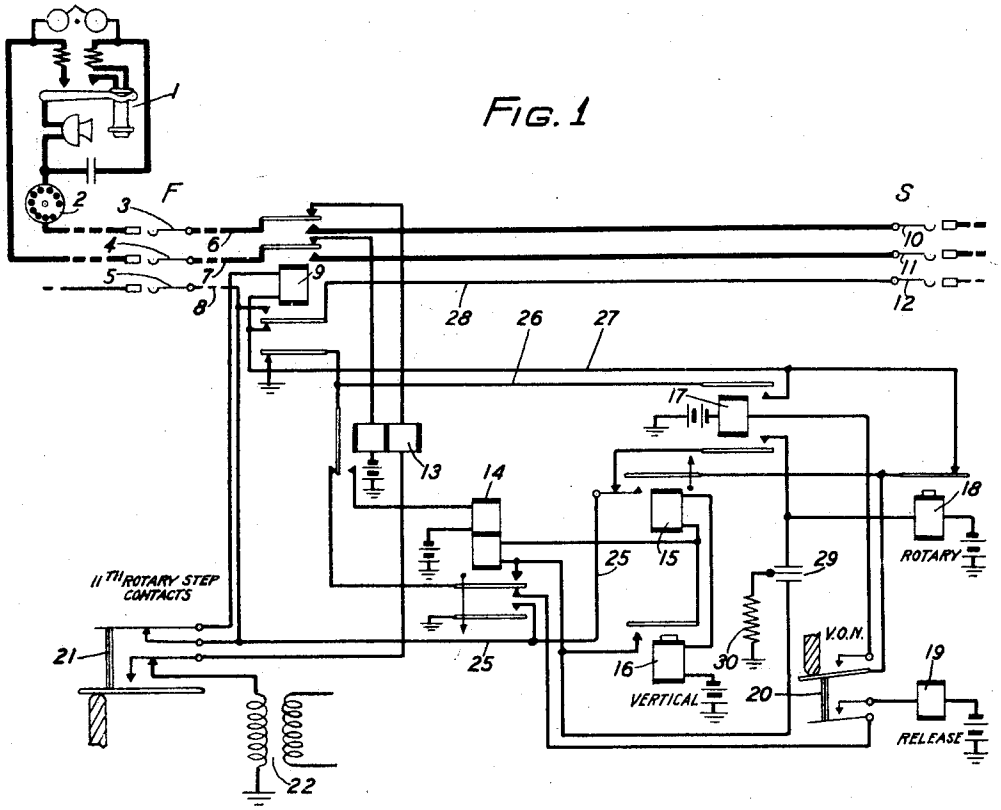
Jan. 5, 1932. C. L. GOODRUM 1,840,090

IMPULSE CIRCUIT

Filed July 31, 1930

FIG. 1



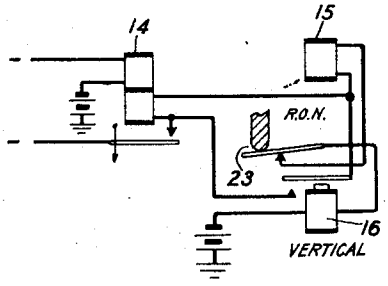


FIG. 2

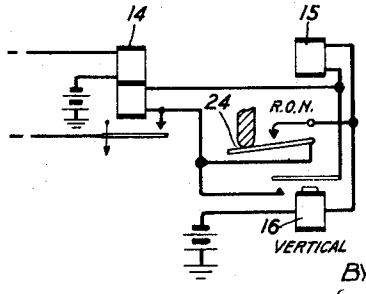


FIG. 3

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IMPULSE CIRCUIT

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This invention relates to impulse circuits and particularly to those employed in the operation of switches for telephone systems.

The objects are to improve the operating conditions of holding relays, to render these relays less liable to release while impulses are being received, to render the adjustments of these relays easier to meet, and to otherwise improve the effectiveness and reliability of impulse circuits.

Heretofore it has been the usual practice to arrange the impulse circuits of step-by-step switches such that the holding and release relay receives its operating energy over a circuit closed through the front contact of the impulse relay. Since the impulse relay releases and operates successively in response to a series of impulses, the circuit of the holding relay is opened on each successive impulse from the time the impulse relay opens its front contact until this contact is again closed. To prevent it from retracting its armature during these openings, the holding relay is constructed so as to release slowly. However, it has been found that unless the relay is properly adjusted it will lose enough energy on a long series of impulses to release, thus causing improper operation of the apparatus.

According to the present invention, these defects are overcome by means of an arrangement in which the holding relay receives energy from two separate circuits, one of which is closed over a front contact and the other of which is closed over a back contact of the impulse relay. With the impulse relay energized, the holding relay is maintained operated over the usual circuit extending through the front contact of the impulse relay. Each time the impulse relay releases its armature to deliver impulses to the vertical stepping magnet, a circuit is closed over the back contact of said relay through a second winding on the holding relay and thence through the winding of the magnet. The holding relay receives energy in this circuit until the vertical magnet has partially operated, at which time the second winding of the holding relay is shunted.

The advantage of this circuit arrangement is that the holding relay receives energy over both front and back contacts of the impulse relay and, therefore, will not accidentally release while impulses are being received, whether the series consists of a few impulses or the maximum number of impulses.

In the drawings Fig. 1 represents a portion of an automatic telephone system in which the circuits for one of the selector switches are shown in detail, other equipment being illustrated diagrammatically. Figs. 2 and 3 show alternative circuit arrangements.

Considering Fig. 1 first, a subscriber's line 1 appears at the central office in a suitable switching device such as a line finder F. When the line calls, the finder F is operated in the usual manner to set its brushes 3, 4 and 5 on the terminals of the line 1, thereby extending said line to a selector switch such as the selector S having the brushes 10, 11 and 12. As soon as the subscriber's line is extended to the selector S, a circuit is closed for the impulse relay 13 and may be traced from battery, through the left-hand winding of said relay, inner upper back contact of relay 9, conductor 7, brush 4, thence over the loop of the calling line and returning through the brush 3, conductor 6, uppermost back contact of relay 9, right winding of relay 13, contacts 21, through the secondary winding of the tone coil 22 to ground. The relay 13 operates and closes an energizing circuit for the holding relay 14. This circuit may be traced from ground, through the lowermost contact of relay 9, front contact of relay 13, upper winding of relay 14 to battery. The relay 14, which controls the release of the switch S, is designed with a slow-release characteristic in order that it will maintain its armatures in their attracted position during the intervals that it is deprived of energizing current while impulses are being received.

The coil 22 causes a tone to be transmitted to the subscriber's substation to notify him that impulses may be transmitted. In response to this tone, the subscriber manipulates his dial 2 to send a series of impulses representing a digital place in the wanted designation. On the first opening of the sub-

scriber's line by the impulse transmitter 2, the impulse relay 13 releases its armature, first opening its front contact and immediately thereafter closing its back contact. The opening of the front contact of relay 13 results in the opening of the energizing circuit of the holding relay 14, and this relay commences to lose energy. However, due to its slow-releasing characteristic, it will retain its armatures. Relay 13 at its back contact closes a circuit for delivering the first impulse to the vertical stepping magnet 16. This circuit may be traced from ground, through the lowermost contact of relay 9, back contact of relay 13, inner front contact and winding of holding relay 14, winding of relay 15, winding of the magnet 16 to battery. Current flowing in this circuit energizes the relay 15 and the vertical magnet 16 which attracts its armature to move the brush shaft one vertical step. The relay 15 is slow to release and maintains its armature attracted during a series of impulses. Since the lower winding of the holding relay 14 is also included in series with the magnet 16, additional energy is supplied to the relay 14 to replenish the energy lost during the momentary opening of its original energizing circuit. The magnet 16 also closes the contact shown and in so doing shunts the lower winding of the holding relay 14. The shunt circuit may be traced from ground, through the lower armature of relay 9, back contact of relay 13, inner contact of relay 14, contact of magnet 16, thence through the windings of relay 15 and magnet 16 to battery. The contact of the magnet 16 is so adjusted that it closes slightly before the vertical pawl seats itself in the ratchet on the brush shaft. The purpose of this will be explained more in detail hereinafter. The closure of the shunt around the lower winding of relay 14 tends to maintain the flux in that winding so that the energy is not dissipated immediately. The vertical magnet 16, continuing its stroke in the circuit which now excludes the lower winding of the relay 14, advances the brushes to a full step.

As soon as the switch takes its first vertical step the contacts 20 are closed, and relay 17 is energized in a circuit from battery, through its winding, upper contacts 20, closed contacts of relay 15, conductor 25 to ground at the lower contact of relay 14. Relay 17 operates and locks in a circuit from battery, through its winding, upper contacts 20, contact of the rotary magnet 18, upper contact of relay 17, conductor 26 to ground at the lowermost contact of relay 9.

At the end of the first impulse, the line is again closed, and relay 13 operates to shift its armature from the back contact to the front contact. Relay 14 is now again supplied with energy over its upper winding, and the energizing circuit of magnet 16 and relay 15 is temporarily opened. Magnet 16 immediately releases its stepping armature and also opens its contact, removing the shunt from the lower winding of the relay 14. For each succeeding impulse in the series, the relay 13 releases and delivers an impulse to the magnet 16 over a circuit which extends first through the lower winding of relay 14 and then in shunt of said winding, through the relay 15 and the winding of the magnet 16. In this manner the switch is stepped vertically to the proper level, and during the stepping operation relay 14 is successively supplied with energy through its upper and lower windings.

At the end of the impulse series, the line is re-closed for a long interval, and relay 13 attracts and holds its armature against the front contact. After an interval, relay 15 releases its armature and in so doing prepares an energizing circuit for the rotary magnet 18 to advance the brushes 10, 11 and 12 over the contacts of the selected group. The circuit for the magnet 18 may be traced from battery through the winding of the magnet, lower contact of relay 17, normal contacts of relay 15 to the grounded conductor 25. The magnet 18 energizes and steps the brushes onto the first set of contacts in the group. Magnet 18 also attracts its armature and opens the holding circuit of relay 17. Relay 17 immediately releases and opens the energizing circuit of the magnet 18, whereupon the magnet releases preparatory to taking the next rotary step. If the circuit appearing in the first set of contacts is busy, the test brush 12 encounters a ground potential on the test terminal, and the relay 17 is reenergized in the following circuit: Battery, through the winding of said relay, upper contacts 20, normal contacts of magnet 18, conductor 27, inner lower back contact of relay 9, conductor 28 to the grounded test brush 12. A parallel circuit may be traced from battery, through the winding of relay 17, upper contact 20, contact of the magnet 18, conductor 27, winding of switching relay 9, upper contacts 21 to the grounded conductor 25. Since there is a direct ground potential on the brush 12, relay 9 is shunted and does not operate. Relay 17 in operating recloses the circuit of the magnet 18, which advances the brushes another step and opens the circuit of relay 17. Relay 17 releases, in turn releasing the magnet 18. This action continues until the test brush 12 encounters an idle terminal, which is represented by the absence of ground potential. At this time, the shunt is removed from the winding of relay 9, and said relay immediately energizes. Relay 17, however, does not energize in this circuit due to the resistance of relay 9; accordingly the circuit of the stepping magnet 18 is maintained open,

and the switch ceases to advance, coming to rest on the terminals of the idle circuit.

Relay 9 in operating switches the tip and ring conductors of the circuit through the brushes 10 and 11 and thence to the next succeeding switch. Relay 9 by attracting its armatures opens the circuit of relay 13 which releases its armature. After an interval, relay 14 releases since no current flows through either its upper or lower windings. Before relay 14 can release to remove ground from conductor 25, ground potential will have been substituted on this conductor from the succeeding switch over a circuit extending through the brush 12 and the inner lower armature and front contact of relay 9. This substitute holding ground may serve to maintain the line finder F and also to hold the relay 9 energized.

When it is desired to release the selector S, ground potential is removed from the conductor 28, thereby permitting the release of relay 9. Relay 9 closes an energizing circuit for the release magnet 19 traceable from battery, through the winding of said magnet, lower contacts 20, inner back contact of relay 14, back contact of relay 13, lowermost contact of relay 9 to ground. The release magnet 19 energizes and releases the switch S. When the switch S fully restores, the vertical off-normal contact 20 is opened, and the magnet 19 deenergizes.

The condenser 29 and resistance 30 are provided for the purpose of protecting the contact of relay 13 during the vertical pulsing operation and the lower contact of relay 17 during the rotary stepping movement. The lower plate of the conductor 29 is connected in parallel with the impulse circuit extending to the vertical magnet 16, and the upper plate of said condenser is connected in parallel with the impulse circuit of the rotary magnet 18.

Should the subscriber abandon the call before transmitting impulses to the switch, relay 13 releases, closing the circuit hereinbefore traced through the lower winding of relay 14, winding of relay 15 and winding of magnet 16 to battery. The magnet short-circuits the lower winding of relay 14, and, since the upper winding is deenergized, the relay releases after an interval causing the restoration of the switch. Should the subscriber abandon the call during the rotary movement of the switch, relay 13 releases and completes a circuit from ground through the lowermost contact of relay 9, back contact of relay 13, thence as traced through the windings of relays 14 and 15 and the magnet 16 to battery. Inasmuch as the brushes of the switch are now in the level of terminals, the magnet 16 will not be able to advance its stepping dog a full step. Since, however, the magnet closes its contact just before the stepping dog is fully seated in the vertical ratchet, the lower winding of the relay 14 is certain to be short-circuited under these conditions. Therefore, after an interval the relay 14 deenergizes and closes the release circuit to restore the switch to normal.

Figs. 2 and 3 illustrate modifications of the pulsing circuit. In Fig. 2, a rotary off-normal contact 23 is provided and opens as soon as the switch has taken its first rotary step. In Fig. 3, the rotary off-normal contact 24 closes as soon as the switch has taken is first rotary step. By providing these rotary off-normal contacts, it is possible to adjust the contact on the vertical magnet 16 so that it closes later in the stroke, namely, just about the time the magnet has completed the full forward movement of the shaft. With the circuit shown in Fig. 2, should the subscriber abandon the call during the rotary movement, no impulse can be delivered to the vertical magnet 16, and consequently current is not caused to flow through the lower winding of relay 14 due to the fact the contact 23 is open. After an interval therefore, the holding relay 14 releases and causes the restoration of the switch. Similarly in Fig. 3, should the subscriber abandon the call during the rotary movement, an impulse is delivered to the vertical magnet, but, since the contacts 24 are closed, the lower winding of relay 14 is shunted and consequently this relay is not held energized by reason of its lower winding. The circuit for the magnet 16 in this case extends through the armature and contact of relay 14, contacts 24, winding of the magnet 16 to battery.

The finder F and the selector switch S disclosed in this application may be of any suitable construction. Selector S is preferably of the two-movement step-by-step type, having a first stepping movement to select groups of trunks or lines and a second stepping movement to select individual trunks or lines. A switch of this general character is disclosed in the patent to Keith et al. No. 815,876, granted March 13, 1906.

While the invention has been illustrated in connection with a specific circuit arrangement, it is to be understood that it is not limited to these particular circuits. It should also be noted that this invention is applicable to repeaters for repeating impulses from an incoming circuit to an outgoing circuit and that it is also applicable to connector switches in which both the primary and secondary movements are directively controlled by impulses.

What is claimed is:

1. The combination in an impulse circuit of an impulse relay, a stepping magnet responsive to impulses delivered by said relay, a holding relay, a circuit including the front contact of the impulse relay for supplying energy to said holding relay, and a circuit

including a back contact of the impulse relay for supplying energy to said holding relay.

2. The combination in an impulse circuit of an impulse relay, a source of current, a holding relay, a circuit closed by said impulse relay when energized for supplying current from said source to the holding relay, and a circuit closed by said impulse relay when released for supplying current from plying energy to said holding relay.

3. In combination, an impulse relay, a holding relay, a circuit including the front contact of the impulse relay for supplying energy to said holding relay, and a circuit including a back contact of the impulse relay and a contact of the holding relay for supplying energy to said holding relay.

4. In combination, an impulse relay, a stepping magnet responsive to impulses delivered by said relay, a control relay, a circuit including the front contact of the impulse relay for operating said control relay, and a circuit including the back contact of the impulse relay for supplying energy to said control relay and for delivering an impulse to said magnet.

5. In combination, an impulse relay, a stepping magnet responsive to impulses, a control relay, a circuit including the front contact of the impulse relay for operating said control relay, a circuit including a back contact of the impulse relay for delivering operating impulses to said magnet, and a winding for the control relay in said last mentioned circuit.

6. In combination, an impulse relay, an operating magnet responsive to impulses delivered by said relay, a control relay, a circuit closed by the front contact of the impulse relay for operating said control relay, a circuit including a back contact of the impulse relay and a contact on the control relay for delivering impulses to said magnet, and means in said last mentioned circuit for supplying energy to said control relay.

7. In combination, an impulse relay, a holding relay having two windings thereon, a circuit closed at a front contact of the impulse relay for energizing one of said windings, and a circuit closed at the back contact of said impulse relay and a front contact of said holding relay for energizing the other of said windings.

8. In combination, an impulse relay, a stepping magnet, a holding relay having two windings, a circuit closed at the front contact of the impulse relay for energizing one of said windings, and a circuit closed at the back contact of said impulse relay for energizing said stepping magnet and the other of said windings.

9. The combination in an impulse circuit of an impulse relay, a stepping magnet responsive to impulses delivered by said relay, a holding relay, a circuit including the front contact of the impulse relay for supplying energy to said holding relay, a circuit including a back contact of the impulse relay for supplying energy to said holding relay, and means controlled by said magnet for preventing the further supply of energy in said second circuit to the holding relay.

10. The combination with an impulse relay of a stepping magnet responsive to said relay, a holding relay, a source of current, a circuit closed by the front contact of the impulse relay for supplying current to the holding relay from said source, a circuit closed by the back contact of the impulse relay for supplying current to the holding relay from said source, and means controlled by said magnet for shunting the current in said second circuit away from said holding relay.

11. The combination in an impulse circuit of an impulse relay, a stepping magnet responsive to impulses from said relay, a holding relay having two windings, a circuit closed by the front contact of the impulse relay for one of said windings, a circuit closed by the back contact of the impulse relay for the other of said windings, and contacts closed by the operation of said stepping magnet for short-circuiting said second winding.

12. In combination, an impulse relay, a holding relay having slow-to-release characteristics, a circuit including the front contact of the impulse relay for supplying energy to said holding relay, and a circuit including the back contact of the impulse relay, and a contact of the holding relay for supplying energy to said holding relay.

13. In combination, an impulse relay, a stepping magnet responsive to impulses delivered by said relay, a control relay having slow-to-release characteristics, a circuit including the front contact of the impulse relay for operating said control relay, and a circuit including the back contact of the impulse relay for supplying energy to said control relay and for delivering an impulse to said magnet.

In witness whereof, I hereunto subscribe my name this 28th day of July, 1930.

CHARLES L. GOODRUM.