April 27, 1948. J. KRUITHOF ET AL 2,440,277

CALLING LINE INDENTIFICATION SYSTEM

Filed May 8, 1943 3 Sheets-Sheet 1

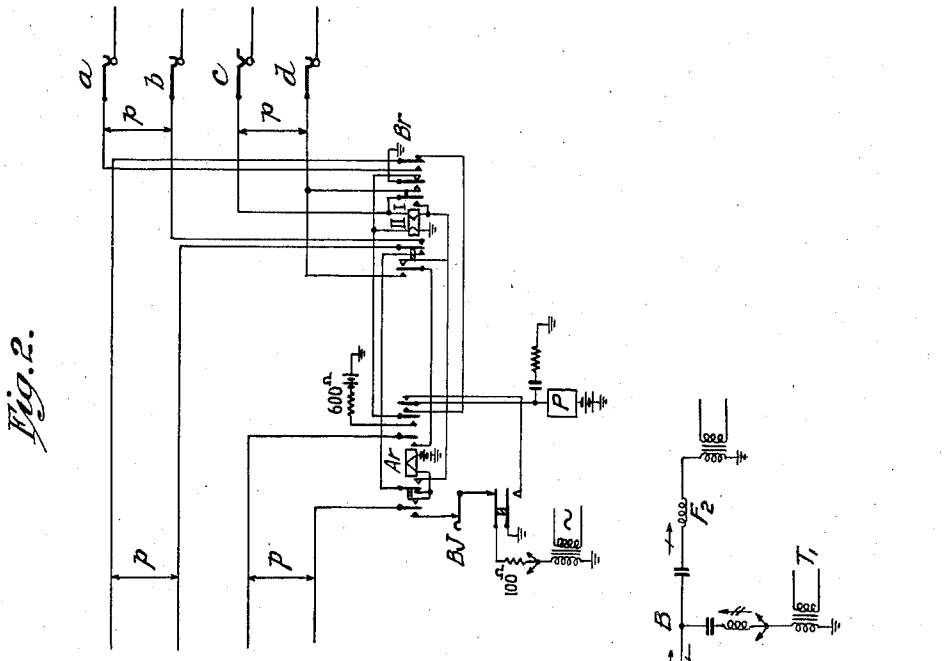

Fig. 2.

Fig. 1.

Fig. 3.

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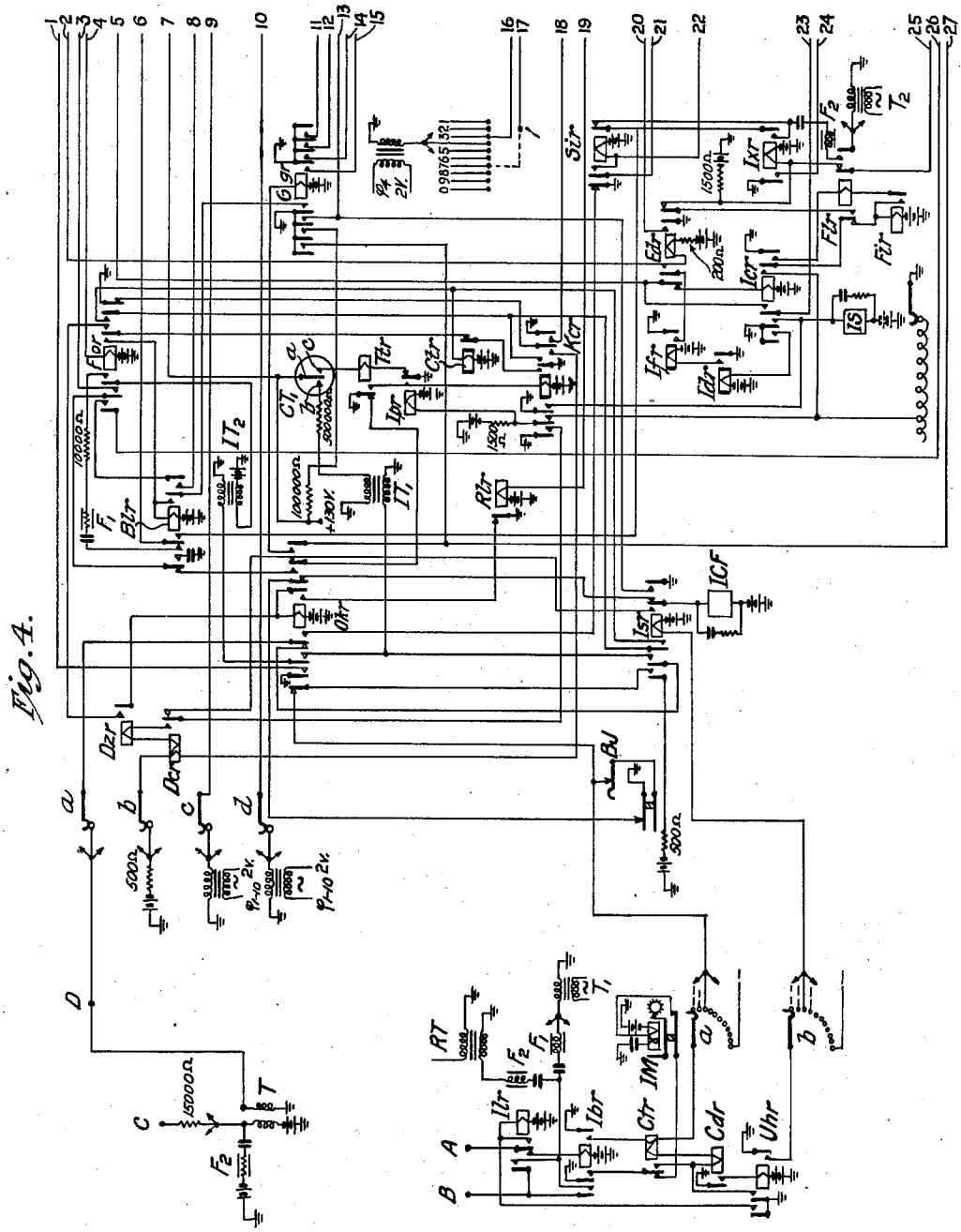

Fig. 4.

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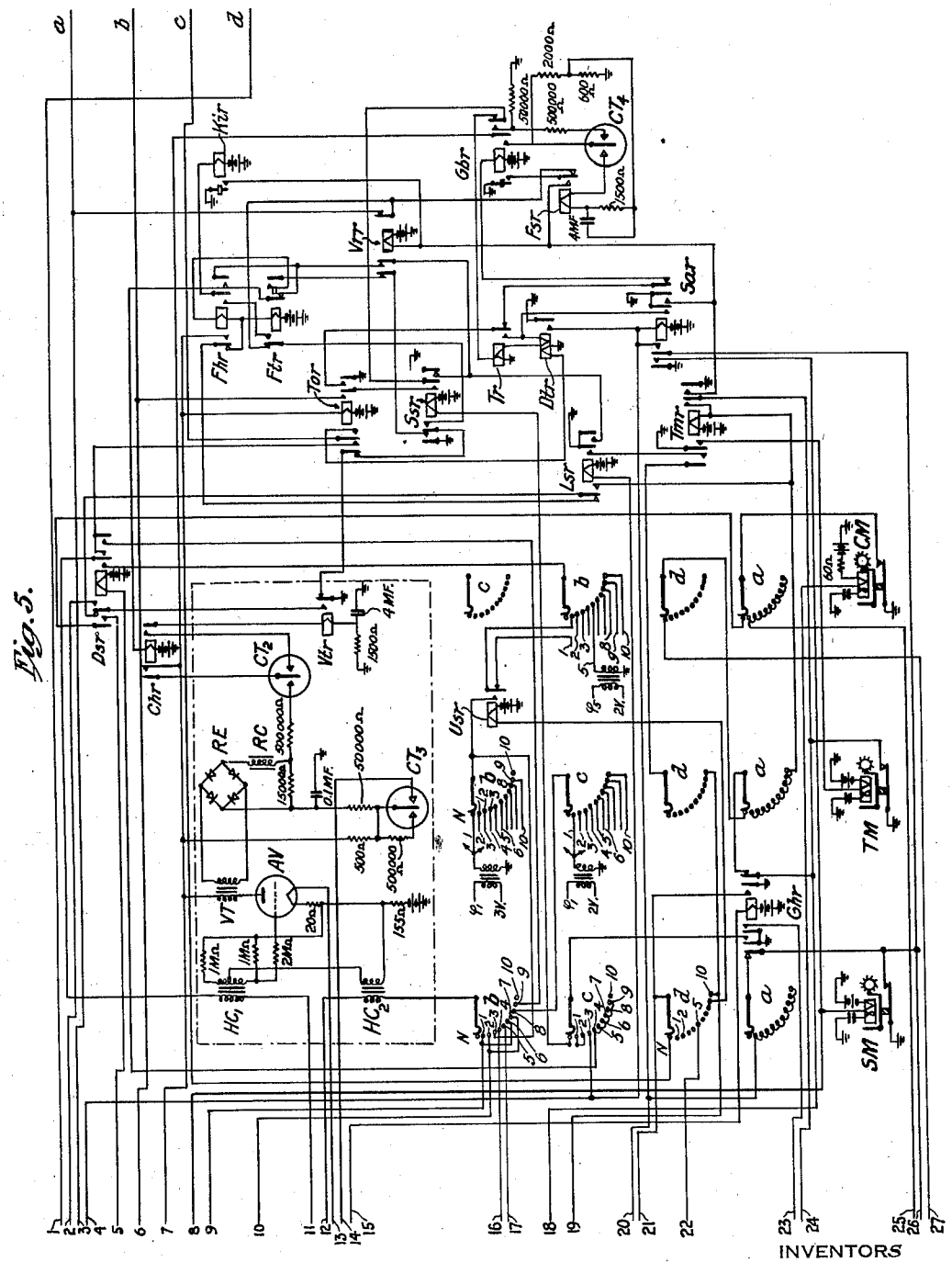
Fig. 5.



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UNITED STATES PATENT OFFICE

2,440,277

CALLING LINE IDENTIFICATION SYSTEM

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Application May 8, 1943, Serial No. 486,273
In the Netherlands August 21, 1941

Section 1, Public Law 690, August 8, 1946
Patent expires August 21, 1961

11 Claims. (Cl. 179—27)

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This invention relates to new and useful improvements in arrangements for identifying calling subscribers' lines.

In telephone systems it is often desirable to identify the number of the calling line in the establishment of certain classes of calls, such as those going to automatic rural areas or to distant toll exchanges. For such calls it is necessary to charge on a time and zone basis, by operating of automatic ticket printers, which print all the information required to debit the call to the calling subscriber, including the number of the calling subscriber.

Identification of this kind may be used to signal the identity of a calling subscriber to an operator, who is reached via an automatic switching train for certain classes of calls, which have to be handled by this operator, so that the operator has to make out a ticket containing all information required for calculating the cost of the call.

Certain identification schemes of this kind, which have found practical application, have as their common feature that use is made of an alternating current potential applied to one wire of the subscriber's line equipment at the exchange whenever it is desired to identify the calling line. Switches are provided for this purpose, either of the line finder or the final selector type, which select the particular line in a given group. However, in order to identify the group, it is necessary that first of all an indication be given as to the switches to be used. This is done by providing a common point for all subscribers belonging to the group, and connecting this point to a circuit which starts the switch in question to hunt for the individual line. In one of the systems here discussed, this common point is provided at the subscriber's line circuit by connecting each 10 or 20 lines through a suitable impedance, individual to the line, to a common starting circuit which is associated with an identification control equipment (see, e. g. application of L. A. Cabes, Serial Number 473,271, filed Jan. 22, 1943, and the Netherlands Patent No. 58,889, dated Feb. 15, 1947.).

This common point is used to select the final selector switch serving the group of 100 or 200 lines comprising the calling line. The subscribers' lines are so commoned that the common point will also indicate the level on the final selector switch on which the calling line is to be found. This system permits connecting the subscribers' lines in any convenient manner to the line finder or preselector or similar non-numerical switch, because the common points may be in the final selector arcs, which are wired in numerical order

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to the subscribers' lines. In such an arrangement the identification control equipment must have access to all final selector groups in the exchange, and it is therefore customary to provide one or more switches which give access to one or two final selectors in each group of, say, 100 or 200 lines. These final selectors are specially arranged so that, when they hunt in the group of lines determined by the common point, they provide a through connection via one of their brushes, from the wire in the subscribers' line circuits on which the identification tone is placed, to the identification control circuit, thereby providing the means at the identification control circuit to test for the presence of tone on the subscriber lines passed over, and to stop the final selector on a line on which this tone is found.

A feature of the present invention is that for identifying subscriber lines use is made of one or more stages of group selectors and of final selectors provided for the completion of regular connections and that the final selector brushes are directed to the line to be identified, access being provided from the identification equipment through the engaged group and final selectors to the wires to which marker potential is connected in the subscribers' line circuits.

Another feature of the invention is that the final selector switch engaged for identification hunts for the set of subscriber's line terminals marked by the presence of marking potential and signals to the identification control equipment the location of this set of terminals with respect to the home position of the switch.

In other arrangements, where the subscribers' lines are connected in numerical order in the line finder arcs or in groups of pre-selectors, it is possible to provide a common point for identification purposes in the line finder or pre-selector circuits of each group of, say, 100 subscribers' lines, depending on the capacity of the line finder, and in this case it is convenient to add in each group of 100 lines a special line finder or, alternatively, to provide for a few groups of 100 lines a common line finder, the brushes of which may be started to hunt for a calling subscriber's line in the group when this has to be identified under the control of the identification control circuit.

According to the present invention the identification is not limited by the number of the switches specially arranged or provided for this purpose as in one of the two methods described above, but access is given from the identification control circuit to all final selectors in each group of subscribers' lines. In order to be able to do this, these

finals are reached through regular penultimate selectors and the identification control circuit has associated with it a group selector or finder by means of which it is possible to reach the regular local group selector equipment of the exchange. For example, it may be possible to provide a finder of which the contact terminals are multiplied in parallel with the local level of the first group selectors. Alternatively, it is possible to associate directly with the identification control circuit a second group selector, the contact terminals of which are multiplied with the regular second group selectors.

For these purposes means are provided for making a number of selections in one or two group selector stages to reach a final selector having access to the particular group of lines of which one has to be identified. This selection can be made under the control of the identification control circuit because the common point on which the identification tone is placed identifies the particular group of, say, 100 lines in which the calling line has to be found. It is necessary to determine the individual line connected to the group of final selectors selected, by letting the final selector hunt over its terminals until it finds the one having the identification tone placed on the subscriber's line connection. Means should, therefore, be provided whereby the final selector and group selectors are so arranged that they can transmit this tone to the identification control circuit, and that the final selector, through the group selector stages, can be moved under the control of the identification control circuit until it reaches the line to be identified.

The requirements for such a scheme are satisfied by the group and final selectors described in patent applications Serial Nos. 473,278 and 472,624, filed January 22, 1943, and January 16, 1943, respectively, in which discriminating signals are used for signaling the position of the brush carriage to the register circuit. One embodiment of the present invention makes use of such group and final selectors. The discriminating signals mentioned are used for the setting of the group selectors as determined by the identification control circuit, whereas discriminating signals connected to the final selector arcs are used for determining the position of the final selector brush carriage, after it was driven under the control of the identification control equipment, to the terminal on which the identification tone was placed. The discriminating signals sent from the final selector arcs to the identification control equipment are then used to determine the particular line in the group which was identified by the common point through which the identification had started.

One of the features of the invention is that the subscriber's line, indicated by the presence of an alternating current marker potential, is located by operating a line finder associated with the identification control circuit, and to certain bank terminals of which the common points of all subscribers' line groups in the exchange are connected, to hunt for the common point in its bank on which the marker potential is present. The position of this finder is indicated by means of characteristic potentials of current applied to other terminals of its bank from certain sources of current. These sources differ in at least one of their electrical characteristics to represent the different digits of the subscribers' numbers corresponding to the common points, there being as many rows of terminals in the finder as there are digits to be identified to determine the common point.

A further feature is that the characteristic potentials, identifying the group of lines from which one is to be identified, are used for the purpose of controlling one or more selections in group selector stages in order to set up from the identification equipment a connection to a final selector in the group to which this subscriber's line is connected. Such characteristic potentials can further be used in systems in which group selectors are set by comparing a signaling current sent from the selector with a reference current denoting the group to be selected. In such systems the characteristic potentials are used as reference currents for the purpose of setting one or more stages of group selectors to extend a connection from the identification control equipment to a final selector in the group to which this subscriber's line is connected.

A further feature is that these characteristic potentials are used to govern the sending of numerical impulses denoting one or more digits of the calling subscriber's number from the identification control equipment to the equipment on which the calling subscriber's identity should be displayed or recorded.

This invention is not limited to the use of the type of group and final selectors shown in this embodiment, but is equally applicable to other switching systems, such as those using forward or directive impulses or revertive impulses sent from group and final selectors to a register circuit. The group and final selectors are so arranged as to be accessible from the identification control circuits. The identification control circuit is connected to one brush of the final selector and causes it to hunt for the identification tone placed on the subscriber's line. The position of the final selector in which this tone is found can be determined from the number of forward or revertive impulses sent, after moving the brush carriage from its normal position.

Another possibility is to determine the number of steps needed to restore the brush carriage to its normal position from the terminal on which the identification tone was found.

There are different ways in which the tens group of the calling line can be determined. This depends on the design of the final selectors. With final selectors having two distinct motions, it is necessary to control from the identification control circuit the setting to one particular group of lines during the act of identification. For this purpose, the identity of this group is indicated by the fact that the subscribers' lines are commoned in groups of, say, 10 or 20 lines, corresponding to the groups of lines connected to the final selector banks. With final selectors having a single motion for reaching all subscribers' lines connected to their banks, it is possible to connect, say, 100 or 200 subscribers' lines to one common point, depending on the capacity of the final selector and to use the final selector for signaling the identity of the tens group to the identification control circuit. This may be done in a number of ways. In one scheme, as shown in the embodiment described below, different characteristic alternating current potentials are provided for the individual lines in each group of ten subscribers' lines. While the final selector is moving from its normal position to the line on which the identification tone is placed, the number of times a particular characteristic potential is met is counted so that one can determine the number

of groups of ten subscriber lines passed over before reaching the line to be identified.

An alternative way is that characteristic potentials are connected in two different rows or groups of terminals in the final selector arcs, one of which is used to identify the tens digit, and the other to identify the units digit of the corresponding subscriber's number. Thus the tens and units digits are directly determined at the identification control circuit when the final selector arrives on the line to be identified, without any counting action taking place whilst the final selector is moving. The manner in which the line is identified depends on the manner in which the final selector works, as described in the application U. S. Ser. No. 472,624 referred to, but in each case the same means which are used for setting the final selector under the control of the register when making a selection to a called subscriber line, can be used for identification purposes to signal the position of the final selector brush carriage to the identification control circuit.

One embodiment of the invention is described with reference to the drawings, in which

Fig. 1 is a junction diagram representing the relation between the different circuits;

Fig. 2 shows the universal selector circuit, which is employed as group and as final selector;

Fig. 3 shows the path of the alternating currents used for the purpose of identification; and

Figs. 4 and 5 show the identification control-circuit.

Considering, by way of example, a telephone exchange of a multi-office area, as shown in Fig. 1, a subscriber's local connection is built up over line finders group and final selectors in the known way. The connections which require identification (automatic toll, rapid toll service (CLR), multi-taxed rural connections, etc.) pass via first group selectors towards a toll main exchange. The identification of the calling subscriber may be initiated over the junction from the main exchange at any appropriate moment. The local exchange end of the junction is equipped with the necessary material required to start the identification process. A part of this equipment, which is either provided per junction or may be separated in common control circuits, is shown in Fig. 4. Two operations have to be started now. The junction circuit engages one free identification control circuit (Figs. 4 and 5) out of the group provided, and at the same time tone frequency current is connected by the junction circuit to the *c* wire of the subscriber's line circuit over first group selector and first and second line finder circuits, as shown in Fig. 3. The identification control circuit engaged starts to hunt with its ICF finder for the identification calling tone, and picks it up over a common point representing one group of first line finder circuits, or in other words, 100 subscribers. The circuit of this common point is shown in the lower left-hand part of Fig. 4. The position of ICF now indicates to the identification control circuit the group of final selectors which has access to the 100 subscriber lines, including the line of the calling subscriber. The identification control circuit engages one free final selector over second and third group selectors, and causes the rotation of the final selector until the calling tone on wire *c* of the subscriber's line circuit is found. The identity of the subscriber is now determined by the position of ICF, and that of the final. ICF gives the thousands and hundreds digits of the subscriber's number, whereas the tens and units

digits are fixed by the position of the final selector. The identification control circuit proceeds now to send out these digits towards the junction circuit, and from there they will be retransmitted to that circuit of the main exchange, which called for the subscriber's number.

One path only being available for identification, the scheme makes use of two tones of different frequencies, i. e. T_1 and T_2 for calling and sending purposes. These frequencies, which are both present on the path at a certain moment, are separated at the ends of this path by tuned filters F_1 and F_2. In Fig. 3 the arrows crossed twice indicate the path of the calling tone T_1, which is picked up first by ICF and then by a final selector. The arrows crossed once trace the circuit of the impulse sending for which the tone T_2 is used. Filter F_1, a filter which passes the tone T_1 and F_2, is the tone T_2.

The group and final selectors involved in identification operation are shown in Fig. 2. The operation of this circuit is described in full detail in application Serial No. 472,624, filed January 16, 1943, and Serial No. 473,278, filed January 22, 1943. The portion within the dotted square in Fig. 5 represents a signal receiving circuit which forms an important part of the signaling system used for selection. The operation of this receiving equipment is described in full detail in application Serial No. 473,278, filed January 22, 1943.

The following is a description of the detailed circuit operations of the identification control circuit:

(*a*) *Seizure of identification control circuits*

The signal sent through the junction from the main exchange, and which calls for identification, causes the grounding of the terminal A (Fig. 4). Relay *Ibr* operates and the step-by-step switch IM driven via back of relay *Ctr* starts to rotate to find a free identification control circuit.

The idle condition of this circuit is characterized by the presence of a free test potential on arc *a* of IM. This test potential is provided via a resistance of 500 ohms and is controlled on the home contact of the access finder ICF. Relay *Ctr* operates and stops switch IM. The front of *Ctr* introduces its low resistance winding and renders the test potential busy against other calls. Relay *Cdr* inserted into the low resistance circuit is a marginal relay and operates only if one such relay is connected to the test potential.

Relay *Cdr* in turn operates relay *Uhr*. Relay *Uhr* then operates relay *Ilr*, which disconnects relay *Ibr* over its left inner armature; the relays *Ctr* and *Cdr*, however, remain operated as long as the test potential is available from the control circuit.

The calling tone T_1 is then connected via the filter F_1 to the terminal marked by B. The filter F_2 is tuned to the sending frequency T_2 and prevents the calling tone from reaching the tone detector circuit prepared for the reception of the identification impulses.

The terminal B as indicated in Fig. 3, is connected to contact *c* on the arc of the first group selector. The calling tone, therefore, passes through the first group selector and the second line finder circuits and reaches terminal C in the first line finder circuit. The details of the further path are shown in Fig. 4. The tone passes over a resistance of 15,000 ohms and is induced over the step-up transformer T to terminal D, which represents a group of 100 subscriber lines.

(b) *Testing on common point*

The finder ICF starts to rotate by the following circuit: Ground, back of relays T*tr*, I*pr* and O*kr*, front of relay I*sr*, magnet ICF, battery.

The tone is tested by the cold cathode tube CT*i* and the finder is stopped by the operation of relay T*tr*. The principal characteristics of such tubes have been described in the patent specifications referred to above. The control anode *b* is connected over the secondary winding of transformer IT*i* to a variable resistance of 100,000 ohms, branched to the 130 volt positive battery. The potential of the control anode with respect to the cathode *c* is, under idle conditions, something like 65 volts, thus below the breakdown voltage of 70 volts. The primary winding of transformer IT*i* is connected to brush *a* of ICF, and whilst the access finder is rotating, the terminals D are checked for the presence of calling tone.

When this calling tone is found, the positive side of the induced current in transformer IT*i* increases the voltage between *b* and *c* of tube CT*i* above the breakdown voltage of the tube. This will then be ionized and consequently a circuit is established between the anode *a* and the cathode *c*. Relay T*tr* operates and switch ICF stops on the terminal on which a calling tone has been detected.

Relay T*tr* energizes relay K*cr* and the circuit now ensures that the finder is stopped by the tone and not by some potential change on one of the *c* wires, over which usually many other operations are performed. Relay C*tr* is energized as soon as the armature of I*sr* has made front. Relay C*tr*I is a slow releasing relay, and now that K*cr* operates, it starts to release. During its releasing time the tube CT*i* is extinguished at least once, and it has to light up again if the tone is still on the tested terminal. Relay K*cr* energizes the magnet of switch IS, which is a dial impulse sender switch. The impulses are directed via front of relay K*cr* to relay I*pr*, which follows these impulses. Relay I*pr* opens the circuit of relay T*tr*, which releases and at the same time the tube CT*i* extinguishes. As soon as relay I*pr* releases, T*tr* has to operate again because the tube is ionized. The brushes of finder ICF are during the release of relay T*tr* disconnected by relay I*pr* and do not move. Relay K*cr* remains operated, being energized alternatively by relay T*tr* or I*pr*.

During the above check, a double D. C. test is carried out in order to ensure that only one finder ICF comes to rest in a certain position. The test potential is furnished by the resistance of 500 ohms connected to terminal *b* on the arc of ICF. The high resistance winding of relay D*cr* is connected by relay K*cr* to this test potential, and the relay operates. Relay D*cr* introduces its low resistance winding and renders the terminal busy in the known way, against other test relays. Relay D*zr* is the marginal relay, the operation of which indicates successful testing.

Since the calling tone remains on terminal *a*, it may happen that other ICF finders started out by other calls, are stopped in this position already occupied by one circuit. In the second circuit, relay D*cr* fails to operate, whereby magnet ICF is energized and the finder leaves this position. If the next position is free, relay D*cr* operates and switch ICF stops. If there is no tone, relay T*tr* does not operate any more, and relay K*cr* releases. The magnet of ICF is now energized again via back of relay T*tr* and hunting continues.

Relay D*cr* energizes relay O*kr* in the following circuit: Ground, K*cr* front, C*tr*I back, F*or* back, D*zr* front, winding of relay O*kr*, battery. The first result of the operation of relay O*kr* is that full ground is connected to brush *a* of ICF, whereby the testing of other control circuits on the same terminal is prevented. Relay O*kr* opens the test potential of 500 ohms connected to arc *a* of switch IM, with the result that relays C*tr*, C*dr* and U*hr* release.

The transformer IT*i* receives now no tone, so that on the next operation of relay I*pr* the tube C*t*I extinguishes. Relay T*tr* does not operate thereafter and relay K*cr* releases. The impulse sender switch stops. Moreover relays D*cr* and D*zr* release, the guarding of the position not being necessary any more.

Relay O*kr* locks itself via the back of relay R*lr* and will only release at the end of the identification. Relay O*kr* energizes the relays G*gr* and G*hr*; the operating ground is thereby controlled via the normal position of the different step-by-step switches of the circuit. Once operated relay G*gr* remains energized as long as relay O*kr* is operated.

(c) *Setting of group selectors*

Relay A*r* of the second group selector, which is associated permanently with the identification control circuit, is operated in the following way.

When relay G*hr* operates, brush *d* of switch SM becomes grounded and relay T*or* is energized. Another ground of relay G*hr* operates relay S*sr* via brush *c* of switch SM.

Relay T*or* then closes the following circuit for relay D*tr*: Ground, winding of relay D*tr*, front of relay T*or*, *c* wire, back of relay A*r*, resistance of 600 ohms, battery.

Relay D*tr* operates relay S*ar*, which, whilst energizing magnet SM, locks itself to the interrupter of this switch.

When both the relays S*sr* and T*or* are energized, an operating circuit is closed for relay A*r*: ground, winding of relay T*r*, back of relay G*br*, S*sr* front, T*or* front, *b* wire, B*r* back, A*r* back, winding of relay A*r*, battery.

The possible operation of relay T*r* in this circuit is of no importance. Relay A*r* operates and locks to the *d* wire to which ground is connected via a front of relay O*kr*. When relay A*r* operates, the battery of 600 ohms is disconnected and relay D*tr* releases. If magnet SM is already fully energized, relay S*ar* releases now, and the brushes of SM make one step. Leaving position normal, SM removes the operating ground of relay T*or*, which releases before G*br* could operate.

Relay S*sr* remains operated in position 1 of SM and the selector switch of the second group selector starts to rotate as soon as relay V*rr*, which is kept operated by relay S*ar*, releases. The circuit of the power magnet P is as follows: ground, back contact of relay V*tr*, back contact of relay T*or*, front contact of relay S*sr*, back contact of relay V*rr*, *a* wire, back contact of relay B*rk*, front contact of relay A*r*, magnet P, battery.

The selection is determined by the thousands digit of the calling subscriber, and this is known from the position of ICF. The selection process itself has been described in detail in the patent specification already mentioned above. The principle of the selection is the comparison of two A. C. sources of different

phases. One A. C. which is called "signaling current" is available over the *d* brush of the second group selector and is furnished by the third group selector and this changes its phase for each group of third group selectors available. The second alternating current, called "reference current," depends on the position of ICF. These two currents are compared by the receiving equipment (Fig. 5). The circuit of the signaling current is: ground, front contact of relay *Ggr*, primary winding of transformer HC1, back contact of relay *Dsr*, back contact of relay *Tor*, *c* wire, front contact of relay *Ar*, back contact of relay *Br*, brush *d* of second group selector, back contact of relay *Ar* (in third group selector), jack BJ, home contact, resistance of 100ω, source of alternating current to ground.

The circuit of the reference current is: ground, front contact of relay *Ggr*, primary winding of transformer HC2, brush *b* and terminal 1 of SM, brush *c* of ICF, source of alternating current to ground.

The receiving equipment has the necessary means to compare the above two currents and at the moment it detects that the currents are in phase, the tube CT2, becomes ionized and relay *Vtr* operates. Relay *Vtr* opens the circuit of the power magnet and the selector stops on the terminals of an outlet in the wanted group.

The tube CT3 is a voltage stabilizer furnishing 75 volts steady potential for the tube CT2.

Relay *Vtr* energizes relay *Ftr* in the circuit: ground, front contact of relay *Vtr*, back contact of relay *Dsr*, back contact of relay *Lsr*, back contact of relay *Fhr*, winding of relay *Ftr*, battery.

Relay *Ftr* prepares a locking circuit for itself over the winding of relay *Fhr* and opens the circuit of relay *Crh*. This latter relay removes the 130 volts positive battery from the anode of tube CT2. Relay *Vtr* is caused to release, whereby the short circuiting ground on relay *Fhr* is removed and this relay operates in series with relay *Ftr*, via the back contact of relay *Vrr* and the front contact of relay *Srr*. Relay *Fhr* closes back the operating circuit of relay *Chr*, which then operates, so that the lamp CT2 lights again, the alternating current signal from the selector still being sent. Relay *Vtr* operates again and energizes relay *Tor* in turn.

The alternating current test is repeated in the above manner twice, in order to ascertain that the selector switch is standing, after stopping on the terminals of the outlet engaged.

Relay *Tor* closes the following direct current test circuit: ground, winding of 2000 ohms of relay *Tr*, back contact of relay *Gbr*, front contact of relay *Ssr*, front contact of relay *Tor*, wire *b*, back contact of relay *Br*, front contact of relay *Ar*, winding I of relay *Br*, brush *c* of second group selector, back contact of relay *Ar*, resistance of 600ω, to battery in the third group selector.

In this circuit only relay *Tr* can operate, whereas relay *Br*, due to the high resistance of relay *Tr*, does not operate. The front contact of relay *Tr* connects relay *Dtr* and its low resistance winding in parallel to its high resistance winding, thereby rendering the test potential of 600ω busy against other calls, and at the same time increasing the current so that *Br* can operate. Relay *Dtr* is a marginal relay, and can only operate if it is connected alone to the test potential. Relay *Dtr* energizes relay *Sar* in an obvious circuit. Relay *Sar* energizes the step-by-step switch SM and operates at the same time also relay *Vrr*.

Relay *Vrr* opens the locking circuit of the relays *Fhr* and *Ftr*, which both release together with relay *Tor*. The test relays, however, remain operated due to the doubling ground connected to the front contact of relay *Tr* via a front contact of relay *Sar*. Relay *Vrr* releases relay *Chr*, so that the tube CT2 extinguishes and relay *Vtr* releases.

Relay *Sar* once operated locks itself to the interrupter contact of SM in order to be sure that SM is fully energized. When the second group selector is through connected by the operated relay *Br*, and the seizure relay *Ar* in the third group selector is energized the 600ω test potential is disconnected.

This part of the circuit operation will now be described in detail:

Relay *Dtr* releases when the test potential is removed and, if SM at this moment is already fully energized, relay *Sar* releases. The brushes of SM now make one step and arrive at terminal 2.

Relay *Sar* releases relay *Vrr* and this relay in turn allows the re-operation of relay *Chr* and now the receiving equipment is ready for the next selection.

As mentioned above, relay *Br* in the first group selector starts to operate as soon as the high resistance winding of relay *Tr* is shunted by relay *Dtr*. Relay *Br* is a slightly slow operating relay due to its short-circuited second winding; this in order to cover the releasing time of the test relays in case of simultaneous test by two or several circuits.

When relay *Br* operates it removes first of all the short circuit on its second winding, thereby providing a locking circuit to the battery over 600ω resistance. In addition, it short-circuits its operating winding via a front contact, which closes later than the back contact removing the short-circuit mentioned above.

The signaling current still available from the third group selector over brush *d* of the second group selector, is rendered busy by a full ground connected over a front contact of relay *Br*. The left contacts connect through the *b* and *c* wires in such a way, that the test potential of the third group selector over the brush *c* is continually guarded.

When relay *Tor*, after successful alternating current testing, has operated, it disconnects the primary winding of transformer HC1 and replaces it by a second low resistance winding of relay *Btr*. As soon as relay *Br* energizes, it connects this second winding of relay *Dtr* on its left outer change-over contact to the *c* wire in parallel with the other winding of relay *Dtr*. The inner left change-over contact connects through the *b* wire towards the third group selector. The test potential at this moment is guarded by the second winding of relay *Dtr*.

When the *b* wire is through connected, the low resistance circuit of relays *Tr* and *Dtr* now energize relay *Ar* of the third group selector in the following circuit: Ground, front contact of relay *Sar*, winding I of relay *Dtr*, winding of relay *Tr*, back contact of relay *Gbr*, front contact of relay *Ssr*, front contact of relay *Tor*, *b* wire, front contact of relay *Br*, brush *b* of the second group selector, back contact of relay *Br*, back contact of relay *Ar*, winding of relay *Ar*, battery in the second group selector.

Relay *Ar* operates in this circuit and locks it-

self over brush *d* to the ground available via the front contact of relay Br in the second group selector. The alternating current which was in any case already short-circuited by the above mentioned ground, is now disconnected at the back contact of relay Ar in the second group selector. Furthermore, relay Ar disconnects also the D. C. test potential of 600ω, which causes the release of relay Dtr in the way already described.

The alternating current test, as was said above, is repeated in order to be sure that the group selector, after stopping, makes contact with terminal *d* of the group selector of the next stage. Should it happen that the selector stops too far, so that the desired contact is passed, the circuit operation changes in the following respect:

On the first operation of relay Vtr, relays Ftr and Fhr operate in the manner described. Relay Chr connects back the positive battery to the tube CT2, but now relay Vtr fails to operate and owing to this relay Kir energizes in the circuit: ground, back contact of relay Vtr, back contact of relay Tor, front contact of relay Ssr, front contact of relay Ftr, front contact of relay Fhr, winding of relay Kir, battery.

Relay Kir energizes relay Vrr, which releases relays Ftr and Fhr. Relay Kir is bound to release as soon as the armature of relay Fhr leaves the front contact, so that relay Vrr releasing re-establishes the alternating current test conditions as before. The power magnet of the group selector is again energized and the brush carriage continues to hunt for another free outlet in the wanted group.

The direct current test cannot be successful if the selector is stopped with some delay, so that the brush *c* is opened, or in case the test potential is kept busy by a circuit, which has just tested the same alternating current, or another reason may be that the fuse of the outlet engaged is missing.

In all the above cases relay Tr does not operate, due to which relay Cbr is energized.

Relay Cbr disconnects the test relay Tr and directs the *b* wire to the control cathode of the cold cathode tube CT4. At the same time it energizes the power magnet of the selector over the *a* wire. The brush carriage leaves the position in which the direct current test was not successful and will have to advance until it reaches the first free test potential of any free outlet.

The control anode of tube CT4 is permanently connected to about 30 v. positive battery. The tube therefore will not light on busied test potential, because the 30 volts is not sufficient to break down. As soon as a free potential of 48 volts is found, the potential difference increases to 78 v. and the tube lights. Furthermore, relay Fsr operates and stops the selector on the terminals of a free outlet which, of course, does not necessarily belong to the same group as the outlet tested before. Relay Fsr energizes relay Vrr, which now in the known manner causes the release of the relays Fhr, Ftr, Tor as well as relays Chr and Vtr.

The release of relay Tor is followed by that of relay Cbr, whereupon the tube CT4 is extinguished and relay Fsr releases. The circuit is now ready to start again the A. C. test. If, therefore, the group selector is at that moment behind the group indicated by the reference current, the selector switch will have to start rotating its brushes again.

The selection in the third group selector is performed in the manner described above. SM is now standing in position 2, and transformer HC2 is connected to the brush *d* of ICF over which the reference current of the hundreds digit is reached. The selection terminates again by the operation of relay Sar and the step-by-step switch SM is advanced to position 3.

(d) Setting of final selector

When leaving position 2, SM releases relay Ssr and in position 3 relays Lsr and For operate. The brushes of the final selector start to rotate, its magnet P being energized in the following circuit: ground, back contact of relay Ttr, back contact of relay Ipr, front contact of relay Okr, back contact of relay Btr, front contact of relay For, *a* wire over the second and third group selector, back contact of relay Br (in final), front contact of relay Ar, magnet P, battery.

The final selector will have to stop when the calling tone is found on the *c* wire of the subscriber to be identified. This tone is detected by the tube CT1, and relay Ttr consequently has to stop the final selector.

The tone is checked in the following circuit: primary winding of transformer IT1, front contact of relay Okr, the transformer IT2, front contact of relay For, resistance R, back contact of relay Btr, *b* wire over second and third group selector, back contact of relay Br (in final), front contact of relay Ar, winding of relay Br, brush *c* of final selector, *c* terminals, sources of alternating current.

Transformer IT2 replaces T on the first tone test. When relay Ttr operates, a timed check is introduced in order to ascertain that the final selector has stopped on the calling tone. This check, which consists in the repeated release of the tube CT1, has been described in connection with the test on the common point. When Ctr releases, Btr operates, since relay For is energized now. Relay Btr opens the tone test circuit, so that relay Kcr is then released on the next opening of the interrupter IS.

Magnet SM is energized in the circuit: ground, interrupter, back contact of SM, front contact of relay For, front contact of relay Btr, magnet SM, battery.

SM leaves position 3 and stops in position 4, due to the release of relay For. In position 3 the sending of the subscriber's number starts.

During the rotation of the final selector the step-by-step switch TM registers the number of times the final selector passes over a sub-normal position, this being the indication of the tens digit of the subscriber's number. This counting is carried out with the help of the receiving equipment. Transformer HC2 is connected via terminal 3 of the SM to the brush *b* of TM. The reference currents connected to this arc *b* are identical to the currents connected to the sub-normal positions of the final selector. The signaling circuit is completed in the known way, like it was for selection purposes. When the first sub-normal position is reached, relay Vtr operates. Relay Lsr being now energized, a circuit is closed for relay Tmr, which locks itself to the interrupter contact of TM. Relay Tmr energizes relay Vrr, whereupon relay Chr releases, tube CT2 extinguishes and relay Vtr releases. If TM is already fully energized, relay Tmr releases and TM takes one step. Relay Vrr releases and when relay Chr re-operates, the final selector switch will have already passed the sub-normal position and a record of this will have

been made by the one step taken by TM. When the next sub-normal position is reached, the phase of which corresponds to the phase connected to terminal 1 of the arc *b* of TM, *Vtr* operates again and one step is taken by TM.

(e) Sending of subscriber's number

The subscriber's number is preceded by a long starting impulse, which is required to signal to the identification calling circuit that sending starts and that the calling tone has to be disconnected.

Relay *Dsr* operates via arc *c* of SM. Relay *Dsr* energizes relay *Icr* in the following circuit: ground, interrupter of CM, position N of CM, *Dsr* front, *Edr* back, winding of relay *Icr*, battery.

Relay *Icr* locks itself via the back contact of relay *Edr*. IS starts its rotation and produces impulses. The first closure, which may be partial, energizes relay *Fir*, and during the following opening relay *Flr* energizes in series with relay *Fir*.

When relay *Flr* operates, the sending tone T2 is connected as follows: Source T2, front contact of relay *Flr*, filter F2, back contact of relay *Sir*, front contact of relay *Btr*, *b* wire over second and third group selector, back contact of relay *Br* (in the final selector), front contact of relay *Ar*, winding of relay *Br*, brush *c* of the final selector, *c* wire over line finders, etc. to the tone detector in the junction circuit.

Relay *Isr* follows the impulses of IS and steps the switch CM. The length of the starting impulse is equal to about the time required for three and a half impulses. The stepping of CM is stopped by the receiving equipment. The reference current circuit terminates via brush *b* of SM, position 4, at the alternating current source of the third phase. The signaling current is changed from phase to phase on arc *b* of CM, whilst this switch is advanced step-by-step. After having taken three steps, the identity of the signaling and reference currents causes the operation of relay *Vtr*. Due to the operated relay *Dsr*, relay *Edr* is also energized. This relay *Edr* is thereby locked via the front contact of relay *Ifr*, which relay, together with relay *Idr*, is kept energized, whilst impulse sending takes place. Relay *Edr* opens the impulse circuit and releases relay *Icr*. The relays *Fir*, *Flr* release instantaneously, whereas the relays *Idr* and *Ifr* release slowly. The releasing time of the two latter relays has to cover the inter-digital time separating two consecutive digits.

When relay *Flr* releases, the step-by-step switch GM returns to its normal position via its interrupter contact and arc *a*.

Relay *Edr* energizes relay *Sar*. This relay *Sar* operates relay *Vrr* in order to extinguish tube CT2 and at the same time the magnet SM is energized.

When relay *Ifr* releases, relay *Edr* releases as do the relays *Sar* and *Vrr*. After operation of relay *Chr* the receiving equipment is ready to control the sending of the first digit. This starts by the re-operation of relay *Icr*, and is performed in the same way as the sending of the starting impulse. The difference is that relay *Sir* is operated via terminal 5 of arc *d* of SM and consequently the short-circuit on the impulse contact of relay *Ixr* is removed. After the correction of the first impulse by relays *Fir* and *Flr*, all the subsequent impulses are reproduced by relay *Ixr* on the impulse sending path towards the indentification calling circuit.

The reference current is changed on the arc *b* of SM. In position 5 a digit is sent out, the value of which depends on the jumpering of the terminal A, and which represents the first digit of the subscriber's number, considered as a fixed digit for the exchange having five digit numbering. In position 6, the thousands digit is sent as signalled by arc *c* of ICF, and in position 7 of SM, the hundreds digit is reproduced under the control of arc *d* of ICF.

The tens digit is stored by TM. The reference current correspondingly is taken in position 8 via arc *c* of TM. In position 9 the units are sent out. The value of this digit is fixed by the position of the final selector and is signalled by the alternating current available over brush *d* of the final selector. This alternating current is connected via wire *c*, via front contact of relay *Dsr* and over terminal 9 of arc *b* of SM to the reference transformer HC2. The signaling current is changed on arc *b* of CM as before, with the only difference that the alternating current source of phase 1 is changed on relay *Usr* operated for this sending to the alternating current source corresponding to the sub-normal position, which is eventually occupied by the final selector.

When the units digit is sent out, SM arrives at position 10 and energizes relay *Rlr*, which opens the locking ground of relay *Okr* and initiates thereby the release of the circuit. The relays engaged release in sequence: *Ggr*, *Ghr*, *Btr*, etc. Relay *Ghr* closes the homing circuit of SM and *Tm*, whereupon both switches return to their normal position under the control of their interrupter contacts. Relay *Okr* closes the homing circuit of ICF, which switch therefore returns to normal. The holding ground of the second group selector is opened, when relay *Okr* releases. The second group selector releases the third group selector and this in turn liberates the final selector, which circuits have been engaged temporarily for identification purposes.

Further it can be mentioned that the ground on the common point D of Fig. 4 is disconnected when the starting impulse is over and relay *Sir* operates. At this moment the calling tone is already disconnected, and the common point is freed to permit testing on calls via other first line finders of the same group. The *c* wires cannot interfere with the sending tone T2 because a filter F2 is connected to the common point as shown in Fig. 4.

In case of premature release, it may happen that after successful test on the common point, no tone will be found on the arc of the final selector. If so, the step-by-step switch TM receives more than ten impulses. Arriving in position 10, TM prepares an operating circuit for relay *Rlr* via arc *d* position 10. If relay *Tmr* operates now indicating an 11th impulse, *Rlr* is energized and the indentification control circuit is released.

What is claimed is:

1. In an automatic telephone exchange system, a plurality of groups of lines each designated by a different number, means including non-numerical switches and numerical group and final selectors for establishing a connection between a calling and a called line, equipment for identifying the number of the calling line, different sources of characteristic A. C. potentials, means for operating at least one of said group selectors and a final selector to connect said equipment with the calling line, means to connect the equipment with the calling line over the non-numerical switch employed in the establishment of said connection, connections from said sources to the last men-

tioned means, and means in said equipment responsive to said A. C. potentials.

2. The telephone system according to claim 1, and in which said non-numerical switch is a line finder and the last mentioned means is connected with a brush of the line finder.

3. The telephone system according to claim 1, and in which the last mentioned means is an access finder having a terminal bank and cooperating brushes connected with said equipment, and multiple connections from the terminal bank of the access finder to the non-numerical switches.

4. The telephone system according to claim 1, and in which one group of said sources represents one and another group another digit of line numbers, said last mentioned means being an access finder having brushes connected with said equipment, terminals connected with one and other terminals connected with the other group of sources.

5. In an automatic telephone exchange system, a plurality of groups of lines each designated by a different number, means including non-numerical switches and numerical group and final selectors for connecting a calling with a called line, said selectors having terminal banks and brushes movable from a home position over the terminals, equipment for identifying the number of the calling line, two groups of different sources of characteristic A. C. potentials, each group representing a different digit of line numbers, an access finder having contacts connected with the equipment and cooperating contacts, the latter connected with said non-numerical switches and said two groups of sources, means in said equipment variably responsive to said sources, circuits controlled by said equipment for operating at least one group selector to select a final selector, means also controlled by said equipment for operating the last mentioned final selector to hunt for the terminals of the calling line, and means controlled by the last mentioned final selector to signal to said equipment the location of said calling line terminals with respect to the home position of the final selector.

6. In an automatic telephone exchange system, a plurality of groups of lines each designated by a different number, means including non-numerical switches and numerical group and final selectors for connecting a calling with a called line, said selectors having terminal banks and brushes movable from a home position over the terminals, equipment for identifying the number of the calling line, sources of characteristic potentials having differences in at least one of their electrical characteristics, said sources representing a digit of a line number, means for applying the potential from each source to a point common to a plurality of lines including the calling line to be identified, means for operating at least one group selector in accordance with one digit of the calling line number to select a final selector, means for operating the last mentioned final selector to select the terminals of the calling line to which the potential has been applied, and means in the identification equipment for counting the number of terminals passed over by the brushes of the final selector when moving from the home position to the terminals of the line to be identified.

7. In an automatic telephone exchange system, a plurality of groups of lines each designated by a different number, means including non-numerical switches and numerical group and final selectors for connecting a calling with a called line, said selectors having terminal banks and brushes movable from a home position over the terminals, equipment for identifying the number of the calling line, sources of characteristic potentials having differences in at least one of their electrical characteristics, said sources representing a digit of a line number, means for applying the potential from each source to a point common to a plurality of lines including the calling line to be identified, means for operating at least one group selector in accordance with one digit of the calling line number to select a final selector, means for operating the last mentioned final selector to select the terminals of the calling line to which the potential has been applied, and means in the identification equipment for counting the number of terminals passed over by the brushes of the final selector when moving from the terminals of the line to be identified to the home position.

8. In an automatic telephone exchange system, a plurality of groups of numerically designated lines, means including a line finder, and a plurality of stages of group selectors, a final selector for connecting a calling with a called line, said finder and said selectors having banks of terminals and cooperating sets of brushes, each line having conductors connected in multiple to terminal banks of final selectors and line finders, identification equipment for identifying the number of the calling line, an access finder associated with the identification equipment and having terminals and a set of brushes cooperating therewith, two groups of sources of current differing in at least one of their electrical characteristics and representing two digits of line numbers, connections from one group of sources to one and from the other group to other terminals of the access finder, means including a group selector and a final selector for connecting the identification equipment with the calling line, and means including said sources of current for controlling the operations of the last mentioned group selector.

9. In an automatic telephone exchange system, a plurality of numerically designated lines, means including a line finder, group selectors and a final selector for connecting a calling with a called line, said line finder and selectors having banks of terminal groups and brushes movable over the terminals, magnets for moving said brushes, each line having conductors connected in multiple to the terminals of final selectors arranged in groups and to the terminals of a line finder, equipment for identifying the number of the calling line, a connection from said equipment to the brushes of one of the selectors, a different source of characteristic A. C. signaling currents connected to each group of selector terminals, those connected to the various selectors representing the different digits of line numbers, an access switch, two groups of sources of characteristic reference current connected to said access switch representing two digits of line numbers, access means for operating the switch to select the calling line and to connect with two reference current sources representing two digits of the calling line number, a circuit for the magnet of the selector connected with the equipment actuated only if a predetermined relationship exists between the signaling current source with which said selector brushes are connected over the terminals thereof and the reference current source representing the corresponding digit with which the access switch is connected, a circuit for the magnet of another selector selected by the last mentioned selector actuated only if a predetermined relationship exists between the signaling current source with which said another selector brushes contact and

the other reference current source with which the access switch connects, an impulse sender associated with said equipment, a receiver responsive to said impulse sender, and means for variably operating said impulse sender in accordance with the setting of the selectors and access switch when connecting said equipment with the calling line.

10. In an automatic telephone exchange system, a plurality of numerically designated lines, means including a line finder, group selectors and a final selector for connecting a calling with a called line, said line finder and selectors having banks of terminal groups and brushes movable from a home position over the terminals, magnets for moving said brushes, each line having conductors connected in multiple to the terminals of final selectors arranged in groups and to the terminals of the line finder, equipment for identifying the number of the calling line, a connection from said equipment to the brushes of one of the group selectors, a different source of characteristic A. C. signaling currents connected to each group of selector terminals, those connected to the various selectors representing different digits of line numbers, an access finder having a bank of terminal groups and a set of cooperating brushes, a different source of characteristic reference current connected to one terminal in each group of terminals of the access finder representing one digit, a different source of characteristic reference current connected to a second access finder terminal of each group representing another digit of line numbers, a source of A. C. of one frequency connected with the terminals of a group selector used in the establishment of the connection between the calling and a called line, multiple connections from the terminals of the access finders to the brushes of the line finders and arranged to pass A. C. of said one frequency, a control circuit for said access finder including a brush thereof and responsive to said one frequency to move the brushes into engagement with terminals connected with the calling line over the brushes of the line finder, means operative thereupon for actuating the magnet of the group selector connected with the equipment, a circuit for the last mentioned magnet actuated only if a predetermined relationship exists between the signaling current source with which the last mentioned group selector brushes are connected over the terminals thereof and the reference current source representing the corresponding digit with which one of the access finder brushes is connected over a terminal of the latter, a circuit for the magnet of another selector selected by the last mentioned selector actuated only if a predetermined relationship exists between the signaling current source with which said another selector brushes contact and the reference current source with which another access finder brush contacts, a control circuit for the magnet of the final selector including brushes of the latter and of the line finder and said group selector of the connection and the A. C. source of one frequency, said control circuit being responsive to the latter, means in the identifying equipment for counting the number of terminal groups traversed by the final selector brushes before they encounter the terminal of the calling line, an impulse sender associated with said equipment comprising an A. C. source of a second frequency, a receiver associated with the connection between the calling and called lines and responsive to said second frequency, and means for variably operating said impulse sender in accordance with the setting of the selectors and access finder when connecting said equipment with the calling line.

11. In an automatic telephone exchange system, a plurality of numerically designated lines, means including a first and a second line finder, group selectors of a first, a second and a third stage, and a final selector for connecting a calling with a called line, said line finders and selectors having banks of terminal groups and brushes movable from a home position over the terminals, magnets for moving said brushes, each line having conductors connected in multiple to the terminals of final selectors arranged in groups and to the terminals of a first line finder, equipment for identifying the number of the calling line, a connection from said equipment to the brushes of one of the second group selectors, a different source of characteristic A. C. signaling currents connected to each group of selector terminals, those connected to the first selector representing the ten thousands digit, those to the second selectors the thousands digit, those to the third selectors the hundreds digit, and those to the groups of terminals of the final selectors the tens digits of line numbers, an access finder having a bank of terminal groups and a set of cooperating brushes, a different source of characteristic reference current connected to one terminal in each group of terminals of the access finder representing the thousands digits of line numbers, a different source of characteristic reference current connected to a second access finder terminal of each group representing the hundreds digit, a source of A. C. of one frequency connected with the terminals of the first group selector used in the establishment of the connection between the calling and a called line, multiple connections from the terminals of the access finders to the brushes of first line finders and arranged to pass A. C. of said one frequency, a control circuit for said access finder including a brush thereof and responsive to said one frequency to move the brushes into engagement with terminals connected with the calling line over the brushes of the first line finder, means operative thereupon for actuating the magnet of said one of the group selectors of the second stage, a circuit for the last mentioned magnet actuated only if a predetermined relationship exists between the thousands signaling current source with which said second stage group selector brushes are connected over the terminals thereof and the reference current source representing the thousands digit with which one of the access finder brushes is connected over a terminal of the latter, a circuit for the magnet of a third selector selected by the second selector actuated only if a predetermined relationship exists between the hundreds signaling current source with which the third selector brushes contact and the hundreds reference current source with which another access finder brush contacts, a control circuit for the magnet of the final selector including brushes of the latter and of the first and second line finders and first group selector of the connection and said A. C. source of one frequency, said control circuit being responsive to the latter, means in the identifying equipment for counting the number of terminal groups traversed by the final selector brushes before they encounter the terminal of the calling line, an impulse sender associated with said equipment comprising an A. C. source of a second frequency, a receiver connected with the first selector of the

connection responsive to said second frequency, and means for variably operating said impulse sender in accordance with the setting of the selectors and the access finder when connecting said equipment with the calling line.

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