Jan. 6, 1948. H. C. HAYES ET AL 2,433,845

SOUND OPERATED RELAY SYSTEM

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FIG. 1

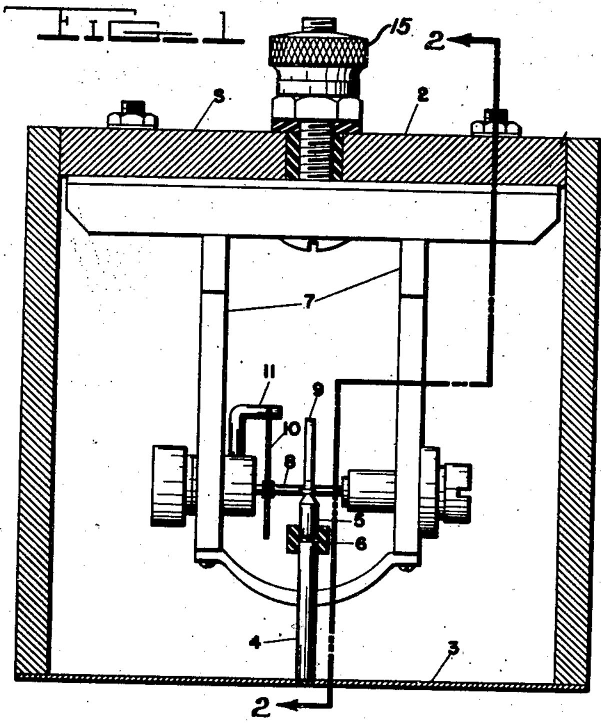


FIG. 3

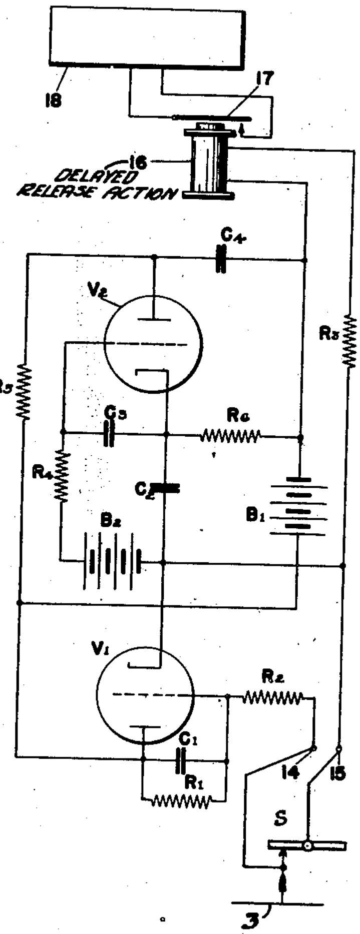
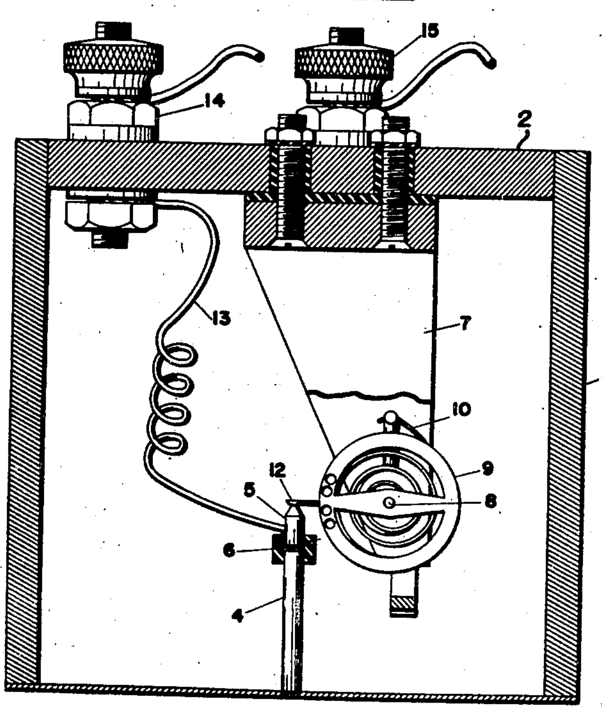


FIG. 2



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SOUND OPERATED RELAY SYSTEM

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4 Claims. (Cl. 175—320)

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This invention relates to a relay system which is responsive to sound waves or to vibratory impulses of a similar nature.

The system comprises a trigger circuit containing a relay coil and an impulse operated switch. The circuit is so arranged as to remain ineffective to energize the relay coil to its operating level as long as the impulse operated switch remains closed. Reception of an impulse by the switch causes it to open and causes the circuit to energize the relay coil to operation. After a predetermined period of time the circuit returns to its unexcited state unless the switch is open at the time. The switch is so constructed as to operate particularly well upon the reception of random noises or impulses of this nature. Among the various objects of this invention are:

To provide a sound operated means for varying the energization of a work circuit.

To provide means operated by the reception of random vibratory impulses for varying the energization of a work circuit.

To provide a relay trigger circuit containing a switch responsive to the reception of sound waves or similar impulses to energize the circuit.

To provide an impulse operated switch capable of being opened by the reception of sound waves or similar impulses.

To provide an impulse operated switch capable of being set into a chattering condition by the reception of random impulses.

To provide an impulse actuated relay circuit capable of exercising on a work circuit a variety of sequential control actions.

Other objects will become apparent from a consideration of the following description when taken together with the accompanying drawings in which:

Fig. 1 is a side elevational view partly in cross section of the impulse operated switch forming a part of the invention;

Fig. 2 is a side elevational view of the switch shown in Fig. 1 taken along the section indicated by line 2—2 in Fig. 1, and having portions broken away, and

Fig. 3 is a schematic diagram of a trigger circuit forming a part of the invention.

The impulse operated switch S illustrated in Figs. 1 and 2 comprises a casing having thick

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cylindrical side walls 1 and a heavy rigid end wall 2, the opposite end of the casing being closed by a sound or impulse sensitive diaphragm 3. Mounted on the vibrating diaphragm 3 is a post 4 which is sectionalized so that its tip 5 is separated from its main portion by a connecting means 6 formed of electrical insulation material. The tip of the post serves as one contact of the switch and may be made of a polished non-corrodible metal suitable for this purpose. Rigidly secured to heavy end wall 2 of the housing are a pair of depending arms 7 in the lower ends of which is journalled a shaft 8 carrying a spring actuated balance wheel 9 of the type normally found in clock mechanisms. Instead of the wheel 9 a balanced rod could be used. The spring 10 is shown as a spiral spring having one end secured to an arm 11 forming a rigid part of the supporting means of the shaft 8 and having its other end secured to the shaft 8. The natural period of the balance wheel may be changed by varying the length of the spring. Obviously other forms of springs may be employed. A polished metal peg 12 extends from the circumference of the balance wheel and forms the other contact for the switch. The tip 5 of the post 4 has secured to it a conductor 13, the other end of which is secured to a binding post 14 which passes through and is electrically insulated from the end wall 2 of the housing. The balance wheel assembly including the arms 7 forms a conducting circuit from the peg 12 to a binding post 15 which likewise passes through and is insulated from the end wall 2. The wheel 9 is carefully balanced and its sensitivity may be enhanced by the employment of jeweled bearings to support the shaft 8. Conventional means is provided for adjusting the tightness of the bearings.

The switch as described above is sensitive to the reception of sound waves or similar pulses by the diaphragm 3. Upon the reception of such waves the contact 12, which is normally lightly pressed against the contact 5 by means of the spring 10, transmits the received impulse to the balance wheel. The wheel is rotated thereby and the switch is thus opened. After a period of time which is normally quite long with respect to the period of the received sound waves the spring 10 will reverse the rotation of the wheel and return the contact 12 to its contacting position with respect to contact 5. The switch will then preferably remain closed unless the diaphragm 3 is being vibrated. The continued reception of sound waves causes a chattering condition to be set up in the switch.

While the switch will respond effectively to sinusoidal excitation it works particularly well upon the reception of random noises which contain a good many pulses of high intensity. One of the best fields of use of the invention lies in the detection of random impulses and their utilization to control the operation of various mechanisms.

The switching means forms a part of the trigger circuit shown in Fig. 3, its position in the circuit being indicated by the binding posts 14 and 15. A pair of cold-cathode tubes V_1 and V_2 are contained in the circuit. The impulse responsive switch S is connected across the binding posts 14 and 15 which puts it in series with resistance R_2, time constant circuit R_1C_1, battery B_1 relay 16 and resistance R_3. The R. C. time constant circuit R_1C_1 is connected directly across the grid and plate of V_1.

The plate and cathode of V_2 are connected by a circuit made up of resistance R_6 in series with two parallel branches, one containing battery B_1 and resistance R_5 and the other containing the condenser C_4. The cathodes of the two tubes are connected together through condenser C_2. Biasing battery B_2 is connected between the grid of V_2 and the cathode of V_1, a resistance R_4 lying between the battery B_2 and the grid. A blocking condenser C_3 lies between the grid and cathode of V_2. The purpose of the circuit is to control the energization of the coil 16 of a relay switch 17 forming part of a work circuit diagrammatically illustrated at 18.

Since in the normal unexcited condition of the relay circuit the switch S is in the closed position, it is essential that the battery drain across it be reduced to the minimum. The circuit shown in Fig. 3 accomplishes this result very effectively. With the switch S closed, a short circuit exists between the binding posts 14 and 15. In this condition the current through the path comprising the positive terminal of B_1, resistances R_1 and R_2, contacts 14 and 15 (closed), R_3, element 16 and the negative terminal of B_1, is the only one of appreciable size flowing in the circuit. The values of the resistances R_1 and R_2, can be made such that the drain across them compares favorably with that normally occurring during the shelf life of the battery. The above outlined path is the only path in the circuit not blocked by electronic tubes or condensers. Thus, if the condensers and tubes were perfect, there would be no possibility of current flow through other paths of the circuit. If good condensers are used their leakage current is negligible. The current through R_1 and R_2 is small because the total resistance in the circuit is preferably about 2,100,000 ohms, which gives a current of .000064 ampere.

The cold cathode tubes V_1 and V_2 are preferably of the 313C type and normally operate as follows:

The tube is non-conducting until the potential difference between grid and cathode exceeds 75 volts. Once the tube becomes conducting, the grid loses control and conduction continues until two conditions are satisfied simultaneously, (*a*) the potential difference between plate and cathode must be less than 75 volts, and (*b*) the potential difference between grid and cathode must be less than 60 volts.

In the unexcited state with contacts 14—15 closed, the following voltages appear on the elements of the tubes, with reference to the negative terminal of battery B_1.

	V_1	V_2
	Volts	*Volts*
Plate	135	135
Grid	6.7	45
Cathode	0.3	0

Since neither grid has a potential 75 volts greater than its corresponding cathode, both tubes remain non-conducting.

When the contacts 14—15 open due to a noise disturbance, C_1 starts discharging through R_1 so that the grid potential of V_1 starts raising. In .0015 second the grid potential of V_1 will reach 75 volts with respect to the cathode and the tube will become conducting. The current follows the path, positive terminal of B_1, plate of V_1, cathode of V_1, R_3, relay coil 16 to negative terminal of B_1. This current operates the relay thus closing contact 17. When V_1 is conducting, the voltages of the tube elements with reference to the negative terminal of B_1 or as follows: plate 135 volts, cathode 60 volts, grid 120 volts if contacts 14—15 are open, 60 volts if contacts 14—15 are closed and V_1 is still conducting.

At the instance V_1 becomes conducting, the 60 volts between its cathode and negative terminal of B_1 (drop across R_3 and 16, V_1 conducting) is added to the grid circuit of V_2. If it were not for the presence of R_4 and C_3 the grid potential of V_2 would become 105 volts instantaneously and V_2 would become conducting. The function of the elements R_4 and C_3 is to prevent the grid potential of V_2 from exceeding 75 volts the instant V_1 becomes conducting. They introduce a delay in the rise of potential of the grid of V_2 so that some time elapses before V_2 is rendered conducting. This delay is determined by the product R_4 and C_3 and may have values between $^1/_{25}$ and 10 seconds with ease. The potential of the grid of V_2 can rise only by charging the condenser C_3. It is charged through the circuit, cathode of V_1, B_2, R_4, C_3, R_6, B_1, plate of V_1 back to cathode of V_1.

When C_3 has been charged sufficiently to make the grid potential of V_2 75 volts with respect to its cathode, V_2 becomes conducting. C_4 is discharged through V_2 and R_6 in approximately .005 second. C_3 is discharged through the grid and cathode of V_2. At the completion of these discharges, V_2 becomes non-conducting. C_4 is recharged through the circuit; B_1, R_5, and C_4, and with V_1 still conducting and contacts 14—15 remaining open the cycle repeats itself so long as 14—15 are open. Thus V_2 and associated parts constitute a relaxation oscillator in which C_4 and C_3 are discharged at regular intervals.

Each time V_2 becomes conducting, the potential of its cathode relative to the negative terminal of B_1 suddenly jumps from 0 to 60 volts. This sudden jump in the cathode voltage of V_2 caused a corresponding instantaneous rise in the potential of the cathode of V_1 since these two cathodes are connected through the condenser C_2. This satisfies the conditions for the extinction of V_1 and so it becomes momentarily non-conducting and V_1 will remain non-conducting if this moment finds contacts 14—15 closed, otherwise it becomes conducting again as soon as the cathode potential of V_1 returns to its normal conducting value (60 volts). Upon closure of contacts 14—15 during a non-conducting period of V_2, then the next discharge of C_4 and C_3 through V_2 will render V_1 permanently non-conducting. While V_1 is non-conducting, the potential of the grid of V_2 cannot exceed 45 volts so that V_2 can never become conducting again until V_1 is rendered conducting. The circuit now has returned to its normal state.

Many types of control actions are possible with this invention. If the relay must remain in continuous operation while a noise persists, a slow opening relay must be used. This is necessary because there is always the probability that the switch S may make a contact at the same instant V_2 fires in which case V_1 becomes non-conducting for a very small fraction of a second. Allowance must also be made for the relay remaining closed after the noise has stopped for an interval not exceeding the periodicity of the intermittent operation of V_2. By varying both the periodicity of operation of V_2 and the type of relay employed quite a large variation can be secured in the type of control established. The number of operations such a device might initiate from its relay contacts is without limit.

According to the provisions of the patent statutes, we have set forth the prinicipal mode of operation of our invention and have illustrated and described what we now consider to represent its best embodiments. However, we desire to have it understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

We claim:

1. In an impulse actuated relay system a normally-closed compressional-wave operated switch, said switch being closed in its unexcited state, a trigger circuit, a relay coil, a source of electrical current for energizing said coil, a high resistance path forming a part of said circuit, said path including said source, said switch and said coil, a cold cathode tube having an anode, grid and cathode, an alternate low resistance path including said source and said coil and being shunted around said switch through said tube, an R. C. time-constant circuit comprising a resistance and condenser connected in multiple across the anode and grid of said tube and in series in said high resistance circuit whereby the condenser remains charged during closure of said high resistance circuit to apply a blocking bias to said tube as long as said switch remains closed, the condenser of said R. C. circuit being discharged to remove said blocking bias from said tube when said switch is opened by the reception of impulses thereby, whereby said tube will be rendered conducting and the energization of said coil will be raised to an operating level and means rendered operative by the flow of current through said alternate path momentarily to render said tube non-conducting after a predetermined period of time.

2. In an impulse actuated relay system a normally-closed compression-wave operated switch, said switch being closed in its unexcited state, a trigger circuit, a relay coil, a source of electrical current for energizing said coil, a high resistance path forming a part of said circuit, a relay circuit in said path, said path including said source, said switch and said coil, a cold cathode detector tube, an alternate low resistance path including said source and said coil being shunted around said switch through said tube, an R. C. time-constant circuit comprising a resistance and condenser connected in multiple across the anode and grid of said tube and in series in said high resistance circuit whereby the condenser remains charged during closure of said high resistance circuit to apply a blocking bias to said tube as long as said switch remains closed, said condenser being discharged through said resistance to remove said blocking bias from said tube when said switch is opened by the reception of an impulse thereby, whereby said tube will be rendered conducting and the energization of said coil will be raised to an operating level, a relaxation oscillator in said trigger circuit, means for utilizing the flow of current through said alternate path to excite said oscillator, and means for causing each oscillation of said oscillator momentarily to render said detector tube non-conducting.

3. A relay system comprising a source of direct current, a cold cathode triode, a first limiting resistance and an electrically actuated relay all connected in series, the positive side of the current source being connected to the plate of the said triode, a normally-closed compressional-wave operated switch connecting the grid of the triode with the negative terminal of the source in series with said relay said first limiting resistance and a second limiting resistance, a time constant circuit comprising a resistance and capacity connected in multiple across the plate and grid of said triode to apply a blocking bias to the triode, a dropping resistance connecting the negative terminal of the source through a coupling condenser to the cathode to effect a rise in potential of the cathode upon a flow of current through the dropping resistance, a storage condenser, a second cold cathode triode, said storage condenser connecting the negative terminal of said source with the plate of said second triode, the cathode of said second triode being connected to that side of the dropping resistance which connects to the coupling condenser, a grid condenser connected directly across the grid and cathode of the second triode, a second direct current source and a timing resistance connected in series between the cathode of the first triode and the grid of the second triode with the positive terminal of said source nearer said grid and the negative terminal nearer said cathode, and a charging resistance connecting the positive terminal of said first source to the plate of said first triode and therefore to that side of the storage condenser which is connected to the said plate.

4. A relay system comprising a first source of unidirectional current, a cold cathode tube, a first limiting resistance and an electrically operated relay all connected in series, the positive side of the current source being connected to the plate of said tube, a normally-closed compressional-wave operated switch connecting the grid of the tube with the negative terminal of the source in series with said relay said first limiting resistance and a second limiting resistance, a time constant circuit comprising a resistance and a capacity connected in multiple across the plate and grid of said tube whereby disconnection of said grid from the said negative terminal will permit the grid to rise in potential relative to the said negative terminal during discharge of the condenser and render the triode conducting, and means

intermittently raising the potential of said cathode relative to the negative terminal of said source controlled in the output circuit of the tube.

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