E. C. MOLINA.

CONTROLLING APPARATUS FOR TELEPHONE SWITCHING SYSTEMS

APPLICATION FILED OCT. 2, 1907.

1,114,174.

Patented Oct. 20, 1914.

3 SHEETS—SHEET 1.

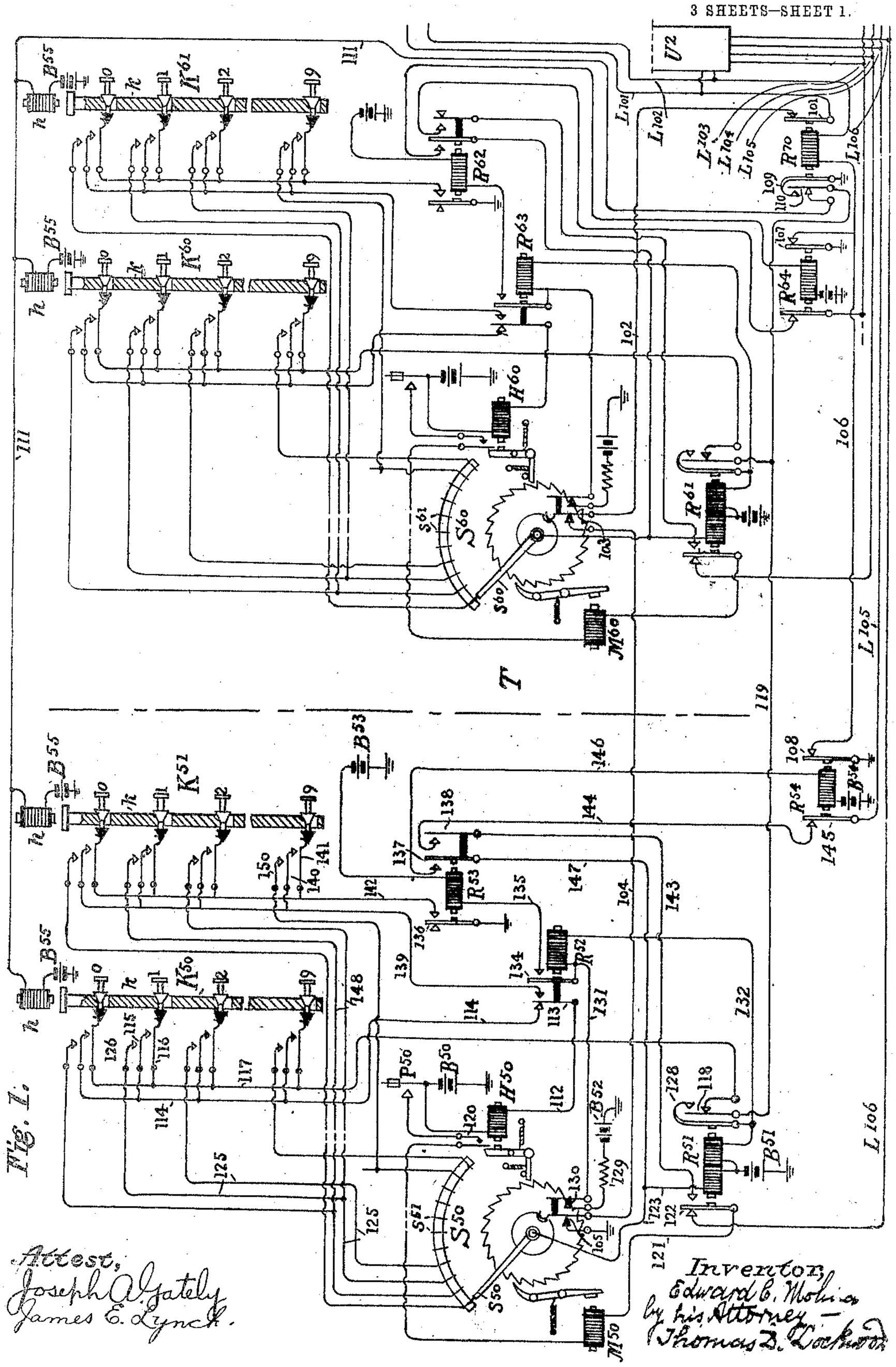

Fig. 1.

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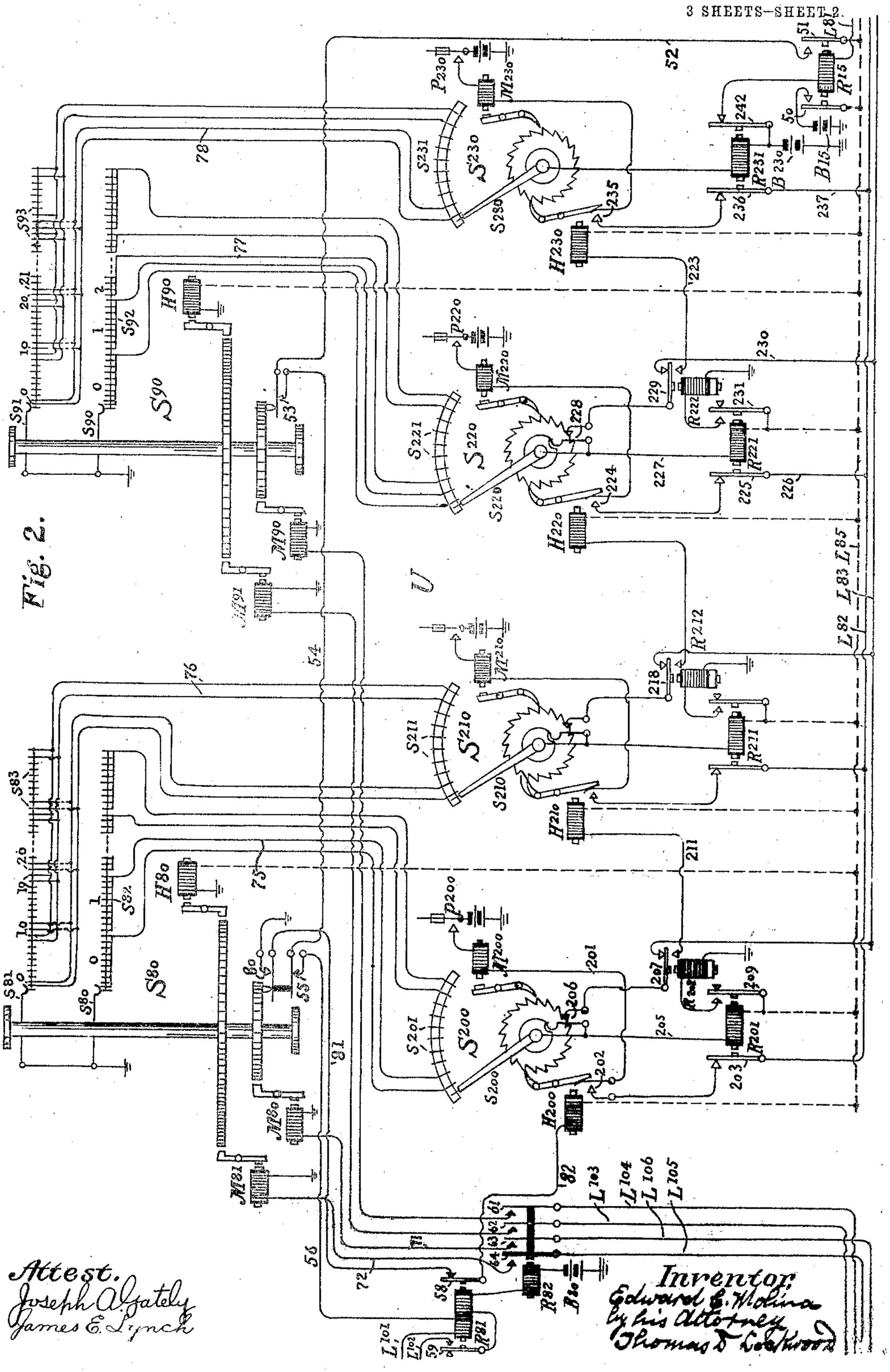

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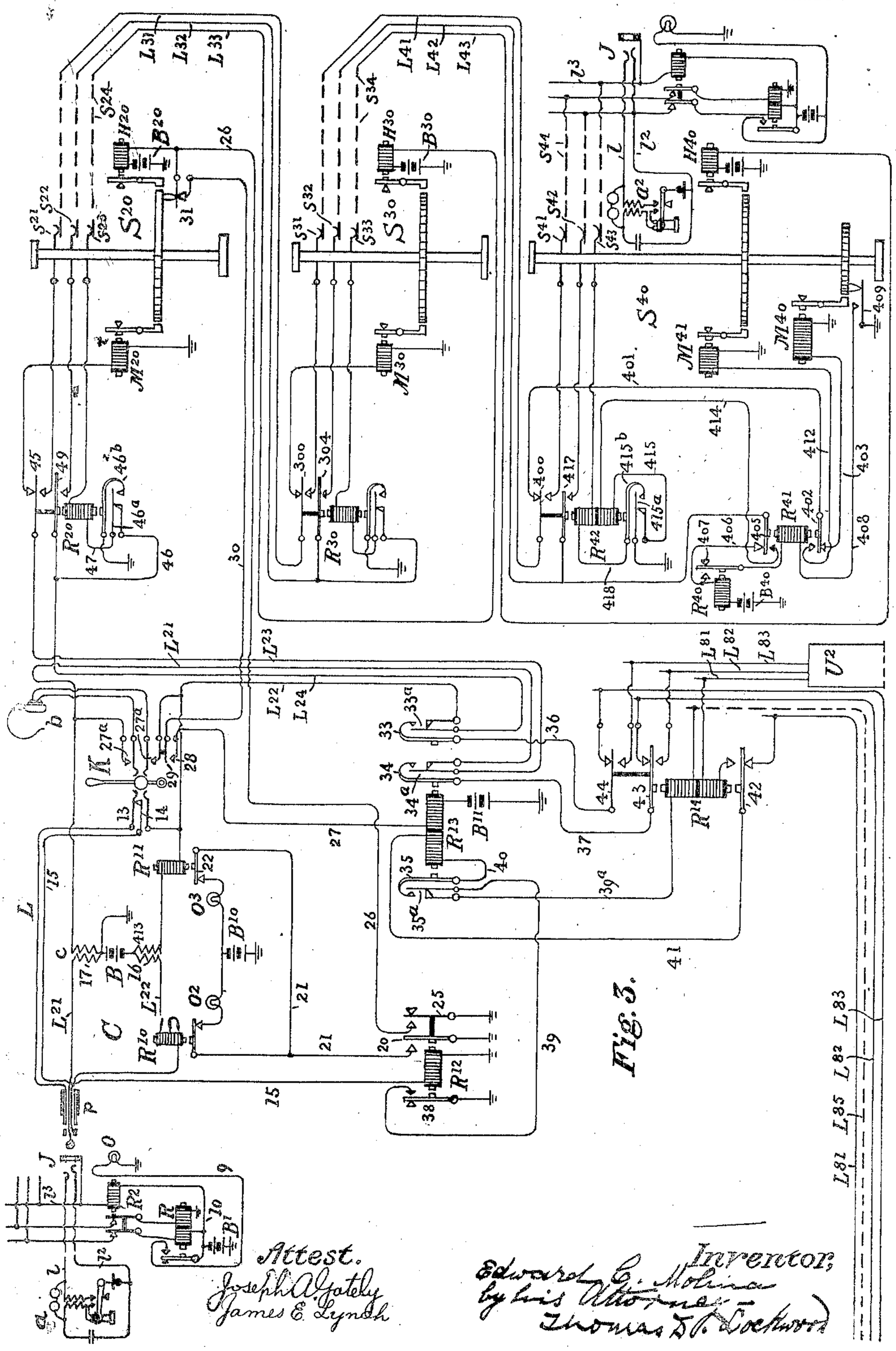

Fig. 3.

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UNITED STATES PATENT OFFICE.

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CONTROLLING APPARATUS FOR TELEPHONE SWITCHING SYSTEMS.

1,114,174. Specification of Letters Patent. **Patented Oct. 20, 1914.**

Application filed October 2, 1907. Serial No. 395,642.

To all whom it may concern:

Be it known that I, EDWARD C. MOLINA, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain Improvements in Controlling Apparatus for Telephone Switching Systems, of which the following is a specification.

This invention concerns telephone systems in which both manually operable switches and mechanical switching apparatus are employed in the connection of calling and called lines, said mechanical or selecting apparatus being governed in its movement by controlling apparatus; this latter having key mechanism upon which the operater registers the number of the desired line, and transmitting mechanism, acting in accordance with such registration, and in synchronism with which the selecting apparatus moves. It takes considerably longer for such controlling apparatus to complete its operation than it does for the operator to perform all the acts attending each connection, consequently if provided with but a single controller her efficiency may be decreased by periods of enforced idleness. To remedy this it has been proposed that two complete controllers be assigned to each operator, with means for rendering either available for use when idle. Such an arrangement, however, necessitates the putting of two keyboards before the operator, lessening the already limited space within which it is feasible to place the manual switches. It also has the effect of dividing the attention of the operator between alternative pieces of apparatus, requiring consideration as to which shall be used and tending to put a drag upon the work.

The present invention improves these conditions by providing a single primary controlling apparatus having its registering devices or keys before the operator, and which is adapted to govern a plurality of secondary controllers which directly determine the movement of the selecting apparatus. That one primary controller may thus serve a plurality of secondary controllers is due chiefly to the fact that I arrange the controlling sections of the former to operate simultaneously, while those in the latter act successively.

My invention further consists in simplifying the controlling apparatus by causing a single switch or transmitting mechanism to serve a plurality of series of keys or registering means.

In the accompanying drawings, Figure 1 represents diagrammatically one embodiment of my primary controlling apparatus, with a portion of a secondary controller conventionally indicated; Fig. 2 illustrates diagrammatically and in detail a secondary controlling apparatus; and Fig. 3 shows a diagram of an operator's cord circuit, together with a chain of selecting apparatus connected therewith; it also includes another portion of the secondary controller already referred to in connection with Fig. 1.

In telephone exchange systems of the class previously mentioned the lines l, l^2, with their third conductors l^3, of substations of which two, a, a^2 are illustrated, extend to answering jacks J located at a central station and furnishing one element of manually operable switching means. A suitable group of these jacks is situated at the position of each operator, who for the purpose of answering calls is provided with a number of connecting or cord circuits C, one, only, of which appears in Fig. 3 of the drawings. The main or talking strands L^{21}, L^{22}, of each cord and the third conductor, beginning with a portion L, are connected to the tip, ring and sleeve, respectively, of a plug p for coöperation with the jacks J and completing a portion of the manual switching means.

Associated with the cord circuits, in the present instance being joined thereto by leads L^{23} and L^{24} extending from the strands L^{21} and L^{22}, is mechanical switching apparatus serving to select the wanted line and unite it to the cord and therefore to the calling line. This selecting apparatus preferably consists, in the main, of rotatable switches acting successively, the number of switches in the series depending upon the character and magnitude of the symbols employed to designate the subscribers. In the present case it is assumed that numbers are used and that these may include four digits, and for selection for a line thus designated three classes of switches are provided, represented at S^{20}, S^{30}, and S^{40}, the first or primary selector

S^{20} picking out the thousands group, the second selector S^{30} the hundreds group, and the third selector or connector S^{40} the tens group and then the units terminals therein. Similar apparatus arranged in the same general manner is familiar to those skilled in the art and therefore need not be particularly described. It is only essential to this invention that there shall be some selective apparatus and a very simple organization has been shown. Of the details of this system it merely will be stated that the switches S^{20}, S^{30} and S^{40} have sets of three revoluble contact members or arms s^{21}, s^{22}, s^{23}; s^{31}, s^{32}, s^{33}; s^{41}, s^{42}, s^{43}, respectively, suitably mounted upon supporting shafts and propelled step by step over fixed terminals s^{24}, s^{34}, s^{44} by ratchet mechanism, operated by motor magnets M^{20} and M^{30} in the switches S^{20}, S^{30} and by long and short step motor magnets M^{40} and M^{41}, respectively, in the connector S^{40}. The arms are held in the positions to which they are advanced by retaining mechanism operated by magnets H^{20}, H^{30}, and H^{40}. Leads L^{31}, L^{32}, L^{33} and L^{41}, L^{42}, L^{43} unite the terminals of S^{20} and S^{30} to the next group of switching apparatus of the series, while the substation lines are multipled to the terminals s^{44} of the connectors and to the answering jacks, as is shown in connection with substation a^2 in Fig. 3.

At the position of each operator is means for controlling the movement of the selecting apparatus to cause its arms to come to rest upon the proper terminals. This consists of primary and secondary apparatus, the former for manipulation by the operator, while the latter is governed by the primary apparatus, and in turn directly affects the selectors. But one primary controller T is supplied for each position, while there is a plurality of secondary apparatus, the number of these depending upon the rate at which the operator works and the relative time of operation of the primary and secondary controllers. Two secondary apparatus U, U^2 have been shown, with means for automatically placing the primary apparatus upon the completion of its action in operative relation with the secondary apparatus which is then idle.

The primary controller has series of contact devices, conveniently in the form of keys for actuation by the operator, there being in the present instance four series each of ten keys, corresponding to the thousands, hundreds, tens and units digits and designated by the characters K^{50}, K^{51}, K^{60} and K^{61}, respectively. The keys may be locked in their depressed position by bars k and released therefrom by the attraction of magnets h. Each series of keys governs a switch mechanism by which the condition registered upon said keys is transmitted to a secondary controller. In the present embodiment of the invention one switch is made to serve two sets of keys, the thousands-hundreds starting switch S^{50} having its eleven fixed contacts s^{51}, over which the arm s^{50} sweeps, multipled by conductors 125 and 148 to contacts in the keys K^{50} and K^{51}, while the tens-units starting switch S^{60} has terminals s^{61} and an arm s^{60} similarly related to the keys K^{60}, K^{61}. Thus each section of starting electromechanism corresponds to a plurality of groups of symbols in a single line designation, that is, to a plurality of movements of the selecting apparatus. In both switches S^{50} and S^{60} there are eleven contacts with but ten digit keys in each series, because the thousands key 0 K^{50} and the tens key 0 K^{60} are required to produce a movement of the register switches, to be later described, from their initial position to their zero contacts. On the other hand, the hundreds and units keys 0 K^{51}, 0 K^{61} effect no movement, since the thousands and tens keys will have already caused the stopping of the register switches upon the contacts to which they correspond. Therefore, the first of the contacts s^{51}, s^{61} are joined only to the zero hundreds and units keys, respectively, upon which the arms s^{50}, s^{60} are normally resting, and the zero thousands and tens keys are multipled with the one hundreds and units keys, respectively to the second contacts, and so on throughout the series. These starting switches S^{50} and S^{60} are of the same character as those of the selectors, having motor magnets M^{50}, M^{60} and retaining magnets H^{50}, H^{60}, functionating in the same manner.

Of the secondary controllers but one, U, is shown in detail in Fig. 2. U^2 being a duplicate of it is indicated by portions of rectangles in Figs. 1 and 3. These secondary apparatus are connected in multiple to the primary controller by leads L^{101}, L^{102}, L^{103}, L^{104}, L^{105}, L^{106}. Each of the secondary controllers has, instead of the manually operable registering means, electromechanical registers furnished by switches S^{80} and S^{90}, the pairs of contact arms s^{80}, s^{81} and s^{90}, s^{91} of which are advanced simultaneously by long step motor magnets M^{80}, M^{90}, under the control of the starting switches S^{50} and S^{60} as determined by the depressed thousands and tens keys, and then simultaneously in short steps by motor magnets M^{81} and M^{91}, controlled by the same starting switches as determined by the hundreds and units keys. In either case retaining magnets H^{80} and H^{90} act to hold the arms at points to which they have been moved. The arms s^{80}, s^{90} each cooperate with ten fixed terminals s^{82}, s^{92}, each substantially equaling in extent one tenth of the total movement of the arms. As illustrated, ten terminals separated by spaces equivalent to the short steps produced by the magnets M^{81} and M^{91} have been strapped

together to furnish these longer terminals. These fixed contacts s^{82}, s^{92} are successively connected by conductors 75 and 77 to ten terminals s^{201} and s^{221} of sending switches S^{200} and S^{220}. The sets of fixed terminals s^{83} and s^{93} over which the arms s^{81} and s^{91} pass are each one hundred in number and are multipled in groups of ten, each group comprising one of the first ten terminals and every tenth terminal thereafter. The multipled groups are joined in sequence by conductors 76 and 78 to the ten terminals s^{211} and s^{231} of sending switches S^{210} and S^{230}. The contact arms s^{200}, s^{210}, s^{220} and s^{230} of the four sending switches are caused to travel over series of the ten active terminals s^{201}, s^{211}, s^{221}, s^{231} by motor magnets M^{200}, M^{210}, M^{220}, M^{230} and retained under the influence of magnets H^{200}, H^{210}, H^{220} and H^{230}. These sending switches transmit to the selectors, by means of leads L^{81}, L^{82} and L^{83} connected in multiple to all the cord circuits of an operator using this controlling apparatus, the condition registered by the switches S^{80} and S^{90}. A main battery lead L^{85}, indicated in heavy dotted lines, is also multipled to the cords from the secondary controller U only. It will be noted that there is a section of sending mechanism for each group of symbols in a single line designation or each selective movement, and, as will hereinafter appear, they act successively.

The mechanisms which have been described are the more important ones of the system, viewed in the light of the present invention. Certain minor or secondary mechanisms and elements will now be mentioned and their principal functions briefly stated.

Bridged across the strands L^{21} and L^{22} of the cords between the sections of the usual repeating coils c is the common battery B with its positive pole grounded. This for convenience in illustration has been shown in various places and designated by different reference characters, as has the pulsator by which the battery current is rendered intermittent. Each cord circuit includes a key K, which when thrown to the right, as seen in Fig. 3, connects the operator's telephone set b to the strands L^{21}, L^{22} and at the same time initiates the action of associating the cord with a secondary controller. A line signal or lamp O is situated in proximity to each answering jack J, being controlled by the well known line and cutoff relays R, R^2. The cords contain the usual supervisory lamps O^2 and O^3 with their relays R^{10} and R^{11}. In addition to the supervisory relays each cord has relays R^{12}, R^{13} and R^{14}. The first, when the operator has plugged into a jack, establishes a ground connection upon which depend the automatic operations of the cord alone and in conjunction with the various selectors. The second associates the calling end of the cord with an idle secondary controller and maintains said association until the controller has finished its operation. Relay R^{14} determines which of the two secondary controllers shall be associated with the cord by relay R^{13}.

In the primary controller T relay R^{70}, as soon as a secondary controller has locked itself to the primary controller, as will appear hereinafter, opens the initial circuit by which it would be possible for another secondary controller to become associated with the primary and closes momentarily the circuit of the key release magnets h. The starting switches S^{50} and and S^{60} have, respectively, relays R^{51}, R^{52}, R^{53}, R^{54} and relays R^{61}, R^{62}, R^{63}, R^{64}. After the pulses governed by the depressed thousands key have been transmitted, relay R^{51} (1) disconnects the motor magnet M^{50} of the switch S^{50} from the long step motor magnet M^{80} of register switch S^{80}; (2) removes ground from the thousands keys thereby releasing the holding magnet H^{50}, in order that the switch S^{50} may return to its normal position before operating in conjunction with the hundreds key; and (3) prepares the circuit by which relay R^{52} will be energized. Relays R^{52} and R^{53} together associate the switch S^{50} with the hundreds keys and the motor magnet M^{50} with the short step motor magnet M^{81} of switch S^{80}. Relay R^{54}, after pulses corresponding to the hundreds digit of the called number have been transmitted, opens the circuit of motor magnets M^{50} and M^{81}. Relays R^{61}, R^{62}, R^{63} and R^{64} act similarly with respect to the keys K^{60} and K^{61}, the starting switch S^{60} and the register switch S^{90}. Furthermore, relays R^{54} and R^{64} unlock the secondary controller from the primary controller after the latter has completed its operation.

Each of the secondary controllers includes relays R^{15}, R^{81} and R^{82}, and in these controllers the sending switches have relays R^{201}, R^{202}; R^{211}, R^{212}; R^{221}, R^{222}; and R^{231}. In addition, each of the retaining magnets of these switches serves to close a contact device. Relay R^{15} establishes the connection of the battery with the lead L^{85} upon which all the operations of the secondary controller depend, and closes one link in the circuit which associates a secondary controller with the primary controller. Relays R^{81} and R^{82} lock the secondary controller to the primary controller and connect the motor magnets of the register switches S^{80} and S^{90} to the corresponding motor magnets of the primary controller starting switches S^{50}, S^{60}. The contact device of each retaining magnet closes the circuit of the motor magnet of its switch. Relays R^{201}, R^{211}, R^{221} and R^{231} open said circuits when desired number of current im-

pulses have passed. Relays R^{202}, R^{212}, R^{222} initiate the operation of the succeeding sending switch.

As to the primary and secondary selecting switches S^{20} and S^{30}, in the former, after motor magnet M^{20} has received through its winning the series of impulses for the thousands digit of the desired number, a relay R^{20} (1) locks itself in series with the retaining magnet of switch S^{30}, thereby applying the retention pawl of this switch; (2) cuts out of the circuit the motor magnet M^{20}; and (3) closes one link of the desired connection by extending the leads L^{23} and L^{24} to the leads L^{31} and L^{32}. A relay R^{30}, in connection with the selecting switch S^{30} effects results which are exactly analogous to those accomplished by the relay R^{20}.

In the connector S^{40}, after the motor magnet M^{40} has received the actuating pulses or the tens digit of the desired number, the energizing of a relay R^{40}, which in turn energizes relay R^{41}, causes the substitution of the short step motor magnet M^{41} for the long step motor magnet M^{40} and prepares the circuits for the operation of a relay R^{42}. The last named relay after the motor magnet M^{41} has received the units pulses, upon attracting its armatures (1) locks itself in series with the cut-off relay of the selected line; (2) cuts motor magnet M^{41} out of the circuit; and (3) closes the last link of the desired connection by extending the leads L^{41} and L^{42} to the links of the wanted line.

Besides the contacts of the relays which perform the operation just mentioned, there are throughout the system other contacts forming a part of the various switches, some termed "normal" contact devices which are closed when the switch arms are in their initial position and open immediately upon movement, and other "off normal" devices closing when the travel of the arms begins. There are additional contacts associated with the retaining magnets. None of these need here be described, since when their operation is of any importance with relation to the present invention it will be made clear in tracing the circuits of the system.

The operation of the improved system will now be described, stating in detail the conductors and contacts making up the circuits involved.

The subscriber at substation *a*, upon removing the receiver from its hook, energizes the line relay R, thereby closing a circuit from battery B′ to ground through conductor 9 and the line lamp O. In response to this signal the operator inserts the plug *p* of one of the cords C into the jack J of the calling subscriber's line. This act on the part of the operator results in the energizing of the cut-off relay R^2, cord relay R^{12} and supervisory relay R^{10} by the simultaneous closing of two circuits, one from battery B′ to ground through conductor 10, winding of relay R^2, third conductor l^3 of the calling subscriber's line, thimble of jack J and sleeve of the plug P, third conductor L of the cord, springs 13 and 14 of the listening key K, conductor 15 and the winding of relay R^{12}; and the other from the free pole of battery B through winding 16 of the repeating coil *c*, strand L^{22} of the cord, winding of supervisory relay R^{10}, ring of the plug and cooperating spring of the jack, limb l^2 of the line, the substation set at *a*, the other limb *l* of the line, spring of the jack and tip of the plug, lead L^{21} and winding 17 of the repeating coil to battery. The energization of relay R^2 disconnects relay R from the line, therefore extinguishing the lamp O, while relay R^{10} opens the circuit of supervisory lamp O^2 to prevent it from lighting. Relay R^{12} completes two circuits, the first from ground through its armature 20, conductor 21, armature 22 and its back contact in supervisory relay R^{11} and lamp O^3 to battery B^{10}, lighting said lamp; while the second circuit is from ground through spring 25 of relay R^{12}, conductor 26 and winding of the retaining magnet H^{20} of the thousands selecting switch S^{20} to battery B^{20}, thereby energizing the magnet.

The operator throws the key K into the listening position, connecting her telephone set *b* with the talking leads L^{21} and L^{22} of the cord at the contacts 27^a 27^a, and closing a circuit from battery B^{11} through one winding of relay R^{13}, conductor 27, springs 28 and 29 of key K, conductor 30, normal contact device 31 of switch S^{20}, conductor 26 and spring 25 of relay R^{12} to ground. This energizes the relay R^{13}, the armatures 34 and 33 of which disconnect leads L^{23} and L^{24} from the strands L^{21} and L^{22} of the cord at the springs 34^a 33^a and join the leads to conductors 36 and 37. Armature 35 of relay R^{13}, contacting with its spring 35^a completes a circuit from ground through armature 38 of relay R^{12}, conductors 39 and 40, second winding of relay R^{13}, conductor 41, armature 42 and its back contact in relay R^{14}, lead L^{81} of the secondary controller U, winding of relay R^{15}, back contact and armature 242 of relay R^{231} to battery B^{230}. This circuit energizes relay R^{15} and makes relay R^{13} independent of the circuit established by the springs 29 and 28 of the key K. Armature 50 of relay R^{15} connects battery B^{15} to the main battery lead L^{85} of the secondary controller U. From this lead current then flows to ground through the winding of the retaining magnets H^{80} and H^{90} of the register switches S^{80} and S^{90}. Assuming that the primary controller T is not at this time coöperating with the secondary controller U^2 in the establishment of some other connection, current will also flow from the main battery lead to ground through armature 51 of relay

R^{15}, conductor 52, normal contact device 53 of the switch S^{90}, conductor 54, normal contact device 55 of the switch S^{80}, conductor 56, one winding or relay R^{81}, lead L^{101} of the primary controller, armature 101 and its back contact in relay R^{70}, conductor 102, normal contact device 103 of the starting switch S^{60}, conductor 104 and normal contact device 105 of the starting switch S^{50}. This circuit operates relay R^{81}, which separates its armature 58 from its back contact and closes the front contact of its armature 59. A circuit which locks relays R^{81}, R^{82} and R^{70} is completed at the front contact of armature 59 from battery B^{80} through the winding of relay R^{82}, second winding of relay R^{81}, lead L^{102}, winding of relay R^{70}, conductor 106, and then to ground in two directions—through the back contact and armature 107 of relay R^{64} and through the back contact and armature 108 of relay R^{54}. Thereupon relay R^{82} closes the front contacts of its springs and armature 61, 62, 63 and 64, connecting the secondary controller U with the primary controller T, while relay R^{70} opens the back contact of its armature 101, closes the contact between armature 109 and spring 110 and opens the resting contact of said spring.

As the armature 101 of relay R^{70} constituted a part of the initial circuit by means of which relay R^{81} of the secondary controller U was enabled to associate said secondary controller with the primary controller, it is evident that the corresponding relay of the secondary controller U^2 cannot be energized until the series of operations which the primary controller has to execute in conjunction with controller U has run out, and the contact of armature 101 is again closed by the release of relay R^{70}. The inclusion of the front contact of armature 51 of relay R^{15} in this initial circuit provides for the association of the secondary controller with the cord circuit before the primary controller is joined to it, while the normal contact devices of both starting switches and both register switches insures that the previously united primary and secondary controllers shall both have completed their operation before the new association occurs. When armature 109 of relay R^{70} makes contact with its spring current will momentarily flow from the batteries B^{55} to ground through the windings of the key release magnets *h* and conductor 111. These pulses of current result in the release of any digit key which may have been accidentally depressed since the previous call registered by the operator.

While the association of the controlling system with the cord is not a part of my invention, it will be briefly stated what occurs when the secondary controller U is still in use at the time the operator places the plug *p* in the jack J. In this case there will be a circuit from ground through armature 38 and its front contact in relay R^{12}, conductor 39, spring 35^a and its resting contact in relay R^{13}, conductor 39^a and one winding of relay R^{14} to the main battery lead L^{85} of the secondary controller U, to which battery B^{15} is still joined by relay R^{15}. This energizes relay R^{14}, disconnecting by its armatures 42, 43 and spring 44 the conductors 41, 37 and 36 from the leads L^{81}, L^{83} and L^{82} of the secondary controller U and uniting them with the corresponding leads of the secondary controller U^2. Then when relay R^{13} operates as a result of the movement of listening key K, relay R^{14} is kept energized by a circuit from ground to battery through conductor 39, spring 35^a and armature 35 of relay R^{13}, conductor 40, second winding of relay R^{13}, conductor 41, armature 42 and its front contact in relay R^{14}, second winding of said relay, lead L^{81} to secondary controller U^2 and winding of relay R^{15} of said controller. This secondary controller then proceeds to pick up the primary controller as has been described in connection with controller U.

The controlling system being thus associated with the cord circuit, it is ready for the registration by the operator upon the keys of the primary controller of the number of the desired line. Assume now that "1921" is the number called for by the [illegible]ason at substation *a*; thereupon the operator depresses the thousand key 1 K^{50}, the hundreds 9 K^{51}, the tens key 2 K^{60} and the units key 1 K^{61} of the primary controller T. The depression of the thousands key closes a path from battery B^{50} through the winding of retaining magnet H^{50} of the starting switch S^{50}, conductor 112, spring 113 and its back contact in relay R^{52}, conductor 114, springs 115 and 116 of the key 1 K^{50}, conductor 117, spring 118 and its resting contact in relay R^{51}, conductor 119 and spring 110 and armature 109 of relay R^{70} to ground. This circuit energizes the retaining magnet H^{50}, which, in turn, not only applies the pawl to the switch mechanism, but by closing contact device 120 establishes a circuit from pulsator P^{50} to ground through the winding of motor magnet M^{50} of the thousands-hundreds starting switch, conductor 121, armature 122 and its back contact in relay R^{51}, lead L^{106}, spring 63 and its front contact in relay R^{82}, conductor 71 and the winding of motor magnet M^{80} of the thousands-hundreds register switch. The motor magnets M^{50} and M^{80} will now operate simultaneously to advance the switch arms s^{50}, s^{80}, s^{81} each time the pulsator transmits current through the circuit just traced. When two impulses have been sent a circuit will be closed at the arm of switch S^{50} and its third contact from battery B^{51} through one winding of relay R^{51} conductor

123, conductor 125, springs 126, 115 and 116 of key 1 K^{50} and thence to ground through conductor 117, spring 118 of relay R^{51}, conductor 119 and spring 110 and armature 109 of relay R^{70}. This results in the energizing of relay R^{51}, which opens the back contact of its armature 122 and separates the spring 118 from its resting contact, and also closes the front contact of armature 122 and that between armature 128 and spring 118. Opening the back contact of armature 122 breaks the circuit through motor magnets M^{50} and M^{80}, stopping the arm s^{80} of the register switch S^{80} at the beginning of the second active contact s^{82}, or that corresponding to the thousands group, while the arm s^{81} is upon the eleventh active contact s^{88}. The contact of the armature 128 with its spring allows relay R^{51} to lock itself by a path from battery B^{51} to ground through its second winding, conductor 119 and spring 110 and aramture 109 of relay R^{70}. Since the resting contact of the spring 118 formed part of the circuit by which retaining magnet H^{50} was operated, this magnet will now be deënergized so that contact device 120 will be opened and the holding pawl of the switch S^{50} removed, allowing the arm s^{50} to return to its initial position.

As soon as the thousands-hundreds starting switch is on its first contact a circuit is closed from battery B^{52}, through resistance 129, normal contact device 130, conductor 131, winding of relay R^{52}, conductor 132, armature 128 and spring 118 of relay R^{51} and thence to ground through conductor 119 and spring 110 and armature 109 of relay R^{70}. On operating the relay R^{52} opens the back contact of its spring 113 and closes its front contact and that of armature 134. The path from the winding of relay R^{52} to battery B^{52} through conductor 131 and resistance 129 is now shunted by a path through armature 134 of relay R^{52}, conductor 135 and winding of relay R^{53} to battery B^{53}. This shunt serves the double purpose of energizing relay R^{53} and preventing the dëenergization of relay R^{52} by the opening of contact device 130 upon the second operation of switch S^{50}, which will immediately take place, now in connection with the hundreds keys. Relay R^{53} closes the front contacts of its armatures 136 and 137 and of spring 138. Current will thereupon flow from battery B^{50} through the winding of the retaining magnet H^{50}, conductor 112, spring 113, and its front contact in relay R^{52}, conductor 139, springs 140 and 141 of the depressed hundreds key 9 K^{51}, conductor 142 and front contact and armature 136 of relay R^{53} to ground. As before, on operating, the retaining magnet H^{50} applies its pawl to the switch S^{50} and closes the contact device 120, the latter completing a circuit from the pulsator P^{50} to ground through the winding of motor magnet M^{50}, conductor 121, armature 122 and its front contact in relay R^{51}, conductor 143, the spring 138 and its front contact in relay R^{53}, conductor 144, back contact and armature 145 of relay R^{54}, lead L^{105}, armature 64 and its front contact in relay R^{82}, conductor 72 and the winding of motor magnet M^{81}. Motor magnets M^{50} and M^{81} will now be operated in synchronism from the pulsator P^{50} over the circuit just traced. After the passing of nine current impulses, a circuit will be closed by the arm of the starting switch S^{50} and its tenth contact, from battery B^{54} through the winding of relay R^{54}, conductor 146, front contact and armature 137 of relay R^{53}, conductors 147, 123, 125 and 148, springs 150, 140 and 141 of the depressed hundreds key 9 K^{51}, conductor 142 and the front contact and armature 136 of relay R^{53} to ground. Relay R^{54} immediately operates and breaks the circuit of motor magnets M^{50} and M^{81} by opening the back contact of its armature 145. Relay R^{54} also opens the back contact of its armature 108, but this has no effect until the relay R^{64} of the starting switch S^{60} operates.

Considering the register switch S^{80}, as previously pointed out two pulses of current were transmitted through the winding of the long step motor magnet M^{80} and now nine pulses have passed through the winding of the short step magnet M^{81}, thus bringing the arm s^{81} to rest upon contact numbered 19 and the arm s^{80} upon a similar position in its contacts by two series of steps—two long steps to the eleventh contact numbered ten and nine short steps from said contact to the contact numbered nineteen. The arm s^{80} is now at the end of its second contact. Since both of the register arms are connected to ground it is clear that by means of conductors 75 and 76, ground has been established on the contacts of the thousand sending switch S^{200} and hundreds sending switch S^{210} at points that correspond to the thousands digit one and the hundreds digit 9 of the desired number "1921."

It will be obvious without detailed explanation, that by a series of operations analogous to those in which the depressed thousands and hundreds keys successively coöperated with the starting switch S^{50} in driving the arms of the register switch S^{80} to positions corresponding to the conditions represented by said depressed keys, so the tens key 2 K^{30} and the units key 1 K^{31}, simultaneously with the thousands-hundreds registration, will have coöperated with the starting switch S^{60} in driving the arm s^{91} of the register switch S^{90} to the twenty-second contact s^{93} numbered twenty-one, while the arm s^{90} rests at the beginning of its third contact. That is, motor magnet M^{60} will have first operated three times in

conjunction with magnet M^{90} and then once with magnet M^{91}. Thus, by means of the conductors 77 and 78 ground has also been established on the contacts of the tens sending switch S^{220} and the units sending switch S^{230} corresponding, respectively, to the tens digit two and the units digit one of the number called for. It should be noted that there is no necessary sequence between the operations controlled by the two starting switches. Their time of completion depends entirely on the relative magnitude of the digits of the desired number and the order in which the operator depresses the keys.

As hereinbefore described, relay R^{54} is energized when the switch S^{50} has finished its series of operations, likewise relay R^{64} is energized when the switch S^{60} has performed its functions. Therefore, when both switches have operated, the two paths to ground from conductor 106 are opened at the armatures 108 and 107 of relays R^{54} and R^{64}, respectively. This results in the deënergization of relays R^{70} and R^{82} and also of relay R^{81}, since the initial circuit for the last named relay depends upon the now open normal contact devices of the registering and starting switches. The release of relays R^{81} and R^{82} disconnects the secondary controller U from the primary controller. Relay R^{70} on release closes the contact of armature 101 and the resting contact of the spring 110 and opens the contact between the spring and armature 109. Since the retaining magnets and relays associated with the starting switches S^{50} and S^{60} all depend upon the path to ground through conductor 119 and the contact of the spring and armature, said magnets and relays are deënergized and the arms s^{50} and s^{60} return to their normal position. While the spring 110 momentarily touches both its resting contact and the armature 109 current flows through the key release magnets h freeing the depressed digit keys. The primary controller is now ready for coöperation with the secondary controller U^2, the operation of the controller U, after its register switches have been properly set, going on independently, as will now be described.

The release of relay R^{81} of the secondary controller U closed a path from ground through the off normal contact device 80 of register switch S^{80}, conductor 81, back contact and armature 58 of relay R^{81}, conductor 82 and winding of retaining magnet H^{200} of the thousands sending switch S^{200} to the main battery lead L^{85}. Magnet H^{200}, being energized, applies the retention pawl of the switch S^{200} and also closes the contact device 202, giving a path from pulsator P^{200} to ground through the winding of motor magnet M^{200}, conductor 201, back contact and armature 203 of relay R^{201}, lead L^{82}, back contact and armature 43 of relay R^{14}, conductor 37, armature 34 and spring 34^a of relay R^{13}, lead L^{23}, spring 45 and its back contact in relay R^{20} and the winding of motor magnet M^{20} of the thousands selector. Until this circuit is opened motor magnets M^{200} and M^{20} will operate in synchronism on each pulse of current transmitted by the pulsator. When two pulses have passed the arm s^{200} of the switch S^{200} arrives at the ground established through conductor 75 by the arm s^{80} of switch S^{80}. Two circuits from this ground are then closed, one through the arm s^{200}, conductor 205 and the winding of relay R^{201} to the battery lead L^{85}, and one through said arm, off normal contact device 206 of switch S^{200}, armature 207 and its back contact in relay R^{202}, lead L^{83}, back contact and spring 44 of relay R^{14}, conductor 36, armature 33 and spring 33^a of relay R^{13}, lead L^{24}, conductor 46, resting contact and spring 46^a of relay R^{20}, conductor 47, winding of relay R^{20}, arm s^{23} of switch S^{20}, lead L^{33} and the winding of retaining magnet H^{30} of the hundreds switch S^{30} to battery B^{30}. Relay R^{201}, energized by the first circuit, opens the back contact of its armature 203 and closes the front contact of armature 209, thus breaking the circuit containing the motor magnets M^{200} and M^{20} and energizing relay 202 by current from the main battery lead. The opening of the motor magnet circuit stops the travel of the arms of switches S^{200} and S^{20}, the latter with its arms upon the set of terminals s^{24} connected to an idle hundreds switch S^{30} in the second thousands group. The relay R^{202} is designed to operate sluggishly in order that it will not open the back contact of its armature 207 before the relay R^{20} functionates. Relay R^{20} now energized by the second circuit from ground at the register arm, closes the front contacts of spring 45 and armature 49, opens the back contact of the former and connects conductor 47 directly to ground through spring 46^a and armature 46^b. This renders the winding of relay R^{20} independent of the ground at the register switch picked up by the arm of the sending switch S^{200}. The retaining mechanism of the hundreds selector is operated by the same circuit.

When the armature 207 of sluggish relay R^{202} has closed its front contact, a path is obtained from ground by arm s^{200} to battery lead L^{85} through off normal contact device 206 of the switch S^{200}, conductor 211, and the winding of retaining magnet H^{210} of hundreds switch S^{210}. In precisely the same manner as has just been explained, the hundreds selector S^{30} governed by the sending switch S^{210} picks out an idle connector S^{40} at which terminates the line of the desired substation.

After the sluggish relay R^{212} of the hundreds sending switch, acting as did the re-

lay R^{202} of the thousands sending switch, has opened the back and closed the front contact of its armature 218, magnet H^{220} of the tens sending switch applies its retention pawl and closes contact 224, establishing a circuit from pulsator P^{220} to ground through winding of motor magnet M^{220}, back contact and armature 225 of relay R^{221}, conductor 226, lead L^{82}, back contact and armature 43 of relay R^{14}, conductor 37, armature 34 and spring 34^a of relay R^{13}, lead L^{23}, spring 45 and its front contact in relay R^{20}, arm s^{21} of the thousands selecting switch S^{20}, lead L^{31}, spring 300 and its front contact in relay R^{30}, arm s^{31} of the hundreds selecting switch S^{30}, lead L^{41}, spring 400 and its back contact in relay R^{42}, conductor 401, armature 402 and its back contact in relay R^{41}, conductor 403 and the winding of the tens or long step motor magnet M^{40}. Said motor magnet with that of the sending switch S^{220} will be operated synchronously from pulsator P^{220}. When three pulses have been transmitted the arm s^{220} of switch S^{220} closes two circuits from the ground established through the conductor 77 by the arm s^{90} of the register switch S^{90}—one through the winding of relay R^{221} and conductor 227 to battery lead L^{85}, and the other through the off normal contact device 228, armature 229 and its back contact in relay R^{222}, conductor 230, lead L^{83}, back contact and spring 44 of relay R^{14}, conductor 36, armature 33 and spring 33^a of relay R^{13}, lead L^{24}, armature 49 and its front contact in relay R^{20}, arm s^{22} of switch S^{20}, lead L^{32}, armature 304 and its front contact in relay R^{30}, arm s^{32} of the switch S^{30}, lead L^{42}, armature 405 and its back contact in relay R^{41}, conductor 406 and the winding of relay R^{40} to battery B^{40}. Relay R^{221}, energizes by the first circuit, opens at its armature 225 the circuit containing motor magnets M^{220} and M^{40}, stopping the arms of the connector at the beginning of the tens sections sought. At its armature 231 this relay operates sluggish relay R^{222}. Relay R^{40}, included in the second circuit, closes the front contact of its armature 407 and thus locks itself to ground through the winding of relay R^{41}, conductor 408 and off normal contact device 409 of switch S^{40}. This path through the winding of relay R^{41} becomes effective when sluggish relay R^{222} opens the back contact of its armature 229 and removes the ground connection which exists at the junction of conductor 406 and the winding of relay R^{40} by virtue of the second circuit closed by the arm s^{220}. Said contact of relay R^{222} having opened, relay 41 becomes energized, opens the back contacts of its armatures 402 and 405 and closes their front contacts.

As soon as the armature 229 of relay R^{222} coöperates with its front contact a path is obtained from the ground at the arm s^{220} to battery lead L^{85} through off normal contact device 228 of the switch S^{220}, conductor 223 and the winding of the retaining magnet H^{230} of the units sending switch S^{230}. Magnet H^{230} thereupon applies its pawl and closes contact device 235, giving a circuit from pulsator P^{230} to ground through the winding of motor magnet M^{230}, back contact and armature 236 of relay R^{231}, conductor 237, lead L^{82}, back contact and armature 43 of relay R^{14}, conductor 37, armature 34 and spring 34^a of relay R^{13}, lead L^{23}, spring 45 and its front contact in relay R^{20}, arm s^{21} of switch S^{20}, lead L^{31}, spring 300 and its front contact in relay R^{30}, arm s^{31} of the switch S^{30}, lead L^{41}, spring 400 and its back contact in relay R^{42}, conductor 401, armature 402 and its front contact in relay R^{41}, conductor 412 and the winding of the units or short step motor magnet of the connecting switch S^{40}. Until this circuit is opened the motor magnets M^{230} and M^{41} will operate simultaneously on each pulse of current from P^{230}. When two impulses have been transmitted the arm s^{230} of the units sending switch reaches the ground established through conductor 78 by the arm s^{91} of the register switch S^{90}. This energizes relay S^{231}, which opens the back contact of its armature 236 and prevents any further actuation of the switches S^{230} and S^{40}. Relay R^{231} also opens the back contact of its armature 242, thereby deënergizing relay R^{15} of the secondary controller U and the cord relay R^{18}, the initial circuit for the latter relay having been opened previously by the separation of the normal contact springs 31 of switch S^{20}. The release of relay R^{15} disconnects the battery B^{15} from the lead L^{85}, thus deënergizing the retaining magnets of all the switches of the secondary controller, permitting their arms to return to zero and releasing relays R^{201}, R^{211}, R^{221} and R^{231}, and also relays R^{202}, R^{212} and R^{222}; but before the back contact of armature 242 of relay R^{231} has been closed, armature 35 of relay R^{13} has fallen off and disconnected conductor 40 from conductor 39, so that relays R^{13} and R^{15} will not be again associated. The release of armatures 33 and 34 of relay R^{13} disconnects conductors 36 and 37 from the leads L^{24} and L^{23} and reconnects the latter to the leads L^{22} and L^{21}. A circuit now exists from the battery B of the cord through winding 413 of repeating coil c, winding of the supervisory relay R^{11}, leads L^{22}, and L^{24}, armature 49 and its front contact in relay R^{20}, arm s^{22} of switch S^{20}, lead L^{32}, armature 304 and its front contact in relay R^{30}, arm s^{32} of switch S^{30}, lead L^{42}, armature 405 and its front contact in relay R^{41}, conductor 414, one winding of relay R^{42} and conductor 415 to ground, energizing relay R^{42}. This by its armature 417 and spring 400 joins the leads L^{42} and L^{41} to the arms s^{42} and s^{41} of the connecting switch S^{40}, while spring 415^a discon-

nects conductor 415 from ground, and with the armature 415^b closes a locking circuit from ground through conductor 418, second winding of relay R^{42} and the arm s^{43} of the switch S^{40}, to battery through the winding of the cut-off relay of the line selected by the switch S^{40}. Remembering that the arms of the thousands selecting switch have taken two steps, the hundreds selecting switch ten steps and the connecting switch first three long steps then two short steps, it will be seen that the calling subscriber is connected with the line "1921" for which he asked.

The testing of the line secured, the ringing over it and the release of the selecting apparatus will not be described, not being essential to the present invention.

I claim:

1. In a telephone exchange system, line selecting apparatus having a plurality of selective movements, primary controlling apparatus therefor having sections of mechanism, with a section corresponding to a plurality of different selective movements, and secondary controlling apparatus provided with a section of mechanism for each selective movement.

2. The combination with a central station and telephone lines extending thereto, of operators' cord circuits and mechanical switching apparatus for joining the lines, a plurality of controlling apparatus for the mechanical switching apparatus, means for uniting a cord circuit with an idle controlling apparatus, said means being operable when the cord circuit is employed to originate a connection, means adapted to be set by the operator to govern the action of any one of the controlling apparatus, and means for associating the governing means with a controlling apparatus upon the appropriation of said controlling apparatus by a cord circuit, substantially as and for the purpose described.

3. A controlling apparatus for electrical line selecting apparatus comprising manually operable registering devices, secondary mechanism temporarily associated with the manually operable devices for registering the conditions produced thereat, and transmitting means governed by the secondary mechanism and operable while the manually operable devices are disssociated from said secondary mechanism.

4. The combination with a starting switch, of key mechanism for determining the movement of the starting switch, a register switch provided with a plurality of motor mechanisms any one of which may be connected with the starting switch, and a sending switch governed by the register switch.

5. In a telephone exchange system, the combination with switching means comprising operators' connecting circuits and mechanical switching apparatus having a plurality of selective movements, of a primary controlling apparatus provided with a set of keys corresponding to each selective movement and also having a less number of transmitting mechanisms than there are sets of keys, and a secondary controlling apparatus provided with register mechanisms governed by the primary transmitting mechanisms and with a secondary transmitting mechanism for each selective movement of the switching apparatus.

6. In a telephone exchange system, the combination with switching means comprising operators' connecting circuits and mechanical switching apparatus having a plurality of selective movements, of a single primary controlling apparatus provided with a set of keys corresponding to each selective movement and also having a less number of transmitting mechanisms than there are sets of keys, a plurality of secondary controlling apparatus provided with register mechanisms governed by the primary transmitting mechanisms and with a secondary transmitting mechanism for each selective movement, and means for operatively associating any one of the secondary controlling apparatus with the primary controlling apparatus, substantially as described and for the purpose set forth.

7. In a telephone line switching system, the lines of the system being designated each by a plurality of symbols belonging to different groups of symbols, line selecting apparatus, and selection controlling apparatus having a plurality of electromechanisms each corresponding to a plurality of symbols in a single line designation.

8. In a telephone line switching system, the lines of the system being designated each by a plurality of symbols belonging to different groups of symbols, line selecting apparatus, a selection controlling apparatus having a plurality of electromechanisms each corresponding to a plurality of groups of symbols, and secondary electromechanisms under the influence of the primary electromechanisms and each corresponding to a single group of symbols.

9. The combination with a central station and telephone lines extending thereto, of connecting circuits and mechanical switching apparatus for joining the lines, a plurality of automatic controlling apparatus for the mechanical switching apparatus, means for uniting a connecting circuit with an idle controlling apparatus, means adapted to be set to govern the action of any one of the controlling apparatus, and means for associating the governing means with the controlling apparatus when said controlling apparatus is united with the connecting circuit.

10. The combination with a central sta-

tion and telephone lines extending thereto, of connecting circuits and mechanical switching apparatus for joining the lines, a plurality of automatic controlling apparatus for the mechanical switching apparatus, means for uniting a connecting circuit with an idle controlling apparatus, a set of keys, and means for associating the keys with the controlling apparatus when said controlling apparatus is united with the connecting circuit.

11. The combination with line selecting apparatus, of a controlling apparatus having keys, automatic registering means, means for temporarily associating said registering means with the keys, and means governed by the registering means for controlling line selection while said registering means and keys are dissociated.

12. The combination with line selecting apparatus, of a controlling apparatus having keys, an automatic register switch, means for temporarily associating said register with the keys, and an automatic switch governed by the register switch for controlling line selection when said register switch and keys are dissociated.

13. Controlling apparatus for line selecting apparatus comprising a plurality of sets of manually operable contact devices, and a plurality of automatic transmitting means, each transmitting means being governed by a plurality of the sets of contact devices.

14. Controlling apparatus for line selecting apparatus comprising a plurality of sets of manually operable contact devices, automatic transmitting means governed by a plurality of the sets of manually operated contact devices, and means controlled by said transmitting means for changing its connection from one set of contact devices to another.

15. Controlling apparatus for line selecting apparatus comprising a plurality of sets of keys, and an automatic transmitting switch governed in its initial movement by one set of keys, said transmitting switch thereafter upon assuming its normal position thereby causing its connection to be changed to another set of keys.

16. In a controlling apparatus for telephone line selectors including a plurality of keys, a plurality of controlling switch mechanisms, electromagnetic means for operating each switch mechanism, and means for bringing said electromagnetic means successively under the influence of the keys.

17. Controlling apparatus for line selecting apparatus comprising a plurality of sets of keys, and an automatic transmitting switch governed by its initial movement by one set of keys, said transmitting switch thereafter upon assuming its normal position operating under the influence of another set of keys.

18. In a controlling apparatus for telephone line selectors, a plurality of keys, controlling switch mechanism, electromagnetic means for operating said switch mechanism, means for bringing said electromagnetic means successively under the influence of the keys, and means whereby the switch mechanism must travel to its normal position before it can be operated under the influence of another key.

19. A controlling apparatus for automatic switching apparatus comprising a plurality of controlling switches, and a plurality of sets of governing keys for the controlling switches, one of said controlling switches being adapted to operate in response to the depression of the keys of two of said sets.

20. In a telephone exchange system, the combination with automatic switching apparatus, of an operator's controlling apparatus comprising a plurality of controlling switches, and a plurality of sets of keys governing their operation, the operation of keys in a plurality of the sets causing the operation of one of said controlling switches to govern a plurality of selections by said automatic switching mechanism.

21. In a telephone exchange system, the combination with automatic switching apparatus, of operators' controlling apparatus comprising a plurality of automatic controlling switches, and a plurality of sets of designation keys adapted when operated in establishment of a connection to cause the repeated action of one of said controlling switches.

22. An electrical controlling apparatus comprising a plurality of keys, and automatic controlling switches simultaneously governed by different keys.

23. A controlling apparatus for electrical line selecting apparatus comprising a plurality of keys, and automatic controlling switches simultaneously governed by different keys, a controlling switch being also successively governed by different keys in a single line selecting operation.

24. In a telephone exchange system, the combination with telephone lines, of automatic switching mechanism therefor, a controlling mechanism comprising keys corresponding to the digits of line designations, and plural transmitting means adapted to be governed simultaneously by keys corresponding to different digits.

25. In a controlling apparatus for electrical line selecting systems, the combination with line designating devices, of a plurality of registers responsive to said devices, selection controllers governed by said registers, and means for switching said devices into operative relation to any register.

26. In a controlling apparatus for electrical line selecting systems, the combina-

tion with a set of line designating keys, of a plurality of registers responsive to said keys, selection controllers governed by said registers, and automatic means for associating the set of keys with an idle register.

27. In a controlling apparatus for electrical line selecting systems, the combination with a set of line designating keys, of a plurality of registers responsive to said keys, selection controllers one for each register adapted to operate in accordance with the line designation produced at the registers, one of said registers and the controller associated therewith being normally in operative relation to said keys, and automatic means for associating another register and controller with the keys when the first mentioned register and controller are in use.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this twenty-third day of September 1907.

EDWARD C. MOLINA.

Witnesses:

WILLIAM G. BLAUVELT,

ROBERT S. SUTLIFFE.