March 16, 1926. 1,576,723

T. F. CROCKER

WIRE CHIEF'S TEST CIRCUITS FOR TELEPHONE SYSTEMS

Filed July 28, 1922 3 Sheets-Sheet 1

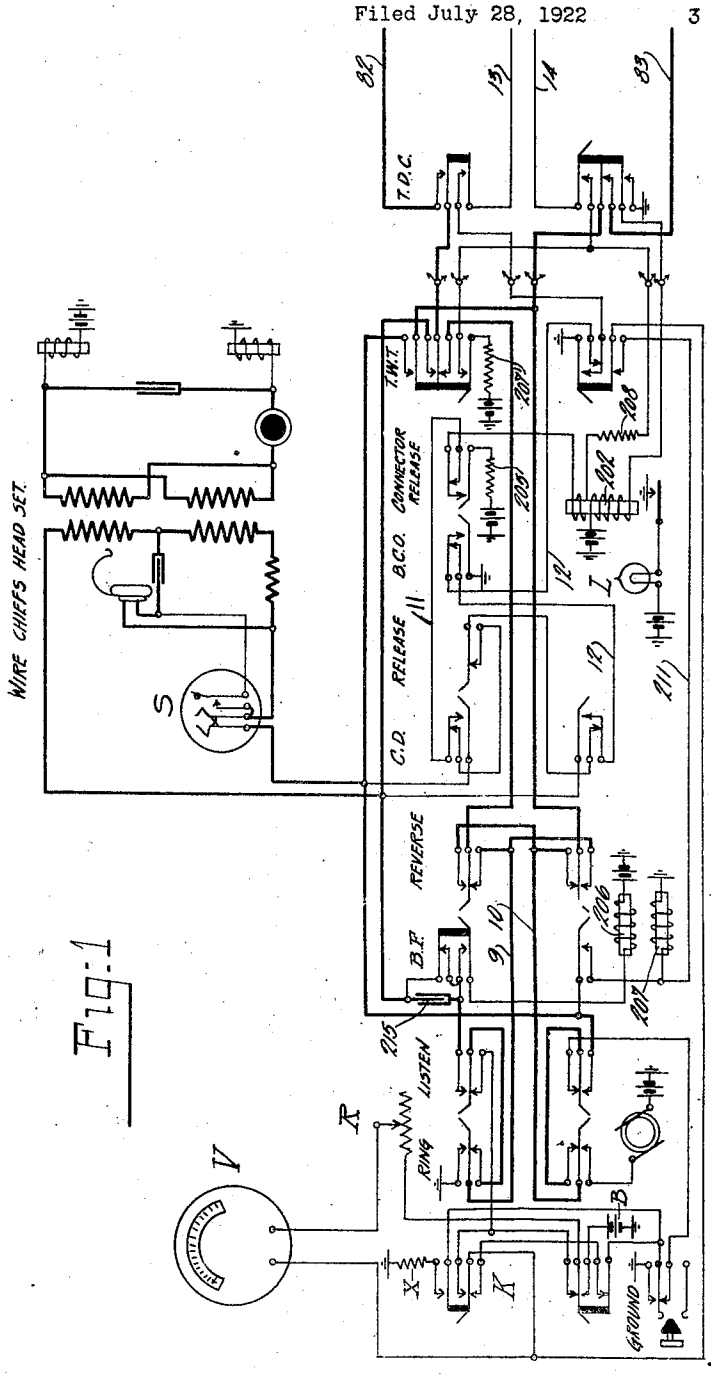


Fig. 1

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Filed July 28, 1922 3 Sheets-Sheet 2

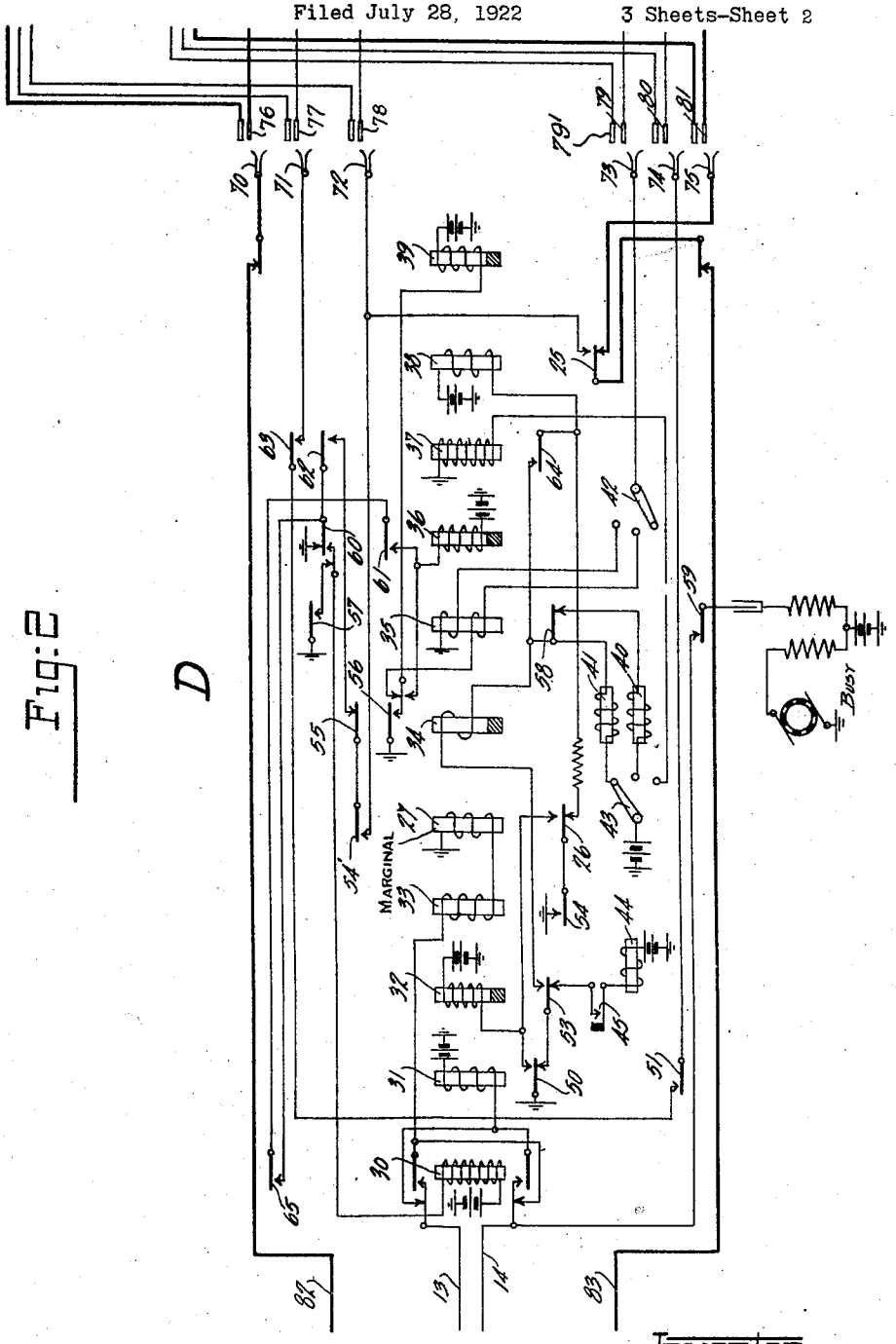


Fig. 2

D

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Filed July 28, 1922 3 Sheets-Sheet 3

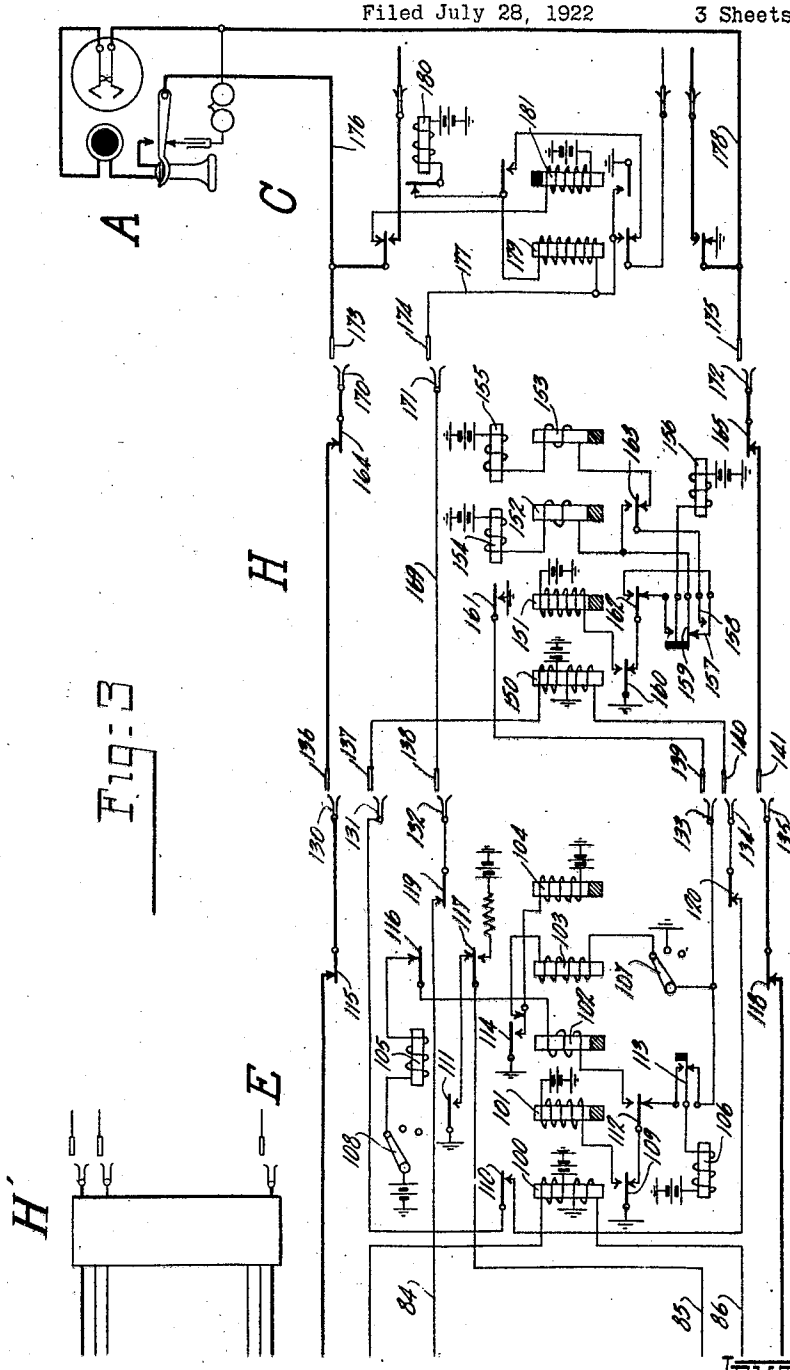


Fig. 3

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Patented Mar. 16, 1926. 1,576,723

UNITED STATES PATENT OFFICE.

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WIRE CHIEF'S TEST CIRCUITS FOR TELEPHONE SYSTEMS.

Application filed July 28, 1922. Serial No. 573,174.

To all whom it may concern:

Be it known that I, THOMAS F. CROCKER, a citizen of the United States of America, and a resident of Chicago, Cook County, and State of Illinois, have invented certain new and useful Improvements in Wire Chiefs' Test Circuits for Telephone Systems, of which the following is a specification.

The present invention relates in general to wire chief's test circuits for telephone systems, but more especially to test circuits of this kind which are adapted for use in automatic telephone systems; and the object of the invention, briefly stated, is revision and rearrangement of the circuits and the addition of certain new features, whereby certain desirable tests heretofore not provided for can now be performed accurately and with the maximum facility. The apparatus employed, and the various features of the invention will be described fully hereinafter, reference being had to the accompanying drawings, in which the system is illustrated by means of the usual circuit diagrams.

Referring to the drawings, in order to enable the circuits to be readily understood, the three sheets should be arranged from left to right in proper alignment with each other. When laid out in this manner, it will be perceived that Fig. 1 shows the test circuits proper, together with the necessary auxiliary apparatus, which is located at the wire chief's desk; while Figs. 2 and 3 show the circuits of three automatic switches known respectively as a test distributor, a test connector selector, and a test connector, which are used for connecting the test circuit to any subscriber's line which it is desired to test.

To provide for connecting the test circuits with subscribers' lines which it is desired to test, the wire chief's position is equipped with a number of outgoing test distributor connecting keys such as the key TDC, to which the test circuit shown in Fig. 1 is connected in multiple, there being one key TDC for each test distributor D accessible to the wire chief's position. The test distributor D is a vertical and rotary switch of the well-known Strowger type, having 100 sets of bank contacts arranged in ten horizontal rows or levels. In addition to the usual operating magnets and controlling relays, the switch is provided with a side switch controlled by the well-known private magnet, which is for the purpose of altering the circuits after each series of controlling impulses is received. The switch circuits are shown complete, and will be described in full hereinafter.

The test connector selector switch E, Fig. 3, is also of the Strowger type, but differs from the test distributor D principally in having only a single level of bank contacts. It will be understood from this that the switch has a rotary movement only, and that the vertical magnet and those parts which have to do only with the vertical movement of the switch may be omitted. It may be mentioned also that the off normal spring 113 is arranged so that it will be shifted on the first rotary step of the switch rather than on a vertical step, as is usually the case. The test connector H is also a Strowger vertical and rotary switch, has the full 100 contact sets, and so far as its mechanical construction is concerned is similar to the test distributor D. The side switch is omitted, however, and the circuits are very much simplified in accordance with the simpler functions which the switch has to perform. The rectangle H′ indicates a test connector similar to H.

It will be understood that the subscribers' lines in the system are divided into groups of 100 lines each in accordance with the capacity of the connector switches which are ordinarily used for completing local connections. In every 100 line unit, in addition to the 10 or 12 local connectors which are ordinarily provided, there is one test connector such as the test connector H, the latter connector switch being exclusively for the use of the wire chief in testing the subscribers' lines. One of the subscribers' lines of the group, to which the connector H belongs, is shown at the extreme right of Fig. 3, and extends to the automatic telephone substation A. The reference character C indicates an individual line switch of the well-known rotary type, which is provided for the use of the subscriber at substation A in extending

his line, when calling, to an idle first selector switch in the regular exchange trunking system.

The arrangement of the trunking between the test switches will now be explained a little more fully. If we assume a 4 digit system of 10,000 lines capacity, there will be 100 groups of connector switches, and as a test connector is provided in each of these groups there will be 100 test connectors. Now, since the test distributors have 100 contact sets and are directively controlled in both their vertical and rotary movements, all of these test connectors may be reached by way of the test distributors without any intervening switches. This is the usual arrangement for a straight 4 digit system. There will be perhaps three or four of the test distributors such as the test distributor D, Fig. 2, which have common access to all of the test connectors in the various groups. It happens quite often, however, that in systems which include a number of party lines, in addition to the individual or private lines, third selectors are inserted between the second selectors and connectors in those major groups of the system which are used for the party line traffic. The party line subscribers are then called by means of five digits, instead of four, the extra digit being the third which controls the operation of the third selectors in selecting the proper group of connectors. The drawing shows an arrangement of test switches which is adapted for use in a composite system of the type described, which includes both individual and party lines. The test distributors have direct access to all of the test connectors, such as H^1, Fig. 3, which are located in the individual line connector groups, but on the particular level, or possibly levels, which are assigned to the party lines, the test distributors have access to test connector selectors such as the test connector selector E. It is noted in this connection that the contacts in the party line level are not multipled between the several test distributors, but a trunk line extends from each contact set to a separate connector selector. For instance, considering the first contact set in the eighth level, if this contact set corresponds to a party line group, which we may assume to be the case, it is not multipled between the several test distributors but a separate trunk line extends from this contact set in each test distributor to a different test connector selector. The test connector selectors which correspond to the same numbered contact sets in the test distributors have their bank connected in multiple and have common access to the test connectors in ten different connector groups.

A general description having been given, the operation of the circuits will now be explained more in detail, and a description will be given of the procedure followed in connecting the test circuit with a subscriber's line. Assuming that it is desired to test the line of substation A, Fig. 3, the telephone number of which is 45678, the wire chief first operates the calling device key C.D. and the key T.D.C. associated with the test distributor D, Fig. 2, assuming that this particular test distributor is the one which is to be used. When the calling device key is operated, the calling device S, Fig. 1, is connected across the conductors 11 and 12 of the test circuit, and since these conductors have been extended to the operating conductors 13 and 14 of the test trunk by the operation of the key T.D.C., the relays 31, 33, and 27 of the test distributor D will be energized in series over a circuit which may be traced from ground, winding of relay 27, winding of relays 33, lower break springs of relay 30, conductor 14, contacts of T.D.C. key, resistance 208, upper winding of polarized relay 202, contacts of connector release key, C.D. key, calling device S, back through contacts of the C.D. key, B.C.O. key, T.W.T. key, T.D.C. key, conductor 13, upper break contacts of relay 30, winding of relay 31 to battery. The relay 31 in operating closes a circuit for the slow acting release relay 32, which, upon energizing, breaks the release circuit at its armature 53 and at the same armature prepares a circuit for the vertical magnet 41 in the usual manner. It will be noticed that the upper winding of the electro-polarized relay 202 is included in series with the conductor 14 of the line at the test circuit. Relay 202 is not operated, however, since a circuit has already been closed at the T.D.C. key for its lower polarizing winding. The two windings are so connected that at this time their magnetizing effects oppose each other and the relay accordingly remains inoperative.

The calling device dial may now be operated in accordance with the first digit of the desired number, which is the digit 4. As a result a series of four interruptions is produced in the circuit of relays 31, 33, and 27, and all of these relays accordingly deenergize momentarily four times. Relay 31, at each deenergization, transmits an impulse of current to the vertical magnet 41 over a path which may be traced from ground by way of armature 50 and its resting contact, armature 53 and its working contact, the winding of the slow acting series relay 34, winding of the vertical magnet 41, and the side switch wiper 43, in first position, to battery. By the operation of the vertical magnet, the switch wipers 70–75, inclusive, are raised step by step until they stand opposite the fourth level of bank contacts. Relay 34 is energized in series with the vertical magnet, and being slow acting retains

its armature in operated position throughout the vertical movement of the switch. In its operated position relay 34 closes circuits for the slow acting relay 36 and for the private magnet 39, which is also slow acting. The energization of relay 36 is without function at this time, but the private magnet controls the usual escapement mechanism by means of which the side switch is prepared for its advance to second position. At the end of the vertical movement of the switch, the slow acting relay 34 falls back and breaks the circuits of relay 36 and the private magnet 39. Upon the deenergization of the latter, the side switch wipers 42 and 43 are advanced to their second positions by the operation of the escapement.

The dial of the calling device S may now be operated in accordance with the second digit of the desired number, which is the digit 5. As before, a series of interruptions is produced in the circuit of relays 31, 33, and 27, and these relays are accordingly deenergized intermittently five times. Relay 31 now sends a series of impulses to the rotary magnet 40 over a path which extends from ground by way of armature 50 and its resting contact, armature 53 and its working contact, winding of relay 34, resting contact of armature 58 and the said armature, winding of the rotary magnet 40 and the side switch wiper 43, in second position, to battery. By the operation of the rotary magnet, the wipers 70–75, inclusive, are rotated step by step and are finally brought to rest in engagement with the particular contact set which corresponds to the desired major, or thousands, group of lines. This contact set is assumed to be the one shown in the drawing comprising bank contacts 76–81, inclusive. The slow acting relay 34 is energized in series with the rotary magnet 40 the same as in the previous case and closes circuits for relay 36 and for the private magnet 39. The energization of the latter magnet adjusts the escapement in readiness to permit the said switch wipers to pass to third position when it deenergizes. At the end of the rotary movement of the switch, the slow acting relay 34 deenergizes and breaks the circuit of the private magnet which thereupon deenergizes also and permits the side switch wipers to pass to their third position.

The operations described at the end of the preceding paragraph invariably result when a party line number is called, because of the fact that the set of bank contacts in the test distributor, which is connected with, has its own test connector selector individual to it, and hence this set of contacts cannot be busy. However, in case a private or individual line number is called, in which case the test connector required is reached directly by way of the test distributor, it may be that such test connector is busy and in such case it is necessary to prevent the seizure of the connector at the test distributor and to give the calling wire chief a busy signal. It will be convenient to explain these operations. Now, if we assume, for example, that the trunk line shown at the right of Fig. 2 extending to the test connector H′ is connected with, rather than the trunk to the test connector selector E, and if we assume furthermore that this test connector is busy, there will be a ground potential on the test contact 79′. Under these circumstances, when the slow acting relay 34 falls back after the rotary movement of the switch is completed, a locking circuit is closed for the private magnet 39, which extends from the grounded test contact 79′ by way of the test wiper 73, side switch wiper 42, in second position, the lower winding of the test relay 35, normally closed contact springs controlled by armature 56, and the winding of the private magnet 39 to battery. The private magnet is thus locked in energized position and prevents the side switch wipers from going to their third position. The heavy test conductors 82 and 83 are also held open at contact springs controlled by the private magnet, and are thus kept disconnected from the wipers 70 and 75. The test relay 35 is energized in series with the private magnet. This relay opens the rotary magnet circuit at its armature 53, and at its armature 59 connects a lead from the busy signalling machine to the lower side of the test trunk, thereby placing an audible busy signal upon the line which will be heard by the wire chief, and which will indicate to him that he has encountered a busy test connector. At the same time relay 35 closes a circuit at its armature 57 for the reversing relay 30 which, upon operating, reverses the conductors 13 and 14 of the test trunk as regards their connections to the windings of relays 31, 33, and 27. By this operation, the direction of current flow in the lower winding of the electropolarized relay 202 is reversed, and the said relay is accordingly operated to close a circuit through the lamp L to battery. The lighting of the lamp L at this stage of the operation gives the wire chief a visual busy signal, supplementing the audible signal. He may now follow either of two courses, that is, he may release the connection by restoring the T.D.C. key to normal, in which case the test distributor is restored to normal as will be explained subsequently, or he may leave the connection up until the desired test connector shall have become idle. Assuming the latter course is followed, when the test connector is freed, ground is removed from test contact 79′ and the circuit by which the test relay 35 and private magnet 39 are be-

ing held energized is broken. The private magnet accordingly deenergizes, closes the heavy test conductors through to the wipers, and permits the side switch wipers to pass to third position, and when the test relay 35 deenergizes it disconnects the audible busy signal, and also breaks the circuit of the reversing relay 30. Upon the deenergization of this relay, the direction of current flow in the conductors of the test trunk is restored to normal, and the electropolarized relay 202 is caused to retract its armature and extinguish the lamp L. This notifies the wire chief that the desired test connector is now available and has been connected with, and he may, therefore, proceed to call the remaining digits.

After this digression we will now return to the establishment of the connection under consideration, and explain its further progress. By the operation of the test distributor which has been described, the connection has been extended through as far as the test connector selector E, Fig. 3. When the side switch wiper 43 of the test distributor reaches its third position, a circuit is closed for relay 37, which energizes and extends the operating circuit through to the relay 38 in order to provide for further energization of the slow acting relay 34, and at the same time relay 37 prepares a point in the circuit of the test wiper 72, and also closes a bridge across the wipers 71 and 74 at armature 63. By the latter operation a circuit is completed for the windings of the line relay 100 of the test connector selector E, and the said relay is accordingly energized and completes a circuit for the slow acting release relay 101. Upon energizing in turn, relay 101 connects ground to the release trunk conductor 85, whereby the connector selector E is made busy. Relay 101 also opens a point in the circuit of the release magnet 106 at its armature 112, and at the same armature prepares a circuit for the rotary magnet 105. It will be queried why it is necessary to ground the test contact 79 to make the test connector selector E busy, inasmuch as according to the previous explanation of the trunking arrangement, the test distributor D is the only switch which has access to the test connector selector E. This is a pertinent question and the answer is that if the trunking is arranged as described, there is no particular utility in grounding the test contact 79 when the test connector selector is taken for use. The provisions for grounding this test contact cause no harm, however, and they render it possible to use switches such as the test connector selector E in alternative trunking arrangements without change. For instance, when the testing facilities are increased, the number of test distributors D will increase faster than the number of test connector selectors in any one group. Thus, the number of test connector selectors need not exceed three no matter what size the system is, but it is conceivable that the number of test distributors might be increased to six or even more. In such case there would be two test distributors having access to each of the three test connector selectors in each group.

The wire chief may now operate the dial of the calling device S in accordance with the third digit of the desired number, and as a result, another series of interruptions are produced in the circuit of relays 31, 33, and 27 of the test distributor D. As before, the relay 31 sends an impulse of current, at each deenergization, through the slow acting series relay 34, and the said relay is energized and remains in operated position throughout the transmission of the third series of impulses, the same as it did during the transmission of the first and second series. Since this circuit is completed by way of the relay 38, however, no further mechanical operation of the test distributor D will take place, but relays 36, 38, and the private magnet 39 are operated nevertheless, and the latter opens the test conductors 82 and 83 while the impulses are being received. It will be noticed that the bridge across the wipers 71 and 74 which was closed at armature 63 of relay 37 includes also the armature 51 of relay 31, and it follows, therefore, that each time relay 31 deenergizes, it will open the bridge to cause the deenergization of the line relay 100 of the test connector selector E. It will be seen then that the test distributor D operates as a repeater after it has itself been operated to repeat impulses to the next switch taken for use, which in this case is the aforesaid test connector selector E.

The operation of this switch may now be described. At each deenergization of the line relay 100, responsive to the impulses which are repeated from the test distributor D, an impulse of current is transmitted to the rotary magnet 105 over a path which extends from ground by way of armature 109 and its resting contact, armature 112 and its working contact, winding of the slow acting series relay 102, armature 116 and its resting contact, winding of the rotary magnet 105, and side switch wiper 108, in its first position, to battery. By the operation of the rotary magnet 105, the wipers 130–135, inclusive, are rotated step by step and are stopped in engagement with the particular set of contacts in which is terminated the trunk line which extends to the test connector in the desired hundred line group. This trunk line is assumed to be the line shown in the drawing, which terminates in bank contacts 136–141, inclusive, and extends to the test con-

nector H. The slow acting relay 102 is energized in series with the rotary magnet 105 and remains in operated position throughout the rotary movement of the switch. At its armature 114, relay 102 closes a circuit for the private magnet 104 which is energized and adjusts the escapement to permit the subsequent release of the side switch. At the end of the rotary movement, relay 102 falls back and breaks the circuit of the private magnet 104. Whether or not the private magnet will be energized at this time depends upon whether or not the test connector H is busy. Assuming first that the connector is busy, there will be a ground potential upon the test contact 139 and when relay 102 deenergizes, a locking circuit will be established which extends from ground on the test contact 139 by way of the test wiper 133, side switch wiper 107, in first position, winding of test relay 103, normally closed contact springs controlled by armature 114, and the winding of private magnet 104 to battery. Since this locking circuit includes the winding of the test relay, this relay is energized in series with the private magnet. At its armature 115 and 118, test relay 103 opens the heavy test conductors 82 and 83, at its armature 116 it breaks the rotary magnet circuit, and at its armature 117 the conductor 85 is disconnected from ground and is connected instead through a low resistance to the ungrounded pole of the battery. By the latter operation a circuit is completed by way of the said conductor 85, test contact 79, test wiper 73, side switch wiper 42, in third position, and the upper winding of the test relay 35 to ground. Test relay 35 is accordingly energized and at its armature 59 places an audible busy signal on the line in the direction of the wire chief's test board. At the same time, at armature 57 a circuit is completed for the reversing relay 30, which operates to reverse the direction of current flow in the lower winding of the electropolarized relay 202 at the test circuit and thus gives the wire chief a visual busy signal by lighting the lamp L. The wire chief may disconnect at once, or he may wait on the line until the test connector H is cleared and becomes available for use. When this occurs, ground is disconnected from the test contact 139, the test relay 103, and the private magnet 104 of the test connector selector E are deenergized, and the said test relay breaks the circuit of the test relay 35 in the test distributor D. Relay 35 then drops back, removes the audible busy signal from the line and breaks the circuit of relay 30. The deenergization of the latter relay then reverses the direction of current flow in the circuit of the electropolarized relay 202 back to normal, and thus causes the lamp L to be extinguished.

Returning to the test connector selector E, when the private magnet 104 deenergizes, either on the breaking of its initial energizing circuit at relay 102, or upon the breaking of its locking circuit when the selected test connector is found to be busy and eventually becomes idle, a bridge is closed across wipers 131 and 134 at armature 120. This operation completes a circuit in an obvious manner for the double wound line relay 150 of the test connector H, which energizes and at its armature 160 closes a circuit for the slow acting release relay 151. Upon energizing, the latter relay grounds the test contact 139 at its armature 161 in order to make the connector H busy, and at its armature 162 opens the release magnet circuit and prepares a circuit for the vertical magnet 154.

The dial of the calling device S may now be operated in accordance with the next digit in the desired number, which is the digit 7. As a result of the operation of the calling device, a series of seven interruptions are produced in the circuit of relays 31, 33, and 27 at the test distributor D, and these interruptions are repeated by relay 31 into the circuit of relay 100 of the test connector selector E. Responsive to the interruptions of its circuit, relay 100 then operates to repeat a like series of interruptions into the circuit of the line relay 150 of the connector H, the bridge across the wipers 131 and 134 being opened at armature 110 every time relay 100 falls back. In response to the interruptions thus produced in its circuit, relay 150 is deenergized momentarily seven times and at each deenergization transmits a current impulse to the vertical magnet 154 over a path which may be traced from ground by way of armature 160 and its resting contact, armature 162 and its working contact, off normal springs 157 and 159, winding of slow acting series relay 152, and the winding of the vertical magnet 154 to battery. By the operation of the vertical magnet 154, wipers 170–172, inclusive, are raised step by step and are brought to rest opposite the seventh level of bank contacts. Relay 152 is energized in series with the vertical magnet, and being slow acting, remains in operated position throughout the vertical movement of the switch. The operation of this relay is effective to maintain the vertical magnet circuit closed notwithstanding the fact that the off normal springs 157–159, inclusive, are shifted, which occurs at the first upward movement of the switch shaft. At the end of the vertical movement of the switch, relay 152 falls back and transfers the operating circuit to the rotary magnet 155.

The calling device may now be operated for the final digit in the desired number, which is the digit 8. A series of eight in-

terruptions is thus produced in the circuit of relays 31, 33, and 27 of the test distributor D, and these interruptions are repeated as before into the circuit of relay 100, of the test connector selector E, which in turn operates to repeat them into the circuit of the line relay 150 at the test connector H. Relay 150 is, therefore, again deenergized momentarily a plurality of times and sends a series of impulses to the rotary magnet 155 over a circuit which extends from ground by way of armature 160 and its resting contact, armature 162 and its working contact, off normal springs 157 and 158, armature 163 and its resting contact, winding of the slow acting relay 153, and the winding of the rotary magnet 155 to battery. By the operation of the rotary magnet wipers 170–172, inclusive, are rotated step by step and are finally brought to rest in engagement with the particular set of bank contacts in which is terminated the line of substation A, these bank contacts being indicated in the drawing by reference character 173–175, inclusive. Relay 153 is energized in series with the rotary magnet 155, and being slow acting, retains its armatures 164 and 165 attracted during the rotary movement and thus disconnects the wipers 170 and 172 until the switch is finished operating, when it falls back and again connects up the wipers to the heavy testing conductors.

Further operations at this stage depend upon whether or not the line of substation A is busy or idle. It will be recalled that the circuit of the test distributor D is such that after this switch has been operated, the line relay 31 continues to send impulses to the slow acting relay 34 at the same time that it repeats impulses to the switches beyond. Thus, the said relay 34 is energized not only responsive to a series of impulses intended to operate the test distributor D, but also to the several series of impulses which operate the test connector selector E and the test connector H. It will be evident also that whenever relay 34 pulls up, circuits are closed for the slow acting relay 36 and the private magnet 39. With these facts in mind, the operations which take place, if the called line is busy, will be readily understood.

If the line is busy when connection is established therewith by means of the test connector H, as explained in the foregoing, the test wiper 171 will find a ground potential on the test contact 174 and when the slow acting relay 34 in the test distributor D falls back at the end of the final series of impulses, a circuit is completed for the reversing relay 30, which may be traced from the grounded test contact 174 by way of test wiper 171, conductor 169, test contact 138, test wiper 132, armature 119 and its resting contact, conductor 84, test contact 78, test wiper 72, working contact of armature 54 and said armature, armature 55 and its resting contact, working contact of armature 62 and the said armature, armature 60 and its working contact (slow acting relay 36 being still in energized position), and the winding of the reversing relay 30 to battery. Upon energizing, relay 30 closes a branch of the above traced circuit which extends from armature 62 by way of the working contact of armature 65 and the said armature, armature 61 and its working contact, and the winding of the slow acting relay 36 to battery. It may be explained that relay 30 pulls up and closes this branch circuit before the slow acting relay 36 has had time to deenergize following the breaking of its initial energizing circuit by the falling back of slow acting relay 34, and relays 30 and 36 are thus both held in operated position by the ground on the test contact 174 of the busy called line. Then relay 30 operates to reverse the direction of current flow in the upper winding of the electropolarized relay 202 in the test circuit in the usual manner and this relay is, therefore, operated to light the lamp L and thus give the wire chief the visual busy signal. It will be noticed, however, that no audible busy signal is in this case placed on the line, and indeed it would not be practical to do this inasmuch as the heavy test conductors are now actually connected with the two line conductors of the called line. Furthermore, the audible busy signal is unnecessary because the wire chief's head set is connected across the test conductors in series with the calling device, and by listening on the line he can at once ascertain whether it is engaged or not.

Finding that a conversation is going on, the wire chief may, of course, release the connection and try the number again later on, or he may restore the calling device key C.D. in order to leave the connection under the control of the electropolarized relay 202. If this latter course is followed, it will be evident that when the called line becomes idle and ground is removed from the test contact 174, the circuit of relays 30 and 36 of the test distributor D will be broken, and the former relay, upon deenergizing, will reverse the direction of current flow in the lower winding of relay 202 back to its normal direction of flow. Relay 202 is thus caused to deenergize and lamp L is extinguished, the wire chief being notified by this operation that the called line has become idle.

Having explained the operations which take place when the called line is busy, we will now consider what occurs when the line is idle, it being immaterial whether we consider that the line is idle when called, or becomes so some time after the connec-

tion has been established. In either case, when the slow acting relay 36 of the test distributor D falls back, a circuit is completed which extends from ground by way of the resting contact of armature 60 and the said armature, armature 62 and its working contact, resting contact of armature 55 and the said armature, armature 54 and its working contact, test wiper 72, test contact 78, conductor 84, resting contact of armature 119 and said armature, test wiper 132, test contact 138, conductor 169, test wiper 171, test contact 174, private normal conductor 177, winding of the cut off relay 179, and the winding of the rotary or stepping magnet 180 of the line switch C to battery. By the closure of the above circuit, a ground potential is placed on the test contact 174 to make the line busy in the usual manner, and at the same time relay 179 is energized and clears the line of substation A of its normal battery and ground connections in the line switch C. It may be explained at this time that relay 179 is operated only about half way because of a mechanical locking device controlled by the line relay 181, and the wipers of the line switch are not connected up.

Having completed the connection to the line which is is desired to test, the wire chief may now restore the calling device key CD, thereby disconnecting the calling device S from the operating circuit and again closing the operating conductors. It will be seen now that as long as the TDC key is in operated position, the connection will be held closed in the outgoing trunk, while the heavy line conductors of the test circuit are extended over direct metallic conductors to the two sides of the subscriber's line, respectively.

If it is desired to talk to the subscriber, the ringing key may now be operated momentarily in order to ring his bell and call him to the telephone. This act simply opens the two sides of the test circuit and connects a ringing current generator in bridge thereof in the usual manner. The listening key is now thrown and also the battery feed key BF. By the operation of the listening key, the wire chief's headset is connected across the heavy lined test conductors of the test circuit in series with the condenser 215, while the listening key and the BF key together connect the battery feed coils 206 and 207 across the test conductors, in order to supply talking current to the transmitter at the subscriber's telephone.

If it is desired to release the entire connection without disconnecting the test circuit from the outgoing test trunk, the release key is operated for a short interval. This opens the energizing circuit for relays 31, 33, and 27 in the test distributor D. Assuming now that all the other keys in the test circuit are in normal position, there will be no circuit closed to maintain the said relays 31 and 33 energized and they will fall back. Relay 31 breaks the operating circuit extending to the test connector selector E, and also breaks the circuit of the slow acting release relay 32. When the latter relay falls back, it closes a circuit for the release magnet 44 which restores the test distributor D to normal position in the well-known manner. At the test connector selector E when the circuit of the line relay 100 is broken, this relay falls back and breaks the circuit of the slow acting release relay 101, and, upon deenergizing, the latter relay closes the circuit of the release magnet 106. The operation of release magnet 106, of course, restores the connector selector E to normal also. The line relay 100, on deenergizing, breaks the circuit of the line relay 150 of the test connector H, and this switch is accordingly restored to normal by the operation of release magnet 156, whose circuit is closed in an obvious manner by the joint action of relays 150 and 151. Thus, all the test switches in use are returned to normal position and are ready to be reoperated to connect with the same or another line.

Sometimes it is desirable to release the test connector selector and the test connector without restoring the test distributor as, for example, in case it is desired to test another line in the same group. This can be accomplished by the operation of the connector release key. When this key is operated, the exchange battery is connected by way of resistance 205 through the upper winding of polarized relay 202, resistance 208, contacts of TDC key, to the conductor 14 of the test circuit, while at the same time the original operating loop for the relays 31, 33, and 27 of the test distributor D is opened at the break of contacts of the connector release key. Since, the lower conductor of the operating circuit is now connected to the ungrounded pole of the battery, relays 33 and 27 will be held energized, but the circuit for relay 31, being now open, that relay will fall back. Relays 33 and 27 hold the slow acting release relay 32 energized in order to prevent the release of the test distributor D, while relay 31 breaks the operating circuit of the test connector selector E, and thereby causes the test connector selector and test connector to be released and restored to normal, as previously described. It will be observed that relay 31 closes a circuit through the slow acting relay 34, which in turn energizes, and closes a circuit for the private magnet 39. The operation of the private magnet at this time opens the heavy testing conductors and prevents the application of

battery potential to other lines while the test connector selector E and the test connector H are returning their wipers to normal position. The connector release key need be operated only for a brief interval, and after it is restored to normal, the calling device key CD may be operated for the purpose of connecting the calling device S across the test circuit to reoperate the test connector selector and the same or another test connector.

The BCO key is provided to enable the wire chief to deenergize the cut off relay of a called line and permit the testing of said line in the direction of the automatic switchboard. When the BCO key is operated, the conductor 12 is divided into two sections and direct ground is placed on the section which extends to the outgoing operating conductor 13, while the other section extends through the various test keys to conductor 14, and is opened simultaneously by the operation of the BCO key, causing relays 33 and 27 of the test distributor D to deenergize. Relay 31 is maintained energized by ground extending from the BCO key, while relays 33 and 27 are permitted to fall back. The deenergization of relay 27 disconnects at its armature 54′ ground from the test wiper 72 of the test distributer switch D, and thus breaks the circuit of the cut off relay 179 of the line switch C. By means of the volt milammeter, the wire chief may now test the two sides of the subscriber's line for battery and ground, respectively, in a manner which will be explained subsequently.

The standard routine tests for line troubles are performed in substantially the same manner as in ordinary practice, and hence will require only a cursory discussion. Considering first the method of testing for a short or a ground, with all the keys in the test circuit at normal, the volt milammeter V and rheostat R are connected in series with the conductors 9 and 10. The wire chief proceeds by operating the test key K, which connects the volt milammeter V and the rheostat R, from the line test conductor 82 of the test circuit to ground, in series with the 100 volt testing battery B. The circuit may be briefly traced from the conductor 82 of the testing circuit at the T.D.C. key, by way of contacts of the T.W.T. key, contacts of the ringing key, contacts of the listening key, contacts of the reversing key, contacts of the test key K, now operated, through the volt milammeter V and rheostat R, contacts of the test key K, to the test battery B in series to ground. Ground is also connected to the line test conductor 83 by the operation of the key K. This circuit may be briefly traced from ground, resistance X, contacts of Key K, contacts of the ground key, contacts of the listening key, contacts of the ringing key, contacts of the reversing key, contacts of the T.D.C. key to conductor 83. Under the above described circuit conditions it will be seen that if there is a ground on conductor 82 or if conductors 82 and 83 are crossed, or shorted together, the needle of the volt milammeter will be deflected. The reverse key may now be operated momentarily in order to determine whether the deflection is due to a short or a ground on conductor 82. To test for a ground, the ground key may now be operated, which removes ground on conductor 83 from conductor 83. If the volt milammeter needle remains deflected, it will indicate that conductor 83 is grounded.

If desired, tests for foreign battery may be made by restoring the test key K, and by operating the ground key. Under the above described conditions, a circuit is completed from ground at the ground key, contacts of key K, the volt milammeter V and rheostat R, contacts of key K, through the previously traced key sets to test conductor 82, extending to the upper conductor of the called line. If there is any foreign battery on this conductor, the needle will be deflected accordingly. A similar test may be made on test conductor 83 extending to the lower line conductor by operating the reversing key.

In case it is desired to test the adjustment of the bridge cut off relay 179 of the subscribers' individual line switch C (hereinafter referred to as BCO relay 179), the wire chief operates the reversing key, and the third wire test key T.W.T. The operation of the key T.W.T. connects the conductor 13 direct to ground, and connects the conductor 14 through a high resistance 207′ to battery. The line relay 31 of the test distributor D is now maintained energized independent of relays 33 and 27, while the relays 33 and 27 receive current independent of relay 31. Due to the high resistance 207′, and the high resistance of relay 33 as compared to that of relay 27, the latter relay deenergizes at this time and at its armature 26 closes an operating circuit for relay 38, which now pulls up. The operation of relay 38 at its armature 25 disconnects the test conductor 83 from the wiper 75, and connects the same to the test wiper 72 leading to the BCO relay 179. It will also be noted that the relay 27 in falling back, at its armature 54′ disconnected the original holding ground from the wiper 72. Keeping in mind the fact that the keys T.D.C., T.W.T., and the reverse key are now in operated position, a test circuit for the BCO relay 179 may now be traced from ground, winding of battery feed coil 207, conductor 211, springs of the key T.W.T., through the volt meter V, rheostat R, through springs of the battery test key K,

listening and ringing keys, the reversing key, in operated position, through operated springs of key T.D.C., conductor 83, lower resting contact and armature of relay 39, armature 25 and its working contact, wiper 72, bank contact 78, conductor 84, resting contact of armature 119 and said armature, wiper 132, bank contact 138, conductor 169, wiper 171, bank contact 174, winding of bridge cut off relay 179, and motor magnet 180 to battery. The operation of the T.W.T. key also bridged the wire chief's headset across the conductors 82 and 83. The wire chief may now proceed to test the adjustment of the bridge cut off relay 179 by manipulating the rheostat R, observing the volt milammeter needle in the meantime in order to determine the current value at which the BCO relay will restore.

Assuming that the adjustment of BCO relay 179 is correct, the same will restore at the proper time, and in so doing will reconnect, at its upper armature and resting contact, the line relay 181 to the upper line conductor, thus closing a circuit extending to conductor 82, keys T.D.C. and T.W.T., through the wire chief's headset, back to the T.W.T. key, where the circuit divides, one branch extending to conductor 83 and thence over the previously traced circuit to the BCO relay 179, battery and ground, and the other branch extending over the previously traced circuit to the battery feed coil 207 and ground. It will be readily seen that when the above described circuit is completed through the wire chief's headset, that a distinctive click will be heard, indicating that the BCO relay has deenergized. Due to the high resistance circuit in which the line relay 181 is included, this relay will not be operated, its connection in multiple with the BCO relay will, however, cause an increased flow of current through the volt milammeter which will further indicate to the wire chief that the BCO relay has deenergized.

If the BCO relay falls back before the volt milammeter needle has been deflected to a predetermined point, it will indicate that the spring tension is too great, whereas if the relay fails to fall back at the predetermined releasing value, it will indicate that the spring tension is insufficient.

Having described my invention, what I consider to be new and desire to have protected by Letters Patent will be pointed out in the appended claims.

1. In a telephone system, a calling line, a called line, means including a series of automatic switches for extending a connection to said called line, testing apparatus associated with said calling line and including a test circuit, an automatic switch associated with said called line, a cut-off relay in said automatic switch operated when a connection is extended to said line, a relay in a switch of said series operable through the medium of said testing apparatus to cause said cut-off relay to be included in said test circuit, and means included in said testing apparatus for varying at will the current flow in said cut-off relay.

2. In a telephone system, a calling line, a called line, means including a series of automatic switches for extending a connection to said called line, testing apparatus associated with said calling line and including a test circuit, an automatic switch associated with said called line, a cut-off relay in said automatic switch operated when a connection is extended to said line, a relay in a switch of said series operable through the medium of said testing apparatus to cause said cut-off relay to be included in said test circuit, means for varying the current in said circuit, and visual indicating means included in said circuit for determining the amount of current flowing.

3. In a telephone system, a calling line, a called line, means including a series of automatic switches for extending a connection to said called line, testing apparatus associated with said calling line and including a test circuit, an automatic switch associated with said called line, a cut-off relay in said automatic switch operated when a connection is extended to said line, a relay in a switch of said series operable through the medium of said testing apparatus to cause said cut-off relay to be included in said test circuit, a rheostat included in said circuit to cause the current flow to be varied, and an ammeter included in said circuit to indicate the current value at any position of said rheostat.

4. In a telephone system, a calling line, a called line, means including a series of automatic switches for extending a connection to said called line, testing apparatus associated with said calling line and including a test circuit, an automatic switch associated with said called line, a cut-off relay in said automatic switch operated when a connection is extended to said line, a relay in a switch of said series operable through the medium of said testing apparatus to cause said cut-off relay to be included in said test circuit, a rheostat included in said circuit to cause the current flow to be varied, an ammeter included in said circuit to indicate the current value at any position of said rheostat, and means for transmitting an audible signal over the calling line when the current in said circuit is reduced sufficiently to cause said cut-off relay to deenergize.

5. In a telephone system, a test circuit including a test conductor, means including an automatic directively controlled switch for

extending said test conductor into connection with one line conductor of a line to be tested, a cut-off relay for said line, a third conductor for said line connected with said relay, and means for shifting said test conductor from connection with said line conductor into connection with said third conductor.

6. In a telephone system, a test circuit including a test conductor, means including an automatic directively controlled switch for extending said test conductor into connection with one line conductor of a line to be tested, a cut-off relay for said line, a third conductor for said line connected with said relay, wire chief's testing apparatus including a key associated with said test circuit, and means responsive to the actuation of said key for shifting said test conductor from connection with said line conductor into connection with said third conductor to permit the testing of said relay.

7. In a telephone system, a test circuit including two test conductors, means including an automatic directively controlled switch for extending said conductors, respectively, into connection with the two line conductors of a line to be tested, a cut-off delay for said line, a third conductor over which said relay is energized, and means for disconnecting one of said test conductors from the line conductor with which it is connected and for connecting it instead to said third conductor.

8. In a telephone system, a test circuit including two test conductors, means including an automatic directively controlled switch for extending said conductors, respectively, into connection with the two line conductors of a line to be tested, a third conductor over which said relay is energized, testing apparatus associated with said test circuit, and means for shifting one of said test conductors from the associated line conductor to said third conductor in order to test said cut-off relay.

9. In a telephone system, a test circuit including two test conductors, means including an automatic directively controlled switch for extending said conductors, respectively, into connection with the two line conductors of a line to be tested, a cut-off relay for said line, a third conductor over which said relay is energized, and means for breaking the initial energizing circuit of said relay and for closing a new circuit for said relay including one of said test conductors.

10. In a telephone system, a test circuit including two test conductors, means including an automatic directively controlled switch for extending said conductors, respectively, into connection with the two line conductors of a line to be tested, a cut-off relay for said line, a third conductor over which said relay is energized, means for breaking the initial energizing circuit of said relay and for closing a new circuit for said relay including one of said test conductors, means for varying the resistance of said test conductor to cause said cut-off relay to deenergize, and means for indicating the point at which deenergization takes place.

11. The combination, with a wire chief's test circuit, of means including an automatic directively controlled switch for connecting said test circuit with a line to be tested, means for testing the two line conductors of said line, a cut-off relay and a third conductor for said line, and circuit arrangements whereby the means employed for testing said line conductors may be used also for testing said relay over said third conductor.

12. The combination, with a wire chief's test circuit, of means including an automatic directively controlled switch for connecting said test circuit with a line to be tested, means for testing the two line conductors of said line, a third conductor individual to said line, and circuit arrangements whereby the means employed for testing said line conductors may be used also for testing said third conductor, independent of said line conductors.

13. The combination, with a wire chief's test circuit, of means including an automatic directively controlled switch for connecting said test circuit with a line to be tested, a test conductor extending from said test circuit to said switch, a second test conductor individual to said line, and means in said switch for connecting said first test conductor to a conductor of said line and to said second test conductor separately.

14. The combination, with a wire chief's test circuit, of a directively controlled automatic switch, a test conductor extending from said test circuit to said switch, a line including two line conductors and a third conductor, means including said automatic switch for connecting said test conductor to one of said line conductors, and means in said switch for disconnecting said test conductor from said line conductor and connecting said test conductor to said third conductor at will.

15. The combination, with a wire chief's test circuit, of a directively controlled automatic switch, two test conductors extending from said test circuit to said switch, a line including two line conductors and a third conductor, means including said automatic switch for connecting said test conductors to said line conductors, and means in said switch for disconnecting one of said test conductors from the corresponding line conductor and connecting such test conductor to said third conductor at will.

16. The combination, with a wire chief's

test circuit, of two testing conductors and a controlling conductor, a line including two line conductors and a third conductor, means for connecting said test circuit with said line conductors via said test conductors, and means remotely controlled over said controlling conductor for disconnecting one of said test conductors from the corresponding line conductor and for connecting such test conductor to said third conductor at will.

In witness whereof, I hereunto subscribe my name this 22d day of July, A. D. 1922.

THOMAS F. CROCKER.