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J. W. LATTIG & C. L. GOODRUM.

TWO WIRE MULTIPLE TELEPHONE SYSTEM.

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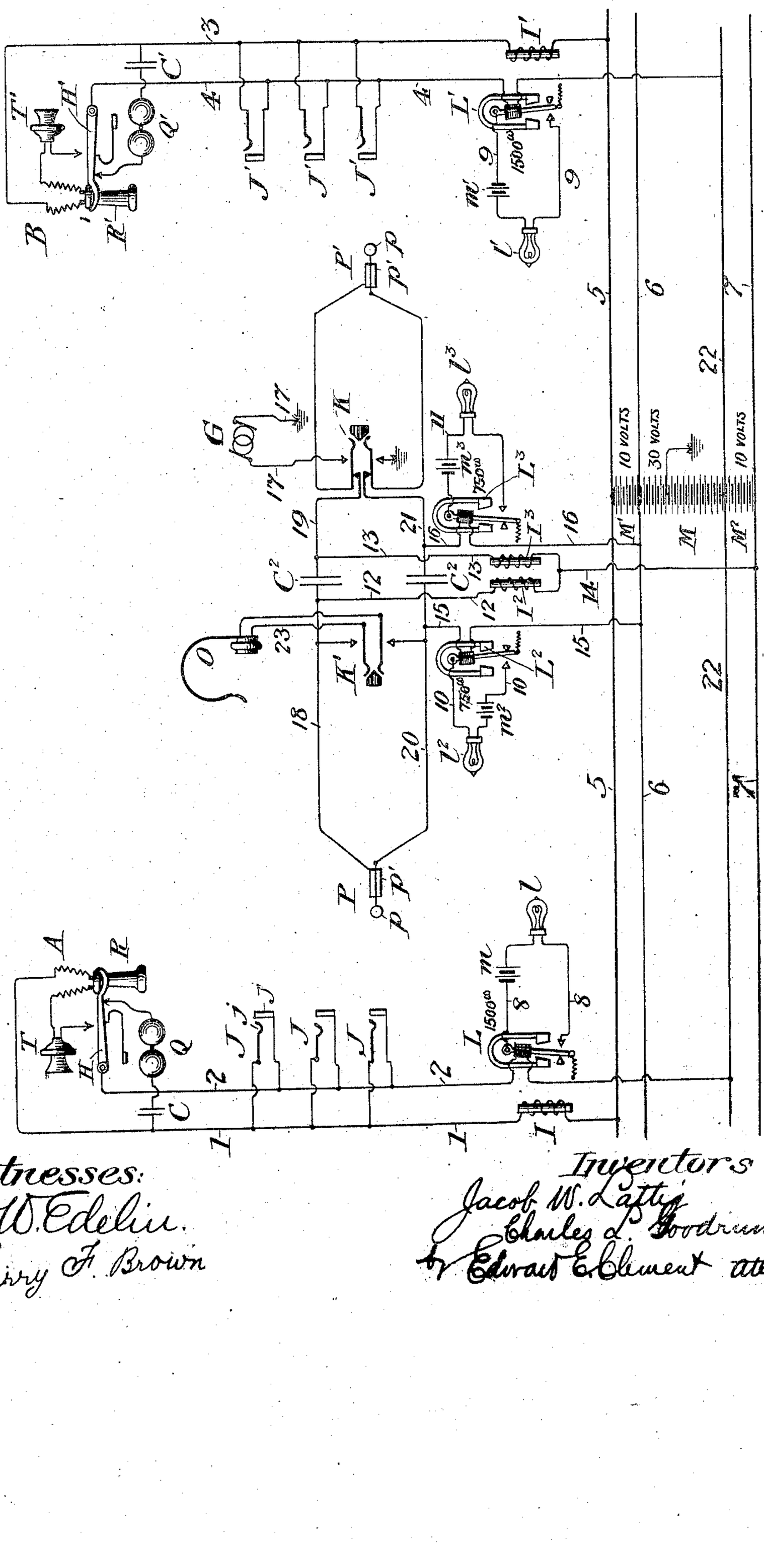

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TWO-WIRE MULTIPLE-TELEPHONE SYSTEM.

No. 859,774. Specification of Letters Patent. Patented July 9, 1907.

Application filed June 6, 1903. Serial No. 160,322.

To all whom it may concern:

Be it known that we, JACOB W. LATTIG and CHARLES LANE GOODRUM, citizens of the United States, residing, respectively, in West Bethlehem, Lehigh county, and in Philadelphia, Philadelphia county, Pennsylvania, have jointly invented a new and useful Two-Wire Multiple-Telephone System, of which the following is a specification.

Our invention relates to telephone exchange systems, and has for its object the production of such a system employing a common source of energy at the central office, in which all signals will be automatic in their operation and automatically restored in proper sequence in the ordinary use of the apparatus on the switchboard, the switchboard spring-jacks having no more than two contacts each, and the plugs being "two-way" plugs. When used in connection with a multiple switchboard such a system is called a "two-wire-multiple" system.

The reduction of the number of contacts in the spring-jacks of multiple switchboards has long received assiduous study by the best engineers, and the problems involved have been only partly solved. Individual engineers and individual companies adopt certain standard circuits as a rule, for the sake of economy in manufacture, to which all changing is fatal. When once adopted there is a slowness commonly displayed in altering a standard, and improvements that are sought for to meet the users demands are trimmed and shaped to fit the standard. This is particularly true of those who have done the best work and the most work in the development of the common battery telephone art. Thus, it is standard practice to employ cut-off relays for the purpose of removing the line-signal and bus-bar connections from the line during a connection. It is also standard to employ supervisory relays, either differential or straight wound, in the cord-conductors, designing them so as to offer the least possible impedance to voice currents. Sometimes they are shunted by condensers, thus avoiding one difficulty by creating another. Many of these expedients are justifiable on the score of the necessity of having a uniform standard not only for local line service but for trunks and long distance lines, where a common battery is employed. In some of the larger exchanges, in densely populated cities like New York, from fifty to seventy-five percent of calls received are trunked. Obviously therefore if it is advantageous in trunk connections, where apparatus of slightly different ages or types may be involved, to disconnect the various lines except through the cords and trunks, with their interposed repeating coils, condensers, etc., the function of the cut-off relay is strongly apparent. In many systems however the older conditions do not inhere, and where uniform designing can be done throughout, the least amount of apparatus should be employed with which it is possible to produce results.

By our present invention we dispense with cut-off relays, reduce the number of contacts in jack and plug to two each, keep all relays out of the talking circuit, simplify the circuits throughout, and provide a clean through talking circuit.

Our invention is fully described in the following specification and illustrated in the accompanied drawing, wherein the figure is a diagram of a system embodying our invention, showing two subscribers' stations and a central station to which they are connected, with operator's connective apparatus, signals, and subsidiary apparatus, thereat.

Referring to the drawing, A and B are two subscribers' stations, connected with the central office by lines 1—2 and 3—4 respectively. Line 1—2 has jacks J, and line 3—4 has jacks J′, and at the substations they are provided with the usual signaling and talking instruments, comprising transmitters, receivers, ringers, condensers and switchhooks, lettered respectively T—T′, R—R′, Q—Q′, C—C′, and H—H′. At each station, when the switchhook is down the ringer and condenser are bridged in series across the line; when the hook is up the transmitter and receiver in series are similarly bridged across the line. For direct current the former bridge is impassable, while for alternating ringing current it furnishes a closed path. When the telephone instruments are bridged, however, direct current passes, and by reason of their resistances being low considered with relation to the voltages employed, sufficient current passes to permit control of signals at central thereby, as well as to furnish transmitter energy.

All of the above parts and connections are of usual and well known design, not forming part of our present invention. They may be replaced by others without altering the operation of the whole.

Line wire 1 enters the central office, is connected by branch wires to the several multiple springjacks on the switchboard, and passes thence to the bus 5 of the main battery through a resistance and impedance coil I. This coil is properly wound to limit the total current supply of the line, for purposes presently to be noticed, and to choke back any speech waves from the battery bus, whence they might pass to other lines.

Line wire 2 enters the central office, and is connected to the bus bar 22 of the main battery, through the winding of a relay L, controlling the line signal l. This relay L is polarized, and of a type described and claimed by us in Letters Patent No. 722,367 granted to us March 10, 1903. It consists essentially of a pair of pole

pieces permanently polarized by a horseshoe magnet, between which plays a bar-armature carrying a coil whereby it may be caused to assume magnetic polarity of either sign at either end. Thus according to the direction of current flow in the coil the armature will move to one side or the other. It is normally biased by a spring to the side shown in the drawing, as in this position it opens the local circuit 8—8 of the signal lamp *l* and battery *m*, which must be a normal condition. The coil of the relay is wound to a resistance of about 1500 ohms and it offers sufficient impedance to high frequency alternations to insure its choking out any speech waves on the line. Thus it supplements the coil I in its action. This line relay may be of any type, so long as it is polarized, and need by no means be limited to our own type of relay described. Many forms of double contact polar relays are made, and we may select any of them for our purpose without altering the invention.

The line wire 3 enters the central office and passes from jack connections to the coil I′ and thence to the battery bus 5, like its corresponding wire of the other line. Wire 4 enters and passes to a line relay L′ in all respects similar to the other, L. It is of the same resistance in winding, 1500 ohms, is polarized the same, and controls a local circuit 9—9, containing a battery *m′* and signal lamp *l′*.

P and P′ are answering and calling plugs, respectively, of a pair, having contacts *p*—*p′* corresponding to and adapted to register with contacts *j*—*j′* of the jacks when the plugs are inserted therein. These plugs are connected by cord conductors 18—19, 20—21, inductively continuous but conductively discontinuous by reason of the inclusion of the condensers C^2—C^2. Across the conductors 18—20 are connected the contacts of the listening key K′, whereby the operator's telephone O, through its circuit 23, may be put to line. In the two conductors 19 and 21 are included the double normally closed contacts of the ringing key K, by the operation of which the calling plug can be segregated from the rest of the apparatus and connected through wires 17 to the calling generator G. The listening key K′ may be of this same type if desired. We have shown it conventionalized, but it may be changed to suit the operator's circuit used.

Associated with the plugs P and P′ are the supervisory signals l^2 and l^3, connected respectively in local circuits 10 and 11, with batteries m^2 and m^3, and controlled by relays L^2 and L^3. These relays are in all respects like the line relays L and L′, with the exception that their coils are wound to a resistance of only 750 ohms each. Their armatures are biased like those of the line relays to normally open their local circuits. The relay L^2 is in a branch circuit 15 from conductor 20 to the battery bus 6, while relay L^3 is in a like branch 16 from conductor 21′ to the same bus, 6.

In order to constitute battery returns for connected circuits, branches 12 and 13 are provided, leading to opposite sides of the condenser C^2, containing coils I^2 and I^3, and united in branch 14 leading to battery bus 7. These coils are of the same resistance as coils I and I′, and are of high impedance.

The above connections have all been described with reference to the bus bars 5—6—7— and 22. The successful operation of our entire system depends on the method of connection of the battery to these bus-bars, and thence to the various pieces of apparatus. The battery itself is preferably a secondary battery of an ampere-hour capacity determined by the size of the exchange and by the load curves. It is to be understood that we are not limited in our choice of a battery, and in fact, as will sufficiently appear when the operation of the system has been traced, dynamo-generators might be substituted, or one generator with several windings, for the battery shown.

In number the cells are preferably twenty-five, so as to give approximately fifty volts difference of potential on the bus-bars. The four busses are connected at four different and separate points on the battery series. Busses 5 and 7 are connected respectively to opposite end-cells. Bus 6 is connected between the fifth and sixth cell from the negative end, and bus 22 between the fifth and sixth cell from the positive end of the cell series. Thus between 5 and 7 there is a p. d. of 50 volts; between 5 and 6 a p. d. of 10 volts positive to 6; between 6 and 22 a p. d. of 30 volts, positive to 22; and between 22 and 7 a p. d. of 10 volts positive to 7.

The potential difference between the terminals of the winding of coil on relay L is 40 volts less the drop due to the line and coil I. The p. d. between terminals of relays windings of L^2 and L^3, on the other hand, is 10 volts less the drop due to coil I alone, until the line is closed, when the polarity is reversed as will appear later. The p. d. at subscriber's transmitter during a connection is 50 volts less drop due to line, coils I and I^2 and the receiver.

The operation of our system, thus described, is as follows: Suppose subscriber A calls by removing his receiver R from the switchhook H. A circuit is closed as follows: battery bus 22, line relay L, line wire 2, switchhook H, the subscriber's transmitter and receiver T and R, line wire 1, coil I, bus 5, and to battery. Current flowing in this circuit energizes relay L by polarizing its armature so as to cause it to be attracted against the force of its spring, and the local circuit 8 is forthwith closed, lighting the lamp *l* and signaling the call. The operator, perceiving the call, inserts the answering plug P in the line or answering jack J, which is not shown separately because all the jacks are alike in that they have the same number of contacts in all cases. By this act she accomplishes three things: she retires the line signal, brings the cord conductors 18—20 into connection with the line, and cuts in the supervisory signal relay L^2. She retires the line signal for this reason: In the call the relay L had a difference of potential between its terminals of 40 volts less the drop due to the coil I, the line, etc., this p. d. being positive to bus 22, or the No. 2 side of line. When the plug P is inserted, bus 7 is connected to the No. 2 side of line at the jack sleeve, thus putting another connection of the same polarity and higher e. m. f. outside of the line relay. The return is still by way of coil I and line wire 1. Now, if the bus 22 itself were to be connected both outside and inside of the relay there would obviously be no p. d. at its terminals, but in that case the armature might possibly stick, and the action could not be regarded as quite positive; so we have here made a reversal on the relay terminals. In other words we put a point of greater p. d. from the return wire 1, outside the relay, the less p. d. being on the inside. The

difference, therefore, or in this case a p. d. of 10 volts, is impressed on the relay terminals in reversed direction, being positive to the line side and negative to bus 22. The current flow due to this, while small, owing to the high resistance of the relay, is sufficient to positively release and throw back the armature, particularly as it reinforces the spring in such action. Thus the local circuit is opened, and the signal is retired. It will be observed that in this case, as in the case of our patented system to which reference has been made, that a distinction is to be drawn between this overbalancing of potentials in the use of the same source, by connection of different points of the source to different points of the same circuit, and the overbalancing of potentials by merely shortcircuiting or by separate sources. While such a method of procedure might fall within the scope of our invention and the claims defining the same, we consider the arrangement described herein as being the best because of the economies effected, and the simplicity and positive nature of the means and the results attained. The portion of the battery which produces the reversal on the line relay terminals is lettered M^2; that which works the relay in giving the signal is M—M′; while the portion M′ by itself is particularly appropriated to the supervisory relays.

When plug P is inserted in jack J a circuit is completed for supervisory relay L^2 as follows: bus bar 6, wire 15, coil of L^2, cord conductor 20, tip *p*, spring *j*, wire 1, coil I, bus bar 5, and battery M′. If the subscriber A were to return his telephone to the hook H after calling current would flow in this circuit to polarize the armature of L^2 so as to throw over the same and close the local circuit 10, lighting the lamp l^2. As the subscriber remains at the telephone, however, with the receiver down, a path is closed, as already traced, from the positive end cell of the battery through the sub-station to the No. 1 side of line and to the spring *j* of each jack. This again brings a higher p. d. on the terminals of relay L^2, from the outside, that is by way of the tip *p* back to conductor 20, and the net difference on the relay terminals is 30 volts less the drop due to coils in the path, and positive to conductor 20 and that side of the relay. This causes a reversal of polarity of the relay armature, although the current flow is small as the relay is wound to about 750 ohms. Thus the armature is kept in the position of inaction shown, with the local circuit 10 open and the lamp l^2 dark. After obtaining the number wanted, the operator proceeds to make a test to ascertain if the desired line is free, using for this purpose any suitable circuit. We have not deemed it necessary to illustrate any specific test circuit because the same forms no part of the invention and we wish to avoid complications in the drawing and specification. Having ascertained the line to be free, the plug P′ is inserted in jack J′ of line to station B, which we will assume to be wanted. As soon as this plug is so inserted a circuit is closed for the supervisory relay L^3, as follows: bus-bar 6, relay L^3, wire 16 to cord conductor 21, tip *p*, jack spring of J′, line wire 3, coil I′, bus-bar 5, and battery M′, bringing a p. d. of ten volts across the terminals of relay L^3; positive to the bus 6 and lower side of relay. Current in this circuit causes the polarization of armature of relay L^3 so as to throw it over against the force of its spring to close local circuit 11 and light lamp 13, which remains lighted until the called subscriber answers. The operator then calls by means of the ringing key K, putting the generator G to line 3—4. When the subscriber B answers by taking down his receiver from the hook H′, a path is completed from bus-bar 7 by wire 14 through coil I^3 to cord conductor 19, to sleeve *p′* of plug P′, to jack thimble J′, line wire 4, sub-station B, line wire 3, coil I′, bus-bar 5, and battery M′, M, M^2. As in the case of relay L^2, the potential difference across the terminals of relay L^3 is immediately reversed, and aided by spring pressure the armature is thrown over to break local circuit 11 and darken lamp l^3. When the plug P′ is inserted line relay L′ has a circuit closed as follows: bus-bar 7, coil I^3, cord conductor 19, sleeve *p′* of plug P′, jack thimble J′, relay L′, bus 22, and battery M^2, giving a p. d. of ten volts negative to bus 22 and the lower side of relay. When the subscriber answers this negative connection remains, so the relay is not actuated at all. If either subscriber hangs up his receiver his supervisory relay becomes exposed at once to the reversed p. d. due to battery section M′ and closes the local circuit of its lamp l^2 or l^3, as the case may be. If both hang up, both signals are displayed to indicate that the conversation is terminated.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. In a telephone system, a subscriber's metallic circuit, a springjack therefor having tip and sleeve connections, a battery having terminal bus-bars and an intermediate bus-bar so connected as to have a greater potential difference on one side than on the other, a polarized signal magnet connected from the sleeve side of line to the intermediate bus-bar, a connection from the tip side of line to the high potential terminal of the battery referred to the intermediate bus-bar, means operable in making connection with the line to connect the low potential terminal of the battery to the sleeve of the jack, and means under control of the subscriber to cross the two sides of the line together in his use thereof, substantially as described.

2. In a telephone exchange system, a subscriber's line, circuit closing means therefor at the subscriber's station, a springjack at the central station having contacts connected to opposite sides of the line, a cord circuit having terminal plugs adapted to coöperate with the springjack, a source of current having three terminals so arranged that the potential differences between the intermediate terminal and the outer ones are unequal, a polarized relay connected between the intermediate terminal and one side of line, a direct connection between the high potential terminal to the other side of line, and a connection to the cord circuit such that when a plug is inserted in the jack the low potential terminal is connected to the first side of line outside the relay, the whole operating so that current in the line from the high side of the source will operate to set the relay and display its signal, while the insertion of a plug and the connection of the low side thereby will operate to reverse the action of the relay and obliterate its signal, substantially as described.

3. In a telephone exchange system, a subscriber's line and a cord circuit, a source of current having two outer and two intermediate terminals, the potential differences between the intermediate terminals and the outer terminals being unidirectional when used in series, a polarized line signal magnet connected from one intermediate terminal to one side of line, a polarized supervisory signal magnet connected from the other intermediate terminal to the opposite side of the cord circuit, a connection from one outer terminal of the source to the second side of line, and a common connection from the other outer terminal to the side of the cord circuit corresponding to the signal side of line, together with means at the subscriber's station to control the flow of current in the line, whereby the subscriber may set the line signal, the operator may retire the

same and may connect the supervisory signal in proper relation to be set, and the subscriber my retire the supervisory, all in the ordinary sequential use of the line and cord, substantially as described.

4. In a telephone exchange system, a subscriber's station and a central station, and a line circuit interconnecting them, a source of current connected to the line, and a polarized signal magnet permanently connected from the line to said source at a point intermediate its terminals so as to divide it into unequal parts, together with means controlled by the subscriber to close a circuit through the polarized signal magnet and one side or division of the source, and means under the control of the central office to close a circuit through the magnet and the other side or division of the source, whereby the current through the magnet may be reversed and the signal may be controlled and restored as desired.

5. In a telephone system, a subscriber's station and a central station and a metallic circuit connecting them, a source of current connected to the metallic circuit at the central station and means at the subscriber's station to determine the flow of current therefrom in the line, a polarized signal magnet permanently connected from one side of the line to a point intermediate of the terminals of the source of current to divide it into unequal parts during connection with the line of the central office circuits or of other lines, a signal controlled by the magnet, and means to keep said signal normally retired.

In witness whereof, we have hereunto signed our names in the presence of two subscribing witnesses.

JACOB W. LATTIG.
CHARLES LANE GOODRUM.

Witnesses:
M. S. LEWIS,
EDWARD E. CLEMENT.