Aug. 18, 1931. E. F. CARTER 1,819,868

ELECTRORESPONSIVE DEVICE

Filed Dec. 8, 1924

Fig. 1.

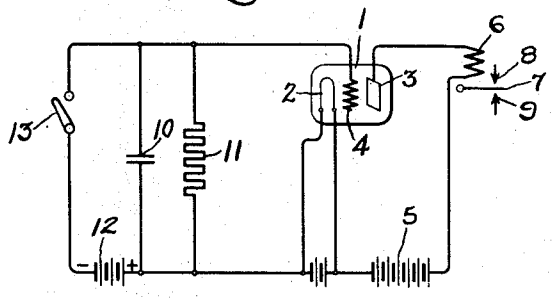
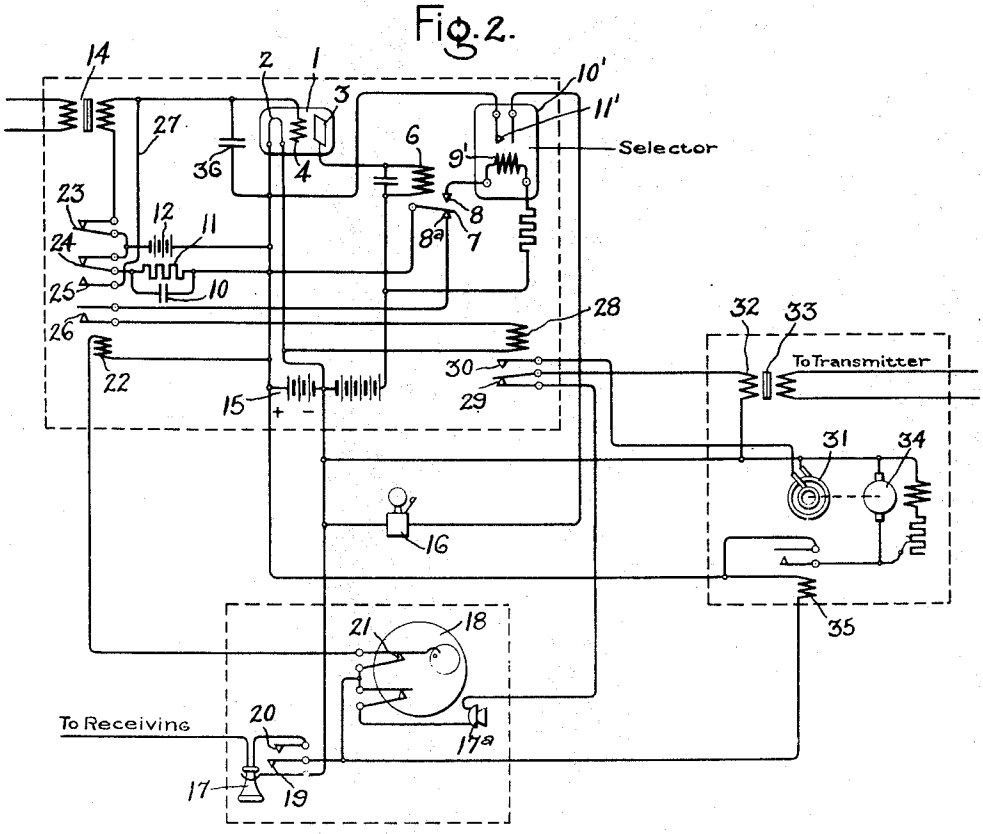


Fig. 2.



Inventor:
Emmett F. Carter;
by Alexander S. Lunt.
His Attorney.

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UNITED STATES PATENT OFFICE

EMMETT F. CARTER, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

ELECTRORESPONSIVE DEVICE

Application filed December 8, 1924. Serial No. 754,482.

My present invention relates to apparatus adapted to respond to electric currents or impulses and more particularly to apparatus which is adapted to be actuated in response to an electrical condition only at the end of a predetermined time interval after the electrical condition has been produced.

More specifically my invention relates to a time limit apparatus for delaying the operation of a relay or other electro-responsive mechanism.

One of the objects of my invention is to provide a time limit apparatus which will not depend upon any moving parts for the introduction of the time limit feature of its operation and which will at the same time be positive and reliable in its action.

Another object of my invention is to provide an apparatus in which the time required for operation may be fixed at any desired value.

In carrying my invention into effect I provide an electrical energy storage means for controlling the operation of an electro-responsive device. The operation of the electro-responsive device is dependent upon the amount of electrical energy in the energy storage means. In order to produce an operation of the electro-responsive device means may be provided for causing a change in the amount of energy stored in the energy storage means. Means may also be provided for controlling the rate of change in the amount of stored energy. By adjustment of this last mentioned means the time required for a change in the amount of stored energy from a value at which the electro-responsive device will not operate to a value at which it will operate may be fixed at any period desired.

In the specific embodiment of my invention, which I am about to describe, I employ in conjunction with the energy storage means a means which is controlled by the potential resulting from the stored energy, which potential is of course dependent upon the amount of stored energy. One convenient form of potential operated device is a three electrode electron-discharge device having associated therewith the usual grid or control circuit and plate or output circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation will best be understood by reference to the following description taken in connection with the accompanying drawings, in which Fig. 1 shows diagrammatically a circuit organization embodying my invention, and Fig. 2 shows the utilization of my invention in a selective calling system for telephone communication.

I have indicated in Fig. 1 of the drawings an electron discharge device 1 of the three electrode type having the usual cathode 2, anode 3 and grid 4. The output or plate circuit of this device comprises the usual source of energy 5 and winding 6 of a relay, the armature 7 of which, when the relay is energized makes contact at 8 for closing a circuit. When the relay is not energized the armature 7 makes contact at 9 and thereby may close the second circuit.

In the grid or control circuit of device 1 there is included in parallel an energy storage device consisting of a condenser 10, a high resistance 11, and the battery 12 having its negative terminal connected to the grid 4 through a switch 13. This battery is of such a value that the negative potential impressed thereby upon the grid 4 is sufficient to either entirely interrupt the current in the plate circuit, or reduce it to such a value that the winding 6 will not be energized sufficiently to operate the relay. If then the battery 12 is disconnected from the grid as by opening the switch 13, the grid will still be negative by reason of the charge upon the condenser 10. The energy stored up in the condenser 10, however, will gradually be discharged through the resistance 11 until the potential of the grid 4 has fallen to such a value as to permit enough current to flow in the output circuit of device 1 to operate the relay.

The time required for this operation to take place will depend of course upon the amount

of energy stored in the condenser 10 and the value of resistance 11, as well as the difference between the normal potential of the grid 4 and potential at which sufficient current will be permitted to flow in the plate circuit to operate the relay.

By adjustment of these different variables the time interval between the opening of switch 13 and the operation of the relay may be fixed at any desired value. The time delay varies directly as the product of the resistance and capacity and with the logarithm of the ratio between the charging voltage and the grid voltage at which the relay operates. I have found that in actual practice the period may be fixed very accurately at any value desired and that the period will remain constant over long intervals of operation.

In the system shown in Fig. 2 I have illustrated the application of a time delay device, such as described in a system adapted for receiving a call and ringing a bell or operating any other desired form of signal, and also a system for transmitting a call for ringing a bell at another desired station. This system is especially suitable for operation on the so-called carrier current telephone communication system although it may be applied to ordinary wire or radio communication. In the system illustrated operation is produced by the interruption of a calling current. When the system is to be used for receiving a call the calling current, which may be a modulated high frequency current, is received and detected by any suitable apparatus, and the detected current impressed by means of the transformer 14 upon the input circuit of device 1. When current is thus received the potential of the grid 4 is raised sufficiently to cause the operation of the relay 6, which closes the contact at 8 and completes a circuit from the battery 15 through the winding 9′ of a selector relay 10′. This selector relay 10′ is of any well known type, which may be adjusted to respond only to a predetermined succession of impulses. When the calling current is interrupted the relay 6 immediately releases its armature and the circuit through winding 9′ is thus broken. Thus it will be seen that the circuit through the winding 9′ is opened at each interruption of the calling current and immediately closed when the calling current starts again. When the number of interruptions in the calling current and the order in which these interruptions are produced corresponds to the number fixed with the operation of the selector 10′, contact is made at 11′, thereby closing the circuit from the source 15 through the bell 16. This circuit will remain closed as long as the calling current continues as the relay 6 will remain energized.

The system is provided with a telephone instrument which may be of the type commonly used in machine switching telephone systems. This is indicated merely diagrammatically in the drawings as comprising the usual receiver 17, transmitter 17*a* and a dialing device 18. When the call is received in the manner described the person answering the call removes the telephone receiver 17 from the hook and thereby closes contacts 19 and 20. Contact 19 completes a circuit from the negative terminal of the source 15 through the contact 21 of the dialing mechanism and the winding 22 of a master relay back to the positive terminal of source 15.

This relay operates to open contacts at 23 and 24, and make contacts at 25, 26. By the opening of contact 23 the secondary of transformer 14 is disconnected from the grid circuit, thus precluding any possibility of supplying energy to the device 1 during subsequent operations. The opening of contact 24 and making contact 25 disconnects the battery 12 from the grid circuit and connects resistance 11 and condenser 10 directly to the grid through the connection 27. The condenser 10 being fully charged and the calling current supplied to grid 4 being interrupted the relay 6 will be de-energized and its armature 7 will be making contact with the lower contact 8*a*. The winding 9′ being deenergized the contact at 11′ will open and the bell circuit will be interrupted. At the same time that contact is made at 26 a circuit is closed from the positive terminal of source 15 through contacts 8*a* and 26 and the winding 28 of a relay. This relay being energized breaks contact 29 and makes contact at 30. The result of this is to connect the tone generator or source of calling current 31 through the primary winding 32 of the transformer 33 and to disconnect the microphone 17ª from this primary.

The tone generator 31 is driven by a motor 34, which is supplied with current from a battery 15. The motor circuit is closed by means of relay 35, which in turn is energized by the making of contact 19 when the receiver is removed from the hook. At the same time that relay 35 operates, other mechanism may also be brought into action to start the operation of the transmitting equipment for producing modulated high frequency current. A short time will be required for this apparatus to come into operation, hence the tone generator 31 will not immediately cause a calling signal to be sent out. By the time the transmitting equipment is in condition for operation the charge on condenser 10 will have been reduced sufficiently to permit the operation of relay 6. This will open the circuit through relay 28 and disconnect the tone generator from the microphone transformer and connect the microphone. The system will then be ready for transmitting conversation.

When the operator desires to call another station he removes the receiver 17 from the

hook and gives the transmitting set time to come into operation. The same cycle of relay operations takes place as described previously. The operator then dials the called station in the usual way. Upon releasing the dial for each digit in the call the dial returns to normal, breaking the circuit through the master relay 22 as many times as there are units in the digit. On each interruption the master relay 22 opens and also instantly closes again. For each interruption therefore the condenser 10 and discharge resistance 11 are momentarily connected across the battery 12 and then reconnected to the grid 4. This action keeps the charge on the grid negative throughout the dialing process and the relay 6 thus remains deenergized. For this purpose the time delay should be made great enough so that the relay will not operate during the normal period between dialing of the successive digits of the number called. The interruption in the calling current is effected by the momentary break at the contact 26 and the consequent break at contact 30.

The calling system described may properly be termed an interrupter system rather than an impulse system of calling as the impulses are of long duration with respect to the interruptions. A system using short impulses and long interruptions will be much more susceptible to static or other disturbances giving the effect of extra impulses in the received signal train and therefore causing failure to complete the desired call or the making of a false call.

The grid circuit of device 1 is preferably shunted by a by-pass condenser 36 of comparatively small value for the purpose of protecting the device 1 from damage due to high frequency pick-up when the transmitting equipment is in operation.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination of an electrical circuit, an electron discharge device comprising a cathode and an anode connected between different parts of said circuit and with a grid arranged to control the current transmitted between said cathode and anode, energy storage means connected between said cathode and grid, energy dissipating means connected in parallel with said storage means, a source of energy, switching means arranged to connect said source between said grid and cathode in parallel with said storage and dissipating means and to disconnect said source from said storage means whereby the current in said anode is controlled by said energy storage means after said source is disconnected, and a transformer having a secondary winding connected between said grid and cathode whereby alternating electromotive force may be applied to said grid.

2. The combination of an electrical circuit, an electron discharge device comprising a cathode and an anode connected between different parts of said circuit and with a grid arranged to control the current transmitted between said cathode and anode, energy storage means and energy dissipating means connected in parallel between said grid and cathode, means for supplying energy to said storage means, and means connected between said grid and cathode in series with said storage and dissipating means for causing current to be transmitted through said circuit indicating means responsive to said current, transmitting means, means for simultaneously operating said transmitting and energy supply means, and means including the energy storage and dissipating means for interrupting the operation of said transmitting means after a predetermined time interval.

3. The combination of an electrical circuit, an electron discharge device comprising a cathode and an anode connected between different parts of said circuit and with a grid arranged to control the current transmitted between said cathode and anode, energy storage means connected to said grid and cathode, energy dissipating means connected in parallel with said storage means, a source of energy, switching means arranged to connect said source between said grid and cathode in parallel with said storage and dissipating means and to disconnect said source from said grid and storage means whereby the current in said anode is controlled by said energy storage means after said source is disconnected from said grid and storage means by said switching means, and means connected between said cathode and grid in series with said source for causing a modulated high frequency potential to be applied to said grid.

4. The combination of an electrical circuit, an electron discharge device comprising a cathode and an anode connected between different parts of said circuit and with a grid arranged to control the current transmitted between said cathode and anode, energy storage means connected between said grid and cathode, energy dissipating means connected in parallel with said storage means, a source of energy, switching means arranged to connect said source between said grid and cathode in parallel with said storage and dissipating means whereby the current in said anode is controlled by said energy storage means after said source is disconnected from said grid by said switching means, a relay connected in said electrical circuit, and high frequency current supply means connected between said grid and cathode in series with said source for energizing said relay.

5. The combination of an electrical circuit, an electron discharge device comprising a cathode and an anode connected between different parts of said circuit and with a grid arranged to control the current transmitted

between said cathode and anode, energy storage means connected between said grid and cathode, energy dissipating means connected in parallel with said storage means, a source of energy, switching means arranged to connect said source between said grid and cathode in parallel with said storage and dissipating means, a relay connected in said electrical circuit, high frequency current supply means connected between said grid and cathode in series with said source for energizing said relay, and additional means controlled jointly by said relay and said switching means.

6. In combination, a space discharge device provided with an anode, a cathode and a grid for controlling the current flowing between said cathode and anode, energy storage means and energy dissipating means connected in parallel between said grid and cathode, an energy source connected between said grid and cathode, a pair of transmitting devices, a circuit for each transmitting device, means for interrupting the connection of said energy source between said grid and cathode and for simultaneously completing a circuit for one of said devices, and means responsive to current flowing between said anode and cathode to interrupt said circuit and to complete a circuit for said other transmitting device when the energy of said storage device has decreased to a predetermined value.

7. In combination, a space discharge device provided with an anode, a cathode, and a grid for controlling the current flowing between said cathode and anode, energy storage means and energy dissipating means connected in parallel between said grid and cathode, an energy source connected between said grid and cathode, a pair of transmitting devices, a circuit for each transmitting device, means for interrupting the connection of said energy source and for simultaneously completing one of said circuits, and means connected between the anode and cathode for interrupting said circuit and completing the other circuit at a predetermined time after interrupting the connection of said source.

8. The combination in an electrical system of an electron discharge device having input and output circuits, a condenser, a source of potential and a resistance all connected in parallel in said input circuit, a relay which is responsive to the current in said output circuit, means for disconnecting the source of potential, from the input circuit, the whole being so arranged and proportioned that the relay will operate at a predetermined time interval after the source of potential has been disconnected from the input circuit, and additional means for applying electromotive force to the grid to cause instantaneous operation of said relay.

9. The combination in an electrical system of an electron discharge device having a cathode, an anode and a grid, and having grid and output circuits associated therewith, a relay which is responsive to the current in the output circuit, a source of potential, a condenser and a resistance all connected in parallel in said grid circuit in such a way that the potential of the grid is normally of such a negative value that the relay will not be energized, means for disconnecting the source of potential from the grid circuit, the whole being so arranged and proportioned that the relay will operate by reason of the decrease in the negative potential of the grid at a predetermined time interval after a source of potential has been disconnected from the grid circuit, and means for applying alternating electromotive force to the grid to cause instantaneous operation of the relay.

In witness whereof I have hereunto set my hand this 6th day of December, 1924.

EMMETT F. CARTER.