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C. L. GOODRUM.

TELEPHONE SYSTEM.

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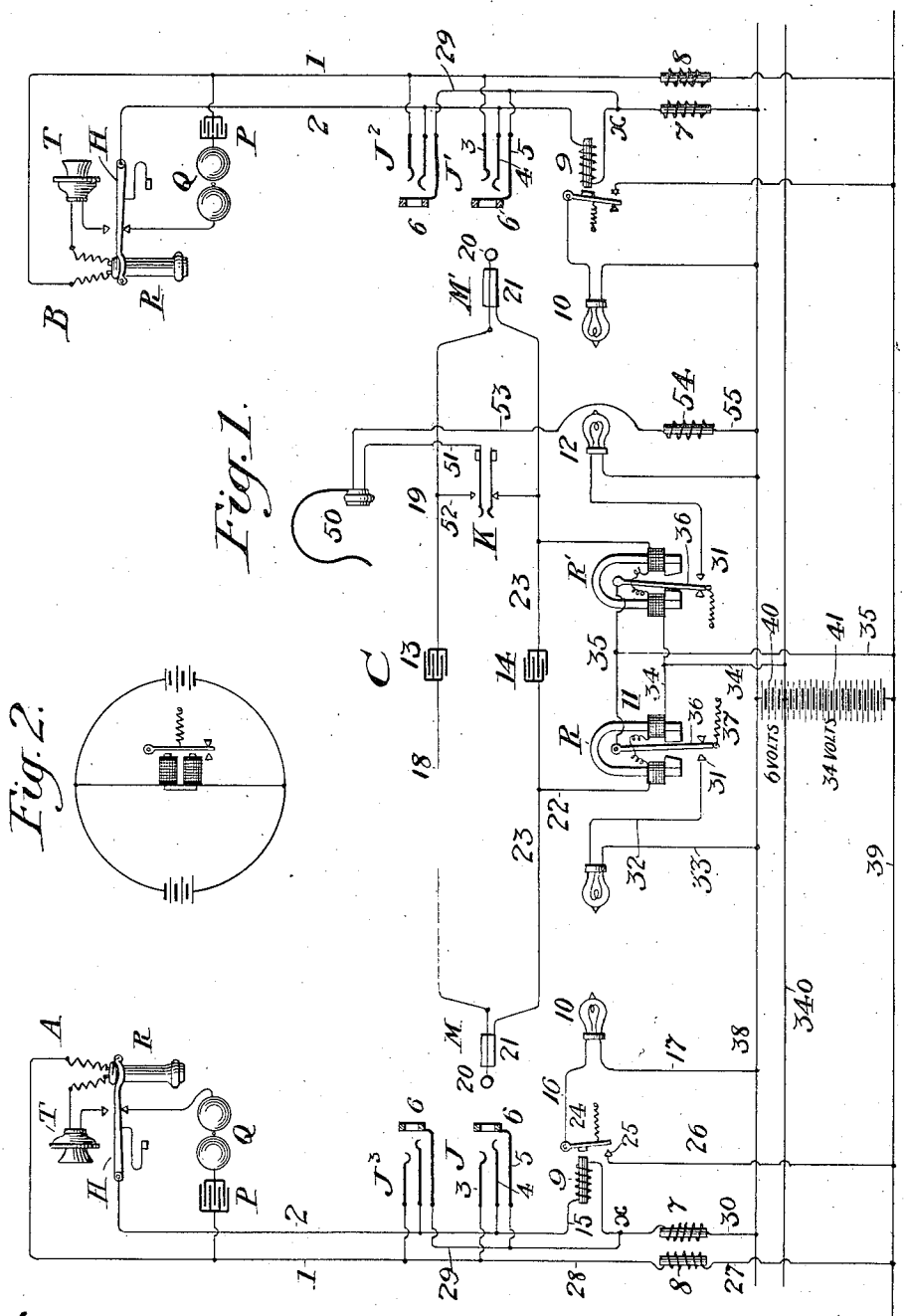

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UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

No. 896,103. Specification of Letters Patent. Patented Aug. 18, 1908.

Application filed July 31, 1903. Serial No. 167,707.

To all whom it may concern:

Be it known that I, CHARLES LANE GOODRUM, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Telephone Systems; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to telephone-exchange systems, and has for its object the production of a system such that all the exchange functions may be more perfectly performed by simpler apparatus than heretofore.

In telephone-exchange systems, even of small size, it is now customary to employ a centralized or common source of electrical energy, from which current is derived for use at the subscribers' stations as well as at the central station. Such centralization of the power-supply has rendered it possible to employ automatic signals throughout—that is, signals which do not require separate acts specially performed by subscriber or operator for their actuation or restoration to normal, but which respond directly to conditions as they are produced or changed in initiating, setting up, responding to, and terminating a conversational connection. Thus in modern systems a subscriber performs no special act in calling, but simply removes his receiver from its hook and places it to his ear ready to converse and to listen, giving no thought to the signal, which nevertheless, has responded to his closure of the line-circuit. When the operator has set up the desired connection, she need use no switch to ascertain the wishes of the subscribers or the condition of the lines by listening or otherwise, for each cord-circuit is provided with telltale signals, (usually two in number, one for each subscriber,) which respond faithfully to each change in condition of the line as it is affected by the use or disuse of the subscriber's talking apparatus. Such systems are called "supervisory" systems, the automatic signals affording an opportunity for constant and perfect supervision simultaneously of all the connected lines controlled by each operator.

In most common battery systems the lines are normally extended when in disuse to the main-battery bus-bars through the windings of the line-signal magnet or relay and through the contacts of another relay, which is connected to contacts in the jack or jacks to be energized when a plug is inserted therein and thereupon cut off the extension of the line, whereby the line-signal, being deprived of current, is restored to its normal condition. The cut-off relay thus employed requires a three conductor cord; but this disadvantage is considered preferable to cutting off in the jack, which is the alternative method. I employ neither method, but avoid the disadvantages of both by using shunts, closed when the plugs are inserted.

Upon reading the following description it will be apparent that the signals I describe as supervisory signals might very well have other functions—for instance, replacing line-signals or trunk-signals. I desire it to be expressly understood that I consider myself to be the originator of this type of signal controlled by the differential action of divisions of a single battery or generator or of separate units employed in the relations pointed out with the regard to the supervisory signals herein. As it would not require more than the skill of a trained electrician or telephone engineer to make the changes required, I consider that all such changes are well within the scope of my invention.

Other features of my invention will appear hereinafter from the description and claims.

In the accompanying drawing, wherein similar parts are pointed out by the same characters throughout, Figures 1 and 2 are diagrams illustrating my invention.

In the drawing, A and B represent two subscribers' stations, each connected to the central office C by line-wires 1 and 2. As these stations are alike in their equipment and connections, I will describe the station A for both. At this station the line-wires 1 and 2 are normally connected for alternating currents through the condenser P, ringer Q, and switch-hook H, the hook being down. When the receiver is removed from the hook, the bell or ringer circuit is broken and the talking-circuit is completed through the transmitter T and the receiver R.

At the central office the main battery B is connected between bus-bars 38 and 39. The

line wire 1 is connected to the bus-bar 39 through the choke-coil 8 and wires 27 and 28. Line-wire 2 is connected to the bus-bar 38 through the line-relay winding 9, the choke-coil 7, and wires 15 and 30. Line-wires 1 and 2 terminate, respectively, in jack-springs 3 and 4 of the spring-jack J. A test ring or thimble 6 is also provided in the jack, and this is connected, as shown, to the same thimble in all the multiple jacks of the same line and by stem 5 and wire 29 to a point x, intermediate the line-relay 9 and the choke-coil 7. The spring 4 is so positioned with regard to the thimble 6, that when a plug is inserted the sleeve thereof will cross the spring and thimble together. The purpose of this will be pointed out later.

The resistance of the coil 8 I usually make about two hundred ohms, that of the relay 9 I make one thousand three hundred ohms, and of the coil 7 one thousand two hundred ohms. The relay 9 controls an armature 24, which closes on a contact point 25, connected by wire 26 to the bus-bar 39. The armature or its equivalent, which may be a twin contact to 25, is connected by wire 16 to the line-signal lamp 10 and thence by wire 17 to the other side of battery at bus-bar 38. It will be understood that these wire connections are not necessarily carried individually to the power-board, but that common wires may form continuations of the bus-bars.

The multiple jacks (represented by J^3) are in every respect duplicates of the jack J and are connected in parallel therewith to the wires 1, 2 and 29.

Interconnection of the lines for conversation is effected through the cord-circuit 18—19 23—23. This cord-circuit terminates in plugs M M′ and is conductively divided, but inductively completed by the condensers 13 and 14. For continuous currents, therefore, a complete conversation-circuit consists of two independent sections, which are fed separately. Each plug M or M′ is provided with a tip-contact 20, connected to one side 18 or 19 of the cord, and with a sleeve-contact 21, connected with the other side 23 of the cord.

For each cord circuit two supervisory relays R R′ are provided. I will describe the one R for both. This consists in the present case of a horseshoe permanent magnet 11, having windings upon its two poles of approximately seven hundred and fifty ohms resistance connected by wires 22 and 34 to the cord-conductor 23 on one side and to bus-bar 340 on the other. This bus-bar 340 is a third bus-bar of the main battery, being connected thereto at such a point that the difference of potential between it and the bus 38 will be much less than that between it and bus 39, the former being, for instance, six volts and the latter thirty-four volts where the total voltage of the main battery is forty. All the supervisory relays are connected to this third bus-bar. Its purpose will be referred to in the statement of operation.

Pivoted to swing between the poles of the permanent magnet 11 is an armature 36, which forms one terminal of a normally open circuit 35, whose connection is to the main bus-bar 39 and whose continuation 33 passes from bus 38 to a lamp 12, and so by wire 32 to the contact-point 31 which lies in the path of the armature 36. A spring 37 gives the armature a normal bias to the right; but it is obvious that this may be accomplished in other ways, and, in fact, the entire construction of the relay may be varied in a hundred ways without departing from the spirit of the invention. I reserve to myself the right to make this relay in any convenient way therefore.

The operation of the system so described is as follows: The subscriber A, I will suppose, wishes to converse with subscriber B. He removes the receiver R from the hook H, which thereupon rises and closes the circuit through the talking set and permits direct current from the main battery to pass through the following circuit: bus-bar 39, wire 27, choke-coil 8, wire 28, line-wire 1, talking set R T H, line-wire 2, wire 15, relay 9, choke-coil 7, wire 30 to bus-bar 38. This energizes the relay 9, which thereupon attracts its armature 24 and closes the local-line lamp-circuit as follows: bus-bar 39, wire 26, point 25, armature 24, wire 16, lamp 10, wire 17 to bus-bar 38. The lamp 10 then lights, informing the operator of the call. She responds by inserting the answering plug M, by the mere insertion of which three results are produced, viz: The cord conductors are brought into connection with the line-wires, the relay 9 is shunted by the wire 29, stem 5 of the test-thimble, the thimble itself, 6, and the sleeve of the plug to spring 4, thus causing the relay-armature to fall away and extinguish the lamp 10, and the supervisory relay is connected to the jack-thimble 6 through the sleeve conductor 23 of the cord by the following path to battery: wire 22, cord-conductor 23, plug-sleeve 21, jack-thimble 6, stem 5, wire 29, coil 7, wire 30 to bus 38 and battery B, through the upper division 40 of the battery to the bus 340, and by wire 34 back to the relay. This current flowing through the relay-coils under an electromotive force of, say, six volts if unopposed would suffice to overcome the spring 37 of the armature 36, drawing the latter over to the left and closing on the contact 31, this lighting the lamp 12 by current flowing in circuit 39, 35, 36, 31, 32, 12, 33, 38 to battery. The lighting of the lamp in answering the call is prevented, however, by an opposing current that flows in the following circuit:

bus-bar 39, wire 27, coil 8, wire 28, line-wire 1, subscriber's talking set (which is in service line-wire 2, spring 4, sleeve or thimble 6, sleeve of plug 21, wire 23, wire 22, windings of relay R, wire 34 to bus-bar 340, and so to battery. We thus have a divided battery connected so that there are opposed electromotive forces through the windings of the relay R, and as they are unequal the resultant current is in a direction to reinforce the spring 37 and not to oppose it. Thus the supervisory lamp does not light for the calling-line. Having received the number wanted, the operator proceeds to test to determine if the wanted line is free. This she does by throwing over the listening key K to listening position, and thereby bringing her head-phone into connection with the tip of the calling-plug M' on one side by the path 51, K, 52, 19, and 20, and into connection with the bus-bar 38 of the main battery on the other side by the path 53, choke-coil 54, 55 to bus 38. Now when the tip 20 is touched to the thimble 6 of the wanted line if the subscriber has called from station B and has not yet been answered a circuit will be completed from the tip through the thimble 6 to line and back and by conductor 28, coil 8, and wire 27 to the bus-bar 39, the current flowing in this circuit producing a characteristic "busy" click in the operator's ear. If the subscriber has not answered a previous call, but another operator has already made connection with his line, then a click will be obtained by current in a circuit through the thimble 6 to the corresponding thimble of the multiple jack already in use and over the sleeve of the plug therein and its cord conductor 23 to the polarized relay R' and to bus-bar 340. If a cord at another section has already been brought in to connection with the wanted subscriber's line and he has answered the call, then both the paths traced will be available and the click will be heard, as a matter of course. If the line is idle, however, no click can be obtained, because the tip 20 and sleeve or thimble 6 will be at the same potential.

It will be observed that connection is made to but one side of the cord from the battery B, and a word of explanation is here in place concerning the current-supply for talking. The battery has the permanent branches 27 and 30, including the choke-coils 8 and 7, respectively, by which direct current is fed to the lines in parallel, the choke-coils preventing any propagation of the changes due to speech in the battery-bridge, but forcing all speech currents to go across through the cord from line to line past the battery branches. The branch 22 34 through the supervisory relays is solely for the purpose of supplying current to said relays; but incidentally it also carries part of the line-supply.

While I have described the supervisory relays in my system as of the polar type, I do not claim the same specifically in combination with the other elements of the system, such combination, and the principle of reversed electromotive forces upon which it depends being specifically aside from the present invention, although included thereunder. As I have previously stated, these relays may be of ordinary neutral type, the intermediate bus-bar of the battery being adjusted so that in any case the insertion of a plug and the simultaneous closure of the subscriber's line will produce a balance or an approximate balance of electromotive forces across the terminals of the relay in question. This statement can be made broader, as I intend it to include the divided battery principle as applied to line signal relays, as well as to supervisory relays. In the ordinary form of relay the armature is normally biased away from the poles of the magnet by a retracting spring. This corresponds to the polar bias of the relays I have described. Such a relay if included in the line connection between the jacks and the battery, would respond to the current flow when the subscriber closes the line circuit, by holding up its armature, the relay connection being always to the intermediate bus-bar and the subscriber therefore closing through one-half or division of the battery. When the operator plugs in she brings the other half of the battery into circuit by connecting its opposite end cell to the relay side of line outside of the relay. We have therefore, in such case, the full battery from end to end bridged across the line, with the line relay connected from its intermediate point around one side or division of the battery. In a figure this could be graphically represented by a circle divided by a diameter, with one-half of the battery on each side of the diametral line, and the line relay in the diametral line, as shown in Fig. 2. As long as both arcs of the circle are complete, the relay receives no current, unless the two portions of the battery be made unequal, as in the case described, which would be required where the lines were of unequal length and connected to different points on the battery in order to maintain equal potentials on all line terminals. In such case, any marginal current is compensated for by strong or weak adjustment of the tension of the retracting spring. In the figure mentioned, one portion of the arc represents the subscriber's line, and the other portion represents the cord-circuit connection to the battery.

I believe I am the first to suggest and to devise practical means of applying the suggestion of a divided battery, with means under the control of a subscriber to produce a current flow from one division of the battery, means under the control of another sub-

scriber or an operator to control the current flow from the other half or division of the battery, and a translating device common to both halves or divisions, whereby the translating device may be energized, neutralized, again deënergized, and again neutralized, if desired, with any combination of these effects, by the simple making and breaking of the respective circuits in proper order. I shall therefore claim the same broadly, and desire it to be understood that it is my purpose and intention to include under my claims all forms of apparatus and circuits whatever by which the principle enunciated is applied in the general manner and for the general purposes stated.

Having thus described my invention, what I claim, and desire to secure by Letters Patent of the United States is—

1. In a telephone exchange system, the combination of the following instrumentalities: a plurality of substations and a central station, with metallic line circuits interconnecting them, a plurality of testing terminals for each line connected together in multiple, an operator's cord circuit with terminal plugs for interconnecting the lines, a main battery permanently connected in its entirety across the central office terminals of each line, a line signal magnet connected in one side of each line, a normally incomplete shunt for each line signal magnet terminating on the testing terminals, a supervisory signal magnet connected from the sleeve side of the operator's cord to an intermediate point on the main battery, spring jack contacts for each line associated with the testing terminals and adapted to coöperate with the respective contacts on the plugs to simultaneously short-circuit the line signal magnet and to connect the supervisory signal magnet so that it will be exposed to a potential difference through the line circuit which will maintain it in an inoperative or non-signaling condition while the line is in use, and an operator's test set connected from the tip side of the cord to the sleeve side of the battery, substantially as described.

2. In a telephone exchange system, a plurality of substations and a central station with metallic line circuits interconnecting them, multiple jacks for each line, each jack having a tip and sleeve spring and a testing terminal, a line relay connected in one side of each line beween the test terminal and the sleeve spring, a two-conductor cord with terminal plugs for interconnecting the lines, a main battery permanently connected in its entirety across the terminals of each line, an electromagnet and a connection therethrough from an intermediate point of the battery to the sleeve side of the cord, and an operator's test set connected from the tip side of the cord to the outside or main terminal of the battery which is connected to the sleeve side of the line, whereby the insertion of a plug in any multiple jack will simultaneously raise the potential of its multiple test terminals with respect to the tips of the testing plugs and short-circuit the line relay, substantially as described.

3. In a telephone exchange system, a plurality of subscribers' stations and a central station with a line circuit interconnecting them, a source of current connected to the line and a signal magnet connected to said source at a point intermediate its terminals so as to divide it, means controlled by each subscriber to close the circuit through the signal magnet and one side or division of the source of current, means under control of the central office to close a circuit through the magnet and the other side or division of the source, whereby the signal may be controlled and restored as desired, together with an operator's testing set and a movable test terminal therefor connected to the outside of the battery, whereby the closure of the magnet circuit may be utilized for indicating that the line is busy, substantially as described.

In witness whereof I have hereunto set my hand this 30th day of July A. D. 1903, in the presence of two subscribing witnesses.

CHARLES LANE GOODRUM.

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