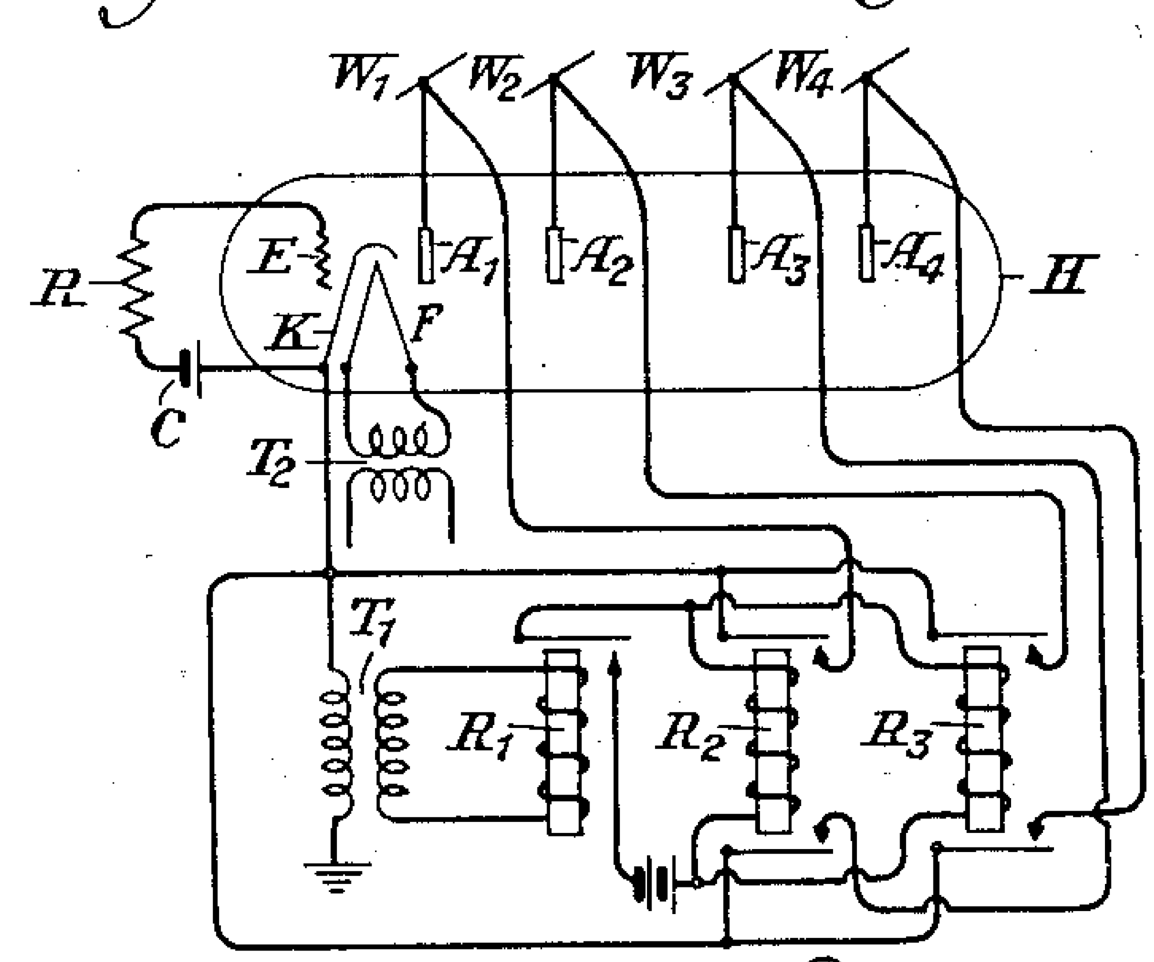

Fig. 9

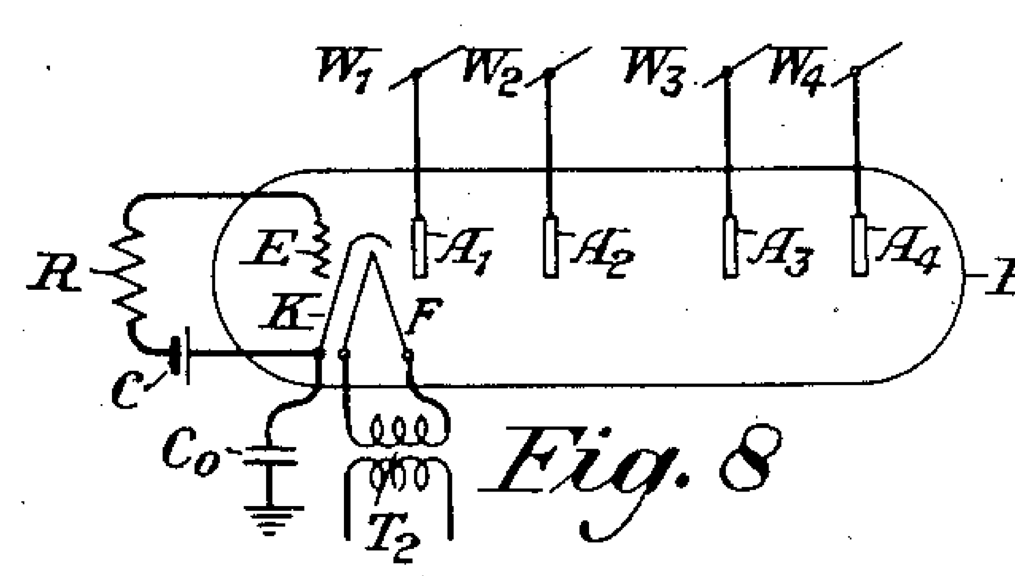

Fig. 8

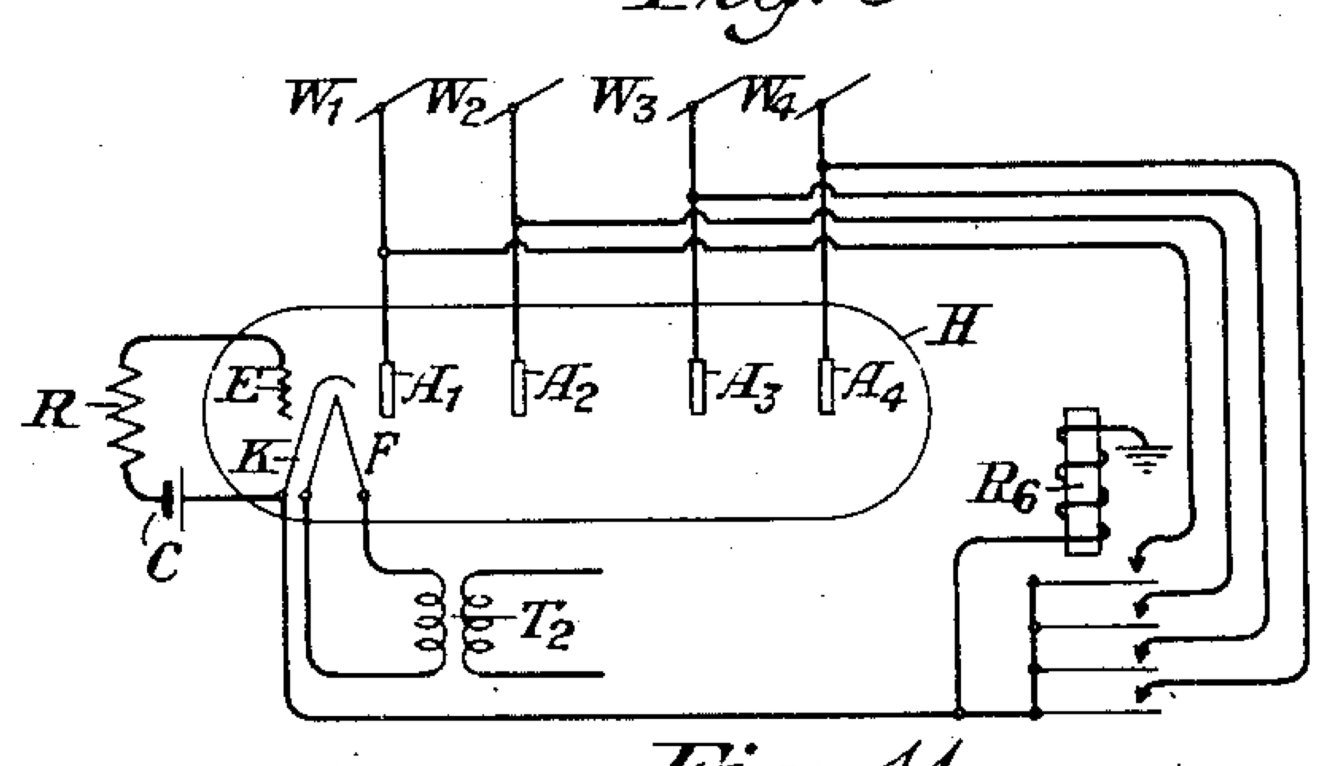

Fig. 11

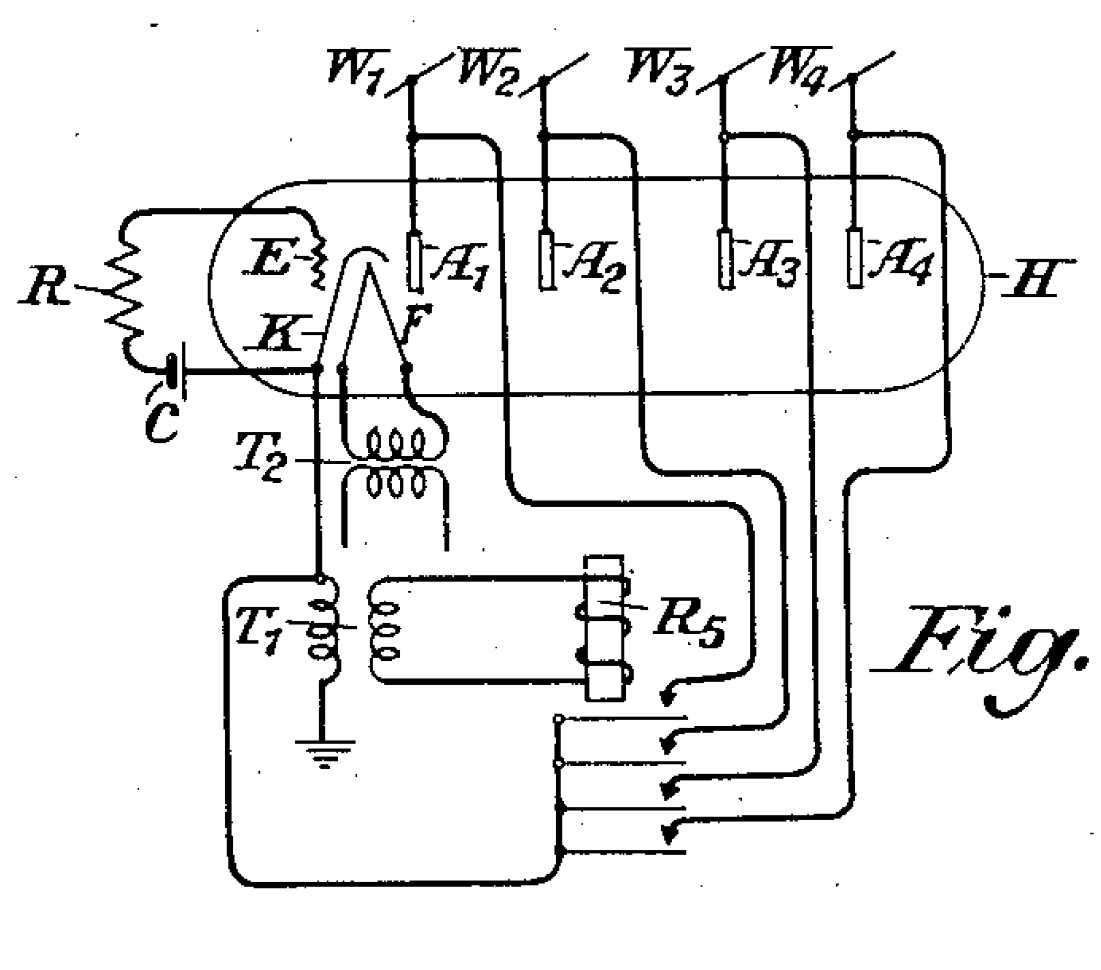

Fig. 10

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ELECTRICAL PROTECTIVE SYSTEM

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Application August 1, 1936, Serial No. 93,911

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 cable lines or other circuits, and for simultaneously grounding a plurality of lines or circuits when excessive induced and other disturbing 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. However, when signal circuits are protected by this standard form of protector blocks, several disadvantages have been found to occur. For instance, upon the breaking of the gaps of one or more of the protector blocks, unequal voltage drops may be developed which in turn set up in the metallic circuits substantial voltages which appear 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 breakdown operations, build up surplusage material on one side of the protector block, which in due course reaches the other side of the block and thus closes the space therebetween causing permanent grounding of the device and consequent inoperativeness of the circuit or circuits to which they are connected.

This invention has for its purpose the attainment of a protective system which gives a greater reliability of operation than formerly, a shorting of all the circuits involved, and immediate restoration of all circuits when the disturbing voltages have been dissipated, a freedom from high maintenance cost and a long life. This is accomplished by the replacement of former devices of uncertain characteristics by a device of a definite breakdown voltage, the behavior of which is substantially independent of the number of times of operation and which is fully self-restoring. The device contemplated for use in this invention is also one in which the voltage of breakdown can be determined reliably beforehand in its manufacture, or which can be adjusted from time to time, as desired, after installation.

The invention will be better understood by reference to the following specification and the accompanying drawing, in which Figure 1 shows my new protective circuit connected for operation in a simple manner. Fig. 2 shows a similar circuit diagram adapted for lines normally subjected to reasonably high direct current signaling voltages. Fig. 3 shows the relative position of the plurality of electrodes in such a protective device as is shown in Figs. 1 and 2. Figs. 4, 5 and 6 show protective systems embodying my protective device supplemented by relay circuits which will short circuit the primary protective device under certain circumstances. Figs. 7 and 8 show a different form of protective device arranged in circuits in a manner analogous to those of Figs. 1 and 2. Figs. 9, 10 and 11 are modified circuits related to the circuit of Fig. 7 in the same manner that Figs. 4, 5 and 6 are related to Fig. 1.

Referring more specifically to Fig. 1, there is shown a communication system comprising circuits or transmission lines W_1, W_2, W_3, W_4, which lines are subject to excessive disturbing voltages from time to time. An insulating containing tube H, which may be of glass, or other suitable materials, contains a plurality of electrodes here shown as mercury pools A_1, A_2, A_3, A_4, or pools of other materials which are readily vaporizable, each connected to one of the wires or circuits to be protected. In addition, the vessel H contains another electrode K, preferably a mercury pool and of larger area, which electrode is connected to ground at G. The tube H is at least partially evacuated, and may, if desired, be sufficiently evacuated so that the only vapor present is that due to the vaporizable materials in the electrodes, such as mercury, the vapor pressure in the vessel being determined then by the material and ambient temperature. The conducting electrodes may be coated with activating material to render them more readily electron emitting. In some cases special gases, such as argon or neon, may be introduced to such amount as may be desired for reasons to be given hereinafter.

Such a device as just described and commonly known as a gaseous discharge tube has the characteristic of practically infinite resistance until a certain critical voltage is impressed between the electrodes. When a voltage equal to or in excess of this critical voltage is applied, breakdown occurs and copious ionization rapidly builds up filling the tube and bringing the resistance between any of the electrodes to a comparatively low value. Furthermore, when such ionization is set up and current, therefore, flows through the tube, the voltage across the terminals drops to some low value, such as 15 or 20 volts, and remains at this value as long as ionization is maintained, being practically independent of the magnitude of the current flowing through the tube.

Thus it is seen that if an excessive disturbing voltage is present on any one of the lines, it will trip off the protective device, produce ionization throughout the whole volume of the tube, and thus substantially short circuit all the conductors to ground simultaneously. This ground will continue so long as excessive voltage is present on any one of the conductors, and upon the removal or dissipation of that voltage, deionization within the tube will occur rapidly and restore its resistance to practically infinite value.

The critical voltage at which breakdown occurs is subject to control, and may take on, for example, any value from 200 volts up. This critical value can be modified over a substantial range by the introduction of a gas or mixture of gases at one pressure or another in the container H.

Furthermore, the critical voltage for any one tube, after being completed, remains constant to a high degree being independent of the number of times that the device may have operated previously, thus distinguishing sharply from previous protective blocks and devices.

In order that there shall be as great uniformity as possible in the behavior of each conductor to the grounded electrode, it is desirable that the electrodes A_1, A_2, etc. should be symmetrically located with respect to the electrode K. This, of course, can be readily attained by arranging the electrodes, as shown in Fig. 3.

At times the circuits to be protected may have direct current potentials used for signaling purposes, such as telegraph or local batteries on telephone lines. If these direct current potentials exceed 20 volts, and can pass sufficient current through the device to sustain the arc, the gas tube protective device would be held operated when once broken down. To prevent this a condenser of large capacity may be inserted in the common ground connection at a given protector point, as shown by C_0 in Fig. 2.

In case the current to be discharged to ground is excessively large, it may not be desirable to have it flow through the discharge device for a long period, and to this end I provide relays which will short circuit the signaling wires around the protective device. Thus by connecting, as in Fig. 4, a saturated transformer T_1 between the electrode K and ground with its secondary windings connected to a master a. c. relay R_1, the armature and contact of which operate short circuiting relays R_2 and R_3, the gas device is short circuited after a few thousands of a second, so that the gas discharge device need only be designed to carry the desired amount of current for this short interval of time, and therefore can be made of smaller dimensions and still be satisfactory as a protection device. The initial operation of the device will take place from either half of the a. c. cycle of a disturbing voltage. Furthermore, on operation of the relays voltage is removed from the tube and deionization immediately takes place.

Fig. 5 is a modification of Fig. 4 in that the a. c. relay R_1 and plurality of d. c. relays of Fig. 4 are replaced by the multi-contact a. c. relay R^5.

A still further simplification of the circuit is shown in Fig. 6 wherein the transformer T_1 and associated relays of Fig. 4 are replaced by a single multi-contact saturating type of a. c. relay directly connected between the electrode K and the ground.

In Figs. 7 and 8 I have shown a form of protective device which is similar in many respects to that described in connection with Fig. 1. It consists, however, of a hot cathode gas-filled tube, which contains a heating filament F supplied with power from a transformer T_2, and heating the cathode K sufficiently so that it becomes electron emitting. In addition there are a plurality of anodes A_1, A_2, A_3, A_4, one for each circuit to be protected. There is also a control grid member E, which is connected to the cathode K through a suitable resistance R, and a bias battery C. In this container there is also included some suitable gas, such as mercury vapor, neon or argon, or mixtures of these. This tube has the characteristic that if one of the anodes is rendered positive with respect to the cathode by a certain amount, ionization will take place, filling the whole tube, whereupon the voltage between the anodes and the cathode will be brought to a low value depending upon the gases present. Thus, if there is a reasonable amount of mercury vapor present, this voltage will drop to 15 or 20 volts, and the ionization, with corresponding flow of current, will continue so long as the potential of one or another of the anodes remains above the maintaining voltage of 15 or 20 volts. This device has the advantage that the critical voltage at which breakdown occurs may be readily adjusted to any desired value by the potential applied to the grid E. With this in mind, then, it will be apparent that the circuit of Fig. 7 will operate in identically the same manner as was given in connection with Fig. 1.

It will be understood, of course, that power must be supplied continuously to maintain the temperature of the filament F and cathode K, but this amount of power can be kept to low values. In this respect the device differs from that of Fig. 1, for which no power supply is necessary.

Fig. 8 is analogous to Fig. 2 in that a condenser C_0 is connected in the ground circuit in the in the event that signaling d. c. voltages in excess of 15 volts are to be used on any of the circuits to be protected.

Figs. 9, 10 and 11 are analogous to Figs. 4, 5 and 6 in showing arrangements for short circuiting the protective device after the said device has been broken down for a short interval of time, but long enough to permit operation of the short circuiting relays.

It will be noted that the arrangements of Figs. 1 to 6 will operate on either half of a disturbing a. c. cycle. In Figs. 7 and 8, on the other hand, it will be noted that operation occurs only for potentials where the conductors are at positive potential with respect to the cathode K or affords protection for but one-half of a disturbing a. c. cycle. In Figs. 9, 10 and 11, on the other hand, protection is afforded for either half cycle, but may fail to operate for the first half cycle depending upon the polarity.

What is claimed is:

1. A protective apparatus for a plurality of paralleling circuits transmitting signals and exposed to extraneous disturbing voltage effects comprising a gaseous discharge tube, a grounded electrode in said tube, a plurality of additional electrodes in said tube, one of the additional electrodes being provided for each circuit to be protected, the gas within the tube being ionized when excessive voltage appears on any of the circuits, and means for adjusting the voltage at which ionization occurs within the tube.

2. A protective apparatus for a plurality of paralleling circuits transmitting signals and exposed to extraneous disturbing voltage effects comprising a gaseous discharge tube, a grounded electrode in said tube, a plurality of additional electrodes in said tube, one of the additional electrodes provided for each circuit to be protected, the gas within the tube becoming ionized and conductive when excessive voltage appears on any of the circuits and to virtually short circuit all the electrodes to ground, and means including a control electrode for said tube for controlling the voltage at which ionization occurs within the tube.

3. A protective apparatus for a plurality of paralleling circuits transmitting signals and exposed to extraneous disturbing voltage effects comprising a gaseous discharge tube, a grounded electrode in said tube, a plurality of additional electrodes in said tube, one of said additional electrodes being provided for each circuit to be protected, the gas within the tube ionized when excessive voltage appears on any of the circuits and to virtually short circuit all the electrodes to ground, and means including a control electrode for said tube for predetermining the voltage at which ionization will occur within the tube.

4. Protective apparatus for a circuit exposed to extraneous disturbing voltage effects comprising a gaseous discharge tube break down device, a grounded electrode in said tube, an additional electrode within the tube connected to the circuit to be protected, means including a third electrode within the tube for predetermining the voltage at which ionization will take place within the tube, a relay operated by the discharge through the protective device, said relay short circuiting the line to ground around the discharge tube and so connected as to maintain the relay in operated condition so long as the excessive voltage remains on the line.

5. Protective apparatus for a plurality of circuits transmitting signals and exposed to extraneous disturbing voltage effect, said device comprising a gaseous discharge tube break down device, a grounded terminal in said tube, a plurality of electrodes in said tube, one of said electrodes being provided for each circuit to be protected, means including an additional electrode within the tube for predetermining the voltage at which ionization of the gas within the tube will occur, the gas within the tube becoming ionized when excessive voltage appears on any of the circuits, a relay system operated upon ionization of the gas within the protective device, said relay system short circuiting the protective device and grounding all the circuits to be protected and maintaining said ground so long as excessive voltage remains on one or more of the circuits to be protected.

6. Protective apparatus for a plurality of circuits transmitting signals and exposed to extraneous disturbing voltage effects, said device comprising a gaseous discharge tube, a grounded terminal in said tube, a plurality of electrodes in said tube, one electrode being provided for each circuit to be protected, the gas within the tube becoming ionized when excessive voltage appears on any of the circuits, means including an additional electrode within the tube for controlling the voltage of ionization of the gas within said tube, a relay system operated by and upon breakdown of the protective device, said relay short circuiting the protective device and grounding all the circuits to be protected, said relay system maintaining said ground so long as excessive voltage remains on one or more of the circuits to be protected.

7. Protective apparatus for a plurality of circuits transmitting signals and exposed to extraneous disturbing voltage effects, said device comprising a gaseous discharge tube with a heated cathode, a grid and a plurality of anodes, one for each circuit to be protected, the tube being designed to break down when excessive voltage appears on any of the circuits, means for biasing the grid to control the anode potential of breakdown.

8. Protective apparatus for a plurality of circuits transmitting signals and exposed to extraneous disturbing voltage effects, said device comprising a gaseous discharge tube with a heated cathode, a grid and a plurality of anodes, one for each circuit to be protected, the tube being designed to break down when excessive voltage appears on any of the circuits, means for biasing the grid to control the anode potential of breakdown, a relay system operated by and upon breakdown of the protective device, said relay system short circuiting the protective device and grounding all the circuits to be protected and maintaining said ground so far as excessive voltage remains on one or more of the circuits to be transmitted.

9. Protective apparatus for a plurality of circuits transmitting signals and exposed to extraneous disturbing voltage effect, said device comprising a gaseous discharge tube, a heated cathode, a grid and a plurality of anodes, one for each circuit to be protected, the tube being designed to break down when excessive voltage appears on any of the circuits, a transformer with its primary connected from the cathode to ground, an a. c. relay operated by said transformer on the breakdown of the tube, and means controlled by the relay to short circuit the tube and connect all conductors to be protected to the high side of the transformer primary.

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