

June 17, 1941.

F. KESSLER

2,245,683

TELEPHONE SYSTEM

Filed Oct. 2, 1939

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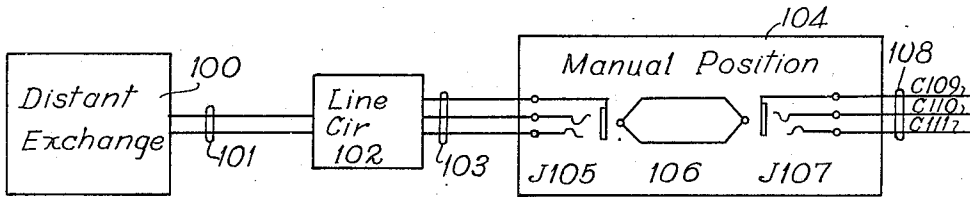
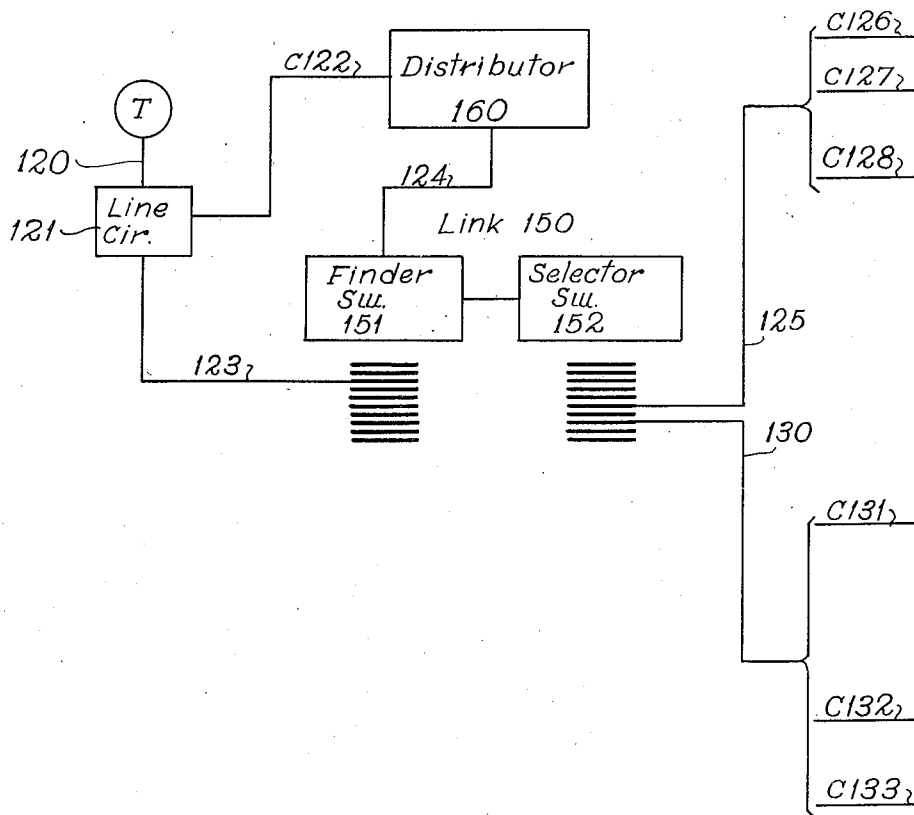


Fig. 1

Local Exchange
115



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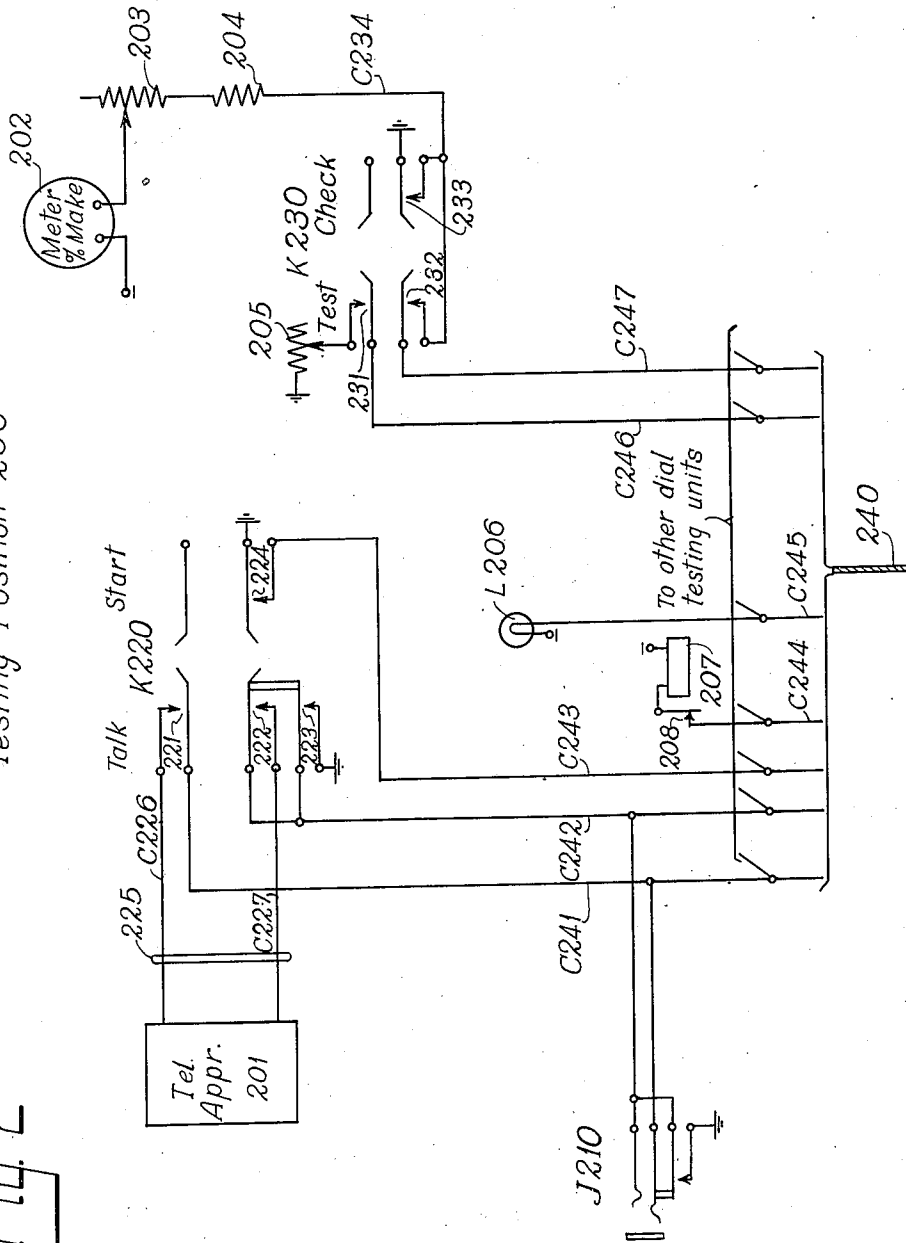
TELEPHONE SYSTEM

Filed Oct. 2, 1939

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Testing Position 200

Fig. 2



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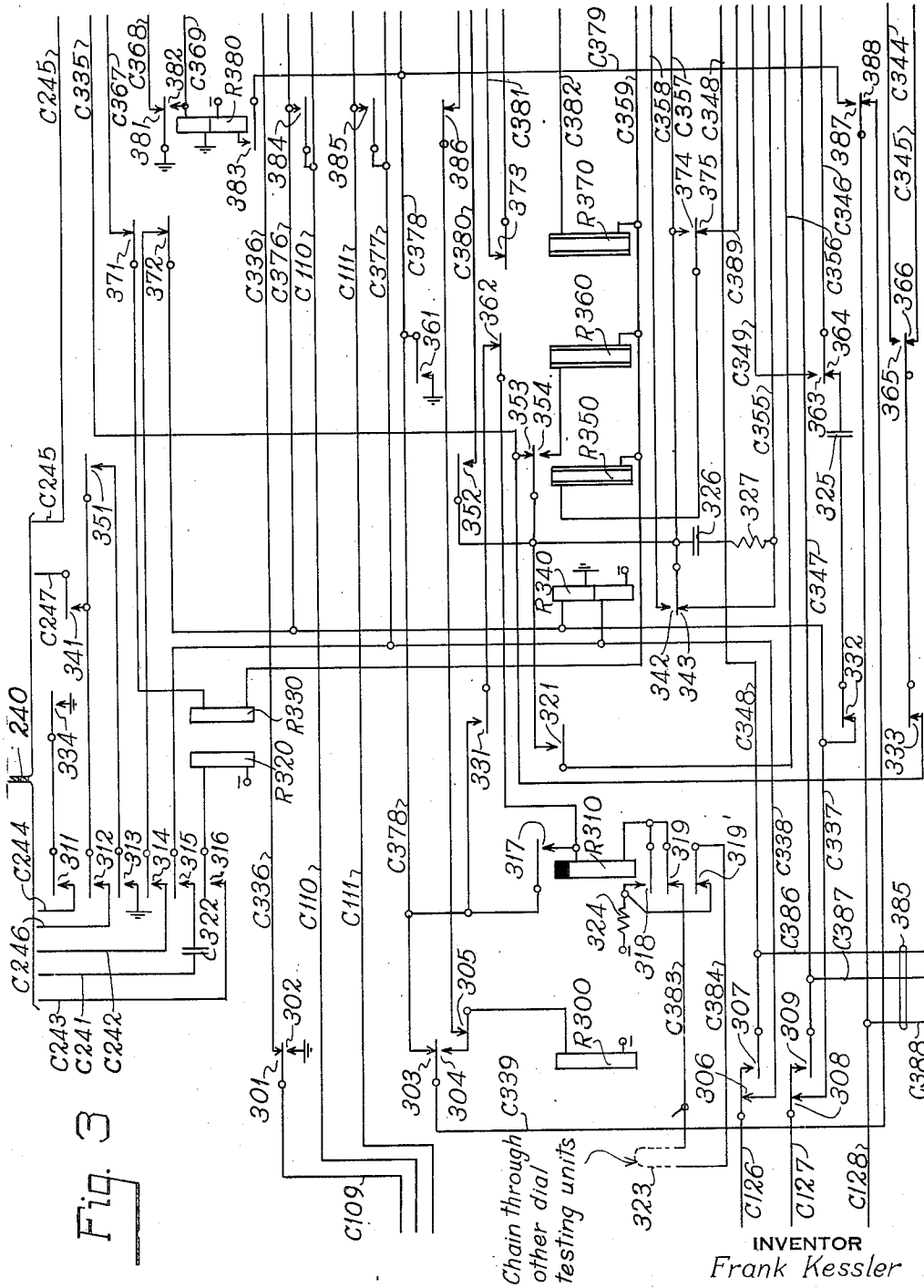
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Filed Oct. 2, 1939

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June 17, 1941.

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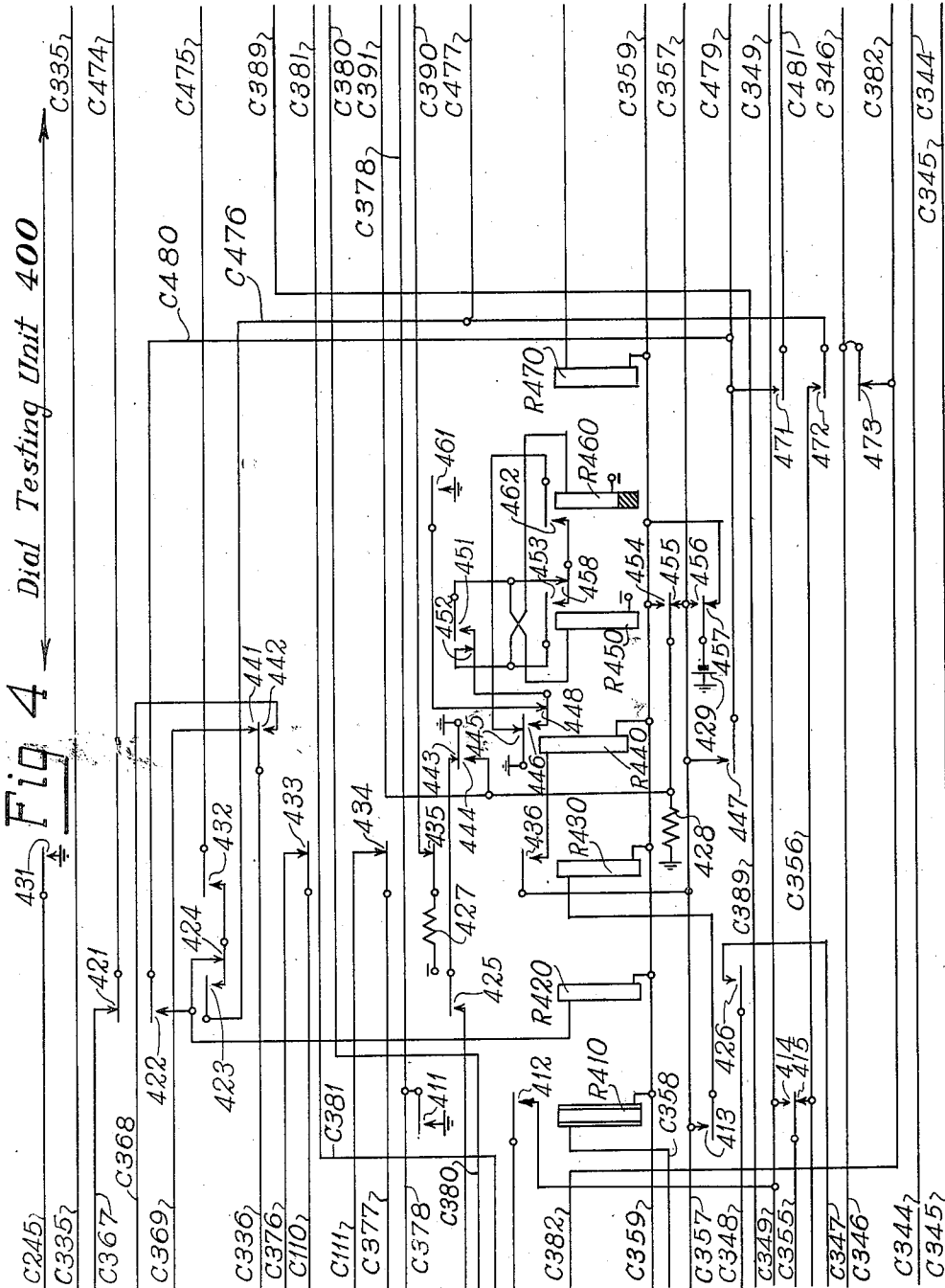
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TELEPHONE SYSTEM

Filed Oct. 2, 1939

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Fig 4 Dial Testing Unit 400



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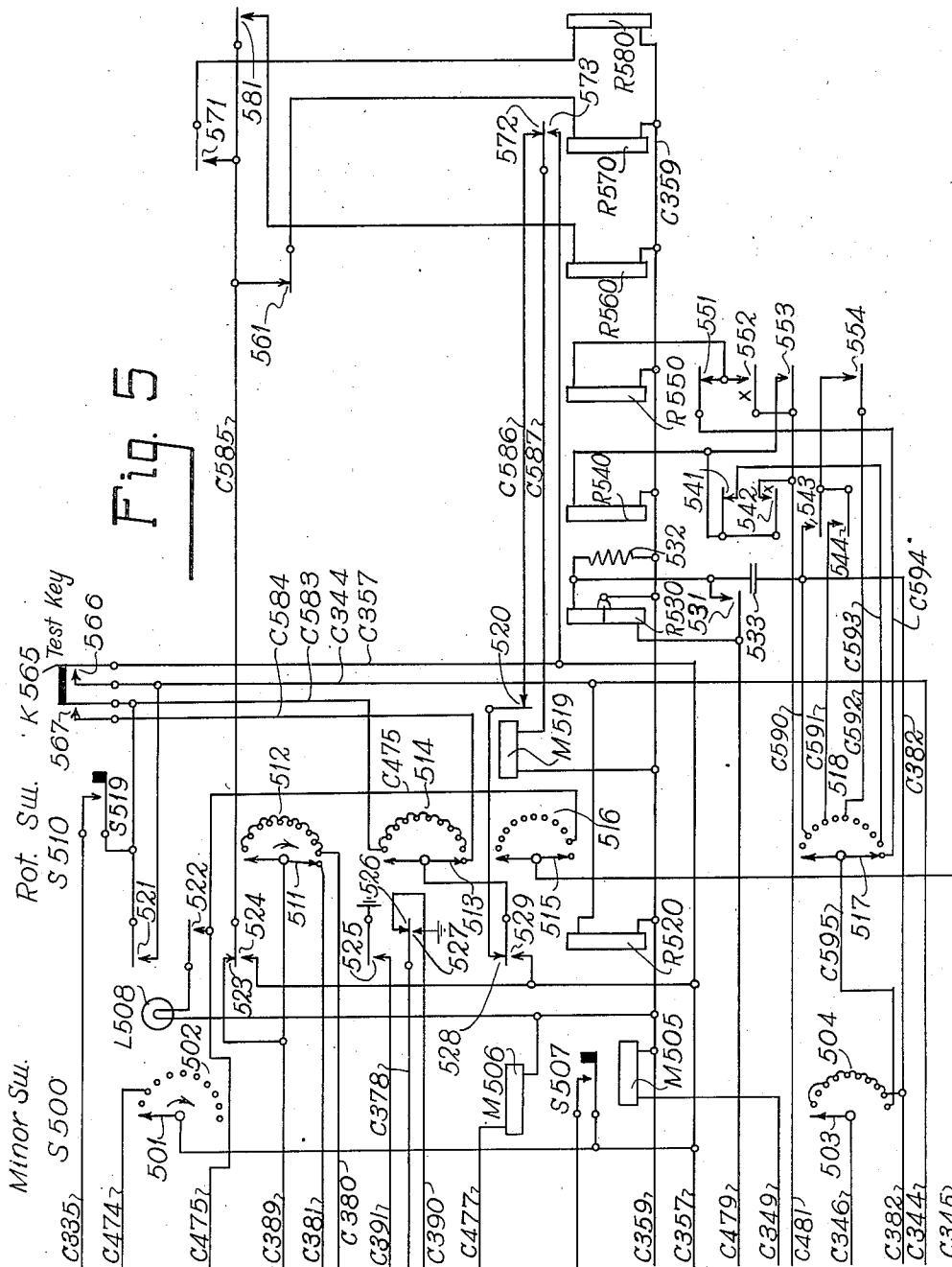
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Filed Oct. 2, 1939

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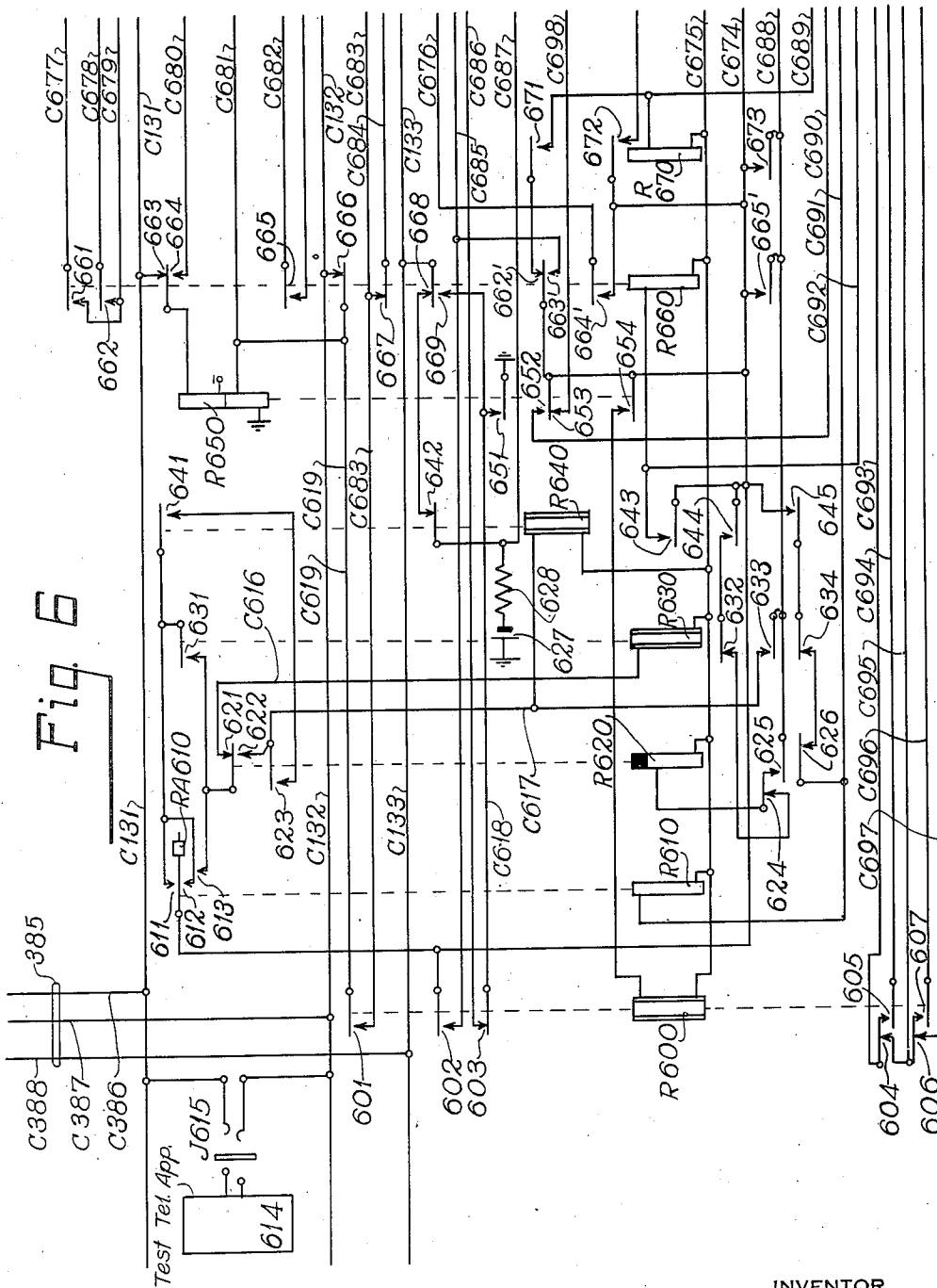
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Filed Oct. 2, 1939

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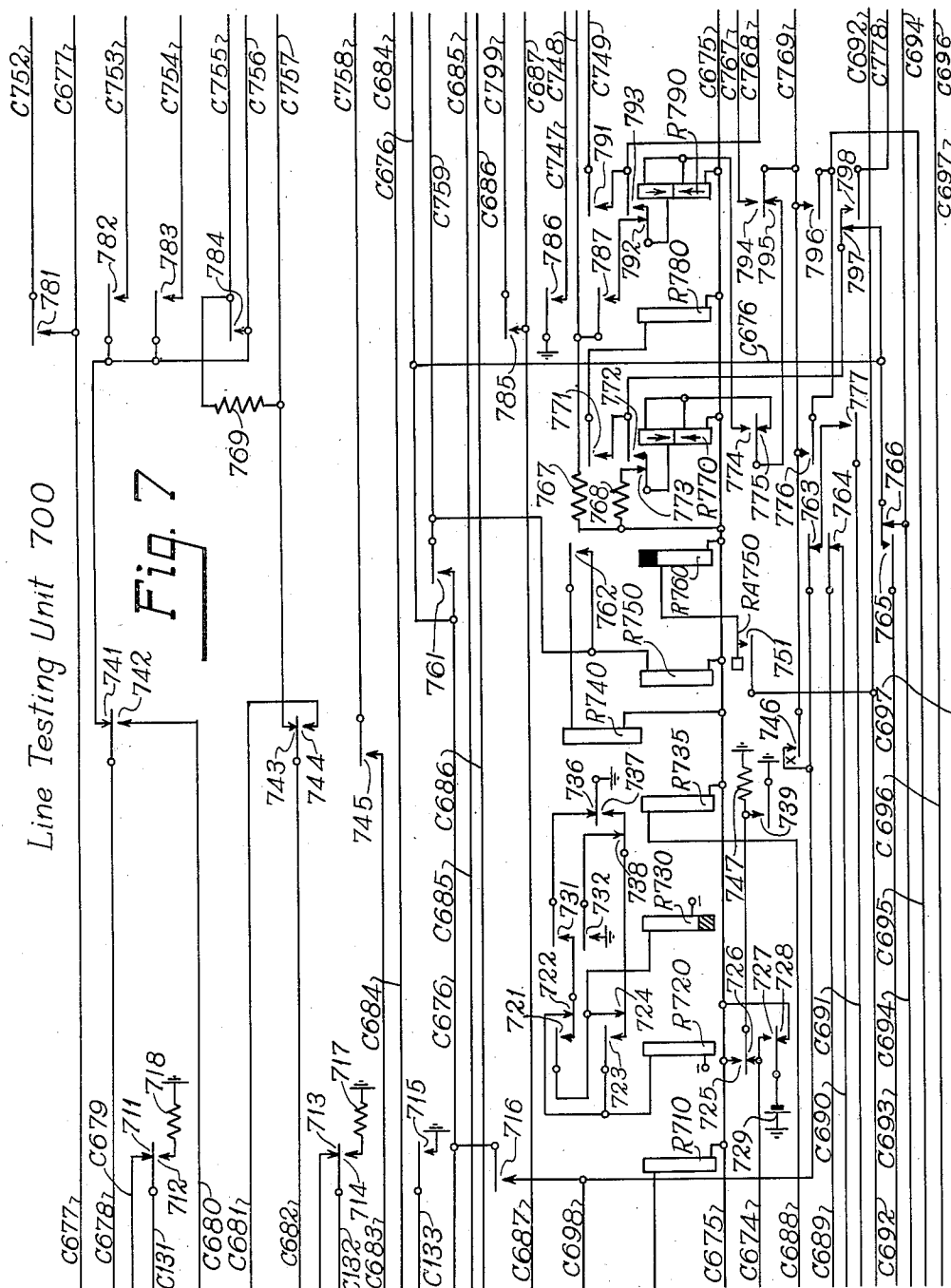
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TELEPHONE SYSTEM

Filed Oct. 2, 1939

8 Sheets-Sheet 7



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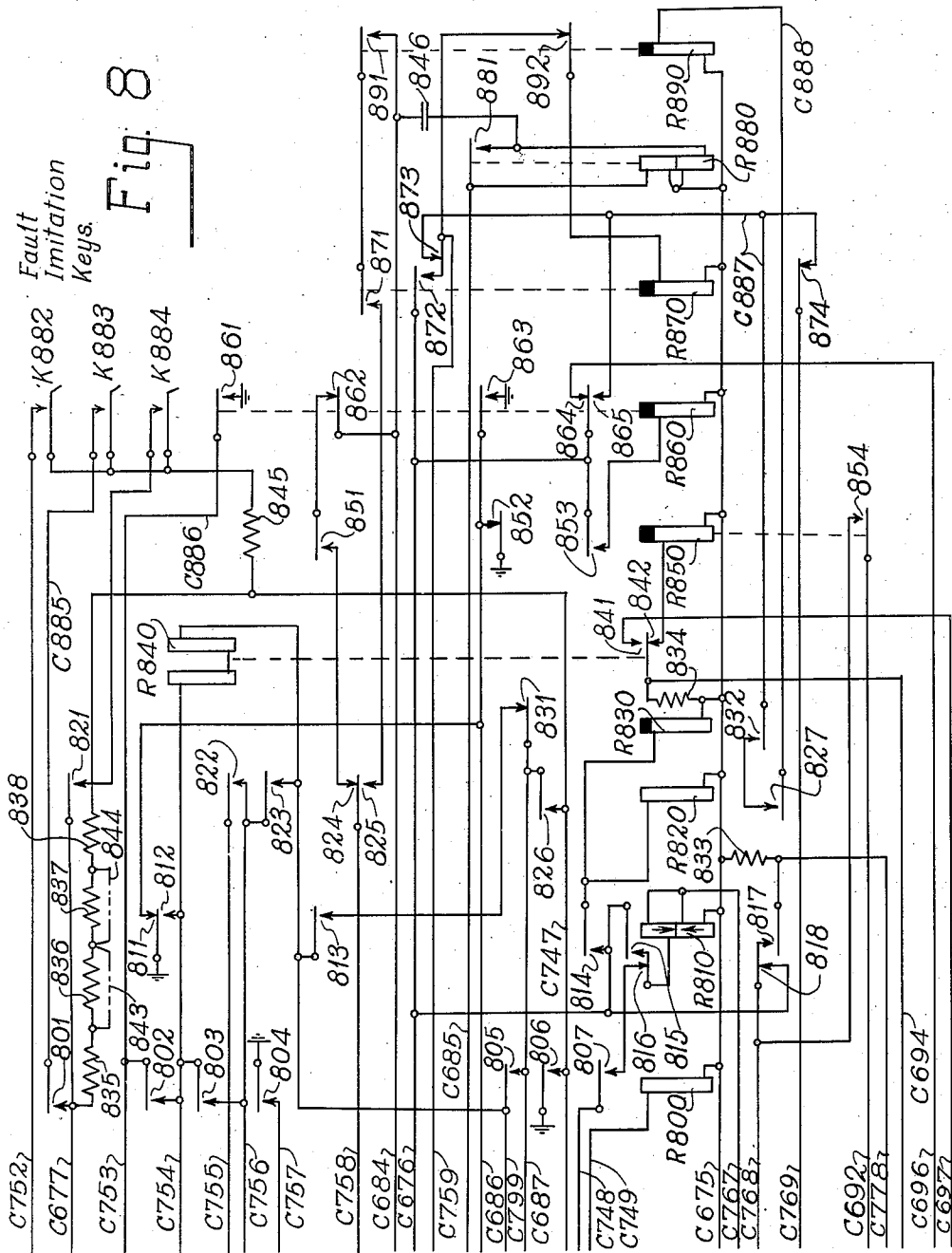
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8 Sheets-Sheet 8



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TELEPHONE SYSTEM

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Application October 2, 1939, Serial No. 297,477

46 Claims. (Cl. 179—175.2)

The present invention relates to telephone systems and more particularly to testing apparatus for telephone systems of the automatic type.

An automatic telephone system conventionally comprises an exchange provided with a switch train, a number of subscriber substations and subscriber lines extending between the exchange and the subscriber substations. The switch train is under the control of substation equipment located at each subscriber substation and is operative to set up the various connections between the subscriber lines. Ordinarily the switch train is impulse responsive and the substation equipment located at each subscriber substation comprises a telephone instrument, a telephone switch and an impulse transmitter.

The operation of the switch train may be properly controlled from a subscriber substation only in the event the impulse transmitter thereat is operative to transmit impulses which have a speed within prescribed limits and which have a relationship between the make contact and the break contact thereof within prescribed limits. More particularly, the impulsing speed of the transmitter should be approximately ten impulses per second; while the relationship between the make contact and the break contact of each impulse should be approximately 40:60, the contacts being closed forty per cent and open sixty per cent of each impulse period. Moreover, the line conductors of the subscriber line must be free of ground and battery faults thereon and cross connection faults therebetween in order properly to control the operation of the switch train from the subscriber substation.

While individual pieces of testing apparatus operative to test the impulsing speed of a transmitter, to test the impulse ratio of the make contact and the break contact of the impulses transmitted by a transmitter, and to test a subscriber line for the different types of faults thereon are usually provided in the exchange of an automatic telephone system, the different pieces of testing apparatus are ordinarily manually controlled at the exchange and require the services of a competent testman. Furthermore, it is ordinarily necessary to remove the transmitter from the subscriber substation to the exchange in order to perform the above-mentioned tests thereon and to render out of service a subscriber line in order to perform the above-mentioned tests thereon.

Accordingly, it is an object of the present invention to provide in a telephone system of the

type described, testing apparatus which is operative under the control of a subscriber substation to test both the impulse transmitter located at the subscriber substation and the subscriber line extending to the subscriber substation.

It is another object of the invention to provide in a telephone system of the type described, improved testing apparatus which is operative under the control of a subscriber substation to test the impulsing speed of the transmitter located at the subscriber substation.

Another object of the invention is to provide in a telephone system of the type described, improved testing apparatus which is operative under the control of a subscriber substation to test the impulsing speed of the transmitter located at the subscriber substation.

Another object of the invention is to provide in a telephone system of the type described, testing apparatus which is operative under the control of a subscriber substation to test the impulse ratio of make contact to break contact of the impulses transmitted by the transmitter located at the subscriber substation.

Another object of the invention is to provide in a telephone system of the type described, testing apparatus which is operative under the control of a subscriber substation to test a subscriber line extending to the subscriber substation.

It is a further object of the invention to provide composite testing apparatus operative under the control of a remotely disposed impulse transmitting device to test both the device and a line extending to the device.

A further object of the invention is to provide testing apparatus which is selectively operative to perform different tests upon an impulse transmitting device associated therewith and to perform different tests upon a line extending between the device and the testing apparatus.

A further object of the invention is to provide in a telephone system including a number of subscriber substations and an operator position, testing apparatus which may be selectively controlled from the subscriber substations and from the operator position.

A further object of the invention is to provide improved testing apparatus which is of simple connection and arrangement and which is economical to manufacture and thoroughly reliable in operation.

The features of the present invention are illustrated as being incorporated in an automatic

telephone system comprising a distant exchange, a local exchange including a switch train and a manual operator position, trunk lines extending between the distant exchange and terminating at the operator position, a number of subscriber substations, and subscriber lines extending between the local exchange and the subscriber substations. Also, the local exchange comprises testing equipment accessible to the switch train and to the operator position.

In accordance with one feature of the invention the testing equipment comprises a test position including testing apparatus operative to test the impulse ratio of make contact to break contact of the impulses transmitted by an impulse transmitter associated therewith, a group of first testing units each operative to test the impulsing speed of an impulse transmitter associated therewith, and a group of second testing units each operative to test for ground and battery faults on the line conductors and cross connection faults between the line conductors of a line associated therewith, the groups of first and second testing units being arranged in associated pairs.

In accordance with another feature of the invention the system comprises means controlled by initial operation of the substation equipment at one of the subscriber substations for associating the telephone instrument and the transmitter thereat with the subscriber line extending between the subscriber substation and the local exchange and for associating the subscriber line with the switch train at the local exchange. Also the system comprises means controlled by a first initial operation of the transmitter for causing the switch train to select an idle one of the first testing units, means controlled by further operation of the transmitter for operating the one first testing unit, switching means operative to associate the one first testing unit with the associated one of the second testing units, and means controlled by a second initial operation of the transmitter for causing the switch train to select an idle one of the second testing units. Further the system comprises means controlled by another operation of the substation equipment following the first initial operation and the further operation of the transmitter for disassociating the transmitter and the telephone instrument from the subscriber line and for operating the switching means and for operating the one second testing unit, and means controlled by another operation of the substation equipment following the second initial operation of the transmitter for disassociating the transmitter and the telephone instrument from the subscriber line and for operating the second testing unit. Further the system comprises means controlled by further operation of the substation equipment for again associating the transmitter and the telephone instrument with the subscriber line.

In accordance with a further feature of the invention each of the first testing units is operative to transmit over the subscriber line to the subscriber substation a signal indicative of the tested speed of the transmitter, this signal comprising different numbers of splashes of tone; while each of the second testing units is operative to transmit over the subscriber line to the subscriber substation a signal indicative of a particular type of fault on the subscriber line in the event the subscriber line is tested as having a particular type of fault thereon, this signal comprising different numbers of splashes of tone.

In accordance with a further feature of the

invention each of the first testing units comprises impulse responsive means operative to test the idle or busy condition of the testing apparatus at the testing position, switching means operative to associate the first testing unit with the testing apparatus at the testing position in the event the testing apparatus at the testing position is tested idle, and means controlled when the first testing unit is associated with the testing apparatus at the testing position for rendering busy the testing apparatus at the testing position. The first testing unit and the testing apparatus at the testing position are so connected and arranged that the testing apparatus at the testing position is operated substantially simultaneously with the operation of the first testing unit in the event the switching means is operated. The testing apparatus at the testing position and the first testing unit may be repeatedly operated in order to check the operation of the testing apparatus and the operation of the first testing unit by successively operating the impulse transmitter associated with the first testing unit to transmit successively a predetermined digit. Also the testing position comprises telephone apparatus and means operative to establish a connection between the telephone apparatus and a telephone instrument associated with the first testing unit in the event the switching means is operated.

In accordance with a further feature of the invention the operator position comprises means for establishing a connection between the distant exchange and the local exchange, the connection including an impulse transmitting device at the distant exchange, and means for selecting an idle one of the first testing units and for associating therewith the established connection extending between the distant exchange and the local exchange, whereby the first testing unit may be operated by the impulse transmitting device in the distant exchange. Further the operator position comprises an impulse transmitter operative to cause operation of the impulse responsive testing means in the first testing unit, whereby the testing apparatus at the testing position may be associated with the first testing unit while the first testing unit is associated by way of the manual position with the established connection extending between the distant exchange and the local exchange, thereby to permit the impulse ratio of make contact to break contact of impulses transmitted by the impulse transmitting device at the distant exchange to be tested by the testing apparatus at the testing position.

In accordance with a further feature of the invention, when an idle one of the first testing units is selected by the operator position the one first testing unit and the associated one of the second testing units are rendered busy to the switch train; when an idle one of the first testing units is selected by the switch train the one first testing unit is rendered busy to the switch train and to the operator position and the associated one of the second testing units is rendered busy to the switch train; and when an idle one of the second testing units is selected by the switch train the second testing unit is rendered busy to the switch train and the associated one of the first testing units is rendered busy to the switch train and to the operator position.

Further features of the invention pertain to the particular arrangement of the circuit ele-

ments thereof, whereby the above-outlined and additional operating features are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the following specification taken in connection with the accompanying drawings in which Figures 1 to 8, inclusive, taken together, illustrate a telephone system having incorporated therein a testing system embodying the present invention.

Description of the apparatus incorporated in the telephone and testing systems.

Referring now more particularly to Fig. 1 of the drawings, the telephone system there illustrated comprises a distant exchange 100 of any well-known type and a local exchange 115 of the combination manual and automatic type. The local exchange 115 includes a manual position 104 terminating a plurality of trunk lines extending to the distant exchange 100 and including the illustrated trunk line 101. The trunk lines are provided with line circuits individual thereto and terminate in individual jacks at the manual position 104, the trunk line 101 being provided with a line circuit 102 individual thereto and terminating in an individual jack J105 at the manual position 104.

The local exchange 115 serves a number of local subscriber substations including the subscriber substation indicated at T and comprises an automatic switch train. The automatic switch train comprises a plurality of links including the link 150 and a distributor 160 for assigning idle ones of the links to the use of the subscriber substations. The link 150 comprises a finder portion or switch 151 which is preferably of the Strowger type and a selector portion or switch 152 which is preferably of the Strowger type. A subscriber line and a line circuit individual thereto are associated with each subscriber substation, the subscriber line 120 and the line circuit 121 individual thereto being associated with the subscriber substation T.

Each of the finder switches has access to each of the subscriber lines, while each of the selector switches has access to a number of groups of connector switches, not shown, to a first group of trunks including the trunk 125 and to a second group of trunks including the trunk 130.

Each of the subscriber substations is provided with a telephone instrument, a telephone switch, dialing apparatus and a ringer; while the manual position 104 is provided with the usual telephone apparatus including a telephone instrument and a number of cord circuits, one of the cord circuits being indicated at 106. Also, a second group of trunks including the trunk 108 terminates in individual jacks at the manual position 104, the trunk 108 being terminated in an individual jack J107 at the manual position 104.

The testing system is disposed in the local exchange 115 and comprises a testing position 200, shown in Fig. 2, and a plurality of testing apparatus, each testing apparatus including a dial testing unit and a line testing unit. Preferably, each testing apparatus is identical to the testing apparatus illustrated which comprises a dial testing unit 400, shown in Figs. 3, 4 and 5, and a line testing unit 700 shown in Figs. 6, 7 and 8.

Referring now to Fig. 2, the testing position

200 comprises conventional telephone apparatus 201, a meter 202 calibrated to measure the per cent make contact of an impulsing apparatus, an audible signal 207, a visual signal 206, a jack J210, two sets of control keys K220 and K230, a control trunk 240 and a control network connected and arranged in a manner more fully described hereinafter.

Referring now to Figs. 3, 4 and 5, the dial testing unit 400 comprises a switch S500 of the minor type including two wipers 501 and 503 provided with individually associated contact banks 502 and 504, a rotary magnet M505 for driving the wipers noted and a release magnet M506 for releasing the wipers noted and for causing the wipers to be returned to their normal positions. Also associated with the minor switch S500 is a set of switch springs S507 which is actuated into engagement when the wipers noted of the minor switch S500 are actuated away from their normal positions. Also, the dial testing unit 400 comprises a switch S510 of the rotary type including four wipers 511, 513, 515 and 517 provided with individually associated contact banks 512, 514, 516 and 518, and a rotary magnet M519 for driving the wipers noted. Also associated with the rotary switch S510 is a set of switch springs S519 which is actuated into engagement when the wipers noted of the rotary switch S510 are actuated away from their normal positions. Further, the dial testing unit 400 comprises a visual signal L508; a test key K565; a switching relay R310; an impulse relay R340; a hold relay R410; a battery reversing relay R450; a tone relay R530; three timing relays R560, R570 and R580; a number of control relays R300, R320, R330, R350, R360, R370, R380, R420, R430, R440, R460, R470, R520, R540 and R550; and a control network for the relays noted.

The dial testing unit 400 further comprises apparatus operative to transfer a connection extending thereto from the manual position 104 by way of the trunk 108 or a connection extending thereto from the switch train by way of the trunk 125 to the control trunk 240 extending to the testing position 200, provided the control trunk 240 is not busy due to the previous transfer of a connection thereto by another one of the dial testing units. Also, the dial testing unit 400 comprises apparatus operative to transfer a connection extending thereto from the switch train by way of the trunk 125 to a transfer trunk 385 extending to the associated line testing unit 700.

Referring now to Figs. 6, 7 and 8, the line testing unit 700 comprises test telephone apparatus 614 including a telephone instrument; three fault imitation keys K882, K883 and K884; a hold relay R600; two timing relays R610 and R750; an impulse relay R650; a battery reversing relay R720; a tone relay R880, a testing relay R840; three test checking relays R770, R790 and R810; a number of control relays R620, R630, R640, R660, R670, R710, R730, R735, R740, R760, R780, R800, R820, R830, R850, R860, R870 and R890; and a control network for the relays noted.

It is noted that the trunk 108 terminating at the manual position 104 is individual to the dial testing unit 400; the trunk 125 accessible to the switch train is individual to the dial testing unit 400; the trunk 130 accessible to the switch train is individual to the line testing unit 700; while the control trunk 240 extending to the testing position 200 is commonly associated with the dial testing units of the testing apparatus.

Before proceeding with the operation of the testing system in conjunction with the telephone system it is noted that the manual position 104 comprises apparatus operative to seize any one of the dial testing units by way of the associated trunk terminating at the manual position 104 and to establish a connection thereto from the distant exchange 100 by any one of the trunk lines terminating at the manual position 104. The selector switch of each of the links in the switch train is selectively operative automatically to search for a trunk in the first group of trunks extending to an idle one of the dial testing units and to search for a trunk in the second group of trunks extending to an idle one of the line testing units, and to seize a trunk extending to an idle one of the units. Accordingly, the switch train may be selectively controlled to establish a connection from any one of the subscriber substations associated therewith to an idle one of the dial testing units and to establish a connection from any one of the subscriber substations associated therewith to an idle one of the line testing units.

Each of the dial testing units is operative to test by way of the switch train the dialing or impulsing speed of the dialing apparatus disposed at any one of the subscriber substations and to test by way of the manual position 104 the dialing or impulsing speed of any impulsing apparatus disposed in the distant exchange 100. Furthermore, after a connection has been established to any one of the dial testing units by way of the switch train or by way of the manual position 104, it may be transferred by way of the associated control trunk to the testing position 200, in the event that the testing position 200 is idle at this time. Also, after a connection has been established to any one of the dial testing units by way of the switch train, it may be transferred by way of the associated transfer trunk to the associated line testing unit.

Each of the line testing units is operative to perform certain line tests upon any subscriber line in the system either when the connection is established to the line testing unit directly from the switch train or when the connection is transferred to the line testing unit from the associated dial testing unit. More particularly, each of the line testing units is operative to perform the following tests upon any subscriber line in the system:

1. A test to determine whether there is a ground fault on either of the line conductors of the subscriber lines.
2. A test to determine whether there is a cross connection fault between the line conductors of the subscriber line.
3. A test to determine whether there is a battery leak fault on either of the line conductors of the subscriber lines.

The apparatus at the testing position 200 is operative to test any connection transferred thereto from any one of the dial testing units to determine the impulse ratio of the impulsing apparatus included in the connection. More particularly, the apparatus at the testing position 200 determines the per cent make contact of the impulsing apparatus included in the connection transferred thereto from one of the dial testing units.

Accordingly, the testing system is effective to perform, by way of the manual position 104, both impulse speed and impulse ratio tests and to perform, by way of the switch train, impulse

speed and impulse ratio tests as well as complete line tests.

In order to control the testing system to perform an impulse speed test upon the impulsing apparatus in the distant exchange 100 connected by way of one of the trunk lines to the manual position 104, a connection is first established from the manual position 104 to an idle one of the dial testing units. The digit 0 is then dialed, thereby to cause the selected dial testing unit to perform the impulse speed test and thereafter transmit a characteristic tone over the connection indicative of the impulse speed of the impulsing apparatus in the distant exchange 100. The digit 0 may be dialed several times in order to cause the selected dial testing unit to repeat the impulse speed test several times, thereby to check the operation of the selected dial testing unit.

In order to control the testing system to perform both an impulse ratio test and an impulse speed test upon the impulsing apparatus in the distant exchange 100 connected by way of one of the trunk lines to the manual position 104, a connection is first established from the manual position 104 to an idle one of the dial testing units. Thereafter, the digit 2 is dialed at the manual position 104 in order to cause the selected dial testing unit to transfer the connection to the testing position 200, assuming that the testing position 200 is idle at this time. The impulsing apparatus in the distant exchange 100 is then operated to transmit the digit 0 over the trunk line to the manual position 104, which digit it transmits by way of the selected dial testing unit to the testing position 200, whereupon the meter 202 indicates the per cent make contact of the impulsing apparatus in the distant exchange 100, which indication of the meter 202 is observed by the operator at the testing position 200.

Also, the selected dial testing unit operates at this time to test the impulse speed of the impulsing apparatus in the distant exchange 100 and to return a characteristic tone over the connection indicative of the impulse speed of the impulsing apparatus in the distant exchange 100 as previously explained.

In order to control the testing system to perform an impulse speed test upon the dialing apparatus at any one of the subscriber substations, a connection is first established between the subscriber substation and one of the links in the switch train. The digit 5 is then dialed, thereby to cause the selector switch of the selected link to search automatically for a trunk extending to an idle one of the dial testing units. After an idle dial testing unit has been found by the selector switch of the selected link in the switch train, the digit 0 is dialed at the dialing apparatus at the subscriber substation, whereupon the selected dial testing unit operates in order to perform the impulse speed test upon the dialing apparatus at the subscriber substation and to return over the connection a tone characteristic of the speed of the dialing apparatus at the subscriber substation as previously explained.

In order to control the testing system to perform both impulse ratio and impulse speed tests upon the dialing apparatus at any one of the subscriber substations, a connection is first established between the subscriber substation and one of the links in the switch train. The digit 5 is then dialed, thereby to cause the selector switch of the selected link to search automatical-

ly for a trunk extending to an idle one of the dial testing units. After an idle dial testing unit has been found by the selector switch of the selected link in the switch train, the digits 2 and 0 are dialed successively, thereby to cause the previously described operations of the apparatus at the testing position 200 and the selected dial testing unit.

In order to control the testing system to perform a line test upon any one of the subscriber lines in conjunction with either an impulse speed test upon the dialing apparatus at the associated subscriber substation or an impulse speed test and an impulse ratio test upon the dialing apparatus at the associated subscriber substation, a connection is first established between the subscriber substation and one of the links in the switch train as previously explained. After this connection has been established from the subscriber substation to one of the links in the switch train the digits 5 and 0 or the digits 5, 2 and 0 are dialed at the dialing apparatus at the subscriber substation as previously explained, whereupon either the impulse speed test is performed by the selected dial testing unit or both the impulse ratio test and the impulse speed test are performed by the apparatus at the testing position 200 and by the selected dial testing unit as previously explained. After the test or tests noted have been performed, the receiver of the telephone instrument at the subscriber substation is momentarily replaced upon its associated switchhook, thereby to cause the selected dial testing unit to operate and transfer the connection by way of the transfer trunk to the associated line testing unit. The line testing unit then operates to perform the line tests previously mentioned upon the subscriber line. Subsequently the receiver of the telephone instrument at the subscriber substation is removed from its associated switchhook, whereupon the line testing unit associated with the selected dial testing unit operates to cause a characteristic tone indicative of a particular type of fault to be returned over the connection in the event a fault is present upon the subscriber line.

In order to control the testing system to perform only a line test upon any of the subscriber lines, a connection is first established between the subscriber substation and one of the links in the switch train as previously explained. After this connection has been established from the subscriber substation to one of the links in the switch train, the digit 3 is dialed at the dialing apparatus at the subscriber substation as previously explained, whereupon the selector switch of the selected link in the switch train operates automatically to find a trunk extending to an idle one of the line testing units. After one of the line testing units has been found by the selector switch of the selected link in the switch train the receiver of the telephone instrument at the subscriber substation is momentarily replaced upon its associated switchhook, thereby to cause the selected line testing unit to perform the previously mentioned line tests upon the subscriber line. The receiver of the telephone instrument at the subscriber substation is then removed from its associated switchhook, whereupon the selected line testing unit operates to cause a characteristic tone indicative of a particular type of fault to be returned over the connection in the event a fault is present upon the subscriber line.

Operation of the testing system to test the impulse speed of the dialing apparatus at a subscriber substation

In order to test the impulse speed of the dialing apparatus at one of the subscriber substations, such, for example, as the dialing apparatus at the subscriber substation T, a call is first initiated at the subscriber substation upon the associated subscriber line. More particularly, the receiver of the telephone instrument at the subscriber substation T is removed from its associated switchhook, thereby to initiate a call upon the subscriber line 120, whereupon the line circuit 121 individually associated with the subscriber line 120 operates to initiate operation of the distributor 160 included in the switch train by way of the control conductor C122. The distributor 160 then operates to assign an idle one of the links, such, for example, as the link 150 to the use of the calling subscriber line 120, operation of the link 150 being initiated by the distributor 160 by way of the trunk 124. The finder switch 151 of the link 150 then operates to find the line 123, the line 123 extending to the line circuit 121 and operatively connected to the subscriber line 120. When a connection is thus established between the subscriber substation T and the finder switch 151 of the link 150, dial tone current is returned from the selector switch 152 of the link 150 over the subscriber line 120, thereby to indicate to the testman at the subscriber substation T that may proceed to dial the first digit. In the present instance, the testman at the subscriber substation T dials the digit 5, thereby to cause the selector switch 152 of the link 150 to operate automatically and search for a trunk in the first group of trunks extending to an idle one of the dial testing units. Assuming that the dial testing unit 400 is the first idle dial testing unit in this group of units the selector switch 152 of the link 150 operates automatically to seize the trunk 125 individual to the dial testing unit 400 and included in the first group of trunks. The trunk 125 is marked for selection by the presence of battery potential upon the control conductor thereof. The path for applying battery potential to the control conductor C128 of the trunk 125 extends from battery by way of the resistor 427, the contacts 435, C390, the contacts 526, C378, the contacts 303, C339 and the contacts 338 to the control conductor C128.

This application of battery potential to the control conductor C128 of the trunk 125 causes the selector switch 152 to seize the trunk 125 and switch through, thereby to establish a connection between the subscriber substation T and the trunk 125. When the selector switch 152 switches through a loop circuit is completed for energizing in series the upper and lower windings of the impulse relay R340, this circuit extending from ground by way of the upper winding of R340, C337 and the contacts 308 to the line conductor C127 of the trunk 125 and from battery by way of the lower winding of R340, C338 and the contacts 306 to the line conductor C126 of the trunk 125, the line conductors C126 and C127 of the trunk 125 being connected together by way of the selector switch 152 and the finder switch 151 of the link 150, the line 123, the line circuit 121, the subscriber line 120 and the telephone instrument at the subscriber substation T.

When energized over the above-traced circuit

the impulse relay R340 operates, to complete, at the contacts 342, a circuit for energizing the winding of the hold relay R410, this circuit extending from ground by way of the resistor 428, the contacts 455, the ground conductor C357, the contacts 342, C358, the winding of R410, the battery conductor C359 and the contacts 457 to the ungrounded terminal of the grounded battery 429. When energized over the above-traced circuit the hold relay R410 operates, to complete, at the contacts 413, a circuit for energizing the winding of the control relay R430, this circuit extending from the ground conductor C357 by way of the contacts 413 and the winding of R430 to the battery conductor C359. Also upon operating the hold relay R410 completes, at the contacts 411, a path for applying ground potential to the control conductor C128 of the trunk 125, this path extending from ground by way of the contacts 411, C378, the contacts 303, C339 and the contacts 388 to the control conductor C128 of the trunk 125. Further, this path extends from the control conductor C128 of the trunk 125 by way of the control conductor C388 of the transfer trunk 387 to the control conductor C133 of the trunk 130. Accordingly, at this time direct ground potential is applied to the control conductors C128 and C133 of the respective trunks 125 and 130, thereby to mark these trunks as busy to the selector switches of the links having access thereto.

When energized over the above-traced circuit, the control relay R430 operates to complete, at the contacts 436, an obvious circuit for energizing the winding of the control relay R440, thereby to cause the relay R440 to operate. Also upon operating the control relay R430 disconnects, at the contacts 433 and 434, the line conductors C110 and C111 of the trunk 108 extending to the manual position 104 from the dial testing unit 400, thereby to prevent interference from the manual position 104. Also, the control relay R430 completes, at the contacts 431, a circuit for illuminating the lamp L206 at the testing position 200, this circuit extending from ground by way of the contacts 431, the conductor C245 of the control trunk 240 and the lamp L206 to battery. The illumination of the lamp L206 indicates to the operator at the testing position 200 that one of the dial testing units has been seized and that subsequently an impulse ratio test may be required. Further, the control relay R430 interrupts, at the contacts 435, the previously traced path for applying battery potential by way of the resistor 427 to the control conductor C128 of the trunk 125, ground potential being applied to the control conductor C128 of the trunk 125 at this time as previously noted.

Upon operating, the control relay R440 completes, at the contacts 442, a path for applying ground potential to the control conductor C109 of the trunk 108 extending to the manual position 104, this path extending from ground by way of the contacts 381, C368, the contacts 442, C336 and the contacts 301 to the control conductor C109 of the trunk 108. This application of ground potential to the control conductor C109 of the trunk 108 marks this trunk as busy in the jack J107 at the manual position 104. Also, the control relay R440 completes, at the contacts 446, a circuit for energizing the winding of the control relay R460, this circuit extending from ground by way of the contacts 446 and 452 and the winding of R460 to battery. Further, the control relay R440 completes, at the contacts 75

444, an obvious path for applying direct ground potential to the ground conductor C357 and completes, at the contacts 447, a circuit for energizing the lower winding of the tone relay R530, this circuit extending from the ground conductor C357 by way of the contacts 447, C479 and the lower winding of R530 to the battery conductor C358. When energized over the above-traced circuit, the tone relay R530 operates, to complete, at the contacts 531, an obvious path for short-circuiting in series the upper and lower windings thereof. When the upper and lower windings of the tone relay R530 are thus short-circuited, this relay restores, thereby to interrupt, at the contacts 531, the previously mentioned path for short-circuiting in series the upper and lower windings thereof, whereupon the previously traced circuit for energizing the lower windings thereof is recompleted. Accordingly, the tone relay R530 operates intermittently.

At this point it is noted that the principal relays in the dial testing unit 400 are operated and are held in their operated positions by way of circuits extending between the conductors C357 and C359. In the present instance ground potential appears upon the conductor C357, while battery potential appears upon the conductor C359. However, it is noted that under certain other conditions of operation, ground potential appears upon the conductor C359, while battery potential appears upon the conductor C357. More particularly, each odd time the dial testing unit 400 is seized for use, ground potential appears upon the conductor C357 while battery potential appears upon the conductor C359. On the other hand, each even time the dial testing unit 400 is seized for use battery potential appears upon the conductor C357 while ground potential appears upon the conductor C359. This reversal of potential between the conductors C357 and C359 is effected upon each alternate operation and restoration of the control relay R440 and is provided for the purpose of preventing the contacts included in the various circuits extending between the conductors C357 and C359 from continuously conducting current in the same direction. Accordingly, this battery reversal arrangement between the conductors C357 and C359 prevents undue pitting and corrosion of the contacts included in the circuits extending between the conductors C357 and C359. The manner in which alternate operation and subsequent restoration of the control relay R440 effect the reversal of potential between the conductors C357 and C359 is explained below.

Upon the first operation of the control relay R440 the previously traced circuit for energizing the winding of the control relay R460 is completed, thereby to cause the relay R460 to operate. Upon operating, the control relay R460 prepares, at the contacts 461, a holding circuit, traced hereinafter, for energizing the winding of the battery reversing relay R450. Also, upon operating, the control relay R460 prepares, at the contacts 462, an operating circuit, traced hereinafter, for energizing the winding of the battery reversing relay R450.

When the dial testing unit 400 is released the control relay R440 restores, to complete, at the contacts 445, the previously mentioned operating circuit for energizing the winding of the battery reversing relay R450, this circuit extending from ground by way of the contacts, 445, 462 and 458, and the winding of R450 to battery. When the winding of the battery reversing relay R450 is

thus energized it operates, to complete, at the contacts 451, the previously mentioned holding circuit for energizing the winding thereof, this circuit extending from ground by way of the contacts 461, 448 and 451, and the winding of R450 to battery. Also, upon operating, the battery reversing relay R450 completes, at the contacts 453, a holding circuit for energizing the winding of the control relay R460, this circuit extending from ground by way of the contacts 445, 462, 453 and the winding of R460 to battery. Accordingly, at this time when the dial testing unit 400 is released, the battery reversing relay R450 and the control relay R460 remain in their operated positions.

When the dial testing unit 400 is again seized for use the control relay R440 reoperates in order to interrupt, at the contacts 445, the previously traced holding circuit for energizing the winding of the control relay R460, whereupon the relay R460 restores shortly thereafter, this relay being of the slow-to-release type. Upon reoperation the control relay R440 completes, at the contacts 446, an alternative holding circuit for energizing the winding of the battery reversing relay R450, this circuit extending from ground by way of the contacts 446 and 451 and the winding of R450 to battery. Accordingly, at this time the battery reversing relay R450 occupies its operated position while the control relay R460 occupies its restored position. Subsequently, when the dial testing unit 400 is again released, the control relay R440 again restores, to interrupt, at the contacts 446, the previously traced alternative holding circuit for energizing the winding of the battery reversing relay R450, thereby to cause this relay to restore. Accordingly, at this time both the battery reversing relay R450 and the control relay R460 occupy their restored positions.

In view of the above description of operations of the control relays R440 and R460 and the battery reversing relay R450, it will be readily understood that each odd time the dial testing unit 400 is seized the battery reversing relay R450 occupies its restored position; and each even time the dial testing unit 400 is seized the battery reversing relay R450 occupies its operated position.

When the battery reversing relay R450 occupies its restored position, ground potential is applied by way of the previously traced path to the conductor C357 and battery potential is applied by way of the previously traced path to the conductor C359. On the other hand, when the battery reversing relay R450 occupies its operated position battery potential is applied to the conductor C357 and ground potential is applied to the conductor C359, the path for applying battery potential to the conductor C359 extending from the ungrounded terminal of the grounded battery 429 by way of the contacts 456 to the conductor C357 and the path for applying ground potential to the conductor C359 extending from ground by way of the contacts 444 and 454 to the conductor C359.

Continuing now with the operation of the dial testing unit 400, ground potential appears upon the conductor C357 and battery potential appears upon the conductor C359 as previously explained and the tone relay R530 is operating intermittently. Each time the tone relay R530 operates a circuit is completed for charging the condensers 533 and 325 in series, this circuit extending from the ground conductor C357 by way of the

contacts 447, C479, the contacts 531, the condenser 533, C382, the contacts 473, C346, the contacts 364, the condenser 325, the contacts 332, C337 and the contacts 308 to the line conductor C127 of the trunk 125, and from battery by way of the lower winding of the impulse relay R340, C338 and the contacts 306 to the line conductor C126 of the trunk 125, the line conductors C126 and C127 of the trunk 125 being connected together by way of the previously traced circuit including the receiver of the telephone instrument at the subscriber substation T. Each time the tone relay R530 restores, a path is completed for short-circuiting in series the condensers 533 and 325, this path extending from battery potential appearing upon the conductor C359 by way of the resistor 532, the condenser 533, a portion of the previously traced path, the condenser 325 and another portion of the previously traced path including the receiver of the telephone instrument at the subscriber substation T to battery potential at the lower winding of the impulse relay R340. Accordingly, each time the tone relay R530 operates and restores, the condensers 533 and 325 are charged and discharged, thereby to cause a tone to be reproduced in the receiver of the telephone instrument at the subscriber substation T.

When the testman at the subscriber substation T receives the dial tone he proceeds to dial the digit 0 at the dialing apparatus at the subscriber substation T. The dialing apparatus at the subscriber substation T operates in the usual manner, thereby intermittently to interrupt and to complete the previously traced circuit for energizing in series the lower and upper windings of the impulse relay R340; whereupon the impulse relay R340 intermittently restores and operates. Each time the impulse relay R340 restores, it interrupts, at the contacts 342, the previously traced circuit for energizing the winding of the hold relay R410 and each time the impulse relay R340 operates, it re completes, at the contacts 342, the previously traced circuit for energizing the winding of the hold relay R410. However, the hold relay R410 does not restore during impulsing, this relay being of the slow-to-release type. Also, each time the impulse relay R340 restores, it completes, at the contacts 343, a circuit for energizing the winding of the rotary magnet M505 of the minor switch S500, this circuit extending, when completed, from the ground conductor C357 by way of the contacts 343, C355, the contacts 414, C349 and the winding of the rotary magnet M505 to the battery conductor C359. Each time the rotary magnet M505 of the minor switch S500 is energized, the rotary magnet M505 operates to drive the wipers noted of the minor switch S500 one step in the clockwise direction away from their normal positions.

Upon the first restoration of the impulse relay R340 a circuit is completed for energizing the winding of the control relay R350, this circuit extending from the ground conductor C357 by way of the contacts 343, C355, the contacts 414, C349, the contacts 412 and 373, C381, the wiper 511 and engaged normal contact in the associated contact bank 512 of the rotary switch S510, C389, the contacts 375 and the winding of R350 to the battery conductor C359. When energized over the above-traced circuit, the control relay R350 operates, to complete, at the contacts 354, an obvious circuit for energizing the winding of the control relay R360, thereby to cause the relay

R360 to operate. Upon operating, the control relay R360 interrupts, at the contacts 364, the previously traced circuit for returning dial tone current over the subscriber line 120 and completes, at the contacts 361, an obvious path in multiple with the contacts 411 for applying ground potential to the control conductors C128 and C133 of the respective trunks 125 and 130. Also, upon operating, the control relay R360 interrupts, at the contacts 362, a circuit, traced hereinafter, for energizing the winding of the switching relay R310, thereby to prevent operation of the relay R310 at this time.

When the wipers noted of the minor switch S500 are rotated one step in the clockwise direction away from their normal positions the set of switch springs S507 is actuated into engagement, thereby to complete an obvious circuit for energizing the winding of the control relay R470 in order to cause the relay R470 to operate. Also, when the wiper 503 of the minor switch S500 is actuated away from its normal position one step in the clockwise direction into engagement with the first contact in the associated contact bank 504, a circuit is completed for energizing the winding of the control relay R370, this circuit extending from the ground conductor C357 by way of the contacts 343, C355, the contacts 414, C349, the contacts 363, C346, the wiper 503 and engaged first contact in the associated contact bank 504 of the minor switch S500, C382 and the winding of R370 to the battery conductor C359. When energized over the above-traced circuit, the control relay R370 operates to complete, at the contacts 374, an obvious holding circuit for energizing the winding of the control relay R350 and interrupts, at the contacts 372, a further point in a circuit, traced hereinafter, between the dial testing unit 400 and the apparatus at the testing position 200.

When the previously traced original circuit for energizing the winding of the control relay R360 is completed, at the contacts 343, incident to the restoration of the impulse relay R340, a multiple circuit is also completed for energizing the winding of the timing relay R570. This multiple circuit extends from the ground conductor C357 by way of the contacts 343, C355, the contacts 414, C349, the contacts 412 and 373, C361, the wiper 511 and engaged normal contact in the associated contact bank 512 of the rotary switch S510, C389, the contacts 523, C585, the contacts 561 and the winding of R570 to the battery conductor C359. When energized over the above-traced circuit the timing relay R570 operates.

Upon operating, the timing relay R570 completes, at the contacts 571, an obvious circuit for energizing the winding of the timing relay R580, thereby to cause the relay R580 to operate. Upon operating, the timing relay R580 completes, at the contacts 581, an obvious circuit for energizing the winding of the timing relay R560, thereby to cause the relay R560 to operate. Upon operating, the timing relay R560 interrupts, at the contacts 561, the previously traced circuit for energizing the winding of the timing relay R570, thereby to cause the relay R570 to restore. Upon restoring, the timing relay R570 interrupts, at the contacts 571, the previously mentioned circuit for energizing the winding of the timing relay R580, thereby to cause the timing relay R580 to restore and interrupt, at the contacts 581, the previously mentioned circuit for energizing the winding of the timing relay R560. The timing relay R560 then restores, to recomplete, at the

contacts 561, the previously traced circuit for energizing the winding of the timing relay R570, thereby to cause the relay R570 to reoperate. The timing relays R570, R580 and R560 continue to interact in the above-described manner. Each time the timing relay R570 operates it completes, at the contacts 573, an obvious circuit for energizing the winding of the rotary magnet M519 of the rotary switch S510; and each time the timing relay R570 restores, it interrupts, at the contacts 573, the previously mentioned circuit for energizing the winding of the rotary magnet M519. Accordingly, the rotary magnet M519 of the rotary switch S510 operates intermittently. Each time the rotary magnet M519 operates, it conditions the wipers noted of the rotary switch S510 to be driven one step in the clockwise direction and each time the rotary magnet M519 restores, the wipers noted of the rotary switch S510 are driven one step in the clockwise direction away from their positions.

Accordingly, at this time the wipers noted of the minor switch S500 are being driven step by step in the clockwise direction due to the intermittent operation of the impulse relay R340; while the wipers noted of the rotary switch S510 are being driven step by step in the clockwise direction due to the interaction of the timing relays R560, R570 and R580.

When the wiper 511 of the rotary switch S510 is rotated one step in the clockwise direction and into engagement with the first contact in the associated contact bank 512, an alternative path is completed for applying ground potential to the conductor C585, this path extending from the ground conductor C357 by way of the contacts 352, C380, the wiper 511 and engaged first contact in the associated contact bank 512 of the rotary switch S510, C389 and the contacts 523 to the conductor C585.

From the foregoing description of the operations of the minor switch S500 and the rotary switch S510, it will be understood that the speed of operation of the wipers noted of the minor switch S500 corresponds to the speed of operation of the impulse relay R340, which speed corresponds to the dialing speed of the dialing apparatus at the subscriber substation T; while the speed of operation of the wipers noted of the rotary switch S510 corresponds to a standard speed as determined by the operations of the timing relays R560, R570 and R580. Accordingly, the wipers noted of the minor switch S500 and the wipers noted of the rotary switch S510 will engage the tenth contacts in the associated contact banks at substantially the same time in the event these switches are operated at the same speed. On the other hand, the wipers noted of the minor switch S500 will engage the tenth contacts in the associated contact banks before or after the wipers noted of the rotary switch S510 engage the tenth contacts in the associated contact banks in the event the minor switch S500 is operated respectively faster or slower than the rotary switch S510 corresponding to faster or slower than standard impulse speeds. The standard speed of the rotary switch S510, as determined by the timing relays R560, R570 and R580, is approximately ten or eleven steps per second corresponding to approximately ten impulses per second.

In the event the speed of the dial apparatus at the subscriber substation T is approximately ten impulses per second, the wiper 503 of the minor switch S500 will engage the tenth contact in the associated contact bank 504 at approxi-

mately the same time the wiper 517 of the rotary switch S510 engages the tenth contact in the associated contact bank 518, whereupon a circuit is completed for energizing the winding of the control relay R540. The circuit for energizing the winding of the control relay R540 extends from the ground conductor C357 by way of the contacts 343, C355, the contacts 414, C349, the contacts 363, C346, the wiper 503 and engaged tenth contact in the associated contact bank 504 of the minor switch S500, C595, the wiper 517 and engaged tenth contact in the associated contact bank 518 of the rotary switch S510, C593, the contacts 541 and the winding of R540 to the battery conductor C359. When energized over the above-traced circuit the control relay R540 operates to complete, at the contacts 542, a holding circuit for energizing the winding thereof, this circuit extending from the ground conductor C357 by way of the contacts 447, C479, the contacts 471, C481, the contacts 542 and the winding of R540 to the battery conductor C359.

In the event that the speed of the dialing apparatus at the subscriber substation T is somewhat slower than ten impulses per second, the wiper 503 of the minor switch S500 will engage the tenth contact of the associated contact bank 504 of the minor switch S500 at approximately the same time the wiper 517 of the rotary switch S510 engages the eleventh contact in the associated contact bank 518, whereupon a circuit is completed for energizing the winding of the control relay R550. The circuit for energizing the winding of the control relay R550 extends from the ground conductor C357 by way of the previously traced path to the wiper 503 and engaged tenth contact in the associated contact bank 504 of the minor switch S500 and therefrom by way of C595, the wiper 517 and engaged eleventh contact in the associated contact bank 518 of the rotary switch S510, C594, the contacts 551 and the winding of R550 to the battery conductor C359. When energized over the above-traced circuit, the control relay R550 operates, to complete, at the contacts 553, a holding circuit for energizing the winding thereof, this circuit extending from the ground conductor C357 by way of the contacts 447, C479, the contacts 471, C481, the contacts 552 and the winding of R550 to the battery conductor C359. Also, upon operating, the control relay R550 completes, at the contacts 553, an alternative circuit for energizing the winding of the control relay R540, this circuit extending from the ground conductor C357 by way of the contacts 447, C479, the contacts 471, C481, the contacts 553 and the winding of R540 to the battery conductor C359. When energized over the above-traced circuit the control relay R540 operates, to complete, at the contacts 542, the previously traced holding circuit for energizing the winding thereof.

In the event that the speed of the dialing apparatus at the subscriber substation T is somewhat faster than ten impulses per second, the wiper 503 of the minor switch S500 will disengage the tenth contact in the associated contact bank 504 before the wiper 517 of the rotary switch S510 engages the tenth contact in the associated contact bank 518. Accordingly, in this event, neither of the control relays R540 or R550 is operated.

From the foregoing description of the operations of the control relays R540 and R550, as determined by the relative speed of operations of the minor switch S500 and the rotary switch

S510, it will be understood that in the event the impulsing speed of the dialing apparatus at the subscriber substation T is approximately ten impulses per second only the control relay R540 is operated; in the event the impulsing speed of the dialing apparatus is somewhat slower than ten impulses per second, both of the control relays R540 and R550 are operated; and in the event the impulsing speed of the dialing apparatus is somewhat faster than ten impulses per second, neither of the control relays R540 and R550 is operated.

When the wiper 503 of the minor switch S500 disengages the ninth contact in the associated contact bank, the previously traced circuit for energizing the winding of the control relay R370 is interrupted, thereby to cause the relay R370 to restore shortly thereafter, this relay being of the slow-to-release type. Upon restoring, the control relay R370 interrupts, at the contacts 374, the previously traced holding circuit for energizing the winding of the control relay R350, thereby to cause the relay R350 to restore shortly thereafter, this relay being of the slow-to-release type. Upon restoring, the relay R350 interrupts, at the contacts 354, the previously mentioned circuit for energizing the winding of the control relay R360, thereby to cause the relay R360 to restore shortly thereafter, this relay being of the slow-to-release type. When the control relay R350 restores and prior to the restoration of the control relay R360, a circuit is completed for energizing the winding of the control relay R520, this circuit extending from the ground conductor C357 by way of the contacts 353, C335, the contacts 333 and 365, C344 and the winding of R520 to the battery conductor C359. When energized over the above-traced circuit, the control relay R520 operates to complete, at the contacts 524, an obvious path for applying ground potential by way of the ground conductor C357 to the conductor C585, thereby to cause the timing relays R560, R570 and R580 to reoperate as previously explained. The timing relays R560, R570 and R580 then reoperate as previously explained, thereby to cause the rotary magnet M519 of the rotary switch S510 to be energized intermittently, whereupon the wipers noted of the rotary switch S510 are rotated step by step in the clockwise direction.

When the wiper 513 of the rotary switch S510 is rotated to engage the first contact in the associated contact bank 514, a holding circuit is completed for energizing the winding of the control relay R520, this circuit extending from the ground conductor C357 by way of the contacts 529, the wiper 513 and engaged first contact in the associated contact bank 514 of the rotary switch S510, C583, the contacts 521, C344 and the winding of R520 to the battery conductor C359. When the wiper 517 of the rotary switch S510 engages and subsequently disengages the second contact in the associated contact bank 518, a splash of tone current is transmitted over the subscriber line 120 to the subscriber substation T. More particularly, when the wiper 517 engages the second contact in the associated contact bank 518, a path is completed from the battery conductor C359 by way of the resistor 532, the condenser 533, C590, the wiper 517 and engaged second contact in the associated contact bank 518 of the rotary switch S510, C595, the wiper 503 and engaged tenth contact in the associated contact bank 504 of the minor switch S500, C346, the contacts 354, the condenser 325, the contacts 332, C337 and the contacts 308 to the line conductor C127 of the trunk 125, battery potential being

connected by way of the lower winding of the impulse relay R340, C338 and the contacts 306 to the line conductor C126 of the trunk 125; and the line conductors C126 and C127 of the trunk 125 being connected together by way of the loop circuit including the receiver of the telephone instrument at the subscriber substation T. Furthermore, a path substantially identical to that previously traced for transmitting an additional splash of tone current over the subscriber line 120 is completed when the wiper 517 engages the fourth contact in the associated contact bank 518 of the rotary switch S510 in the event the control relay R540 occupies its operated position, this path extending from the battery conductor C359 by way of the resistor 532, the condenser 533, the contacts 543 and 544, C591, the wiper 517 and engaged fourth contact in the associated contact bank 518 of the rotary switch S510 and C595 by way of the previously traced path including the receiver of the telephone instrument at the subscriber substation T to battery at the lower winding of the impulse relay R340. Finally, a path substantially identical to that previously traced for transmitting a further splash of tone current over the subscriber line 120 is completed when the wiper 517 engages the sixth contact in the associated contact bank 518 of the rotary switch S510 in the event both of the control relays R540 and R550 occupy their operated positions, this path extending from the battery conductor C359 by way of the resistor 532, the condenser 533, the contacts 543 and 544, C592, the wiper 517 and engaged sixth contact in the associated contact bank 518 of the rotary switch S510 and C595 by way of the previously traced path including the receiver of the telephone instrument at the subscriber substation T to battery at the lower winding of the impulse relay R340.

Accordingly, the operation of the rotary switch S510 at this time is effective to cause one splash, two splashes or three splashes of tone current to be transmitted over the subscriber line 120 to the subscriber substation T in the event the speed of the dialing apparatus thereat is respectively somewhat faster than ten impulses per second, approximately ten impulses per second, or somewhat slower than ten impulses per second. The number of tone splashes which are received at the receiver of the telephone instrument at the subscriber substation T is indicative of the speed of the dialing apparatus thereat.

When the wipers noted of the rotary switch S510 are rotated back to their normal positions, the wiper 513 disengages the last contact in the associated contact bank 514 included in the previously traced holding circuit for energizing the winding of the control relay R520, thereby to cause the relay R520 to restore. Upon restoring, the control relay R520 interrupts, at the contacts 524, the previously traced path for applying ground potential to the conductor C585, thereby to arrest further operation of the timing relays R560, R570 and R580, and consequently the rotary switch S510.

Just prior to the operation of the wipers noted of the rotary switch S510 back to their normal positions and when the wiper 515 engages the tenth contact in the associated contact bank 516, a circuit is completed for energizing the winding of the control relay R420, this circuit extending from the ground conductor C357 by way of the contacts 353, C335, the contacts 333 and 306, C345, the wiper 515 and engaged tenth contact in the associated contact bank 516 of the rotary switch

S510, C475, the contacts 432 and 424 and the winding of R420 to the battery conductor C359. When energized over the above-traced circuit, the control relay R420 operates, to complete, at the contacts 422, a holding circuit for energizing the winding thereof, this circuit extending from the ground conductor C357 by way of the contacts 447, C479, C480, the contacts 422 and the winding of R420 to the battery conductor C359. Also, upon operating, the control relay R420 completes, at the contacts 423, a circuit for energizing the winding of the release magnet M500 of the minor switch S500, this circuit extending from the ground conductor C357 by way of the contacts 353, C335, the contacts 333 and 306, C345, the wiper 515 and engaged tenth contact in the associated contact bank 516 of the rotary switch S510, C475, the contacts 432 and 423, C476, C477 and the winding of the release magnet M500 to the battery conductor C359. When energized over the above-traced circuit, the release magnet M500 operates, thereby to release the wipers noted of the minor switch S500 and to cause these wipers to be returned to their normal positions. When the wipers noted of the minor switch S500 are returned to their normal positions, the set of switch springs S507 is actuated into disengagement, thereby to interrupt the previously mentioned circuit for energizing the winding of the control relay R470 in order to cause the relay R470 to restore. Upon restoring, the control relay R470 interrupts, at the contacts 471, the previously traced holding circuits for energizing one or both of the control relays R540 and R550, thereby to cause the operated ones of these relays to restore.

At this time the apparatus in the dial testing unit 400 occupies the same position it did after seizure of the dial testing unit 400 and prior to the time the digit 0 was dialed. Accordingly, the digit 0 may be redialed one or more times at the dialing apparatus at the subscriber substation T in order to cause the dial testing apparatus 400 to operate one or more times and retest the impulse speed of the dialing apparatus at the subscriber substation T and thereafter transmit a tone characteristic of the speed of the dialing apparatus at the subscriber substation T over the subscriber line 120 to the receiver of the telephone instrument at the subscriber substation T. Hence, it will be understood that the dial testing unit 400 may be repeatedly operated in order positively to check the impulse speed of the dialing apparatus at the subscriber substation T.

Before proceeding with the description of the release of the apparatus in the dial testing unit 400, it will be assumed that it is desirable to test the impulse ratio of the dialing apparatus at the subscriber substation T as well as the dialing speed thereof after the dial testing unit 400 has been seized.

Operation of the testing system to test both the impulse ratio and impulse speed of the dialing apparatus at a subscriber substation

In order to control the testing system to effect the test of both the impulse ratio and the impulse speed of the dialing apparatus at a subscriber substation, a connection is first established between the subscriber substation, such, for example, as the subscriber substation T, and an idle one of the dial testing units, such, for example, as the dial testing unit 400, by initiating a call at the subscriber substa-

tion T and then dialing the digit 5 as previously explained. Assuming that the link 150 is again utilized, when the dial testing unit 400 is seized by the selector switch 152 of the link 150, the relays R340, R410, R430, R440 and R460 operate as previously explained.

The digit 2 is then dialed at the subscriber station T, whereupon the relays R350 and R360 are operated and the wipers noted of the minor switch S500 are operated away from their normal positions, thereby to cause the control relays R370 and R470 and the timing relays R560, R570 and R580 to operate as previously explained.

At this time the wipers noted of the minor switch S500 are operated into engagement with the second contacts in the associated contact banks. More particularly, the wiper 501 engages the second contact in the associated contact bank 502 of the minor switch S500, thereby to complete a circuit, traced hereinafter, for energizing the winding of the control relay R330; while the wiper 503 engages the second contact in the associated contact bank 504 of the minor switch S500, thereby to interrupt the previously traced holding circuit for energizing the winding of the control relay R370. Shortly thereafter, the control relay R370 restores in order to effect the restoration of the control relays R350 and R360 as previously explained. Upon restoring, the control relay R370 completes, at the contacts 371, the previously mentioned circuit for energizing the winding of the control relay R330, this circuit extending from the ground conductor C357 by way of the wiper 501 and engaged second contact in the associated contact bank 502 of the minor switch S500, C474, the contacts 421, C367, the contacts 371 and the winding of R330 to the battery conductor C359.

When energized over the above-traced circuit, the control relay R330 operates, to interrupt, at the contacts 332, the previously traced path for applying tone splashes which are normally produced incident to the reoperation of the rotary switch S510 as determined by the impulse speed test performed by the minor switch S500 and the rotary switch S510, as previously explained. Also upon operating, the control relay R330 interrupts, at the contacts 333, the previously traced circuit for energizing the winding of the control relay R520, thereby to prevent operation of the relay R520 at this time.

Upon restoring, the relay R350 interrupts, at the contacts 352, the previously traced path for applying ground potential to the conductor C585, thereby to arrest operation of the timing relays R560, R570 and R580. Also upon restoring, the control relay R350 completes, at the contacts 353, an alternative circuit for energizing the winding of the rotary magnet M519 of the rotary switch S510, this circuit extending from the ground conductor C357 by way of the contacts 353, C335, the set of switch springs S519, C583, the wiper 513 and engaged contact in the associated contact bank 514 of the rotary switch S510, the contacts 528 and 520, C586, the contacts 572, C587 and the winding of the rotary magnet M519 to the battery conductor C359. When energized over the above-traced circuit the rotary magnet M519 operates, to interrupt, at the contacts 520, the previously traced circuit for energizing the winding thereof, whereupon the rotary magnet M519 restores, to recomplete, at the contacts 520, the previously traced circuit for energizing the winding thereof. Accordingly, the rotary magnet

M519 operates intermittently, thereby to drive the wipers noted of the rotary switch S510 back into their normal positions, whereupon the wiper 513 disengages the last contact in the associated contact bank 514 connected to the conductor C583, thereby to interrupt the previously traced circuit for energizing the winding of the rotary magnet M519. Accordingly, at this time the wipers noted of the minor switch S500 engage the second contacts in the associated contact banks while the wipers noted of the rotary switch S510 engage the normal contacts in the associated contact banks.

Upon restoring, the control relay R360 completes, at the contacts 362, a test circuit for energizing the winding of the switching relay R310 in the event the testing position 200 is idle at this time. Assuming that the testing position is idle at this time, the last-mentioned circuit extends from ground by way of the contacts 411, C378, the contacts 331 and 362, the winding of the relay R310, the contacts 319, C383, the chain circuit 323 extending through the other dial testing unit corresponding to the dial testing unit 400, C384, the contacts 319' and the resistor 324 to battery. Shortly after the switching relay R310 is energized over the above-traced circuit it operates, this relay being of the slow to operate type, to complete, at the contacts 317 and 318, a holding circuit for energizing the winding thereof, this circuit extending from ground by way of the contacts 411, C378, the contacts 317, the winding of R310, the contacts 318 and the resistor 324 to battery. Also upon operating, the switching relay R310 interrupts, at the contacts 319 and 319', points in the previously mentioned circuit including the chain circuit 323, thereby to prevent operation of the switching relay in any of the other dial testing units corresponding to the dial testing unit 400 at this time in view of the fact that the testing position 200 is rendered busy by the operation of the switching relay R310.

Upon operating, the switching relay R310 completes, at the contacts 311, a circuit for energizing the winding of the audible signal 207, this circuit extending from ground by way of the contacts 334 and 311, the conductor C244 of the control trunk 240, the contacts 208 and the winding of the signal magnet 207 to battery. When energized over the above-traced circuit, the signal magnet 207 operates, thereby to interrupt, at the contacts 208, the previously traced circuit for energizing the winding thereof, whereupon the signal magnet 207 restores, to complete, at the contacts 208, the previously traced circuit for energizing the winding thereof. Accordingly, the signal magnet 207 operates intermittently in order to produce an audible signal which indicates to the operator at the test position 200 that the control trunk 240 has been seized by one of the dial testing units and that an impulse ratio test is desired.

The operator at the testing position 200 then operates the control key K230 to its check position, thereby to complete a check circuit for the meter 202, this circuit extending from ground by way of the contacts 233 of the key K230, C234, the resistor 204, the adjustable resistor 203 and the meter 202 to battery. The operator at the testing position 200 then adjusts the adjustable resistor 203 in order to cause the meter 202 to indicate one hundred per cent make contact. Thereafter, the key K230 is operated to its test position. When the key K230 is operated to its test position, it prepares, at the contacts 232, a test circuit, traced

hereinafter, for energizing the meter 202 in accordance with the per cent make contact of the dialing apparatus at the subscriber substation T and completes, at the contacts 231, a priming circuit for energizing the meter 202, the last-mentioned circuit extending from ground by way of the adjustable resistor 205, the contacts 231 of the key K230, the conductor C240 of the control trunk 240, the contacts 312 and 341, the conductor C247 of the control trunk 240, the contacts 232 of the key K230, C234, the resistor 204, the adjustable resistor 203 and the meter 202 to battery. The operator at the test position 200 then observes the meter 202 to determine whether or not the indication thereof corresponds approximately to the desired percentage make contact. This desired percentage make contact is approximately forty per cent, and in the event the indication of the meter 202 departs somewhat from the desired per cent make contact, the resistor 205 is adjusted in order to cause the meter 202 to indicate the desired per cent make contact.

Also, upon operating, the switching relay R310 prepares, at the contacts 314 and 315, a connection between the trunk 125 extending to the subscriber line 120 and the conductors C241 and C242 of the control trunk 240 extending to the control key K220 associated with the telephone apparatus 201 at the testing position 200. The operator at the testing position 200 then operates the key K220 to its start position, thereby to complete, at the contacts 224 thereof, a circuit for energizing the winding of the control relay R320, this circuit extending from ground by way of the contacts 224 of the key K220, the conductor C243 of the control trunk 240, the contacts 316 and the winding of R320 to battery. When energized over the above-traced circuit, the relay R320 operates, to complete, at the contacts 321, a circuit for energizing the winding of the release magnet M506 of the minor switch S510, this circuit extending from the ground conductor C357 by way of the contacts 321, C356, the contacts 472, C476, C477 and the winding of the release magnet M506 to the battery conductor C359. When energized over the above-traced circuit, the release magnet M506 operates to release the wipers noted of the minor switch S500 and to cause these wipers to be returned to their normal positions; whereupon the set of switch springs S507 is actuated into disengagement, thereby to interrupt the previously mentioned circuit for energizing the winding of the control relay R470. The control relay R470 then restores, to interrupt, at the contacts 472, the previously traced circuit for energizing the winding of the release magnet M506. When the wiper 501 of the minor switch S500 is returned to its normal position, the previously traced circuit for energizing the winding of the control relay R330 is interrupted, thereby to cause the relay R330 to restore. Upon restoring, the control relay R330 interrupts, at the contacts 334, the previously traced circuit for energizing the winding of the audible signal magnet 207 in order to arrest further operation thereof. Also the control relay R330 completes, at the contacts 332, the previously traced circuit for returning dial tone current over the trunk 125 and the subscriber line 120 to the receiver of the telephone instrument at the subscriber substation T.

When dial tone is received at the subscriber substation T, the testman thereat dials at the dialing apparatus at the subscriber substation T the digit 0, thereby to cause the impulse relay

R340 to operate intermittently as previously explained. The first time the impulse relay R340 restores, it completes, at the contacts 343, the previously traced circuits for energizing the winding of the control relay R350 and the winding of the rotary magnet M505 of the minor switch S500, thereby to initiate operation of the minor switch S500 and to cause the control relays R350, R360 and R370 to operate as previously explained.

Each time the impulse relay R340 operates, it completes, at the contacts 341, the previously mentioned test circuit including the meter 202, this circuit extending from ground by way of the contacts 313, 351 and 341, the conductor C247 of the control trunk 240, the contacts 232 of the key K230, C234, the resistor 204, the adjustable resistor 203 and the meter 202 to battery. The intermittent operation of the impulse relay R340 is effective to complete intermittently the test circuit including the meter 202 previously traced, thereby to cause the meter 202 to produce an indication corresponding to the per cent operation of the impulse relay R340, and accordingly the per cent make contact of the dialing apparatus at the subscriber substation T. The operator at the testing position 200 observes the indication of the meter 202 in order to determine whether the indication of the meter departs from the desired per cent make contact indication thereof as determined by the priming circuit previously traced.

The operation of the remainder of the apparatus embodied in the dial testing unit 400 and including the minor switch S500, the rotary switch S510, the timing relays R560, R570 and R580, and the control relays R420, R520, R540 and R550 is the same as that previously described. Accordingly, at this time the dial testing unit 400 effects the previously described impulse speed test upon the dialing apparatus at the subscriber substation T and subsequently causes tone splashes to be returned over the subscriber line 120 indicative of the speed of the dialing apparatus at the subscriber substation T in the manner previously described. As previously noted, the testman at the subscriber substation T may dial the digit 0 several times in order to cause the dial testing unit 400 to test several times the impulsing speed of the dialing apparatus thereat and to give the operator at the testing position 200 an opportunity to check several times the impulse ratio of the dialing apparatus thereat.

After the testman at the subscriber substation T has dialed the digit 0 one or more times and the impulse ratio tests and impulse speed tests have been performed several times, as previously described, the operator at the testing position 200 operates the key K220 to its talk position, thereby to complete, at the contacts 221 and 222, an operative connection between the telephone apparatus 201 at the testing position 200 and the telephone instrument at the subscriber substation T.

The above-mentioned connection extends from the line conductor C126 of the trunk 125 by way of the contacts 306, C338, the contacts 315, the condenser 322, the conductor C241 of the control trunk 240, the contacts 221 of the key K220, the line conductor C226 of the line 225, the telephone apparatus 201, the line conductor C227 of the line 225, the contact 222 of the key K220 and the conductor C242 of the control trunk 240, the contacts 314 and 372, C337, and the contacts 308

to the line conductor C127 of the trunk 125, the line conductors C126 and C127 of the trunk 125 being connected together by way of the previously traced loop circuit including the telephone instrument at the subscriber substation T.

Accordingly, at this time the operator at the operator's position 200 may converse with the testman at the subscriber substation T and advise him concerning the impulse ratio of the dialing apparatus at the subscriber substation T.

Before proceeding with the description of the release of the apparatus in the dial testing unit 400 and the apparatus at the testing position 200, it will be assumed that it is desirable to perform line tests upon the subscriber line 120 in addition to the impulse ratio and impulse speed tests performed upon the dialing apparatus at the subscriber substation T, as previously explained.

Operation of the testing system to test a subscriber line extending to a subscriber substation as well as the impulse ratio and the impulse speed of the dialing apparatus at the subscriber substation

In order to control the testing system to effect a line test upon a subscriber line extending to a subscriber substation as well as the impulse ratio and the impulse speed of the dialing apparatus at the subscriber substation, a connection is first established between the subscriber substation, such, for example, as the subscriber substation T, and an idle one of the dial testing units, such, for example, as the dial testing unit 400, as previously explained, by initiating a call at the subscriber substation T and then dialing the digit 5 as previously explained. Assuming that the link 150 is utilized, when the dial testing unit 400 is seized by the selector switch 152 of the link 150 the apparatus therein operates in the manner previously explained. The testman at the subscriber substation T then proceeds to dial the digit 2 and then to dial the digit 0 one or more times in order to cause the dial testing unit 400 and the apparatus at the testing position 200 to effect, respectively, the impulse speed test and the impulse ratio test in the manner previously explained.

After the result of the impulse speed test has been transmitted by tone splashes over the subscriber line 120 and the result of the impulse ratio test has been communicated by the operator at the testing position 200 over the subscriber line 120, the testman at the subscriber substation T initiates operation of the line test of the subscriber line 120 by replacing momentarily the receiver of the telephone instrument upon its associated switchhook, thereby to cause the impulse relay R340 to restore. Upon restoring, the impulse relay R340 interrupts, at the contacts 342, the previously traced circuit for energizing the winding of the hold relay R410. However, the hold relay R410, being of the slow-to-release type, does not immediately restore. Accordingly, the hold relay R410 and the control relays R430 and R440 remain in their operated positions for a short interval of time. At the conclusion of the operation of the rotary switch S510 to return the tone splash indicative of the speed of the dialing apparatus at the subscriber substation T over the subscriber line 120, the control relay R420 operates as previously explained. Also, upon operating, the control relay R420 completes, at the contacts 426, a loop circuit for energizing in series the upper and lower windings of the impulse relay R650 in the line testing unit 700

individually associated with the dial testing unit 400. This loop circuit extends from ground by way of the lower winding of the impulse relay R650, C681, the contacts 666, the line conductor C132 of the trunk 130, the line conductor C387 of the transfer trunk 385, C347, the contacts 426, C348, the line conductor C386 of the transfer trunk 385, the line conductor C131 of the trunk 130, the contacts 663 and the upper winding of R650 to battery.

When energized over the above-traced circuit, the impulse relay R650 operates to complete, at the contacts 654, a circuit for energizing the winding of the hold relay R600, this circuit extending from ground by way of the resistor 747, the contacts 726, the ground conductor C674, the contacts 654, the winding of R600, the battery conductor C675 and the contacts 728 to the ungrounded terminal of the grounded battery 729. Also, upon operating, the impulse relay R650 completes, at the contacts 652, a circuit for energizing the winding of the control relay R670, this circuit extending from the ground conductor C674 by way of the contacts 652, C690, the contacts 764, C689 and the winding of R670 to the battery conductor C675, thereby to cause the relay R670 to operate. Upon operating, the hold relay R600 completes, at the contacts 602, a circuit for energizing the upper winding of the tone relay R880, this circuit extending from the ground conductor C674 by way of the contacts 602, C685 and the upper winding of R880 to the battery conductor C675.

When the upper winding of the relay R880 is energized, this relay operates to complete, at the contacts 881, an obvious path for short-circuiting in series the upper and lower windings of the relay R880, thereby to cause the relay R880 to restore. Upon restoring, the relay R880 interrupts, at the contacts 881, the previously mentioned path for short-circuiting in series the upper and lower windings thereof, thereby to complete the previously traced circuit for energizing the upper winding thereof. Accordingly, the tone relay R880 operates intermittently. Each time the tone relay R880 restores, a circuit is completed for charging the condenser 846, this circuit extending from ground by way of the lower winding of the impulse relay R650, C681, C619, the contacts 601, C683, the contacts 667, C684, the condenser 846 and the lower winding of R880 to the battery conductor C675. Also, each time the tone relay R880 operates, it completes, at the contacts 881, a path for discharging the condenser 846, this path extending from ground at the lower winding of the impulse relay R650 by way of the previously traced path to the condenser 846 and therefrom by way of the contacts 881, C685 and the contacts 602 to the ground conductor C674. Accordingly, the condenser 846 is alternately charged and discharged, thereby to cause corresponding surges of current to be transmitted over the line conductor C132 of the trunk 130 connected by way of the contacts 666 to the lower winding of the impulse relay R650. These surges of current transmitted over the line conductor C132 of the trunk 130 will be returned over the subscriber line 120 subsequently in a manner more fully described hereinafter.

Upon operating, the control relay R670 completes, at the contacts 672, an obvious circuit for energizing the winding of the control relay R710, thereby to cause operation of the relay R710. Also, upon operating, the control relay R670 completes, at the contacts 673, an obvious circuit for

energizing the winding of the control relay R735, thereby to cause operation of the relay R735.

Shortly following the restoration of the impulse relay R340 in the dial testing unit 400, the hold relay R410 restores in order to interrupt, at the contacts 411, the previously traced holding circuit for energizing the winding of the switching relay R310, thereby to cause the latter relay to restore. Also, the hold relay R410 interrupts, at the contacts 413, the previously traced circuit for energizing the winding of the control relay R430. The control relay R430 then restores to interrupt, at the contacts 436, the previously traced circuit for energizing the winding of the control relay R440, thereby to cause the relay R440 to restore. Upon restoring, the control relay R440 completes, at the contacts 443, a circuit for energizing the winding of the control relay R300, this circuit extending from ground by way of the contacts 443, 425, 386 and 305, and the winding of R300 to battery. When energized over the above-traced circuit, the control relay R300 operates, to complete, at the contacts 304, a holding circuit for energizing the winding thereof, this circuit extending from ground in the line testing unit 700 by way of the contacts 715, the line conductor C133 of the trunk 130, the line conductor C388 of the transfer trunk 385, the line conductor C128 of the trunk 125, the contacts 388, C339, the contacts 304 and the winding of R300 to battery. Upon restoring, the control relay R440 interrupts, at the contacts 447, the previously traced circuit for energizing the winding of the control relay R420, thereby to cause the relay R420 to restore.

Also, upon operating, the control relay R300 completes, at the contacts 302, an obvious path for applying ground potential to the control conductor C109 of the trunk 108 extending to the manual position 104, thereby to mark the trunk 108 as busy. Further, the control relay R300 completes, at the contacts 307 and 309, a connection between the line conductors C126 and C127 of the trunk 125 and the line conductors C131 and C132 of the trunk 130, this connection extending from the line conductor C126 of the trunk 125 by way of the contacts 307, the line conductor C386 of the transfer trunk 385 to the line conductor C131 of the trunk 130, and from the line conductor C127 of the trunk 125 by way of the contacts 309, the line conductor C387 of the transfer trunk 385 to the line conductor C132 of the trunk 130, the line conductors C126 and C127 of the trunk 125 being connected by way of the link 150 to the subscriber line 120, as previously explained. Also it is noted that the relay R710 in the line testing unit 700 operates to complete the previously traced path for applying ground potential to the control conductor C128 of the trunk 125 shortly after the hold relay R410 in the dial testing unit 400 restores and prior to the restoration of the control relay R520 in the dial testing unit 400.

Accordingly, the link 150 is not released incident to the transfer of the connection of the trunk 125 from the dial testing unit 400 to the line testing unit 700. Hence, the link 150 is operatively connected to the subscriber line 120 and to the trunk 125 at this time, the trunk 125 being connected by way of the transfer trunk 385 to the trunk 130 as previously noted.

Continuing now with the operation of the line testing unit 700, upon operating, the control relay R735 completes, at the contacts 739, an obvi-

ous path for applying direct ground potential to the ground conductor C674 and completes, at the contacts 737, a circuit for energizing the winding of the control relay R730. This circuit extends from ground by way of the contacts 737 and 724 and the winding of the relay R730 to battery. The control relay R730 then operates.

It is noted that the conductors C674 and C675 have, respectively, ground and battery potentials appearing thereon upon each odd operation of the line testing unit 700 and have, respectively, battery and ground potentials appearing thereon upon each even operation of the line testing unit 700. More particularly, each time the line testing unit 700 is seized the control relay R735 operates. The first time the control relay R735 operates, it completes, at the contacts 737, the previously traced circuit for energizing the winding of the control relay R730, thereby to cause operation thereof. When the line testing unit 700 is subsequently released the control relay R735 restores, to complete, at the contacts 736, a circuit for energizing the winding of the battery reversing relay R720, this circuit extending from ground by way of the contacts 736, 731, 722 and the winding of R720 to battery. When energized over the above-traced circuit, the battery reversing relay R720 operates, to complete, at the contacts 721, a holding circuit for energizing the winding of the control relay R730, this circuit extending from ground by way of the contacts 736, 731, 721 and the winding of R730 to battery. Also, the relay R720 completes, at the contacts 723, a holding circuit for energizing the winding thereof, this circuit extending from ground by way of the contacts 732, 738, 723 and the winding of R720 to battery. When the line testing unit 700 is again seized, the control relay R735 reoperates, thereby to complete, at the contacts 737, an alternative holding circuit for energizing the winding of the battery reversing relay R720, this circuit extending from ground by way of the contacts 737, 723 and the winding of R720 to battery. Also, upon operating, the control relay R730 interrupts, at the contacts 736, the previously traced holding circuit for energizing the winding of the control relay R730, thereby to cause the relay R730 to restore shortly thereafter, this relay being of the slow-to-release type. When the line testing unit 700 is again released, the control relay R735 again restores, thereby to interrupt, at the contacts 737, the previously traced holding circuit for energizing the winding of the battery reversing relay R720, thereby to cause the relay R720 to restore.

From the foregoing description of the operations of the control relays R730 and R735 and the battery reversing relay R720 it will be understood that each odd time the line testing unit 700 is seized the battery reversing relay R720 occupies its restored position and each even time the line testing unit 700 is seized the battery reversing relay R720 occupies its operated position. When the battery reversing relay R720 occupies its restored position, battery potential is applied by way of the previously traced path, including the contacts 728 to the conductor C675, and ground potential is applied by way of the previously traced path including the contacts 726 to the conductor C674. On the other hand, when the battery reversing relay R720 occupies its operated position ground potential is applied by way of an obvious path including the contacts 725 to the conductor C675, and battery potential is applied by way of an obvious path in-

cluding the contacts 727 to the conductor C674. Accordingly, each alternate time the line testing unit 700 is seized, battery and ground potentials are reversed upon the conductors C674 and C675, this arrangement being provided to prevent the contacts of the relays in the line testing unit which are energized across the conductors C674 and C675 from being pitted and corroded.

Continuing now with the operation of the line testing unit 700, upon operating, the control relay R710 completes, at the contacts 712, an obvious path for connecting ground potential by way of the resistor 718 to the line conductor C131 of the trunk 130 and completes, at the contacts 714, an obvious path for applying ground potential by way of the resistor 717 to the line conductor C132 of the trunk 130. Ground potential through the resistors 718 and 717 is applied respectively to the line conductors C131 and C132 of the trunk 130 in order to cause any potentials appearing upon the line conductors of the trunk 130, the trunk 125 and the subscriber line 120 to be drained therefrom.

As previously noted, shortly after the subscriber at the subscriber substation T replaces the receiver of the telephone instrument thereat upon its associated switchhook, the control relay R420 in the dial testing unit 400 restores, thereby to interrupt, at the contacts 426, the previously traced loop circuit for energizing in series the upper and lower windings of the impulse relay R650 in the line testing unit 700 in order to cause the relay R650 to restore. Upon restoring, the impulse relay R650 interrupts, at the contacts 654, the previously mentioned circuit for energizing the winding of the hold relay R600, thereby to cause the relay R600 to restore shortly thereafter, this relay being of the slow-to-release type. Upon restoring, the hold relay R600 interrupts, at the contacts 602, the previously traced circuit for energizing the upper winding of the tone relay R880, thereby to arrest further operation of the relay R880 at this time. The control relay R670 remains in its operated position at this time due to a completed holding circuit for energizing the winding thereof, this circuit extending from the ground conductor C674 by way of the contacts 662' and 671 and the winding of R670 to the battery conductor C675. The operated control relay R670 retains the control relays R710, R735 and R730 in their operated positions.

Also, upon restoring, the impulse relay R650 completes, at the contacts 653, a circuit for energizing the winding of the control relay R850, this circuit extending from the ground conductor C674 by way of the contacts 653, C698, the contacts 716, the common ground conductor C676, the contacts 766, C694, the contacts 842 and the winding of R850 to the battery conductor C675. When the control relay R850 is energized over the above-traced circuit, it operates shortly thereafter, this relay being of the slow-to-operate type.

Upon operating, the control relay R850 completes, at the contacts 853, a circuit for energizing the winding of the control relay R860, this circuit extending from the ground conductor C674 by way of the contacts 653, C698, the contacts 716, the common ground conductor C676, the contacts 853 and the winding of R860 to the battery conductor C675. Shortly after the control relay R860 is energized over the above-traced circuit, it operates, this relay being of the slow-

to-operate type. Also, upon operating, the control relay R850 completes, at the contacts 854, a circuit for energizing the winding of the control relay R860, this circuit extending from the common ground conductor C676 by way of the contacts 818, C768, the contacts 854, C692 and the winding of R860 to the battery conductor C675. When energized over the above-traced circuit, the control relay R860 operates. Also, upon operating, the control relay R860 completes, at the contacts 865, a multiple circuit for energizing the windings of the timing relay R750 and the control relay R870, this circuit extending from the common ground conductor C676 to the contacts 865, from the contacts 865 by way of C887, the contacts 873 and 892 and the winding of R870 to the battery conductor C675, and from the contacts 865 by way of C887, the contacts 873, C759 and the winding of R750 to the battery conductor C675. When the winding of the timing relay R750 is thus energized, this relay operates immediately; however, when the winding of the control relay R870 is thus energized, this relay operates shortly thereafter, this relay being of the slow-to-operate type. Also, upon operating, the control relay R860 completes, at the contacts 865, a circuit for energizing in multiple the upper and lower windings of the test check relay R770, this circuit extending from the common ground conductor C676 by way of the contacts 865, C887, the contacts 874, C769 and the contacts 795 to the contacts 775, from the contacts 775 by way of the lower winding of R770 to the battery conductor C675, and from the contacts 775 by way of the upper winding of R770, the contacts 773 and the resistor 768 to the battery conductor C675.

It is noted that the test check relay R770 is of the differential type and does not operate at this time when both the upper and lower windings thereof are steadily energized. Further, it is noted that the upper and lower windings of the test check relay R770 are energized prior to the operation of the control relay R870. When the control relay R870 operates, it interrupts, at the contacts 874, the previously traced circuit for energizing in multiple the upper and lower windings of the test check relay R770, whereupon an inductive kick is produced in the upper and lower windings of the test check relay R770 which causes a current surge to traverse a path extending from the battery conductor C675 by way of the lower and upper windings of R770, the contacts 773 and the resistor 768 to the battery conductor C675. The current traversing the path above traced is sufficient to cause the test check relay R770 to operate partially in order to interrupt, at the contacts 773, the previously traced surge current path and to complete, at the contacts 772, a circuit for energizing in accumulative series relation the upper and lower windings of the test check relay R770. The last-mentioned circuit extends from the common ground conductor C676 by way of the contacts 797 and 772 and the upper and lower windings of R770 to the battery conductor C675. When the above-traced circuit for energizing in accumulative series relation the upper and lower windings of the test check relay R770 is completed, this relay fully operates to complete, at the contacts 771, a circuit for energizing the winding of the control relay R780, this circuit extending from the common ground conductor C676 by way of the contacts 797 and 771 and the winding of R780 to the battery conductor

C675. When energized over the above-traced circuit, the control relay R780 operates.

Upon operating, the control relay R660 completes, at the contacts 664', an obvious connection between the ground conductor C674 and the common ground conductor C676 and interrupts, at the contacts 662', the previously traced holding circuit for energizing the winding of the control relay R670, thereby to cause the relay R670 to restore. Also, the control relay R660 completes, at the contacts 665', an alternative holding circuit for energizing the winding of the control relay R735, this circuit extending from the ground conductor C674 by way of the contacts 665', C688 and the winding of R735 to the battery conductor C675. Further, the control relay R660 completes, at the contacts 663', an alternative circuit for energizing the upper winding of the tone relay R880, this circuit extending from the ground conductor C674 by way of the contacts 663', C685 and the upper winding of R880 to the battery conductor C675. When the upper winding of the tone relay R880 is thus energized, the relay R880 again operates intermittently as previously explained. Also, the control relay R660 completes, at the contacts 669, an alternative path for applying ground potential to the control conductor C133 of the trunk 130, this path extending from ground by way of the contacts 863, C686, the contacts 603, C618 and the contacts 669 to the control conductor C133 of the trunk 130. Further, the control relay R660 prepares, at the contacts 661, 662 and 665, a test circuit, traced herein-after, for the test relay R840 and interrupts, at the contacts 663 and 666, the connections between the upper and lower windings of the impulse relay R650 and the line conductors C131 and C132 of the trunk 130, thereby to free the line conductors of the trunk 130 extending to the subscriber line 120 of impedance elements.

Upon restoring, the control relay R670 interrupts, at the contacts 672, the previously mentioned circuit for energizing the winding of the control relay R710, thereby to cause the relay R710 to restore. Upon restoring, the control relay R710 interrupts, at the contacts 712 and 714, the previously traced paths for applying ground potential by way of the resistors 718 and 717 to the line conductors C131 and C132 of the trunk 130 and prepares, at the contacts 711 and 713, additional points in the previously mentioned test circuit for the test relay R840.

Upon operating, the control relay R780 completes, at the contacts 782, 783 and 785, a primary circuit for energizing the windings of the test relay R840, this circuit extending from ground by way of the contacts 861, C753, the contacts 782 and 783, C754, the windings of R840, C799, the contacts 785, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627. Also, upon operating, the control relay R780 completes, at the contacts 783, 785 and 786, an artificial leak to ground circuit for energizing the windings of the test relay R840, this circuit extending from ground by way of the contacts 786, C747, the resistor 838, the bridge 844 in multiple with the resistor 837, the bridge 843 in multiple with the resistor 836, the resistor 835, C677, the contacts 661 and 662, C678, the contacts 741 and 783, C754, the windings of R840, C799, the contacts 785, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627. Also, upon operating, the control relay R780 com-

pletes, at the contacts 783 and 784, paths for connecting the line conductors 131 and 132 of the trunk 130 to the windings of the test relay R840. One of these paths extends from the line conductor C131 of the trunk 130 by way of the contacts 711, C679, the contacts 662, C678, the contacts 741, the contacts 783 and C754 to one winding of the test relay R840; and from the line conductor C132 of the trunk 130 by way of the contacts 713 and 665, C682, the contacts 743, the resistor 769, the contacts 784 and 783 and C754 to the one winding of the test relay R840. As previously noted, the line conductors C131 and C132 of the trunk 130 are connected by way of the previously traced path to the line conductors of the subscriber line 120. Accordingly, a multiple path is completed by way of the line conductors C131 or C132 of the trunk 130 for energizing the winding of the test relay R840 in the event either of the line conductors of the subscriber line 120 has ground potential thereon.

Accordingly, at this time, the windings of the test relay R840 are energized by way of the above-traced primary circuit and artificial ground leak circuit. Further, the windings of the test relay R840 are energized by way of the test circuits including the line conductors of the trunk 130 and the subscriber line 120 in the event a ground fault is present on either one of the line conductors of the subscriber line 120. When the test relay R840 is thus energized, it operates to interrupt, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850, thereby to cause the relay R850 to restore and interrupt, at the contacts 853, the previously mentioned circuit for energizing the winding of the control relay R860, thereby to cause the relay R860 to restore. Also, upon operating, the test relay R840 completes, at the contacts 841, a circuit for energizing in multiple the upper and lower windings of the test check relay R790, this circuit extending from the common ground conductor C676 by way of the contacts 766, C694, the contacts 841, C697, the contacts 606, C695, the contacts 776, C769 and the contacts 795 to the contacts 774, from the contacts 774 by way of the lower winding of R790 to the battery conductor C675, and from the contacts 774 by way of the upper winding of R790, the contacts 792 and 787, C748 and the resistor 767 to the battery conductor C675. When the upper and lower windings of the test check relay R790 are thus energized, this relay does not operate as the relay R790 is of the differential type.

Upon restoring, the control relay R860 interrupts, at the contacts 861, the primary circuit for energizing the windings of the test relay R840. The test relay R840 then restores, in the event that there is no ground fault upon either of the line conductors of the subscriber line 120, as the resistance of the artificial ground leak circuit is sufficiently great to prevent the test relay R840 from remaining in its operated position. However, in the event that there is a ground fault upon either of the line conductors of the subscriber line 120, the energizing circuit completed due to the presence of the ground fault upon the line conductor of the subscriber line 120, together with the completed artificial ground leak circuit, affords adequate energization for the windings of the test relay R840 to retain the relay R840 in its operated position.

Assuming, however, that there are no ground faults upon the line conductors of the subscrib-

er line 120 at this time, the test relay R840 restores. Upon restoring, the test relay R840 interrupts, at the contacts 841, the previously traced circuit for energizing in multiple the upper and lower windings of the test check relay R790, whereupon an inductive kick is produced in the upper and lower windings of the relay R790 which causes a current surge to traverse a path extending from the battery conductor C675 by way of the lower and upper windings of R790, the contacts 792 and 787, C748 and the resistor 767 to the battery conductor C675. The current traversing the path above traced is sufficient to cause the test check relay R790 to operate partially in order to interrupt, at the contacts 792, the previously traced surge current path and to complete, at the contacts 793, a circuit for energizing in accumulative series relation the upper and lower windings of the relay R790. The last-mentioned circuit extends from the common ground conductor C676 by way of the contacts 818, C768, the contacts 793 and the upper and lower windings of R790 to the battery conductor C675. When the above-traced circuit for energizing in accumulative series circuit relation the upper and lower windings of the test check relay R790 is completed, this relay fully operates to complete, at the contacts 791, a circuit for energizing the winding of the control relay R800, this circuit extending from the common ground conductor C676 by way of the contacts 818, C768, the contacts 791, C749 and the winding of R800 to battery. When the control relay R800 is energized over the above-traced circuit, it operates.

Also, upon operating, the test check relay R790 interrupts, at the contacts 797, the previously traced holding circuit for energizing in accumulative series relation the upper and lower windings of the test check relay R770 and the previously traced circuit for energizing the winding of the control relay R780, thereby to cause the relays R770 and R780 to restore.

Also, upon restoring, the test relay R840 completes, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850, thereby to cause the relay R850 to operate shortly thereafter and complete, at the contacts 853, the previously mentioned circuit for energizing the winding of the control relay R860, thereby to cause the relay R860 to operate shortly thereafter. Upon operating, the control relay R860 completes, at the contacts 861, a primary circuit for energizing the windings of the test relay R840. This circuit extends from ground by way of the contacts 861, C753, the contacts 802, the windings of R840, C799, the contacts 805, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627. Upon operating, the control relay R800 completes, at the contacts 803, 805 and 806, an artificial leak to ground circuit for energizing the windings of the test relay R840, this circuit extending from ground by way of the contacts 806, C747, the resistor 838, the bridge 844 in multiple with the resistor 837, the bridge 843 in multiple with the resistor 836, the resistor 835, C677, the contacts 661 and 662, C678, the contacts 741, C756, the contacts 803, the windings of R840, C799, the contacts 805, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627. Further, the control relay R800 completes, at the contacts 804, a path for applying ground potential to the line conductor C132 of the trunk 130, this path extending from ground

by way of the contacts 804, C757, the contacts 743, C682 and the contacts 665 and 713 to the line conductor C132 of the trunk 130. This application of ground potential to the line conductor C132 of the trunk 130 completes a test circuit for energizing the windings of the test relay R840 in the event the line conductors of the subscriber line 120 are crossed. In the event the line conductors of the subscriber line 120 are crossed, this test circuit extends from ground potential appearing upon the line conductor C132 of the trunk 130 by way of the transfer trunk 385, the trunk 125 and the link 150 to one of the line conductors of the subscriber line 120; from the one line conductor of the subscriber line 120 to the other line conductor thereof by way of the cross connection, from the other line conductor of the subscriber line 120 by way of the link 150, the trunk 125 and the transfer trunk 385 to the line conductor C131 of the trunk 130, and from the line conductor C131 of the trunk 130 by way of the contacts 711, C679, the contacts 662, C678, the contacts 741, C756, the contacts 803, C754, the windings of R840, C799, the contacts 805, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627.

Accordingly, at this time, the test relay R840 is energized by way of the above-traced primary circuit and artificial ground leak circuit. Further, the test relay R840 is energized by way of the above-traced test circuit in the event the line conductors of the subscriber line 120 are crossed. Accordingly, the test relay R840 operates at this time. Upon operating, the test relay R840 completes, at the contacts 841, a circuit for energizing the multiple the upper and lower windings of the test check relay R810, this circuit extending from the common ground conductor C676 by way of the contacts 766, C694, the contacts 841, C697, the contacts 606, C695, the contacts 796, C769 and the contacts 794 to C767, from C767 by way of the lower winding of R810 to the battery conductor C675, and from C767 by way of the upper winding of R810, the contacts 816 and 807, C748 and the resistor 767 to the battery conductor C675. When both the upper and lower windings of the test check relay R810 are energized, this relay does not operate, the relay R810 being of the differential type.

Also, upon operating, the test relay R840 interrupts, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850, thereby to cause the relay R850 to restore and interrupt, at the contacts 853, the previously mentioned circuit for energizing the winding of the control relay R860, thereby to cause the relay R860 to restore. Upon restoring, the control relay R860 interrupts, at the contacts 861, the previously traced primary circuit for energizing the winding of the test relay R840, thereby to cause the test relay R840 to restore in the event the previously traced test circuit is not completed by the presence of a cross fault between the line conductors of the subscriber line 120.

Assuming that there is no cross fault between the line conductors of the subscriber line 120, the above-traced test circuit is not completed. Accordingly, the test relay R840 restores as the windings thereof are not adequately energized by the previously traced completed artificial ground leak circuit to retain the relay R840 in its operated position.

Upon restoring, the test relay R840 interrupts, at the contacts 841, the previously traced circuit

for energizing in multiple the upper and lower windings of the test check relay R810, whereupon an inductive kick is produced in the upper and lower windings of the test check relay R810 which causes a current surge to traverse a path extending from the battery conductor C675 by way of the lower and upper windings of R810, the contacts 816 and 807, C748 and the resistor 767 to the battery conductor C675. The current traversing the path above traced is sufficient to cause the test check relay R810 to operate partially in order to interrupt, at the contacts 816, the previously traced surge current path and to complete, at the contacts 815, an obvious circuit for energizing in accumulative series relation the upper and lower windings of the test check relay R810. When the upper and lower windings of the test check relay R810 are thus energized in accumulative series relation, this relay fully operates to complete, at the contacts 814, an obvious circuit for energizing in multiple the windings of the control relays R820 and R830, thereby to cause the relay R820 to operate immediately and the relay R830 to operate shortly thereafter, the latter relay being of the slow-to-operate type. Also, upon operating, the test check relay R810 interrupts, at the contacts 816, the previously traced circuit for energizing in accumulative series relation the upper and lower windings of the test check relay R790 and the circuit for energizing the winding of the control relay R800, thereby to cause the relays R790 and R800 to restore.

Substantially immediately the test relay R840 restores, the test check relay R810 and the control relay R820 operate, the operation of the relays R810 and R820 being prior to the operation of the control relay R830. Upon operating, the test check relay R810 completes, at the contacts 813 and 812, a primary circuit for energizing the winding of the test relay R840, this circuit extending from ground by way of the contacts 812, C754, the windings of R840, C799, the contacts 813 and 831, C687, and the resistor 628 to the ungrounded terminal of the grounded battery 627. Accordingly, the test relay R840 immediately re-operates to interrupt, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850. Hence, the control relay R850 does not operate at this time. Also, upon operating, the control relay R820 completes, at the contacts 823 and 826, an artificial ground leak circuit for energizing the windings of the test relay R840, this circuit extending from ground by way of the contacts 812, the windings of R840, C799, the contacts 823, C756, the contacts 741, C678, the contacts 662 and 661, C677, the resistor 835, the bridge 843 connected in multiple with the resistor 836, the bridge 844 connected in multiple with the resistor 837, the resistor 838, C747, the contacts 826, C687 and the resistor 628 to the ungrounded terminal of the grounded battery 627. Further, the control relay R820 completes, at the contacts 822 and 823, a test circuit for energizing the windings of the test relay R840 in the event that there is a battery leak to either of the line conductors of the subscriber line 120. This circuit extends, when completed, from ground by way of the contacts 812 and the windings of R840 to C799, from C799 by way of the contacts 823, C756, the contacts 741, C678, the contacts 662, C679 and the contacts 711 to the line conductor C131 of the trunk 130, and from C799 by way of the contacts 823 and 822, C755, the resistor 769, C757, the contacts

743, C682 and the contacts 665 and 713 to the line conductor C132 of the trunk 130, the line conductors C131 and C132 being connected by way of the link 150 to the respective line conductors of the subscriber line 120 and battery potential appearing upon at least one of the line conductors of the subscriber line 120 due to the battery leak fault thereon.

Accordingly, at this time, the test relay R840 is energized by way of the above-traced primary circuit and the artificial ground leak circuit. Further, the test relay R840 is energized by way of the previously traced test circuit in the event a battery fault appears upon either of the line conductors of the subscriber line 120.

Shortly after the test check relay R810 and the control relay R820 operate, the control relay R830 operates to interrupt, at the contacts 831, the previously traced primary circuit for energizing the windings of the test relay R840. Assuming that there is no battery fault upon the line conductors of the subscriber line 120, the test relay R840 then restores due to the fact that the windings thereof are not adequately energized by way of the completed artificial leak circuit to retain the test relay R840 in its operated position.

Upon restoring, the test relay R840 completes, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850, thereby to cause the relay R850 to operate shortly thereafter and complete, at the contacts 853, the previously mentioned circuit for energizing the winding of the control relay R860, thereby to cause the relay R860 to operate shortly thereafter. Upon operating, the control relay R860 completes, at the contacts 865, a circuit for energizing the winding of the control relay R890, this circuit extending from the common ground conductor C676 by way of the contacts 865, C887, the contacts 832 and 827, C888 and the winding of R890 to the battery conductor C675. Shortly after the control relay R890 is energized over the above-traced circuit, the relay R890 operates, this relay being of the slow-to-operate type. Upon operating, the control relay R890 interrupts, at the contacts 892, the previously traced holding circuit for energizing the winding of the control relay R870, thereby to cause the latter relay to restore.

Further, it is noted that, upon operating, the control relay R850 interrupts, at the contacts 852, the previously mentioned path for applying ground potential to the conductor C686, a multiple point for applying ground potential to the conductor C686 being interrupted at the contacts 811 incident to the operation of the test check relay R810. Accordingly, ground potential is removed from the conductor C686, thereby to interrupt the previously traced path for applying ground potential to the control conductors C133 and C128 of the trunks 130 and 125, respectively. When ground potential is removed from the control conductor C128 of the trunk 125, the link 150 of the switch train is released, thereby to interrupt the established connection between the subscriber line 120 and the trunk 125.

Before proceeding with further discussion of the release of the link 150, the dial testing unit 400 and the line testing unit 700, it is noted that immediately the test check relay R770 operates at the beginning of the first or ground fault test upon the subscriber line 120, it completes, at the contacts 777, a circuit for energizing the winding of the timing relay R610, this circuit extend-

ing from the common ground conductor C676 by way of the contacts 716, C698, the contacts 763 and 777, C691 and the winding of R610 to the battery conductor C675. When energized over the above-traced circuit, the timing relay R610 operates. Upon operating, the timing relay R610 completes, at the contacts 612 and 613, a circuit for energizing the winding of the control relay R630, this circuit extending from the ground conductor C674 by way of the contacts 612, 613 and 621, C616 and the winding of R630 to the battery conductor C675. When energized over the above-traced circuit, the control relay R630 operates to complete, at the contacts 633, a circuit for energizing the winding of the control relay R640, this circuit extending from the ground conductor C674 by way of the contacts 665', the contacts 633, C617 and the winding of R640 to the battery conductor C675. When energized over the above-traced circuit, the relay R640 operates to complete, at the contacts 643, an obvious holding circuit for energizing the winding of the control relay R660.

At the conclusion of the first or ground test upon the line conductors of the subscriber line 120, the test check relay R770 restores in the event that there is no ground fault upon the line conductors of the subscriber line 120. Upon restoring, the test check relay R770 interrupts, at the contacts 777, the previously traced circuit for energizing the winding of the timing relay R610, whereupon the relay R610 releases its armature RA610. The armature RA610 continues to vibrate to close the contacts 611 and 612 alternately, thereby to retain completed a holding circuit for energizing the winding of the control relay R630 for a predetermined time interval, this circuit extending from the ground conductor C674 by way of the contacts 611—612, 631 and 621, C616 and the winding of R630. However, after a first time interval the armature RA610 assumes an intermediate position in order to interrupt, at the contacts 611—612, the previously traced holding circuit for energizing the winding of the control relay R630. Shortly thereafter, the control relay R630, being of the slow-to-release type, restores to interrupt, at the contacts 633, the previously traced circuit for energizing the winding of the control relay R640; however, the control relay R640 does not immediately restore, this relay being of the slow-to-release type. Also, upon restoring, the relay R630 completes, at the contacts 634, an alternative circuit for energizing the winding of the timing relay R610, this circuit extending from the ground conductor C674 by way of the contacts 645, 634 and 626 and the winding of R610 to the battery conductor C675. When the above-traced circuit for energizing the winding of the timing relay R610 is completed, the relay R610 reoperates. Also, upon restoring, the control relay R630 completes, at the contacts 632, a circuit for energizing the winding of the control relay R620, this circuit extending from the ground conductor C674 by way of the contacts 644, 632 and 624 and the winding of R620 to the battery conductor C675. Shortly after the above-traced circuit for energizing the winding of the control relay R620 is completed, the relay R620 operates, this relay being of the slow-to-operate type. Upon operating, the control relay R620 interrupts, at the contacts 621, the previously traced original circuit for energizing the winding of the control relay R630 and completes, at the contacts 622, an alternative holding circuit for

energizing the winding of the control relay R640. The last-mentioned circuit extends from the ground conductor C674 by way of the contacts 612, 613 and 622, C617 and the winding of R640 to the battery conductor C675. Also, upon operating, the control relay R620 interrupts, at the contacts 626, the previously traced alternative circuit for energizing the winding of the timing relay R610, thereby to cause the relay R610 to restore. Finally, the control relay R620 completes, at the contacts 625, a holding circuit for energizing the winding thereof, this circuit extending from the ground conductor C674 by way of the contacts 665' and 625 and the winding of R620 to the battery conductor C675. The timing relay R610 again releases its armature RA610, thereby to cause the armature RA610 to vibrate for a predetermined time interval in order intermittently to complete, at the contacts 611—612, a further holding circuit for energizing the winding of the control relay R640, this circuit extending from the ground conductor C674 by way of the contacts 611—612, 641 and 623, C617 and the winding of R640 to the battery conductor C675. However, after a second time interval, the armature RA610 assumes an intermediate position, thereby to interrupt, at the contacts 611 and 612, the above-traced holding circuit for energizing the winding of the control relay R640, thereby to cause the control relay R640 to restore shortly thereafter. Upon restoring, the relay R640 interrupts, at the contacts 643, the previously traced holding circuit for energizing the winding of the control relay R660, thereby to cause the relay R660 to restore. Upon restoring, the control relay R660 interrupts, at the contacts 664', the previously traced path for applying ground potential by way of the ground conductor C674 to the common ground conductor C676, thereby to cause the relays having holding circuits completed between the battery conductor C675 and the common ground conductor C676 to restore. Further, upon restoring, the control relay R660 interrupts, at the contacts 669, the previously traced alternative path for applying ground potential to the control conductor C133 of the trunk 130, thereby to cause the link 150 to restore and release the established connection between the subscriber line 120 and the trunk 125.

In view of the foregoing description of the operation of the timing relay R610 and the control relays R620, R630 and R640, it will be understood that the release of the line testing unit 700, the dial testing unit 400 and the link 150 is effected by the relays mentioned a predetermined time interval after the test check relay R770 operates. Accordingly, the subscriber at the subscriber substation T must remove the receiver of the telephone instrument thereat from its associated switchhook within this predetermined time interval in order to receive information as to the result of the line tests performed upon the subscriber line 120 as explained more fully hereinafter.

When the testman at the subscriber substation T initiated operation of the line testing unit 700 by replacing the receiver of the telephone instrument thereat upon its associated switchhook, the control relays R850, R860 and R870 operated as previously explained. Upon operating, the control relay R870 completes, at the contacts 872, a circuit for energizing the winding of the timing relay R750, the control relay R660 being operated at this time. The circuit for energizing

the winding of the timing relay R750 extends from the common ground conductor C676 by way of the contacts 812, C759 and the winding of R750 to the battery conductor C675. When energized over the above-traced circuit the timing relay R750 operates in order to set its armature RA750 into vibration. The vibrating armature RA750 intermittently completes, at the contacts 751, a circuit for energizing the winding of the control relay R760, this circuit extending, when completed, from the common ground conductor C676 by way of the contacts 818, C768, the contacts 854, C692, the contacts 751 and the winding of R760 to the battery conductor C675. Subsequently, when the control relay R640 operates, it completes, at the contacts 643, an alternative circuit for energizing the winding of the control relay R760, this circuit extending from the ground conductor C674 by way of the contacts 643, C692, the contacts 751 and the winding of R760 to the battery conductor C675. The control relay R760 does not immediately operate when either of the above-traced circuits for energizing the winding thereof is intermittently completed, this relay being of the slow-to-operate type. However, after a predetermined time interval, the armature RA750 of the timing relay R750 establishes steady contact between the contacts 751, and shortly thereafter the control relay R760 operates to complete, at the contacts 761, a holding circuit for energizing the winding of the timing relay R750, this circuit extending from the common ground conductor C676 by way of the contacts 761 and the winding of R750 to the battery conductor C675. Also, upon operating, the control relay R760 completes, at the contacts 761 and 762, a circuit for energizing the winding of the control relay R740, this circuit extending from the common ground conductor C676 by way of the contacts 761 and 762 and the winding of R740 to the battery conductor C675. When energized over the above-traced circuit, the relay R740 operates to complete, at the contacts 742 and 744, a connection between the line conductors C131 and C132 of the trunk 130 and the upper and lower windings of the impulse relay R650 in a manner more fully described hereinafter.

Before proceeding with the operation of the line testing unit 700 incident to the operation of the control relay R740 due to the completion of the timing interval by the timing relay R750, it is noted that this timing interval is not completed and the control relays R760 and R740 are not operated in the event the previously described line tests are performed and no fault is found upon the subscriber line 120. As previously explained, at the conclusion of any one of the first, second or third previously described tests upon the subscriber line 120, the test relay R840 restores in the event the particular fault tested for upon the subscriber line 120 is not present thereon. On the other hand, in the event the particular fault tested for on the subscriber line 120 is present upon the subscriber line 120, the test relay R840 remains in its operated position and the subsequent tests are not performed. In other words, in the event a ground fault is present upon either of the line conductors of the subscriber line 120, the test relay R840 does not restore and the test check relay R770 remains in its operated position; in the event a cross fault is present between the line conductors of the subscriber line 120, the test relay R840 does not restore and the test check relay R790 remains in its operated position; and in the event a battery

fault appears upon either of the line conductors of the subscriber line 120, the test relay R840 does not restore and the test check relay R810 remains in its operated position.

Continuing now with the operation of the control relay R740 due to the completion of the timing operation of the timing relay R750, upon operating, the control relay R740 completes, at the contacts 746, a holding circuit for energizing in multiple the upper and lower windings of the test check relay R790 in the event the test check relay R770 is operated due to the presence of a ground fault upon the subscriber line 120, thereby positively to prevent the operation of the test check relay R790; and upon operating, the control relay R740 completes, at the contacts 746, a holding circuit for energizing in multiple the upper and lower windings of the test check relay R810 in the event the test check relay R790 is operated due to the presence of a cross fault between the line conductors of the subscriber line 120, thereby positively to prevent the operation of the test check relay R810. The previously mentioned holding circuit for energizing in multiple the upper and lower windings of the test check relay R790 extends from the ground conductor C674 by way of the contacts 653, C698, the contacts 746, C769 and the contacts 795 to the contacts 774, from the contacts 774 by way of the lower winding of R790 to battery, and from the contacts 774 by way of the upper winding of R790, the contacts 792 and 787 and the resistor 767 to the battery conductor C675; the previously mentioned holding circuit for energizing in multiple the upper and lower windings of the test check relay R810 extends from the ground conductor C674 by way of the contacts 653, C698, the contacts 746, C769 and the contacts 794 to C767, from C767 by way of the lower winding of R810 to the battery conductor C675, and from C767 by way of the upper winding of R810, the contacts 816 and 807, C748 and the resistor 767 to the battery conductor C675.

After the testman at the subscriber substation T momentarily replaces the receiver of the telephone instrument theret at upon its associated switchhook in order to initiate operation of the line testing unit 700, he removes the receiver from its associated switchhook, thereby to recomplete a connection between the receiver of the telephone instrument at the subscriber substation T and the line conductors C131 and C132 of the trunk 130. However, at this time, the impulse relay R650 is not reoperated in view of the fact that the control relay R660 is operated at this time. However, assuming that there is a fault upon the subscriber line 120 and that the timing operation is completed by the timing relay R750 in order to cause the control relay R740 to operate, upon operating, the control relay R740 completes, at the contacts 742 and 744, a circuit for energizing in series the upper and lower windings of the impulse relay R650, this circuit extending from ground by way of the lower winding of R650, C681, the contacts 744, C682 and the contacts 665 and 713 to the line conductor C132 of the trunk 130, and from battery by way of the upper winding of R650, the contacts 664, C680, the contacts 742, C678, the contacts 662, C679 and the contacts 711 to the line conductor C131 of the trunk 130, the line conductors C131 and C132 of the trunk 130 being connected in the previously traced loop circuit including the receiver of the telephone instrument at the subscriber substation T. Accordingly, the impulse relay

R650 reoperates at this time, thereby to complete, at the contacts 654, the previously traced circuit for energizing the winding of the hold relay R600. The hold relay R600 then reoperates to prepare, at the contacts 601, a path, traced hereinafter, for returning tone splashes over the line conductors of the trunk 130 and to complete, at the contacts 602, the previously traced circuit for energizing the upper winding of the tone relay R880. Accordingly, the tone relay R880 operates intermittently at this time. Also, upon reoperating, the impulse relay R650 interrupts, at the contacts 653, the previously traced holding circuit for energizing in multiple the upper and lower windings of the test check relay R790 in the event this holding circuit is completed, or interrupts, at the contacts 653, the previously traced holding circuit for energizing in multiple the upper and lower windings of the test check relay R810 in the event this circuit is completed. Also, upon operating, the control relay R740 interrupts, at the contacts 741 and 743, any one of the previously traced test circuits between the line conductors C131 and C132 of the trunk 130 and the test relay R840, thereby to cause the test relay R840 to restore after it has been retained in its operated position due to the presence of a fault upon the line conductors of the subscriber line 120. Upon restoring, the test relay R840 completes, at the contacts 842, the previously traced circuit for energizing the winding of the control relay R850, thereby to cause operation of the control relays R850 and R860 as previously explained.

Accordingly, at this time, one or both of the test check relays R790 and R810 which have not been previously operated are now operated in the manner previously described.

More particularly, in the event the subscriber line 120 has a ground fault thereon, the test check relays R790 and R810 and the control relay R890 operate subsequent to the operation of the control relay R740; in the event the subscriber line 120 has a cross fault between the line conductors thereof, the test check relay R810 and the control relay R890 operate subsequent to the operation of the control relay R740; in the event the subscriber line 120 has a battery fault thereon, the control relay R890 operates subsequent to the operation of the control relay R740; and in the event there are no faults upon the subscriber line 120, the control relay R740 operates subsequent to the operation of the control relay R890. Incident to the operation of the test check relay R790, the control relay R850 is operated; incident to the operation of the test check relay R810, the control relay R850 is reoperated; and incident to the operation of the control relay R830, the control relay R890 is operated. Accordingly, under the conditions mentioned, when there is a fault upon the subscriber line 120 and the control relay R740 is operated, a circuit is completed for returning a splash of tone over the subscriber line 120 each time the control relay R850 operates and when the control relay R890 operates. The path for returning the splash of tone over the subscriber line 120 incident to the operation of the control relay R850 extends from the condenser 846 by way of C684, the contacts 862, 851 and 824, C758, the contacts 745, C683, the contacts 601, C619, C681, the contacts 744, C682, the contacts 665 and the contacts 713 to the line conductor C132 of the trunk 130, the line conductor C132 of the trunk 130 being included in the previously

traced loop circuit including the receiver of the telephone instrument at the subscriber substation T. The path for returning the splash of tone over the subscriber line 120 incident to the operation of the control relay R890 extends from the condenser 846 by way of C684, the contacts 891, 871 and 825, C758, the contacts 745, C683, the contacts 601, C619, C681, the contacts 744, C682, the contacts 665 and the contacts 713 to the line conductor C132 of the trunk 130, the line conductor C132 of the trunk 130 being included in the previously traced loop circuit including the receiver of the telephone instrument at the subscriber substation T.

In view of the above description of the operation of the line testing unit 700 to return splashes of tone over the subscriber line 120 in the event a fault appears upon the subscriber line 120, it will be understood that three separate splashes of tone are returned over the subscriber line 120 in the event the subscriber line 120 has a ground fault thereon; two separate splashes of tone are returned over the subscriber line 120 in the event there is a cross fault between the line conductors of the subscriber line 120; one splash of tone is returned over the subscriber line 120 in the event the subscriber line 120 has a battery fault thereon; and no splashes of tone are returned over the subscriber line 120 in the event there are no faults of any kind thereon.

As previously explained, the line testing unit 700, the dial testing unit 400 and the link 150 are automatically released in the event the testman at the subscriber substation T does not remove the receiver of the telephone instrument thereat from its associated switchbook within the predetermined time interval as determined by the operation of the timing relay R610; also, the line testing unit 700, the dial testing unit 400 and the link 150 are automatically released by the operation of the control relay R850 following the completion of the line tests performed by the line testing unit 700 in the event no faults appear upon the subscriber line 120, while the test check relay R810 occupies its operated position. More particularly, the operation of the timing relay R610 is effective to cause the control relay R660 to restore, thereby to interrupt, at the contacts 669, the previously traced path for applying ground potential to the control conductor C133 of the trunk 130; while the operation of the control relay R850, while the test check relay R810 is operated, is effective to interrupt, at the contacts 852, the previously traced path for applying ground potential to the control conductor C133 of the trunk 130. In either event, the removal of ground potential from the control conductor C133 of the trunk 130 is effective to initiate the release of the line testing unit 700, the dial testing unit 400 and the link 150.

Release of the line testing unit 700, the dial testing unit 400 and the link 150

When ground potential is removed from the control conductor C133 of the trunk 130 due either to the operation of the timing arrangement including the timing relay R610 incident to a delay on the part of the testman at the subscriber substation T in removing the receiver of the telephone instrument from its associated switchhook or the operation of the control relay R850 while the test check relay R810 is operated, indicating a test of the subscriber line 120 as having no faults thereon, the previously traced

path for applying ground potential to the control conductor C128 of the trunk 125 is interrupted, thereby to cause the link 150 to be released in the usual manner. When the link 150 is released, the line circuit 121 is also released in order to mark the subscriber line 120 as idle in the event the receiver of the telephone instrument at the subscriber substation T is replaced upon its associated switchhook at this time. On the other hand, when the link 150 is released, the line circuit 121 operates to lock the subscriber line 120 out of service in the event the receiver of the telephone instrument at the subscriber substation T is removed from its associated switchhook at this time.

Also, when ground potential is removed from the control conductor C128 of the trunk 125, the previously traced holding circuit for energizing the winding of the control relay R300 in the dial testing unit 400 is interrupted, thereby to cause the relay R300 to restore. Upon restoring, the control relay R300 interrupts, at the contacts 302, the previously mentioned path for applying ground potential to the control conductor C109 of the trunk 108, thereby to mark the trunk 108 extending to the manual position 104 as idle. As previously noted, the switching relay R310 restores when the connection including the trunk 125 is transferred from the dial testing unit 400 to the line testing unit 700, thereby to prepare, at the contacts 319 and 319', points in the previously traced chain circuit extending to the other dial testing units corresponding to the dial testing unit 400, in order to render the other dial testing units operative to transfer a connection by way of the control trunk 240 to the testing position 200. Also, upon restoring, the switching relay R310 interrupts, at the contacts 314 and 315, the connection between the conductors C337 and C338 and the conductors C242 and C241 of the control trunk 240, thereby to disconnect the dial testing unit 400 from the testing position 200. Also, upon restoring, the control relay R300 interrupts, at the contacts 307 and 309, the previously traced connection between the line conductors C126 and C127 of the trunk 125 and the line conductors C131 and C132 of the trunk 130, including the line conductors C386 and C387 of the transfer trunk 385.

At this time, the apparatus in the dial testing unit 400 is completely released with the exception of the control relay R460 and the battery reversing relay R450, these relays being retained in their operated positions in order to effect the reversal of battery upon the conductors C357 and C359 as previously explained. However, the trunk 125 extending to the dial testing unit 400 is marked as busy in spite of the fact that the dial testing unit 400 is completely released at this time due to the operated condition of certain of the apparatus in the dial testing unit 700, as will be explained more fully hereinafter.

At this point it is noted that after the operator at the testing position 200 communicates with the testman at the subscriber substation T advising him of the result of the impulse ratio test and prior to the time the testman at the subscriber substation T replaces the receiver of the telephone instrument thereat upon its associated switchhook, in order to initiate operation of the line testing unit 700, the operator at the testing position 200 returns the key K220 to its normal position, thereby to interrupt, at the contacts 221 and 222 of the key K220, the connection be-

tween the line 225 extending to the telephone apparatus 201 at the testing position 200 and the line conductors of the trunk 125. Also, the operator at the testing position 200 returns the key K230 to its normal position. Accordingly, at this time, the apparatus at the testing position 200 is completely released and the testing position 200 is available to other of the dial testing units. Further, it is noted that the jack J210 provided at the testing position 200 may be utilized in order to establish a connection to the line conductors of the trunk 125 instead of the key K220, the jack J210 being accessible to the plug of another telephone instrument, not shown, at the testing position 200.

When the link 150 is released, the impulse relay R650 restores, in the event this relay is operated at this time, in order to interrupt, at the contacts 654, the previously traced circuit for energizing the winding of the hold relay R600, thereby to cause the relay R600 to restore in the event it is operated at this time. During the operation of the line testing unit 700 previously described, the timing relay R750 operates and causes the operation of the relays R740 and R760 prior to the time the link 150 is released, in the event there is a fault on the subscriber line 120. On the other hand, the timing relay R750 and the control relays R740 and R760 operate subsequent to the release of the link 150 in the event there is no fault on the subscriber line 120. Furthermore, the timing relay R610 and the control relays R620, R630 and R640 complete the cycle of operations previously described regardless of whether the testman at the subscriber substation 120 again removes the receiver of the telephone instrument thereat from its associated switchhook after it has been replaced thereon at the conclusion of the impulse speed test. After the timing relay R610 and the control relays R620, R630 and R640 have completed the cycle of operation previously described, the control relay R620 occupies its operated position, while the timing relay R610 and the control relays R630 and R640 occupy their restored positions. When the control relay R640 restores, it interrupts, at the contacts 643, the previously traced holding circuit for energizing the winding of the control relay R660, thereby to cause the relay R660 to restore and interrupt, at the contacts 664', the previously traced connection between the ground conductor C674 and the common ground conductor C676. Further, the control relay R660 interrupts, at the contacts 665', the previously traced alternative holding circuit for energizing the winding of the control relay R735 and the previously traced holding circuit for energizing the winding of the control relay R620. The control relay R620 then restores and the control relay R735 then restores to interrupt, at the contacts 739, the previously traced path for applying direct ground potential to the ground conductor C674. Also, upon restoring, the relay R735 completes, at the contacts 736, the previously traced circuit for energizing the winding of the battery reversing relay R720 in order to cause operation of the relay R720. Accordingly, at this time, the battery reversing relay R720 and the control relay R730 are retained in their operated positions, the operation of the battery reversing relay R720 being effective to reverse battery upon the conductors C674 and C675, as previously explained. When ground potential is removed from the common ground conductor C676, the previously traced holding cir-

culits for energizing the windings of the timing relay R750 and the control relay R740 are interrupted, thereby to cause the relays R750 and R740 to restore. Also, upon restoring, the control relay R640 interrupts, at the contacts 643, the previously traced circuit for energizing the winding of the control relay R760, thereby to cause the relay R760 to restore. Furthermore, when ground potential is removed from the common ground conductor C676, the previously traced holding circuit for energizing in series the upper and lower windings of the test check relay R810 and the previously traced circuits for energizing the windings of the control relays R820 and R830 are interrupted, thereby to cause the relays R810, R820 and R830 to restore. Also, when ground potential is removed from the common ground conductor C676, the previously traced circuits for energizing the windings of the control relays R850, R860 and R890 are interrupted, thereby to cause the relays R850, R860 and R890 to restore. At this time, the apparatus in the line testing unit 700 is completely released, rendering the line testing unit 700 available for further use. Further, it is noted that, when ground potential is removed from the control conductor C133 of the trunk 130, battery potential is effectively applied to the control conductor C133 of the trunk 130 and to the control conductor C128 of the trunk 125, this path extending from battery in the dial testing unit 400 by way of the resistor 427 and the previously traced paths to the control conductors C128 and C133 of the respective trunks 125 and 130. Accordingly, at this time, the trunk 108 extending to the manual position 104 and the trunks 125 and 130 extending to the switch train are marked as idle and the dial testing unit 400 and the line testing unit 700 are available for further use.

In view of the foregoing description of the operation of the testing system to test both the impulse ratio and the impulse speed of the dialing apparatus at the subscriber substation T and to perform the various line tests upon the subscriber line 120, it will be readily understood that in the event only an impulse speed test upon the dialing apparatus at the subscriber substation T is required, only the digits 5 and 0 will be successively dialed at the dialing apparatus at the subscriber substation T following seizure of the subscriber line 120 by the link 150. After this test is performed, the testman at the subscriber substation T replaces the receiver of the telephone instrument thereat upon its associated switchhook and allows the receiver to remain upon its associated switchhook for a sufficient time interval to permit the complete release of the dial testing unit 400 and the associated line testing unit 700 as previously explained. Although the operation of the line testing unit 700 associated with the dial testing unit 400 is initiated when the testman at the subscriber substation T replaces the receiver of the telephone instrument thereat upon its associated switchhook, the dial testing unit 400 and the line testing unit 700 are subsequently released, in the manner previously explained, in the event the testman at the subscriber substation T allows the receiver of the telephone instrument thereat to remain upon its associated switchhook a predetermined time interval.

Similarly, it will be understood that in the event only an impulse ratio and an impulse speed test are desired upon the dialing apparatus at the subscriber substation T, the digits 5, 2 and

0 are successively dialed at the dialing apparatus at the subscriber substation T after the link 150 operates to establish a connection to the subscriber line 120. After the dial testing unit 400 has operated to indicate the result of the impulse speed test and the operator at the testing position 200 has communicated the result of the impulse ratio test to the testman at the subscriber substation T, the testman replaces the receiver of the telephone instrument at the subscriber substation T upon its associated switchhook, thereby to effect the release of the line testing unit 400 and the dial testing unit 700 as previously explained.

15 *Operation of the testing system to test only a subscriber line*

In the event that it is desirable to test only a subscriber line, such, for example, as the subscriber line 120, a call is first initiated upon the subscriber line 120 by removing the receiver of the telephone instrument at the subscriber substation T from its associated switchhook, thereby to cause the finder switch of an assigned one of the links in the switching apparatus to find the subscriber line 120 in the previously described manner. Assuming that the link 150 has been assigned to the use of the calling subscriber substation T, after the finder switch 151 thereof finds the subscriber line 120 and dial tone is received at the subscriber substation T over the subscriber line 120, the testman at the subscriber substation T dials the digit 3. When the digit 3 is dialed at the dial apparatus at the subscriber substation T, the selector switch 152 of the link 150 operates automatically to search for one of the trunks in the second group of trunks extending to an idle one of the line testing units 700. Assuming that the trunk 130 is the first trunk in the second group of trunks extending to an idle one of the line testing units, the selector switch 152 operates to seize the trunk 130 in the usual manner. When the trunk 130 is seized by the selector switch 152 an obvious loop circuit is completed between the subscriber substation T and the line conductors C131 and C132 of the trunk 130, thereby to cause the impulse relay R650 to operate as previously explained. Upon operating, the impulse relay R650 completes, at the contacts 654, the previously traced circuit for energizing the winding of the hold relay R600, thereby to cause the relay R600 to operate. Upon operating, the hold relay R600 completes, at the contacts 602, the previously traced circuit for energizing the upper winding of the tone relay R880, whereupon the tone relay R880 operates to cause dial tone to be returned over the trunk 130 to the subscriber substation T in the previously described manner. When the testman at the subscriber substation T receives dial tone he momentarily replaces the receiver of the telephone instrument thereat upon its associated switchhook, thereby to initiate operation of the line testing unit 700 in the previously described manner. Shortly thereafter the subscriber at the subscriber substation T again removes the receiver of the telephone instrument thereat from its associated switchhook in order to receive the results of the tests performed upon the subscriber line 120 by the line testing unit 700 in the previously explained manner. The operation of the line testing unit 700 to return splashes of tone over the trunk 130 to the subscriber substation T indicative of a fault present upon the subscriber line 120 and the release of the line

testing unit 700 subsequent to the operation thereof are the same as previously described.

Operation of the testing system to test the impulse speed or the impulse ratio or both the impulse speed and the impulse ratio of apparatus in the distant exchange 100

In order to effect a test upon an impulsing apparatus in the distant exchange 100 a call is first initiated at the distant exchange 100 upon one of the trunk lines, such, for example, as the trunk line 101 extending between the distant exchange 100 and the local exchange 115, the impulsing apparatus which it is desired to test being associated with the trunk line 101. When a call is initiated upon the trunk line 101, the line circuit 102 individually associated therewith is operated in order to indicate to the operator at the manual position 104 that a call is present upon the trunk line 101. The operator at the manual position 104 then inserts the answering plug of one of the cord circuits thereat, such, for example, as the cord circuit 106, into the jacket J105 extending by way of the line 103 to the line circuit 102, thereby to establish a connection between the distant exchange 100 and the telephone apparatus at the manual position 104. The operator at the manual position 104 is then advised concerning the particular test which is required upon the impulsing apparatus in the distant exchange.

The operator at the manual position 104 then inserts the calling plug of the cord circuit 106 into one of the jacks at the manual position 104 terminating one of the trunks extending to an idle one of the dial testing units. Assuming that the dial testing unit 400 is idle at this time, the operator at the manual position 104 inserts the calling plug of the cord circuit 106 into the jack J107 terminating the trunk 108 extending to the dial testing unit 400, thereby to complete a circuit for energizing the upper winding of the control relay R380, this circuit extending from ground by way of the upper winding of R380, C369, the contacts 441, C336, the contacts 301, the control conductor C109 of the trunk 108, the jack J107 and the calling plug of the cord circuit 107 to battery, not shown, at the manual position 104. When energized over the above-traced circuit, the control relay R380 operates to complete, at the contacts 384 and 385, a circuit for energizing in series the upper and lower windings of the impulse relay R340, this circuit extending from ground by way of the upper winding of R340, C337, C376 and the contacts 384 to the line conductor C110 of the trunk 108 and from battery by way of the lower winding of R340, C338, C377 and the contacts 385 to the line conductor C111 of the trunk 108, the line conductors C110 and C111 of the trunk 108 being connected together by way of a bridge circuit at the manual position 104.

When energized over the above-traced circuit, the impulse relay R340 operates to complete, at the contacts 342, the previously traced circuit for energizing the winding of the hold relay R410, thereby to cause operation of the relay R410. Upon operating, the hold relay R410 completes, at the contacts 411, a holding circuit for energizing the winding of the control relay R380, this circuit extending from ground by way of the contacts 411, C378, C379, the contacts 383 and the lower winding of R380 to battery. Also, upon operating, the hold relay R410 completes, at the contacts 411, a path for applying ground potential to the control conductors C128 and C133 of

the respective trunks 125 and 130, this path extending from ground by way of the contacts 411, C378, C379 and the contacts 387 to the control conductor C128 of the trunk 125 and from C128 by way of the control conductor C388 of the transfer trunk 385 to the control conductor C133 of the trunk 130. The trunks 125 and 130 extending respectively to the dial testing unit 400 and the line testing unit 700 are thus marked as busy to the selector switches of the links in the switch train. The subsequent operation of the apparatus in the dial testing unit 400 incident to operation of the impulse relay R340 and the hold relay R410 is the same as that previously explained.

At this time, the tone relay R530 operates to complete the previously traced path for returning dial tone current over the trunk 108 to the manual position 104, thereby to indicate to the operator at the manual position 104 that the dial testing unit 400 is in readiness to receive the digit or digits to be dialed therein.

In the event only an impulse speed test is required upon the impulsing apparatus in the distant exchange 100, the operator at the manual position 104, upon receiving dial tone, advises the operator in the distant exchange 100 to operate the impulsing apparatus therein in accordance with the digit 0. The operator in the distant exchange 100 then operates the impulsing apparatus therein in accordance with the digit 0, whereupon the dial testing unit 400 operates in the previously described manner in order to test the impulsing speed of the impulsing apparatus in the distant exchange 100 and to return a tone over the trunk 108 and the trunk line 101 connected thereto indicative of the speed of the impulsing apparatus in the distant exchange 100.

In the event an impulse ratio as well as an impulse speed test are required upon the impulsing apparatus in the distant exchange 100, the operator at the manual position 104, upon receiving dial tone by way of the trunk 108, dials the digit 2, thereby to cause the dial testing unit 400 to operate and transfer the connection by way of the control trunk 240 to the testing position 200 in the manner previously explained. The operator at the manual position 104 then advises the operator in the distant exchange 100 to operate the impulsing apparatus therein which is to be tested in accordance with the digit 0. The operator in the distant exchange 100 then operates the impulsing apparatus in accordance with the digit 0, whereupon the dial testing unit 400 operates to perform the impulse speed test and to return a characteristic tone over the trunk 108 and the connected trunk line 101 indicative of the speed of the impulsing apparatus in the distant exchange 100 in the previously described manner. Further, the operator at the testing position 200 advises the operator in the distant exchange 100 concerning the impulse ratio of the impulsing apparatus therein. As previously explained, the impulsing apparatus in the distant exchange 100 may be operated in accordance with the digit 0 several times in order to check the operation of the apparatus in the dial testing unit 400 and the apparatus at the testing position 200.

The release of the connection between the distant exchange 100 and the dial testing unit 400 is primarily under the control of the operator at the manual position 104 and is effected by the operator at the manual position 104 when the

calling plug of the cord circuit 106 is withdrawn from the jack J107. When the calling plug of the cord circuit 106 is withdrawn from the jack J107 the previously traced loop circuit for energizing in series the upper and lower windings of the impulse relay R340 is interrupted, thereby to cause the impulse relay R340 to restore. The release of the remainder of the apparatus in the dial testing unit 400 incident to the restoration of the impulse relay R340 is the same as that previously explained. It is noted that when the control relay R440 in the dial testing unit 400 restores it completes, at the contacts 441, the previously traced path for applying ground potential to the control conductor C109 of the trunk 108, thereby to cause apparatus, not-shown, at the manual position 104 to be operated in order to indicate that the dial testing unit 400 has been released. Further, it is noted that when the hold relay R410 restores, it interrupts, at the contacts 411, the previously traced holding circuit for energizing the lower winding of the control relay R380, thereby to cause the relay R380 to restore. Upon restoring, the control relay R380 interrupts, at the contacts 387, a further point in the previously traced path for applying ground potential to the control conductors C128 and C133 of the respective trunks 125 and 130. When ground potential is removed from the control conductors C128 and C133 of the respective trunks 125 and 130, the previously traced paths for applying battery potential by way of the resistor 427 to the control conductors C128 and C133 of the respective trunks 125 and 130 are effectively recompleted. Accordingly, at this time, the dial testing unit 400 is marked as idle by way of the trunk 108 extending to the manual position 104; and the dial testing unit 400 and the line testing unit 700 are marked as idle by way of the trunks 125 and 130, respectively, extending to the selector switches of the links in the switch train. The established connection between the distant exchange 100 and the manual position 104 is released under the joint control of the operator in the distant exchange 100 and the operator at the manual position 104, the end of this connection at the local exchange 115 being released when the operator at the manual position 104 withdraws the answering plug of the cord circuit 106 from the jack J105 extending by way of the line 103 to the line circuit 102. At this time the line circuit 102 restores, thereby to indicate to the operator at the manual position 104 that the trunk line 101 extending between the distant exchange 100 and the local exchange 115 is idle.

Checking the operation of a dial testing unit

The attendant at the local exchange 115 may test the operation of any one of the dial testing units, such, for example, at the dial testing unit 400, in order to check the standard speed of operation of the rotary switch therein as determined by the three timing relays associated with the rotary switch. More particularly, in order to test the standard speed of operation of the rotary switch S510 embodied in the dial testing unit 400, the attendant operates the test key K565, thereby to complete, at the contacts 566, a circuit for energizing the winding of the control relay R520, this circuit extending from the battery conductor C359 by way of the winding of R520, C344 and the contacts 566 to the ground conductor C357. When energized over the above-traced circuit, the relay R520 operates to complete, at the contacts 525, a path for applying direct ground potential to the ground conductor

C357, this path extending from ground by way of the contacts 525, C391 and the contacts 455 to the ground conductor C357. Also, upon operating, the control relay R520 completes, at the contacts 527, a path for applying ground potential to the control conductors C128 and C133 of the respective trunks 125 and 130, this path extending from ground by way of the contacts 527, C378, the contacts 303, C339 and the contacts 388 to the control conductor C128, from C128 by way of the control conductor C388 of the transfer trunk 385 to the control conductor C133. This application of ground potential to the control conductors C128 and C133 of the respective trunks 125 and 130 marks the dial testing unit 400 and the individually associated line testing unit 700 as busy to the selector switches of the links in the switch train. Also, upon operating, the control relay R520 completes, at the contacts 524, the previously traced connection between the ground conductor C357 and the conductor C585, thereby to cause completion of the previously traced circuits for energizing the windings of the timing relays R560, R570 and R580, the timing relays R560, R570 and R580 being set into operation as previously explained. Each time the timing relay R570 operates, it completes, at the contacts 573, the previously traced circuit for energizing the winding of the rotary magnet M519; and each time the timing relay R570 restores, it interrupts, at the contacts 573, the previously traced circuit for energizing the winding of the rotary magnet M519. Accordingly, the rotary magnet M519 operates intermittently in order to drive the wipers noted of the rotary switch S510 step by step in the clockwise direction. Each time the wiper 515 engages the tenth contact in the associated contact bank 516 of the rotary switch S510, a circuit is completed for illuminating the visual signal or lamp L508, this circuit extending from the ground conductor C357 by way of the contacts 553, C335, the contacts 333 and 366, C345, the wiper 515 and engaged tenth contact in the associated contact bank 516 of the rotary switch S510, C475, the contacts 522 and the lamp L508 to the battery conductor C359. Accordingly, the lamp L508 flashes once each cycle of operation of the rotary switch S510. In the event the rotary switch S510 is operating at its proper speed, the lamp L508 will flash approximately once per second, corresponding to a standard impulse speed of approximately ten impulses per second. In the event the lamp L508 does not flash approximately once per second, the contacts of the timing relays R560, R570 and R580 may be adjusted slightly in order to correct the speed of operation of the rotary switch S510 to the desired standard.

When the key K565 is returned to its normal position the previously traced original circuit for energizing the winding of the control relay R520 is interrupted at the contacts 566 thereof; however, the relay R520 remains in its operated position until the wipers noted of the rotary switch S510 are actuated back into their normal positions, whereupon the previously traced holding circuit for energizing the winding of the control relay R520 is interrupted. The relay R520 then restores to interrupt, at the contacts 524, the previously traced connection between the ground conductor C357 and the conductor C585, thereby to arrest further operations of the timing relays R560, R570 and R580. Also, upon restoring, the relay R520 interrupts,

at the contacts 525, the previously traced path for applying direct ground potential to the ground conductor C357 and interrupts, at the contacts 527, the previously traced path for applying ground potential to the control conductors C128 and C133 of the respective trunks 125 and 130. At this time the dial testing unit 400 and the line testing unit 700 are completely released and marked as idle by way of the trunks 125 and 130, respectively, to the selector switches of the links in the switch train.

Checking the operation of a line testing unit

The attendant at the local exchange 115 may test the operation of any one of the line testing units, such, for example, as the line testing unit 700, in order to check the operation thereof to test for the different types of faults upon a subscriber line. More particularly, in order to check the operation of the line testing unit 700 to test for a ground fault upon a subscriber line, the fault imitation key K882 is first operated; in order to check the operation of the line testing unit 700 to test for a cross fault between the line conductors of a subscriber line, the fault imitation key K883 is first operated; and in order to check the operation of the line testing unit 700 to test for a battery fault upon a subscriber line, the fault imitation key K884 is first operated. After one of the fault imitation keys has been operated, the plug associated with the test telephone apparatus 614 is inserted into the jack J615, it is again withdrawn therefrom and subsequently reinserted therein in order to simulate the acts of replacing the receiver of the telephone instrument upon its associated switchhook and thereafter removing the receiver of the telephone instrument from its associated switchhook.

In the event the fault imitation key K882 is operated, ground potential is applied to the line conductor C131 of the trunk 130 incident to the operation of the test check relay R770 and the control relay R780. More particularly, the control relay R780 completes, at the contacts 786 and 781, a path for applying ground potential to the line conductor C131 of the trunk 130, this path extending from ground by way of the contacts 786, C747, the resistor 845, the contacts of the key K882, C752, the contacts 781, C677, the contacts 661, C679 and the contacts 711 to the line conductor C131 of the trunk 130. When this imitation ground fault is present upon the line conductor C131 of the trunk 130, the testing unit 700 should operate in the previously described manner in order to cause three separate splashes of tone to be transmitted over the trunk 130 to the test telephone apparatus 614.

In the event the fault imitation key K883 is operated, ground potential is applied to both of the line conductors C131 and C132 of the trunk 130 incident to the operation of the test check relay R790 and the control relay R800. More particularly, the control relay R800 completes, at the contacts 804, a path for applying ground potential to the line conductor C132 of the trunk 130 and completes, at the contacts 806, a path for applying ground potential to the line conductor C131 of the trunk 130. The first-mentioned path extends from ground by way of the contacts 804, C757, the contacts 743, C682, the contacts 665 and 713 to the line conductor C132 of the trunk 130; and the second-mentioned path extends from ground by way of the contacts 806, C747, the resistor 845, the contacts of the key K883, C885, the contacts 801, C677, the contacts 661, C679 and the contacts 711 to the line conductor C131 of the trunk 130. When this imitation cross fault is present between the line conductors of the trunk 130, the testing unit 700 should operate in the previously described manner in order to cause two separate splashes of tone to be transmitted over the trunk 130 to the test telephone apparatus 614 in the previously described manner.

In the event the fault imitation key K884 is operated, battery potential is applied to the line conductor C131 of the trunk 130 incident to the operation of the test check relay R810 and the control relay R820. More particularly, the control relay R820 completes, at the contacts 821 and 826, a path for applying battery potential to the line conductor C131 of the trunk 130, this path extending from the ungrounded terminal of the grounded battery 627 by way of the resistor 845, the contacts of the key K884, C886, the contacts 821, C677, the contacts 661, C679 and the contacts 711 to the line conductor C131 of the trunk 130. When this imitation battery fault is present upon the line conductor C131 of the trunk 130, the line testing unit 700 should operate in the previously described manner in order to cause one splash of tone to be transmitted over the trunk 130 to the test telephone apparatus 614 in the previously described manner.

In the event none of the fault imitation keys K882, K883 and K884 is operated, the trunk 130 having no fault appearing thereon, the line testing unit 700 should operate in the previously described manner in order to transmit no splashes of current over the trunk 130 to the test telephone apparatus 614.

Conclusion

From the foregoing it is apparent that there is provided in a local exchange a telephone testing system which embodies an improved arrangement under the direct control of a subscriber substation for performing certain tests upon the dialing apparatus at the subscriber substation and for performing certain tests upon the subscriber line extending to the subscriber substation, and an improved arrangement under the control of an operator at a manual position in the local exchange for performing certain tests upon impulsing apparatus in a distant exchange by way of a trunk line extending between the distant exchange and the local exchange.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and a transmitter operative to transmit impulses, a subscriber line extending to said subscriber substation, a plurality of first testing units, each of said first testing units being operative to test a transmitter associated therewith, a plurality of second testing units, each of said second testing units being operative to test a subscriber line associated therewith, said first testing units and said second testing units being arranged in associated pairs, means controlled by initial operation of said switch for associating said telephone instrument and said transmitter

with said subscriber line, means controlled by initial operation of said transmitter for associating said subscriber line with an idle one of said first testing units, means controlled when said subscriber line is associated with said one first testing unit for rendering busy said one first testing unit and the associated one of said second testing units, means controlled by further operation of said transmitter for operating said one first testing unit, switching means operative to associate said one first testing unit with said one second testing unit, and means controlled by another operation of said switch for disassociating said telephone instrument and said transmitter from said subscriber line and for operating said switching means and for operating said one second testing unit.

2. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and a transmitter operative to transmit impulses, a subscriber line extending to said subscriber substation, a first testing unit operative to test a transmitter associated therewith, a second testing unit operative to test a subscriber line associated therewith, means controlled by initial operation of said switch for associating said telephone instrument and said transmitter with said subscriber line, means controlled by initial operation of said transmitter for associating said subscriber line with said first testing unit, means controlled by further operation of said transmitter for operating said first testing unit, switching means operative to associate said first testing unit with said second testing unit, and means controlled by another operation of said switch for disassociating said telephone instrument and said transmitter from said subscriber line and for operating said switching means and for operating said second testing unit.

3. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and a transmitter operative to transmit impulses, a subscriber line extending to said subscriber substation, a first testing unit operative to test a transmitter associated therewith, a second testing unit operative to test a subscriber line associated therewith, means controlled by initial operation of said switch for associating said telephone instrument and said transmitter with said subscriber line, means controlled by initial operation of said transmitter for associating said subscriber line with said first testing unit, means controlled by further operation of said transmitter for operating said first testing unit, means operative to transmit a signal over said subscriber line to said subscriber substation indicative of the tested condition of said transmitter, means governed by the operation of said first testing unit for controlling the operation of said last-mentioned means, switching means operative to associate said first testing unit with said second testing unit, means controlled by another operation of said switch for disassociating said telephone instrument and said transmitter from said subscriber line and for operating said switching means and for operating said second testing unit, means controlled by further operation of said switch for again associating said telephone instrument and said transmitter with said subscriber line, additional means operative to transmit a signal over said subscriber line to said subscriber substation indicative of the tested condition of said subscriber line, and means governed

by the operation of said second testing unit for controlling the operation of said additional means.

4. In a signaling system, a device operative to transmit impulses, a line extending to said device, a plurality of first testing units, each of said first testing units being operative to test a device associated therewith, a plurality of second testing units, each of said second testing units being operative to test a line associated therewith, said first testing units and said second testing units being arranged in associated pairs, means operative to associate said device with said line, means operative to associate said line with an idle one of said first testing units, means controlled when said subscriber line is associated with said one first testing unit for rendering busy said one first testing unit and the associated one of said second testing units, means controlled by the operation of said device for operating said one first testing unit, switching means operative to associate said one first testing unit with said one second testing unit, and means operative to disassociate said device from said line and to operate said switching means and to operate said one second testing unit.

5. In a signaling system, a device operative to transmit impulses, a line extending to said device, a first testing unit operative to test a device associated therewith, a second testing unit operative to test a line associated therewith, means operative to associate said device with said line, means operative to associate said line with said first testing unit, means controlled by the operation of said device for operating said first testing unit, switching means operative to associate said first testing unit with said second testing unit, and means operative to disassociate said device from said line and to operate said switching means and to operate said second testing unit.

6. In a signaling system, a device operative to transmit impulses, a line extending to said device, a first testing unit operative to test a device associated therewith, a second testing unit operative to test a line associated therewith, means operative to associate said device with said line, means operative to associate said line with said first testing unit, means controlled by the operation of said device for operating said first testing unit, means operative to transmit a signal over said line indicative of the tested condition of said device, means governed by the operation of said first testing unit for controlling the operation of said last-mentioned means, switching means operative to associate said first testing unit with said second testing unit, means operative to disassociate said device from said line and to operate said switching means and to operate said second testing unit, additional means operative to transmit a signal over said line indicative of the tested condition of said line, and means governed by the operation of said second testing unit for controlling the operation of said additional means.

7. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to faults thereon, a testing unit operative to test for a fault on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, and means

controlled by further operation of said substation equipment for operating said testing unit.

8. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to different types of faults thereon, a testing unit operative to test for the different types of faults on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, means controlled by further operation of said substation equipment for operating said testing unit, and means controlled by said testing unit in the event said subscriber line is tested as having a particular type of fault thereon for transmitting a signal over said subscriber line to said subscriber substation indicative of the particular type of fault on said subscriber line.

9. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to different types of faults thereon, a testing unit operative to test for the different types of faults on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, means controlled by further operation of said substation equipment for operating said testing unit, a source of tone current, and means controlled by said testing unit in the event said subscriber line is tested as having a particular type of fault thereon for transmitting a number of splashes of tone current from said source over said subscriber line to said subscriber substation indicative of the particular type of fault on said subscriber line.

10. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line having two line conductors extending to said subscriber substation, said subscriber line being subject to different types of faults thereon including ground and battery faults on the line conductors thereof and cross connection faults between the line conductors thereof, a testing unit operative to test for the different types of faults on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, means controlled by further operation of said substation equipment for operating said testing unit, and means controlled by said testing unit in the event said subscriber line is tested as having a particular type of fault thereon for transmitting a signal over said subscriber line to said subscriber substation indicative of the particular type of fault on said subscriber line.

11. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to faults thereon, a testing unit operative to test for a fault on a subscriber line associated therewith, means controlled by an initial operation of said switch and an operation of said transmitter for associating said subscriber

line with said testing unit, and means controlled by a further operation of said switch for operating said testing unit.

12. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to faults thereon, a plurality of testing units, each of said testing units being operative to test for a fault on a subscriber line associated therewith, a switch train having access to said testing units, means controlled by an initial operation of said substation equipment for associating said subscriber line with said switch train, means controlled by another operation of said substation equipment for causing said switch train to select an idle one of said testing units, means controlled when said one testing unit is selected for rendering busy said one testing unit, and means controlled by further operation of said substation equipment for operating said one testing unit.

13. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending to said subscriber substation and subject to faults thereon, a plurality of testing units, each of said testing units being operative to test for a fault on a subscriber line associated therewith, a switch train having access to said testing units, means controlled by an initial operation of said switch for associating said telephone instrument and said transmitter with said subscriber line and for associating said subscriber line with said switch train, means controlled by an operation of said transmitter for causing said switch train to select an idle one of said testing units, means controlled when said one testing unit is selected for rendering busy said one testing unit, means controlled by another operation of said switch for disassociating said telephone instrument and said transmitter from said subscriber line and for initiating operation of said one testing unit, means controlled by a further operation of said switch for again associating said telephone instrument and said transmitter with said subscriber line, and means controlled by said one testing unit in the event said subscriber line is tested as having a fault thereon for transmitting a signal over said subscriber line to said telephone instrument.

14. In a telephone system, an exchange, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending between said exchange and said subscriber substation and subject to faults thereon, a testing unit at said exchange operative to test for a fault on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, means controlled by further operation of said substation equipment for operating said testing unit, a device at said exchange operative to associate with said testing unit apparatus simulating a subscriber line having a fault thereon, and means at said exchange operative to simulate the operations of said substation equipment, thereby to test said testing unit.

15. In a telephone system, an exchange, a sub-

scriber substation provided with substation equipment including a telephone instrument and a telephone switch and an impulse transmitter, a subscriber line extending between said exchange and said subscriber substation and subject to different types of faults thereon, a testing unit at said exchange operative to test for the different types of faults on a subscriber line associated therewith, means controlled by initial operation of said substation equipment for associating said subscriber line with said testing unit, means controlled by further operation of said substation equipment for operating said testing unit, a device at said exchange selectively operative to associate with said testing unit different apparatus simulating a subscriber line having different types of faults thereon, and means at said exchange operative to simulate the operations of said substation equipment, thereby to test said testing unit.

16. In a telephone system, a subscriber substation, a subscriber line extending to said subscriber substation and subject to a number of different types of faults thereon, a testing unit operative automatically to test successively for the different types of faults on a subscriber line associated therewith, means controllable from said subscriber substation for associating said subscriber line with said testing unit, additional means controllable from said subscriber substation for initiating operation of said testing unit, means included in said testing unit and operative in response to the test of said subscriber line as having a particular type of fault thereon for arresting further operation of said testing unit, and means controlled by the operation of said last-mentioned means for transmitting a signal over said subscriber line indicative of the particular type of fault on said subscriber line.

17. In a telephone system, a subscriber substation, a subscriber line extending to said subscriber substation and subject to a number of different types of faults thereon, a testing unit including a test relay and a circuit network, said testing unit being operative automatically through a cycle to complete successively a number of test circuits each including said test relay and a subscriber line connected to said testing unit and a portion of said circuit network, thereby to test successively for the corresponding types of faults on the subscriber line connected to said testing unit, means controllable from said subscriber substation for connecting said subscriber line to said testing unit, additional means controllable from said subscriber substation for initiating operation of said testing unit, and means controlled by said test relay in response to the test of said subscriber line as having a particular type of fault thereon for arresting the operation of said testing unit prior to the completion of said cycle, thereby to indicate the particular type of fault on said subscriber line.

18. In a telephone system, a subscriber substation, a subscriber line extending to said subscriber substation and subject to a number of different types of faults thereon, a testing unit operative automatically through a cycle to perform successively a number of different tests for the corresponding different types of faults on a subscriber line associated therewith, means controllable from said subscriber substation for associating said subscriber line with said testing unit, additional means controllable from said subscriber substation for initiating operation of

said testing unit, means for arresting the operation of said testing unit upon the completion of said cycle, and additional means operative in response to the test of said subscriber line as having a particular type of fault thereon by said testing unit for arresting the operation of said testing unit prior to the completion of said cycle, thereby to indicate the particular type of fault on said subscriber line.

19. In a telephone system, a subscriber substation, a subscriber line extending to said subscriber substation and subject to a number of different types of faults thereon, a testing unit operative automatically through a cycle to perform successively a number of different tests for the corresponding different types of faults on a subscriber line associated therewith, means controllable from said subscriber substation for associating said subscriber line with said testing unit, a timer, additional means controllable from said subscriber substation for initiating operation of said testing unit and for setting said timer into operation, means for arresting the operation of said testing unit upon the completion of said cycle, additional means operative in response to the test of said subscriber line as having a particular type of fault thereon by said testing unit for arresting the operation of said testing unit prior to the completion of said cycle, and means controlled jointly by a predetermined operation of said timer and the operation of said last-mentioned means for transmitting a signal over said subscriber line indicative of the particular type of fault on said subscriber line.

20. In a signaling system, a line subject to a number of different types of faults thereon, a testing unit operative automatically through a cycle to perform successively a number of different tests for the corresponding different types of faults on a line associated therewith, means including an automatic switch operative to associate said line with said testing unit, means for operating said automatic switch, first and second timers, means for initiating operation of said testing unit and for setting said timers into operation, means for arresting the operation of said testing unit upon the completion of said cycle, additional means operative in response to the test of said line as having a particular type of fault thereon by said testing unit for arresting the operation of said testing unit prior to the completion of said cycle, means controlled jointly by a predetermined operation of said first timer and the operation of said last-mentioned means for transmitting a signal over said line indicative of the particular type of fault on said line, and means controlled by a predetermined operation of said second timer for releasing said automatic switch.

21. In an electric control system, a control unit comprising first and second busses, a number of control devices, circuits for energizing said devices including contacts and extending between said busses, a source of direct current having positive and negative source of direct current having positive and negative terminals, apparatus operative through a cycle respectively to connect the positive and the negative terminals of said source of current to said first and second busses and then respectively to connect the negative and the positive terminals of said source of current to said first and second busses, thereby to reverse the direction of current flow in said circuits in order to minimize corrosion of said contacts, a device operative to initiate operation of

said unit, and means controlled by the operation of said device a predetermined number of times for operating said apparatus through one cycle of operation.

22. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to perform a first test on a transmitter associated therewith, a plurality of testing units, each of said testing units being operative to perform a second test on a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with an idle one of said testing units, means controlled when said device is associated with said one testing unit for rendering busy said one testing unit, means included in said one testing unit operative to test the idle or busy condition of said apparatus, means controlled by another operation of said transmitter for operating said last-mentioned means, means for associating said one testing unit with said apparatus in the event said apparatus is tested idle, means controlled when said one testing unit is associated with said apparatus for rendering busy said apparatus, and means controlled by further operation of said transmitter for operating substantially simultaneously said apparatus and said one testing unit.

23. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, a testing unit operative to test the impulsing speed of a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said testing unit, switching means operative to associate said apparatus with said testing unit, means controlled by another operation of said transmitter for operating said switching means, and means controlled by further operation of said transmitter for operating said testing unit and for operating said apparatus in the event said switching means is operated.

24. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to perform a first test on a transmitter associated therewith, a testing unit operative to perform a second test on a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said testing unit, switching means operative to associate said apparatus with said testing unit, means controlled by another operation of said transmitter for operating said switching means, and means controlled by further operation of said transmitter for operating said testing unit and for operating said apparatus in the event said switching means is operated.

25. In a signaling system, a device operative to transmit impulses, apparatus operative to perform a first test on a device associated therewith, a plurality of testing units, each of said testing units being operative to perform a second test on a device associated therewith, means for associating said device with an idle one of said testing units, means controlled when said device is associated with said one testing unit for rendering busy said one testing unit, means included in said one testing unit operative to test the idle or busy condition of said apparatus, means for controlling the operation of said last-mentioned means, means for

associating said one testing unit with said apparatus in the event said apparatus is tested idle, means controlled when said one testing unit is associated with said apparatus for rendering busy said apparatus, and means controlled by an operation of said device for operating substantially simultaneously said apparatus and said one testing unit.

26. In a signaling system, a device operative to transmit impulses, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a device associated therewith, a testing unit operative to test the impulsing speed of a device associated therewith, means for associating said device with said testing unit, switching means operative to associate said apparatus with said testing unit, means governed by the operation of said device for controlling the operation of said switching means, and additional means controlled by an operation of said device for operating said testing unit and for operating said apparatus in the event said switching means is operated.

27. In a signaling system, a device operative to transmit impulses, apparatus operative to perform a first test on a device associated therewith, a testing unit operative to perform a second test on a device associated therewith, means for associating said device with said testing unit, switching means operative to associate said apparatus with said testing unit, means governed by the operation of said device for controlling the operation of said switching means, and additional means controlled by the operation of said device for operating said testing unit for operating said apparatus in the event said switching means is operated.

28. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said apparatus, and means controlled by further operation of said transmitter for operating said apparatus.

29. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said apparatus, and means controlled by a repeated further operation of said transmitter for operating repeatedly said apparatus, thereby to check the operation of said transmitter.

30. In a telephone system, a subscriber substation including a telephone instrument and a transmitter operative to transmit impulses, a test position including a telephone instrument and apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said apparatus, means controlled by further operation of said transmitter for operating said apparatus, and means at said test position operative to establish a communication connection between said telephone instruments.

31. In a telephone system, a subscriber sub-

station including a transmitter operative to transmit impulses, a plurality of circuits, means controlled by initial operation of said transmitter for selecting an idle one of said circuits and for associating said transmitter therewith, means controlled when said one circuit is selected for rendering busy said one circuit, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, additional means controlled by initial operation of said transmitter for testing the idle or busy condition of said apparatus, means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, and means controlled by further operation of said transmitter for operating said apparatus.

32. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, a plurality of circuits, means controlled by an initial operation of said transmitter for selecting an idle one of said circuits and for associating said transmitter therewith, means controlled when said one circuit is selected for rendering busy said one circuit, apparatus operative to test a transmitter associated therewith, means controlled by another operation of said transmitter for testing the idle or busy condition of said apparatus, means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, and means controlled by a further operation of said transmitter for operating said apparatus.

33. In a telephone system, a subscriber substation including a transmitter operative to transmit impulses, apparatus operative to test the impulsing speed of a transmitter associated therewith, means controlled by initial operation of said transmitter for associating said transmitter with said apparatus, means controlled by further operation of said transmitter for operating said apparatus, a source of tone current, and means controlled by the operation of said apparatus for transmitting a number of splashes of tone current from said source to said subscriber substation dependent upon and indicative of the tested impulsing speed of said transmitter.

34. In a signaling system, a device operative to transmit impulses, a plurality of circuits, means for associating said device with an idle one of said circuits, means controlled when said device is associated with said one circuit for rendering busy said one circuit, apparatus operative to determine the relationship between the make contact and the break contact of the impulses of a device associated therewith, said one circuit including impulse responsive means operative to test the idle or busy condition of said apparatus and means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, and means controlled by an operation of said device for operating said apparatus.

35. In a signaling system, a device operative to transmit impulses, a plurality of circuits, means for associating said device with an idle one of said circuits, means controlled when said

device is associated with said one circuit for rendering busy said one circuit, apparatus operative to test a device associated therewith, said one circuit including impulse responsive means operative to test the idle or busy condition of said apparatus and means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, and means controlled by a repeated operation of said device for operating repeatedly said apparatus, thereby to check the operation of said device.

36. In a signaling system, a device operative to transmit impulses, a plurality of circuits, means for associating said device with an idle one of said circuits, a test position including apparatus operative to test a device associated therewith, means controlled when said device is associated with said one circuit for rendering busy said one circuit and for transmitting a first signal to said test position, said one circuit including impulse responsive means operative to test the idle or busy condition of said apparatus and means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus and for transmitting a second signal to said test position, and means controlled by an operation of said device for operating said apparatus.

37. In a signaling system, a device operative to transmit impulses, a plurality of circuits, means for connecting said device to an idle one of said circuits, means controlled when said device is connected to said one circuit for rendering busy said one circuit, a test position including apparatus operative to test a device connected thereto, a trunk extending to said test position, said one circuit including impulse responsive means operative to test the idle or busy condition of said trunk and means operative to connect said one circuit to said trunk in the event said trunk is tested idle, means controlled when said one circuit is connected to said trunk for rendering busy said trunk, means at said test position operative to connect said apparatus to said trunk, and means controlled by an operation of said device for operating said apparatus.

38. In a signaling system, a device operative to transmit impulses, a plurality of circuits, means for associating said device with an idle one of said circuits, means controlled when said device is associated with said one circuit for rendering busy said one circuit, apparatus operative to test a device associated therewith, a trunk associated with said apparatus, each of said circuits including a switching relay for controlling the association of the circuit with said trunk and an impulse responsive switch for controlling the switching relay, means governed when the switching relay of said one circuit is controlled for preventing the control of the switching relays of the other of said circuits, and means controlled by an operation of said device for operating said apparatus.

39. In a telephone system, a distant exchange including a device operative to transmit impulses, a local exchange including a manual position and a plurality of circuits and apparatus operative to test a device associated therewith, a trunk line extending between said exchanges and terminating at said manual position, means for associating said device with said trunk line, means

at said manual position for selecting an idle one of said circuits, means controlled when said one circuit is selected for rendering busy said one circuit, said one circuit including means operative to test the idle or busy condition of said apparatus, means at said manual position for controlling the operation of said last-mentioned means, means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle, means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, means at said manual position operative to associate said trunk line with said one circuit, and means controlled by the operation of said device for operating said apparatus.

40. In a telephone system, a distant exchange including a device operative to transmit impulses, a local exchange including a manual position and a plurality of circuits and apparatus operative to test a device associated therewith, a trunk line extending between said exchanges and terminating at said manual position, trunks associated with said circuits and terminating at said manual position, means for associating said device with said trunk line, means at said manual position for selecting an idle one of said trunks associated with an idle one of said circuits, means controlled when said one trunk is selected for rendering busy said one trunk, said one circuit including impulse responsive means operative to test the idle or busy condition of said apparatus, means including an impulse transmitter at said manual position for controlling the operation of said last-mentioned means over said one trunk, said one circuit including means operative to associate said one circuit with said apparatus in the event said apparatus is tested idle and means controlled when said one circuit is associated with said apparatus for rendering busy said apparatus, means at said manual position operative to associate said trunk line with said one trunk, and means controlled by the operation of said device for operating said apparatus.

41. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and a transmitter operative to transmit impulses, a subscriber line extending to said subscriber substation, apparatus operative to test the relationship between the make contact and the break contact of the impulses of a transmitter associated therewith, a first testing unit operative to test the impulsing speed of a transmitter associated therewith, a second testing unit operative to test a subscriber line associated therewith, means controlled by initial operation of said switch for associating said telephone instrument and said transmitter with said subscriber line, means controlled by initial operation of said transmitter for associating said subscriber line with said first testing unit, first switching means operative to associate said apparatus with said first testing unit, means controlled by another operation of said transmitter for operating said first switching means, means controlled by further operation of said transmitter for operating said first testing unit and for operating said apparatus in the event said first switching means is operated, second switching means operative to associate said first testing unit with said second testing unit, and means controlled by another operation of said switch for disassociating said telephone instrument and said transmitter from said subscriber line and

for operating said second switching means and for operating said second testing unit.

42. In a signaling system, a device operative to transmit impulses, a line extending to said device, apparatus operative to perform a first test upon a device associated therewith, a first testing unit operative to perform a second test upon a device associated therewith, a second testing unit operative to test a line associated therewith, means operative to associate said device with said line, means operative to associate said line with said first testing unit, first switching means operative to associate said apparatus with said first testing unit, means operative to control the operation of said first switching means, means controlled by the operation of said device for operating said first testing unit and for operating said apparatus in the event said first switching means is operated, second switching means operative to associate said first testing unit with said second testing unit, and means operative to disassociate said device from said line and to operate said second switching means and to operate said second testing unit.

43. In a telephone system, a subscriber substation provided with substation equipment including a telephone instrument and a telephone switch and a transmitter operative to transmit impulses, a subscriber line extending to said subscriber substation, a plurality of first testing units, each of said first testing units being operative to test a transmitter associated therewith, a plurality of second testing units, each of said second testing units being operative to test a subscriber line associated therewith, said first testing units and said second testing units being arranged in associated pairs, a switch train having access to said first testing units and to said second testing units, means controlled by initial operation of said substation equipment for associating said transmitter with said subscriber line and for associating said subscriber line with said switch train, means controlled by a first initial operation of said transmitter for causing said switch train to select an idle one of said first testing units, means controlled when said one first testing unit is selected for rendering busy said one first testing unit and the associated one of said second testing units, means controlled by further operation of said transmitter for operating said one first testing unit, switching means operative to associate said one first testing unit with said one second testing unit, means controlled by a second initial operation of said transmitter for causing said switch train to select an idle one of said second testing units, means controlled when said one second testing unit is selected for rendering busy said one second testing unit and the associated one of said first testing units, means controlled by another operation of said substation equipment following said first initial operation and said further operation of said transmitter for disassociating said transmitter from said subscriber line and for operating said switching means and for operating said one second testing unit, and means controlled by another operation of said substation equipment following said second initial operation of said transmitter for disassociating said transmitter from said subscriber line and for operating said second testing unit.

44. In a signaling system, a device operative to transmit impulses, a line extending to said device, a first testing unit operative to test a device associated therewith, a second testing unit

operative to test a line associated therewith, a switch train having access to said first testing unit and to said second testing unit, means operative to associate said device with said line and to associate said line with said switch train, means controlled by a first initial operation of said device for causing said switch train to select said first testing unit, means controlled when said one first testing unit is selected for rendering busy said first testing unit and said second testing unit, means controlled by further operation of said transmitter for operating said first testing unit, switching means operative to associate said first testing unit with said second testing unit, means controlled by a second initial operation of said transmitter for causing said switch train to select said second testing unit, means controlled when said second testing unit is selected for rendering busy said second testing unit and said first testing unit, means controlled by another operation of said substation equipment following said first initial operation and said further operation of said transmitter for disassociating said transmitter from said subscriber line and for operating said switching means and for operating said second testing unit, and means controlled by another operation of said substation equipment following said second initial operation of said transmitter for disassociating said transmitter from said subscriber line and for operating said second testing unit.

45. In a telephone system, a distant exchange including a first device operative to transmit impulses, a local exchange including a manual position, a trunk line extending between said exchanges and terminating at said manual position, a subscriber substation including a second device operative to transmit impulses, a subscriber line extending between said subscriber substation and said local exchange, a switch train at said local exchange, a testing unit operative

to test a device associated therewith and accessible to said manual position and to said switch train, means at said distant exchange operative to associate said first device with said trunk line, means at said manual position operative to associate said trunk line with said testing unit in the event said testing unit is idle, means controlled when said trunk line is associated with said testing unit for rendering busy said testing unit, means at said subscriber substation operative to associate said second device with said subscriber line and to associate said subscriber line with said switch train, means operative to cause said switch train to associate said subscriber line with said testing unit in the event said testing unit is idle, means controlled when said subscriber line is associated with said testing unit for rendering busy said testing unit, and means controlled by the operation of either one of said devices for operating said testing unit.

46. In an electric control system, a test unit operative to test an associated piece of equipment and comprising first and second busses, a number of control devices, circuits for energizing said devices including contacts and extending between said busses, a source of direct current having positive and negative terminals, apparatus operative through a cycle respectively to connect the positive and the negative terminals of said source of current to said first and second busses and then respectively to connect the negative and the positive terminals of the said source of current to said first and second busses, thereby to reverse the direction of current flow in said circuits in order to minimize corrosion of said contacts, means for operating said test unit, and means controlled by the operation of said test unit a predetermined number of times for operating said apparatus through one cycle of operation.

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