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LINE-CLEARING APPARATUS FOR A TELEPHONE SYSTEM

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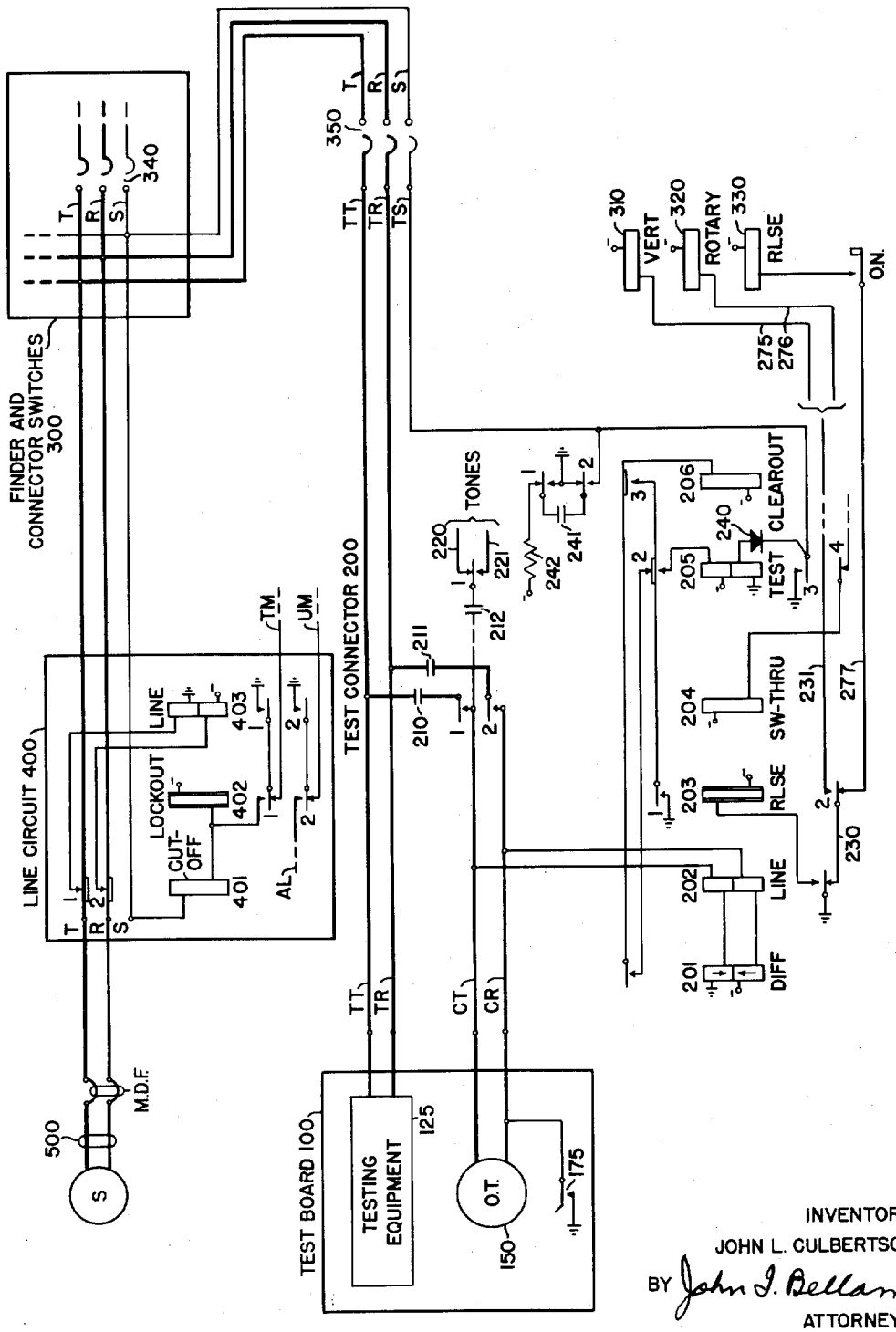

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LINE-CLEARING APPARATUS FOR A TELEPHONE SYSTEM

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6 Claims. (Cl. 179—175.2)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to improvements in line-clearing apparatus for a telephone system, being concerned particularly with the clearing of lines for test, as through a test connector.

Its principal object is to provide an improved line-clearing arrangement suitable for clearing the switchboard attachments from a line which has been locked out of normal service at its individual lockout line circuit responsive to an abnormal line condition.

General description

In order to facilitate the testing of telephone lines from a remote test board, test switching apparatus is commonly provided for extending a three-wire connection to the switchboard multiple of any desired line, regardless of its idle or busy condition. If idle, potential applied over the third wire (sleeve) of the connection acts to guard the called line and to clear it of its normal attachments so that such attachments will not adversely affect the line test.

If the line called from the test board tests busy and is in use, the test operator is expected to release the test connection and call back later. If the called line tests busy but is not in use, the test operator should be enabled to free the line switchboard attachments in preparation for its test. Known arrangements for performing this operation involve the forced restoration of the concerned line attachments (in this case the operated line relay) by temporarily connecting battery of opposed polarities to the respective conductors of the called line to shunt the windings of the connected line relay, or to set up a balanced differential current flow therein. Such arrangements, however, do not operate satisfactorily for a line having a low-resistance path between its conductors (a so-called close-in short).

The lines of unattended exchanges are commonly each provided with an individual lockout line circuit. The usual form of such a circuit includes a slow-releasing lockout relay serially related with a sleeve-connected cutoff relay. The cutoff relay when operated disconnects the line relay from the line conductors. The so-called lockout relay remains operated long enough after the cutoff relay restores that it becomes locked operated by the line relay which immediately reoperates if the line is shorted or grounded. The present invention provides an arrangement for clearing such a locked-out line by reoperating the cutoff relay over the sleeve wire of the three-wire test connection, notwithstanding the busy marked condition of the locked-out line.

An important feature of the invention relates to provisions for preventing premature operation of the test relay in the test switching apparatus incidental to applying sleeve current to operate the cutoff relay of the locked-out line. In the preferred embodiment, the free pole of a grounded reversed-polarity source is temporarily connected directly to the sleeve conductor of the test connection, and the test relay is rectifier poled to prevent its operation until sleeve current flows in the normal test direction responsive to the locked-out condition having been cleared.

A related important feature concerns the use of a suitably charged condenser and switching means for connecting it between ground and the sleeve to serve as the noted reversed polarity source, whereby the timing of the flow of clearing current is simply and efficiently accomplished.

Further objects and features of the invention will become apparent from the following description, reference being made to the accompanying drawing which discloses a diagrammatic view of a portion of a telephone system incorporating the principles of the present invention.

For purposes of making routine tests upon the telephone lines, a test board **100** is provided which has access to all lines in the exchange over test-board controlled automatic switching equipment including a test connector such as test connector **200**. The bank of the test connector **200** is connected in multiple to the banks of the standard subscriber-controlled switching equipment through which calls are extended to desired lines. Test connector **200** is associated with test board **100** over a pair of test conductors TT and TR and a pair of control conductors CT and CR. The control pair is used to exercise control over the switchgear of test connector **200** from the test board operators' telephone and the test pair is connected to the testing equipment **125** and is used for testing purposes only.

The general procedure in making tests upon desired subscriber lines will now be described.

Assuming that the operator at test board **100** desires to make a test on line **500**, the operators' telephone **150** is connected to test connector **200** over control wires CT and CR to seize the connector for use. Next, by means of a suitable calling device, the test connector apparatus is operated to cause its wiper set **350** to move into engagement with associated bank contacts multipled to line **500**.

As will be explained in detail hereinafter, a test relay **205** determines if line **500** is busy or idle and accordingly transmits an identifying tone to the test board.

If the line to be tested is idle, test connector **200** automatically clears the line of switchboard apparatus, in this case line relay **403**, and informs the operator at the test board that testing operations may begin and automatically renders the line busy to all other calls. The operator thereupon makes the desired tests upon line **500** from the testing equipment **150** over test conductors TT and TR, which as will be observed, is now connected directly to the line being tested. After the testing operations are completed, the test connector **200** is released and the line is returned to its normal idle condition.

If the line to be tested is busy from a call in progress or from a permanent condition existing on the line as by the line conductors accidentally being bridged or grounded, the operator receives a tone indicating a busy condition, ascertains which condition is causing the line to be busy, and accordingly releases the connection or forcibly clears the line.

Assuming the line to be busy from a call in progress, the operator at the test board **100** releases the test connection extended to line **500** by opening the usual bridge across the control conductors CT and CR to restore all operated switching apparatus.

Assuming the line is locked-out from a permanent condition on line **500**, this condition being described hereinafter, the operator after finding no call in progress proceeds to clear the line for test. Operation of clear-out key **175** causes test connector **200** to cause a simulated booster battery to disconnect the switching equipment attached to line **500**. Test connector **200** thereafter auto-

matically transmits a tone to test board **100** indicating that the line is clear and testing operations may begin.

After completion of any desired tests on line **500**, the operator releases the test connection and all operated switching apparatus by removing the bridge from across the control conductors CT and CR.

Detailed description

The procedure involved in clearing a telephone line of switchboard attachments in preparation for making test thereon having been described in general, a detailed description will now be given.

As hereinbefore pointed out, the condition of the line to be tested determines the procedure that the operator at the test board must follow in order to clear the line. Therefore, a brief description will be given of line circuit **400** under various line conditions.

Line circuit **400** is a three-relay line circuit individual to line **500** and including a line relay **403** normally connected to the line conductors T and R, a cutoff relay **401**, and a lockout relay **402**. A subscribers substation S is bridged across the conductors of line **500** which are connected to line circuit **400** through main distributing frame jumpers MDF and are terminated on switch set **340**.

When line **500** is idle, the relays in line circuit **400** are in their illustrated position, with line relay **403** bridged across the tip and ring conductors through break contacts **1** and **2** of cutoff relay **401**. At this time, battery potential from the battery connected winding of lockout relay **402** appears on the sleeve conductor S which terminates at its respective open contacts on switch set **340**.

When line **500** is bridged by operation of the hookswitch (not shown) of substation S, an operate circuit is completed for line relay **403** from its battery and ground connected windings. Line relay **403** operates and at its contacts **1** and **2** and contacts **1** and **2** of lockout relay **402** ground the tens and units mark wires TM and UM to cause line-finding equipment (not shown) to extend the calling line through contacts on finder switches **300** to seize an idle connector (not shown) for extending a connection to a desired line.

Immediately following this line-finding action, ground is returned to the sleeve conductor S of line **500** from the seized connector thereby completing an operate circuit for cutoff relay **401** and lockout relay **402** in series.

Relays **401** and **402** operate. Break contacts **1** and **2** of cutoff relay **401** open the bridge across the windings of line relay **403** permitting it to restore. Contacts **1** and **2** of relay **402** open the mark wires TM and UM to prevent a reoperation of line relay **403** from starting a new line-finding action. The call is then extended to the desired line by operation of the calling device (not shown) at substation S in a normal manner. Relays **401** and **402** are the only relays operated in line circuit **400** during the time that a normal call is in progress.

If there is timing apparatus in the connector extending the call and a predetermined time has elapsed to open the connection while the line **500** is bridged by substation S having its hookswitch operated, ground is removed from the sleeve conductor S by such timing apparatus. This removal of ground from the sleeve opens the operate circuit of relays **401** and **402**.

Cutoff relay **401** restores immediately and at its contacts **1** and **2** completes an operate circuit for line relay **403** again. Lockout relay **402**, being slow-restoring due to its indicated sleeved core, is still operated when line relay **403** operates. Contacts **1** of relay **403** extend ground through make contacts **1** of relay **402** to the battery-connected winding of relay **402**. Lockout relay **402** is now held operated and the line is in a locked-out condition with lockout relay **402** and line relay **403** operated. At its contacts **2**, relay **402** extends the ground at contacts **2** of relay **403** to the alarm conductor AL to indicate to alarm equipment (not shown) that the line is locked-out.

If the line **500** became accidentally bridged or one of its conductors grounded, a calling condition would be simulated on line **500** and the above noted operations would ensue to eventually place the line in a locked-out condition.

Therefore, when line **500** is in an idle condition, line relay **403** is bridged across the line conductors; when line **500** is in a calling condition, switching apparatus in the connector (not shown) extending the call, is connected to the line conductors; and when line **500** is locked-out, the line relay **500** is bridged across the tip and ring conductors. In order for the operator to satisfactorily test line **500**, the above noted switching apparatus must be removed first. The operations involved in clearing a line under the condition above noted will now be described in detail.

Assuming that the operator at test board **100** desires to test line **500**, test connector **200** is seized by the bridging of control conductors CT and CR by any suitable control from the operator's telephone **150**. An operate circuit is completed from the battery and ground connected windings of differential relay **201** for line relay **202**.

Line relay **202** operates. Differential relay **201** does not operate at this time as its windings are differentially-connected, as indicated by the arrows, and the generated flux in its two windings are in opposition. Contacts on line relay **202** extend ground to the battery-connected winding of release relay **203** which operates and prepares a pulsing circuit for the vertical and rotary magnets associated with the switch contact set **350** of test conductor **200**.

The operator at the test board **100** operates the usual calling device to cause the restoration and reoperation of line relay **202** according to the line number of line **500**. The restoration and reoperation of line relay **202** generates impulses of ground which are transmitted over wire **230**, through contacts **2** on relay **203** to wire **231**, and through contacts not shown to pulse wire **275** and **276** causing the vertical and rotary magnets **310** and **320** to position wiper set **350** into engagement with the bank contacts terminating line conductors T, R, and S of line circuit **400**.

Immediately upon being so positioned, the ground-connected winding of test relay **205** is extended to the sleeve conductor S of line circuit **400** over test sleeve conductor TS and rectifier **240**. As will be described hereinafter, rectifier **240** serves to prevent condenser **241** from discharging through the winding of relay **205**.

Assuming line **500** to be idle, current flow through the battery-connected winding of lockout relay **402** in series with the winding of cutoff relay **401** to the ground-connected winding of test relay **205** operates these three relays in series. Immediately upon operating, contacts **3** of relay **205** place ground directly on the sleeve conductor TS to hold relays **401** and **402** operated and to short-circuit rectifier **240** and the lower winding of relay **205**. Relay **205** does not restore as it is held operated from the ground at contacts **1** of release relay **203** through the upper winding of relay **205** and its make contacts **2**.

Operation of cutoff relay **401** causes line relay **403** to be disconnected from the tip and ring conductors of line **500**, thereby clearing line **500** completely of all switchboard attachments. Make contacts **1** of test relay **205** place a suitable tone, such as trunk-ring-tone, on the control conductor CT through tone coupling condenser **212** and other contacts not shown, to inform the operator at test board **100** that line **500** is clear of switchboard attachments and ready for testing. Line **500** is busy to all calls being directed thereto by the ground on sleeve conductor S.

At this time, the tip and ring conductors of line **500** are connected directly to the testing equipment **125** over test

conductors TT and TR. The operator thereupon operates the testing equipment to perform any desired tests and upon completion of such tests, opens the bridge circuit across the conductors CT and CR to restore line relay **202** of test connector **200**. Line relay **202** restores and releases relay **203** which open-circuits test relay **205** and closes an operate circuit for the release magnet **330**. Relay **205** restores and release magnet **330** operates from ground now appearing on wire **277** from back contacts of relays **202** and **203**. This operate circuit includes the conventional off-normal contacts ON which are now closed as the vertical magnet is in an off-normal position. Operation of release magnet **330** causes the restoration of the rotary and vertical magnet armatures, and thereafter restores with the opening of the off-normal contacts ON. With switch set **350** being opened, test relay **205**, cutoff relay **401** and lockout relay **402** restore. The line **500** and test connector **200** are now in their idle illustrated position.

If line **500** is busy from a normal call when a test connection is extended thereto in the manner previously described, the noted ground on the sleeve conductor S of line **500**, from the connector (not shown) used in the extension of a connection, appears on the test sleeve conductor TS preventing the operation of test relay **205**. Break contacts **1** of relay **205** place a busy-indicating tone, such as busy-tone, through condenser **212** to the control conductor CT in a manner hereinbefore described. Upon receipt of such a tone, the operator at test board **100** dials one additional digit to operate relay **204** over an operate circuit not shown to connect the control conductors CT and CR to test conductors TT and TR, respectively, and monitors the connection through condensers **210** and **211** to determine whether line **500** is busy from a normal call or a locked-out condition.

After determining that the line is busy from a call in progress, the operator opens the bridge across the control conductors and restores all operated equipment as previously described.

Assuming line **500** to be busy from a lockout condition, ground appears on the sleeve conductor S of line **500** from make contacts **1** of relays **402** and **403** as they are both operated as hereinbefore noted when the line is in a lockout condition. The operator monitors the connection to determine if a reverting call is in progress or if the line is accidentally locked-out. If the line is busy from a reverting call, the operator releases the connection as hereinbefore described.

Assuming that line **500** is in a locked-out condition from an accidental bridging of the line conductors or the grounding of one of them, the operator upon ascertaining that no call is in progress, proceeds to forcibly clear the line for test.

With the line and differential relays bridged across the control conductors and connected to battery and ground, the operator actuates release key **175** to ground the ring conductor CR thereby short-circuiting the upper winding of each of relays **201** and **202**. Relay **202** remains operated from current flow through its lower winding and relay **201** immediately operates as there is no opposing flux generated in its short-circuited upper winding.

Contacts on differential relay **201** extend the ground potential at break contacts **1** of release relay **203** to the battery-connected winding of clearout relay **206** through break contacts **2** of non-operated test relay **205**. Relay **206** operates and locks through its make contacts **3** to its operate ground independent of contacts on relay **201**, which may be opened, when desired, by the restoration of release key **175** and the consequent release of relay **201**. Contacts **1** and **2** of relay **206** place condenser **241** in circuit with the test sleeve conductor TS to forcibly remove line relay **403** from line **500**.

In its normal illustrated position condenser **241** is fully charged, the negative pole being connected to the exchange battery through current-limiting resistor **242** and break contacts **1** and the positive pole being connected to ground through break contacts **2**. With the operation of clearout relay **206**, the negative pole of condenser **241** is transferred from resistor **242** to ground potential at contacts **1** of relay **206** and the positive pole is transferred to the test sleeve conductor TS through make contacts **2**. The charge on condenser **241** is therefore impressed upon the sleeve conductor TS placing it at a potential, exchange battery voltage, above the ground potential maintaining lockout relay **402** operated.

Condenser **241** discharges through the winding of cutoff relay **401** to ground at make contacts **1** of line relay **403**, it being prevented from discharging through the winding of test relay **205** by action of rectifier **240**.

Cutoff relay **401** operates from the condenser discharge current flowing therethrough and at its contacts 1 and 2 open-circuits line relay **403**.

Line relay **403** restores and at its contacts **1** opens one operate circuit of lockout relay **402**. Relay **402** remains held operated in series with the cutoff relay from the discharging current of condenser **241**.

When condenser **241** is discharged, the sleeve conductor S reaches a potential indicative of an idle condition and the ground-connected winding of test relay **205** being connected over sleeve conductor TS to the battery-connected winding of lockout relay **402** in series with cutoff relay **401**, operates and locks operated as hereinbefore described to maintain relays **401** and **402** operated in series.

Contacts on test relay **205** removes the busy indicating tone, short-circuits its lower winding and rectifier **240**, and at its contacts **4** restore switch-through relay **204** to disconnect the control conductors from the test conductors to free line **500** for test. The ground on the sleeve conductor S from make contacts **3** of relay **205**, busy line **500** to all calls thereto.

After the operator performs the desired test on line **500**, all operated switching apparatus is restored to normal as hereinbefore described and condenser **241** is charged again in preparation for another line-clearing operation.

I claim:

1. In a switching system, lines and switching apparatus common thereto for extending connections between respective calling and called lines, individual sleeve conductors and individual line equipments for respective lines, each line equipment including a normally connected line attachment and a cutoff relay for disconnecting it, a current source having first and second poles, the cutoff relay being normally connected serially in a circuit path extending between the first pole of the current source and the associated sleeve conductor, means in each line equipment for locking the associated line out of normal service, including means for effectively transferring the cutoff relay thereof from connection with the first pole into connection with the second pole of the current source, a test board and means controllable therefrom for operating a portion of said switching apparatus to extend a test connection to any desired line, including a connection to its associated sleeve conductor from the said second pole of the current source, said test connection being extended in preparation for testing the selected line with the line attachment thereof disconnected therefrom, means rendering the consequent current flow over the said sleeve connection sufficient to operate the cutoff relay when the selected line is idle, but not when such line is in the said locked-out condition, and means controllable from said test board for substituting a potential on the sleeve connection of such a value and polarity that the resulting current flow operates the cutoff relay of a selected locked-out line, whereby the line attachment thereof is disconnected to permit the desired test of the selected line to be made.

2. In a switching system according to claim 1, means in the line equipment of any selected locked-out line for

terminating the locked-out condition thereof responsive to operation of its cutoff relay, thereby effectively transferring the cutoff relay back into connection with the first pole of the current source, the said means for placing a substitute potential on the sleeve connection including timing means for terminating the substitution after sufficient time has elapsed for the locked out condition of the selected line to have been terminated.

3. In a switching system, lines and switching apparatus common thereto for extending connections between respective calling and called lines, individual sleeve conductors and individual line equipments for respective lines, each line equipment including a normally connected line attachment and a cutoff relay for disconnecting it, a current source having first and second poles, the cutoff relay being normally connected serially in a circuit path extending between the first pole of the current source and the associated sleeve conductor, means in each line equipment for locking the associated line out of normal service, including means for effectively transferring the cutoff relay thereof from connection with the first pole into connection with the second pole of the current source, a test board and means controllable therefrom for operating a portion of said switching apparatus to extend a test connection to any desired line, including a connection to its associated sleeve conductor from the said second pole of the current source, said test connection being extended in preparation for testing the selected line with the line attachment thereof disconnected therefrom, means rendering the consequent current flow over the said sleeve connection sufficient to operate the cutoff relay when the selected line is idle, but not when such line is in the said locked-out condition, said sleeve connection including a test relay connected serially therein between the sleeve conductor and the second pole of the current source, means controlled by current flow through said test relay for indicating whether or not the line attachment has been disconnected from the selected line, means for making and thereafter nullifying a second connection to the sleeve conductor of the called line in parallel with the said sleeve connection to place a higher potential on the sleeve conductor of the same polarity as the second pole of the current source, whereby the cutoff relay is operated to terminate the locked out condition and remains operated over the initial sleeve connection after the said second connection has been nullified, and polarizing means for preventing the test relay from responding to current flow over the said second sleeve connection.

4. In a switching system according to claim 3, the said means for making and thereafter nullifying a second connection to the sleeve conductor including a normally-charged condenser whereby the charge thereon supplies the said higher potential, and the said second connection is nullified responsive to the condenser becoming discharged.

5. In a switching system, communication links and first switching means for extending connections respectively thereover, means including a separate electromagnet for each link for controlling the first switching means, circuit elements for each link providing an incomplete circuit path for the electromagnet of the link through a direct-current source, control apparatus common to the links including a condenser and means for charging it in a given polarity direction, second switching means and means for selectively operating it to connect the control apparatus to any link, circuit elements included in the common apparatus and in the second switching means for completing the said incomplete circuit path of the electromagnet of the connected link by connecting the charged condenser in series therewith in series-aiding relationship to the potential of the said current source therein, circuit elements providing a by-pass path around the condenser including a by-pass rectifier serially related therein and so poled as to resist discharge of the condenser therethrough, whereby the electromagnet of the connected link is first energized by discharge current through the condenser and current source in series and is thereafter maintained energized by current through the rectifier and the current source in series.

6. In a switching system according to claim 5, the said second switching means and completing means being operable to complete discharge paths for the condenser through the said circuit paths of the said links in succession, means for providing interspersed idle intervals during which the said condenser is maintained out of discharge connection with all the said circuit paths, and means rendering the said means for charging effective during such idle intervals.

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