

April 26, 1932.

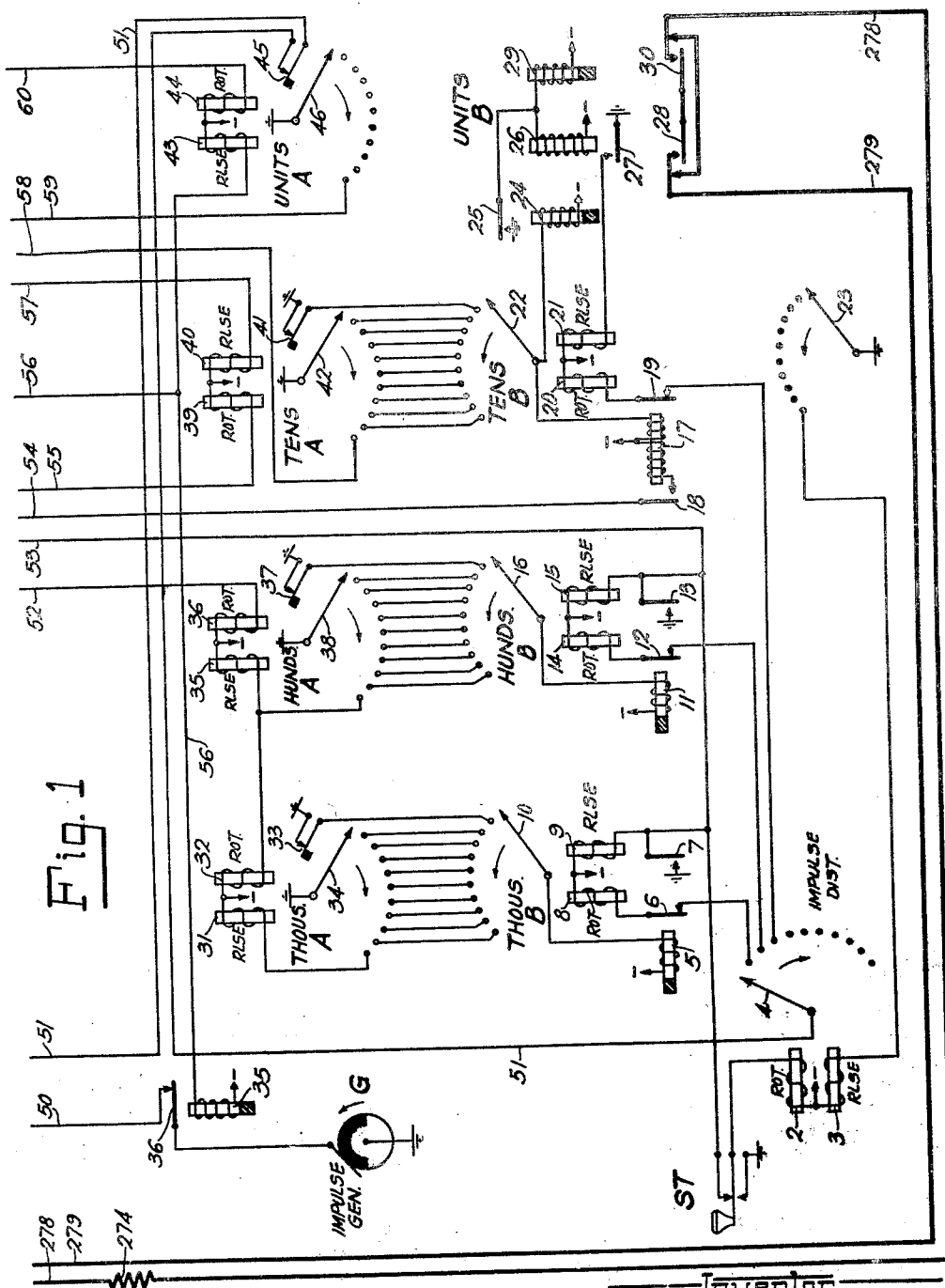
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1,855,852

TELEPHONE TESTING SYSTEM

Filed May 13, 1930

4 Sheets-Sheet 1



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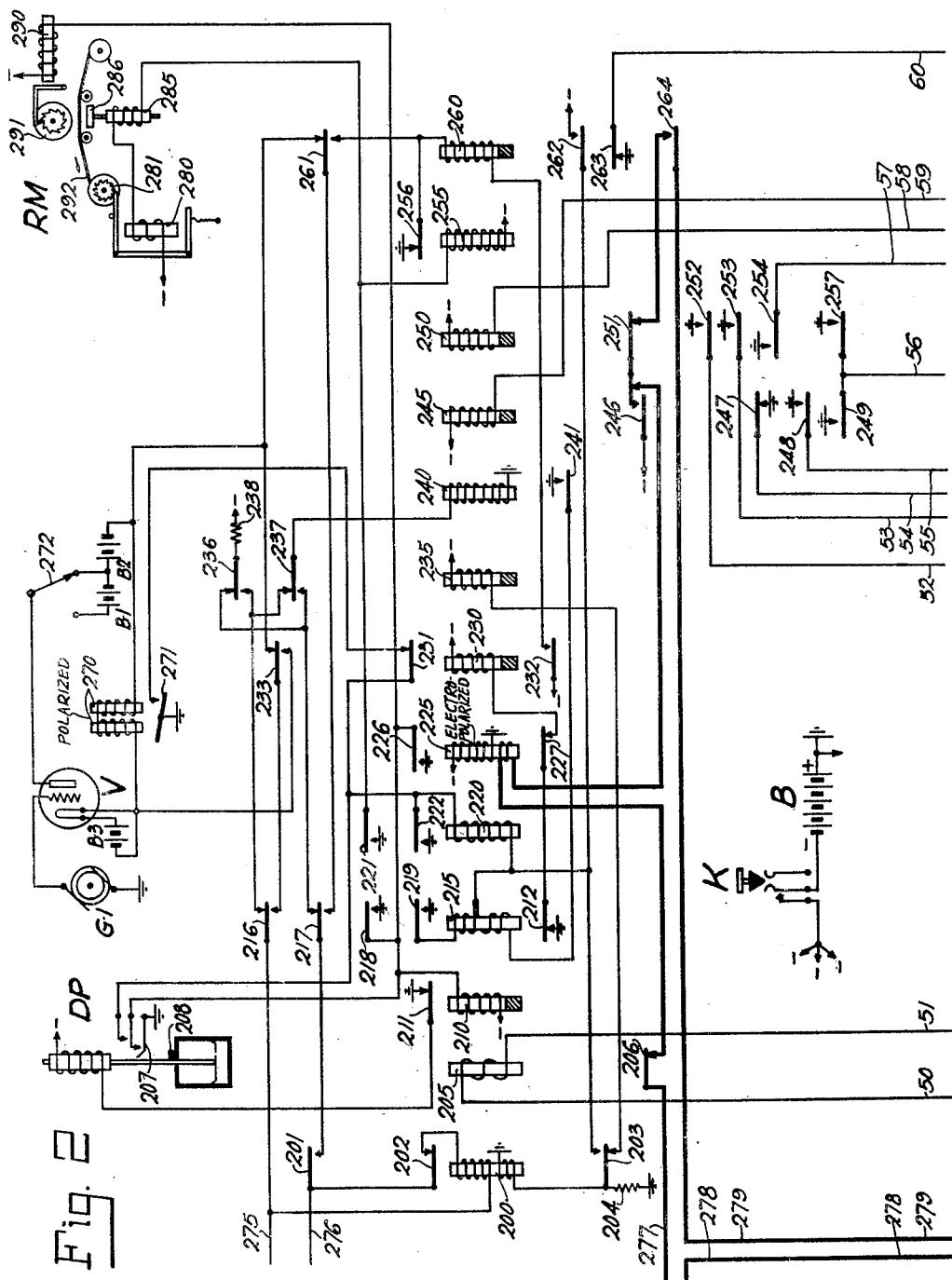
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4 Sheets-Sheet 2



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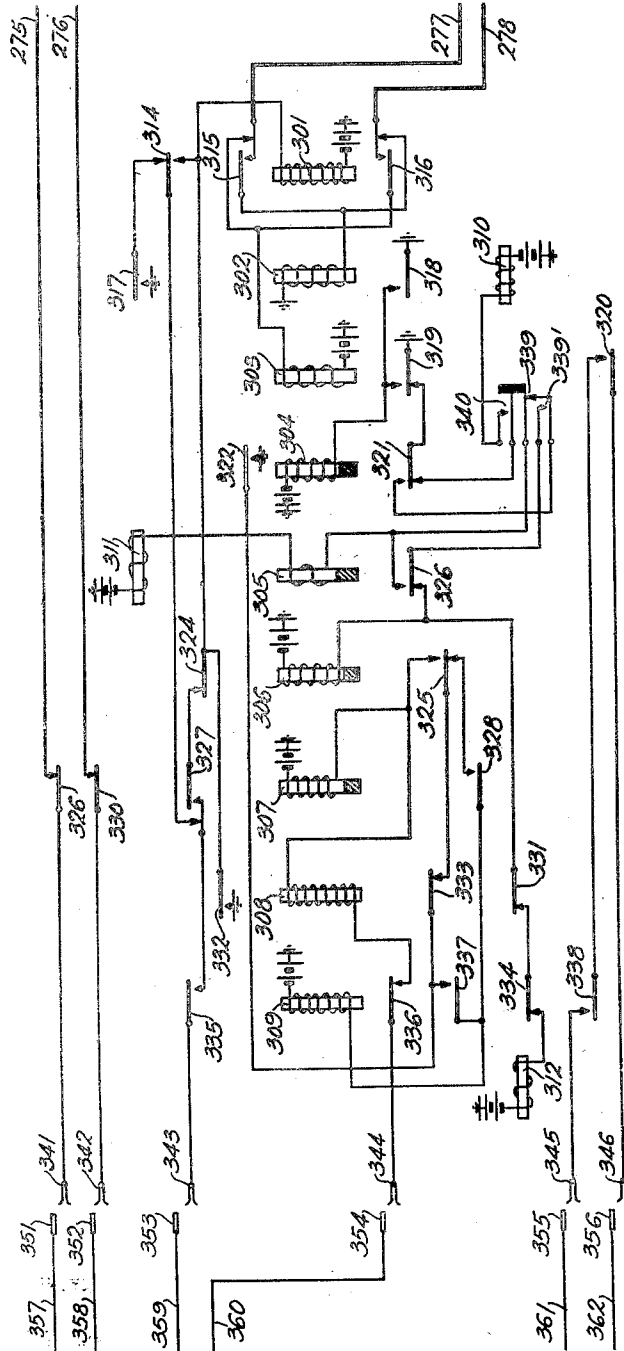
TELEPHONE TESTING SYSTEM

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Fig. 3

TD



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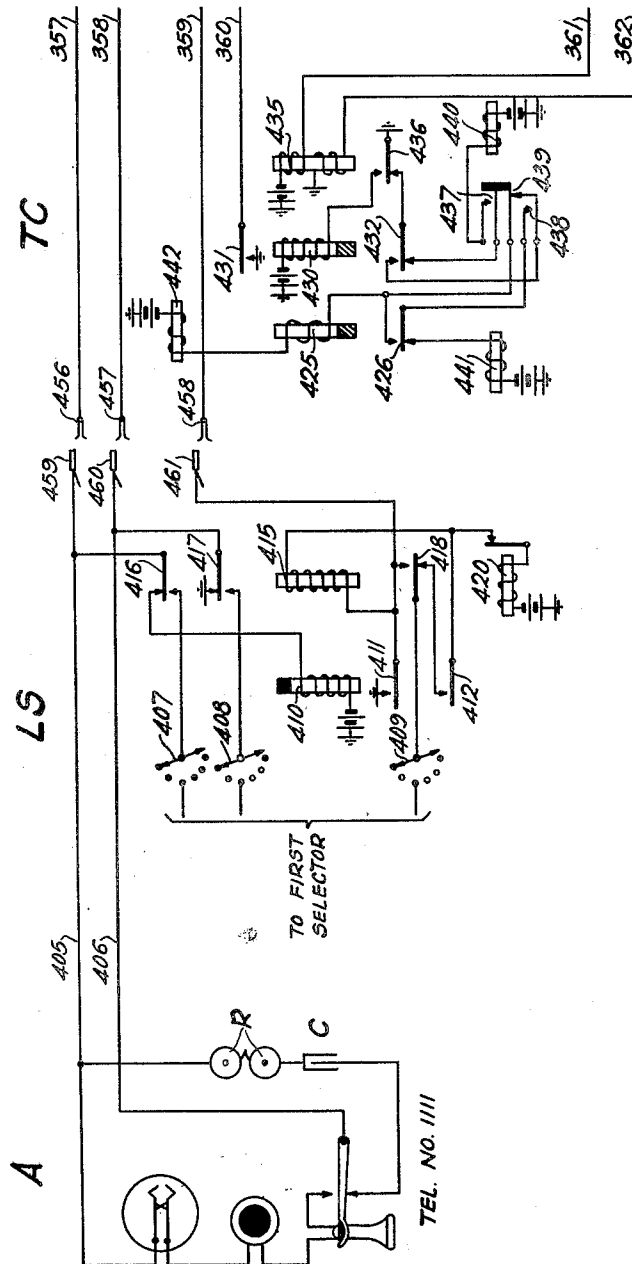
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Fig. 4



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UNITED STATES PATENT OFFICE

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TELEPHONE TESTING SYSTEM

Application filed May 13, 1930. Serial No. 452,065.

This invention relates in general to testing systems, but more particularly to testing circuits especially adapted for use in automatic telephone systems, and the principal object of the invention is the provision of means for automatically routine testing all of the subscribers' lines of a complete automatic telephone system.

A further object of the invention resides in the provision of means whereby the testing equipment is started to automatically test each of the subscribers' telephone lines in the system in sequence until all of the lines have been tested, whereupon the equipment automatically restores to normal.

In previous types of telephone testing systems, an attendant or wire chief of a telephone exchange was required to operate automatic switches to associate the testing equipment by means of his dial with each of the telephone lines in the exchange, and then manually test them for any trouble which may be on the line. In a system of this kind, considerable time and labor was consumed by the wire chief in testing the lines in the system, and in addition, it depended entirely upon the wire chief's judgment as to whether a line in the system required repairing or not.

It is an object of this invention to dispense with the necessary labor and manual testing equipment formerly required in the testing of telephone lines in the exchange, and provide a testing system whereby all of the selecting and testing functions are performed automatically without requiring any attention except to start the apparatus, the testing equipment being arranged to automatically test each line in the exchange successively before being released to normal.

In the former manual system of testing telephone lines, no provisions were made for automatically recording the number of a line which had been tested and found in operative condition. Likewise when a line had been tested and trouble encountered on it, no provisions were made for identifying this line. Accordingly, it is a further object of the invention to provide means whereby a permanent indication is given of the number

or code number of each line which has been tested and found in operative condition. Likewise, the number of each line which has been found to have a case of trouble on it, is automatically recorded so that an attendant at the exchange can, at any time, consult the record and note the numbers of the lines in trouble and send a repairman out to correct them.

A feature of the invention resides in the means whereby the lines are automatically and successively seized by the testing equipment, one at a time in numerical order, and then associated with the testing equipment which performs certain tests on them, so that when the test on one line has been completed, the equipment automatically functions to seize the next line and until all the lines in the system have been tested.

A further feature of the invention resides in providing a vacuum tube or three-element valve for detecting different kinds of trouble that may be encountered on a line to be tested, and operating the testing equipment in a manner to indicate the trouble.

Another feature of the invention resides in a recording mechanism comprising a meter for indicating the code or number of each line which has been tested, and providing a stamping relay for making an impression on a moving tape of the code or number of any line encountered which may be in trouble, so that a permanent record may be kept of all lines which are not in standard condition.

A number of other objects and features not specifically pointed out, will be described in detail by reference to the following detailed description, which together with the four sheets of drawings, constitutes the preferred embodiment of the invention.

The drawings are illustrated by means of the usual circuit diagrams in which Fig. 1 illustrates the line selecting equipment comprising a number of rotary switches, the upper row of switches being designated the "A" group or register switches, and the lower group the "B" group or counting switches. These switches are used for automatically associating the testing equipment with one line after another, and for operating the train of

automatic switches used in establishing the connection.

Fig. 2 illustrates another portion of the testing equipment comprising a group of relays which are operable to effect certain tests on the lines. In the upper right-hand corner of the drawings there is indicated the recording mechanism RM.

Fig. 3 shows a test distributor switch TD which is associated with the testing mechanism for selecting the particular group or groups of test connector switches which are used in establishing the test connections.

Fig. 4 shows a subscriber's telephone A and its associated lineswitch LS whereby this telephone may make connections with other telephones in the exchange or be connected with them. The test connector TC is one of a number which is adapted to be seized by the test distributor TD of Fig. 3 to connect with the line A.

Before proceeding with the detailed description of the operation of the system, a few general statements relating to the system as a whole will be made.

It will be assumed that the testing mechanism of Figs. 1 and 2 is adapted to perform the testing functions of an automatic telephone exchange comprising ten thousand subscribers' lines, and each of these lines will be automatically tested by the mechanism without the assistance of a wire chief or an attendant in any manner during the testing except to start the apparatus. In a ten thousand line capacity automatic system, it will require the dialling of four digits to reach any telephone over the automatic switches. There will, therefore, be 100 groups of regular connector switches, each group associated with 1000 subscribers' lines, and one test connector TC, Fig. 4, will be provided for each group of connectors as its bank contacts consist of 100 terminals, each of which are reached by a vertical and a rotary movement of the switch. There are, therefore, 100 test connectors. Since the test distributor TD of Fig. 3 has 100 contact sets and this switch is selectively controlled in both its vertical and rotary movements, all of the test connectors may be reached by way of this test distributor without any intervening switches. The bank contacts of the test connector TC are all multiplied with the regular connector switches in the group with which it is associated. Likewise, all the bank contacts of the test distributor are associated with all the test connectors in the system. Each test connector will likewise have access to one hundred lines which are multiplied throughout the regular connectors in the group. A further description of the trunking arrangement is thought to be unnecessary in view of the arrangement being well known in the automatic telephone art.

The switches illustrated in Figs. 3 and 4 are

of the well-known Strowger type of construction, the circuits only being shown, the mechanism having been eliminated in order to make the drawings clearer. Each of the rotary stepping switches shown in Fig. 1 is likewise well known and comprises a single level of ten bank contacts having a wiper which is adapted to rotate successively over the bank contacts under control of a rotary magnet by means of a pawl and ratchet. The wiper is restored to normal under control of a tensioned spring which is released by the release magnet withdrawing its pawl from the ratchet. Each of the upper row of stepping switches or A switches is provided with an off-normal spring which is adapted to open immediately when the wiper takes one step off of its normal position.

The testing mechanism shown in Figs. 1 and 2 may be mounted in any suitable type of cabinet, at any convenient position in the exchange, so that it can be accessible to the wire chief or attendant who may desire to supervise the testing. For this reason it is desirable to have all battery and ground connections disconnected from the apparatus and only connected up when the testing mechanism is to be used. A key K of Fig. 2 is therefore provided so that the operation of this key will connect negative battery through to all the various pieces of apparatus and relays shown in Figs. 1 and 2. In Figs. 3 and 4 the regular exchange battery will be assumed to be always connected up, and no key is provided to place this equipment in condition to be operated, it being assumed that it is directly connected to the battery of the telephone exchange. The first act of an attendant or wire chief, therefore, in preparing to test the telephone lines of the exchange, is to operate the key K to connect the battery to the testing mechanism.

The mechanism used for selecting the various telephone lines to be tested is shown in Fig. 1 and comprises the upper row of switches designated A which are used for registering the position of the particular automatic switches and the lines which are tested, and the lower row of switches designated "B", which operate to select the various switches and the lines. The impulse distributor, in the lower left-hand corner of the drawings, is for the purpose of automatically distributing impulses to the various "A" and "B" switches which are generated by the impulse generator G which commences to rotate at the time the key K is operated and generates impulses of a standard nature to operate the automatic switches.

A detailed description will first be given of the manner in which the testing mechanism operates the test distributor TD and selects the first thousands group of test connectors, then selects the first test connector TC in the hundreds group, and then the first

line or telephone number 1111 of the group by means of the switches A and B.

Referring to Fig. 1, the attendant to start the test operates the key K and connects battery to the testing mechanism. Relays 230, 235, 260, and others of Fig. 2 become energized and prepare to start the test on the first line after it has been seized as will be later on pointed out in detail. The start key ST, Fig. 1, is momentarily pressed. This completes a circuit extending from ground on the lower closed contacts of the start key ST, through the winding of the rotary magnet 2 of the impulse distributor switch to battery.

The rotary magnet 2 energizes and advances the wiper 4 onto the first bank contact which completes a circuit through this wiper extending from ground at the impulse generator G, armature 36 and its back contact, conductor 50, winding of relay 205, Fig. 2, conductor 51, normally-closed off-normal springs 45 of the units A switch, wiper 4, first bank contact upon which it is now resting, back contact and armature 6 of relay 5, through the winding of the rotary magnet 8 of the thous. B switch, to battery. The rotary magnet 8 energizes and the relay 205 energizes and subsequently deenergizes when the commutator of the impulse generator G strikes its insulated portion, thereby transmitting one impulse over the above-traced circuit. The rotary magnet 8 of the thous. B switch steps its wiper 10 on to its first bank contact thereby completing a circuit extending from ground through the normally-closed off-normal springs 33 of thous. A switch, first bank contact, wiper 10, through the winding of slow-release relay 5 to battery. Relay 5 upon energizing operates its armature 6, thereby opening the circuit of the rotary magnet 8 so that no further impulses from the impulse generator G can operate it. At front contact and armature 7, relay 5 places ground through the winding of release magnet 9 of the thous. B switch, thereby restoring the wiper 10 to its normal position again. A branch of this ground circuit from the front contact of armature 7, extends by way of the normally-closed contacts of the start key ST, through the winding of the rotary magnet 2 of the impulse distributor, to battery. The wiper 4 is thereby stepped on to its second bank contact. The wiper 10 after having been released by the release magnet 9, opens the circuit of the slow-release relay 5 which falls back slowly and restores its armatures to normal.

Impulses from the generator G now flow from ground, armature 36 and its back contact, conductor 50, winding of relay 205, conductor 51, off-normal springs 45, wiper 4, second bank contact upon which it is now resting, back contact and armature 12 of relay 11, through the winding of the rotary magnet 14 of the hund. B switch to battery. The

relay 205 is again energized, but this time in series with the rotary magnet 14, and the wiper 16 is stepped on to its first bank contact, whereupon a circuit is completed from ground through the off-normal springs 37, first bank contact of the hund. B switch, wiper 16, through the winding of slow-release relay 11 to battery. Relay 11 upon energizing at its back contact and armature 12, opens the energizing circuits of the rotary magnet 14 and relay 205 to prevent further impulses from the impulse generator G, from operating them. At front contact and armature 13, relay 11 places ground onto the release magnet 15, thereby restoring the wiper 16 of the hund. B switch to normal position. A branch of this grounded circuit from armature 13 extends again through the normally-closed contacts of the start key ST through the winding of the rotary magnet 2 to battery. The wiper 16 upon being restored opens the circuit of the slow-release relay 11 which thereupon slowly deenergizes and after an interval restores its armatures. During this interval, the ground from front contact and armature 13 operates the rotary magnet 2 and thereby steps its associated wiper 4 onto its third bank contact, whereupon an impulse of current from the impulse generator G will flow over the previously-traced circuit in series with the relay 205, off-normal springs 45 of the units A switch, wiper 4, third bank contact upon which it is resting, back contact and armature 19, through the winding of rotary magnet 20 of the tens B switch, to battery. The rotary magnet 20 and the relay 205 energize in series over this circuit, and the rotary magnet 20 moves the wiper 22 onto its first bank contact, thereby completing a circuit extending from ground on the off-normal contacts 41, first bank contact upon which wiper 22 is now resting, through the right-hand winding of relay 17 to battery. Relay 17 thereupon energizes and operates and completes a locking circuit for itself extending from battery through its high resistance left-hand winding, front contact and armature 18, conductor 54, armature 247 and its back contact to ground. Accordingly, relay 17 remains locked up over this circuit. At armature 19 and its back contact, relay 17 opens the original energizing circuit of the rotary magnet 20 and prevents further impulses from the impulse generator G from operating the magnet and also relay 205. The wiper 4 of the impulse distributor remains on its third bank contact.

A branch of the original energizing circuit of relay 17 extends from the wiper 22 through the winding of slow-release relay 24 to battery. Relay 24 upon operating closes its grounded front contact and armature 25, and completes a circuit through the windings of relays 26 and 29 in parallel to battery, whereupon both of these relays energize and op-

erate armature springs 28 and 30 and their associated alternate contacts without opening the circuit extending over conductors 278 and 279, for a purpose which will be later on apparent. Relay 26 places ground from its armature 27 and front contact, through the winding of the release magnet 21 to battery. The release magnet 21 upon operating restores the wiper 22 to its normal position to open the circuit of slow-release relay 24, which, upon restoring its armature 25, opens the multiple circuits of relay 26 and 29. Relay 26 immediately restores its armature 28, but relay 29 being slow-acting, will take longer to restore its armature 30, thereby providing a short interval during which the conductors 279 and 278 will be momentarily opened.

Referring now to the operation of relay 205, it will be remembered that this relay was energized and deenergized or received one impulse when the thous. B, hund. B, and tens B switches and relay 29 were operated. At its back contact and armature 206, relay 205 thereby opened the switch-operating loop circuit comprising conductors 277, 278, and 279, four times. This loop circuit is indicated in heavy lines and extends from ground, through the winding of line relay 302 of the test distributor switch TD, Fig. 3, normally-closed alternate contact of armature 316 of relay 301, conductor 278, Figs. 2 and 1, resistance 274, normally-closed alternate contacts of armatures 30 and 28 of relays 29 and 26, conductor 279, Fig. 2, armature and front contact 264 of relay 260 (this relay energized as soon as the key K operates), back contact and armature 251, normally-closed alternate contacts 246, lower winding of polarized relay 225, back contact and armature 206 of relay 205, conductor 277, Fig. 3, normally-closed alternate contacts 315 of relay 301, through the winding of relay 303 to battery.

The above-traced circuit indicated on the drawings in heavy lines is the circuit over which the switches such as the test distributor TD and all of the test connectors TC, are operated. As each of the three "B" switches have been operated once, the impulse relay 205 has likewise been operated three times and, consequently, its armature 206 and its back contact has interrupted the above-operating loop circuit three times. In addition to this, it will be remembered the relays 26 and 29 operated their armatures 28 and 30. Relay 26, when its circuit was opened, immediately fell back and opened its armature 28. Relay 29, however, being slow-acting slowly released its armature 30, thereby momentarily opening the operating loop circuit and transmitting an additional impulse over this loop circuit. As a ten-thousand-line system is assumed, the four impulses or digits will connect the test equipment over the automatic switches with the

subscriber's telephone A, number 1111, as will now be explained.

Briefly stated, due to the operation of the thous. B switch, the test distributor TD receives one impulse and moves its wipers one step vertically opposite its first level associated with the thousand group of test connectors. Due to the operation of the hund. B switch, the test distributor circuit was opened the second time, thereby rotating its wipers onto the first contact of the first level and connected the wipers to the test connector TC in the 1100 group of lines. When the tens B switch operated, test connector TC was operated and moved its wipers vertically opposite the first level associated with the lines 11 to 10, and when the operating loop circuit to the test distributor was again interrupted momentarily, due to the slow operation of relay 29, another impulse was transmitted over the loop circuit and the test connector operated its wipers in a rotary manner to connect with the first contact of the first level in the test connector bank which is the first telephone connected with in the exchange to be tested. This is telephone number 1111 or substation A, as indicated.

The manner in which the impulses received over the operating loop circuit 277 and 278 operate the test distributor TD and the test connector TC to connect with line number 1111, will now be pointed out in detail.

The operating loop circuit is initially closed because the operation of the battery key K and the resultant energization of slow-release relay 260 of Fig. 2 closes the loop circuit at its front contact and armature 264. The line relays 302 and 303 of the test distributor TD, therefore, energize and remain in this condition until the first impulse is received over the operating loop circuit 277 and 278. Relay 303, upon operating, closes a circuit for slow-release relay 304 at armature 319 and its front contact, and prepares the impulse-repeating circuit for the test connector TC, to be described later, at armature 320. Relay 302 also operates and closes an alternate circuit for the release relay 304 at its front contact and armature 318. The operation of armature 317 has no utility at this time. Slow-release relay 304 operates and at armature 321 prepares a circuit for the operating magnets of the switch.

The first impulse received over the operating loop circuit deenergizes relays 302 and 303, and relay 303, upon falling away, closes a circuit extending from grounded armature 319 and its back contact, armature 321 and its front contact, normally-closed off-normal springs 339, winding of slow-release series relay 305, through the winding of the vertical stepping magnet 311 to battery. Vertical magnet 311 operates and raises the wipers 341-346 of the test distributor TD one step opposite the first level of bank con-

tacts, at the same time permitting the closure of off-normal contacts 339' and opening the contacts 339. Slow-release relay 305 operates in this circuit and closes its front contact onto its armature 323, so that if further impulses in addition to the first one of this series are received, the vertical magnet continues to be operated over the initial circuit except that now it includes closed contacts 339' and armature 323, and relay 305 being slow-acting remains energized throughout the series of impulses, but as only one impulse has been received, relay 305 de-energizes and prepares a circuit for the rotary magnet 312 at armature 323 and its back contact. Relays 302, 303, and 304 again energize.

When the second impulse or second digit is received over the operating loop circuit, relay 303 again momentarily deenergizes and this time completes a circuit for the rotary stepping magnet 312 over a circuit extending from grounded armature 319 and its back contact, armature 321 and its front contact, closed off-normal springs 339', armature 323 and its back contact, armature 331 and its back contact, armature 334 and its back contact, and through the winding of the rotary magnet 312 to battery. Accordingly, the wipers 341-346, inclusive, of the switch TD are rotated horizontally one step onto the first set of bank contacts. If there were additional impulses in this series, the rotary magnet would continue to step the wipers across this level of bank contacts. A branch of the energizing circuit of the rotary magnet 312 extends through the winding of slow-release relay 303 to battery. This relay remains energized if there are any additional impulses in this series. At front contact of armature 325, relay 306 completes a circuit for relay 307 extending from grounded front contact and armature 322, armature 333 and its back contact, armature 325 and its front contact, through the winding of slow-release relay 307 to battery. Relay 307, upon operating, prepares a circuit for the relay 309 at armature 328, and disconnects the testing conductors 275 and 276 at the back contacts of armatures 326 and 330. Armature 324 of relay 306, and armature 327 of relay 307 have no utility at this time. The wipers of the test distributor TD are now resting on the first bank contact of the first level of the switch, which, in this case, is bank contacts 351 to 356, inclusive. Line relays 302 and 303, and 304 again energize, and after an interval relays 305 and 307 deenergize and release their armatures.

If the test connector TC is idle or not in use by a wire chief who may be at this time checking up for some trouble which has been found by the testing mechanism, there will be no ground on test bank contact 354, consequently, relay 308, which is the busy relay,

will not energize, and a circuit is thereby closed for relay 309 extending from grounded front contact and armature 322, armature 333 and its back contact, armature 325 and its back contact, front contact and armature 328, through the winding of relay 309 to battery. As relay 307 is slow acting, its armature 328 will remain closed for a sufficient length of time to enable this circuit to be completed. Relay 309 operates and opens another point in the circuit of the rotary magnet 312 at armature 334, and at armature 337 establishes a locking circuit for itself independent of armature 325, 333, and 328. At armature 335, it prepares a circuit for testing the subscriber's line for the busy or idle condition of it, which will be described more in detail later. At armature 336, it opens the connector test circuit and at armature 338 closes the impulse-repeating circuit for the test connector TC. This circuit includes armatures 338 and 320, wipers 345 and 346, bank contacts 355 and 356, conductors 361 and 362, and through the upper and lower windings of line relay 435 of test connector TC.

When line relay 435 of test connector TC is operated, it completes the circuit for slow-release relay 430 over an obvious circuit extending from armature 436 and its front contact. At front contact and armature 431 relay 430 places ground on test conductor 360 to guard the test conductor TC from seizure by any other test distributor which may be at this time operated by a wire chief. At front contact and armature 432, the circuit for vertical stepping magnet 442 is prepared.

The third impulse or digit is now received over the operating conductor loop circuit 277 and 278 and relays 302 and 303 again deenergize. Relays 306 and 307 are operated as previously described, but perform no useful function at this time. The circuit of the line relay 435 of test connector TC, however, is open each time the armature 320 falls back, if there is more than one impulse. Relay 435, therefore, deenergizes in synchronism with the deenergizations of line relay 303. Responsive to the first deenergization of line relay 435, it completes a circuit for the vertical stepping magnet 442 from ground on armature 436 and its back contact, armature 432 and its front contact, normally-closed off-normal springs 439, through the winding of slow-release series relay 425, and through the winding of vertical stepping magnet 442 to battery. In response to the energization of the vertical magnet 442, the wipers 456, 457, and 458 of the test connector TC are elevated one step opposite their first level of bank contacts, and at the same time the off-normal springs 438 close and 439 open. Relay 425 operates in this circuit, and prepares a circuit for any additional impulses for the vertical magnet at armature 426 and its front contact, and over off-normal con-

tacts 438 instead of 439. When the impulse of current is terminated over operating loop circuits 277 and 278, line relay 302 and 435 again energize and a short time afterwards relay 425 deenergizes and prepares a circuit for the rotary stepping magnet 441.

When the fourth impulse or digit is received over the operating loop circuit, relay 303 again repeats the impulse at armature 320 for the line relay 435, which, upon restoring its armature 436, completes a circuit for the rotary stepping magnet 441 from grounded armature 436 and its back contact, armature 432 and its front contact, closed off-normal springs 438, armature 426 and its back contact, and through the winding of rotary stepping magnet 441 to battery. The rotary magnet upon operating advances the wipers 456, 457, and 458 in a rotary manner one step onto the first set of bank contacts in the first level of the connector TC, corresponding to bank contacts 459, 460, and 461, which extend to the lineswitch LS and the subscriber's station A.

If the substation A is not at this time in a busy condition, the wiper 458 upon coming to rest on bank contact 461, completes a circuit extending from battery through the winding of rotary magnet 420 and its interrupter contacts 421, winding of switching relay 415, bank contact 461 and wiper 458, conductor 359, bank contact 353 and wiper 343, armature 335 and its front contact, closed contacts of armature 327, armature 314 and its back contact, to ground on the front contact of armature 317. Relay 415 energizes in the circuit, but due to its resistance the rotary magnet 420 does not. Relay 415, upon operating, opens the back contacts from armatures 416, 417, and 418, but due to an interlocking arrangement controlled by relay 410, the front contacts of the armatures are not closed to the lineswitch wipers 407, 408, and 409, which are arranged to automatically hunt for an idle trunk leading to a first selector connected to their bank contacts, when the substation A is calling. The line conductors 405 and 406 are thereby disconnected from the lineswitch LS and connected through to the testing apparatus of Fig. 2.

The test distributor TD and the test connector TC have now been positioned to connect with substation A or telephone number 1111, which is the first telephone in the first hundreds group of connectors and the first thousands group of lines. The telephone line conductors 405 and 406 are extended through the test connector TC over conductors 357 and 358, test distributor TD, conductors 275 and 276, to the testing equipment disclosed in Fig. 2. This equipment will then function to test the telephone line at substation A for cross connections, short circuits, grounds, etc., as will hereinafter be pointed out in detail, and after this line has been tested the

wipers of the test connector TC are rotated one step onto the next contact so as to connect with telephone number 1112, as will now be pointed out.

Each time a test has been completed on a particular line, relay 260 of Fig. 2 deenergizes and at its grounded back contact and armature 263 completes a circuit extending over conductor 60, through the winding of the rotary magnet 44 of the units A switch. The rotary magnet 44 upon energizing advances the wiper 46 onto the second bank contact, it having previously been positioned on the first bank contact immediately upon the battery key K becoming closed, and before relay 260 could become energized. At front contact and armature 264, relay 260 opens the operating loop circuit extending over conductors 277, 278, and 279. This transmits an impulse of current over the operating loop circuit and, therefore, deenergizes relay 303 which upon deenergizing opens its front contact and armature 320 to repeat the impulse of current to the line relay 435 of test connector TC. Relay 435 at its armature 436 transmits this impulse over previously-traced circuits to the rotary stepping magnet 441 which upon energizing rotates the wipers 456, 457, and 458 onto the next bank contact, so that a telephone line connected to this bank contact will be connected through the test connector TC, test distributor TD, direct to the testing equipment of Fig. 2, whereupon a test is performed on the line.

In this manner, as each telephone line is tested, the wipers of the test connector TC and the units A switch advance their wipers from contact to contact, relay 260 falling back each time a test has been completed so as to energize the rotary magnet 44 of the units A switch and advance wiper 46 to the next contact. After all ten telephone lines in the first level of the test connector TC have been tested, the units A switch will have advanced its wiper 46 onto its last bank contact, thereby completing a circuit extending from ground through wiper 46, its last bank contact, conductor 59, through the winding of slow-release relay 245 to battery. Relay 245, upon operating, closes its armature 246 onto its front contact, thereby connecting battery to one side of the operating loop circuit extending over armature 251 and its back contact, front contact and armature 264, before relay 260 can restore, conductor 279, Fig. 1, alternate closed contacts 28 and 30, conductor 278, compensating resistance 274, alternate closed contacts of armature 316 of the test distributor TD, through the winding of line relay 302 to ground, thereby maintaining this relay energized. At the alternate contacts of armature 246, the loop circuit is interrupted over conductor 277, through relay 225, armature 206 and its back contact,

alternate closed contacts of armature 315 and the line relay 303. The line relay 303, consequently, deenergizes, and upon falling away, opens its front contact from its armature 320, thereby opening the loop circuit extending through the line relay 435 of the test connector TC. Line relay 435 upon retracting its armature 436 extends ground from armature 436 and its back contact, armature 432 and its back contact, closed off-normal springs 437, and through the winding of the release magnet 440 to battery. Release magnet 440 upon operating restores the wipers 456, 457, and 458 of the test connector TC back to their normal position. In this manner, the test connector TC is released while the test distributor TD maintains its wipers connected with this connector.

As a further result of the energization of relay 245, ground is connected from its front contact and armature 249, conductor 56, through the winding of the release magnet 43 of the units A switch. The release magnet 43 upon operating restores the wiper 46 to its normal position and also closes off-normal contacts 45. A branch of this circuit extends over conductor 56, through the winding of slow-release relay 35 to battery. Relay 35 upon operating opens its armature 36 from its back contact to prevent further impulses from the impulse generator G from being extended to the impulsing relay 205 at this time. Relay 245 likewise, at its back contact and armature 247, removes ground from conductor 54, which at armature 18 locked up relay 17, and this relay thereby deenergizes. At grounded front contact of armature 248 it completes a circuit extending over conductor 55, through the winding of the rotary magnet 39, and battery of the tens A switch. This rotary magnet, upon operating, advances its wiper 42 upon its first bank contact. As soon as the wiper 46 of the units A switch releases, the circuit for relay 245 is interrupted and it slowly retracts its armatures, so that at armature 249 the circuit of relay 35 is opened and it closes its armature 36 onto its back contact to permit impulses to again flow. At armature 246, relay 245 again closes the operating loop circuit to the switch TD.

The wiper 4 of the impulse distributor, it will be recalled, is resting on its third bank contact, so that impulses from the impulse generator G now flow over the previously-traced circuit from armature 36 and its back contact, winding of relay 205, off-normal contacts 45, wiper 4, the third bank contact upon which it is now resting, back contact and armature 19, through the winding of rotary magnet 20 of the tens B switch to battery. Responsive to the first impulse from the impulse generator G, the rotary magnet 20 advances the wiper 22 one step onto the first bank contact. However, as the tens A switch has ad-

vanced its wiper 42 upon its first bank contact, the off-normal springs 41 will therefore be open, and as a result, the rotary magnet 20 receives an additional impulse from the impulse generator G so that the wiper 22 is stepped onto the second bank contact. In this position it closes a circuit extending from ground through wiper 42, the first bank contact upon which it is now resting, second bank contact and wiper 22, through the right-hand winding of relay 17 to battery. Relay 17, upon operating, closes its front contact and locks to armature 18 from ground over conductor 54 and armature 247. At armature 19, relay 17 opens the circuit for the rotary magnet 20, which thereupon restores the wiper 22 to its normal position.

The two impulses from the impulse generator G have also operated the relay 205 a corresponding number of times, which at its armature 206 opens the operating loop circuits 277 and 278 twice and thereby transmit two impulses to the line relay 203 of the test distributor TD, which at armature 320 repeats the impulses to the line relay 435 of test connector TC. Line relay 435 responding to the two impulses, operates the vertical magnet 442 of this switch in a manner to step up the wipers 456, 457, and 458 two steps so that they are now positioned opposite the second level of bank contacts in the connector TC.

A branch of the energizing circuit of relay 17 extends from wiper 22 of the tens B switch through the winding of slow-release relay 24 to battery. This relay, upon energizing, at its armature 25 closes a parallel circuit for relays 26 and 29, to battery. When the wiper 22 restores to normal, due to the operation of the release magnet 21 from armature 27, these relays deenergize and as has been explained, relay 26 immediately falls back while relay 29 being slow-acting slowly retracts its armature 30, thereby momentarily opening the loop operating circuits 278 and 279. This transmits an additional impulse over the operating loop circuit so that line relay 303 of the rest distributor TD again falls away and opens its armature 320, and the impulse will be repeated to the line relay 435 of the test connector. Relay 435 responding to this additional impulse operates the rotary magnet 441 of this switch, as has been explained, to rotate the wipers 456, 457, and 458 onto the first bank contact of the second level of the connector, or telephone line No. 1121.

The testing equipment of Fig. 2 then functions to test this line, and upon being tested the equipment is set to connect with and test the next line in the level. In this manner, all ten levels and ten lines in each level of the test connector TC are tested. The units A switch is stepped one step for each contact of the connector level which is tested, while the tens A switch steps one step for each level of the connector which is tested. The connector TC ro-

tates its wipers one step at a time across each level of bank contacts, and when it is to test the next level it releases to normal position and then is again operated by the equipment of Fig. 1.

The units B (relays 24, 26, and 29) and the tens B switches, it will be recalled, are also operated to set the connector switch, and when the tens B switch reaches its tenth bank contact, the auxiliary bank contact and wiper 23 completes the circuit to the release magnet 3 of the impulse distributor switch to restore its wiper 4 to normal position.

In response to the seizure of telephone line No. 1100, or the last line in the bank of the connector TC, and the testing of that line by the testing equipment, the tens A switch steps its wiper 42 onto its tenth bank contact. This completes a circuit extending from ground on wiper 42 of the tens A switch, its last bank contact, conductor 58, through the winding of slow-release relay 250, to battery. Relay 250 upon operating opens its back contact from armature 251, thereby producing a break in the operating loop circuit comprising conductors 277 and 278, to restore the test distributor TD to normal. As a result of the break in the operating loop circuit line, relays 302 and 303 of the test distributor TD restore. Slow-release relay 304 after a short interval likewise restores its armatures, and a circuit is thereby completed extending from ground on armature 319 and its back contact, armature 321 and its back contact, closed off-normal springs 340, through the winding of the release magnet 310, to battery. Release magnet 310, upon operating, restores the wipers 341-346, respectively, to normal position and the test distributor TD has now been released.

As a further result of the operation of slow-release relay 250, ground is extended from front contact and armature 257 of this relay, conductor 56, through the winding of slow-release relay 35, to battery. Relay 35 upon operating, at armature 36 opens the impulsing circuit to prevent further impulses from being generated. A branch of this circuit extends through release magnet 43 of the units A switch so that its wiper 46 is restored to normal. At front contact and armature 254, relay 250 extends ground over conductor 57 through the winding of the release magnet 40 to battery, of the tens A switch, so that the wiper 42 of the tens A switch is restored to normal. At grounded front contact and armature 252, ground is extended over conductor 52, through the winding of the rotary magnet 36 to battery, of the hunds. A switch. The rotary magnet 36 upon energizing moves the wiper 38 onto its first bank contact and this wiper extends ground through to the second bank contact of the hunds. B switch, so that wiper 16 will be grounded when the hunds. B switch is oper-

ated. At armature 253 and its grounded front contact, relay 250 extends ground over conductor 53, through the normally-closed contacts of the start key ST and the winding of the rotary magnet 2 of the impulse distributor, to battery. The ground over conductor 53 likewise extends in parallel to the release magnets 9 and 15 of the thous. B and hunds. B switches, however, without effect. After the above has taken place, slow-release relay 250 falls back, due to the opening of its circuit when wiper 42 of the tens A switch is restored.

The rotary magnet 2 upon operating rotates the wiper 4 of the impulse distributor onto its first bank contact. It will be recalled that the impulse distributor was restored to normal at the time the tens B switch had its wiper 23 rotated to the tenth contact so that the release magnet 3 of the impulse distributor was grounded and restored the impulse distributor to normal. As soon as the wiper 42 of the tens A switch is restored to normal, the circuit of relay 250 is interrupted and it slowly restores its armatures, thereby allowing relay 35 to again retract its armature 36 to close the impulse generating circuit from the impulse generator G. The impulses flowing from the generator G operate the B switches as before, but in this case, as the hunds. A switch wiper 38 has moved onto its first contact, the hunds. B switch will encounter ground from its wiper 16 at its second bank contact. As a result of this, the test distributor TD will be operated to raise its wipers as before one vertical step, but in this instance as two impulses are transmitted to operate the relay 205, the wipers are rotated onto the second bank contact so that the test distributor now has access to the twelve-hundred line group of test connectors. The tens B switch and the units B group of relays likewise, each permit one impulse to flow to the line relay of the test distributor TD, which in turn repeats this impulse to the first test connector in the twelve hundred group of connectors. This test connector then elevates its wipers one step and rotates them one step onto the first set of bank contacts to connect with telephone line number 1211.

As before, all of the lines in the eleven hundred group are tested by the testing apparatus of Fig. 2. The hunds. A switch is operated one step each time a different test connector is reached, while the tens A switch operates one step for each level of a particular test connector and the units A switch operates one step each time a different line is seized in the level. In this manner, all of the lines in the one-thousand group of lines from eleven hundred to ten hundred are seized and tested. When line number 1000 has been tested or the last line in the first thousand group of lines the wiper 38 of the hunds. A switch is rotated onto its last bank contact in which

position it completes a circuit from ground through wiper 38 and the last bank contact, through the winding of release magnet 35, to battery. The operation of the release magnet 35 restores wiper 38 to normal position. A branch of this circuit extends through the winding of the rotary magnet 32 to battery, of the thous. A switch, so that this magnet upon operating rotates the wiper 34 onto its first bank contact, in which position ground is extended to the second bank contact of the thous. B switch to which wiper 10 has access. The equipment then operates the test distributor TD and test connector TC, as before, to connect with all the lines in the two-thousand group of lines.

When the thousand lines in the two-thousand group have all been tested, the wiper of the thous. A switch moves onto its second bank contact, in which position the thous.-B switch has its wiper 10 rotated onto its third bank contact, thereby connecting the test distributor TD with the first test connector in the three-thousands group of lines. The wiper 34 of the thous.-A switch advances one step each time a thousand group of lines have been tested. When the last line in the last group of the last thousand has been tested, wiper 34 will be positioned on its last bank contact and after line number 0000 has been tested, ground extends through wiper 34, through the winding of its release magnet 31, to battery. This magnet upon operating restores the wiper 34 back to its normal position. All of the other A and B switches of Fig. 1 are at this time also in their normal positions, as has been explained before.

The method of operating the test distributor TD and the test connector TC by the apparatus of Fig. 1 to connect the testing apparatus of Fig. 2 with each of the lines of the exchange having been described, it will now be pointed out how the testing equipment of Fig. 2 tests each line for any trouble which may exist on it.

It may be well to point out first the purpose and kind of apparatus of Fig. 2 utilized in making the line tests. The dash-pot DP is the usual type of well known solenoid having a compartment filled with oil to which one end of the core of the relay extends. The solenoid upon being energized slowly pulls up its armature against the resistance of the oil in the dash-pot which is expelled through a small hole in the plunger attached to the core. In its fully attracted position, the movable core has a stop 208 which engages the contact springs 207. When the dash-pot is deenergized, the armature quickly restores to normal. At the right-hand side of Fig. 2, the recording mechanism RM is indicated. The numerical registering device 290 is of well known construction such as is used for metering telephone calls and comprises an

armature which, upon being attracted by the magnet 290, rotates the commutator wheels 291 so that for each energization a different numeral will be displayed. Positioned immediately below the commutator wheels 291 is a stamping relay 285 which, upon being energized, moves its core 286 against the movable tape 292 so that an impression of the numeral displayed by the commutator wheel 291 will be left on the tape 292. Each time the stamping magnet 285 is energized, the tape-moving magnet 280 also energizes, and when the current is interrupted to these magnets, the armature of magnet 280 will be released, thereby rotating the paper reel 281 each time after an impression has been made upon the movable paper tape 292.

Each time a telephone line has been tested, the recording magnet 290 is operated whether there has been trouble on the line or not. When trouble of any nature is encountered on the line, the stamping relay 285 is operated so that the tape 292 only contains a record of those lines which the testing mechanism has encountered and found trouble thereon.

At V is indicated the well-known type of a three-element vacuum tube having a grid, plate and filament, the filament being energized by the five-volt battery B3, while the grid is connected to an alternating current generator G1 of about 85 volts and 25 cycles. The plate circuit of the tube is connected to the switch arm 272 having two taps so that it may be manually moved to either connect with battery B1 or battery B2. The purpose of these two batteries is so that when the testing mechanism is operated in dry weather, both sets of batteries will be connected in circuit, whereas when it is operated in wet weather, only one battery is needed. The polarized relay 270 is connected in circuit with the vacuum tube V and the alternating current generated by the generator G1 is rectified by the vacuum tube V and is fed through the polarized relay 270 as pulsating direct current. The purpose of the above mechanism is for detecting high resistance grounds, crosses, and shunts which may be encountered on the line being tested. Relays 235 and 240 of the mechanism when connected in circuit of the lines being tested, will test these lines for open circuits.

Referring now to the substation A or telephone number 1111, it will be assumed first that no trouble exists on its line and therefore the condenser C of the substation is charged with current over the circuit extending through the condenser C, ringer coils R, contacts on the switch hook, line conductors 405 and 406, back contact and armature 416, to battery through the winding of relay 410, and to ground on the back contact of armature 417. The condenser C is thereby at all times normally maintained charged. Immediately

upon the lineswitch LS being seized by the test connector TC, as has been described, the switching relay 415, due to a mechanical interlock between this relay and relay 410, attracts its armatures only part way, opening the back contacts, but without closing the front contacts. In this condition a charge is maintained in the condenser C of substation A which is utilized to start the test of the line. With the line and testing conductors connected through to the testing mechanism of Fig. 2, a circuit is now completed extending from the condenser C, line conductors 405 and 406, bank contacts 459 and 460, wipers 456 and 457, conductors 357 and 358 of the test connector TC, bank contacts 351 and 352, wipers 341 and 342, armatures 326 and 330 and their back contacts, conductors 275 and 276, armature 202 and its back contact, and through the winding of relay 200. The condenser C of substation A thereby discharges current through the winding of relay 200 so that this relay immediately energizes and opens its back contact from its armature 202 and closes its front contact onto its armature 201. At front contact and armature 203, relay 200 completes a locking circuit for itself extending from ground through its lower winding, armature 203 and its front contact to armature 262 and front contact of relay 260 to battery. At the back contact of armature 203 the energizing circuit of slow-release relay 235 is interrupted which extended from ground through resistance 204, and this relay slowly restores its armature.

It will be recalled at this time, that immediately upon the operation of the battery key K, the battery was connected to the various relays of the equipment of Fig. 2. This immediately energized relay 235 from ground through the resistance 204 and the back contact of armature 203. Relay 230 is likewise energized from ground on the back contact of armature 212, armature 227 and its back contact, through the winding of slow-release relay 230, to battery. Relay 230, upon energizing, closed battery from its armature 232 and its front contact, winding of slow-release relay 260, armature 256 and its back contact to ground, so that relay 260 is also energized. The dash-pot relay DP also has its circuit closed, extending from ground on the back contact of armature 211, through the winding of the solenoid of the dash-pot DP to battery, and it slowly commences to operate.

Upon the energization of relay 200 and the consequent opening of the circuit of relay 235, the relay 235 slowly restores its armatures to allow the capacity discharge from the condenser C to be fully absorbed by relay 200. Before relay 235 has completely restored, however, a circuit was completed extending from ground through the high resistance winding of relay 240, armature 237 and its front contact, back contact and armature 217,

front contact and armature 201, out through conductor 276, the lower test conductor 406, closed switchhook contacts, through the condenser C at the substation A, back through the upper test conductor 405, conductor 275, armature 216 and its back contact, front contact and armature 236, through the resistance 238 to battery. This circuit is to test the continuity of the line circuit, or to test it for "opens". At the same time, the condenser C is recharged over this circuit. After a short interval relay 235 has completely de-energized and restored its armatures 236 and 237 onto their back contacts. This action reverses the current flow over the above-traced circuit through the condenser C at the substation A. This reversal of current will cause a sufficient momentary flow of current to be absorbed by the condenser C through the winding of relay 240. This takes place provided the line circuit extending to substation A is complete and is not open at any point, otherwise relay 240 would not operate. If the line is complete, relay 240 is operated and at its grounded front contact and armature 241 completes a circuit extending through the lower winding of relay 215, to battery at the front contact and armature 262. Relay 215 upon operating, at its grounded back contact and armature 212 opens the circuit of slow-release relay 230; at its grounded front contact and armature 219 it completes a locking circuit for itself extending through its upper winding to battery at front contact and armature 262; at grounded front contact and armature 218 completes a circuit through the winding of slow-acting relay 210 to battery. Relay 210 upon operating opens the circuit at back contact and armature 211, extending to the dash-pot DP to maintain the circuit of the dash-pot opened. At grounded front contact and armature 218, relay 215 completes a circuit extending through the winding of the recording meter 290 to battery. The armature of the meter 290 upon operating rotates the commutator wheel 291 to the first number to indicate that telephone line number 1111 is being tested. This is the first line in the exchange, it will be recalled. At the back contacts and armatures 216 and 217, relay 215 disconnects relay 240 from the test conductors and transfers them directly to the circuit of the vacuum tube circuit V, for the purpose of testing the line for high resistance grounds, crosses and short circuits.

Relay 215, it will be recalled, at its back contact and armature 212, opened the circuit of slow-release relay 230, but before this relay has time to fully restore its armatures, a circuit is completed extending from ground at the A. C. generator G—1, filament of the vacuum tube V, front contact and armature 233 of relay 230, front contact and armature 216, testing conductor 275 over one side of

the testing circuit, and from ground on the back contact of armature 256, front contact and armature 261 of relay 260, front contact and armature 217, front contact and armature 201, to the other side of the line over testing conductor 276 to the condenser C at the substation A which is thereupon recharged. This is done to insure that condenser C is charged before tests. The next test is for any trouble or grounds which may occur on the upper-line conductor 405. The polarized relay 270 may be operated in the plate circuit extending from the plate of the vacuum tube switch 272, battery B2, relay 270, and the filament, while the condenser is charging. However, relay 230 has not fully restored as yet, therefore, the ground from armature 271 of relay 270 will have no effect at this time.

After a short interval, relay 230 fully retracts its armatures, and at front contact and armature 232, battery is removed from slow-release relay 260 and this relay slowly restores its armatures. At the back contact of armature 231 relay 230 prepares a circuit for relay 220, and at the back contact of armature 233 connects the vacuum tube circuit V to the test conductor 275. The grid circuit of the vacuum tube V is now extended through the winding of the polarized relay 270, back contact and armature 233, front contact and armature 216, over conductor 275, over one side of the line under test. If no ground is encountered on this side of the line, the grid circuit is not completed, and no current will flow in the plate circuit of the tube to operate relay 270. After a short interval, relay 260 closes its armature 261 onto its back contact, so that the grid circuit of the vacuum tube V extends through the polarized relay 270, back contact and armature 261, front contact and armature 217, front contact and armature 201, out over the test conductor 276 to test this side of the line. If no trouble is encountered on this side of the line, relay 260 completely restores its armature, and at front contact and armature 262, removes battery from the windings of relay 215 and relay 200 which maintained them locked in energized position.

At front contact and armature 264, relay 260, upon falling away, opens the operating loop circuit 277 and 278 so that the test connector TC is stepped onto the next contact to be tested as has been explained; at the back contact of armature 263, ground is projected over conductor 60 to the rotary magnet 44 of the units-A switch which thereupon operates and rotates the wiper 46 onto the next bank contact. Relay 215 after having its circuit interrupted by relay 260, restores its grounded back contact onto its armature 212 and again completes a circuit for slow-release relay 230. Relay 200 upon restoring its armature 203, again completes the circuit for

slow-release relay 235 from ground through the resistance 204, armature 203 and back contact, and through the winding of relay 235, to battery.

The testing equipment is now in position to test the next line with which the test connector TC has been connected, and the same testing process as has been described is repeated provided, of course, no trouble is encountered.

In the foregoing, it has been assumed that all the lines tested have been found in their correct operating condition, and that no trouble of any nature has been encountered by the testing apparatus. The meter 290 which registers the number of the line, is operated each time that a line is tested, and this indicates the exact position of the apparatus on the lines in the exchange.

It will now be assumed that the subscriber's telephone line has an open circuit somewhere in it. This open circuit may occur anywhere on a local subscriber's line, on the heat core terminals, jumpers and cable pairs or at the instrument, as is well known. In this event, when the testing equipment of Fig. 2 is connected direct to the line, there will be no condenser discharge from condenser C at substation A to operate relay 200, likewise relay 240 would not operate with the result that relay 215, which is controlled from relay 240, would also not be operated, so that relay 215 at its grounded front contact and armature 218 does not close the circuit to slow-release relay 210. Relay 210, therefore, remains in normal condition, so that ground is extended from its back contact and armature 211, through the winding of the solenoid of the dash-pot relay DP, to battery. As a result of this, the dash-pot DP is permitted to attract its movable core to its uppermost position, permitting the insulated portion of the core 208 to strike the contact springs 207 and close the contacts. At the center pair of contacts, the dash-pot DP closes a circuit extending from ground through springs 207, through the winding of the recording meter 290 to battery, so that the number of this line being tested is recorded on the meter. A branch of this circuit extends through the winding of relay 210 to battery so that this relay at armature 211 opens the circuit of the dash-pot DP. At the uppermost contact springs of the dash-pot DP, ground is extended from spring 207, through the contacts, through the winding of relay 220 to battery at armature 262 and its front contact. Relay 220 energizes, and at its front contact and armature 222 completes a locking circuit for itself. At grounded front contact and armature 221, relay 220 completes a circuit extending through the winding of the stamping relay 285, and through the winding of tape-moving relay 280 to battery. Stamping relay 285 moves its movable core 286 against

the tape 292, so that an impression of the number displayed by the recording wheel 291 is left on the tape. The tape moving magnet 280 attracts its armature and its associated pawl away from the ratchet, and upon restoring forces the pawl into a tooth of the ratchet wheel, causing the tape, to which the ratchet wheel is attached, to be moved a short distance. In this manner, the tape is always moved after an impression of the telephone number has been stamped on it by the stamping relay 235.

As a further result of the energization of relay 220, a branch of the circuit from ground and armature 221 passes through the winding of relay 255 to battery. At its grounded back contact and armature 256, relay 255 interrupts the circuit extending through slow-release relay 260, and this relay slowly restores its armatures after a short interval. Relay 260 upon restoring, at armatures 263 and 264 operates the equipment of Fig. 1 as has been pointed out, to step the test connector onto the next line to be tested. At armature 262, relay 260 opens the circuit extending through the winding of relay 220 and ground on armature 222 and its front contact. At the grounded front contact of armature 221, the circuit extending to the stamping relay and the tape-moving magnet 280 is interrupted, so that the armature of the tape-moving magnet 280 upon restoring moves the tape a short distance. A branch of this circuit previously extended through the winding of relay 255, so that this relay, upon falling back, closes ground on its armature 256, so that the circuit for relay 260 is again completed. This relay energizes, and the equipment is now ready to proceed with the testing of the next line.

It will now be assumed that there is a shunt or cross circuit connected between the line conductors 405 and 406 extending to the substation A. This shunt will probably be above the predetermined minimum voltage usually existing on the line, and the condenser C will in all probability discharge through it. With the shunt circuit across the line conductors of the substation A, relay 200 receives discharge or "kick" from the back contacts and armatures 416 and 417 of the line-switch, which operates this relay. At the front contact and armature 203, its locking circuit is completed to battery at armature 262, while at front contact and armature 201, it extends on one side of the test conductor 276 to the testing equipment. At the back contact of armature 203, relay 200 interrupts the circuit of relay 235 which, upon deenergizing at its back contacts and armatures 236 and 237, reverses the connection of battery and ground through relay 240 over the line conductors, so as to again attempt to charge the condenser at the substation. Relay 240 operated over this circuit through the shunt, and

at its grounded front contact and armature 241, completes a circuit through the lower winding of relay 215 to battery at the front contact of armature 262. Relay 215 upon energizing, completes a locking circuit for itself at armature 219; at armatures 216 and 217 switches the test conductor 275 and 276 to the vacuum circuit V; while at grounded front contact and armature 218, it completes the circuit for slow-release relay 210, which at armature 211 and its back contact holds open the circuit of the dash-pot relay DP. At the back contact of armature 212, the circuit for slow-release relay 230 is interrupted, and at armature 218, the circuit to the recording meter 290 is closed. The rectified direct current from the vacuum tube V now extends through the polarized relay 270, back contact and armature 233, front contact and armature 216, over the test conductor 275, through the shunt or cross on the line in trouble, back over the other side of the line and conductor 276, armature and front contact 201, armature 217 and its front contact, armature 261 and its front contact, before relay 260 has fully restored, to ground on the armature 256 and its back contact.

Due to the shunt or cross on the line, the grid circuit of the tube is completed and thereby the increased potential in the plate circuit of the vacuum tube causes the polarized relay to operate each time the grid of the vacuum tube V is positive potential. At its grounded armature and front contact 271, the polarized relay 270 completes a circuit extending through the back contact and armature 231, through the winding of relay 220, to battery at front contact and armature 262. Relay 220, at its grounded front contact and armature 222, completes a locking circuit for itself, while at its grounded front contact and armature 221, it completes the circuit for relay 255 and also for the stamping magnet 285, and when its circuit is interrupted, magnet 280 deenergizes to move the tape. At the time relay 215 operated, it will be recalled, it closed a circuit from ground on its front contact and armature 218 for the recording meter 290, so that when the stamping magnet 285 operates, it will print an impression of the number of the line on the moving tape 292. Relay 255 upon operating, opens the circuit of relay 260 at armature 256 and its back contact, and relay 260 upon falling away at armatures 263 and 264, steps the test connector or test distributor, as the case may be, onto the next line to be tested. At its armature 262, it opens the battery circuit for relays 215 and 220, which thereupon deenergize. Relays 200 and 240 are likewise restored to normal, and the testing equipment is ready to test the next line which is to be seized.

Assuming there is a high resistance or cross encountered on the negative side of the sub-

scriber's testing circuit over conductor 275, the same operation will occur as if the ground or cross occurred on both lines, and in this event, the circuit for the polarized relay 270 is completed direct to the ground or cross on the line instead of to ground on the back contact of armature 256 and the front contact of armature 261, and the apparatus would operate in a similar manner as it did when the cross was across both sides of the line.

In the event of trouble occurring on the positive side of the line over conductor 276, the same operation occurs in the testing equipment when relay 261 retracts its armature 261 with the exception that the current through the polarized relay 270 passes out through the positive side of the line comprising conductor 276, back contact and armature 261, out to the trouble on the line.

The foregoing operations all take place in the event of trouble occurring on the line. It may be stated that it is not necessary to indicate in any manner the exact nature of the trouble encountered on the line being tested, but it is only necessary to know that it exists and is probably rendering some subscriber's line inoperative or nearly so. Each time a line is encountered which has trouble on it, the stamping relay 285 leaves an impression of the number of that line upon the moving tape 292, the recording meter operating in all cases whether there is trouble or not on the line.

A condition will now be assumed in which the subscriber's substation A is in a busy condition at the time the test connector TC has encountered the lines 405 and 406 and prepared to operate the test equipment of Fig. 2 to test this line. In this event, the line relay 410 of the line switch LS would be operated, and ground is extended from front contact and armature 411 of relay 410, bank contact 461, the wiper 458 which is now resting on it, conductor 359, bank contact 353, wiper 343 of the test distributor TD, armature 335 and its front contact, relay 309 being operated, front contact and armature 327 of relay 307 which is slow-acting and, therefore, momentarily holds up its armatures after impulsing has ceased, back contact and armature 324 of relay 326, through the winding of reversing relay 301 to battery. At front contact and armature 314, relay 301 upon operating completes a locking circuit for itself after relays 306 and 307 fall back. At armature 315 and 316 and the alternate closed front and back contacts, relay 301 reverses the battery and ground connections of relays 302 and 303 over the operating loop circuit 277 and 278 extending through the lower winding of electropolarized relay 225. The upper winding of this relay is normally connected to battery and ground, but the flow of current in this

winding is in opposition to that normally flowing through its lower winding from the operating loop circuit in its normal condition and consequently the relay will not energize. However, when the current is reversed in the operating loop circuit, the current flowing through the lower winding is in such a direction as to assist its upper winding that the relay will energize. At its grounded front contact and armature 226, relay 225 completes a circuit to the recording meter 290, while a branch of this circuit extends to relay 210 which energizes and maintains the circuit of the dash-pot relay DP open at its armature 211. At the back contact of armature 227, relay 225 interrupts the circuit extending to relay 230. At the front contact of armature 232, relay 230 interrupts the circuit for relay 260, and relay 260 upon retracting its armatures operates the selecting switches of Fig. 1 in a manner to send out additional impulses over the operating loop circuit, so that the test connector TC will step to the next contact and off of the busy line, so that reversing relay 301 reverts to its original state.

In this manner, all busy lines are passed over by the testing equipment and are not tested. In the greater majority of cases it can be assumed that a line which is busy has no trouble on it, otherwise it would not be possible to carry on a satisfactory conversation over the line, and it is, therefore, assumed that the busy lines are in operative condition.

In the event that a number of lines or a group of lines are not utilized in the exchange and, therefore, would not be connected to telephones, the testing apparatus would indicate these lines after the test connector TC has seized them as being open. This condition, however, is avoided by placing a permanent ground connection on all the private bank contacts of the test connector TC which are not utilized, such as bank contact 461, which would be grounded in the event that line conductors 405 and 406 would not be connected up.

From the foregoing description it will be seen that from the time battery key K is operated and the start key ST operated, all ten thousand lines in the exchange from number 1111 to 0000 will each be tested one after the other in regular sequence, and no attention is necessary from any wire chief or supervisor to observe the operation of the apparatus as it is entirely automatic. This apparatus may be operated during the periods of low traffic, such as in the evening, when there would be less chance of encountering busy lines by the testing apparatus. The wire chief upon noting that the apparatus has completed a test of all of the lines, will watch until the last line is completed, whereupon he restores the battery key K, so that the

testing equipment will come to rest in its normal position again. After the testing mechanism has completely tested all of the lines in the exchange, the wire chief will remove the tape from the recording mechanism RM and note the numbers of the lines appearing thereon which have been in trouble, so that during periods of low traffic he can operate his manual selecting equipment which comprises the usual dial, and connect with the test connector TC and dial it up to the particular line which is in trouble. Then after having connected with this line, he can verify the trouble conditions occurring on the line and, if possible, correct them. He can determine the exact nature of the trouble occurring on the line by means of volt meters and other well-known means as is well known in the art, and if the trouble is of such a nature that he cannot himself correct it, he may dispatch a trouble man out to the substation to rectify the trouble.

The association of the wire chief's connecting circuits with the test connector TC will not interfere in any manner with any of the testing equipment or selecting equipment of Figs. 1 and 2.

From the foregoing it will be seen that a novel type of subscriber's line testing equipment has been designed which automatically and in a routine manner tests all of the lines of a single telephone exchange, and as only one specific embodiment of the invention has been described and illustrated in the drawings, it will be appreciated that there may be any number of variations possible from that shown, for example, either a larger or a smaller size of exchange may have its lines tested by merely connecting the test distributor TD direct to the lines, or if there are more, by adding additional selector switches before the test connector TC. Similarly, the A and B group of switches may be reduced or added to. It is, therefore, not desired to be limited to the specific structure illustrated and described, but only to the extent of the appended claims.

What is claimed is:

1. In an automatic telephone exchange system, comprising a plurality of telephone lines connected with subscribers' substations, automatic-routine testing equipment for testing said lines, means in said testing equipment for automatically and selectively associating each of said lines in numerical order with said testing equipment, means responsive to the connection of said testing equipment with each of said lines for performing a plurality of tests on the lines, and means at each of the subscribers' substations on each of said lines and controlled thereby for starting said tests.

2. In an automatic telephone exchange system having a plurality of telephone lines connected with subscribers' substations, auto-

matic-routine testing equipment for testing said lines, means in said testing equipment for automatically and selectively associating each of said telephone subscribers' lines with said testing equipment, means at each subscriber's substation and responsive to each of said connections and controlled from said subscriber's substation over the line for initiating the testing of said line by said testing equipment, means controlled by said testing equipment after said line has been tested for automatically releasing said line and for automatically associating said testing equipment with the next line to be tested.

3. In an automatic telephone exchange system having a plurality of telephone lines connecting the subscribers' substations thereto, automatic-routine testing equipment for testing said lines, means in said testing equipment for automatically associating each of said lines in succession with said testing equipment, a relay in said testing equipment controlling the initiating of a test on said line, and means at each of the substations and controlled over said lines for operating said relay.

4. In a telephone system comprising a plurality of telephone lines connected with subscribers' substations, automatic-routine testing equipment for testing said lines, means in said testing equipment for automatically and selectively connecting said testing equipment with each of said lines in succession, a relay in said testing equipment connected to said line, means at the subscribers' substations and controlled over said telephone line for operating said relay to initiate the operation of said testing equipment to perform a series of tests on said line, and means in said testing equipment responsive to the completion of said tests for disconnecting said line from said testing equipment and releasing said relay and to automatically associate the testing equipment with the next line to be tested.

5. In an automatic telephone exchange system comprising a plurality of subscribers' telephone lines, automatic-routine testing equipment for testing said lines, a condenser normally bridged across each of said lines, means in said testing equipment for automatically and selectively associating each of said subscribers' lines with said testing equipment, a relay in said testing equipment connected to any selected line, means responsive to the connection of said testing equipment to said line for discharging the condenser of the subscriber's line through said relay to operate it, and means responsive to the operation of said relay for initiating the operation of said testing equipment to test said line.

6. In an automatic telephone exchange system comprising a plurality of subscribers' telephone lines, automatic-routine testing equipment for automatically testing each of

said lines, marking switches in said testing equipment operated each time a line has been tested to mark the position of said line, counting switches in said testing equipment connected to said marking switches and automatically operative each time a test on a test line has been completed, and means controlled by said switches to automatically and selectively connect the testing equipment with each of said lines to be tested.

7. In an automatic telephone exchange comprising a plurality of subscribers' lines, an automatic-routine testing equipment for testing said lines, counting switches in said testing equipment for selectively operating automatic switches in said exchange to connect with said line to be tested and to associate said testing equipment with said line, marking switches in said testing equipment connected to said counting switches and operative automatically by said testing equipment each time a line has been tested to mark the position of said line in the bank of said counting switches, and means in said testing equipment for automatically testing each of said lines selected by said counting switches.

8. In an automatic telephone exchange system comprising a plurality of selectively-controlled switches for establishing connections between subscribers' telephone lines, automatic-routine testing equipment for testing said telephone lines, counting switches in said testing equipment operative to operate said selective switches to associate said testing equipment with each of said lines, marking switches in said testing equipment operative responsive to the completion of a test by said testing equipment to mark the position of said tested line in the bank of said counting switches and means in said testing equipment for performing a plurality of tests on said connected line.

9. In an automatic telephone exchange system comprising a plurality of telephone lines each connected to a subscriber's substation, automatic-routine testing equipment for automatically connecting with and testing said lines, a test-ending and a test-starting relay in said test equipment, means at each of the substations responsive to the automatic connection of said testing equipment with one of said lines for operating said test-starting relay to initiate the testing of said line, and means after said test has been completed for energizing said test-ending relay to automatically associate said testing equipment with the next line to be tested.

10. In an automatic telephone exchange system, a plurality of telephone subscribers' lines having substations thereon connected to said exchange, automatic-routine testing equipment for testing each of said lines in successive order, a test-starting relay and a test-ending relay in said testing equipment, means at each of the substations automatical-

ly responsive to the association of said testing equipment with any of said lines for operating said test-starting relay to initiate the testing of said line by said testing equipment, means responsive to the completion of said tests for energizing said test-ending relay, and means responsive to the energization of said test-ending relay for automatically associating said testing equipment with the next successive line to be tested.

11. In an automatic-routine testing equipment for testing subscribers' telephone lines, means for automatically and selectively associating said testing equipment successively with all of said subscribers' telephone lines, means responsive to said association for automatically performing a series of tests on said lines, recording mechanism in said testing equipment, and means responsive to the performance of said tests on said lines for operating said recording mechanism when a line is in operative condition or has a case of trouble on it.

12. In an automatic-routine testing equipment for testing subscribers' telephone lines, means for automatically and selectively associating said testing equipment with said subscribers' lines in succession recording mechanism in said testing equipment, means responsive to the association of said testing equipment with any of said subscribers' lines for operating said recording mechanism to indicate the number of said line being tested, and additional means in said recording mechanism for automatically making a permanent record of the number of said line in case there is trouble on it.

13. In an automatic-routine testing apparatus for testing the subscribers' lines in an automatic telephone exchange system, means for automatically and selectively associating said testing equipment with each of said telephone lines, recording mechanism in said testing equipment, and means for automatically operating said recording mechanism responsive to the association of any particular telephone line with said testing equipment for giving an indication of the number of said telephone line whether in busy or idle condition.

14. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic-routine testing equipment for testing said lines, means in said testing equipment for selectively associating said equipment with any of said subscribers' lines, means responsive to the connection of said equipment with one of said lines for initiating the testing of said line, a relay in said testing equipment connected to said line, means for operating said relay over said line in case there is no trouble on it, and means controlled by said relay for initiating the next test of said line and for

leaving a permanent record of the number of the line.

15. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic routine testing equipment for selectively associating said lines with said testing equipment, means responsive to the association of any line with said testing equipment for initiating the testing of said line by said testing equipment, an electron discharge device connected by said testing equipment to said line, means controlled by trouble existing on said line for operating said electron discharge device, and means controlled by said device for giving an indication of said trouble.

16. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic-routine testing equipment for selectively testing said lines, means in said testing equipment for successively associating said testing equipment with each of said lines, means responsive to said association for operating said testing equipment to initiate the testing of said line, a three-element vacuum tube in said testing equipment connected to said line, means controlled by any trouble existing on said line under test for operating said three-element vacuum tube, and means controlled by said vacuum tube for making a record of the trouble on said line.

17. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic-routine testing equipment for testing said lines, means in said testing equipment for selectively associating said telephone lines in succession with said testing equipment, a three-element vacuum tube connected to said line, means controlled by said vacuum tube for making a record of a line which may be in trouble, and means controlled over both sides of said line or of either side for operating said vacuum tube only in case of trouble on the line.

18. In an automatic telephone exchange system having a plurality of subscribers' lines, automatic-routine testing equipment for testing said lines, means in said testing equipment for selectively associating said lines in succession with said testing equipment, means responsive to the establishment of a connection with one of said lines for initiating the testing of said line by said testing equipment, a three-element vacuum tube connected to said line for testing trouble thereon, a relay controlled by said vacuum tube and operative to make a record of the number of said line in trouble, and means controlled from any trouble on said line for energizing said vacuum tube to operate said relay.

19. In an automatic telephone exchange system having a plurality of subscribers' lines connected thereto, automatic-routine

testing equipment for testing said lines, means in said testing equipment for selectively associating said lines in succession with the said testing equipment, a relay in said testing equipment operative responsive to the connection of said testing equipment with said line when said line is in operative condition, a slow-acting device in said testing equipment, said slow-acting device controlled by said relay, and means responsive to the non-operation of said relay for permitting said slow-acting device to completely operate and make an indication of the number of said line.

20. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic-routine testing equipment for testing said lines, means in said testing equipment for selectively associating said lines in succession with said testing equipment, means responsive to the association of any line with said testing equipment for initiating the test of said line, a three-element vacuum tube connected to said line in said testing equipment, means controlled by any trouble existing on said line for energizing said three-element tube, a polarized relay controlled by said vacuum tube and energized in case of trouble on said line, means controlled by said polarized relay for making a permanent record of the number of said line in trouble, and means after said line has been tested for releasing said equipment to normal position and for connecting it with the next line to be tested.

21. In an automatic telephone exchange system having a plurality of subscribers' telephone lines connected therewith, an automatic-routine testing equipment for testing said lines, a plurality of marking switches in said testing equipment operated each time a line has been connected with by the testing equipment, and a plurality of counting switches in said testing equipment operated in accordance with the setting of said marking switches for selectively associating said testing equipment with each of said lines in succession.

22. In an automatic telephone exchange system comprising a plurality of selectively operated automatic switches for establishing connections between subscribers' telephone lines, automatic-routine testing equipment for testing each of said lines in succession, a plurality of marking switches in said testing equipment operative to mark the position of the last line which has been tested by the testing equipment, counting switches connected to said marking switches and automatically operative after a line has been tested to automatically associate the testing equipment over the automatic switches with the next line to be tested, said marking switches controlled according to the position of said counting switches, and means for

automatically testing each of said subscribers' lines as they are seized by said testing equipment.

23. In an automatic telephone exchange system having a plurality of automatic switches therein for establishing connections between subscribers' telephone lines, automatic-routine testing equipment for testing said lines, means for starting the operation of said testing equipment, a plurality of counting switches in said testing equipment, means responsive to the operation of said testing equipment for operating said counting switches to control said automatic switches to connect with a subscriber's line and associate it with said testing equipment, means responsive to the testing of said line by said testing equipment for releasing it, and a plurality of marking switches in said testing equipment operative responsive to the release of said tested telephone line for marking the position of said line in the banks of said counting switches.

24. In automatic-routine testing apparatus for testing the subscribers' lines in a telephone exchange system, means for automatically and selectively associating each of said subscribers' lines to said testing equipment to perform a plurality of tests thereon, recording mechanism in said testing equipment comprising means for indicating the number of the line being tested, means for giving an indication of the number of the line when there is a case of trouble on it, and means automatically responsive to the association of said testing equipment with any of said telephone lines for operating said number recording means in all cases and for operating said trouble indicating means only in case there is trouble on said lines.

25. In an automatic telephone exchange system comprising a plurality of subscribers' lines, automatic-routine testing apparatus for testing said lines, means in said testing equipment for automatically and selectively associating the testing equipment with each of said lines in successive order whether they are in a busy or idle condition, recording mechanism in said testing equipment for indicating the number of the line with which the equipment is engaged, means responsive to the connection of said equipment with said line for automatically performing a plurality of tests thereon and for operating said recording mechanism, and other recording means in said testing equipment for giving a permanent record of the number of the line displayed by said recording device in case trouble of any nature is encountered by the testing equipment on the line.

26. In an automatic telephone exchange system having a plurality of subscribers' lines, automatic routine testing equipment for testing said lines, means in said testing equipment for selectively associating said lines in

succession with said testing equipment, means responsive to the association of any line with said testing equipment for initiating the testing of said line, a three element vacuum tube connected to said line, means controlled by any trouble over said line for energizing said vacuum tube, and a polarized relay controlled by said vacuum tube for making a record of the number of the line in trouble.

27. In an automatic telephone system, a plurality of lines extending from subscribers' substations to the exchange, an automatic-routine testing mechanism for testing said lines for trouble, means for automatically and selectively connecting said testing mechanism with each of the lines in the system in consecutive order, a relay in said testing mechanism for initiating the test on any selected line, a normally charged ringing condenser at each of the substations on the lines, and means responsive to the connection of said testing mechanism with any line for discharging the condenser of the substation through the relay to start the test on the line.

28. In a routine testing equipment for testing the subscribers' lines in an automatic exchange, means in said testing equipment for selecting and associating said lines one at a time with the equipment, and means at the subscriber's substation on any selected line for starting the operation of said testing equipment to test the line.

29. In a routine testing equipment for testing the subscribers' lines in an automatic exchange, means in said testing equipment for selecting and associating said lines one at a time with the equipment, means at the subscriber's substation of a selected line for automatically starting the testing equipment, and means in said testing equipment for then performing a series of tests on the line.

30. In a routine testing equipment for testing the subscribers' telephone lines in an automatic exchange, a normally charged condenser bridged across each of said lines at the substation, means for successively associating each of said lines with said testing equipment, and means responsive to the connection of said testing equipment with any line for discharging said condenser over the line to start the testing equipment to test the line.

31. In a routine testing equipment for testing the lines extending to subscribers' substations in a telephone system, a charged condenser on the line at each substation, means for automatically associating each of the subscriber's lines with said testing equipment, and means for repeatedly charging and discharging said condenser over the line to control said testing equipment in its testing operations of the line.

32. In a telephone system, a routine testing equipment for performing a plurality of tests on the lines extending from the exchange to the subscribers' substations, a con-

denser at each of the substations, means for automatically and successively associating each of said lines with said testing equipment, means responsive to such association for discharging the condenser at the substation over the line to said testing equipment to start the test on the line, and means in said testing equipment for repeatedly charging and discharging said condenser over the line to perform a plurality of tests of the line.

33. In a telephone system, a routine testing equipment for performing a plurality of tests on the lines extending from the exchange to the subscribers' substations, a condenser at each of the substations, means for automatically and successively associating each of said lines with said testing equipment, means responsive to such association for discharging the condenser at the substation over the line to said testing equipment to start the test on the line, and means in said testing equipment for charging and discharging said condenser for each test performed by the testing equipment on the line.

34. In a telephone system, a routine testing equipment for performing a plurality of tests on the lines extending from the exchange to the subscribers' substations, a normally charged condenser at each of the substations, means for automatically and successively associating each of said lines with said testing equipment, means responsive to such association for discharging the condenser at the substation over the line to said testing equipment to start the test on the line, and means in said testing equipment for charging the condenser at the beginning of each test on the line and for discharging the condenser during each test of the line.

35. In an automatic telephone system comprising a plurality of subscribers' telephone lines, automatic routine testing equipment for testing each of said lines, marking switches in said testing equipment operated each time a line has been tested to mark the position of said line, counting switches in said testing equipment connected to said marking switches and automatically operative each time a test on a line has been completed, and means controlled by said marking and counting switches to automatically and selectively connect the testing equipment with each of said lines to be tested, and means responsive to said connection for starting the test on said line by said testing equipment.

36. In a routine testing arrangement for testing the lines in a telephone exchange, a marking switch and a counting switch, means for operating said counting switch to automatically associate said testing equipment with a line to be tested, means in said testing equipment for automatically testing the line selected by said counting switch, and means for operating said marking switch

upon the completion of the test of the line to mark the number of the line tested.

37. In a routine testing arrangement for the lines of a telephone exchange, testing equipment, a marking switch and a counting switch, means for operating said counting switch to automatically associate each of said lines in succession with said testing equipment preparatory to testing the same, means responsive to such association for operating said testing equipment to perform a series of tests on the line, means for operating said marking switch at the end of the tests on each line for marking the line which has been tested so that upon the subsequent operation of the counting switch the next line in succession will be associated with the testing equipment.

38. In a routine testing arrangement for the lines of a telephone exchange system, testing equipment, a marking switch and a counting switch connected together, means for operating said counting switch to automatically associate one of said lines with said testing equipment preparatory to performing a test on the line, means responsive to such association for operating said testing equipment to test said line for trouble, means for operating said marking switch at the end of the test on the line to mark the tested line, and means for operating said counting switch to associate each line in succession with said testing equipment to test the same, the marking switch after each test marking the tested line so the counting switch will select the line next in order and associate it with the testing equipment.

39. In an automatic telephone exchange system wherein selective switches are employed for establishing connections between the subscribers' telephone lines, routine testing equipment for testing said lines, counting switches and marking switches, an impulse distributor, means for transmitting impulses through said distributor to operate said counting switches and control the selective switches in accordance with said impulses to connect a subscriber's line with said testing equipment, said impulse transmitting means operative to control the selective switches to connect each line in the exchange in succession with the testing equipment, means for operating said marking switches after a test on each line has been made to mark the line tested so that said counting switches will control the selective switches to connect the next line in succession with said testing equipment.

40. In an automatic telephone exchange system having a plurality of subscribers' telephone lines, automatic routine testing equipment for selectively testing said lines, means in said testing equipment for successively associating each of said lines with said testing equipment, means responsive to said asso-

ciation for operating said testing equipment to initiate the testing of said line, means for indicating the line being tested, a vacuum tube in said testing equipment connected to said line, means controlled by any trouble existing on said line for operating said vacuum tube, and means controlled by said vacuum tube for making a record of the indicated line to record the fact that it is in trouble.

41. In a telephone system having a plurality of subscribers' telephone lines, automatic routine testing equipment for testing said lines, means for successively associating each of said lines with said testing equipment, means in said testing equipment for giving a temporary indication of the line which is being tested, means in said testing equipment for testing said lines for trouble, and means in case trouble is encountered on the line for giving a permanent indication of the line under test.

In witness whereof, I hereunto subscribe my name this seventh day of May, A. D. 1930.
WILSON S. FREESLAND.