Oct. 23, 1945. A. R. BONORDEN 2,387,558

TELETYPEWRITER TESTING SYSTEM

Filed Sept. 11, 1943 5 Sheets-Sheet 1

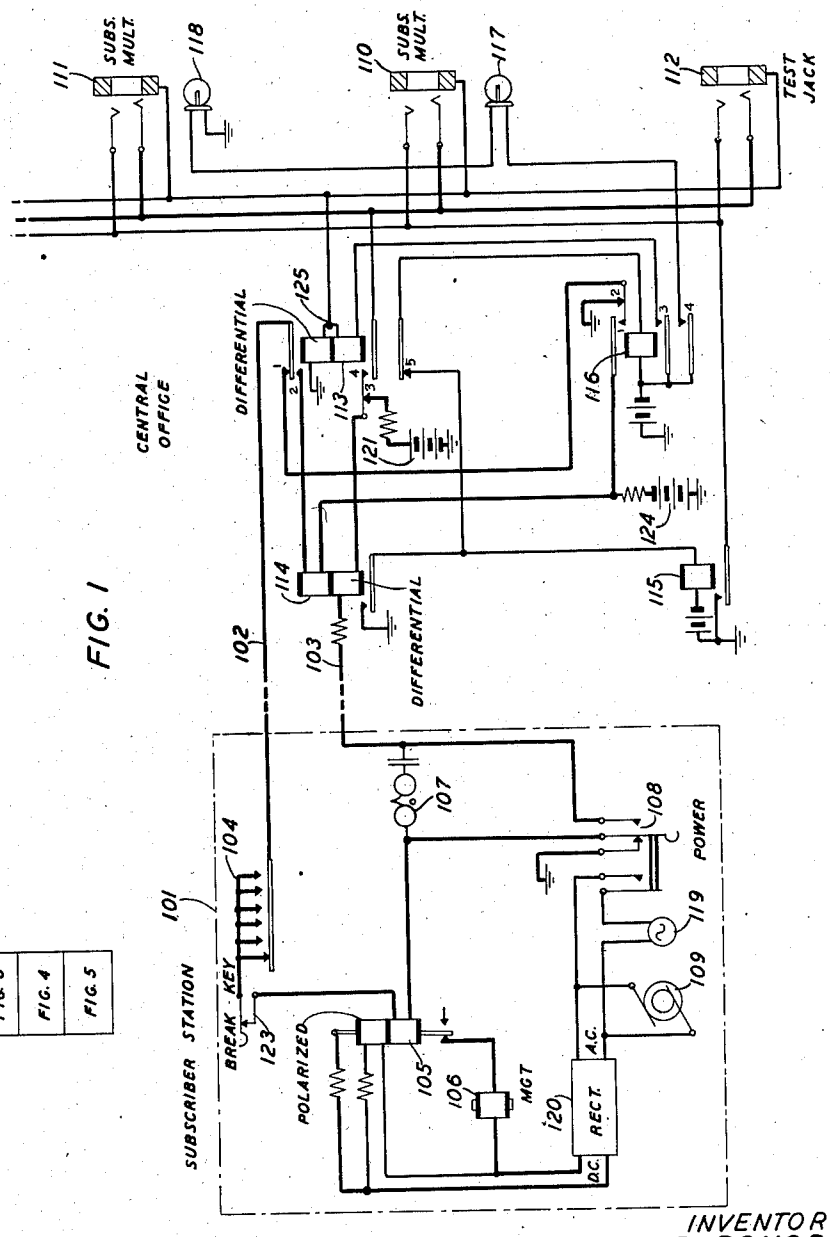

FIG. 1

FIG. 6

FIG. 1	FIG. 2	FIG. 3	FIG. 4	FIG. 5

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TELETYPEWRITER TESTING SYSTEM

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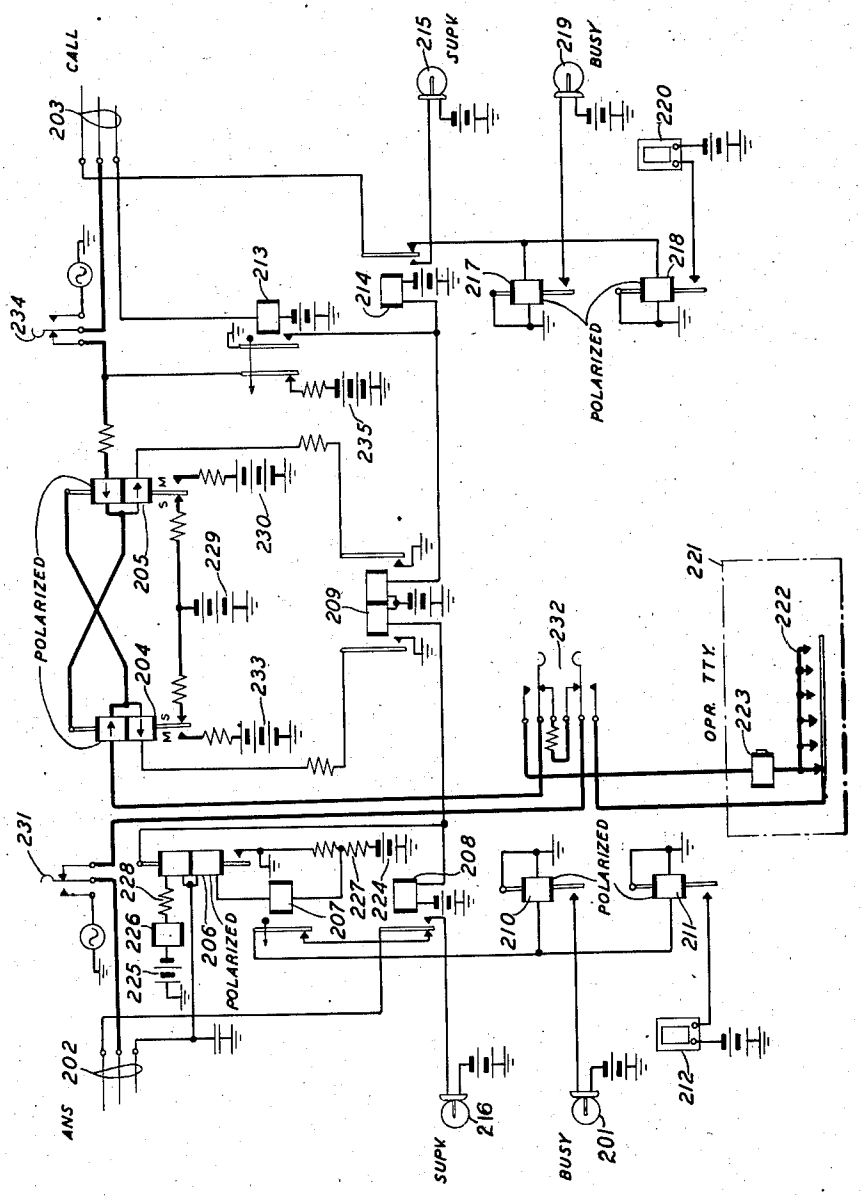

FIG. 2

OPERATOR CORD CIRCUIT

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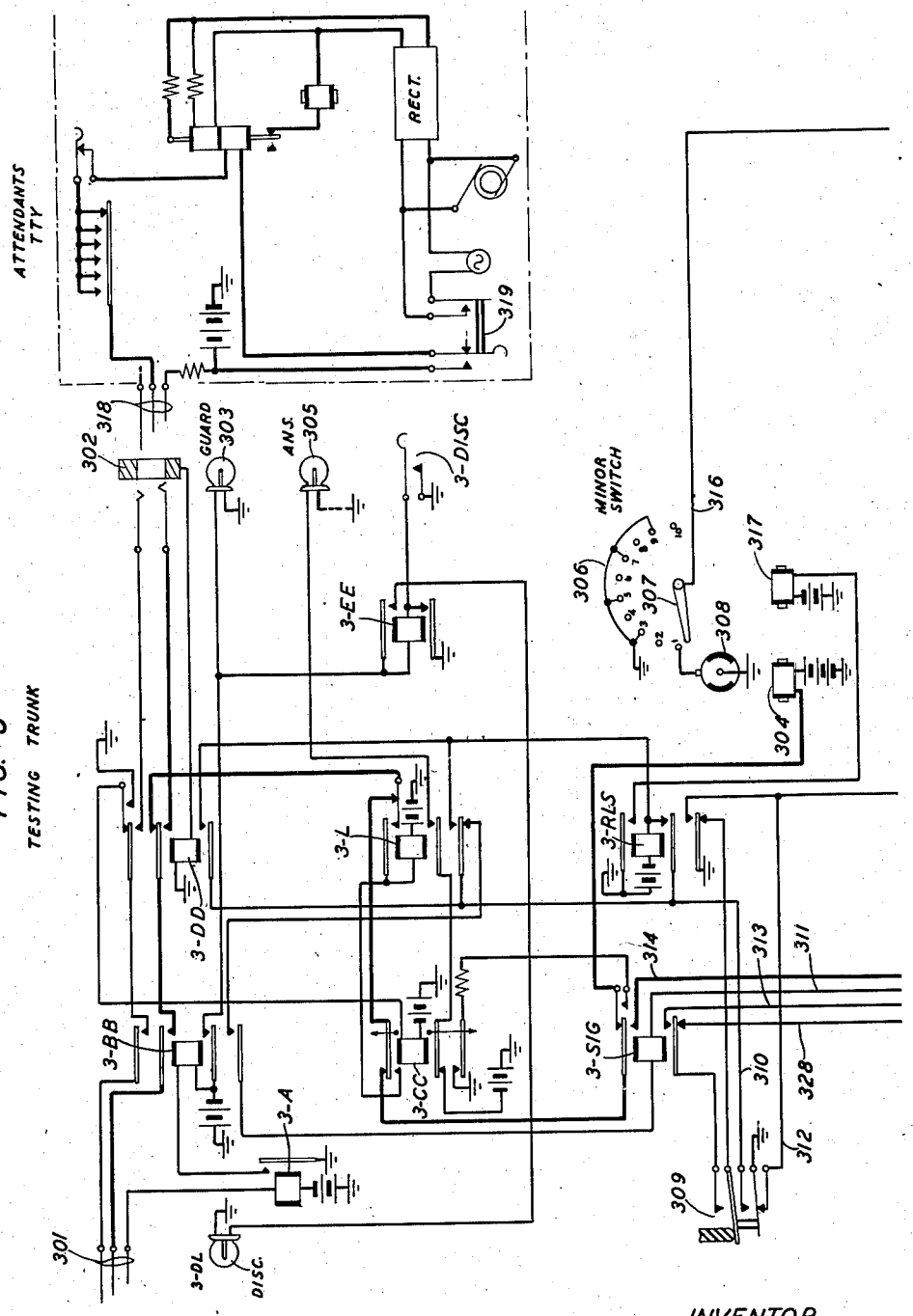

FIG. 3

TESTING TRUNK

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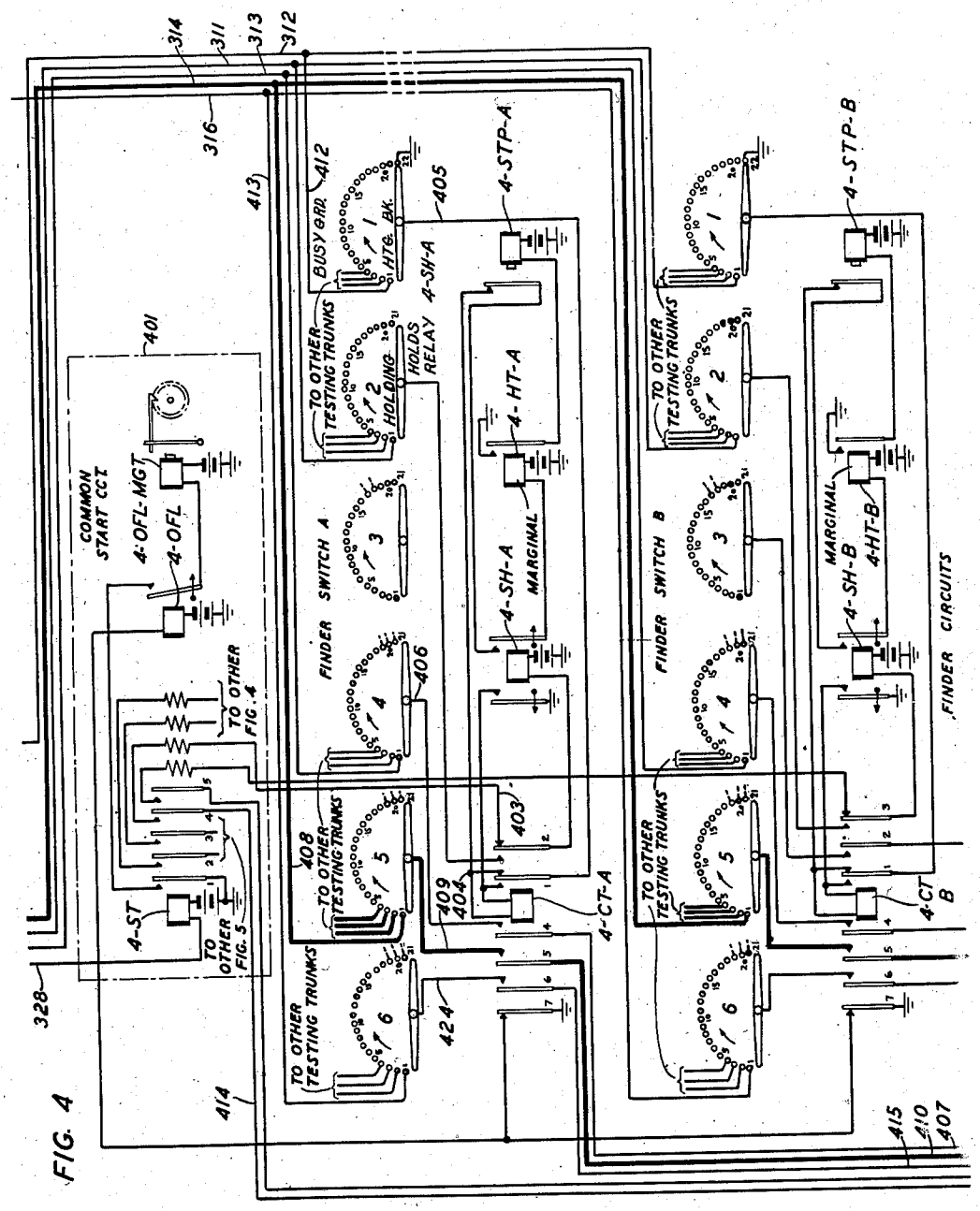

FIG. 4

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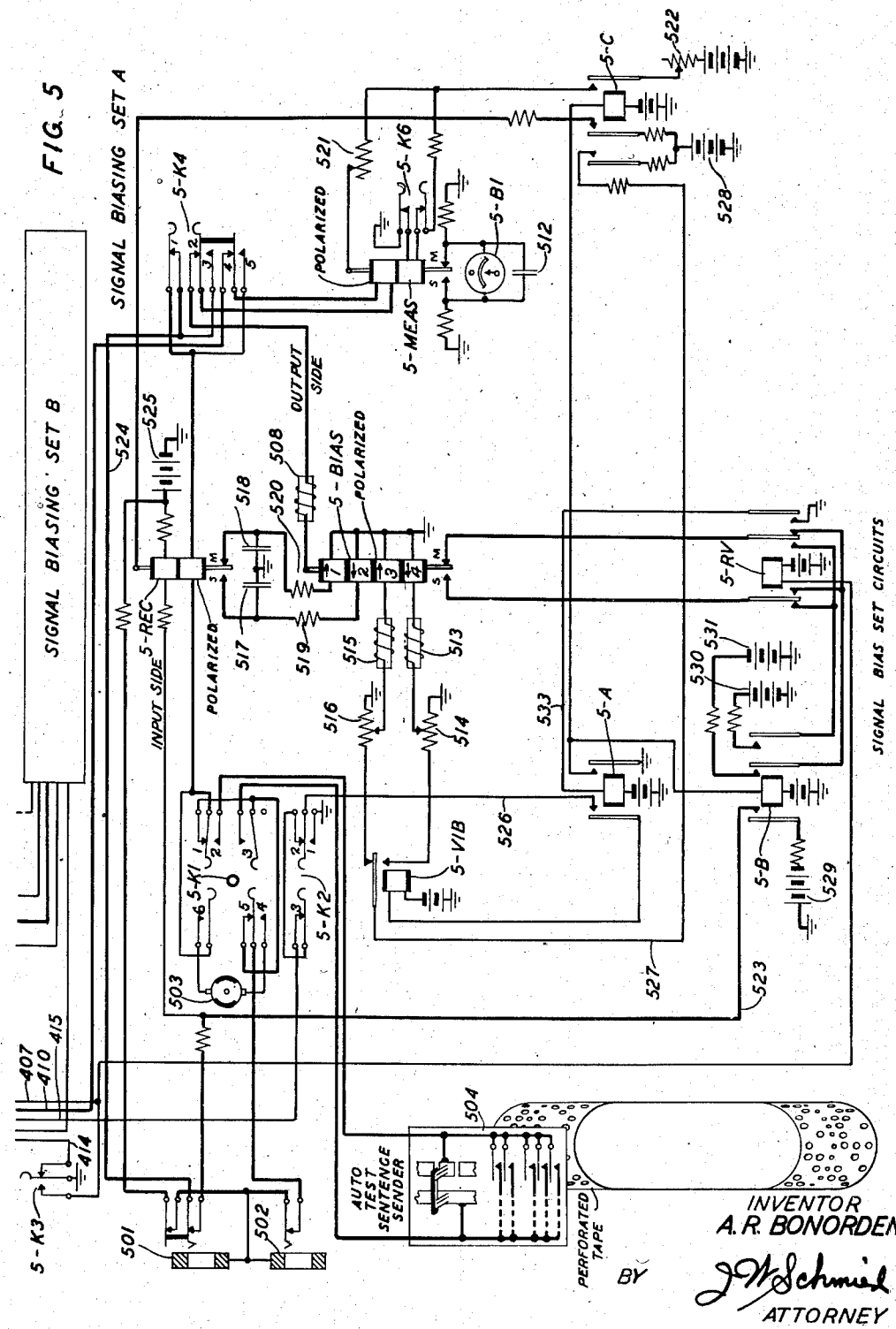
FIG. 5



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UNITED STATES PATENT OFFICE

2,387,558

TELETYPEWRITER TESTING SYSTEM

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Application September 11, 1943, Serial No. 501,972

11 Claims. (Cl. 178—69)

This invention relates to testing arrangements for telegraph circuits employing teletypewriter equipment for transmitting and receiving messages. It is an alternative of the system disclosed in United States Patent 2,347,518, granted to J. S. Soderholm and C. Breen on April 25, 1944.

As is well known, teletypewriter circuits are now provided having teletypewriter equipment at the subscriber's premises and switchboard arrangements at a central office, so that any subscriber may be connected for an interchange of messages by a teletypewriter circuit extending from his own equipment through the central office to the teletypewriter equipment of another subscriber.

To test the teletypewriter equipment of circuits of this type the maintenance man goes to a subscriber's premises and by means of a start, or power, switch at the subscriber's teletypewriter calls the operator at the central office and requests that a testing trunk be connected to the line. The switching operator passes this information to a trouble operator, who then connects into the line a special testing trunk leading to the test board where a test board attendant will be available to cooperate in making the test. Plugging in the test trunk not only makes the line appear busy at all its multiples at the operators' switchboard, but the test trunk is so arranged that the line will appear to be out of order to any operator who tests the line.

Merely plugging in the test trunk does not automatically signal the test board attendant and, indeed, the test trunk is not used immediately for any purpose. On the contrary, the main concern at the subscriber station after the maintenance man has ordered the test trunk, is for him, ignoring the test trunk for the time being, to proceed to make preliminary and routine tests of the subscriber's teletypewriter equipment. These tests include cleaning and adjusting electrical contacts, adjusting relays, oiling mechanical parts and making general mechanical tests to determine whether or not various elements of the printer mechanism are functioning properly.

Having made these preliminary tests, the maintenance man is ready to make those tests which require the use of the test trunk. These tests are of two types. One type of test consists of orientation range measurements to determine whether or not the signal pulses received at the subscriber teletypewriter are of the proper wave shape, that is, whether or not the teletypewriter is adjusted to receive with equal fidelity test signals having extreme permissible "positive" and "negative" bias limits. The other type of test involves transmitting messages from the station equipment to a standard test printer, at the test board to determine whether the signals are coming through properly, that is, whether the keyboard mechanism is transmitting signals the distortion and bias of which are within the required limits. The test board attendant takes no part in the orientation range measurements, but his services are required in making tests on signals incoming at the test board teletypewriter.

The orientation range measurements take considerable time and where they require the assistance of the test board attendant, it means that during these particular tests the test board attendant is tied up and is not available for other services. It is therefore desirable, as disclosed in the Soderholm et al. patent, supra, to have some arrangement by which it will be unnecessary for the test board attendant to take part in the orientation range measurements, especially as the results of the measurements themselves are actually observed by the maintenance man at the subscriber's station and remedial action taken by him.

As is well known, the individual pulses of the permutation code should theoretically be square-topped waves. Actually, of course, this condition does not exist. Even if properly shaped waves could be sent out by the transmitter, upon their arrival at the printer, they would be considerably distorted by the transmission line and the receiving equipment. It is therefore necessary for the maintenance man to determine to what extent the waves had become changed in shape during transmission. This he does by an orientation range measurement equipment which forms no part of the present invention and is not herein disclosed. This equipment is so arranged that it measures the amplitude of parts of successively transmitted wave pulses at relatively different times with respect to the period during which each individual pulse continues.

The effect of distortion is to round off the corners of the square-topped waves so that at the beginning of the wave and at the end thereof the current does not attain its full value. The orientation range measuring device is in effect shifted back and forth with respect to the time of the wave so that it tests brief time elements of the wave ranging from the beginning of the pulse, through its middle portion to the end of the pulse. If these tests show that the wave is too much distorted, adjustment has to be made either to the teletypewriter, that is, the printer, or to the line equipment until proper waves are received.

When the maintenance man has completed the preliminary and routine tests of the subscriber's teletypewriter equipment, as already mentioned, special signals for use during the orientation range measurements will be automatically applied to the trunk leading from the test board.

Heretofore the special signals used for making the orientation range measurements were of the unbiased type whereas recent practice requires that these special signals be of the biased type, namely, marking bias by itself, spacing bias by itself and switched bias, that is, signals of alternate marking bias and spacing bias. Therefore, an object of the present invention is to provide a circuit arrangement whereby the maintenance man at a subscriber's station may, independently of any assistance by the test board attendant, automatically select any one or all of the three different types of biased signals from a common source at the central office for transmission of such type or types of biased signals, as desired, back to the calling subscriber station.

A testing set suitable for furnishing marking bias, spacing bias and switched bias is disclosed in Fig. 2 of H. A. Rhodes, U. S. Patent 2,140,680, issued December 20, 1938. A set of this character is arranged to introduce in test messages known amounts of bias in both the marking and spacing directions. The amount of bias introduced can be varied by adjustment and can be observed in both directions, and the set after such adjustment may be connected to an external circuit and thus will reproduce in that circuit signals biased to a known extent. The known bias may be quickly switched in either direction, without changing the amount of bias, either at odd times by manual means or at regular intervals by automatic means without the need of changing connections.

According to the present invention means, automatically operated, are provided to select, as desired, the different types of signals biased to any degree. Inasmuch as the procedure at the subscriber's station when a maintenance man is making a periodic inspection of the subscriber's teletypewriter equipment, requires the continuous use of the biased signals for orientation range measurements over fairly long intervals of time, the present invention serves to reduce the maintenance man's time and to eliminate the assistance of the test board attendant by providing means for automatically connecting the source of signals to the subscriber's line under test, together with the control means whereby the maintenance man can change the type of the biased signals during the progress of the test. On the completion of the test the maintenance man can dismiss the source of biased signals and signal the test board attendant to connect the test board teletypewriter to the subscriber line in order to receive the report of the test. When the test board attendant receives this signal he connects his test board teletypewriter to the testing trunk to receive signals sent from the subscriber's station, and as these signals are received at the test board teletypewriter he determines whether the proper signals are being sent out from the subscriber's station. The arrangement of the trunk is such that the test board attendant and the maintenance man are able to communicate with each other about the test signals, the former using the test board teletypewriter and the latter employing the teletypewriter equipment located at the subscriber's station.

The invention will now be more fully understood from the following detailed description when read in connection with the accompanying drawings:

Fig. 1 shows a subscriber station connected to its line terminating equipment at the central office.

Fig. 2 shows an operator's cord circuit at the main switchboard in the central office.

Fig. 3 shows the testing trunk terminating in a plug at the main switchboard and in a jack at the attendant's test board. Also shown, in diagrammatic form, in Fig. 3 is the attendant's teletypewriter adapted for connection to the testing trunk.

Fig. 4 shows two of several line finder switches which are respectively associated with common sources of biased signals provided at the central station. Each finder switch is of the single movement rotary type and comprises six banks of twenty-two terminals each, the corresponding terminals on the six banks of each switch being associated with the termination of a test trunk such as shown in Fig. 3.

Fig. 5 shows two of the common sources of biased signals, one in schematic form and the other in diagrammatic form. Usually one to three common sources of bias signals are employed at a central station. They are substantially similar to that shown in Fig. 2 of the Rhodes patent, supra.

Fig. 6 shows the relative arrangement of Figs. 1 to 5.

Apparatus

Subscriber's apparatus and line equipment

Referring to Fig. 1 the subscriber's teletypewriter **101** is shown connected to a line circuit consisting of tip conductor **102** and ring conductor **103**. The subscriber's teletypewriter includes a sender **104**, conventionally represented, a line relay **105** connected in the line circuit, and a printer magnet **106** which by known means, not here illustrated, operates the receiving printer to type received messages. The subscriber's station also includes a ringer, or bell, **107** for ringing the subscriber station, and a power switch **108** for starting the printer motor **109** and throwing the subscriber's line circuit into operative condition. As is well known, the switching arrangement for starting up the teletypewriter motor and otherwise putting the subscriber's circuit into operating condition may be automatically controlled from the central office, but as these facilities form no part of the present invention they are not herein illustrated. It will be understood, however, that they may be used with the present invention, if desired.

The subscriber's station line circuit extends to the central office where it terminates in a jack **110** and multiples thereof, such as jack **111**, through which connections may be established to other line operator positions at the main switchboard whereat all the subscriber lines terminate. Other multiple jacks may be provided, such as a jack, which enables a practice cord circuit to be connected to the line; a jack which enables a busy cord circuit to be connected to the line; and a jack which enables an out-of-order cord circuit to be plugged into the line for purposes which are described in the Soderholm et al. Patent No. 2,347,518, supra. At the trouble operator's position in the main switchboard appears test jack **112** which is also a multiple of the subscriber's line circuit. By means of test jack **112** the testing trunk shown in Fig. 3 may for testing purposes be plugged into the subscriber's line as will be hereinafter described. Adapted for connection to jacks **110** and **111** is an operator's switching cord circuit shown in Fig. 2 whereby a subscriber's operator makes connection from the subscriber's line **102—103** to any other of the other

subscribers' lines by plugging opposite ends of the cord circuit into the jacks terminating the respective two lines between which a connection is desired.

The subscriber line 102—103 has also associated therewith at the central office sleeve relay 113 and a controlling relay 114, both of the differential type. Relay 114 controls relays 115 and 116, the former of which under proper conditions operates the supervisory lamp 216, in the operator's cord circuit, while relay 116 operates line lamps 117 and 118, respectively associated with the subscriber line jacks 110 and 111, and other line lamps, not shown, but respectively associated with other multiples of the line jacks 110 and 111, when provided.

Operator's cord circuit

The operator, or switching, cord circuit shown in Fig. 2 is provided with an answering plug 202 and a calling plug 203 which are used in establishing connections. It also includes a telegraph repeater comprising repeating relays 204 and 205 of the polarized type, with associated apparatus whereby telegraph code impulses may be relayed in either direction through the cord circuit. In the sleeve of the cord circuit associated with the answering plug is a polarized sleeve relay 206 and an additional sleeve relay 207. The former operates two relays 208 and 209, the former of which controls the circuit of the supervisory lamp 216, while the latter renders repeating relays 204 and 205 operative. Relay 207 controls the busy circuit connected to the tip of the answering plug 202. The busy circuit includes polar relays 210 and 211 which respectively operate a busy lamp 201 and buzzer 212, thus enabling the operator to distinguish between a line which is merely busy and one which is out of order as is described in detail in the Soderholm et al. patent, supra.

The calling end of the cord circuit has associated therewith a sleeve relay 213 controlling relay 214 which in turn controls the busy circuit and the calling supervisory lamp 215. The busy circuit is connected to the tip of the calling plug 203 and includes polarized relays 217 and 218. The last-mentioned relays, like the corresponding relays associated with the answering end of the cord circuit, respectively control the busy lamp 219 and buzzer 220.

In order that the operator may communicate with the calling subscriber, an operator teletypewriter 221 including a sender 222 and a printer relay 223, is provided. The printer magnet 223 functions to operate the receiving printer (not shown) in a manner well known in the art.

Testing trunk

In order that a maintenance man may make orientation range measurements and signal tests, a plurality of testing trunks, such as that shown in Fig. 3, are provided, each terminating at one end in a plug, such as plug 301, at the trouble operator's position in the main switchboard and at the other end in a jack, such as jack 302, at the test board. This testing trunk cord circuit has in its sleeve conductor of its answering plug 301 sleeve relay 3—A. Relay 3—A, upon operating, operates relay 3—BB which, when operated, (1) controls guard lamp 303 and (2) closes the tip and the ring conductors of plug 301 in circuits respectively extending through the winding of relay 3—CC and the winding of stepping magnet 304. Relay 3—CC, when operated, transfers the ring conductor to the winding of the lamp relay 3—L which, in turn, controls the lighting of answering lamp 305, lamp 305 serving to call the test board attendant for the purpose of connecting the test board teletypewriter to the testing trunk jack 302. Stepping magnet 304, upon operating, controls the operation of minor switch 306 which when operated to its No. 1 terminal, prepares the connection of source 308 of interrupted ground to terminal No. 1 in bank No. 6 of each of finder switches A, B, etc., finder switches A and B only being shown in Fig. 4. Off-normal switch 309 of minor switch 306 operates as the minor switch moves its brush 307 off its normal position. Off-normal switch 309, upon operating, closes at its upper normally open contacts a circuit for operating start relay 4—ST of a start circuit 401. Each of the testing trunks that are provided in the system is connected in multiple to the finder switches A, B, etc., each trunk being connected in multiple through finder switches A, B, etc. A set of electromagnetic devices, such as relays 4—CT, 4—SH and 4—HT, and stepping magnet 4—STP is provided for each finder switch. The joint operation of minor switch 306 and subsequent seizure of the test trunk by any one of the finder switches prepares the signal biasing set associated with the operated finder switch for producing biased signals.

Signal biasing set

As hereinbefore stated, a signal biasing set is provided for each of the finder switches A, B, etc. Signal biasing sets A and B only are shown, the former being shown in schematic form and the latter in diagrammatic form. The start circuit 401, which is common to all test trunks and to all finder switches A, B, etc., serves to start all idle finder switches hunting for any "calling" testing trunk.

Signal biasing set A which is shown in schematic form will be briefly described herein. Biasing set A is conditioned for operation by the joint operation of a minor switch, such as minor switch 306 and finder switch A whereby an operating circuit for relay 5—RV is closed. Relay 5—RV operates to close the operating circuit for relay 5—A. Relay 5—A operates and thereby operates relays 5—B and 5—C. Relays 5—RV and 5—A may also be operated by operating start key 5—K3 when manual starting of the set is desired. Various sources of signals are adapted to be respectively connected to biasing set A, through key 5—K1. A source of current reversals may be connected in the input circuit by operating key 5—K1 to its left-hand position whereby receive relay 5—REC is capable of operating continuously between marking and spacing contacts in response to the signals transmitted through interrupter 503. Another source, such as source 504, may be connected to the input circuit by operating key 5—K1 to its right-hand position for impressing neutral signals, that is, open and closed circuit conditions upon the operating, or lower, winding of receive relay 5—REC, as by means of a 60-speed transmitter which automatically impresses test sentence signals upon the operating winding of relay 5—REC.

A bias measuring circuit is associated with the output circuit and comprises relay 5—MEAS and bias measuring indicator 5—BI. For purposes of furnishing biased signals to a maintenance man at a subscriber's station to make orientation range measurements, switch 5—K4 will normally be in the position shown and relay 5—MEAS is therefore held on its marking contact by current

flowing in its operating, or upper, winding which now extends from the armature of relay 5—BIAS, retardation coil 508, contacts No. 2 of switch 5—K4, through the upper winding of relay 5—MEAS, contact No. 4 of switch 5—K4 to the output circuit which may be traceable over conductor 410, armature No. 5 and contact of relay 4—CT—A, conductor 409 to the brush in bank No. 5 of finder switch A. Normally, should there be no current in the operating, or upper, winding of relay 5—MEAS, the current in the lower or biasing winding would operate the relay to its spacing position. The meter, or bias indicator 5—BI has a double scale with zero in the center and divisions for indicating marking bias in per cent on the right side of the scale and spacing bias on the left side of the scale. The meter is operated to the right when relay 5—MEAS is on its marking contact and to the left when the relay is on its spacing contact. Condenser 512 serves to dampen the movement of the meter needle.

Provisions are made for changing the bias introducing set at intervals to produce signals alternately with marking bias and with spacing bias.

The input circuit of the signal biasing set A comprises the repeating relays 5—REC and 5—BIAS. Relay 5—REC has its operating, or lower, winding included in the input circuit for operating its armature to marking. The biasing, or upper, winding of relay 5—REC is permanently energized during operation of the signal biasing set A to operate the armature of relay 5—REC to its spacing position when the operating winding is currentless. Relay 5—BIAS has two upper operating windings Nos. 1 and 2 connected to the marking and spacing contacts respectively of relay 5—REC for operation of the armature of relay 5—BIAS to marking and spacing respectively. The armature and contacts of relay 5—BIAS are included in the output circuit of the signal biasing set A.

Signals are impressed upon the input relay 5—REC for testing purposes and are, in turn, repeated to operate relay 5—BIAS for production of impulses in the output side of the signal biasing set. For the purpose of biasing the output signals, relay 5—BIAS is provided with two lower biasing windings Nos. 3 and 4 acting in opposite directions to aid or oppose one or the other of the operating windings to varying extents in accordance with the current strength in the biasing windings. Thus, during operation of signal biasing set A biasing winding No. 4 is connected through a retardation coil 513 to potentiometer 514 which, in turn, is connected to source 528 of positive potential over the armature in operated condition of relay 5—VIB. Similarly, biasing winding No. 3 of relay 5—BIAS is connected through retardation coil 515 to potentiometer 516 which in turn is connected over the armature in retracted position of relay 5—VIB to source 528 of positive potential.

It will first be assumed that the circuit is in the condition as shown in the drawings, however, with potentiometers 514 and 516 adjusted to ground. Under these conditions, the operating, or lower, winding of relay 5—REC is energized to hold the armature to its marking position over a circuit which may be traced from source 529 of negative potential, left-hand armature and contact of relay 5—B, conductor 523, over tip contacts of jack 501, conductor 524, contact No. 1 of key 5—K4, through the operating, or lower, winding of relay 5—REC, contacts Nos. 1 and 5 of key 5—K1, over tip contacts of jack 502 and auxiliary, or upper, contacts of jack 501 to a grounded positive source 525. With relay 5—REC in marking position, the current flows in winding No. 1 of relay 5—BIAS to hold the armature of relays 5—BIAS in its marking position. Under the assumed conditions windings Nos. 2 and 4 will be currentless and winding No. 3 will be ineffective. The output circuit from relay 5—BIAS when subsequently closed, may be traced as follows: From a grounded positive source 530, contact and outer right armature of relay 5—B, over the front contact and inner right-hand armature of relay 5—RV, marking contact and armature of relay 5—BIAS, retardation coil 508, contact No. 2 of key 5—K4, upper winding of relay 5—MEAS, contact No. 4 of key 5—K4, conductor 410 to the armature No. 5 of relay 4—CT—A. Thus immediately after the closing of the start circuit condition, the output circuit is in marking position.

If now the input circuit to the operating, or lower, winding of relay 5—REC be opened as in the case of a spacing signal, relay 5—REC will operate to spacing. Winding No. 1 of relay 5—BIAS will now become deenergized and winding No. 2 will be energized and will operate relay 5—BIAS to spacing, thereby opening the output circuit at the marking contact and closing it to grounded negative source 531, over the front contacts and inner right-hand armature of relay 5—B, over the front contact and inner left-hand armature of relay 5—RV, and the spacing contact and armature of relay 5—BIAS. The output circuit is now in spacing condition. When the input circuit again is closed relays 5—REC and 5—BIAS return to their respective marking positions, thereby placing the output circuit in marking condition.

Condensers 517 and 518 and high resistances 519 and 520 are included in the operating circuit for windings Nos. 1 and 2 of relay 5—BIAS for the purpose of shaping the operating current. These condensers are comparatively large, and besides acting as spark protection, serve in combination with the high resistances to round the front of the operating impulses and to add a fairly long tail to the rear of the impulses thereby permitting a bias of relay 5—BIAS to the extent of 60 per cent in either direction. Thus when relay 5—REC leaves its marking contact, condenser 518 will discharge slowly through winding No. 1 of relay 5—BIAS. In the meantime relay 5—REC reaches its spacing contact and current begins to build up in winding No. 2 of relay 5—BIAS. The result of these two currents will be a gradual reversal of the operating flux in relay 5—BIAS for operating this relay to spacing. When relay 5—REC returns to marking, these conditions are reversed. Thus with no current in windings Nos. 3 and 4, relay 5—BIAS will follow relay 5—REC after a definite short interval in both directions of operation.

It can readily be seen that by adjusting resistances 514 and 516 and properly operating relay 5—VIB a biasing current may be established in either winding No. 3 or winding No. 4 which will affect the operating flux in relay 5—BIAS to bias the operation of the relay either to marking or to spacing. The winding No. 3 is connected to aid the spacing winding No. 1 and thus will produce a spacing bias, whereas winding No. 4 aids the marking winding No. 2 and will pro-

duce marking bias. Retardation coils 513 and 515 included in the circuit of the biasing windings Nos. 3 and 4 are for the purpose of preventing "kick-off" of relay 5—BIAS. Thus, in repeating signals to the signal biasing set, both the marking and spacing impulses impressed upon the set will be repeated as current impulses which are subject to shaping and are combined with biasing effects to be repeated as biased signals in the output circuit.

Relay 5—VIB is connected over contacts Nos. 2 and 3 of key 5—K2 to a source 308 of impulses for continually operating and releasing the relay. In this manner the grounded positive source 528 is connected alternately to potentiometers 514 and 516, thereby alternately energizing the biasing windings Nos. 3 and 4 of relay 5—BIAS. The rate of these alternations may conveniently be one or two cycles per second. By operation of key 5—K2 to its right-hand position so as to open contact No. 2 and close contact No. 1, relay 5—VIB will be continuously operated and relay 5—BIAS will be continuously biased to marking. By operation of key 5—K2 to its left-hand position, relay 5—VIB will be continuously deenergized and relay 5—BIAS will be continuously biased to spacing.

A bias measuring circuit comprises relay 5—MEAS and bias indicator 5—BI. The operating, or upper, winding of relay 5—MEAS is included in the output circuit as already traced and serves to hold the relay to marking. The biasing, or lower, winding is energized through the normal contacts of key 5—K6 to operate the relay to its spacing position when the operating winding is currentless. The current in the meter 5—BI may be adjusted by means of potentiometer 521 and the current in the biasing winding by means of potentiometer 522.

For the purpose of impressing impulses upon the operating winding of relay 5—REC, key 5—K1 may be operated to the left thereby including a source 503 of interruptions to effect current reversals of substantially equal intervals in the input circuit. The input circuit may now be traced as follows: from grounded negative source 529 adapted for connection to conductor 523, over tip contacts of jack 501, conductor 524, contact No. 1 of key 5—K4, through the operating, or lower, winding of relay 5—REC, contact No. 6 of key 5—K1, through source 503 of interruptions, contact No. 4 of key 5—K1, tip contacts of jack 502, auxiliary, or upper, contacts of jack 501, conductor 526, to grounded positive battery 525. In this circuit the receiving relay 5—REC is operated in unison with source 503 of interruptions. With resistances 514 and 516 adjusted to ground, the bias relay 5—BIAS will repeat the reversals in the output circuit which, as already traced above, includes the operating winding of relay 5—MEAS. Any bias that may be present in the impulses from the source 503 of reversals, or interruptions, may thus be noted on the bias indicator 5—BI and should be taken into account in subsequently adjusting the signal biasing set for a desired output bias.

For the purpose of checking relay 5—BIAS, an additional test may be made by switching key 5—K4 to the left, thereby disconnecting the operating, or upper, winding of relay 5—MEAS from the output circuit which includes conductor 410 and connecting it into the input circuit. The input circuit may now be traced as follows: from the grounded negative source 529 adapted for connection to conductor 523, over tip conductor of jack 501, conductor 524, contact No. 3 of key 5—K4, through the upper winding of relay 5—MEAS, contact No. 5 of key 5—K4, through the operating, or lower, winding of relay 5—REC, contact No. 6 of key 5—K1, interrupter 503, contact No. 4 of key 5—K1, tip contacts of jack 502, auxiliary, or upper, contacts of jack 501, conductor 526 to grounded positive battery 525. With the circuit in this condition, the bias of the source of reversals at interrupter 503 may be determined independent of the operation of relay 5—BIAS. From any disagreement between the two readings, it may be determined whether relay 5—BIAS requires adjustment.

Again operating key 5—K4 to normal, that is, into the position shown, relay 5—MEAS will be included in the output circuit which includes conductor 410, and resistances 514 and 516 may each be adjusted to effect the desired bias with the key 5—K2 operated to the right, or marking, or to the left, or spacing as desired. The amount of bias produced in the output circuit is read on bias indicator 5—BI and at this time any bias previously observed in the source of reversals produced by interrupter 503, may be taken into account. Thus if a bias of 35 per cent be desired in both directions and it has been found that the reversals produced by source 503 has a 2 per cent marking bias, it will be necessary to adjust the mark potentiometer 514 to give a reading of 37 per cent marking on the bias indicator 5—BI and to adjust the space potentiometer 516 to give a reading on the bias indicator 5—BI of 33 per cent spacing.

It should be understood that the source 503 used with the signal biasing set though customarily termed a source of reversals, is in the nature of a circuit interrupter serially included in the operating circuit for relay 5—REC to produce current and no-current impulses of substantially equal length and in continuous succession.

When key 5—K1 is operated to its right-hand position, the source of reversals 503 will be disconnected from the input circuit and the source 504 of standard test sentence signals sent out by a transmitter, will be substituted therefor. The input circuit may now be traced as follows: from the grounded negative source 529 adapted for connection to conductor 523, over tip contacts of jack 501, conductor 524, normal contact No. 4 of key 5—K4, through the operating, or lower, winding of relay 5—REC, contact No. 2, through source 504, over contacts Nos. 3 and 5 of key 5—K1, over tip contacts of jack 502, and auxiliary, or upper, contacts of jack 501, conductor 526, to grounded positive battery 525. Standard telegraph signals are thus impressed upon relay 5—REC and will be repeated in the output circuit with a 35 per cent bias to marking or to spacing, depending upon whether relay 5—VIB is in an operated or unoperated condition.

The output circuit which includes conductor 410 may be associated with any external circuit which it is desirable to observe under various biasing conditions by connecting such external circuit by means of plugs to any of the jacks "neutral," "LPG," or "polar" as shown and described in the Rhodes patent, supra. In the present application current reversal impulses, marking impulses and spacing impulses each having a predetermined amount of bias may be selected by the maintenance man at the subscriber's station over conductor 410 which is the part of the

output circuit extending to the testing trunks shown in Fig. 3 and the method of operation which will be hereinafter described will show how the maintenance man may automatically select the three different types of biased signal.

METHOD OF OPERATION

Call from subscriber station 101 to another subscriber station (not shown) whose line also terminates in the same central office

If the subscriber at station 101 wishes to make a call to another subscriber, he will operate power switch 108 to its alternate position. Switch 108, upon being operated, closes at its left-hand contact a circuit for connecting alternating current source 119 to rectifier 220 and also to printer motor 109. The left-hand, or direct current, side of rectifier 120 furnishes current for operating printer magnet 106 and for biasing the upper winding of line relay 105. At its right-hand side, switch 108 closes the subscriber's loop extending from grounded positive 48-volt battery 121, make-before-break contact No. 3 of relay 113, through the lower winding of relay 114, ring conductor 103, right-hand operated contact of power switch 108, through the lower winding of relay 105, normally closed contact of break key 123, transmitting contacts 104, tip conductor 102, upper armature and back contact of relay 113, make-before-break contacts No. 2 of relay 116 to ground. Relay 114 operates and closes at its armature and contact a circuit containing two obvious operating paths for relays 115 and 116, respectively. Relay 115 operates and connects at its armature and contact a ground connection through the tip conductor of the multiple jacks 110, 111 and 112. Relay 116 operates and closes (1) at its upper armature, the tip conductor of the subscriber's loop to grounded negative 48-volt battery 124 and disconnects at its make-before-break contacts No. 2 the ground connection; (2) at its inner lower armature and contact connects grounded negative 24-volt battery to a circuit extending through the lower winding and the upper winding, in series, of relay 113 to ground; and (3) at its outer lower armature and contact closes an operating circuit for calling lamps 117 and 118 respectively associated with jacks 110 and 111 at the operator's switchboard. Relay 114 is held operated under the influence of its lower winding and the circuit of the subscriber's loop is now in readiness to receive the answer plug 202 of the operated cord circuit. Relay 113 is of the differential type and therefore does not operate at this time inasmuch as its two energized windings oppose each other.

Switching operator answers

Assuming that the operator at whose position a calling lamp such as lamps 117 and 118, becomes lighted, answers the call, the operator will insert plug 202 of the switching cord into the jack associated with the lighted lamp at the answering operator's position. Over the sleeve conductor of plug 202 and the particular jack, say jack 110, the following circuit is now established: Grounded negative 24-volt battery 224, through 200-ohm resistance 227, through the winding of relay 207, through the lower winding of relay 206, sleeve conductors of plug 202 and jack 110, through the upper winding of relay 113, to ground. Another circuit is established from grounded negative 24-volt battery 225, through the 17-ohm winding of relay 226, through the 31.5-ohm resistance 228, through the 3.5-ohm upper winding of relay 206, over the sleeve conductors of plug 202 and jack 110, through the 200-ohm upper winding of relay 113 to ground.

The upper winding of relay 113 now receives current from the grounded negative 24-volt battery over three separate paths—one over the inner lower armature and contact of relay 116 and the lower winding of relay 113 to point 125, a second through the winding of relay 207, and the lower winding of relay 206 to point 125, and a third through the winding of relay 226 and the upper winding of relay 206 to point 125. The first of these paths includes a resistance of 1300 ohms, through the lower winding of relay 113. The second path through the winding of relay 207 includes a resistance of 712 ohms made up of the 200-ohm resistance 227, the 432-ohm resistance of the winding of relay 207 and the 80-ohm resistance of the lower winding of relay 206. The third path has a resistance of 52 ohms between grounded negative battery 225 and point 125, this resistance being made up of the 17-ohm resistance of the winding of relay 226, the 31.5-ohm resistance 228 and the 3.5-ohm resistance of the upper winding of relay 206. The resistance of this third path is so low compared with the other two that the current flow through the upper winding of relay 113 is greatly increased and is much greater than the current through the lower winding, thus causing relay 113 to be operated. Relay 113, upon operating, extends the subscriber's loop which now may be traced from grounded negative 48-volt battery 124, through the upper winding of relay 114, front contact and upper armature of relay 113, tip conductor 102, through the subscriber station, ring conductor 103, through the lower winding of relay 114, front contact No. 4 and lower armature of relay 113, ring conductors of jack 110 and plug 202, normally closed contact of ringing key 231, normally closed contacts of teletypewriter key 232, through the upper winding of repeater relay 204, armature and spacing contact of repeater relay 205, to grounded negative battery 229. Relay 114 being of the differential type and having both windings energized at this time now releases. Relays 115 and 116 also releases at this time.

We now have the relays 207 and 206 in the cord circuit energized and the sleeve relay 113 of the line operated. Relay 207, upon operating, opens the busy circuit to the tip conductor of plug 202. This circuit, however, does not come into play at the present time. Relay 206, upon operating, actuates relay 208 and also completes a path through the left-hand winding of relay 209 which operates. Relay 208, upon operating, opens at its back contact and armature the busy circuit at another point, and at its front contact and armature closes the circuit for operating supervisory lamp 216, which circuit extends over the tip conductor of plug 202. Supervisory lamp 216, however, due to the release of relay 115, is prevented from lighting.

Cord circuit repeater operation

Relay 209 which is operated under the influence of its left-hand winding connects ground to the lower winding of repeater relays 204 and 205 in the cord circuit. Current now flows from grounded negative 48-volt battery 229 over the spacing, or right-hand, contact and armature of relay 204, through the lower winding of relay 205, to ground at the right-hand armature and contact of relay 209. This current is in such a direction as to shift the armature of relay 205 to its

marking, or right-hand position. Current from the grounded positive 48-volt battery **230** now flows over the marking, or right-hand, contact and armature of relay **205**, through the lower winding of relay **204**, to ground at the left-hand armature and contact of relay **209**. This current is in such a direction as to hold the armature of relay **204** upon its spacing, or right-hand, contact until a circuit is completed through the upper winding of relay **204** as will be hereinafter described.

As hereinbefore stated, sleeve relay **113** operated and thereby opened at its outer lower armature and contact the operating circuit for relay **116** thereby causing relay **116** to release and calling lamps **117** and **118** to be extinguished. Relay **116**, upon releasing, opens at its inner lower armature and contact the path extending through the lower and upper windings in series of relay **113**, but relay **113** remains energized and operated through its upper winding. Relay **113**, in its operated position, completes the subscriber's loop as hereinbefore described.

It will be noted that the grounded positive 48-volt battery **230** is in series aiding with respect to the grounded negative 48-volt battery **124**. A circuit previously traced also extends from the grounded positive 48-volt battery **230**, over the marking, or right-hand, contact of relay **205**, through the lower winding of relay **204** and over the left-hand armature and front contact of relay **209** to ground. Only half as much current flows in the lower winding as flows through the upper winding of relay **204** due to the fact that the two batteries are in series aiding in the circuit extending through the upper winding. Since the two windings of relay **204** oppose each other when the currents flow as above described, the upper winding prevails and shifts the armature of the relay to its marking, or left-hand, contact where it remains as long as the circuit conditions above described exist.

The shift of the armature of relay **204** reverses the direction of current flow through the lower winding of relay **205** because grounded positive 48-volt battery **233** is now connected over the marking, or left-hand, contact and armature of relay **204** through the lower winding of relay **205**. The current through the lower winding of relay **205** is now in such a direction as to tend to shift the armature of relay **205** to its spacing, or left-hand, contact. This action is prevented by current flowing through the upper winding of relay **205** from grounded positive 48-volt battery **233**, over the marking, or left-hand, contact and armature of relay **204**, through the upper winding of relay **205**, outer left-hand armature and contact of relay **213**, to grounded negative 48-volt battery **235**. This current being slightly greater than that flowing through the lower winding, and the upper winding being oppositely poled, the armature of relay **205** remains on its marking, or right-hand, contact.

It will be noted that even if the armature of relay **205** should be shifted to its spacing, or left-hand, contact, under conditions which will be described hereinafter, the armature of relay **204** will not shift. When the armature of relay **205** is on its spacing, or left-hand, contact the grounded negative 48-volt battery **229** now connected to the upper winding **204** over the spacing, or left-hand, contact and armature of relay **205** opposes the potential of the grounded negative battery **124** applied to the upper winding of relay **204**, through the winding of relay **114** of the line circuit. Current therefore ceases to flow through the upper winding of relay **204**. However, the direction of current through the lower winding of relay **204** is reversed by the shifting of the armature of relay **205** to its spacing contact and is now in such a direction as to hold the armature of relay **204** on its marking, or left-hand, contact.

Operator communicates with the maintenance man at the calling subscriber's station

The operator is now able to communicate with the maintenance man at the calling subscriber's station and to use the sender contacts **222** of teletypewriter **221** by operating teletypewriter key **232** to ask the maintenance man what connection is desired. The operation of the sender contacts for extending the code combination will cause an open circuit condition of the circuit through the upper winding of relay **204** for each spacing impulse. During each spacing impulse the armature of relay **204** will therefore be shifted to its spacing contact. This produces a no-current condition in the upper winding of relay **205**, but it also reverses the current through the lower winding of relay **205** and causes said lower winding to hold the armature of said relay upon its marking contact. No current impulses through the upper winding of relay **205** are without effect, however, because plug **203** is not connected to an outgoing line and hence the signals are in effect not repeated. As soon as the armature of relay **204** is shifted back to marking, the current through the lower winding of relay **205** is again reversed, but the current through its upper winding prevails and holds its armature on its marking contact as hereinbefore described.

Each time the line circuit is opened as above described, the circuit through the two opposing windings of relay **114** is opened but this is without effect. The two windings oppose each other during the marking condition and receive no current during the spacing condition so that the relay is not actuated under either condition. Line relay **105** at the subscriber station, however, responds to the marking and spacing signals to operate the subscriber's printer magnet **106** which causes printed characters to be recorded at teletypewriter **101**.

The maintenance man now uses his sender contacts **104** to send to the central operator's printer **221** a request that the testing trunk at the trouble operator's position be connected to the calling subscriber line. When his request is acknowledged he disconnects. The operator receiving the request will convey the request by any available means, such as a call wire, telephone, or other means, to the operator at the trouble position who will, in turn, insert the plug of a test trunk, such as plug **301** of the test trunk shown in Fig. 3, in the test jack **112** which is a multiple of the line jacks **110** and **111**.

Extending connection to the testing trunk

The operator at the trouble operator's position upon inserting plug **301** into jack **112** automatically starts the testing trunk functioning. The maintenance man at the calling subscriber's station in the meantime restores power switch **102** to its normal position and proceeds to make preliminary tests of the subscriber's printer while the test trunk is being set up. These preliminary tests as hereinbefore stated, include oiling parts, cleaning and adjusting contacts, adjusting relays, and making general mechanical test of the printing mechanism.

When the trouble operator inserts plug 301 into test jack 112, a sleeve circuit is completed from grounded negative 24-volt battery, through the winding of relay 3—A, sleeve conductors of plug 301 and jack 112, through the upper winding of relay 113 to ground. Relay 113 operates at this time in series with relay 3—A.

Relay 3—A, upon operating, operates relay 3—BB which, in turn, causes red guard lamp 303 to light, and closes the tip and the ring conductors of plug 301 over two paths respectively, the tip extending through the winding of relay 3—CC to grounded negative 24-volt battery, and the ring extending through the winding of stepping magnet 304 to grounded positive 48-volt battery. Because the station power switch 108 is in its "off" position at this time the ring conductor will be opened but the tip conductor will be grounded at the armature and contact of relay 115 thereby causing relay 3—CC to operate and transfer the ring conductor to the winding of relay 3—L. Relays 115 and 116 happen, at this time, to be in operated condition because relay 114 is operated by current in its upper winding only, the current flowing in a path extending from ground at the normally closed contact of power switch 108, through the lower winding of relay 105, normally closed contact of break key 123, transmitting contacts 104, tip conductor 102, upper armature and front contact of relay 113, through the upper winding of relay 114, to grounded negative battery 124.

Should the maintenance man operate the power switch 108 as he normally would do to initiate a call, the removal of the ground connection from the tip conductor at the normally closed contacts of power switch 108, followed by the immediate closure of the loop, would cause relay 3—L to operate and the slow-release relay 3—CC to release. Should relay 3—L operate it would lock through its own contact to the ring conductor and prepare a path for lighting of the answer lamp 305 when relay 3—CC subsequently releases. The lighted answer lamp 305 would call the test board attendant to the circuit as at present.

However, in this case the maintenance man does not want to call in the attendant at once but desires to obtain the source of signals. He therefore operates and holds the break key 123 of the subscriber's teletypewriter operated whereby the ground connection is disconnected from the tip conductor of the testing trunk, then operates power switch 108 to its "on" position, and one second later releases break key 123. The operation of break key 123 removed ground from tip conductor 102 to cause relay 114 to release and, in turn, the release of relays 115, 116 and 3—CC. Hence relay 3—CC will have released before the subscriber's loop is closed and after the power switch 108 is operated to its "on" position will have included in the loop circuit the stepping magnet 304 of the minor switch 306. Stepping magnet 304 operates thereby causing the brush 307 of minor switch 306 to step to the contact No. 1 thereby connecting source 308 of interrupted ground operating at sixty impulses per minute, to the terminal No. 1 of bank No. 6 of each of the finder switches A and B. The off-normal spring assembly 309 of minor switch 306 will also operate, removing "busy" ground at its normally closed contact from terminal No. 1 of bank No. 1 (which is the hunting bank) of each of the finder switches and will connect on its lower normally open contact a ground connection to a circuit extending over conductor 310, outer lower armature and back contact of relay 3—L, contact and outer lower armature of relay 3—BB, through the winding of signal relay 3—SIG, holding conductor 311 to terminal No. 1 of bank No. 2 of each of the finder switches. Also off-normal spring assembly 309 closes at its upper, normally open contact a circuit extending from ground at the outer lower armature and back contact of release relay 3—RLS, upper, normally open contact of assembly 309, lower armature and back contact of relay 3—SIG, conductor 328, through the winding of start relay 4—ST, to grounded negative 24-volt battery, and start relay 4—ST operates. Start relay 4—ST together with overflow relay 4—OFL and overflow magnet 4—OFL—MGT of a register comprise a common start circuit which is common to all the testing trunks respectively terminating, in multiples, at the finder switches A and B.

Start relay 4—ST, upon operating, closes at each of its right-hand armatures, Nos. 2, 3, 4 and 5, etc., a circuit extending to ground at the normally closed contact of a local test key in its respective finder switch of switches A, B, etc., the circuit for operating finder switch A being traceable from ground at the normally closed contact of local test key 5—K3, conductor 414, over No. 4 armature and contact of relay 4—ST, conductor 403, back contact and armature No. 2 of relay 4—CT—A, through the winding of slow-release relay 4—SH—A, to grounded negative 24-volt battery and relay 4—SH—A operates. A similar circuit is closed for operating relay 4—SH—B at finder switch B and a similar circuit is closed for each of the other finder switches provided. The local test keys are provided for respectively adjusting the signal biasing sets and during the adjusting operation of any one set, the finder switch associated with such set will not attempt to accept calls.

Relay 4—SH—A, upon operating, closes at its right-hand armature and contact a circuit extending from grounded battery, through the winding of relay 4—HT—A, right-hand armature and contact of relay 4—SH—A, armature and contact of stepping magnet 4—STP—A, to a common point 404, back contact and armature No. 1 of relay 4—CT—A, conductor 405, to the bridging brush of bank No. 1. In general, the brushes of each finder switch are resting on the terminals last served and a ground will be found connected on the terminal if the associated testing trunk is not "calling" for a signal biasing set and no ground will be found on terminals of such trunk "calling" for a set. Where the banks of a finder switch are provided with twenty-two terminals, only the unequipped terminals of bank No. 1, that is, those terminals to which no test trunks are connected, will be grounded. Hence, a finder switch when started to operate, may only engage a grounded terminal when the start relay 4—ST and a relay of those designated 4—SH release as the finder switch is stepping onto a grounded terminal. Usually banks Nos. 2 to 6 have only twenty-one terminals and bank No. 1 has twenty-two terminals in which case the twenty-second terminal is grounded. This is done because when one brush arm of a finder switch is passing over to associated terminals, the other brush arms of the switch are passing over their respective twenty-second terminals resulting in a double frictional load. By omitting five twenty-second terminals the load is increased by one terminal only, namely, the twenty-sec-

ond on bank No. 1. Also relay 4—SH—A, upon operating, closes at its left-hand armature and contact an operating circuit for relay 4—CT—A, the circuit being traceable from ground, over the left-hand armature and contact of relay 4—SH—A, through the winding of relay 4—CT—A, to the common point 404 in the path hereinbefore traced. Relay 4—CT—A is therefore short-circuited during the time that the brush arm in bank No. 1 of finder switch A is connected to ground on its twenty-second terminal or terminal last served. The ground connection in bank No. 1 of finder switch A is effective to close the operating circuit for relay 4—HT—A which operates. Relay 4—HT—A, upon operating, closes at its armature and contact an obvious operating circuit for stepping magnet 4—STP—A which operates to open the operating circuit of relay 4—HT—A. Relay 4—HT—A releases and in turn causes stepping magnet 4—STP—A to release. The release of magnet 4—STP—A causes to step the brushes of finder switch A to their respective next terminals. This sequence of events is repeated until the brush in bank No. 1 of finder switch A moves into engagement with a terminal not grounded since the terminal associated with the testing trunk on which the maintenance man is awaiting the source of signal has an operated off-normal switch assembly such as that designated 309, whereat the normally closed grounded contact is open. When brush No. 1 of finder switch A becomes non-grounded, the shunt around relay 4—CT—A is removed, permitting it to operate, immediately connecting ground at the left-hand armature and contact of relay 4—SH—A to the terminal, say in this case terminal No. 1 of bank No. 1 thus preventing other finder switches from stopping on this terminal. Relay 4—HT—A is marginal and therefore does not reoperate in series with relay 4—CT—A and stepping magnet 4—STP—A remains released.

When relay 4—CT—A operates, the operating path of relay 4—SH—A which is of the slow-to-release type, is transferred from the start conductor 403 to the brush in bank No. 2 of finder switch A and over the holding conductor 311, through the winding of relay 3—SIG, outer lower armature and contact of relay 3—BB, back contact and outer lower armature of relay 3—L, to ground at the lower normally open contact of off-normal switch assembly 309 in operated position. Signal relay 3—SIG in the circuit comprising holding conductor 311 thereupon operates, and relay 4—SH—A is held operated over the holding conductor 311. Relay 3—SIG, upon operating, opens the operating circuit for common start relay 4—ST which thereupon releases unless other testing trunks are awaiting connection to signal sources. Relay 3—SIG, upon operating, closes a circuit extending from ground at the outer lower armature and back contact of relay 3—RLS, operated, upper normally open contact of off-normal switch assembly 309, lower armature and front contact of relay 3—SIG, conductor 313, to contact No. 1 engaged by the brush arm in bank No. 4 of finder switch A, conductor 406, contact and armature No. 4 of relay 4—CT—A, conductor 407, through the winding of relay 5—RV, to grounded negative 24-volt battery and relay 5—RV operates to provide the proper polarity termination of the signals available at the biased signal source required by the station circuit. Other test trunks, accessible to operator's cord circuits, would not connect ground conductor 407, inasmuch as they are respectively connected to different terminals in bank No. 4 of the finder switch A.

Relay 3—SIG, upon operating, opens at its upper armature and back contact the operating circuit for stepping magnet 304 of minor switch 306 and stepping magnet 304 releases, leaving the brush arm 307 of minor switch 306 in engagement with contact No. 1 and placing the further operation of the minor switch under control thereafter of relay 3—CC. Also relay 3—SIG, upon operating, extends the ring conductor of plug 301 over conductors 314 and 408 to terminal No. 1 engaged by the brush arm in bank No. 5 of finder switch A and then over conductor 409, contacts and No. 5 armature of relay 4—CT—A, conductor 410, normally closed contacts No. 4 of key 5—K4, through the upper winding of relay 5—MEAS, normally closed contact No. 2 of key 5—K4, retardation coil 508, to the armature of relay 5—BIAS at which point the signals from the biased signal source are applied.

When relay 5—RV operated it closed at its contact and outer right-hand armature a circuit traceable over conductor 533, through the winding of relay 5—A to grounded negative 24-volt battery and relay 5—A operates. Relay 5—A upon operating closes at its right-hand armature and contact obvious operating circuits for relays 5—B and 5—C, and relays 5—B and 5—C operate. Also when relay 4—CT—A operated it closed at its contact and No. 6 armature a circuit traceable from source 308 of interrupted ground, contact No. 1 in engagement with brush 307 of minor switch 306, conductors 316 and 413, terminal No. 1 engaged by the brush arm of bank No. 6 of finder switch A, conductor 414, contact and armature No. 6 of relay 4—CT—A, conductor 415, normally closed contacts Nos. 3 and 2 of key 5—K2, conductor 526, inner left-hand armature and contact of operated relay 5—A, through the winding of vibrating relay 5—VIB to grounded negative 24-volt battery, and relay 5—VIB vibrates at the the rate of 60 impulses per minute in accordance with the source 308 of interrupted ground. As hereinbefore described, relay 5—BIAS operates in response to current alternately impressed on windings Nos. 3 and 4 by the vibration of the armature of relay 5—VIB and the armature of relay 5—BIAS serves in this case as a source of switched biased signals to be furnished to the maintenance man over conductor 410 as hereinbefore described. The teletypewriter at the subscriber's station will now receive the switched biased signals, followed by the test sentences, all mark and space signals of which are biased. The maintenance man will utilize the biased impulses for testing the subscriber's teletypewriter on incoming signals.

In the event the station teletypewriter records errors on switched biased signals the maintenance man at the subscriber's station will require the source of signals having steady mark bias, and later steady space bias. To change the type of signals from switched to mark bias the maintenance man will turn power switch 108 to its "off" position thereby closing the circuit traceable from ground, normally closed contacts of power switch 108, through the lower winding of line relay 105, normally closed contacts of break key 123, through the sender contacts 104, tip conductor 102, upper armature and front contact of relay 113, through the upper winding of differential relay 114 to grounded negative 48-volt battery 124. Relay 114 operates to close an obvious op-

erating circuit for relay 115. Relay 115 operates and connects ground on its armature and contact to the tip conductor of jack 112 and of plug 301 in a circuit traceable over the outer upper armature and contact of relay 3—BB, outer upper armature and back contact of relay 3—DD, through the winding of relay 3—CC, to grounded negative battery and relay 3—CC operates. Relay 3—CC, upon operating, closes at its outer lower armature and contact a circuit extending from ground, over the make-before-break contact of relay 3—SIG, through the winding of stepping magnet 304 to grounded positive 48-volt battery. Stepping magnet 304 operates to advance brush 307 of minor switch 306 to its No. 2 position thus removing source 308 of interrupted ground from the circuit traceable over conductors 316, 413, contact No. 1 in engagement with the brush arm of bank No. 6 of finder switch A, conductor 414, contact and No. 6 armature of relay 4—CT—A, conductor 415, normally closed contacts of key 5—K2, inner left armature and contact of relay 5—A, through the winding of vibrating relay 5—VIB, to grounded negative 24-volt battery, and relay 5—VIB ceases to vibrate and remains in its released position. Winding No. 3 of relay 5—BIAS is energized whereas winding No. 4 of relay 5—BIAS is deenergized, the energizing circuit for winding No. 3 being traceable from ground through the No. 3 winding, retardation coil 515, resistance 516, back contact and armature of relay 5—VIB, conductor 527, contact and outer left-hand armature of relay 5—C, to grounded positive 24-volt battery 528. Relay 5—BIAS under the influence of winding No. 3 is operated to its marking, or right-hand, position so that the bias signals outgoing over the outgoing circuit are now biased marking, the outgoing circuit including retardation coil 508, normally closed contact No. 2 of key 5—K4, through the upper winding of relay 5—MEAS, normally closed contact No. 4 of key 5—K4, conductor 410, armature No. 5 and contact of relay 4—CT—A, brush in engagement with contact No. 1 in bank No. 5 of finder switch A, conductors 408 and 314, front contact and upper armature of relay 3—SIG to the back contact associated with the operated upper armature of relay 3—CC. The maintenance man now operates and holds operated, break key 123, causing relay 3—CC to release. One second later he operates power switch 108 to its "on" position and then releases the break key. Relay 3—CC upon releasing, closes the subscriber loop at the back contact and upper armature of relay 3—CC, the loop now extending over the make-before-break contact of relay 3—L, back contact and inner upper armature of relay 3—DD, front contact and inner upper armature of relay 3—BB, ring conductor of plug 301 and of test jack 112, inner lower armature and front contact of relay 113, through the lower winding of differential relay 114, right-hand normally open contacts of power switch 108, through the lower winding of line relay 105, normally closed contacts of key 123 (which is released one second after the power switch is operated), sender contacts 104, tip conductor 102, upper armature and front contact of relay 113, through the upper winding of differential relay 114, to grounded negative 48-volt battery 124. The release of slow-to-release relay 3—CC occurs before the release of break key 123 and therefore lamp relay 3—L is prevented from operating and the station teletypewriter will therefore receive the test signals.

When the maintenance man at the subscriber station having made the necessary adjustment required in accordance with the steady mark bias signals received over the output circuit from the signal biasing set, he repeats the procedure hereinbefore described to advance the brush 307 of minor switch 306 to position No. 3. A ground connection at position No. 3 of minor switch 306 completes the operating circuit for vibrating relay 5—VIB and relay 5—VIB operates to close an energizing circuit for winding No. 4 of relay 5—BIAS and deenergizing the winding No. 3 of relay 5—BIAS. Relay 5—BIAS now operates to its spacing, or left-hand, position and thereby completes the outgoing circuit for transmitting steady space bias signals to the subscriber's loop. This procedure may be repeated alternately obtaining steady mark bias and steady space bias signals so that the maintenance man may make the necessary repetition in checking the teletypewriter. Afterwards he may send a recall signal to dismiss the set and call in the test board attendant.

In the event the maintenance man desires to obtain the attention of the test board attendant he will operate the power switch 108 to its "off" position and reoperate it after two seconds, this being the standard procedure for sending a recall signal. When the power switch is turned to its "off" position, ground from the subscriber line over the tip conductor operates relay 3—CC and when the power switch is again operated to its "on" position the subscriber's loop will be reclosed before relay 3—CC releases, thus causing the operation of relay 3—L which operates, locks to the subscriber's loop and opens the holding path of relays 3—SIG and 4—SH—A. Relay 3—SIG and relay 4—SH—A of the seized finder switch A release, the latter relay upon releasing, releasing its associated relay 4—CT—A to open the connection to signal biasing set A associated with seized finder switch A. The brush arms of seized finder switch A remain in their respective operated positions so that signal biasing set A may be available for use with other testing trunk circuits. Relay 3—L upon operating also operates relay 3—RLS in a circuit traceable from ground, lower normally open contact of off-normal switch assembly 309, outer lower armature and front contact of relay 3—L, through the winding of relay 3—RLS to grounded negative battery, and relay 3—RLS operates. Relay 3—RLS, upon operating, (1) locks up in a circuit traceable over its inner lower armature and front contact; (2) closes at its upper armature and front contact, the operating circuit for release magnet 317. Release magnet 317, upon operating, causes brush 307 of minor switch 306 to return to its normal position. When the minor switch 306 is in its normal position, the off-normal spring assembly 309 releases thereby releasing relay 3—RLS which in turn releases magnet 317. When relay 3—CC subsequently releases answer lamp 305 becomes lighted, indicating to the test board attendant that he is wanted. When the attendant inserts plug 318 into jack 302 and operates power switch 319, relay 3—DD becomes operated and the attendant's teletypewriter becomes conditioned for operation. Relay 3—DD, upon operating, (1) closes at its make-before-break contact, an obvious operating circuit for relay 3—CC which again becomes operated and thereby releases relay 3—L, (2) transfers the extension of the subscriber's loop circuit to the ring conductor of jack 302 and plug 318 and thence into the attendant's teletypewriter and (3) opens the

locking circuit for lamp relay 3—L which releases to extinguish answer lamp 305.

Relay 3—CC, upon operating, at this time prevents a false seizure by a finder switch circuit in the event the test board attendant disconnects first. In such a case the release of relay 3—DD will permit relay 3—L to reoperate before relay 3—CC releases, thus preventing connection of the extension of the subscriber's loop circuit to the operating circuit of stepping magnet 304 of the minor switch. If the maintenance man has already disconnected, relay 3—CC will be held operated by the tip conductor ground at the subscriber's station. The momentary operation of this disconnect key 3—DISC will provide a visual disconnect signal to the operator at the trouble position in the operator switchboard so that the trouble operator will thereupon disconnect the testing trunk from the subscriber's line.

In a similar manner, the test board attendant by his biased signal cord may also be terminated on the terminals of the banks of all the finder switches so that when he desires a source of signals, he may cause any idle signal biasing set to be associated with his cord by means of the finder switch circuit. The biased signal cord circuit provides appearances in the form of terminating plugs at the attendant's test board for use in associating a signal biasing set such as one of sets A and B with any subscriber line or intertoll trunk for checking operator's teletypewriters and regenerative repeaters at the switchboard. In the event all sources of signals are busy, the overflow relay 4—OFL releases and the next subsequent operation of start relay 4—ST will cause magnet 4—OFL—MGT of the register to operate, indicating the number of such occurrences.

What is claimed is:

1. A teletypewriter signal testing system for testing signal transmission comprising a plurality of transmission channels each having operable means, a switchboard whereat said transmission channels terminate, a test board, a circuit interconnecting said switchboard and said test board, a source of different types of signals biased to any desired degree, means under the control of said operable means associated with one of said transmission channels for remotely selecting any one of said types of signals from said source, and other means associated with said source for automatically transmitting the different types of said biasing signals from said source to said one transmission channel when an operable connection is established between said one channel and said interconnecting circuit.

2. A teletypewriter signal testing system for testing signal transmission comprising a plurality of transmission circuits each having operable means, a switchboard whereat said transmission circuits terminate, a test board, a circuit connecting said switchboard and said test board, a source of different type of signals biased to any desired degree, means under the control of any one of said operable means for automatically selecting any one of the different types of signals from said source, other means for automatically transmitting the different types of signals from said source to any one of said transmission circuits when said interconnecting circuit is connected to said one transmission circuit in response to the operation of said one operable means associated with said one transmission circuit, an indicating means at said test board responsive to the release of said operable means from its operated position and reoperation of said operable means after a prolonged interval for calling the attendant at said test board in on the established connection.

3. A teletypewriter signal testing system for testing telegraph transmission comprising a plurality of telegraph transmission circuits each having a telegraph printer and a power switch, a switchboard whereat said transmission circuits terminate, a test board, a circuit interconnecting said switchboard and said test board, a source of different types of code signals biased to any desired degree, means operable in conjunction with said power switch in its operating condition for automatically selecting any one of the different types of biased signals from said source for testing the printer in said one transmission circuit when said interconnecting circuit is connected to said one transmission circuit in an established connection.

4. In a telegraph system, a plurality of outlying stations, telegraph sending and receiving equipment at each of said stations, a main office, a plurality of channels respectively connecting said stations to said main office, a testing trunk adapted for connection at said main office to any one of said channels, a source consisting of a single circuit having a pair of adjustable network paths, located at said main office and capable of producing different types of signals biased to any desired degree and means at each of said outlying stations for automatically selecting over an established connection between one of said channels and said testing trunk, any one of said types of biased signals for testing the sending and receiving equipment at the calling outlying station.

5. In a telegraph system, a plurality of outlying stations, telegraph sending and receiving equipment at each of said stations, a main office, an operator's switchboard and a test board at said main office, a plurality of channels respectively connecting said stations to said switchboard, a testing trunk adapted for connection at said switchboard to any one of said channels, a plurality of switches connected in multiple to said testing trunk, a plurality of sources located at said test board and capable of producing different types of signals biased to any desired degree, each of said sources being connected to one of said switches, and means at each of said outlying stations for automatically selecting over an established connection between one of said channels and said testing trunk any one of said types of biased signals from any one of said sources for testing the sending and receiving equipment at a calling outlying station.

6. In a telegraph system, a plurality of subscribers' stations, telegraph printing, sending and receiving equipment at each of said stations, a central office, an operator's switchboard and a test board at said central office, telegraph printing sending and receiving equipment at said switchboard and said test board, a plurality of lines respectively connecting said stations to said switchboard, a plurality of testing trunks each adapted for connection to any one of said lines at said switchboard and to said sending and receiving equipment at said test board, a plurality of selecting switches each connected in multiple to said testing trunks, a signal biasing set connected to each of said selecting switches, a source of biased signals in each of said signal biasing sets, and means in each of said subscribers' stations for automatically selecting over an

established connection between one of said lines and one of said testing trunks any one of a plurality of types of biased signals from any one of said sources independently of an attendant at said test board.

7. In a signaling system, a plurality of outlying stations, a main station, a multiposition switchboard and a test board at said main station, a sending and receiving device at each of said outlying stations and at each position of said switchboard and said test board, a plurality of line circuits respectively connecting said outlying stations to said switchboard, a testing position forming a part of said switchboard and having means for respectively terminating each of said line circuits, a testing trunk having means at one end for conductively engaging any one of said line terminating means at said testing position and means at the other end accessible to the sending and receiving means at said test board, bias signaling means included in said testing trunk comprising a plurality of sources of test signals having predetermined values of bias distortion, each source having means for producing signals with different types of bias distortion, and means under control of any of said outlying stations and operative after said testing trunk is conductively engaged to the line circuit of the selecting outlying station for selecting independently of any attendant at said test board and said switchboard, any of said sources of test signals for connection to the line circuit of said selecting outlying station.

8. A telegraph system comprising a central office, a plurality of subscribers' stations, a plurality of subscriber lines respectively connecting said stations to said central office, telegraph printing, receiving and sending equipment at each of said subscriber's stations, means in said central office to switch any one of said lines in communication with any other of said lines, a testing trunk to associate any one of said lines with a test board position, means whereby said trunk may be associated with a given line without calling the test board attendant, a source of biased signals at the central office, calling means and breaking means at each of said subscriber stations, means at said central office responsive to the prolonged operation of said breaking means and the operation of said calling means followed by the release of said breaking means for automatically selecting said source of biased signals for connection to said given line, said responsive means comprising stepping means for alternatively connecting the different types of biased signals from said source, to said given line in response to the repetition of successive operation and release of said calling and said breaking means.

9. In a teletypewriter system, a central office, subscriber stations, a plurality of subscribers' lines having telegraph printing and sending equipment associated therewith at each subscriber's station, means at the central office to switch any one of said lines in communication with any other of said lines, a test board position at said central office, a teletypewriter adapted for connection to said test board position, a testing trunk to associate any of said lines with a test board position, means whereby said trunk may be associated with a given line without calling the test board attendant, a source located at said central office and capable of producing different types of signals biased to any desired degree, means under control of the equipment at the subscriber station for automatically selecting any one type of biased signals from said source and connecting said source to said calling subscriber's line for transmission of the desired type of biased signal to test the equipment at said subscriber's station, means under the control of a subscriber station to indicate to the test board attendant that said trunk is in use, and other means under the control of a subscriber station to indicate to the test board attendant that monitor signals are to be sent from the subscriber's station to said teletypewriter at said test board position.

10. In a teletypewriter system, a central office, subscriber stations, a plurality of subscribers' lines having telegraph printing and sending equipment associated therewith at each subscriber's station, means at the central office to switch any one of said lines in communication with the other of said lines, a test board position at said central office, a testing trunk to associate any one of said lines with the test board position, means whereby said trunk may be associated with a given line without calling the test board attendant, a source located at said central office and capable of producing different types of signals biased to any desired degree, means under the control of a subscriber station to indicate to the test board attendant that the trunk is in use, means whereby any one of said types of biased signals from said source may be transmitted over said trunk and a given one of said lines in established connection to a subscriber's station under the control of the equipment at said subscriber's station, means whereby the subscriber's station may notify the test board attendant over said trunk to monitor signals sent from the subscriber's station, and means to signal an operator at the central office to disconnect the trunk from the given line.

11. In a teletypewriter system, a central office, subscriber stations, a plurality of subscribers' lines having telegraph printing and sending equipment associated therewith at each subscriber's station, means at the central office to switch any one of said lines into communication with any other of said lines, a test board position at said central office, a testing trunk to associate any of said lines with a test board position, means whereby said trunk may be associated with the given line without calling the test board attendant, sources located at said central office for respectively producing signal impulses having different types of bias distortion, means in each of said sending and receiving equipments for automatically associating selectively each of said sources with said one line for testing equipment at the calling subscriber's station, means under the control of a subscriber station to indicate to the test board attendant that the trunk is in use, means whereby the subscriber's station may notify the test board attendant over said trunk to monitor signals sent from the subscriber's station, and means under control of said selecting means for indicating the number of times said selecting means is unable to find an idle source of biased signals.

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