Dec. 9, 1941.

E. T. BURTON

2,265,224

RELAY CIRCUIT

Filed Nov. 2, 1939

FIG. 1

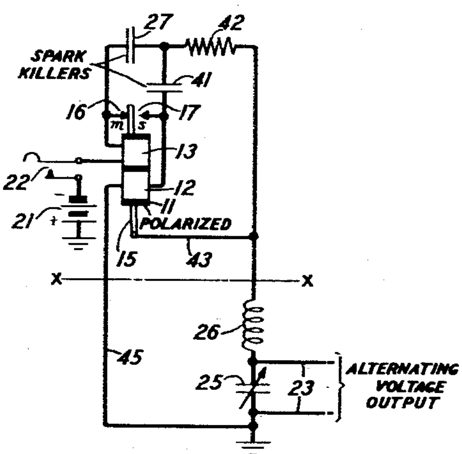


FIG. 2

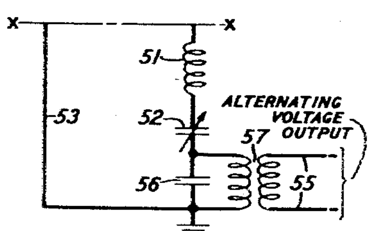


FIG. 3

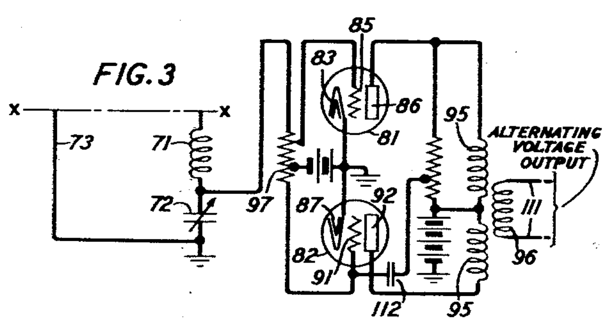


FIG. 4

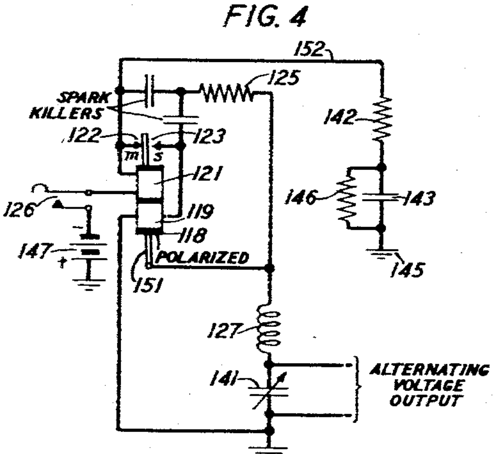
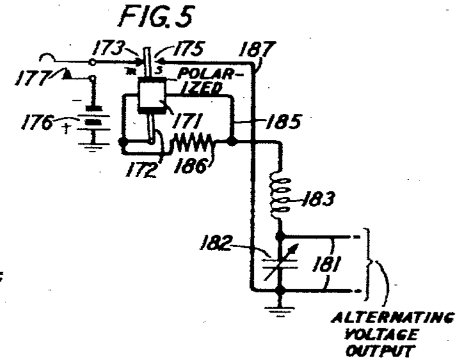


FIG. 5



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2,265,224

RELAY CIRCUIT

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Application November 2, 1939, Serial No. 302,570

10 Claims. (Cl. 175—365)

This invention relates to a relay circuit and particularly to a vibrating circuit for the production of electrical oscillations.

An object of the invention is the production of electrical oscillations in an economical and efficient manner.

In certain types of electrical circuit work it may be necessary to continuously operate one or more oscillators for an extended period, possibly several months. While the vacuum tube type of oscillator may of course be used in such work it is relatively expensive to construct and maintain in operation. A relay type of oscillator in accordance with the present invention has been found especially valuable for use in work of this kind as it is relatively low in cost, simple, compact and low in maintenance expense.

A feature of the invention is means for periodically changing the direction of current flow through a relay winding whereby the relay armature is caused to vibrate.

A further feature of the invention is starting means for initially setting the relay into operation.

In accordance with a specific embodiment of the invention the relay oscillator includes a two-position polar relay with two equal windings, a source of power and a series resonant circuit comprising a condenser and an inductance. The condenser of the resonant circuit is charged through one winding of the relay and discharged through the other. Vibration of the relay armature is caused by current reversals in the charge path and the discharge path resulting from the action of the resonant circuit. The period of these vibrations is governed substantially by the values of the condenser and inductance of the resonant circuit.

In accordance with a modification of the invention a single winding polar relay is utilized.

A complete understanding of the arrangements contemplated by the invention and an appreciation of the various features thereof may be had from consideration of the subsequent detailed description and the accompanying drawing in which:

Fig. 1 illustrates a vibrating relay circuit which embodies features of the present invention;

Fig. 2 illustrates an alternative form of the output circuit illustrated in Fig. 1 which may be used to advantage when a small amount of output current at a low voltage is desired;

Fig. 3 illustrates a second alternative form of the output circuit which may be used to advantage when a large amount of output power is desired;

Fig. 4 illustrates a relay circuit of the nature shown in Fig. 1 modified by the addition of a start circuit; and

Fig. 5 illustrates a modification of the vibrating relay circuit which utilizes a single winding relay instead of the two-winding relay illustrated by the circuit of Fig. 1.

Referring now to the drawing, there is shown in Fig. 1 a relay circuit including a two-position polar relay **11** provided with two equal windings **12** and **13**, an armature **15** and two opposed contacts **16** (mark) and **17** (space). Battery **21** is connected in series with winding **13** through key **22**. Output circuit **23** is connected across variable condenser **25**; condenser **25** together with inductance **26** comprises a tuned series resonant circuit. Condensers **27** and **41** and resistance **42** are provided in order to suppress sparking at the relay contacts.

While the magnitudes of the various elements may, of course, be varied in accordance with varying operating conditions one embodiment of the invention which has operated successfully utilized an inductance (corresponding to inductance **26**) of 20 henries, a capacity (corresponding to condenser **25**) of 11 microfarads, two capacities of ½ microfarad each (corresponding to condensers **27** and **41**) and a resistance of 150 ohms (corresponding to resistance **42**). The inductance of the relay windings was very small in comparison to that of inductance **26** and need not be taken into account when considering the operation of the circuit. A battery of 48 volts (corresponding to battery **21**) was provided. The circuit operated at a frequency of 5 cycles per second.

In order to describe the operation of the circuit of Fig. 1, let us assume that, with armature **15** in engagement with contact **16** as shown, key **22** be closed. Condenser **25** now takes a charging current from source **21** over a path traced from the plus side of battery **21**, condenser **25**, inductance **26**, conductor **43**, armature **15**, contact **16**, winding **13** of relay **11**, key **22** to the minus side of battery **21**. Current flowing in this direction through winding **13** tends to hold armature **15** in engagement with contact **16**.

During the initial flow of this charging current, inductance **26** stores up magnetic energy in its field thereby forcing condenser **25** to charge gradually. As the voltage on the condenser increases, the current eventually begins to decrease and the magnetic energy stored in inductance 26 begins to return to the circuit and aids the current flow therein. The voltage on the condenser eventually exceeds the battery voltage after which the current flow is maintained entirely by the magnetic energy supplied by inductance 26. At such time as the magnetic field of inductance 26 entirely disappears, condenser 25 is charged to a potential considerably in excess of that of battery 21. The current flowing in the path traced above, now reverses its direction therefore, and flows through winding 13 in the opposite direction. Flow of current through winding 13 in this new direction causes armature 15 to leave contact 16 and to move into engagement with contact 17. During the short transition period when armature 15 is not in engagement with either contact 16 or 17, flow of current through winding 13 in the last-mentioned direction is maintained, the current path now including condenser 27 and resistance 42 of the spark killer circuit.

After armature 15 engages contact 17, discharge of condenser 25 is continued over a new path traced from condenser 25, conductor 45, winding 12, contact 17, armature 15, conductor 43 and inductance 26. Flow of current through winding 12 in this direction tends to hold armature 15 in engagement with contact 17.

During the initial flow of the current in the discharge direction, inductance 26 stores up magnetic energy in its field, the inductance tending at first to retard the flow of current in the discharge direction and, later, tending to aid the flow in the manner described above with reference to the flow of charging current. When the condenser voltage reaches zero, i. e., when the condenser is completely discharged, the energy of the magnetic field of inductance 26 causes the flow of current to continue until the condenser is recharged to the opposite polarity. When the magnetic field has died out, condenser 25 again begins to discharge thereby resulting in reversing the direction of current flow in the path last traced. Flow of current through winding 12 in this new direction causes armature 15 to leave contact 17 and to move into engagement with contact 16 whereupon the entire cycle is repeated. During the short transition period when armature 15 is not in engagement with either contact 17 or 16, flow of current through winding 12 in the direction last referred to is maintained, the current flowing to winding 12 through resistance 42 and condenser 41 of the spark killer circuit.

In instances when output voltage of essentially sine wave form is required, output line 23 is connected across condenser 25 as illustrated where the harmonic components of the wave are low; this output line may be associated in suitable manner with the load circuit. This connection is suitable, however, only if the load circuit impedance be sufficiently high that the effectiveness of the condenser 25 as a tuning element is not seriously impaired.

In certain instances a small amount of output current at a low voltage may be required. In such case the circuit of Fig. 1 may be modified as shown in Fig. 2. Except for the connection of the output line, the arrangement is the same as that disclosed by Fig. 1 and is not therefore illustrated in its entirety, only the portion below the dotted line X—X being shown. In Fig. 2 inductance 51 corresponds to inductance 26 of Fig. 1, condenser 52 corresponds to condenser 25 and conductor 53 corresponds to conductor 45. In the instance of Fig. 2, however, the output line 55 is not connected across the condenser of the series resonant circuit as in Fig. 1, but is connected across a supplementary condenser 56 of relatively large capacity, a suitable coupling transformer 57 being included in the connection. The circuit functions in the manner discussed above in connection with Fig. 1 to produce an oscillation across condenser 56 which is transmitted into output line 55 through transformer 57.

In instances when a high current output is required a vacuum tube amplifier may be utilized. A single stage negative grid amplifier of a suitable type for the purpose is illustrated in Fig. 3. Here again as in the case of the circuit of Fig. 2, the arrangement is the same as that of Fig. 1 except for the output circuit and only the portion of the circuit below the dotted line X—X is shown. Inductance 71 of Fig. 3 corresponds to inductance 26 of Fig. 1, condenser 72 corresponds to condenser 25 and conductor 73 corresponds to conductor 45.

The amplifier circuit includes two vacuum tubes 81 and 82, vacuum tube 81 being provided with cathode 83, grid 85 and anode 86 and vacuum tube 82 being provided with cathode 87, grid 91 and anode 92. Anodes 86 and 92 are connected in parallel to primary winding 95 of the output transformer; the secondary winding 96 of the output transformer is connected to the load.

In operation the alternating current wave appearing across condenser 72 is applied to grid 85 through potentiometer 97. This current is amplified by vacuum tube 81 in the usual manner and is supplied to line 111 through primary winding 95 and secondary winding 96 of the output transformer. A portion of the amplified wave is applied to grid 91 of vacuum tube 82 through a comparatively large condenser 112. This portion of the wave is amplified by vacuum tube 82 and is also supplied to line 111 through the output transformer, being superimposed on the current supplied by vacuum tube 81. Since the alternating grid and plate voltages of a vacuum tube are in opposite phase, that is to say, a 180-degree phase shift takes place in passage of a signal through a vacuum tube, it will be evident that the portion of the wave applied to vacuum tube 82 and amplified thereby is in reverse phase with respect to the amplified output of vacuum tube 81. This scheme of amplification has been found to produce an output of reasonably low distortion. The peak-to-peak voltage swing occurring on condenser 72 is higher than the battery voltage and may approach twice the battery voltage. It will be apparent, therefore, that by the use of a suitable single-stage vacuum tube amplifier, as illustrated, considerable output power will be made available.

In the instance of the circuit illustrated in Fig. 1 it is apparent that should the armature be resting on the space contact 17, when key 22 is closed the circuit will not of its own accord establish a state of oscillation. While the circuit may of course be set into operation by manually moving the armature to contact 16, a starting arrangement of the nature illustrated in Fig. 4 may be utilized for greater convenience. With the exception of the starting arrangement, the circuit of Fig. 4 is the same as that of circuit 1, relay 118 with windings 119 and 121 and contacts 122 (mark) and 123 (space) corresponding to relay 11 with windings 12 and 13, and contacts 16 and 17, resistance 125 corresponding to resistance 42, key 126 corresponding to key 22, inductance 127 corresponding to inductance 26, variable condenser 141 corresponding to variable condenser 25, and so on. The starting arrangement which has been added to the circuit of Fig. 4 comprises resistance 142 and condenser 143 connected in series between mark contact 122 and ground 145. Condenser 143 is shunted by a high resistance 146.

In one embodiment of the circuit operated successfully by applicant, resistances of 5000ω and ½ megohm (corresponding respectively to resistances 142 and 146) and a capacity of 2 microfarads (corresponding to condenser 143) were utilized. The magnitudes of the other elements were as listed above in reference to Fig. 1.

The operation of the circuit of Fig. 4 as a whole is the same as that of the circuit of Fig. 1 and it will be described at this point only sufficiently to illustrate the operation of the starting arrangement. When the operation of the relay is interrupted by opening key 126 and disconnecting battery 147, condenser 143 discharges through shunt resistance 146 to ground 145. Assuming that armature 151 is in engagement with contact 122 when key 126 is again closed, the relay will be immediately set into operation as described above in connection with Fig. 1. Should armature 151 be in engagement with contact 123, however, when key 126 is closed, condenser 143 will be charged over a path traced from battery 147, key 126, winding 121 of relay 118, conductor 152, resistance 142, condenser 143 to ground 145. Current flowing through winding 121 over this path operates armature 151 to engage contact 122 whereupon the relay starts to oscillate as described above in connection with the circuit of Fig. 1. During regular operation of the circuit the effect of the start circuit is negligible amounting only to a shunt across winding 121.

Referring now to Fig. 5 a vibrating relay circuit is disclosed which, while operating in a manner generally similar to the circuit of Fig. 1, utilizes a single winding relay instead of a two-winding relay. Polar relay 171 is provided with armature 172 and two contacts 173 and 175, mark and space respectively. Battery 176 is connected in series with contact 173 through key 177. Output circuit 181 is connected across variable condenser 182; condenser 182 together with inductance 183 comprises a tuned series resonant circuit.

In order to describe the operation of the circuit of Fig. 5, let us assume that, with armature in engagement with contact 173 as shown, key 177 be closed. Condenser 182 now becomes charged over a circuit traced from the plus side of battery 176, condenser 182, inductance 183, conductor 185, winding of relay 171 (the resistance of fixed resistor 186 being higher than that of the relay winding), armature 172, contact 173, key 177 to the minus side of battery 176. Current flowing in this direction through the winding of relay 171 tends to hold armature 172 in engagement with contact 173.

During the initial flow of this charging current, inductance 183 stores up magnetic energy in its field thereby forcing condenser 182 to charge gradually. As the voltage on condenser 182 increases, the current eventually begins to decrease and the magnetic energy stored in inductance 183 begins to return to the circuit and aids the current flow therein. The voltage on the condenser eventually exceeds the battery voltage after which the current flow is maintained entirely by the magnetic energy supplied by inductance 183. At such time as the magnetic field of inductance 183 entirely disappears, condenser 182 is charged to a potential considerably in excess of that of battery 176. The current flowing in the path traced above, now reverses its direction therefore, and flows through the winding of relay 171 in the opposite direction. Flow of current through the relay winding in this new direction causes armature 172 to leave contact 173 and to move into engagement with contact 175.

After armature 172 engages contact 175, discharge of condenser 182 is continued over a new path traced from condenser 182, conductor 187, contact 175, armature 172, winding of relay 171, conductor 185 and inductance 183. Passage of current through the winding of relay 171 in this direction tends to hold 172 in engagement with contact 175.

During the initial flow of the current in the discharge direction, inductance 183 stores up magnetic energy in its field, the inductance tending at first to retard the flow of current in the discharge direction and, later, tending to aid the flow in the manner described previously. When the condenser voltage reaches zero, the energy of the magnetic field of inductance 183 causes the flow of current to continue until condenser 182 is recharged to the opposite polarity. When the magnetic field has died out, condenser 182 again begins to discharge thereby resulting in reversing the direction of current flow in the path last traced. Flow of current through the winding of relay 171 in this new direction causes armature 172 to leave contact 175 and to move into engagement with contact 173 whereupon the entire cycle is repeated.

While specific embodiments of the invention have been selected for detailed description, the invention is not, of course, limited in its application to the embodiments disclosed. The embodiments described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. A vibrating relay circuit including a polar relay having two operating windings and an armature adapted to engage either of two opposed contacts, a potential source and a resonant circuit, engagement of said armature with one of said contacts being effective to connect said resonant circuit in series with one of said windings and said potential source and engagement of said armature with the other of said contacts being effective to connect said resonant circuit in series with the other of said windings.

2. A vibrating relay circuit including a polar relay having an operating winding, an armature, and two opposed contacts, a potential source, engagement of said armature and one of said contacts being effective to establish a flow of current from said potential source through said winding in one direction, and means effective upon establishment of said current flow to reverse the direction thereof, flow of current through said winding in the reversed direction being effective to cause said armature to engage the other of said contacts, said means being effective also to again reverse the direction of current flow through said winding after said armature has engaged said other contact.

3. A vibrating relay circuit including a polar relay having an operating winding, an armature,

and two opposed contacts, a potential source, engagement of said armature and one of said contacts being effective to establish a flow of current from said potential source through said winding in one direction, and means effective upon establishment of said current flow to reverse the direction thereof, flow of current through said winding in the reversed direction being effective to cause said armature to engage the other of said contacts, said means being effective also to again reverse the direction of current flow through said winding after said armature has engaged said other contact, said means consisting of a tuned resonant circuit comprising an inductance and a variable condenser connected in series.

4. A vibrating relay circuit including a polar relay having two operating windings and an armature adapted to engage either of two opposed contacts, a source of current, means for causing a flow of current through one of said windings in a direction effective to hold said armature in engagement with one of said contacts, means for causing a flow of current through the other of said windings in a direction effective to hold said armature in engagement with the other of said contacts, and means effective when current is passed through either of said windings in said respective holding directions to cause a reversal of direction of the current through said respective winding; passage of current through either of said windings in the reversed direction being effective to cause movement of said armature from the contact with which it is engaged to the opposed contact.

5. In combination a polar relay having two operating windings and an armature adapted to engage either of two opposed contacts, a potential source, a condenser, a path for charging said condenser from said potential source, said charging path being effective to conduct current through through one of said windings in a direction effective to hold said armature in engagement with one of said contacts, a path for discharging said condenser, said discharging path being effective to conduct current through the other of said windings in a direction effective to hold said armature in engagement with the other of said contacts, and means effective upon passage of current in either of said paths in said holding direction to cause a reversal of direction of current through the respective winding; passage of current through either winding in the reversed direction being effective to cause movement of said armature from the contact with which it is in engagement to the opposing circuit.

6. In combination a polar relay having two operating windings and an armature adapted to engage either of two opposed contacts, a potential source, a condenser, a path for charging said condenser from said potential source, said charging path being effective to conduct current through one of said windings in a direction effective to hold said armature in engagement with one of said contacts, a path for discharging said condenser, said discharging path being effective to conduct current through the other of said windings in a direction effective to hold said armature in engagement with the other of said contacts, and means effective upon passage of current in either of said paths in said holding direction to cause a reversal of direction of current through the respective winding; passage of current through either winding in the reversed direction being effective to cause movement of said armature from the contact with which it is in engagement to the opposing contact, said last-mentioned means including an inductance.

7. A vibrating relay circuit including a polar relay having two operating windings, an armature and two opposed contacts, a potential source, a resonant circuit, one of said contacts being connected in series with one of said operating windings, said potential source and said resonant circuit, the other of said contacts being connected in series with the other of said operating windings and said resonant circuit, and a network including a capacity shunted by a resistance connected in series with said potential source, said first winding and ground.

8. A vibrating relay circuit including a polar relay having two operating windings, an armature and two opposed contacts, a potential source, engagement of said armature and one of said contacts being effective to establish a flow of current from said potential source through one of said windings in one direction, means effective upon establishment of said current flow to reverse the direction thereof, flow of current through said winding in the reversed direction being effective to cause said armature to engage the other of said contacts, said means consisting of a tuned resonant circuit comprising an inductance and a variable condenser connected in series, and an output circuit connected across said condenser, said output circuit including an amplifier.

9. A vibrating relay circuit including a polar relay having two operating windings, an armature and two opposed contacts, a potential source, a resonant circuit, engagement of said armature with one of said contacts being effective to connect said resonant circuit in series with one of said windings and said potential source and engagement of said armature with the other of said contacts being effective to connect said resonant circuit in series with the other of said windings, and means effective when said relay is in non-vibrating condition with said armature in engagement with said other contact for establishing a flow of current from said potential source through the winding in series therewith in a direction effective to cause movement of said armature from the contact with which it is engaged to the opposed contact.

10. A vibrating relay circuit including a polar relay having two operating windings, an armature and two opposed contacts, a potential source, a resonant circuit, engagement of said armature with one of said contacts being effective to connect said resonant circuit in series with one of said windings and said potential source and engagement of said armature with the other of said contacts being effective to connect said resonant circuit in series with the other of said windings, and means effective when said relay is in non-vibrating condition with said armature in engagement with said other contact for establishing a flow of current from said potential source through the winding in series therewith in a direction effective to cause movement of said armature from the contact with which it is engaged to the opposed contact, said means including a network comprising a capacity shunted by a resistance connected in series with said potential source, said last-mentioned winding and ground.

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