

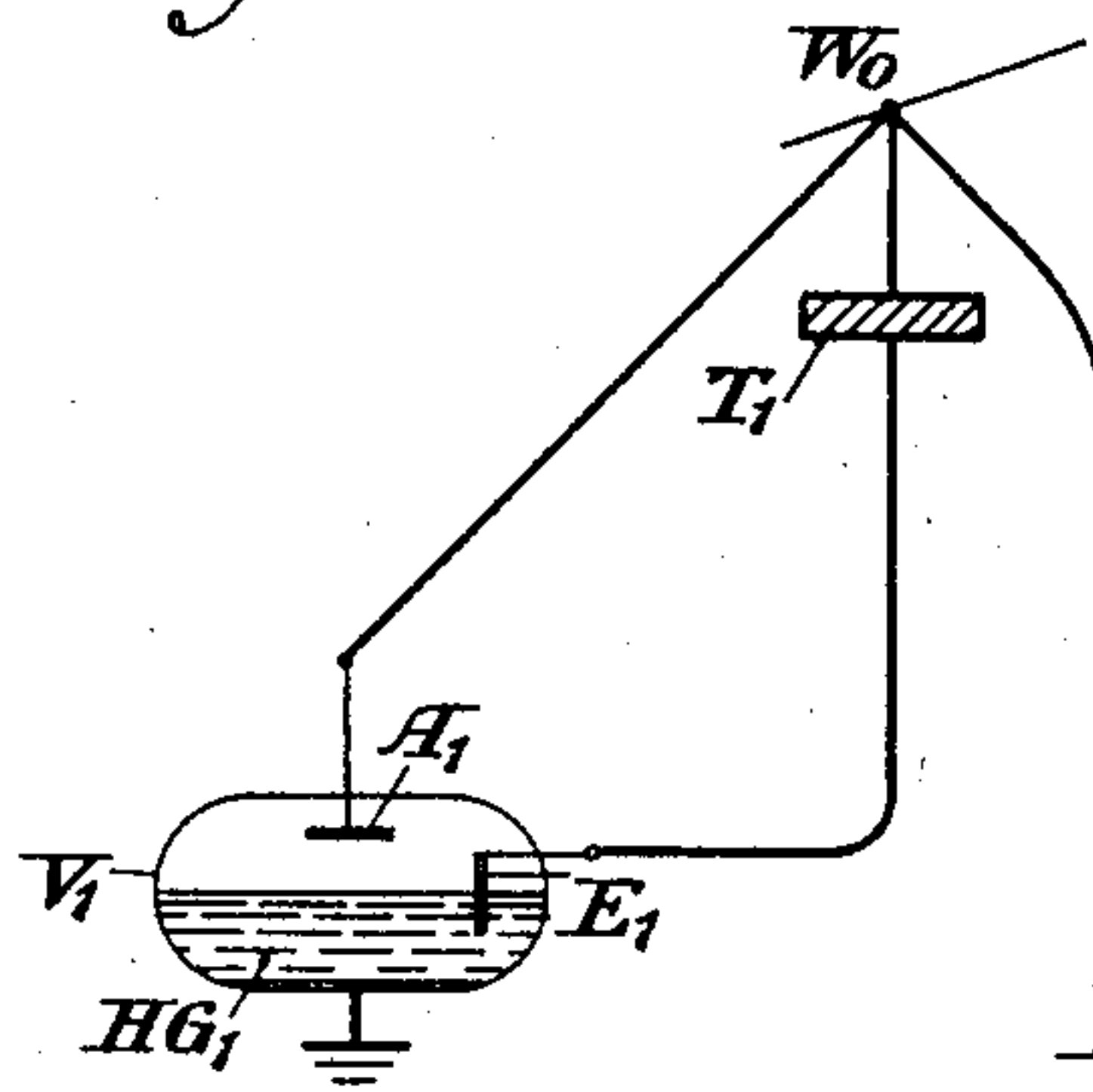
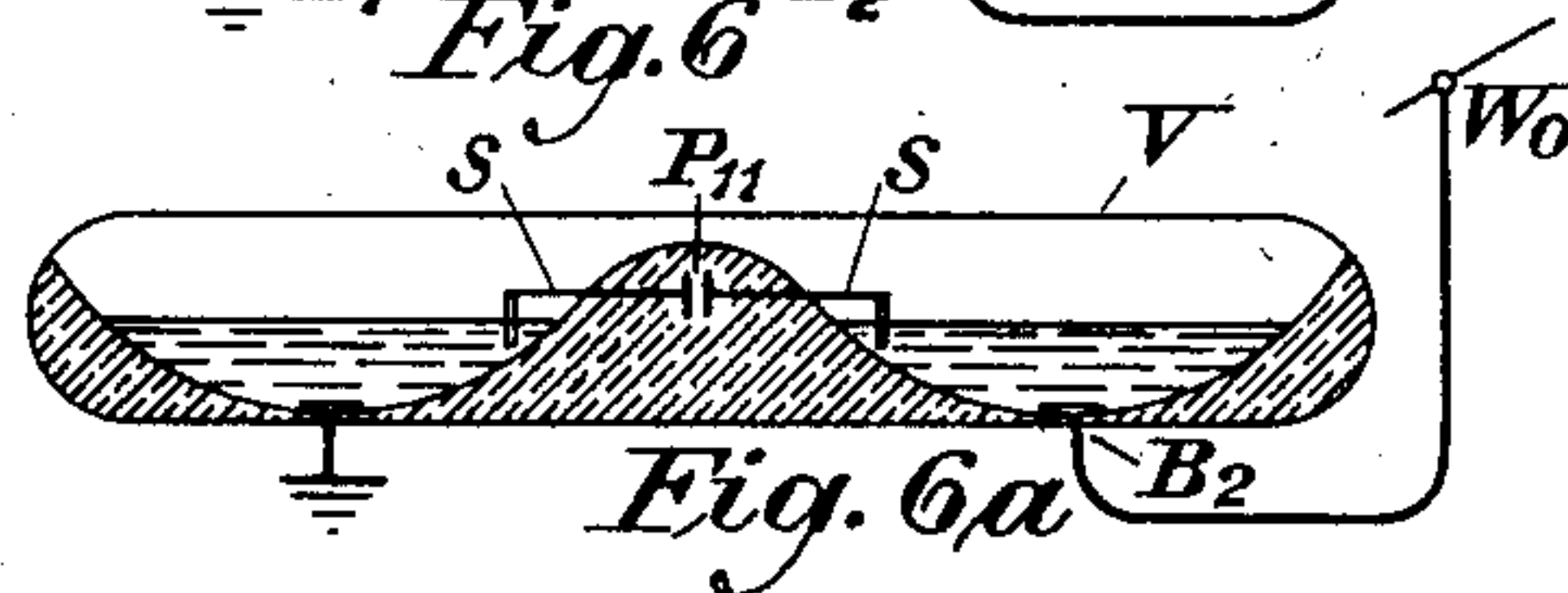
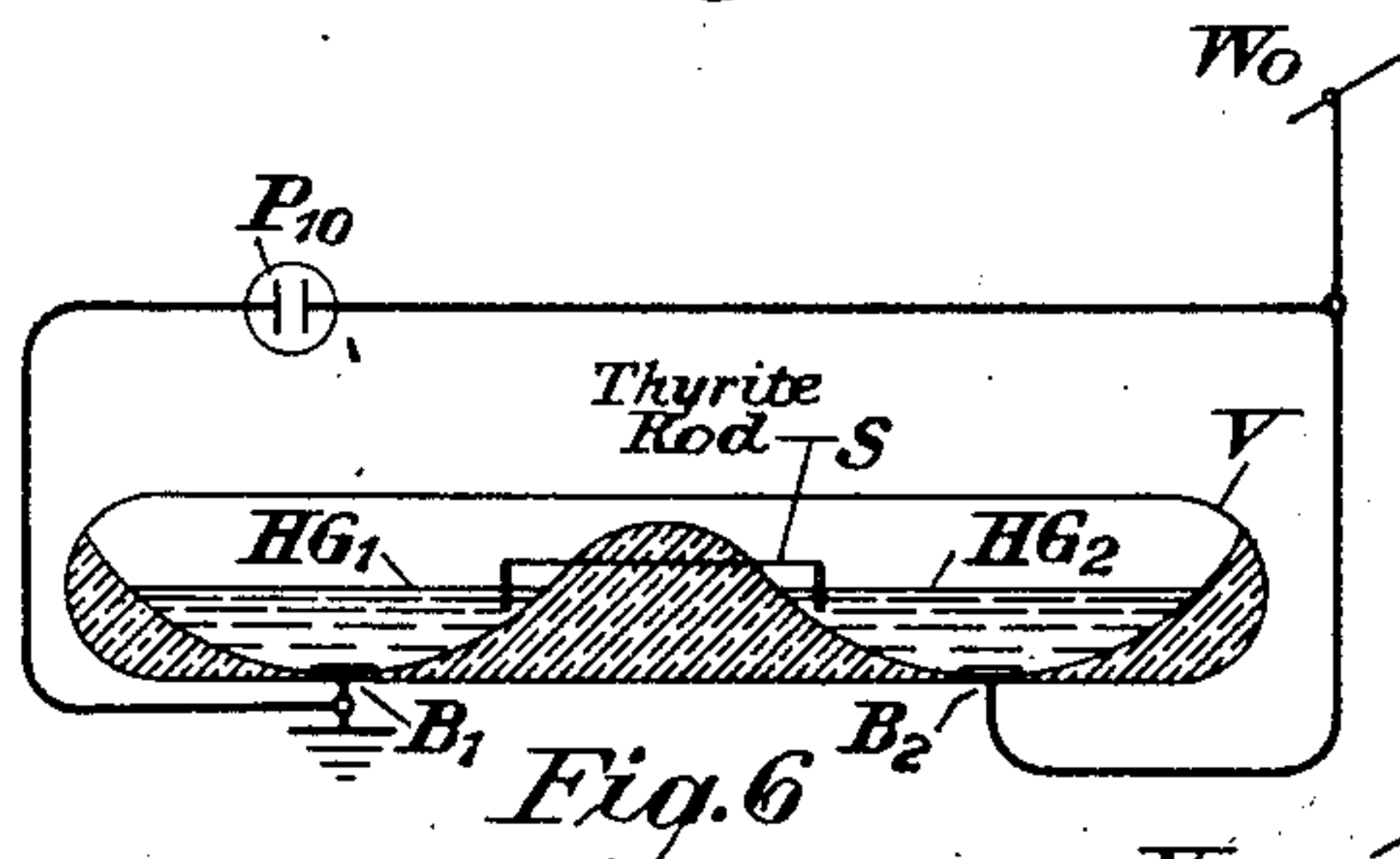
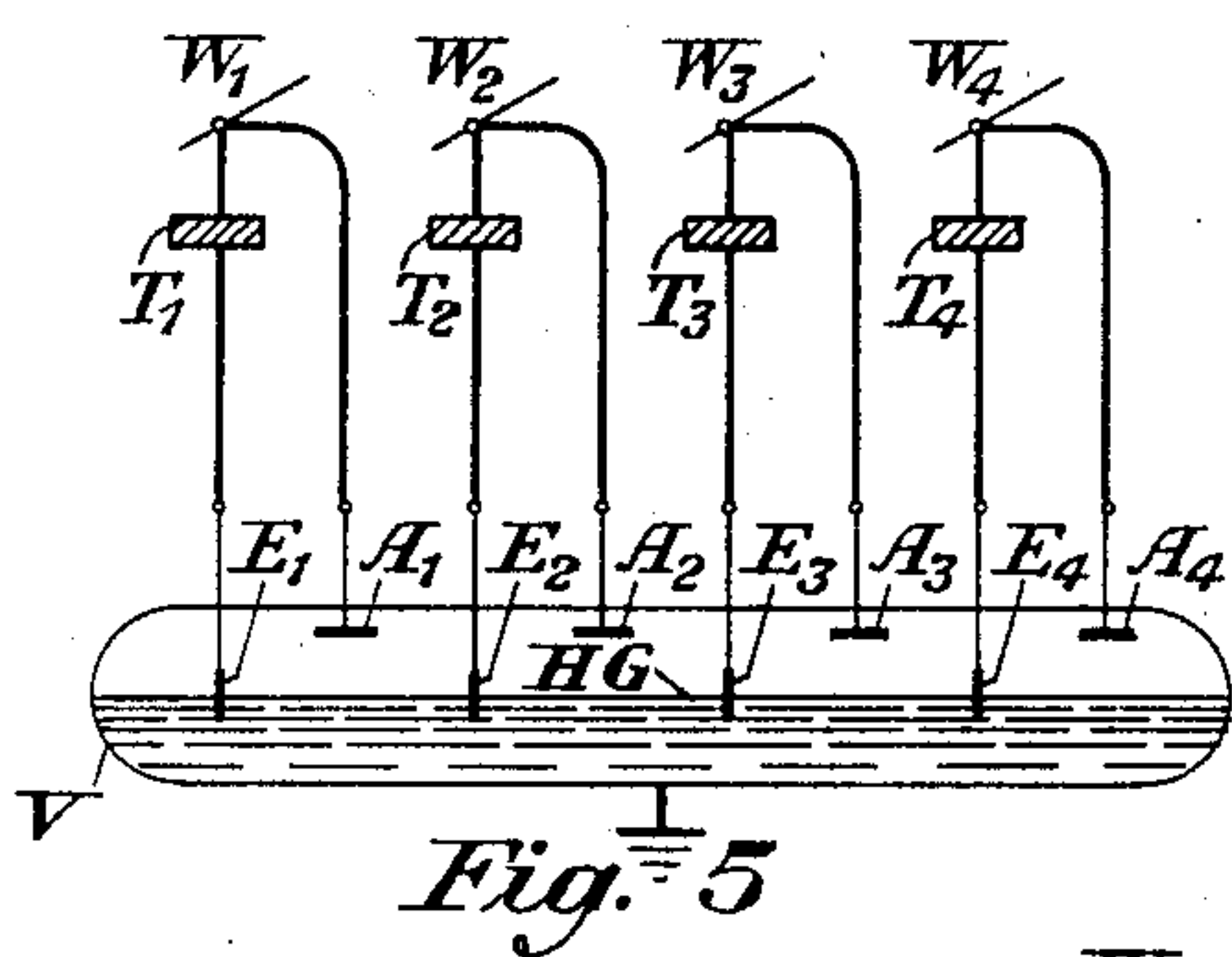
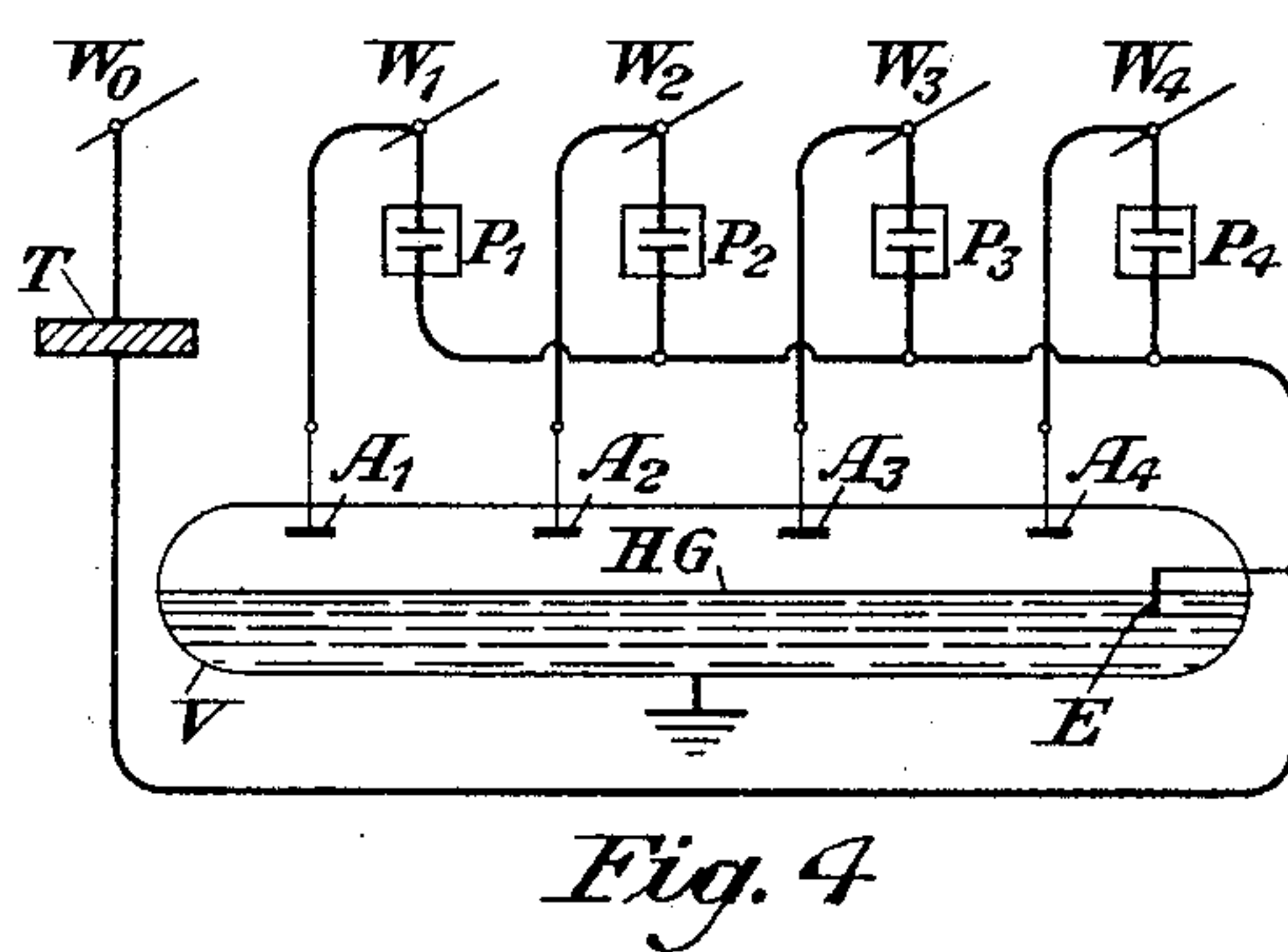
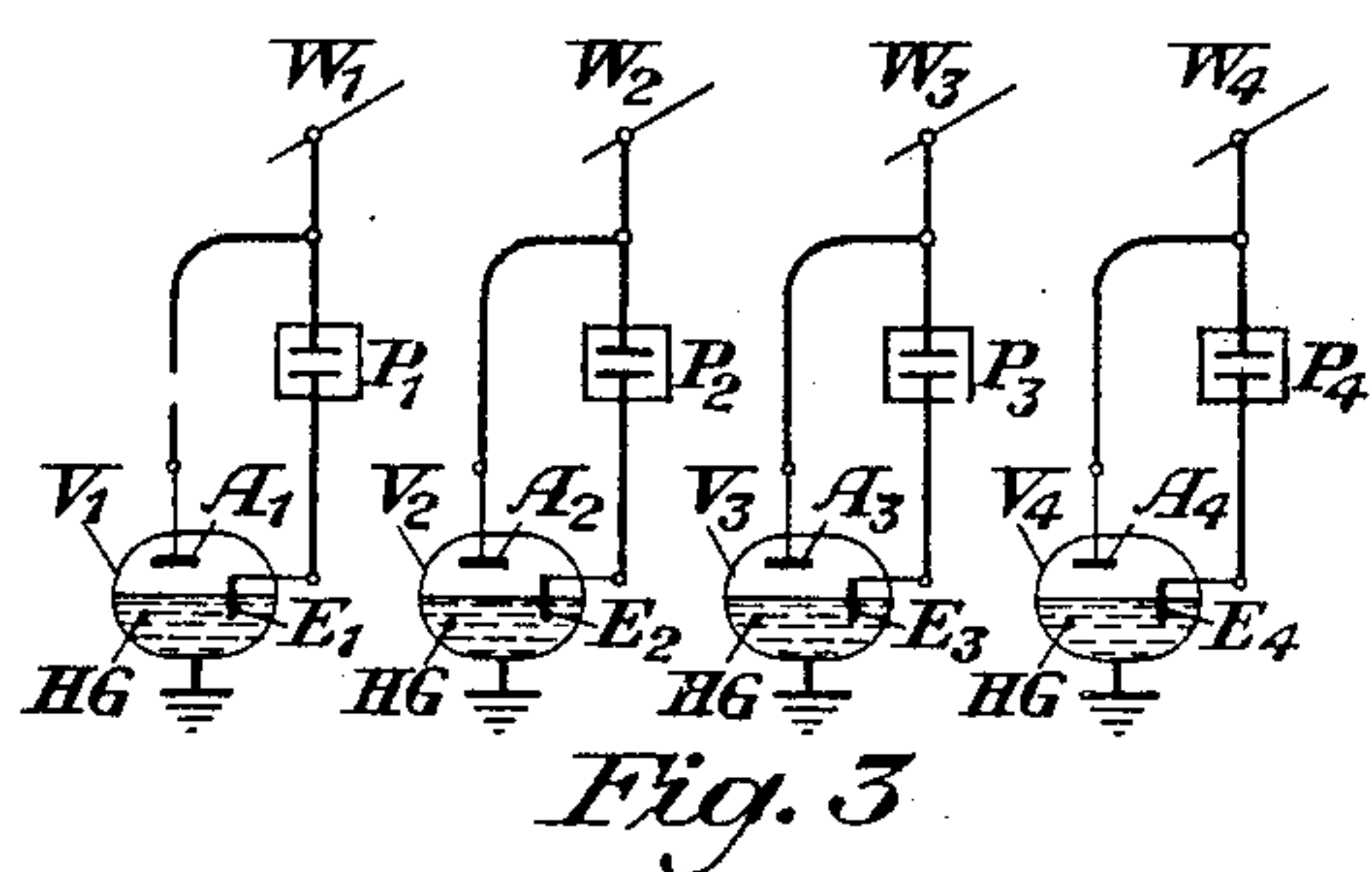
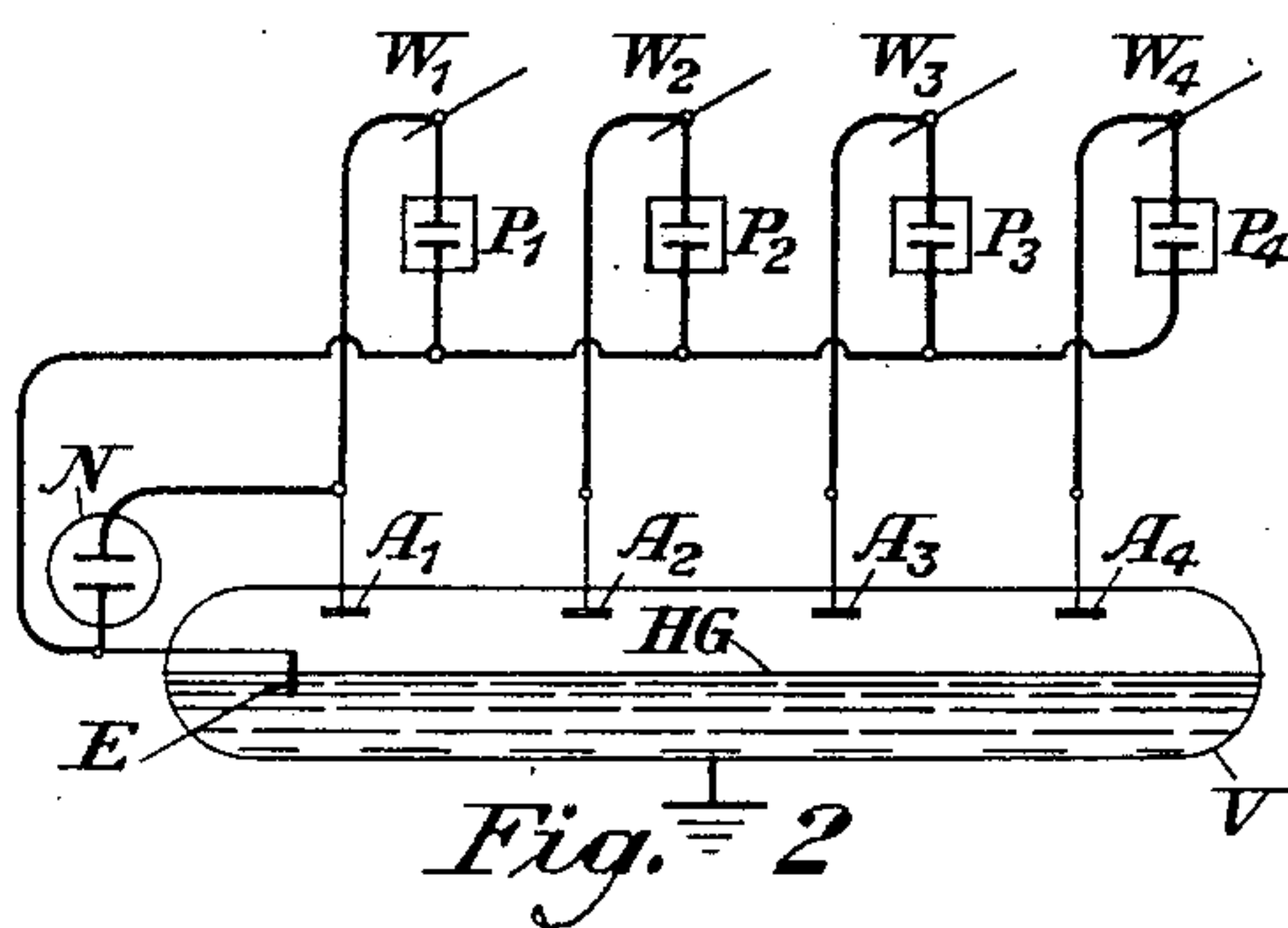
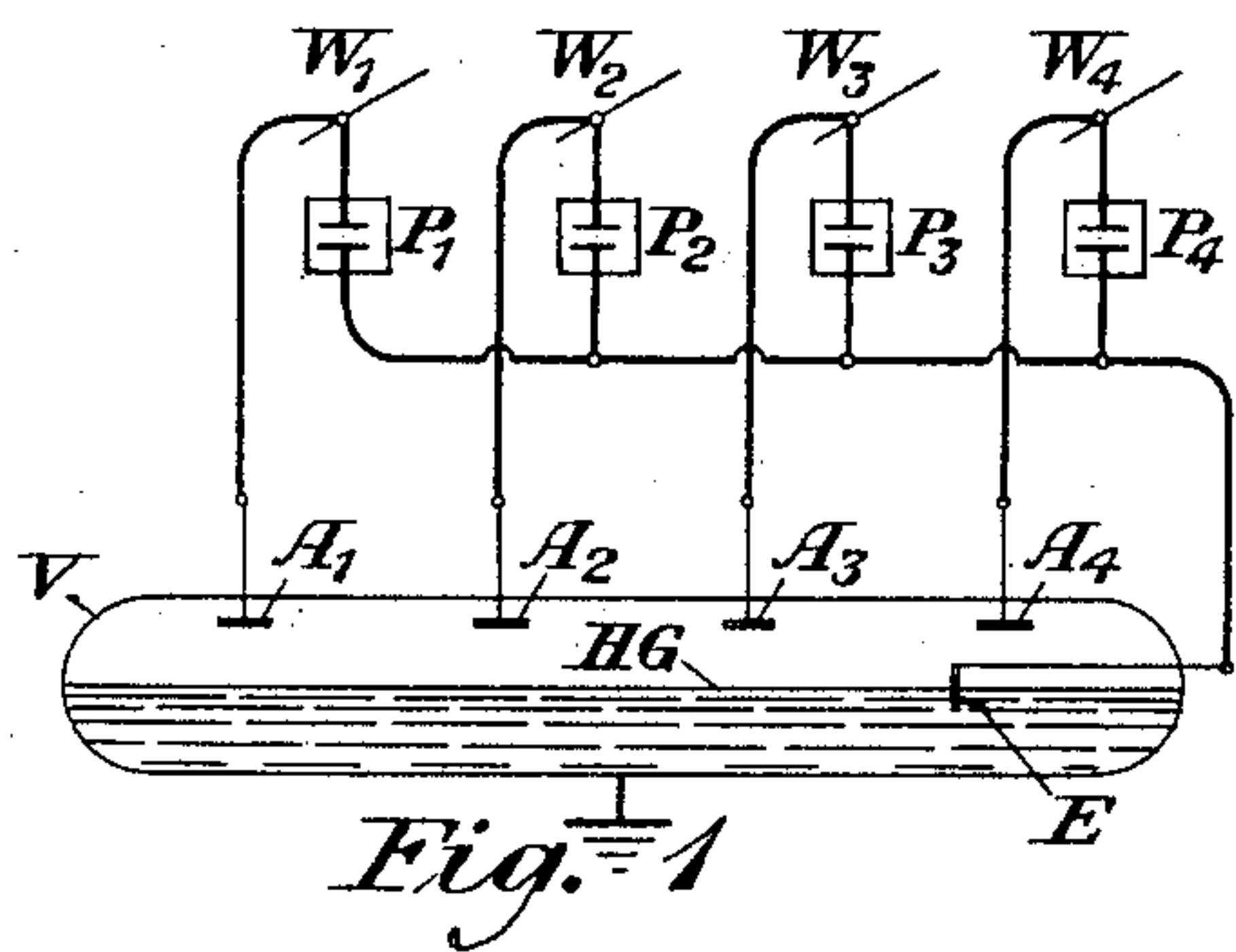
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ELECTRICAL PROTECTION APPARATUS

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ELECTRICAL PROTECTION APPARATUS

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7 Claims. (Cl. 179—78)

This invention relates to tubes containing liquids such as mercury and to circuits employing such tubes. More particularly, this invention relates to electrical protection systems employing such tubes and circuits.

In the tube of this invention a pool of mercury is enclosed in an insulated container such as glass. An electrode of high resistance refractory material, such as Thyrite, carborundum or other refractory material is inserted in the container such that a portion of the electrode is above and a portion within the mercury. A third electrode or anode is also enclosed in the container but not in contact with the mercury.

When a potential is applied between the resistive electrode and the pool of mercury, ionization of the mercury vapor takes place, permitting the passage of current from the anode to the liquid mercury. Current cannot pass in the opposite direction unless the anode is made of some material which can liberate ions.

When a potential of sufficient amount is applied between the high resistance electrode and the mercury pool, ionization can be made to take place in an extremely short time. Direct current voltages of the order of 250 volts can cause this ionization to take place in about 50 microseconds and, for higher potentials, ionization may be made to occur in a shorter time.

This invention will be better understood from the further description hereinafter following when read in connection with the accompanying drawing in which Figure 1 shows one embodiment of the invention employing a vessel of mercury and additional electrodes common to a plurality of exposed circuits; Fig. 2 shows a similar arrangement including also a gas-discharge tube for operation with greater precision; Fig. 3 illustrates a separate vessel of mercury and electrodes for each exposed conductor; Fig. 4 is similar to the arrangement of Fig. 1, but it additionally includes a non-linear device such as Thyrite; Fig. 5 employs a common mercury pool device and separate non-linear or Thyrite elements for the various exposed conductors; Figs. 6 and 6a each show a mercury vessel including two pools of mercury separated from each other, both pools having a rod of material such as Thyrite partially immersed therein; and Fig. 7 shows an exposed conductor connected to two mercury pool devices and two Thyrite elements.

In Fig. 1 of the drawing the reference characters W_1 , W_2 , W_3 , and W_4 designate four of a plurality of exposed conductors and these conductors may, for example, be four independent

signaling circuits. These conductors are connected to the upper terminals of corresponding protector blocks P_1 , P_2 , P_3 , and P_4 . The lower terminals of these blocks are connected together and to the fixed electrode E which is in the form of a rod of any refractory material, partly immersed in a bath of mercury HG contained within a vessel V of glass or other non-conducting material. The vessel V also houses other electrodes or anodes A_1 , A_2 , A_3 , and A_4 which are spaced from the mercury pool and are connected to the respective conductors W_1 , W_2 , W_3 , and W_4 . The pool of mercury is grounded as shown.

The resistive electrode E may be regarded as the starting electrode. When a voltage impressed upon anyone or several of the exposed conductors W_1 – W_4 is sufficient to break down the gap or gaps of the corresponding protector block or blocks P_1 – P_4 , a large voltage will at the same time become applied between the electrode E and the mercury HG . The latter voltage will cause ionization of the mercury vapor to take place. The various conductors W_1 – W_4 will therefore be promptly grounded through the parallel paths formed by the electrodes A_1 – A_4 and the mercury HG .

It will be noted that the vessel V is stationary and does not include any movable electrodes. Vaporous ionization is started automatically by voltage applied to electrode E and the electrodes A_1 – A_4 become grounded only after ionization has started. The latter electrodes remain grounded for the time that the voltage from conductors to ground exceeds the voltage required to sustain the arc between electrodes A_1 , A_2 , etc., and the mercury. Immediately after the voltage on all of the conductors W_1 to W_4 becomes reduced below a predetermined value, ionization will instantly cease and the conductors W_1 – W_4 will no longer be grounded.

In Fig. 2 a gas-discharge tube N is connected in parallel with the electrodes E and A_1 . An additional tube may be connected in parallel with the electrodes E and A_2 if so desired. When a sufficient voltage is applied between the exposed conductor W_1 and ground, for example, the gas within tube N will become ionized and promptly thereafter, a sufficient voltage will reach electrode E . If this voltage is in a proper direction, ionization of the enclosed mercury vapor will occur and all of the conductors W_1 to W_4 will be grounded through the parallel paths provided respectively by electrodes A_1 to A_4 and the mercury HG . All of the conductors W_1 to W_4 will be grounded

even though none of the protector blocks P_1 to P_4 may have become broken down. Furthermore, all of the conductors W_1 to W_4 will become ungrounded immediately after the voltage applied to the conductor W_1 is removed or drops to a low value and no sufficient voltage is applied to the other conductors W_2 to W_4 .

In Fig. 3, separate vessels V_1 to V_4 are provided for the various respective conductors W_1 to W_4 , each corresponding protector block being connected between a partially immersed resistance electrode such as E_1 and the spaced electrode such as A_1 of vessel V_1 . Each conductor may be grounded independently of the others in a manner which needs no further explanation.

The arrangement of Fig. 4 is similar to that of Fig. 1, except that a pilot wire W_0 is added, this pilot wire being connected to the electrode E through a Thyrite element T which, as is well known, is non-linear in its voltage-resistance and voltage-current characteristics. The pilot wire W_0 may transmit to electrode E a properly poled voltage sufficient to cause vapor ionization within vessel V . The conductors W_1 to W_4 may become grounded independently of any action by the blocks P_1 to P_4 . In this arrangement, the blocks P_1 to P_4 may be dispensed with if so desired, in which case the Thyrite element T and the vessel V and its electrodes will be the sole common grounding means.

The utility of the systems shown in Figs. 1, 2, and 4 is to provide a path from the line wires W_1 to W_4 to ground for all wires simultaneously and to avoid the possibility of the protector blocks P_1 , P_2 , etc. being permanently grounded. The operation of the shunting apparatus, namely the tube containing mercury, takes place immediately upon the passage of current from any exposed conductor W_1 , W_2 , etc. through its associated protector block to the electrode E and then to ground.

In Fig. 5 the conductors W_1 to W_4 are connected to the respective partly immersed electrodes E_1 to E_4 through Thyrite elements T_1 to T_4 , the conductors W_1 to W_4 being also connected to the corresponding spaced electrodes A_1 to A_4 of vessel V . Application of sufficient properly poled voltage to anyone of the electrodes E_1 to E_4 will cause ionization within vessel V and all of the exposed conductors will then be simultaneously grounded through the paths provided by electrodes A_1 to A_4 and the grounded mercury pool HG .

In Fig. 6 the protecting apparatus of vessel V includes two separated mercury pools HG_1 and HG_2 , the separation being provided by a wall of glass or other non-conducting material in which is mounted and sealed a rod of material S such as Thyrite, carborundum or other refractory material. Thus the rod S is in effect split into two parts, each of which is partially immersed in one of the mercury pools. The mercury pool HG_1 is grounded at electrode B_1 and electrode B_2 is connected to conductor W_0 . This arrangement allows current to flow from the exposed conductor W_0 to ground at either half cycle, or in the reverse direction. A protector block such as P_{10} may, if desired, be connected between conductor W_0 and ground. Such a protector block will shunt the high resistance path through the Thyrite rod S and this block will bypass to ground steep wave front voltages impressed upon conductor W_0 .

When a sufficiently high voltage is applied between conductor W_0 of Fig. 6 and ground, ionization of the mercury pools HG_1 and HG_2 will take place. The Thyrite rod S will act as a starting

electrode in much the same manner as will the electrode E of Figs. 1, 2, and 4. During ionization, the vapor will provide a low impedance path between the pools HG_1 and HG_2 , which path will shunt the Thyrite rod S out of the circuit. Upon the removal of the applied voltage or upon its reduction to a lower (predetermined) value, ionization will cease within tube V . Thus the rod S presents a large impedance at low voltages, but when voltages are applied to conductor W_0 sufficient to ionize the mercury within tube V , the rod S will be removed in effect from the circuit.

In the arrangement of Fig. 6, one or two or more protector blocks similar to those shown in Figs. 1 and 2 or gas-discharge tubes similar to the one of Fig. 2 may be made a part of the arrangement. Such a device is illustrated as P_{11} in Fig. 6a and may be a protector block, gas tube or Thyrite element and it may be interposed between the two ends of the rod S , if so desired. The rod S will then be separated into distinct parts or if desired, two or more such devices may be connected in series between the two separated parts. Any voltage of such magnitude as to operate the block or tube P_{10} or P_{11} in Figs. 6 and 6a respectively will at the same time produce ionization of the mercury vapor and therefore permit large currents to pass between the mercury pools HG_1 and HG_2 for either half cycle, thereby protecting the block or tube P_{10} or P_{11} against permanent damage.

In a well proportioned arrangement according to Fig. 6, the protector can be made to "fire" at any desired potentials from line to ground or vice versa. There will be a low internal voltage drop, for example, 15 volts, within the vessel V . Moreover, vaporous ionization can take place in 50 microseconds for ordinary potentials and in less time at higher potentials. Because of the low impedance of the mercury vapor and the low resistance of the mercury itself, the temperature rise of the device will not be sufficient to require a large vessel unless unusually heavy currents must be transmitted between the line wire and ground. The apparatus would not be expensive and would not require much space to protect ordinary protector blocks or gas tubes or both without relays or similar devices.

In Fig. 7, two mercury bulbs V_1 and V_2 , each of the type shown, for example, in Fig. 3, and two bilateral conducting devices T_1 and T_2 , each of a material such as Thyrite and of non-linear resistance characteristic, are employed. T_1 and T_2 may, however, be open-spaced protector blocks or gas-discharge tubes. One of these arrangements V_1 and T_1 , will be operated upon one half of the cycle of applied voltage and the other upon the other half cycle. Damage to each device T_1 or T_2 is prevented by the corresponding mercury bulb device, as will be apparent from the description already given.

Thus in the arrangement of Fig. 7 the Thyrite device T_1 and the bulb V_1 will be operated during the positive half of an applied alternating current cycle or when a positive potential is applied to conductor W_0 ; the Thyrite device T_2 and the bulb V_2 will be operated during any applied negative half cycle or when a negative potential is applied to conductor W_0 .

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be apparent that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit

of the invention as defined by the appended claims.

What is claimed is:

1. Protective apparatus including a sealed glass envelope containing mercury liquid, a plurality of electrodes of high resistance each partly immersed in the liquid, ionized mercury vapor being produced in response to the application of a voltage between the liquid and any one of said electrodes which exceeds a predetermined value, a plurality of anodes within said envelope each of which is spaced from the liquid, the space between each anode and the liquid forming a low impedance ionized path when mercury vapor is produced within the envelope, and means including a plurality of non-linear unpoled resistive elements external to said envelope to control the initiation of ionized mercury vapor within said envelope, each of said non-linear resistive elements being connected by a conductive path to one of the high resistance electrodes within the envelope.
2. A protection circuit for a plurality of exposed conductors comprising a non-conductive housing enclosing liquid mercury, a plurality of ionization initiating circuits each of which extends from one of said conductors and includes a resistive electrode partly immersed in the mercury and a non-linear unpoled resistive element external to said housing to control the initiation of mercury vapor within said housing, and a plurality of additional circuits each of which extends from one of said conductors, each of said additional circuits including an electrode within said housing and spaced from the mercury.
3. The combination of a pool of mercury, a plurality of pairs of parallel circuits having said pool of mercury common thereto, a plurality of vapor ionizing resistive electrodes one corresponding to each of said pairs of circuits, each vapor ionizing electrode being connected to one of the circuits of each pair and being partly immersed in the pool of mercury, a plurality of electrodes spaced from the mercury each of which is connected to the other of the parallel circuits of each pair, each of said spaced electrodes forming a low impedance path to the mercury pool during ionization, and means including a plurality of non-linear resistive elements each of which is connected to one of the circuits extending to a

spaced electrode to control the initiation of ionized mercury vapor.

4. A protection system for a plurality of exposed conductors comprising a tube containing grounded liquid mercury, a plurality of Thyrite elements external to the tube, a plurality of high resistance electrodes each of which is partly immersed in the liquid mercury, and a plurality of electrodes positioned within the tube and spaced from the liquid mercury, each exposed conductor being connected through a corresponding Thyrite element to a corresponding high resistance electrode, each exposed conductor being also connected to a corresponding spaced electrode of said tube.

5. Electrical protection apparatus comprising a bulb containing mercury, a plurality of ionization initiating circuits each of which includes a resistive electrode partly immersed in said mercury and a non-linear unpoled high resistance element external to the bulb, and a plurality of discharge circuits each including an electrode positioned within the bulb and spaced from the mercury, the mercury and all of the electrodes being fixed and immovable.

6. Quick acting automatic protection apparatus comprising a mercury pool, a plurality of ionization circuits each of which includes an immovable electrode of high resistance partly immersed in the mercury pool, each ionization circuit also including a non-linear unpoled high resistance element external to the mercury pool, and a plurality of work circuits each controlled by one of the ionization circuits, each work circuit including an immovable electrode insulated from the mercury pool except during ionization.

7. Lighting protection apparatus comprising a container partly filled with vaporizable conducting liquid mercury, vaporizing means including a plurality of resistive impedance elements partially immersed with reference to said liquid, and a plurality of bilateral non-linear high resistance elements external to the container each of which is connected in circuit with one of said resistive impedance elements and with said liquid mercury, each high resistance external element presenting an impedance which varies non-linearly according to the magnitude of the potential applied thereto.

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