J. L. WRIGHT.

TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED APR. 12, 1906.

965,976.

Patented Aug. 2, 1910.

3 SHEETS—SHEET 1.

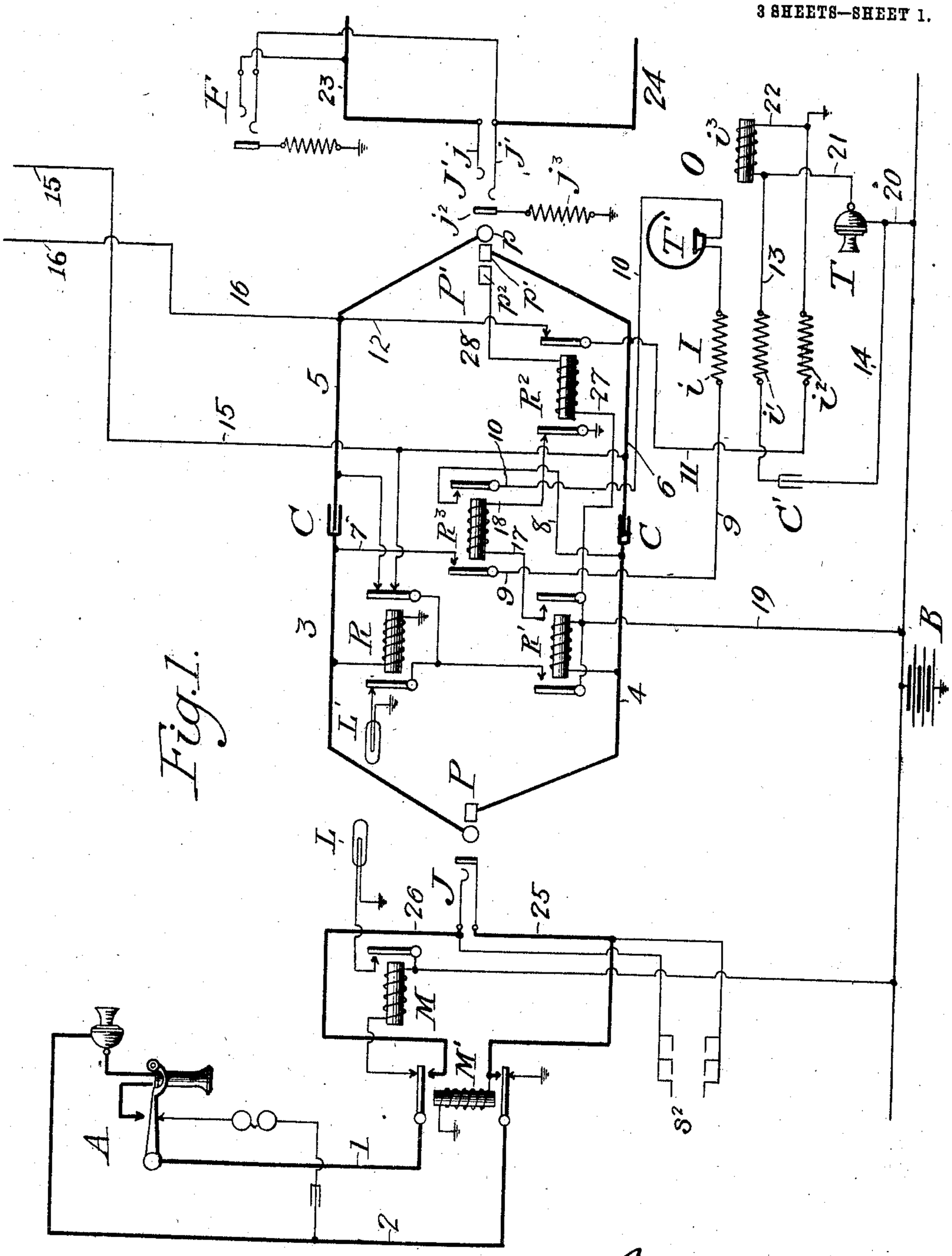

Fig. 1.

Witnesses

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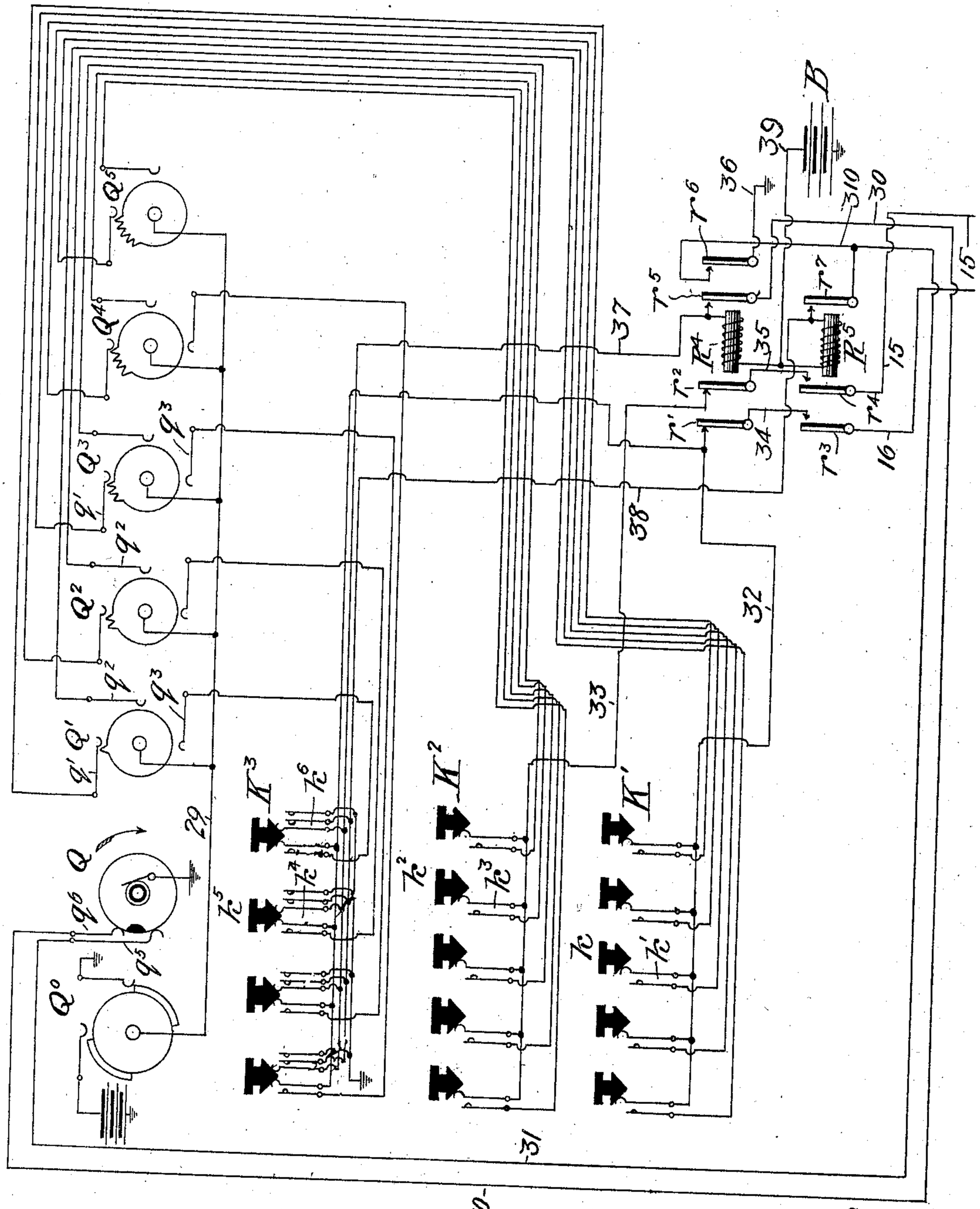

Fig. 2.

Witnesses

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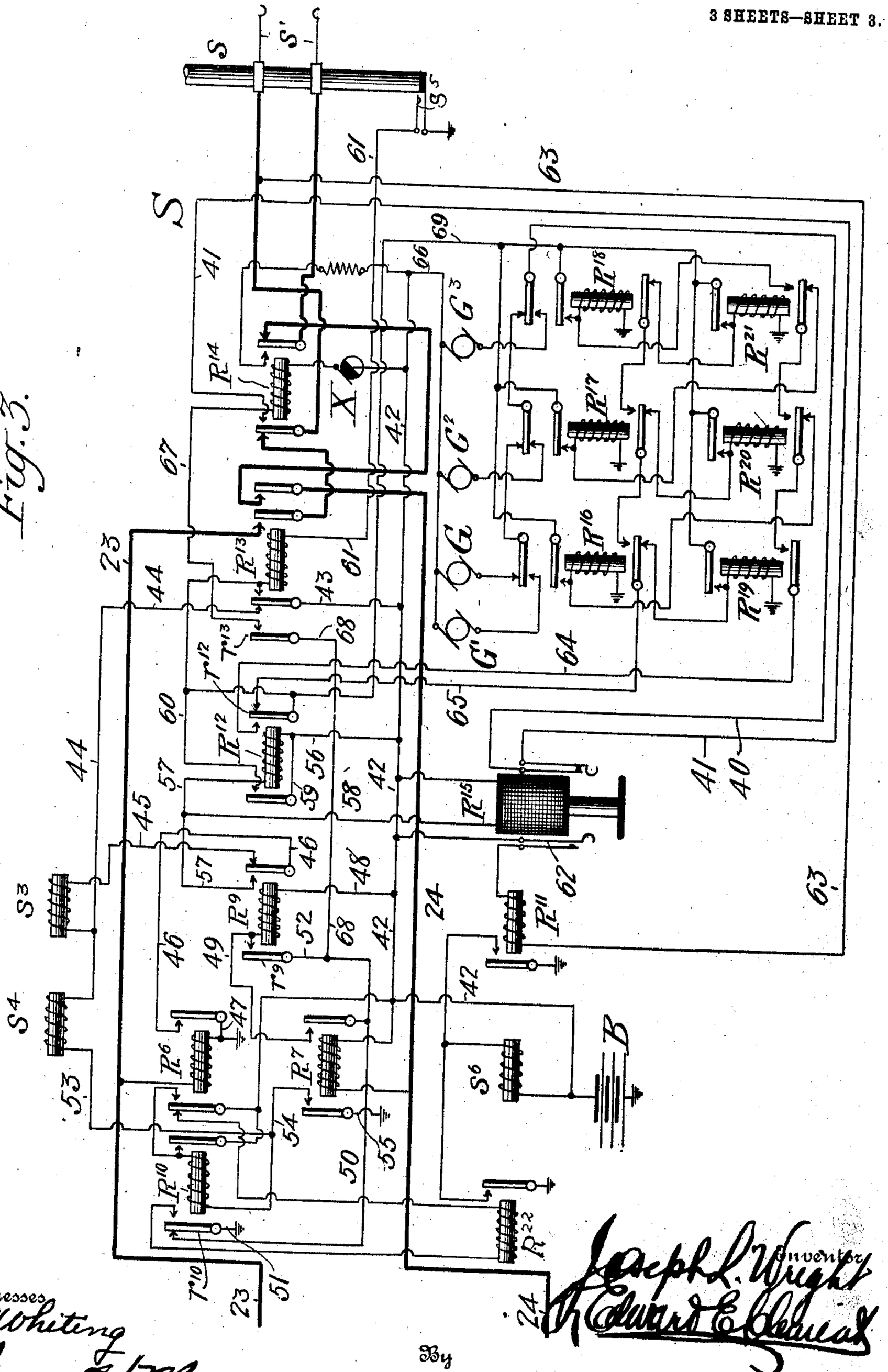
3 SHEETS—SHEET 3.

Fig. 3.



Witnesses

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

965,976. Specification of Letters Patent. **Patented Aug. 2, 1910.**

Application filed April 12, 1906. Serial No. 311,387.

To all whom it may concern:

Be it known that I, JOSEPH LANE WRIGHT, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to telephone exchange systems, and particularly to semi-automatic systems, in which a portion or all of the work of interconnecting subscribers is done by machines controlled by operators.

The object of the invention is to provide a convenient, economical and efficient circuit for the sending or signal transmitting apparatus used by the operators, in which nothing but push-buttons or their equivalent shall be located on the operators' tables, the main control of the circuit shall be by relays, and these together with the signal wheels or circuit-breakers are located in the relay or power room.

The characteristic features of my invention are these: A series of number-wheels having teeth from 1 to 10 are arranged upon a common shaft, and springs adapted to bear upon the teeth are connected to corresponding push-buttons before the operator. When any number desired has been set up by depressing the corresponding buttons, a pair of associated relays are pulled up and locked on a battery circuit which includes a pair of contacts controlled by a disk or break-wheel rotated synchronously with the number-wheels, and acting to cut off the battery from the locking wires successively once in each complete rotation. One of these relays is a guard for the other, so that they must be unlocked in inverse order, that is the second one first, in order to produce any effect. The impulse wires from the push-buttons pass through back contacts on the No. 2 relay and front contacts on the No. 1 relay to the trunk or other wire leading to the switches, which are the subjects of control. Thus, when the second relay is unlocked and lets go this circuit is complete, and as this occurs at the beginning of a round only, the signal which has been set immediately starts to cut in properly. At the end of the round the No. 1 relay is cut off, and since it breaks the impulse circuit when it lets go, the entire signaling apparatus at once becomes thereby detached from the switch circuit.

I have illustrated my invention in the accompanying drawings as applied to a common battery system in which the operator plugs into the desired connector trunk, and sets up the switch by means of the impulses from her sender. I do not lay any claim to the system, nor broadly to the use of number-wheels or push-buttons; my invention relating particularly to the circuit of the sending apparatus, and the method of controlling the same by the two interlocking relays, which render it possible to avoid any other means of control except the contacts of the push-buttons themselves. These push-buttons are preferably provided with latches, and are interlocking, so that the depression of any one push-button releases any other that may have been previously depressed, but each button remains down until another is actuated.

My invention and the system referred to with which it may be used are illustrated in the accompanying drawings, in which—

Figure 1 is a diagram of a subscriber's line, of a trunk-terminal, and an operator's circuit for interconnecting them. Fig. 2 is a diagram embodying my invention, and includes the operator's sending apparatus and its circuit. Fig. 3 is a diagram of a connector switch with its appurtenances. The three figures are all made so they can be put together and constitute one complete diagram of a system employing my invention.

Referring to the drawings and particularly to Fig. 1, A is a subscriber's station having the usual subscriber's common battery outfit, consisting of transmitter, receiver, switch-hook, ringer and condenser. From this sub-station the line-wires 1—2 extend to the central office, where they pass through the contacts of the cut-off relay, M', which normally connects them to the line-relay M and ground, respectively. The line relay is connected on the other side to the main battery, B, and controls a signal lamp, L, associated with the answering-jack J. The answering-jacks J are supposed to be

grouped in a convenient manner, together with their signal lamps, L, in front of the operators, and when any line is calling it is intended that it shall be connected through a trunk-jack, J′, with a trunk-line leading to an automatic switch S (see Fig. 3), by which the subscriber wanted can be directly reached.

In order to interconnect the line and trunk-jacks I provide a pair of plugs, P, P′, having their tips and sleeves respectively connected through the conductors 3—5 and 4—6, these conductors being interrupted for direct currents by the condensers C. The answering-plug P has associated with it a supervisory signaling lamp L′ directly controlled by the tip relay R which responds to current in the subscriber's line as long as the plug is in a jack; the lamp is also indirectly controlled by the sleeve relay R′ which puts battery on the armature of the tip relay when the plug is first inserted. Current through the sleeve relay is also necessary in order to energize the cut-off relay M′ of the line in making connection therewith.

The calling plug P′ has three contacts, which I may call the tip, p, the ring, p', and the sleeve, p^2, the ring in this case corresponding to the sleeve of the plug P. When the plug is inserted in a trunk-jack, J′, the tip and ring come into connection respectively with the jack springs, j, j', while the sleeve, p^2, comes into contact with a thimble, j^2, connected through a resistance, j^3, to ground. This thimble is for test and also to furnish a circuit for the cord cut-off relay R^2. There are two relays, R^2, R^3, associated together for controlling the connection of the operator's telephone. The relay, R^3, takes current through the wires 17 and 18 when the plug P is first inserted in answer to a call, the circuit —B, 19, 17, 18 and ground being then immediately closed by the relay, R′, pulling up. Thereupon the relay, R^3, immediately pulls up, the relay R^2 which also controls it remaining quiescent. In so pulling up it closes the two sides of the operator's secondary circuit —9—10— onto the bridge-wires 7—8 across the cord-conductors 3—4. This secondary circuit contains the operator's receiver, T′, and the secondary winding, i, of the induction coil I. The primary, i', is included in a short-circuit 13—14 with the condenser, C′, and the transmitter, T, the latter deriving its current supply direct from the main battery through the choke-coil, i^3, by the circuit —B, 20, 21, 22 and ground. The tertiary winding, i^2, is included in the test-circuit 11—12, which passes from ground through a back contact on the relay, R^2, to the tip conductor 5 and so to the tip of the calling plug, P′.

The trunk-lines 23—24 which terminate in the jacks, J′, are each multipled to all the sections of the switchboard, so that any operator can reach any trunk. The trunks are arranged in groups, those of each group leading to similar switches in which the same group of subscribers' line-wires are multipled. This is necessary so as to always have enough idle trunks and switches to reach a number of subscribers of the same group at the same time. Each connector switch is supposed to contain the terminals of one hundred lines, and as a fair average I may assign ten switches to each one hundred lines, so as to be able to call ten subscribers out of that particular hundred at the same time. All of these subscribers' lines are multipled into the ten switches, and the ten trunks from the ten switches are carried together to the switchboard where they are multipled and have their jacks appear together in a group on all the switchboard sections. These jacks may be arranged in a continuous line either vertically or horizontally, preferably the former, so that in testing to find an idle trunk, the operator will simply run the tip of her plug down the row in the group desired. These groups are numbered from 0 to 99, which means that through the trunks of No. 0 group the subscribers' lines whose numbers are from 0 to 99 can be reached; through No. 1 group those whose numbers are from 100 to 199 can be reached; through No. 2 group those whose numbers are from 200 to 299 can be reached, and so on up to 9999, or if it be desired to carry it so far, even to 99,999, which would of course require 10,000 multiple jacks per section of three operators' positions; which is the same as in a ten thousand multiple-board now. In other words, the same multiple-board which now serves 10,000 subscribers can be cut over by my present invention without the slightest difficulty to accommodate 100,000 subscribers, at least so far as regards the multiples. In actually reconstructing such a board, it would be necessary in any case to increase the number of answering-jacks, and also of cords and plugs since the operators will handle a great many more calls than at present, which means that a great many more lines per position would be required.

In answering a call and making the connection the operator proceeds as follows: Seeing the lamp, L, light, she inserts plug, P, into the corresponding jack, J, whereupon the battery, B, sends current at once through the sleeve relay, R′, and the cord-conductor 4 to the line-extension 25, to the cut-off relay, M′, and ground. The cut-off relay thereupon pulls up, putting the line-wires 1—2 onto their extensions 26 and 25 and thence onto the cord-conductors 3 and 4, whereupon relay R pulls up and opens the conductor leading to the lamp L′ which had just been

closed by the relay R′, the entire action being too quick for the lamp to have time to light. At the same time, relay, R^3, pulls up and the operator's set, O, is instantly bridged across the answering-end of the cord, while the test-wire 11—12 remains connected to the tip of the calling-plug. The operator picks up this plug and at the same time asks "Number?" Ascertaining the number, she tests with the plug, P′, the trunk-jacks corresponding to the hundreds of the line wanted, by running the tip, *p*, down the row of thimbles, j^2, until she no longer gets a click. If any trunk is busy, having a plug in it, the potential of its jack thimbles, j^2, will be raised by main battery, B, through the circuit —19, 27, 28 and the relay R^2. Hence the tip of the testing plug will take current off of this through the conductors 5, 12 and 11 to the testing operator's tertiary winding, i^2, this producing a click in the receiver, T′, each time the tip, *p*, passes over a charged or busy thimble. Having reached a jack which produces no click, the operator puts in the plug P′. Relay, R^2, instantly pulls up, and the operator's telephone is disconnected at once.

This much of the operation is substantially the same as in any manual system, substituting trunk-jacks for line-multiples, of course. The balance of the operation, however, is entirely different. The trunk 23—24 shown in the diagram, leads to the connector switch, S, shown in Fig. 3, and this switch is operated by means of impulses over the two sides of the trunk, in a manner which is generally familiar to those acquainted with the art. In order to do this I provide the operators with impulse transmitters or "senders" from which the various operators take their impulses as they need them. For convenience I will first describe this arrangement as it is shown in Fig. 2, and will then proceed to point out its effect upon the apparatus of Fig. 3. In this figure, Q^0, Q, Q′, Q^2, Q^3, Q^4, Q^5, etc., are a set of wheels mounted on and turning with a common shaft, which may be driven in any suitable manner. The wheel, Q^0, puts battery and ground alternately on the wire 29, which for purposes of illustration represents the metallic shaft connection between the wheels. The wheel, Q, is insulated from the shaft and is grounded, has an insulating spot in its periphery, and controls by means of this spot the locking and unlocking wires 30 and 31, in a manner which will appear from the statement of operation. The wheels, Q′, Q^2, Q^3, Q^4, etc., are number-wheels, the first one having one tooth, the second two teeth and so on up to ten teeth. (For simplicity of illustration only five wheels are shown). Around these wheels are three sets of pens, connected to the three sets of keys, K′, K^2, K^3. As the wheels revolve from the position in which they are shown in the figure, they first make contact with the upper pens, q', then with the pens, q^2, then with those, q^3. The first set with their buttons or keys, K′, transmit the tens digit of any number, the next set transmit the units digit, and the third set the ringing number for party-line work. All this will appear more clearly from the statement of operation.

The keys, K′, K^2, K^3, are of the so-called self-latching selective ringing type now in common use on manual switchboards, and employ the principle shown in the patent to Ham, No. 605,097, granted June 7, 1898. When any key is pressed down it pushes back the latch and releases the one that was previously down, then latching itself. It will be noted that the bank of keys is divided into three sets or rows, K′ K^2 and K^3 respectively. The rows are each provided with the latching device of Ham, cited, the rows being independent of each other in this respect; thus one key and only one of each row will remain depressed, the previously depressed key of each row being released by the depression of any other. In a bank or row of keys of this nature, a key is depressed through a travel carrying it beyond the locking point; upon release it returns a very short distance and remains locked there until released by the depression of the next key used. I take advantage of this detail in the row of keys K^3 in the following manner: The pairs of springs as k^4 are to remain locked when the key is pressed, as described later, but the triple springs k^6 are springs requiring but a momentary contact to energize primarily the pair of locking relays R^4 R^5. To secure the desired end, I so gage the relation of the springs k^6 to the push button of the key that they are closed by the button when at its point of farthest travel but are released by the slight return travel of the button before it is locked. The springs k^4 however remain closed until the button is unlocked and fully released.

Each set of keys has a common wire, this for the sets, K′, K^3, being marked 32, these two being joined together and carried to a back contact of the relay, R^4, while that for the set, K^2, is marked 33 and carried to another back contact of the same relay. The numbers to be sent are set up by depressing the keys, one of each row, the key of row K^3 being depressed last, and the act of depressing that key serving to energize and lock the relays R^4, R^5, and then the signal is started at the beginning of a rotation of the shaft, when the first tooth of each wheel is about to strike its pen, q', by the relay, R^4, being deënergized, while the relay, R^5, remains energized. The trick of this is in the arrangement of the spring pens, q^5, q^6, on the wheel, Q. This wheel is rotated with

the others in the direction of the arrow, and its insulating spot passes first under the spring pen, q^5, momentarily cutting ground off of that and the wire 31, then under the pen, q^6, taking ground off of that.

In calling the number wanted, which we will assume to be 4432–3, the operator plugs into a jack of No. 44 group, then presses down button No. 3 of the set, K′; No. 2 of the set K^2; and No. 3 of the set K^3. The buttons of the sets K′ and K^2 have their several individual wires connected to the springs on the several individual wheels, Q′, Q^2, etc. and the effect of pressing down the buttons as mentioned is to connect the pen q' of the wheel, Q^3, through the springs, k', of the button, k, to the wire 32. At the same time the pen, q^2, of the wheel, Q^2, is connected through the springs, k^3, of the buttons, K^2, to the wire 33 and the spring, q^3, of wheel, Q^3, is connected through the springs, k^4, of the button, k^5, to the wire 32. The set of buttons, K^3, also have what I may call starting springs, k^6. This set of buttons being the last, or ringing set, the number is ready for transmission when any one of them is depressed, hence any one of these buttons not only finishes setting up the number, but by closing the springs, k^6, puts ground on the starting wires 37 and 38, which pass to the two relays, R^4, R^5, respectively, and thence through the common return wire 39 to battery B and ground. Both the relays pull up, and both lock, the locking circuit of the relay, R^4, being as follows: B, 39, R^4, r^5, 30, q^6, Q and ground. The locking circuit of R^5 is as follows: B, 39, R^5, r^7, 31, q^5, Q and ground. Having thus set up the signal and put it in condition to be started at the beginning of a revolution of the main shaft, and having also plugged into the necessary hundreds group, the operator's work is finished. She pays no further attention to the connection until the subscribers have completed their conversation and have hung up, whereupon the relay, R, in Fig. 1 lets go, and the lamp, L′, lights to call for disconnection. The operator then pulls the plugs.

The signal having been set up as described, the apparatus of Fig. 2 then operates as follows: The wheel, Q, in revolving will bring the insulating spot under the pen, q^5, at first, and might thereby cut off the relay, R^5, prematurely, but this is provided for by making a branch locking circuit 310 which is controlled through a contact of the armature, r^6, and a ground wire 36 of the starting relay R^4. Hence, as long as the relay, R^4, is energized, the relay, R^5, cannot be affected. Moreover, it will be observed that the wires 32 and 33 remain disconnected from the wires 15—16 until the relay R^5 is energized, while the relay R^4 is deënergized. This condition is brought about when the insulating spot reaches the pen, q^6. The relay, R^4, then lets go, and we have a continuous circuit from wire 32 as follows: 32, r', 34, r^3, 16, 5 (in Fig. 1), and to trunk-wire 23. We also have a circuit for wire 33 as follows: 33, r^2, 35, r^4, 15, 5 (Fig. 1) and the other trunk-wire 24. The insulating spot reaches the pen, q^6, just before the first tooth on each wheel reaches its pen, q'; hence as soon as the above desired condition is attained, the set of battery impulses which has been determined by the key, k, of the set, K′, comes over the wire 32 to the wire 16 and so enters the wire 23 of the trunk, through which it passes into Fig. 3 to the relay, R^6, which will be presently described, and which I shall call for convenience the vertical relay. At the end of this group of impulses, the teeth on the wheels will have gotten around to the pens, q^2, and so the next group of impulses determined by the key, k^2, will pass from ground onto the wire 33 and so to the wire 15 and the trunk-wire 24, through which they reach the relay, R^7, in Fig. 3, which will also be presently described and which I shall for convenience call the rotary relay. The names of these two relays are quite accurate in this system, because the relay, R^6, does really produce a vertical motion of the switch, S, while the relay, R^7, produces a rotary motion thereof. At the end of this second group of impulses, the teeth on the wheels have gotten around to the third set of pens, q^3, and the battery impulses determined by the key, k^5, then come through the wire 32 onto the wire 16 and so again to the trunk-wire 23 and to the vertical relay, R^6. After this, the insulating spot on the wheel, Q, reaches the spring, q^5, and momentarily cuts off the ground therefrom. Since the relay, R^4, is already deënergized, this breaks the locking circuit of the relay, R^5, and it lets go, disconnecting the wires 15—16 from the wires 35—34, and leaving the apparatus free for another operation.

It may be stated here that each cord pair is equipped with a pair of relays R^4—R^5 and a bank of keys K′—K^2—K^3 individual to that cord pair, but that the commutator shaft and its series of wheels is common to all cord pairs and connectors in the entire exchange.

Referring now to Fig. 3, I will briefly describe the switch operation. The switch, S, is shown only in diagram, but in so far as its mechanical features are concerned it is of the type shown in the following patents: Keith and Erickson, Nos. 815,176 and 815,321, granted March 13, 1906. The circuits in the present case are entirely different from those of these patents, but the mechanical structure is so far the same that I employ a vertical spindle, s, which carries wipers, s', to coöperate with the line-ter-

minals, s^2, (see Fig. 1) or line-multiples, in the switch-banks; the switch spindle is set up step-by-step by the vertical magnet, s^3, and is rotated step by step by the rotary magnet, s^4, controlled respectively by the relays, R^6 and R^7. There are supposed to be one hundred pairs of line-terminals in the switch-banks, and I do not require any separate test terminals, since I test directly on the tip side of the line for a ground. The switch spindle controls a pair of springs, s^5, which it opens when it is down in its normal position of disuse, for restoring purposes, as will presently appear.

s^6 is the release magnet of the switch, which when energized removes the detent pawls from the respective ratches of the spindle, s, allowing the spindle to drop down and rotate back to zero, as fully described in the patents referred to. This release magnet is under the control of the relay, R^{10}, which in turn is controlled by the relays, R^6 and R^7. It is also under the control of the test relay, R^{11}, which however is only connected at the first instant that the wipers, s', rest on the desired line-contacts, being thereafter cut off.

R^{12} is a ringing control relay; R^{13} is a trunk cut-off relay and R^{14} is a ringing relay controlled by the commutator, X, which is common to the entire exchange, and is mounted upon the shaft carrying the wheels Q^o Q, Q′ etc., of Fig. 2, or is mounted to revolve in synchronism with that shaft and its commutator wheels. R^{15} is a slow acting relay, preferably a solenoid, which connects the test relay, R^{11}, at the moment of effecting connection, as controlled by the first ringing impulse, and at the same time opens the generator circuit 40—41, while the proper current is being selected.

R^{16} to R^{21}, inclusive, are selective relays for enabling one or the other of the ringing generators, G, G′, G^2 and G^3, to be connected onto the ringing contacts of the ringing relay, R^{14}, the particular generator being determined by the number of impulses received through the relay, R^{12}, which operates the relays, R^{16}, R^{19}, etc., in succession, each of them locking as it operates.

The operation of this trunk scheme is as follows: In selecting the number we have assumed 4432–3; the trunk itself corresponds to the number 44, so we have first three impulses coming over the wire 23, to the relay, R^6, followed by two impulses over the wire 24 to the relay R^7 and then three impulses again over the wire 23 to the relay R^6. The first three impulses coming over the wire 23 cause the relay R^6 to pull up three times, each time closing the following circuit: B, 42, 43, 44, s^3, 45, 46, 47 and ground to battery. The vertical magnet, s^3, steps the spindle, s, of the switch up three steps, so that the wipers, s', stand opposite the third row of contacts. Two impulses then come over wire 24, affecting the relay R^7, which pulls up twice, the first time closing the following circuit: B. 42, 48, R^9, 49, 50, armature of R^{10}, 51 to ground and to battery. The relay, R^9, instantly pulls up, cutting off the vertical magnet, s^3, and locking itself by the following path: B, 42, 48, R^9, r^9, 52, 50, 51 and ground back to battery. The vertical magnet, s^3, is therefore cut off for the rest of the transmission. The rotary magnet, s^4, however, gets current each time the relay, R^7, is energized over the following path: B, 42, 43, 44, s^4, 53, 54, 55 and ground back to battery, so that the wipers, s', rest on the second pair of contacts in the third row, or No. 32. Three impulses now come over the wire 23, causing the relay, R^6, again to pull up three times. Each time it closes the following local circuit: B, 42, 56, R^{12}, 57, 46, 47 and ground back to battery. As a branch of this same circuit, the wire 58 comes in from battery wire 42 through the solenoid R^{15} and goes to 57, 46, 47 and ground. At this point in the development of the connection immediately following the closure of the contacts of relay R^6 at the beginning of the first generator-selection impulse, two things occur simultaneously:

(1) The solenoid R^{15} attracts its core, opening the wires 40—41 and closing the switch 62 whereby a test circuit is formed through elements B, 42, 62, R^{11}, 63 to upper s', which at this moment is resting in contact with the line selected through the agency of vertical and rotary magnets s^3 s^4; if the line be busy then a circuit will exist from upper wiper s' to the tip of the plug and through the relay R to ground in case the line tested has called, or to another wiper s' and thence through a trunking equipment following the path through contact of R^{14}, contact of R^{13}, conductor 23 and winding of R^6 to ground if that line has been called; in either case the test relay R^{11} will be energized and in turn will energize the release magnet s^6. If, however, the selected line with which the test wiper rests in contact is not busy no circuit will exist from that test wiper to ground and the test relay R^{11} will not be energized; a branch path for the conductor 63 exists through the talking conductor of the trunk to the left hand contact of relay R^{14} and thence to an armature contact of relay R^{13} where it terminates open, but subsequent to the energization of relay R^{14} as about to be described, this branch path passes to the inner contact of the left hand armature of that relay and thence over the conductor 41 to the right hand switch of the solenoid R^{15} which during the test period is open, and thus test relay R^{11} has its circuit open at all points and the design of the device as a whole is that no energization of that relay may result when the line

selected is in a condition of disuse and subject to use in the connection now being established.

(2) The relay R^{12} is energized over the path B, 42, 56, R^{12}, 57, 46, 47, and ground.

By the closure of the left hand armature of relay R^{12}, circuit is formed through elements B, 42, 56, armature of R^{12}, 60, winding of R^{13}, 61, switch s^5 and ground, energizing relay R^{13} which locks itself energized over the circuit B, 42, 43, armature and inner contact of relay R^{13}, winding of relay R^{13}, 61, s^5 and ground. This energization of trunk-connecting relay R^{13} connects the conductors 23—24 of the trunk through to the outer contacts of the ringing relay R^{14} and through to the wipers s'. This furnishes a path through test relay R^{11} as follows:—B, 42, 62, R^{11}, 63, talking conductor to left-hand armature of R^{14}, back contact and talking conductor to armature of energized relay R^{13}, conductor 23, winding of relay R^6 and ground; however, this circuit is adapted to be opened by the attraction of the armatures of relay R^{14} and it is the function of the connector switch that the opening of this circuit at R^{14} shall succeed its closing at R^{13} by a time limit so small that restoration of the connector switch is not permitted. It will be noted in the study of this time element that the test relay R^{11} must attain the degree of magnetization required to attract its armature, must swing its armature through its full travel to close its contact, and that subsequently to the closure of the contact of R^{11} the release magnet s^6 must reach its required degree of magnetization and must overcome the inertia of its armature and move it through some definite arc before release of the switch S will be effected; this series of necessarily consecutive operations limits the duration of the momentary false test here considered.

The commutator X, as has been mentioned, is carried upon the shaft which carries the number wheels and commutator devices Q^0, Q, Q', Q^2, etc., and the commutator X is adjusted angularly with respect to those wheels so that the conducting portion of X is in electrical connection with its brush at the time that the energization of relay R^{13} occurs. It is seen therefore that by the closing of the contacts of relay R^{13}, by which current flow through test relay R^{11} was permitted, current flow also was simultaneously provided for through the path B, 42, X, winding of R^{14}, contact and armature r^{13}, 68, 50, r^{10}, 51 and ground. Thus current begins to flow through the winding of relay R^{14} at the same instant that current begins to flow through the winding of relay R^{11}, and, assuming equal speed in the operation of armatures, relay R^{14} will have moved its armature and will have broken its back contact, thereby cutting off current from relay R^{11}, in ample time to prevent the restoration of the switch S by operation of release magnet s^6, the break at the armature of R^{14} probably occurring in time to prevent any contact whatever at the armature of relay R^{11}. Thus a test condition is maintained with the test wiper s' isolated from the winding of relay R^6 by the break at the armature of relay R^{14}, and the design and adjustment of the commutator X shall be such that the relay R^{14} is held energized throughout the maximum period occupied by generator-selection impulses and until the opening of the circuit of the test relay R^{11} by the opening of the switch 62 upon release of the armature of the solenoid R^{15}. The armature of the solenoid R^{15} is sluggish and does not open the switch 62 between the generator-selection impulses, so that the test circuit here described is maintained continuously during the period of generator-selection.

Leaving the various parts of apparatus in the condition now considered, we will follow the action of the apparatus in response to the generator-selection impulses. In the instance assumed, since station No. 3 is to be called three battery impulses will be received over the wire 23 operating the armature of the relay R^6 successively three times, which in turn acts over the path 47, 46, 57 R^{12}, etc., to operate the armatures of relay R^{12} in succession three times; the armature r^{12} through its front and back contacts effects the selection of the desired ringing generator as follows: upon attraction of r^{12} by the first generator-selection impulse, it makes electrical connection with its inner contact, but inasmuch as the wire 64 is open at the armature of relay R^{19} no complete circuit is closed. Upon the release of the armature r^{12} at cessation of the first generator-selection impulse, circuit is closed through elements B, 42, 43, contact of R^{13}, 60, r^{12}, 65, contact of R^{16}, winding of R^{19} and ground, energizing relay R^{19} which locks over the circuit B, 42, 43, contact of R^{13}, 60, 69, armature and contact of R^{19}, winding of R^{19} and ground. If but one generator-selection impulse were received, the generator G would remain in connection with conductor 40 ready for connection through conductor 41 to the ringing relay R^{14}. At the beginning of the second generator-selection impulse, relay R^6 is energized and armature r^{12} is attracted, closing circuit through elements B, 42, 43, contact of R^{13}, 60, r^{12}, 64 closed contact of lower armature of relay R^{19}, back contact of unenergized relay R^{20}, winding of relay R^{16} and ground, energizing relay R^{16} which then locks over the circuit B, 42, 43, contact of R^{13}, 60, 69, armature contact and winding of R^{16}. Upon the cessation of the second generator-selection impulse, the armature

r^{12} is released, closing circuit over B, 42, 43, contact of R^{13}, 60, r^{12}, 65, closed contact of lower armature of energized relay R^{16}, back contact of lower armature of unenergized relay R^{17}, winding of relay R^{20} and ground, energizing relay R^{20}, which then locks itself through its own contact by current received over conductor 69 to ground as in the case of relays R^{16} and R^{19}. If no more generator-selection impulses were received, the effect of the two impulses thus far followed would be to leave generator G′ connected to conductor 40 through contact of energized relay R^{16}, that being the proper generator for ringing the second station on a party line. At the beginning of the third and last generator-selection impulse, the armature r^{12} is again attracted, closing circuit over elements B, 42, 43, contact of R^{13}, 60, r^{12}, 64, closed contact of energized relay R^{19}, closed inner contact of energized relay R^{20}, closed outer contact of unenergized relay R^{21}, winding of relay R^{17} and ground, energizing relay R^{17}, which then locks itself by current through its own contact and winding over conductor 69 to ground. Upon the cessation of the third and last generator-selection impulse, the armature r^{12} is released, closing circuit through elements B, 42, 43, contact of R^{13}, 60, r^{12}, 65, closed inner contacts of energized relays R^{16} and R^{17}, closed outer contact of unenergized relay R^{18}, winding of relay R^{21} and ground, energizing relay R^{21} which then locks itself by current through its own armature contact and winding from conductor 69 to ground. This leaves relays R^{16} and R^{17} energized and leaves relay R^{18} unenergized, thus effecting the connection of generator G^2 to the conductor 40, and as the generator-selection impulses now cease, solenoid R^{15} releases its armature, opening the circuit of the test relay R^{11} and closing the circuit between conductors 40—41, thus connecting the selected generator G^2 over conductor 41 to the inner contact of the left hand armature of ringing relay R^{14} and thus through the upper wiper s' and to the line conductor of the selected line to ring the third station upon the party line selected. The ringing will continue until the insulated portion of the commutator X passes under the brush of that commutator when the circuit of the winding of relay R^{14} will be interrupted and by release of that relay's armature the circuit from the wipers s' will be removed from the generator and carried to relays R^7 and R^6 respectively. The line selected will be subjected alternately to periods of ringing when the relay R^{14} is energized and to periods of non-ringing when the relay R^{14} is deënergized. Upon the answering of the called sub-station, or of any sub-station upon that party line, during a period of non-ringing, current immediately will flow through elements B, 42, winding of R^7, 24, lower s', line conductor, substation bridge, return line conductor, upper s', 23, winding of R^6 and earth, energizing R^6 and attracting its armatures.

By the operation of the left hand armature of R^6, circuit is closed through elements B, 42, left hand armature and inner contact of R^6, winding of R^{10}, 54, contact and left hand armature of R^7, 55 and ground, energizing R^{10} which then locks over the circuit B, 42, right hand armature and contact of R^{10} to winding of R^{10}, 54, contact and armature of R^7, 55 and ground. By energization of relay R^{10}, ground is taken off of wire 50 so that ringing relay R^{14} may not again be energized. Also by the energization and locking of R^{10} the relay R^9 is released and remains released throughout the remainder of the connection. This is the condition of conversation and continues until the hanging up of the telephone and the breaking of the substation bridge upon the called line.

Upon the hanging up of the telephone and the breaking of the substation bridge upon the called line, disconnection of the switch S is effected as follows: Circuit is interrupted over the return wire of the line and through relay R^6 to ground, releasing the armatures of relay R^6, but current continues through elements B, 42 winding of R^7, 24, lower wiper s', and the sleeve side of the connected line and the winding of its cut-off relay M′ to ground, maintaining the energization of the relay R^7. By the release of the left hand armature of relay R^6 a release relay circuit is established through elements B, 42, left hand armature and outer contact of deënergized relay R^6, winding of release relay R^{22}, inner contact and armature r^{10} of relay R^{10}, 51 and ground, energizing release relay R^{22} which, by closing its contact, energizes release magnet s^6, which effects immediate restoration of all parts of the switch S to the normal position of disuse.

A consideration of test conditions during the process of the connection is desirable. When the test wiper or upper wiper s' connects with the test conductor of the line, no action is taken either to test for busy or to place a busy test upon the line until the wheels Q′, Q^2, Q^3, etc. have in due course of progress begun to send the generator-selection impulses; at this time, by the action of the solenoid R^{15}, the selected line is tested for busy condition, the testing for busy being continued throughout the receipt of the generator-selection impulses and the line being left unguarded against connection by other connectors; at the close of the generator-selection impulses the test relay is taken off and the ringing generator is substituted. From this time a busy test guard condition is placed upon the test conductor of the selected line, being alternately the potential of the selected ringing generator when the

relay R^{14} is energized, which is sufficient to energize any relay R^{11} which may test the line during the interval of ringing, and between the intervals of ringing the busy test consists of the ground circuit through the relay R^6. If the line thus connected with be tested for busy by some other connector attempting a connection with it and during the interval of deënergization of ringing relay R^{14}, a current will flow from the connector then testing to the test conductor of the line, thence through the test wiper of the connector of Fig. 3 holding the line, and through back contact of relay R^{14}, front contact of R^{13}, 23, and winding of R^6 to ground. This current will be of sufficient strength to energize the test relay R^{11} of the distant connector attempting to take the line being held, and this will effect disconnection of that connector but it will not be of sufficient strength to energize the relay R^6 inasmuch as by the energization and subsequent deënergization of that relay, the said testing current would also restore the holding connector of Fig. 3 to its normal condition of idleness.

Having thus described my invention what I claim and desire to secure by Letters Patent is:—

1. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: a power-driven impulse generator, operators' keys and connections therefrom to said generator such that each key when closed will be supplied with a specific number of impulses per cycle of the impulse generator, and means to limit said impulses to one cycle, substantially as described.

2. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, a plurality of operators' keys connected to said generator so that each one operated will derive a distinctive number of impulses therefrom per cycle, means to connect the keys at the beginning of a cycle to the switches, and means to disconnect the same therefrom at the end of a cycle, substantially as described.

3. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, a set of keys, connections therefrom to the generator such that each key will control the transmission of a distinctive number of impulses per cycle of the generator, normally incomplete connections from the keys to the automatic switches, electromagnetic means for controlling the same, and means to supply current for said electromagnetic means when the keys are actuated, substantially as described.

4. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, a set of operators' keys connected thereto so as to derive distinctive numbers of impulses therefrom per cycle thereof, normally incomplete connections from said keys to the switches, electromagnetic means controlled initially in setting the keys, and thereafter controlled by the impulse generator in its revolution, to connect the same through the keys to the switches at the beginning of a cycle only, substantially as described.

5. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, a set of operators' keys connected thereto so as to derive numbers of impulses therefrom per cycle thereof, normally incomplete connections from said keys to the switches, electromagnetic means controlled initially in setting the keys, and thereafter controlled by the impulse generator in its revolution, to connect the same through the keys to the switches at the beginning of a cycle only, and to disconnect the same from the switches at the end of a cycle, substantially as described.

6. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, operators' selective impulse keys, and a controlling relay, with connections such that the keys when actuated will select the impulses to be transmitted, and will place the relay in condition to be controlled by the generator, the relay when actuated will connect the keys for the transmission of the selected impulses to the switches, and the generator in addition to transmitting the impulses selected will control the relay to complete the transmitting circuit at the beginning of one of its own cycles, and will disconnect the same at the end of one cycle of operation, substantially as described.

7. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: an impulse generator, a set of operators' selective keys, a pair of controlling relays, and circuit connections from the generator to the keys, from the keys to the relays, and from the relays to the switches, together with controlling circuits for the relays passing to the generator,

whereby said circuit connections will be broken at the end of one cycle of operation of the generator, substantially as described.

8. In a telephone system a plurality of lines, automatic switching apparatus for interconnecting the same, and a controlling apparatus therefor comprising the following instrumentalities: a multiple number impulse generator, a series of selective keys, individual connections from the generator to the keys, normally incomplete trunk-connections therefrom to the automatic switching apparatus, and a pair of interlocking relays, together with a pair of locking circuits for said relays supplied with current through the generator, one of said relays adapted to connect and disconnect the trunk-connections to and from the keys, the other relay acting alternately thereto, also serving as a guard relay for its companion, and the locking circuit having current put on and taken off in proper sequence during the operation of the generator so as to deënergize the guard relay first, thereby completing the trunk connection from the keys, and thereafter at the end of a cycle of operation to deenergize the other relay, so as to cut off the trunk connection, substantially as described.

9. In a telephone system, a plurality of lines, automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—commutators; keys; relays; bus conductors connecting said keys and said relays; digit conductors connecting said keys and said commutators, said keys being adapted to connect said digit conductors and said bus conductors, and said relays being adapted to connect said bus conductors to said automatic switching apparatus, substantially as described.

10. In a telephone system, a plurality of lines, automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—commutators; keys; two relays; bus conductors connecting said keys and said relays; digit conductors connecting said keys and said commutators, said keys being adapted to connect said digit conductors and said bus conductors, one of said relays being adapted when deënergized to connect said bus conductors to said automatic switching apparatus, and the other of said relays being adapted when deënergized to disconnect said bus conductors from said automatic switching apparatus substantially as described.

11. In a telephone system, a plurality of lines, automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—commutators; keys; two relays; bus conductors connecting said keys and said relays; digit conductors connecting said keys and said commutators, said keys being adapted to connect said digit conductors and said bus conductors, one of said relays being adapted when deënergized to connect said bus conductors to said automatic switching apparatus, and the other of said relays being adapted when deënergized to disconnect said bus conductors from said automatic switching apparatus; and means for energizing said two relays, substantially as described.

12. In a telephone system, a plurality of lines, automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—commutators; keys; two relays; bus conductors connecting said keys and said relays; digit conductors connecting said keys and said commutators, said keys being adapted to connect said digit conductors and said bus conductors, one of said relays being adapted when deënergized to connect said bus conductors to said automatic switching apparatus, and the other of said relays being adapted when deënergized to disconnect said bus conductors from said automatic switching apparatus; means for energizing said two relays initially; and separate means for continuing said energization, substantially as described.

13. In a telephone system, a plurality of lines; automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—commutators; keys; two relays; bus conductors connecting said keys and said relays; digit conductors connecting said keys and said commutators, said keys being adapted to connect said digit conductors and said bus conductors, one of said relays being adapted when deënergized to connect said bus conductors to said automatic switching apparatus, and the other of said relays being adapted when deënergized to disconnect said bus conductors from said automatic switching apparatus; means for energizing said two relays initially; means for continuing the energization of the first of said relays until the beginning of a cycle of impulses from said commutators through said keys; and means for continuing the energization of said second of said relays until the end of that cycle of impulses, substantially as described.

14. In a telephone system, a plurality of lines; automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities: — continuously revolving commutators; bus wires; keys connecting selected ones of said commutators to said bus wires; and two relays connecting said bus wires to said automatic switching apparatus, substantially as described.

15. In a telephone system, a plurality of

lines; automatic switching apparatus for interconnecting the same; and a controlling apparatus therefor comprising the following instrumentalities:—continuously revolving commutators; bus wires; keys connecting selected ones of said commutators to said bus wires; and two relays connecting said bus wires to said automatic switching apparatus during the interval of one cycle of impulses from said commutators through said keys, substantially as described.

16. In a telephone system, a continuously driven signal transmitting device, producing in every cycle the maximum of signal impulses required for controlling selective switches, and having impulse selecting keys as a part thereof; a starting and stopping device associated with said signal transmitter and adapted to produce first a stopping and second a starting current change in the interim between succeeding cycles of signals from said signal transmitter; an automatic selective switch; a pair of conductors adapted to be associated therewith; a starting relay adapted to connect said pair of conductors to said signal transmitter in response to a starting impulse; a stopping relay placed in operative relation to said starting and stopping device upon the actuation of said starting relay and adapted to disconnect said pair of conductors from said signal transmitting device in response to a stopping current change; and locking means for both of said relays, substantially as described.

17. In a telephone system, a continuously driven signal transmitting device producing in every cycle the maximum of signal impulses required for controlling selective switches; impulse selecting keys; a starting and stopping impulse device associated with said signal transmitter and keys and adapted to produce first a stopping current change and second a starting current change in the interim between succeeding cycles of signals from said signal transmitter and keys; an automatic selective switch a pair of conductors adapted to be associated therewith; a starting relay adapted to connect said pair of conductors to said signal transmitter in response to a starting current change; a stopping relay placed in operative relation to said starting and stopping device upon the actuation of said starting relay and adapted to disconnect said pair of conductors from said signal transmitting device in response to a stopping current change; locking means for both of said relays and manually controlled means for connecting said starting relay operatively with said starting and stopping device, substantially as described.

18. In a telephone system, line circuits and automatic switching apparatus for interconnecting the same, together with a continuously driven commutator device producing impulses adapted to control said selective switching apparatus, a bank of selective keys for selecting from said commutator the combination of impulses required for any particular and definite operation of the automatic switching apparatus, a pair of conductors associated with a portion of the automatic switching apparatus to connect the same with the commutator device, a relay adapted to connect said conductors to said commutator device, a second relay adapted to disconnect said conductors from the commutator, means for energizing both of said relays when the keys are set to select a number, and means associated with the commutator device to deënergize the second relay at the beginning of a cycle of operation, and to deënergize the first relay at the end of a cycle of operation, whereby a signal may be set up on the keys at any time, but signal impulses will not be transmitted thereby to the automatic switching apparatus until the beginning of the next regular cycle of operation, when the impulses will be received in orderly sequence, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

JOSEPH LANE WRIGHT.

Witnesses:
E. EDMONSTON, Jr.,
EDWARD E. CLEMENT.