C. J. ERICKSON.

SEMI-AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 17, 1913.

1,221,299.

Patented Apr. 3, 1917.

5 SHEETS—SHEET 1.

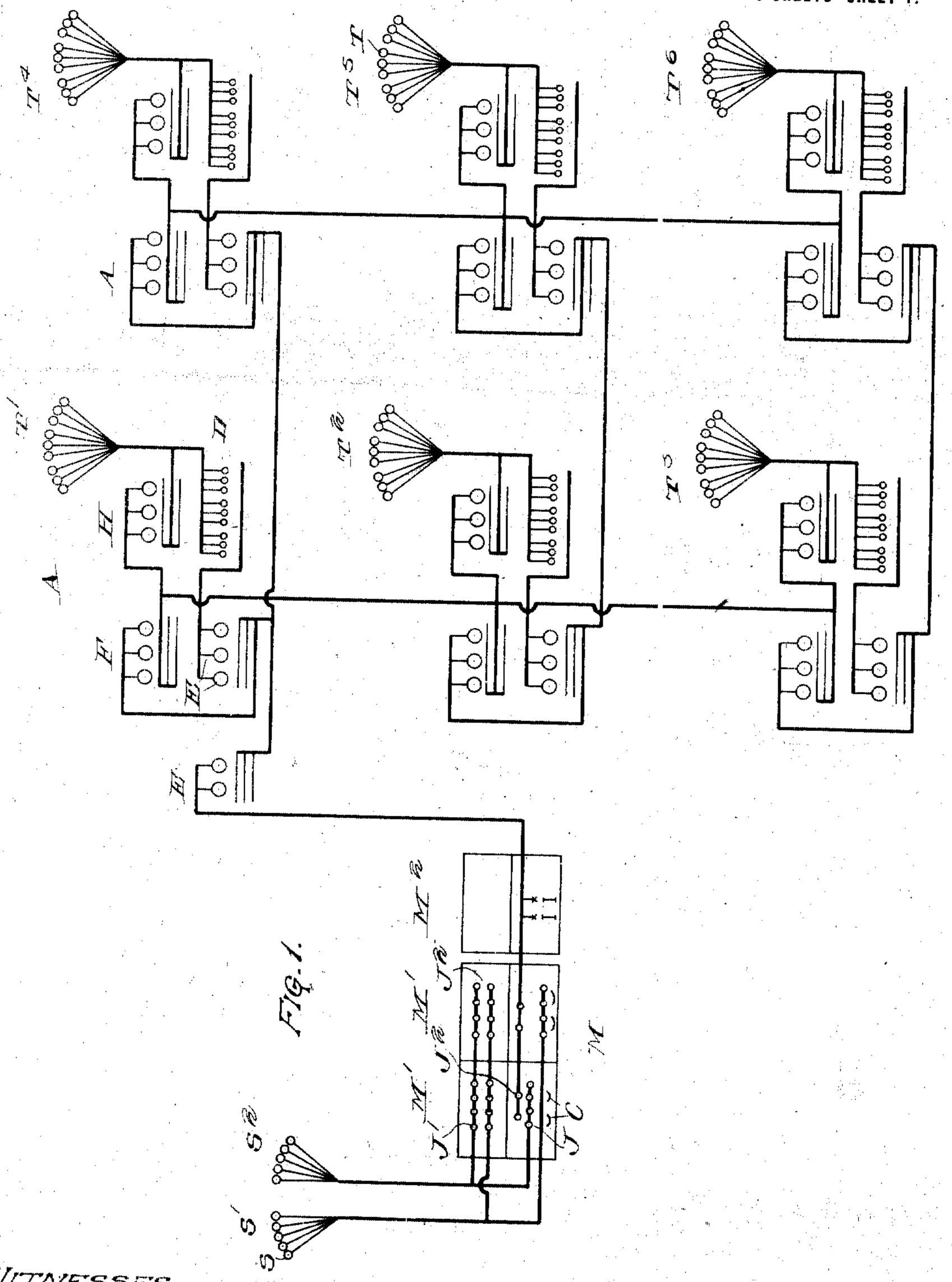

FIG. 1.

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5 SHEETS—SHEET 2.

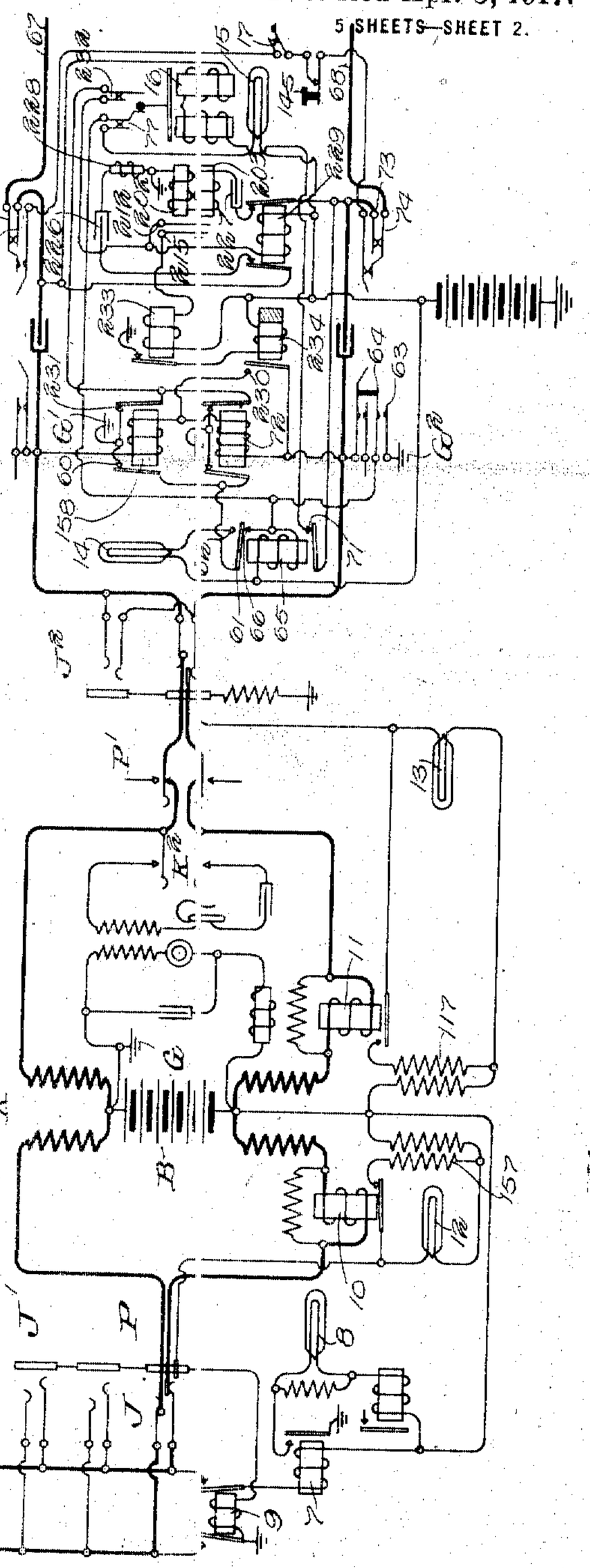

FIG. 2.

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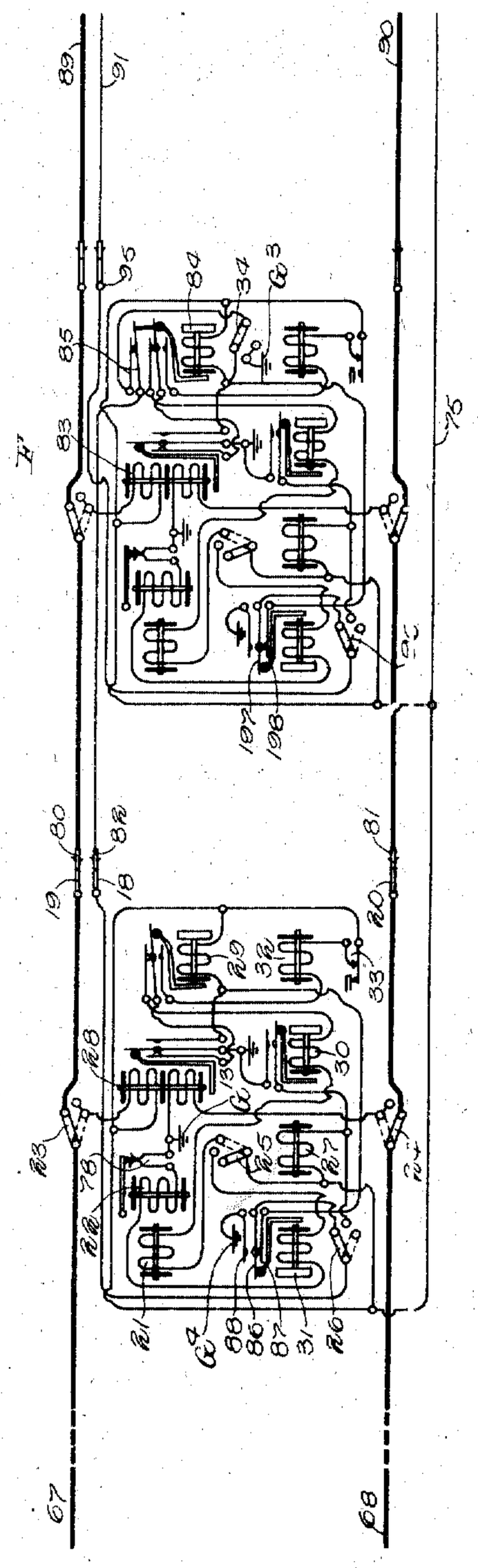

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5 SHEETS—SHEET 4.

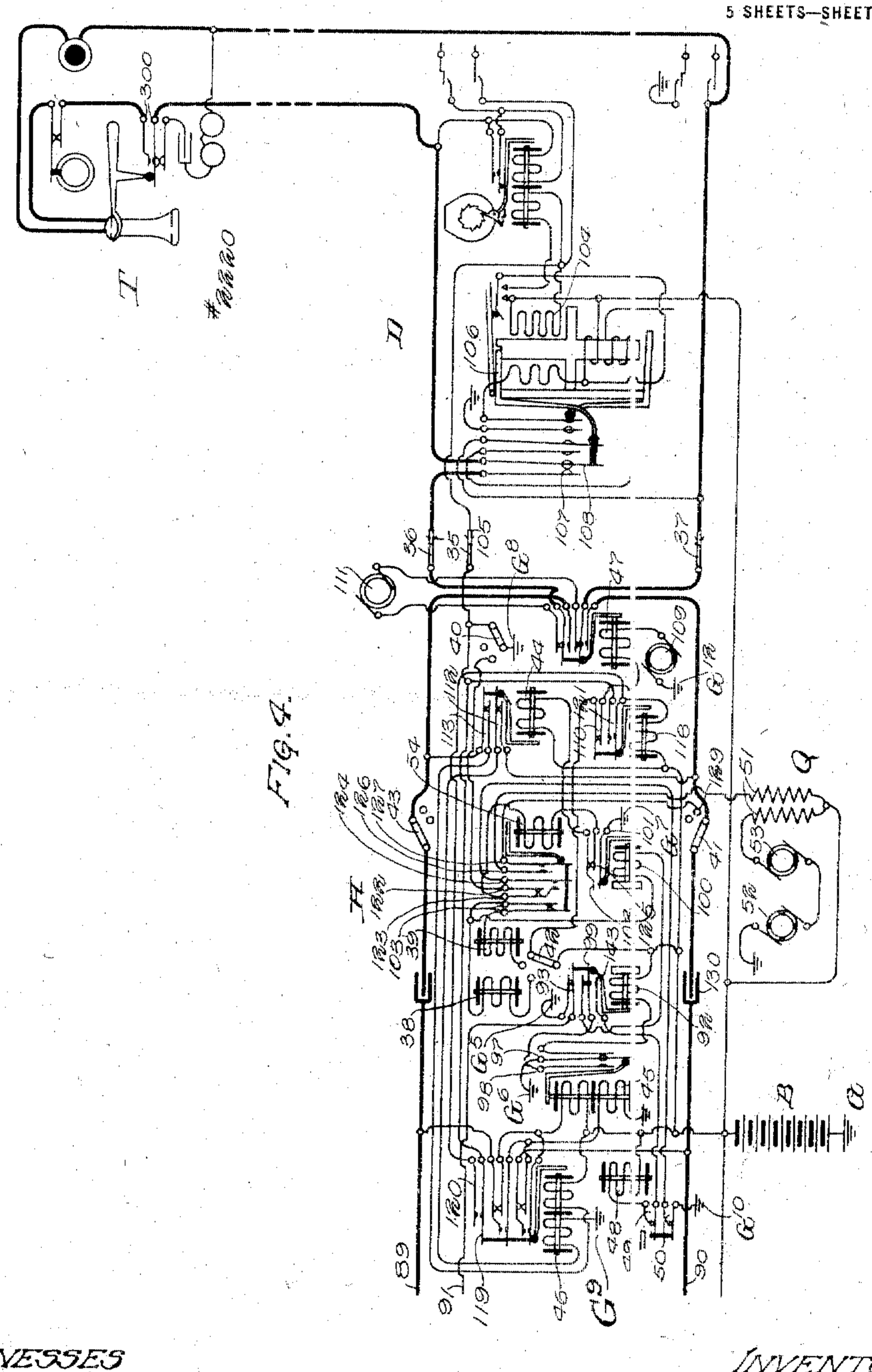

Fig. 4.

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5 SHEETS—SHEET 5.

FIG. 6.

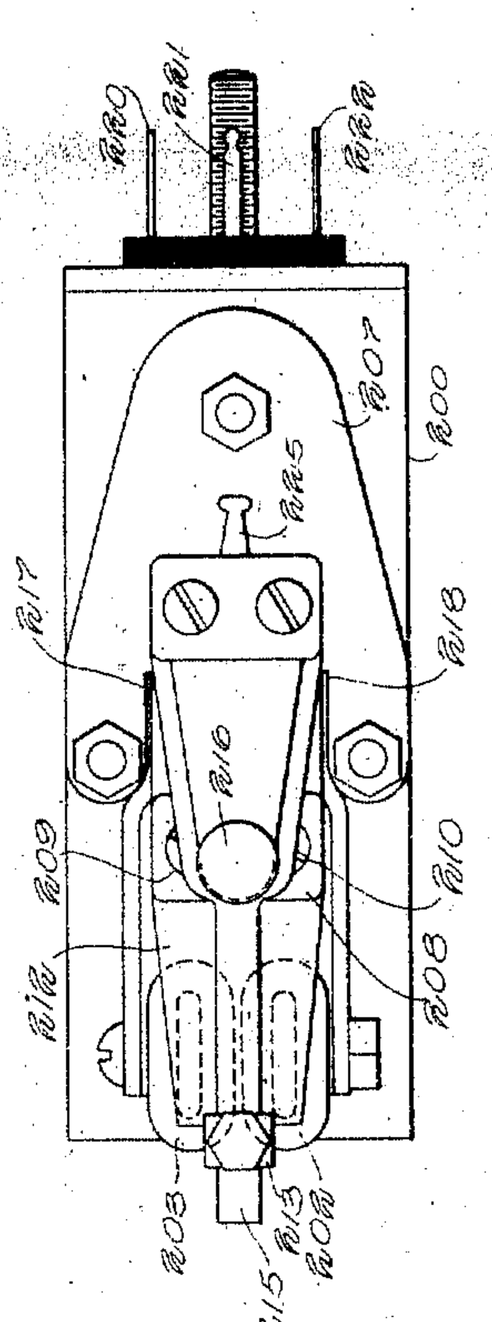


FIG. 5.

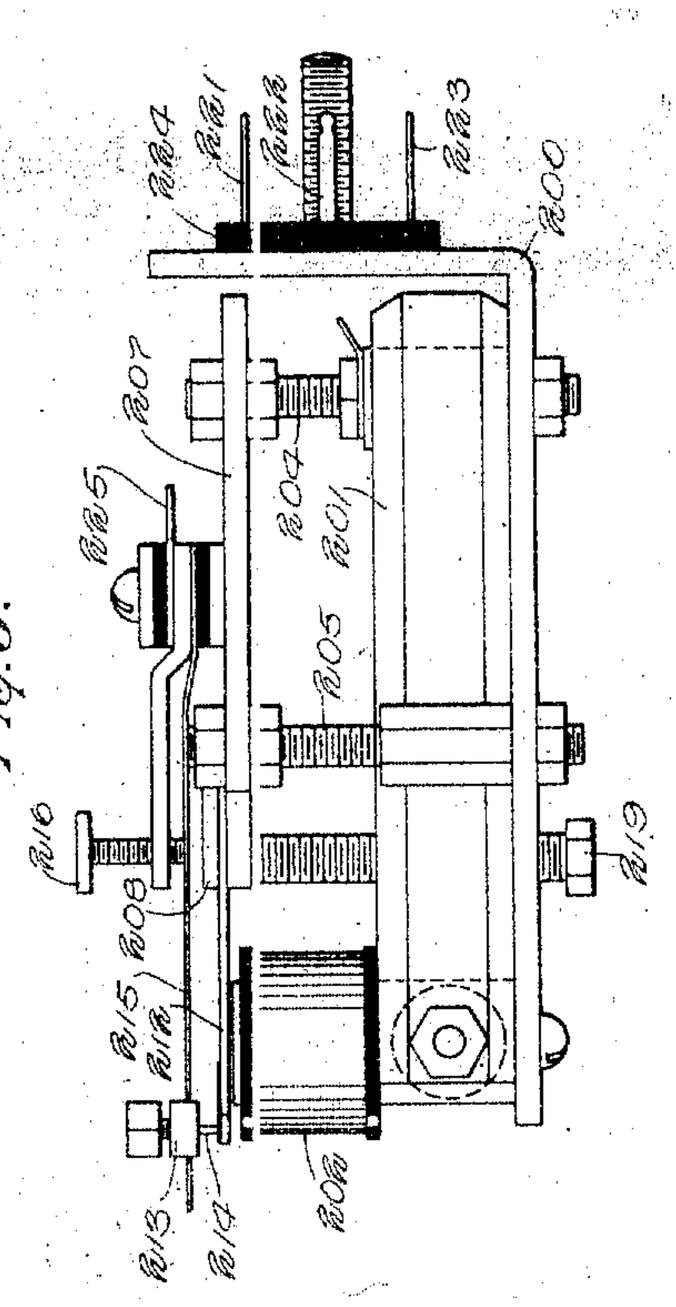
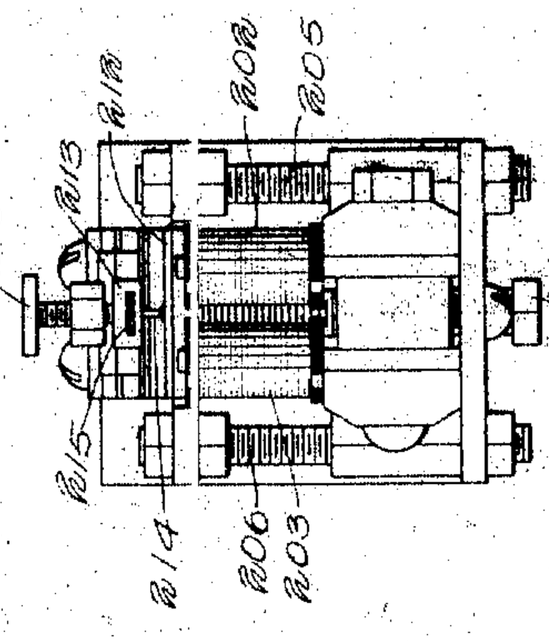


FIG. 7.



WITNESSES

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UNITED STATES PATENT OFFICE.

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SEMI-AUTOMATIC TELEPHONE SYSTEM.

1,221,299. Specification of Letters Patent. Patented Apr. 3, 1917.

Application filed April 17, 1913. Serial No. 761,801.

To all whom it may concern:

Be it known that I, CHARLES J. ERICKSON, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Semi-Automatic Telephone Systems, of which the following is a specification.

My invention relates to improvements in semi-automatic telephone systems, and more particularly to means for indicating to an operator in such a system that the called line is busy, and is in the nature of an improvement upon the applications of Talbot G. Martin, Serial No. 754,801 filed March 17, 1913, and Michael Schwartz, Serial No. 769,284, filed May 22, 1913.

More particularly, my invention relates to the provision of a supervisory signal on the operator's board, and means for flashing this signal when an automatic switch attempts to make connection with a busy line.

Heretofore various means have been devised for giving such a signal, but in these systems it has either been necessary to employ a special form of connector switch, or else provide other special features associated with the busy signaling machine. By my invention I employ the regular busy signaling current for controlling the operation of this signal, and do away with the necessity of providing any special features in connection with the connector switch.

A further object of my invention is the provision of a special form of relay which is bridged across the trunk line and is responsive to the alternating busy signaling current, which relay controls the operation of the supervisory signal, the flashing of which constitutes the busy signal for the operator.

These and other objects of my invention will be more readily understood by reference to the accompanying drawings, in which I have illustrated my invention in connection with a semi-automatic telephone system of one particular type. It will, of course, be understood that other forms of cord circuits and automatic switches can be employed, and that the disclosure is merely for the purpose of setting forth one particular embodiment of my invention.

In the drawings Figure 1 is a diagrammatic lay-out of a telephone system in which I have chosen to illustrate my invention.

Figs. 2, 3 and 4 show a complete connection between a manual line and an automatic line in said system.

Figs. 5, 6 and 7 are top, side and end views, respectively, of a vibratory current relay for accomplishing certain objects of the invention, as will be fully described hereinafter.

The telephone system illustrated in Fig. 1 comprises a manual exchange M and an automatic exchange A. In the manual exchange M there is represented a switchboard comprising a plurality of "A" or subscribers' operators' positions M′ and a "B" or trunking operator's position M^2. At S′ and S^2 there are shown two groups of subscribers' substations S, each of which is provided at the central office with an answering jack J on one A-operator's position and a multiple jack J′ on each A-operator's position in the usual manner. Suitable plug cords C are provided for connecting the lines for conversation.

The automatic exchange A is of a well-known type, comprising subscribers' individual preselecting switches D, so-called first selectors E, second selectors F and connectors H. In the drawings there is represented two thousands of an exchange of ten thousand line capacity on a scale of three to ten. The subscribers' substations T and the lines connected thereto are divided into groups T′, T^2, T^3, etc., usually of one hundred lines each. On a scale of three to ten, therefore, the three groups T′, T^2 and T^3 represent one complete thousand and the groups T^4, T^5 and T^6 represent another thousand. With each group of subscribers' lines there is associated in the central office a group of individual or line switches D, one for each line, a group of first selectors E, a group of second selectors F and a group of connectors H. The selector and connector switches represented herein comprise banks of contacts arranged in horizontal rows or levels, usually ten in number. These groups are represented diagrammatically by horizontal lines, which extend across a group of switches, thereby indicating that the corre-

sponding contacts of all the switches of the group are multipled together. All the line switches D belonging to a single group of subscribers' lines have common access to a group of first selectors E. The bank contacts of all the first selectors of corresponding hundreds are multipled throughout the different thousands. The first level of bank contacts of these first selectors are connected to trunk lines leading to second selectors associated with the first thousand, the contacts of the second level are connected to trunk lines leading to second selectors F associated with the second thousand, etc. All the second selectors associated with a given thousand are multipled together, and the first level is connected to trunk lines leading to connectors which have access to the lines of the first hundred group of that thousand. The second level of the second selectors is connected to trunk lines leading to connectors having access to the lines of the second hundred of the thousand, etc. This trunking arrangement of an automatic exchange is in general well known in the art, and it is not thought necessary to describe it in greater detail herein.

In order to form means of communication between the manual and automatic exchanges, there are provided a number of trunk lines leading from multiple jacks J^3 on the manual switchboard M to selector switches E at the automatic exchange. The bank contacts of these selectors may be connected in multiple with those of some of the subscribers' first selectors. These trunk lines leading from the manual switchboard to the automatic exchange pass through a trunking or B-operator's position M^2, where they are provided with certain equipment I comprising supervisory relays and signals, listening and calling device keys, etc.

Having given a general description of the system in connection with which I have chosen to illustrate my invention, I will now describe the apparatus which is used in connection therewith. The manual telephone S (Fig. 2) is an ordinary common battery manual telephone, comprising the usual receiver 2, transmitter 3, induction coil 4, ringer 5 and condenser 6. At the central office the line of the substation S is provided with the usual answering jack J, a plurality of multiple jacks J', line relay 7, line lamp 8 and cut-off relay 9. The cord circuit C is a well-known type of cord circuit, comprising the usual answering and calling plugs P and P' inductively connected together through the medium of a repeating coil R. The usual supervisory relays 10 and 11 are included in one side of the cord circuit for controlling the supervisory lamps 12 and 13. The trunk circuit leading from the manual exchange to the automatic exchange, as has been before mentioned, leads from multiple jacks J^2 on the A-operator's position to a selector switch E in the automatic exchange and is provided at the B-operator's position with the equipment I. This trunking equipment comprises a calling lamp 14, a disconnect lamp 15, listening and calling device keys K and K' and suitable relays for controlling the various circuits. The relay 16 is an ordinary polarized relay—that is, a relay which attracts its armature in one direction when it receives current of one polarity, and which attracts its armature in the other direction when it receives current of the opposite polarity. This trunk is also provided with a relay 202 which is shown in detail in Figs. 5, 6 and 7 and which is represented diagrammatically in Fig. 2 by the coils 202 and 203, armature 212 and spring 215. This relay is adapted to be bridged across the line through the condensers 226 and 227 and the resistance 228 by the relay 229. The connection between the relay 202 and the resistance 228 is grounded. The key K is for the purpose of connecting the ordinary operator's listening and talking set with the trunk, while the key K' is for the purpose of connecting the calling device with the trunk, through the medium of which the operator may control the automatic switches to set up the proper connection. This calling device may be of any desired type, such, for instance, as that shown in British patent to S. G. S. Dicker No. 29,654 of 1910.

The automatic selector switch E, as represented herein, is of the general type of selector switches disclosed in United States Letters Patent No. 815,321, granted March 13, 1906, to Keith, Erickson and Erickson, the circuits being modified, however, in a manner similar to that shown in British patent to S. G. S. Dicker No. 1298 of 1910, so as to adapt the switch to operate in a system in which the central office apparatus is controlled by impulses delivered over the two sides of the line in series. Among other details, the selector comprises a bank of contacts arranged in horizontal rows or levels and which are adapted to be engaged by set of wipers 18, 19 and 20 carried upon a shaft having a vertical movement controlled by the vertical magnet 21 and a rotary movement controlled by the rotary magnet 22. The usual side switch comprising the wipers 23, 24, 25 and 26 is controlled by the so-called private magnet 27 in a manner well known in the art. The operation of the switch is controlled through the medium of the double-wound line relay 28. The relays 29, 30 and 31 are slow acting relays—that is, relays which deënergize slowly. Means for releasing the switch are provided in the release magnet 32, which magnet releases the switch immediately upon energizing, rather than by its deënergization as shown

in said Patent No. 815,321. The springs 33 are separated by the switch shaft when it is in its lowest or normal position.

The second selector F is similar to the first selector E, with the addition of the side switch wiper 34.

The connector H is of the general type of connector switches disclosed in United States Letters Patent No. 815,176, granted March 13, 1906, to Keith, Erickson and Erickson, the circuits, however, being modified so as to adapt it for operation in a system in which the apparatus is controlled over the two sides of the line in series. The mechanical features of the connector are somewhat similar to those of the selector switches. It comprises a set of wipers 35, 36 and 37 carried upon a vertically and rotatably movable shaft, which shaft is controlled by the vertical and rotary magnets 38 and 39 and a side switch comprising the wipers 40, 41, 42 and 43 which is controlled by the usual private magnet 44. The line relay 45 is connected with the line through springs controlled by the back-bridge relay 46, through the windings of which relay the called telephone is supplied with talking current. The relay 47 is a ringing relay, through the medium of which the application of ringing current to the called line is controlled. 48 is the usual release magnet. The two pairs of springs 49 and 50 are held open by the switch shaft as long as it is in its normal position.

The subscriber's individual switch D is of the general type of subscribers' switches disclosed in British patent to R. W. James No. 26,301 of 1906, being of the particular form, however, shown in British Patent No. 1298 of 1910 hereinabove referred to. A group of these subscribers' individual switches is ordinarily controlled by a so-called master switch, but it is not thought necessary to describe same herein. The automatic substation T is similar to that shown in the said British Patent No. 1298 of 1910.

At Q there is shown a busy signaling machine comprising an induction coil 51, a high speed interrupter 52 and a low speed interrupter 53. The primary winding of the induction coil 51 is included in a local circuit with the two interrupters and the battery, whereby an intermittent interrupted current is caused to flow in the primary winding of said induction coil to induce an intermittent alternating current of high frequency in the secondary winding. When this secondary winding is connected with the subscribers' lines, this interrupted alternating current flowing through said lines produces an interrupted buzzing sound in the subscribers' receivers.

There is shown in the drawings a plurality of batteries B having one terminal grounded at G for the purpose of supplying current for operating the central office apparatus and for furnishing talking current. Although a plurality of batteries is shown, one battery only need be used, or preferably one battery in each exchange.

Referring to Figs. 5, 6 and 7, it will be seen that the relay 202 in the trunk apparatus I consists of a permanent horse-shoe magnet 201 secured to a suitable base 200, which is composed preferably of non-magnetic material. The cores of two small flat electromagnet coils 202 and 203 are secured to the poles of the magnet 201. Secured to the base 200 by means of posts 204, 205 and 206 there is a plate 207 composed also of non-magnetic material. A thin plate of iron 212, which projects forward over the ends of the poles of the electromagnets 203 and 202, is secured to the end of the plate 207 by means of the washer 208 and screws 209 and 210. This plate 212 forms an armature or diaphragm for the permanently magnetized electromagnet composed of the permanent magnet 201 and coils 202 and 203. Secured to the face of the plate 207 and insulated therefrom is a long thin spring 215, which spring extends parallel with the armature or diaphragm 212 and carries at its end a small weight 213 and contact point 214. By means of the adjustable screw 216, the pressure of the contact point 214 on the armature 212 may be varied. The spring 215 and armature 212 form terminals of the local circuit that is to be controlled by the relay, which circuit is normally closed by the engagement of the contact 214 with the armature 212. If an alternating current be transmitted through the coils 202 and 203, the armature 212 will be caused to vibrate in unison with said current in a manner very similar to that of an ordinary telephone receiver diaphragm. This vibration will be transferred through the contact 214 to the weight 213 on the end of the spring 215. The natural period of vibration of the spring 215 is very much lower than the frequency of the alternating current which operates the relay, and therefore when the armature 212 is vibrated, the contact 214 does not vibrate in unison therewith, but vibrates independently in a sort of irregular manner, whereby the contact between the contact point 214 and the armature 212 becomes broken, or at least the connection between the two becomes of such high resistance as to have the effect of opening the local circuit which is controlled by the relay. This construction produces an alternating current relay, which is very sensitive in its operation—that is, it may be operated by an alternating current of very high frequency and of very small volume. In order to form a means of adjustment of the air gap between the armature 212 and the poles of the magnet, two saw cuts 217 and 218 are made in the plate 207 alongside

the portion to which the armature 212 is attached, whereby said armature is attached to a somewhat narrow and flexible strip. Passing up through the base 200 there is a screw 219 which engages the under side of the member to which the armature is attached, and by turning this screw the armature may be forced up slightly or lowered to adjust the air gap to the desired width. Electrical connections to the relay are made through the medium of the terminals 220, 221, 222 and 223 mounted in a block of insulation 224. Two of these terminals are connected to the terminals of the coils, one terminal is connected to the terminal 225, which is in electrical connection with the spring 215, and the other terminal is connected with the armature 212 through the frame of the apparatus.

Having given a general description of the apparatus, I will now describe the operations performed in the process of establishing a connection from the manual substation S (Fig. 2) to the automatic substation T (Fig. 4). Since the automatic apparatus represented herein is in general well known in the art, and is fully described in the publications hereinabove referred to, its operation will be described in a more or less general manner. Upon the removal of the receiver at the calling telephone S, the circuit of the line relay 7 is closed in the usual manner, which relay, upon energizing, closes the circuit of the line lamp 8 to signal the operator. The operator answers the call by inserting the plug P into the jack J, whereby the connection is completed between the line and the cord C. By the engagement of the third conductor of the plug P with the jack J, the circuit of the cut-off relay 9 is closed in series with the lamp 12 of the cord. The relay 9, upon energizing, disconnects the line relay 7 from the line. When connection is extended to the cord, the calling substation is provided with talking current from the battery B through two windings of the induction coil R and through the relay 10. The relay 10, upon energizing, closes a shunt around the lamp 12 through the resistance 157, thereby shunting sufficient current away from said lamp to prevent it from being brought to a glow. The operator then connects her talking set with the line through the medium of the key K^2, and, upon learning from the calling subscriber that a subscriber of the automatic exchange is wanted, she inserts the plug P′ into a multiple jack J^2 of an idle trunk line leading to the automatic exchange. Upon the insertion of the plug into the jack, a circuit is closed from ground at the cord over the tip strand to the plug P′ and jack J^2, through the relay 158, contact 230, thence through the ring conductors of the jack J^2 and plug P′ and relay 11 to the non-grounded terminal of the battery B. The relay 158, upon energizing, closes the circuit of the lamp 14 from ground G′ through the contact 60, armature 61, contact point 62 and lamp 14 to the battery B. The closure of the contact 231 of the relay 158 completes a circuit extending from ground G′ through said contact 231, springs 232 of the relay 16, armature 212 and spring 215 of the alternating current relay and through the relay 233 to battery B. The relay 233, upon energizing, closes the circuit of the relay 234, which, by opening the contact 230, removes a short-circuit from the relay 72, whereby said relay is included in the circuit of the relay 158. This relay 72 has a sufficiently high resistance to prevent sufficient current from flowing through the relay 11 in the cord to operatively energize said relay. Upon the closure of the contact 231 of the relay 158, a second circuit is closed extending from ground G′ through the springs 231 and 232 and relay 229 to battery B. The relay 229, upon energizing, completes the connection between the relay coils 202 and 203 and the line.

Upon noting the signal of the lamp 14, the operator operates the key K to connect her talking set with the trunk and inquires the number of the line desired. Upon the closure of the springs 63 and 64 by the operation of the key K, a circuit is closed from ground G^2 through the relay 65 to the battery. The relay 65, upon energizing, breaks the circuit of the lamp 14 and forms a locking circuit for itself extending from ground G′ through the contact 60, armature 61, contact 66 and through said relay 65 to battery. The relay 65, upon energizing, also operates to close a bridge across the trunk conductors 67 and 68 through the relay 16, whereby a circuit is closed extending from ground G^{13} at the selector E (Fig. 3) through the lower winding of the relay 28, side switch wiper 24, trunk conductor 68, springs 74 and 73 of the key K′, contact 71, relay 16, springs 70 and 69, conductor 67, side switch wiper 23 (Fig. 3) and the upper winding of the relay 28 to the battery lead 75, thence through battery B to ground G. The polarized relay 16 is operatively energized in the direction to close the contact 77, thereby completing the circuit of the lamp 15, which circuit extends from ground G′ through the contact 60, armature 61, contact 66, contact 77 and the lamp 15 to battery. The relay 28 of the selector E, upon energizing, closes the circuit of the slow-acting relay 29.

Upon learning the number desired, the B-operator restores the key K and operates the key K′, whereby the relay 16 is disconnected from the trunk leading to the selector and the calling device springs 17 are bridged across it instead. The operator now operates her calling device in accordance with

the digits of the number of the desired station, which will be assumed to be 2220. Upon the operation of the calling device for the first digit 2, the impulse springs 17 are separated twice momentarily, each time breaking the circuit of the selector line relay 28. Since the relay 29 is slow acting it does not deënergize during the momentary interruptions of its circuit by the deënergizations of the line relay 28. Therefore, each time said relay deënergizes, an impulse of current is transmitted through the vertical magnet 21 and the slow acting relay 30. The magnet 21 thus receives two impulses and operates to raise the shaft wipers 18, 19 and 20 two steps to a position opposite the second level of bank contacts. The slow acting relay 30 is operated by these impulses to close the circuit of the private magnet 27 and maintain it closed continuously until after the last impulse is delivered. Upon the deenergization of the private magnet after the last impulse is delivered to the vertical magnet, the side switch is tripped from first to second position in a well-known manner. The movement of the side switch wiper 25 from first to second position disconnects the battery from the vertical magnet 21 and closes a circuit through the rotary magnet 22 in series with the relay 31. Since the rotary magnet is provided with interrupter springs 78, it begins to operate in a manner similar to that of a buzzer to advance the wipers step by step over the contacts of the level to which they have been raised by the previous operations of the vertical magnet. This operation of the rotary magnet continues as long as the side switch remains in second position. If the first trunk line of the level is idle, however, the side switch will be tripped from second to third position upon the first step of the wipers. If this trunk is busy, however, the private wiper 18 finds the contact which it engages provided with a guarding ground potential and completes an energizing circuit through the private magnet 27 by way of the side switch wiper 26, which is now in second position, whereby the said magnet is energized and locks the said side switch in second position. The rotary magnet therefore continues to rotate the wipers until an idle trunk line is found, whereupon, since the private wiper 18 no longer finds a grounded contact, the private magnet 27 deënergizes and the side switch passes from second to third position. Upon the movement of the side switch from second to third position, the circuit of the rotary magnet 22 is broken, the line relay 28 is disconnected from the line and the line connection is extended through the wipers 19 and 20 and the contacts 80 and 81 to the second selector F, whereupon its line relay 83 becomes energized and closes the circuit of the relay 84. The relay 84, upon energizing, establishes a holding circuit for the relay 29 of the selector E to maintain it energized after its original energizing circuit is broken by the deënergization of the relay 28. This holding circuit extends from ground G^3 through the side switch wiper 34, springs 85, contact 82, wiper 18, side switch wiper 26 of the selector E (in third position), springs 86 and 87 of the relay 31 and relay 29 to the battery lead 75. The relay 31 of the selector E is energized in series with the rotary magnet, and being a slow acting relay remains energized for an instant after the rotary magnet has operated for the last time and the side switch has passed to third position, whereby a guarding potential is immediately supplied to the selector private bank contacts of the selected trunk from ground G^4 through the springs 88 and 86 and the side switch wiper 26. An instant later a second potential is supplied to said contacts from ground G^3 of the selector F over the circuit above traced, and the relay 31 deënergizes in time to close the circuit for the relay 29 before it has time to deënergize.

Upon the operation of the operator's calling device for the second digit 2, the selector F operates in the same manner as explained for the selector E to extend the connection over the trunk conductors 89, 90 and 91 to the connector H (Fig. 4), whereupon the connector line relay 45 becomes energized and closes the circuit of the relay 92, which operates to provide a holding circuit for the relays 84 and 29 of the selectors F and E. This circuit extends from ground G^5 through the springs 93, conductor 91, wiper 95, side switch wiper 96 (in third position), springs 197 and 198, thence through the relay 84 to battery and also in multiple therewith through the side switch wiper 34 (in third position) to and through the relay 29 of the selector E, over the circuit hereinbefore traced to the battery lead 75.

The operator now operates her calling device for the third digit 2, thereby causing the connector line relay 45 to deënergize twice momentarily. The relay 92 being slow acting remains energized during the momentary-interruptions of its circuit, so that each time the relay 45 deënergizes, an impulse is transmitted over the circuit extending from ground G^6 through the springs 97 and 98, spring 99 and its front contact, relay 100, vertical magnet 38 and the side switch wiper 42 to the battery lead 75. The vertical magnet 38 receives two impulses over this circuit and operates to raise the shaft wipers 35, 36 and 37 two steps. The relay 100 is energized by these impulses and operates to close a circuit extending from ground G^7 through the springs 101 and 102 and private magnet 44 to the battery lead 75. The relay 100 being slow acting does not allow its armature to fall back until

after the last impulse is delivered to the vertical magnet, when it breaks the circuit of the private magnet 44, which in turn deenergizes and permits the side switch to pass to second position. The side switch wiper 42, in passing from first to second position, transfers the battery connection from the vertical magnet 38 to the rotary magnet 39. The operator now operates her calling device for the last digit 0, whereby the energizing circuit of the connector line relay 45 is broken ten times. Each time the relay 45 deënergizes in this instance, an impulse is transmitted over the circuit extending from ground G^6 through the springs 97 and 98, spring 99 and its front contact, relay 100, springs 103, rotary magnet 39, and the side switch wiper 42 (in second position) to the battery lead 75. The rotary magnet operates in response to these impulses to step the wipers 35, 36 and 37 ten steps onto the contacts of the desired line, while the relay 100 operates in the same manner as for the previous digit to cause the private magnet 44 to advance the side switch one step—that is, from second to third position—after the last impulse for the digit is delivered. The movement of the side switch wipers 41 and 43 to third position finally completes the talking connection with the called telephone. The wiper 40, upon reaching third position, establishes a guarding ground potential at the connector private bank contacts of the called line, and also provides an energizing circuit for the cut-off winding 104 of the subscriber's individual switch D. This circuit extends from ground G^8 through the side switch wiper 40, shaft wiper 35, private bank contact 105 and also to the corresponding contacts of all the other connectors which have access to the line T and through the cut-off winding 104 of the switch D to the battery lead 75. The winding 104, upon energizing, attracts the armature 106, which operates to disconnect the switch D from the called line and to close the contact between the springs 107 and 108. The side switch wiper 42, upon passing to third position, completes an energizing circuit for the ringing relay 47, which circuit extends from ground G^{12} through the interrupter 109, relay 47, springs 110 and side switch wiper 42 to the battery lead 75. The relay 47, upon energizing, operates to disconnect the calling line from the called line, and to bridge the ringing current generator 111 across the called line to signal the called subscriber. Since the circuit of the relay 47 includes the interrupter 109, said relay is energized only intermittently, so as not to ring the called subscriber continuously.

After having completed the call, the trunking operator restores the key K′ (Fig. 2) to its normal position, whereby the calling device is disconnected from the trunk and the circuit of the relay 16 is reëstablished. The relay 16 again energizes to close the circuit of the lamp 15, said relay, of course, having been deënergized while the call was being set up. When the subscriber at the called telephone T removes his receiver, or as soon thereafter as the ringing relay 47 deënergizes, if it happens to be energized at the time, said telephone is provided with talking current over a circuit extending from ground G^9 at the connector H through the left-hand winding of the back-bridge relay 46, private magnet springs 112, thence over the heavy conductors through the shaft wiper 37, thence to and through the substation T and back over the other side of the line, through the springs 108 and 107, wiper 36, private magnet springs 113 and the right-hand winding of the relay 46 to the battery lead 75. The relay 46, upon energizing, transposes the connections between the windings of the line relay 45 and the trunk conductors 89 and 90, whereby the direction of current flowing through the relay 16 (Fig. 2) is reversed. This reversal of the current causes the relay 16 to open the contact 77 to extinguish the lamp 15 and to open the contact 232, whereby the circuit of the relay 233 is broken, which in turn breaks the circuit of the slow acting relay 234, thereby short-circuiting the high resistance relay 72. The short-circuiting of this relay reduces the resistance in the circuit of the relay 11 of the cord C sufficiently to cause said relay to energize to shunt the lamp 13 by the resistance 117, thereby causing it to be extinguished. Thus, through the medium of the lamps 15 and 13, both the B and A operators are notified when the called subscriber answers.

A further result of the energization of the relay 46 of the connector upon the response of the called subscriber is the closing of a circuit through the relay 118, which circuit extends from ground G^8 through the side switch wiper 40, springs 119 and 120 and the relay 118 to the battery lead 75. The relay 118, upon energizing, breaks the circuit of the ringing relay 47 at the springs 110 and forms a locking circuit for itself through its own springs 121, so that it will not deënergize and cause the ringing relay to again operate when the called subscriber hangs up his receiver.

In the above description it was assumed that the line of the telephone T was idle when called and that the connector H completed connection therewith. It will now be explained how the connector is prevented from completing connection with a busy line and how the calling subscriber and the A-operator are given the busy signal. Whenever a line is busy, either on account of having made a call or on account of hav-

ing been called, its connector private bank contacts corresponding to the contact 105 are grounded. Therefore, when the wiper 35 is rotated onto the contact 105 of a busy line, a connection is completed from ground through said contact and wiper, side switch wiper 40 (in second position), springs 122 and 123 and the relay 54 to the spring 125 of the relay 100. Therefore, when this relay deënergizes after the last impulse for the last digit is delivered, the circuit for the private magnet 44 is not broken, but is shifted from ground G^7 to the ground at the guarded private bank contact of the busy line through the relay 54. The private magnet 44 therefore remains energized and prevents the side switch from passing to third position to complete the talking circuit, and at the same time the relay 54 becomes energized. The relay 54, upon energizing, opens the circuit of the rotary magnet at the springs 103, disconnects itself from the private wiper 35 and establishes a holding circuit to ground G^{10} through the springs 123 and 124 and 50. Upon the closure of the springs 126 and 127 by the energization of the relay 54, a connection is completed from the busy signaling machine through the calling line, which connection extends from the secondary winding of the induction coil 51 through the springs 127 and 126, contact 129, side switch wiper 41, condenser 130, thence over the heavy conductors through the selectors F and E and the cord C to the calling substation and back over the other side of the line to and through the upper winding of the connector line relay 45 to the battery lead 75, thence back to the secondary winding of the induction coil 51 of the busy signaling machine Q. The current which is supplied over this circuit by the busy signaling machine, as before stated, is an intermittent alternating current of comparatively high frequency, but of rather low volume. Some of this current flows to ground through the alternating relay coils 202 and 203 of the trunk I (Fig. 2), causing said relay to operate to interrupt the circuit of the relay 233. It will be understood that as along as the busy current is passing through the relay 202, the energizing circuit of the relay 233 is so affected as to cause the armature of the relay 233 to fall back. This armature therefore remains back as long as the busy current passes through the coil 202. Furthermore, it will be understood that the busy tone producing apparatus is so arranged as to continue to send a busy tone for a sufficient length of time between each interruption as to permit the relay 234 to fall back. Therefore, the relay 234 will fall back once for each tone impulse, if it may so be designated. The relay 233, upon deënergizing, interrupts the circuit of the relay 234, which in turn, upon deënergizing, short-circuits the high resistance relay 72, thereby decreasing the resistance in the circuit of the cord relay 11 sufficiently to cause it to energize and shunt the lamp 13 by the resistance 117 to extinguish the lamp. Since the alternating current which the relays 202 and 203 receive is intermittent, the relay 72 will be short-circuited periodically to cause the lamp 13 to flash periodically. It will thus be seen that at the same time the calling subscriber receives an audible busy buzz in his receiver, the A-operator receives a visual indication of the busy condition of the called line, so that if the calling subscriber does not understand the significance of the busy signal, or is not prompt to hang up his receiver, the operator may inform him verbally that the line called is busy and release the connection. The relay 234 in the trunk I is preferably slightly slow acting, so that it will not be caused to short-circuit the relay 72 by any single momentary separation of the springs 212 and 215 of the alternating current relay, so as not to give a false operation of the lamp 13 in case the alternating current relay should at any time receive a single impulse, such, for instance, as it might receive when the key K′ is restored from its operated to its normal position. When the called subscriber answers, the alternating current relay is disconnected from the line, so as not to form a path for the voice currents. This disconnection is accomplished by the deënergization of the relay 229, the circuit of which is broken at the springs 232 when the current in the relay 16 is reversed upon the response of the called subscriber, in the manner heretofore explained. After the conversation has been completed, the operator is given one disconnect signal by the called subscriber hanging up his receiver. This action breaks the circuit of the back-bridge relay 46 at the springs 300. Upon the relay 46 deënergizing, the direction of the flow of current through the relay 16 is again reversed and is now of the proper direction to cause the springs 77 and 232 to be closed. The closing of the springs 77 lights the lamp 15, and the closing of the springs 232 closes the circuit of the relay 233, which energizes to close the circuit of the slow acting relay 234. Upon the relay 234 becoming energized, the shunt is removed from the high resistance relay 72, which, when placed in the circuit of the relay 11, reduces the current through the latter sufficiently to cause its deënergization, allowing its armature to drop back to remove the shunt from the lamp 13 and causing it to light. The relay 10 deënergizes when the calling subscriber hangs up his receiver and lights the lamp 12. The operator thereupon removes the plugs of the

cord C from the jacks. By the removal of the plug P′ from the jack J², the circuit of the relay 158 is broken, which relay, upon deënergizing, destroys the holding circuit of the relay 65. The relay 65, upon deënergizing, destroys the bridge across the trunk conductors 67 and 68 through the relay 16, allowing said relay to deënergize to extinguish the lamp 15 and at the same time the relay 45 of the connector H deënergizes and breaks the circuit of the relay 92, which, upon deënergizing, closes the circuit of the release magnet 48, said circuit being traced from ground G⁶ through the springs 97 and 98, springs 99 and 143, contact of the normal spring 49 and through said magnet to battery B. Upon the release magnet 48 becoming energized, the holding pawls are removed from the shaft, which, by means of a spring and gravitation, is returned to its normal position. When the shaft reaches its lowest point, the circuit of the release magnet is opened at the contact 49. Upon the springs 93 of the relay 92 separating, the holding circuits of the relays 84 and 29 of the selectors F and E are destroyed. The relay 29, upon deënergizing, closes the circuit of the release magnet 32, which magnet, upon deënergizing, restores the shaft to normal position and its circuit is broken by the shaft reaching its lowest position, as in the case of the connector switch H. The selector F releases in the same manner as the selector E.

The B-operator is provided with a push button 145, by means of which she may open the bridge across the trunk and release the automatic switches in case an error is made in the operation of the calling device.

It will thus be seen that I have devised a very efficient system in which the operator is advised of the fact that the called line is busy. Furthermore, it will be seen that it is not necessary to provide any special arrangement in connection with the connector, but that the ordinary form of connector and busy signaling machine can be employed. The only change necessary resides in the equipment in the trunk line at the B-operator's board.

While I have illustrated and described one particular embodiment of my invention, it is to be understood that I do not wish to be limited to the exact construction and arrangement of apparatus and circuits shown and described, but that various modifications can be made without departing from the scope of my invention.

What I claim as my invention is:—

1. In a telephone system, subscribers' lines, means including an operator's cord circuit and an automatic switch for establishing a connection between two of said lines, a visual signal in said operator's cord, means for transmitting a busy tone current to the calling line when the called line is busy, and means including two tuned vibrating members operated by said busy current for operating said signal.

2. In a telephone system, subscribers' lines, means including an operator's cord circuit and an automatic switch for establishing a connection between two of said lines, a visual signal in said operator's cord, means for transmitting an intermittent busy tone current to the calling line when the called line is busy, and means including two tuned vibrating members operated by said busy current for intermittently operating said signal.

3. In a telephone system, subscribers' lines, means including an operator's cord circuit and an automatic switch for establishing a connection between two of said lines, a supervisory signal associated with said cord, means for operating said signal to indicate when a called subscriber answers and when disconnection is desired, a busy signaling machine associated with said switch for transmitting alternating current to the calling line when an attempt is made to connect with a busy line, and means including two tuned vibrating members controlled by said busy current for operating said signal.

4. In a telephone system, subscribers' lines, means including an operator's cord circuit and an automatic switch for establishing a connection between two of said lines, a supervisory signal associated with said cord, means for operating said signal to indicate when a called subscriber answers and when disconnection is desired, a busy signaling machine associated with said switch for intermittently transmitting alternating current to the calling line when an attempt is made to connect with a busy line, and means including two tuned vibrating members controlled by said busy current for intermittently operating said signal.

5. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a busy signaling machine, means controlled thereby for transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit responsive to said busy signaling current, and means controlled by said relay for operating said signal.

6. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a busy signaling machine,

means controlled thereby for intermittently transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit responsive to said busy signaling current, and means controlled by said relay for intermittently operating said signal.

7. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a supervisory signal in said cord, means for operating said signal for indicating the response of the called subscriber and for indicating that a disconnection is desired, a busy signaling machine, means controlled thereby for transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit responsive to said busy signaling current, and means controlled by said relay for operating said signal.

8. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a supervisory signal in said cord, means for operating said signal for indicating the response of the called subscriber and for indicating that a disconnection is desired, a busy signaling machine, means controlled thereby for intermittently transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit responsive to said busy signaling current, and means controlled by said relay for intermittently operating said signal.

9. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a pair of condensers in said trunk, a bridge across said trunk on the calling side of said condensers, a second bridge across said trunk on the called side of said condensers, a busy signaling machine associated with said automatic switch for transmitting an intermittent tone busy current to the calling line when the called line is busy, a relay in said second bridge responsive to said busy current, means controlled by said relay for changing the resistance of said first-mentioned bridge, and means controlled by said change of resistance for operating said signal.

10. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a pair of condensers in said trunk, a bridge across said trunk on the calling side of said condensers, said bridge including a pair of relays, a third relay bridged across said trunk on the called side of said condensers, a busy signaling machine associated with said switch for transmitting an intermittent tone busy current to the calling line when the called line is busy, means controlled by said current for operating said third relay, means controlled by said relay for short-circuiting one of the relays of said calling bridge to thereby reduce the resistance of said bridge, and means controlled by said reduced resistance for operating said signal.

11. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit and an automatic switch, a signal in said cord, a relay bridged across said trunk, a second relay in a local circuit having normally closed contacts controlled by said first-mentioned relay, means for transmitting a busy signaling current to the calling line when the called line is busy, means whereby said signaling current operates said first-mentioned relay to break said normally closed contacts to thereby deënergize said second relay, and means controlled by the deënergization of said second relay for operating said signal.

12. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit and an automatic switch, a signal in said cord, a pair of condensers in said trunk circuit, a bridge including a resistance across said trunk on the calling side of said condensers, a relay bridged across said trunk on the called side of said condensers, a second relay in a local circuit having a normally closed contact controlled by said first relay, means for transmitting a busy signaling current to the calling line when the called line is busy, means controlled by said current for operating said first relay for breaking said normally closed contact, whereby said second relay is deenergized, means controlled by the deënergization of said second relay for changing the resistance in said calling bridge, and means controlled by said change in resistance for operating said signal.

13. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said

means including a cord circuit, a trunk line and an automatic switch, a signal in said cord, a pair of condensers in said trunk, a pair of relays in a bridge across said trunk on the calling side of said condensers, a third relay bridged across said trunk on the called side of said condensers, a fourth relay in a local circuit having normally closed contacts controlled by said third relay, means for transmitting busy signaling current to the calling line when the called line is busy, means controlled by said busy signaling current for operating said third relay to open said normally closed contacts to thereby deënergize said fourth relay, a short-circuit around one of the relays in said calling bridge, means for closing said short-circuit upon the deënergization of said fourth relay to thereby reduce the resistance in said calling bridge, and means controlled by said reduced resistance for operating said signal.

14. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a pair of condensers in said trunk, a bridge across said trunk on the calling side of said condensers, a second bridge across said trunk on the called side of said condensers, means for changing the resistance of said first-mentioned bridge when the called subscriber answers, means controlled by said change of resistance for operating said signal, a busy signaling machine associated with said automatic switch for transmitting an intermittent tone busy current to the calling line when the called line is busy, a relay in said second bridge responsive to said busy current, and means controlled by said relay for changing the resistance of said first-mentioned bridge to thereby operate said signal to inform the operator that the called line is busy.

15. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a pair of condensers in said trunk, a bridge across said trunk on the calling side of said condensers, said bridge including a pair of relays, means controlled by the response of the called subscriber for short-circuiting one of said relays to thereby decrease the resistance of said bridge, means controlled by said decrease of resistance for operating said signal, a third relay bridged across said trunk on the called side of said condensers, a busy signaling machine associated with said switch for transmitting an intermittent tone busy current to the calling line when the called line is busy, means controlled by said current for operating said third relay, and means controlled by said relay for short-circuiting one of the relays of said calling bridge to thereby reduce the resistance of said bridge to thereby operate said signal to inform the operator that the called line is busy.

16. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected with said trunk circuit, a signal in said cord, a busy signaling machine, means controlled thereby for transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit, said relay having a tuned armature responsive to said busy signaling current, and means controlled by said relay for operating said signal.

17. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a signal in said cord, a busy signaling machine, means controlled thereby for intermittently transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit, said relay having a tuned armature responsive to said busy signaling current, and means controlled by said relay for intermittently operating said signal.

18. In a telephone system, a plurality of subscribers' lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to be connected to said trunk circuit, a supervisory signal in said cord, means for operating said signal for indicating the response of the called subscriber and for indicating that a disconnection is desired, a busy signaling machine, means controlled thereby for transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit, said relay having a tuned armature responsive to said busy signaling current, and means controlled by said relay for operating said signal.

19. In a telephone system, a plurality of subscriber's lines, means for establishing a connection between two of said lines, said means including an operator's cord circuit, a trunk circuit adapted to be connected thereto and an automatic switch adapted to

be connected to said trunk circuit, a supervisory signal in said cord, means for operating said signal for indicating the response of the called subscriber and for indicating that a disconnection is desired, a busy signaling machine, means controlled thereby for intermittently transmitting a busy tone current to the calling line when the called line is busy, a relay bridged across said trunk circuit, said relay having a tuned armature responsive to said busy signaling current, and means controlled by said relay for intermittently operating said signal.

20. In a telephone system, a trunk line, a relay bridged across said trunk, said relay comprising a permanent magnet, a pair of magnetizing coils and a tuned harmonic armature, a circuit controlled by said armature, a relay in said circuit, a signal controlled by said relay, and a tuned member operating in conjunction with said armature.

Signed by me at Chicago, Cook county, Illinois, this 10th day of April, 1913.

CHARLES J. ERICKSON.

Witnesses:

ALBERT ANDERSEN,

ARTHUR J. RAY.