F. M. SLOUGH.

TELEPHONE SERVICE SYSTEM.

APPLICATION FILED NOV. 1, 1918.

1,391,588.

Patented Sept. 20, 1921.

2 SHEETS—SHEET 1.

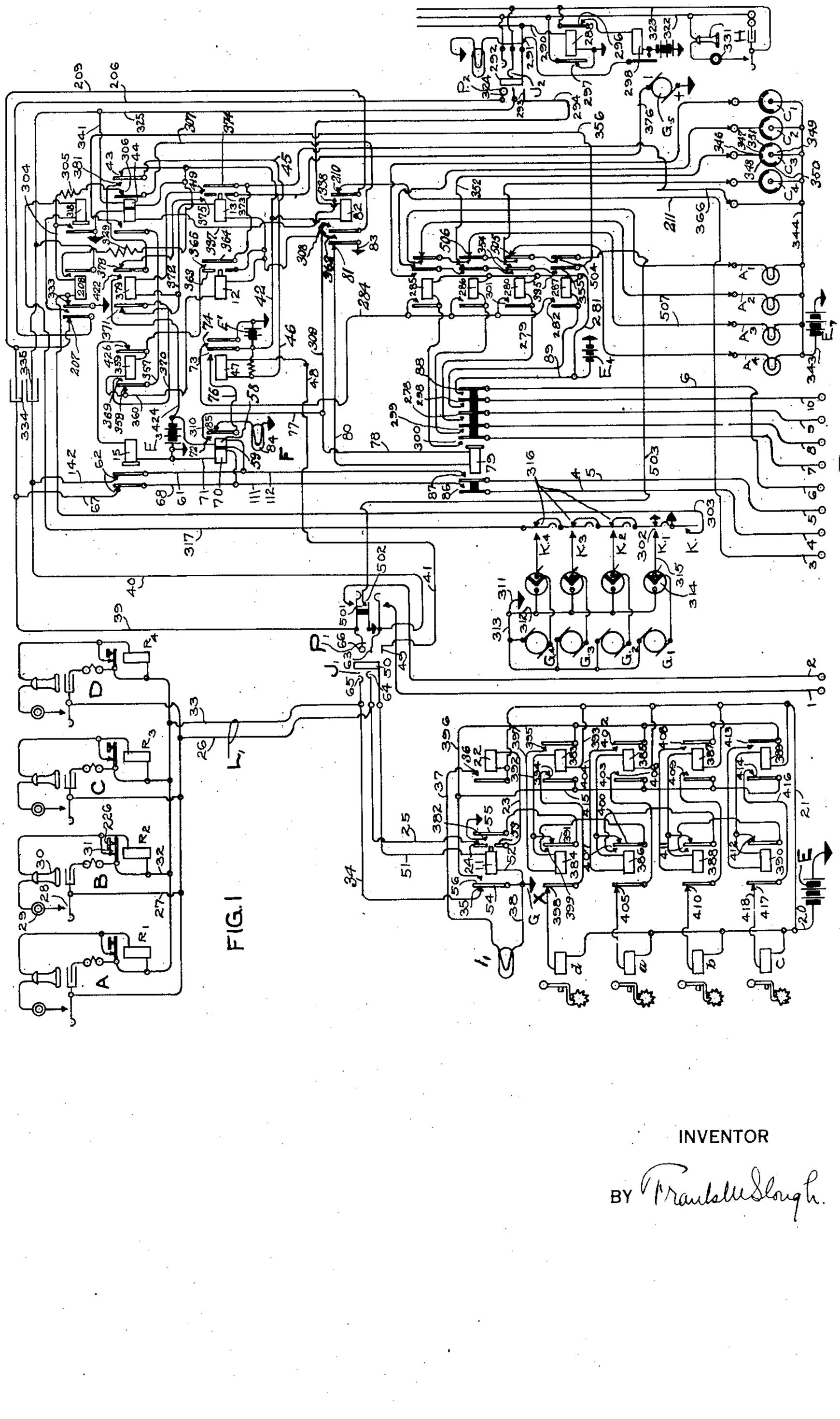

FIG. 1

INVENTOR

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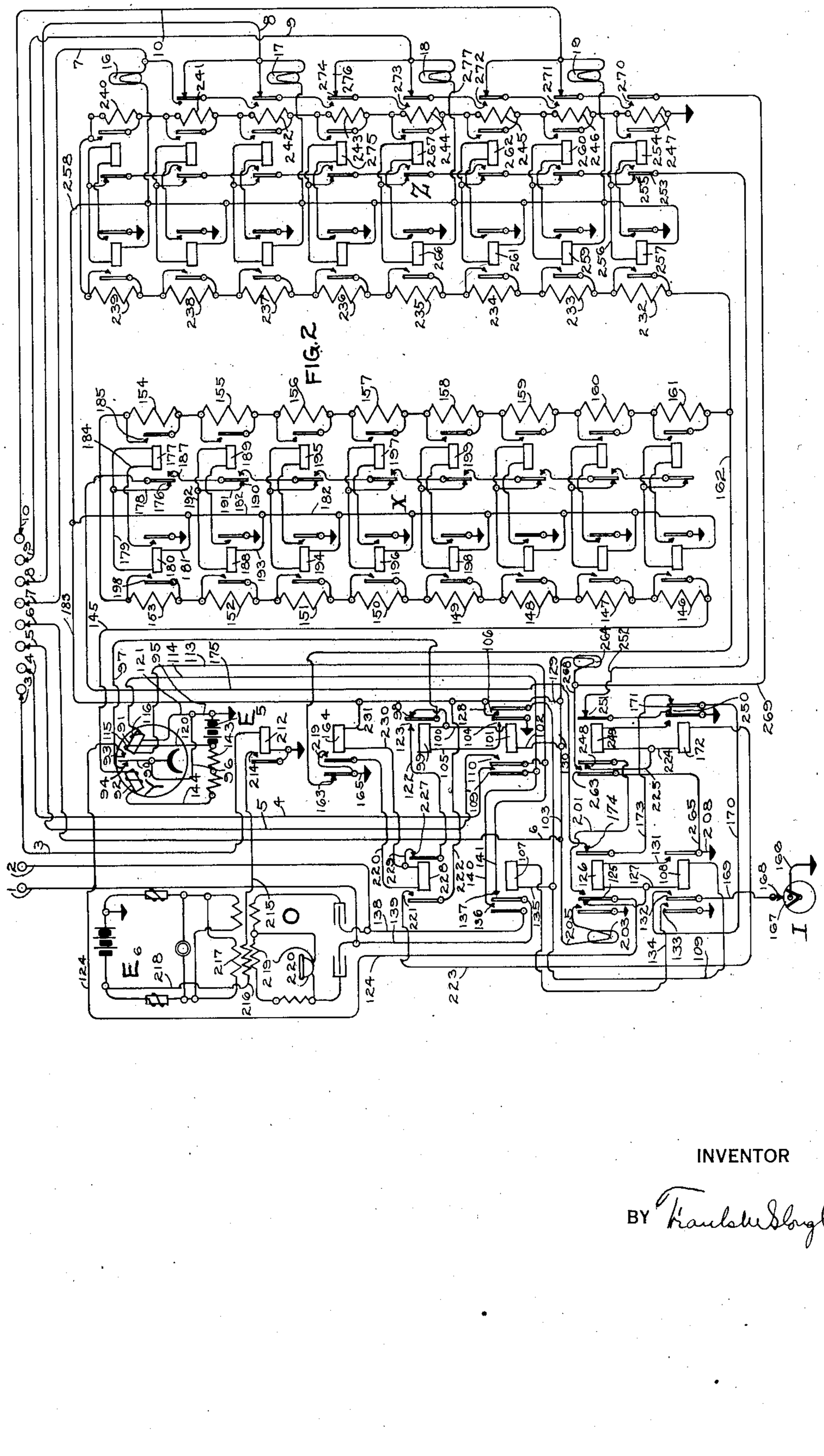

FIG. 2

INVENTOR

BY Frank M. Slough

UNITED STATES PATENT OFFICE.

FRANK M. SLOUGH, OF ROCHESTER, NEW YORK, ASSIGNOR TO THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

TELEPHONE-SERVICE SYSTEM.

1,391,588. Specification of Letters Patent. Patented Sept. 20, 1921.

Original application filed June 11, 1917, Serial No. 174,154. Divided and this application filed November 1, 1918. Serial No. 260,628.

To all whom it may concern:

Be it known that I, FRANK M. SLOUGH, a citizen of the United States, residing in Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Telephone-Service Systems, of which the following is a specification.

My invention relates to the measurement of telephonic service, and has more particularly to do with the selective indication and selective registration of telephonic calls originating in any one of the subscribers' stations connected with and served by a single telephone line.

This application is a division of my co-pending application, Serial No. 174,154, filed June 11, 1917.

Where charges for telephonic service are based upon the number of calls made by a subscriber and several subscribers' stations are served by the same telephone line, it becomes necessary in order correctly to apportion the charges among the various subscribers to provide for ascertaining at which one of the several stations of the line each call originates so that it may be entered up or charged against that station and, when the identity of the calling station has been determined, it is desirable to provide suitable registering mechanism associated with the lines for enabling the calls of the different stations to be separately recorded and totaled.

In accordance with the embodiment of my invention herein described and illustrated, I provide at the central office and associated with the line circuit to which are connected a plurality of telephones, registers, one for each of the telephones connected to the lines, and I furthermore provide central office apparatus adapted to be associated with the connecting circuit which at the time is used to complete the connection from the said line to a called line which operating in conjunction with the aforesaid registers and controlled by suitable resistance coils at each of the substations, serves to selectively register each call made, and to indicate visually to the operator which of the stations has initiated the call. I furthermore provide visual indicating means common to a plurality of connecting circuits under the control of the operator, for indicating to the operator at any time during a connection which of the parties of a party line has initiated the call.

Some of the central office controlling apparatus before mentioned, is individual to the connecting circuit used in completing the connection, the greater part of the apparatus however, is common to an operator's position, or common to a plurality of connecting circuits.

I provide means also to remove the resistance coil included in the line circuit of the calling substation to perform the selective function, after the said function has been performed. Other novel improvements will later appear.

Referring to the drawings, Figure 1, shows a line to which are connected four substations leading to a line circuit at the main exchange. At the main exchange this line circuit is composed of a line and a cut-off relay, and in addition eight register controlling relays whose functions will be later described; associated with these register controlling relays which are in pairs, are four registers corresponding each to one of the stations on the telephone party line.

A connecting circuit is also shown as indicated at F, same being provided in the embodiment illustrated, with terminal plugs at each end for connecting the connecting circuit with a calling and a called telephone line.

In addition to the relays for performing the supervisory listening and ringing control functions which are usual in such connecting circuits, I have provided additional relays for the purpose of properly controlling the selective indication and registration functions, and I have also associated with these relays the aforesaid relays in order to properly perform these last named functions.

Certain of the relays shown in the figure, are especially constructed to perform in a certain manner, the construction being more specifically described in my pending application, Serial No. 135,636, December 7, 1916; such relays are shown as 11, 12 and 13. Relays of other design, but having equivalent functions may however be employed in their place. These relays have a plurality of

armatures and a core extension; one of the armatures magnetically shielding the other. The shielded armature will not operate until the shielding armature has been fully attracted, thus lessening the shielding effect:—Therefore with such relays as 12 and 13, the shielding armature may be operated by rapid impulses of current without affecting the second armature at all, and the second armature may be so adjusted that the strength of current required to operate it must be increased over that required to operate the first or shielding armature. With such a relay as at 11, the first armature will be attracted on a certain value of current, and thereafter the second armature may be operated by intermittent impulses of current, provided the intermittent impulses are of a sufficiently increased value, the value of current sufficient to operate the first armature being not sufficient to even hold the second armature in its attracted position. I make use of such a relay adjustment only at 11; the relays at 12 and 13 being given only such an adjustment as will prevent the shielded armature from operating on rapid impulses of current, but the shielded armature will operate on these relays if the current is maintained in the circuit of the relay winding long enough.

Fig. 1 also shows interrupters c_1, c_2, c_3 and c_4 which each give a train of impulses comprising one long impulse and a varying number of short impulses, these interrupters serving to operate the relays 11, 12 and 13 according to their several characteristics, and to produce results as will be later described.

At the substations, resistance coils R_1, R_2, R_3 and R_4 are provided in the form of electromagnets; these resistance coils being of various resistances; the armatures for these electromagnets are capable of being manually depressed, and when so depressed the windings of the electromagnets are operatively connected to the circuit being normally short circuited. When operatively connected the electromagnets will maintain the depressed position of the armature by magnetical attraction until the circuit is opened at the contacts of the relay 15 as will be later described. The registers *a*, *b*, *c* and *d* are so constructed that they are not capable of being operated by rapid impulses of current, being sluggish in their action and requiring time to operate.

Fig. 2 shows a portion of the controlling apparatus common to a plurality of connecting circuits, and contains the apparatus required to translate the strength of current flowing into a definite number of step-by-step impulses of current which in turn cause signals to be displayed, and the register system of Fig. 1 to be selectively operated as will be later described.

Fig. 2 shows at Y a balanced relay, the armature of which stands normally in a mid position between electromagnets, and being controlled by the electromagnets is capable of being moved toward one or the other according to the relative strengths of the electromagnets, and when so moved will make electrical contacts, thus controlling the translating apparatus as will be later described.

The interrupter is shown at I, which being connected to one or the other of the groups of counting relays X and Z will cause these counting relays to be sequentially operated for a purpose later to be described. The group X may be called the balancing group of counting relays in that it is in effect a step-by-step rheostat current impulse operated, and serves to balance the balanced relay Y for varying line resistances of the lines to which the apparatus may be connected.

The group Z is the selective group and likewise is a kind of automatic step-by-step current impulse operated rheostat, and serves to balance against the resistance added to the line resistance by the inclusion of such a resistance electromagnet as may be inserted in the circuit as R_1, R_2, R_3 or R_4. Signal lamps are provided at 16, 17, 18 and 19 common to the group of connecting circuits served by the apparatus of Fig. 2, and are selectively operated to indicate which of the parties on the connected party line is operatively connected thereto.

Having thus above briefly described some of the apparatus of my invention, I will now to facilitate better understanding of the same, describe its operation in the embodiment illustrated.

In the first place at A, B, C and D are shown four substations connected to the limbs of a party line L_1. The line wires and the instruments, that is the transmitter and receiver of the instruments shown in the drawing may vary in resistance as they will vary in practice, and for the sake of description we will assume that the total resistance of the line wires and a calling one of the instruments above mentioned are equal to *x* ohms. We will assume also that it is the party at B that desires to make a call, and that the resistance of the electromagnet R_2 at the station B is *y* ohms. The subscriber at B making the call will take his receiver from the hook where it normally rests, and the hook will thereafter close its contacts in the usual manner to cause the display of the line signal at the main office. A controlling circuit therefor will be closed including the source of current E, conductors 20 and 21, the winding of the line relay 22, conductors 23, the normally closed contacts 24 of the relay 11, conductor 25, conductor 26 of the line L_1, conductor 27, now closed contacts 28

of the hookswitch of the telephone instrument at B, the transmitter 29, the receiver 30, the normally closed contacts 31 of the electromagnet R_2, the conductor 32, conductor 33 of the line L_1, conductor 34, the normally closed contacts 35 of the relay 11, and thence to ground at G which is connected to the positive pole of the source of current of battery E. Current will therefore flow over this circuit from the battery E energizing the relay 22 which will attract its armature closing its contacts 36 providing an operative circuit for the line lamp l_1 as follows:—from the negative pole of source of current E, the conductor 20, conductor 21, the now closed contacts 36 of the relay 22, the conductor 37, the line lamp l_1, the conductor 38, to the ground pole G of battery E. Current will now flow over this circuit operating the signal lamp l_1, and it will glow directing the attention of the operator to the call. The operator will then answer the call by inserting the plug P_1 into the jack J_1 of the calling line whereupon connection will be made between the talking limbs of the line 33 and 26 and the talking limbs of the connecting circuit 39 and 40, also between the winding of the cut-off relay 11 of the line circuit and the local operating strand 41 of the cord circuit.

The cut-off relay will be operated over a circuit as follows:—from the negative pole of battery E_1, the conductor 42, the normally closed contacts 43 of the supervisory relay 44, the conductor 45, the conductor 46, the winding of the relay 47, the conductor 48, the coöperating contacts 49 and 50 of the plug and jack switch J_1, the conductor 51, the winding of the cut-off relay 11, and conductor 52 leading to the ground pole G and back to battery E_1. This circuit being closed current will flow over the same energizing the relay 47 and the cut-off relay 11 of the line circuit causing them to attract their armatures, and switch circuits for purposes as will be described. The cut-off relay 11 being energized will attract its armatures 53 and 54, but will not attract its armature 55 because this armature is so adjusted as to require an increased flow of current to operate it as has been above mentioned. The armatures 53 and 54 being attracted will break the contacts 24 and 35 severing the connection of the line battery and line relay 22 with the limbs 34 and 25 of the line. Also a circuit will be closed by the making of the contacts 56 for a purpose later to be described.

The circuit of the line relay 22 being opened it will release its armatures opening its contacts 36, and retire the line signal l^1. The connecting of the talking conductors 39 and 40 of the connecting circuit to the talking conductors 26 and 33 of the line circuit will cause current to flow over these conductors and the line circuit over a path traced as follows:—from the negative pole of the battery E_3, the winding 58 of the answering supervisory relay 59, the conductor 61, the normally closed contacts 62 of the relay 15, circuit conductors 142 and 40, coöperating contacts of the plug and jack switch 63 and 64, circuit conductor 26 of the line circuit L_1, circuit conductor 27, the switch contacts 28 of the substation B, transmitter 29, receiver 30, now closed contacts 31 of the substation B, the circuit conductor 32, circuit conductor 33 of the line circuit L_1, coöperating contacts 65 and 66, the plug and jack switch P_1—J_1, circuit conductor 39, circuit conductor 67, circuit conductor 68, circuit conductor, the winding 70 of the relay 59, circuit conductor 71, and from thence to the ground pole of battery E_3. Current flowing over this circuit will energize the answering supervisory relay 59 causing it to attract its armature and close the contacts 72. The closing of these contacts completes a circuit which may be traced as follows, it being understood that the attraction of the armatures of the relay 47 had previously closed contacts 73 and 74; from the negative pole of the source of current at E_1, the now closed contacts 73 of the relay 47, now closed contacts 72 of the relay 59, circuit conductor 77, circuit conductor 78, the winding of the relay 79, the circuit conductor 80, now closed contacts 81 of the relay 82, circuit conductor 83 leading to the ground pole of the battery E_1.

Current will now flow over this circuit energizing the relay 79 which will attract its armatures, each of which closes contacts in circuits later to be described. If there were no subscriber on the line L_1 at the time connection was made with this line by the connecting circuit, the supervisory lamp 84 would be lighted through normal contacts 85 of the supervisory relay 59, and now closed contacts 73 of the relay 47 in the well-known manner. The relay 79 being operated, contacts 86, 87 and 88 will be closed for a purpose to be described; first, the contacts 88 being closed connects the source of battery current E_4 by means of conductors 89, 6, the conductors 6 of Fig. 2, and from thence to negative battery supply leads of Fig. 2, as will be later more specifically mentioned.

Referring now more particularly to Fig. 2, at Y is shown what has been termed a balanced relay. This relay has a balanced armature 90 standing midway between the poles of the electromagnets 91 and 92, and corresponding contacts 93 and 94. This is the position the armature would take if the electromagnets are equal in strength. However, with the circuits connected up as they are in the drawing of Fig. 2, and prior to the operation of the relay 79 of Fig. 1 which

as has been described, the armature would be attracted toward the pole of the magnet 92 closing the contacts 94. The circuit for the magnet 92 would be traced as follows:— from the negative pole of battery E_5, the resistance coil 143, the conductor 144, the winding of the electromagnet 92, conductor 145, the resistance coils 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160 and 161 in series, the conductor 162, the normally closed contacts 163 of the relay 164, and from thence to ground at 165. Over this circuit would pass current from the source of current E_5.

The resulting closure of the contacts 94 would be without effect so far as the operation of any of the circuits is concerned until such a relay is energized as the relay 79 of an associated connecting circuit, such as the connecting circuit shown in Fig. 1 whose operation is being described in connection with the circuits of Fig. 2, and which is designated in the drawing as connecting circuit F. Further the relay 79 being operated and battery being supplied to the common battery supply lead 6 of Fig. 2 as has been described, the closure of contact 94 will complete a circuit for current flow as follows:—from the ground pole of battery, the conductor 95, the conductor 96, the armature 90 of the balanced relay Y, the closed contacts 94 thereof, the circuit conductor 97, the normally made contacts 98 of the relay 99, the circuit conductor 100, the winding of the relay 101, circuit conductor 102, circuit conductor 103 to the common negative battery supply lead 6 whose further circuit has been previously traced through the contacts 88 of the connecting circuit 79 to negative pole of battery E_4. This will cause the operation of the relay 101, and this relay will attract its armatures for purposes to be described. First, the contacts 104 of the relay 101 are closed connecting the ground pole of battery through the circuit conductor 105 to the winding of the relay 99 thereby conditioning the relay 99 to operate in series with the relay 101 whenever the short circuit of the relay 99 from ground pole of battery to ground pole of battery through contacts 94 of the balanced relay Y is removed. However, for the moment the magnet 99 being short circuited will remain deënergized. The contacts 106 are also now closed to condition the relays 107 and 108 for operation, which operation will be later described.

The contacts 109′ and 110 of the relay 101 are also closed completing a circuit for the windings of the electromagnet 91, which windings are thereby placed in multiple with the windings 58 and 70 of the relay 59, and therefore the current flowing over the line and through the subscriber's instrument will be divided, part of this current flowing as has been described through the windings of the supervisory relay 59, and a part flowing over the divided circuit including conductors 111 and 112, the now closed contacts 86 and 87 of the relay 79 of Fig. 1, the circuit conductors 4 and 5, the circuit conductors 4 and 5 of Fig. 2, the now made contacts 109′ and 110 of the relay 101, the circuit conductors 113 and 114, the windings 115 and 116 of the electromagnet 91 and the conductors 120 and 121 leading to the negative and positive poles of the battery E_5.

In passing it may be stated that although a number of sources of battery current are shown in the drawing and designated by different characters, it is understood that all may be and are preferred to be the same battery, although different batteries may be used. But for convenience and simplicity of representation the batteries are shown in many places rather than to show common battery leads leading to a common battery.

The windings of the electromagnet 91 being placed in parallel therefore with the windings of the relay 59, the electromagnet 91 will be energized in proportion to the flow of current over the line wires leading to the subscriber's station, and will exert a pull upon the armature 90 tending to withdraw it from the position adjacent to the core of the electromagnet 92, and to cause it to close contacts 93 instead of contacts 94. At this point in the operation the strength of energization of the magnet 92 is arranged to be very weak as compared with the strength of energization of the magnet 91 when the magnet 91 is connected to any of the lines of the telephone system adapted to operate in connection with the apparatus described. In other words, the effect of the resistance of the circuit including the winding of the magnet 92 is arranged to be relatively high at this stage of the operation as compared with the effect of the line resistances. Therefore, when the magnet 91 is energized by current over a telephone line as just described, it will first withdraw the armature from the contacts 94 causing it to close contacts 93, this being the invariable operation with any of the lines with which it is proposed to operate this system. The opening of the contacts 94 destroys the short circuit previously mentioned which had been established around the winding of the electromagnet 99 from ground pole of battery to ground pole of battery, and the relay 99 will therefore now be operated over a circuit from the ground pole of battery, the now closed contacts 104 of the relay 101, circuit conductor 105, the winding of the relay 99, circuit conductor 100, the winding of the relay 101, circuit conductor 102, circuit conductor 103, and from thence to the negative pole of battery over the previously described circuit to negative battery including the common battery

supply conductor 6. The relay 99 being energized its armature will be attracted and open the contacts 98, and extend the conductor 97 to the conductor 122 by means of now closed contacts 123. However, this closure will be for the present impotent to produce any operative circuit change since the conductor 97 is now opened at the contacts 94 of the balanced relay Y. The circuit from the contacts 94 by means of conductor 97 being extended by conductor 122 for a purpose later to be described and operative when the contacts 94 are again closed as will be later described.

The armature 90 being caused to close contacts 93 as above related, a circuit is closed for the flowing of battery current as follows:—from the ground pole of battery, circuit conductor 95, circuit conductor 96, the armature 90 of the balanced relay Y, now closed contacts 93 thereof, circuit conductor 124, the normally closed contacts 125 of the relay 126, circuit conductor 127, the winding of the relay 108, circuit conductor 109, the now closed contacts 106 of the previously operated relay 101, circuit conductor 128, circuit conductor 129, circuit conductor 130, circuit conductor 103, and from thence to battery over the common battery supply conductor 6 whose circuit has been previously traced through contacts 88 of the connecting circuit relay 79 to the negative pole of battery. The relay 108 will therefore be operated by current flowing over the circuit just traced including its winding and the source of current, and it will attract its armatures producing circuit changes to be described. The contacts 131 are now closed conditioning a circuit for the winding of the relay 126, which winding will for the present however, be short circuited by having ground pole of battery connected to the opposite sides of the winding through contacts 131 of the relay 108 on the one side, and through contacts 125 of the relay 126, and through contacts 93 of the balanced relay Y on the other side. This short circuit will remain about the winding of the relay 126 until the contacts 93 are later opened as will be later described, and at which time the winding of the relay 126 will be connected in circuit with the relay 108 as will be later described.

When the relay 108 was energized the contacts 132 and 133 were also closed. The closing of the contacts 133 completes the circuit of the winding of the relay 107 as follows:—from the ground pole of battery, the contacts 133 of the relay 108, circuit conductor 134 and the winding of the relay 107, circuit conductor 135, the contacts 106 of the relay 101, circuit conductors 128, 129, 130, 103, and common negative battery conductor 6 leading to negative battery as has been described. Thus will the relay 107 be operated attracting its armatures and closing contacts 136 and 137.

The closing of these contacts connects the operator's circuit shown at O to the talking conductors of the connecting circuit which as has been described are now connected to the subscriber's telephone over the subscriber's line circuit, the connection being extended from the operator's circuit to the talking conductors of the connecting circuit by means of conductors 138 and 139, contacts 136 and 137 of the relay 107, conductors 140 and 141, contacts 109′ and 110 of the relay 101, conductors 4 and 5 of Fig. 1, the now closed contacts 86 and 87 of the connecting circuit relay 79, conductors 111 and 112, the normally closed pairs of contacts 62 of the releasing relay 15, and from thence by means of conductors 67 and 142 to the talking strands of the connecting circuit 39 and 40; and from thence to the subscriber's station. The operator is thus placed in conversational circuit with the subscriber and can request the number of the line desired in order to make connection. While she is doing this, the apparatus of Fig. 2 is performing the line balancing function, namely—balancing the apparatus of Fig. 2 for the particular line resistance of the calling line including line wires, telephone substation apparatus of the calling station, etc. This is necessary because many lines vary considerably in resistance also the telephone substation apparatus may vary in resistance, and it is desired to reduce all of the lines to a common basis before proceeding further with the operation of the system.

The balancing function is performed by the reduction of the resistance of the circuit of the winding of the magnet 92. This is accomplished by operating a certain number of the relays of the group X, and therefore at this stage of the operation these relays are operated one at a time, until sufficient resistance has been cut out of the circuit by the short circuiting of the proper number of resistance coils 146 to 161 inclusive. This is done as follows:—When the relay 108 was operated its contacts 132 were closed and a circuit completed including the intermittent contact maker or interrupter I, and the relays of the group X in sequence, operating these relays in order, the operated relays being operatively locked after being energized, each of the relays short circuiting one of the resistance coils above mentioned when the relay is energized. The method of operating these relays and the circuits to cause their operation will now be described. The first circuit completed leads from the ground pole of battery conductor 166, the segment 167 of the interupter I, the brush 168, conductor

169, now made contacts 132 of the relay 108, circuit conductor 170, normally made contacts 171 of the relay 172, circuit conductor 173, now made contacts 174 of the relay 126, circuit conductor 175, now closed contacts 176 of the relay 177, circuit conductor 178, circuit conductor 179, the winding of the relay 180, circuit conductor 181, circuit conductors 182, 183, 129, 130, 103, and the common battery supply conductor 6 leading to conductor 6 of Fig. 1, through now closed contacts 88 of the relay 79 to the negative pole of battery E_4. Thus will the relay 180 be operated by current flowing over this circuit and through its winding and will attract its armature closing its contacts. The right hand contact being closed will condition the relay 177 for operation whenever the segment 167 of the interrupter I breaks contact with the brush 168 thereof, thus removing the short circuit now established around the winding of the relay 177 from the ground pole of battery to the ground pole of battery.

The contacts 198 being closed will short circuit the resistance coil 153 in the circuit of the magnet 92 of the balancing relay Y, thereby strengthening the energization of this magnet a definite amount. We will assume that it does not strengthen it enough to cause it to withdraw the armature 90 of the relay Y from its position where it contacts with the contact 93. In such a case the intermittent interrupter I will revolve until the connection between the conductor 166 and the conductor 169 by means of the brush 168 and the segment 167 is broken, whereupon the short circuit will be removed from about the winding of the relay 177, and the relay 177 will thereupon be energized, attracting its armatures for purposes later to be described.

The energizing circuit for the relay 177 will now be as follows:—from the ground pole of battery, now closed contacts of the relay 180, circuit conductor 184, the winding of the relay 177, circuit conductor 179, the winding of the relay 180, circuit conductor 181, and from thence to negative battery and over the path which has been previously described, comprising in part the conductors 182, 183, 129, 130, 103, conductor 6, etc. The relay 177 thus being energized by current flowing over this circuit and attracting its armatures will cause an additional reduction of resistance in the circuit of the magnet 92 by the closing of contacts 185 which short circuits resistance coil 154. We will assume that the increased flow of current through the winding of the magnet 92 resulting from the short circuiting of this additional resistance coil 154 is still insufficient to cause this magnet to be sufficiently energized so as to withdraw the armature 90 from a position where the contacts 93 will be broken.

The armature of the relay 177 being attracted will break the contacts 176 and close contacts 187, extending the circuit including the interrupter I from the pair of relays 180—177 to the pair of relays 188—189, and the interrupter I continuing to revolve and again causing the segment 167 to contact with the brush 168, a circuit will be closed comprising the winding of the relay 188, and which circuit is very nearly the same as that previously described upon the winding of the relay 180, the circuit being as follows:—from the ground pole of battery, the conductor 166, segment 167 of the interrupter I, brush 168, circuit conductor 169, contacts 132 of the relay 108, circuit conductor 170, normally closed contacts 171 of the relay 172, circuit conductor 173, normally closed contacts 174 of the relay 126, circuit conductor 175, now closed contacts 187 of the relay 177, normally closed contacts 190 of the relay 189, circuit conductors 191 and 192, the winding of the relay 188, circuit conductors 193, 182, 183, 129, 130, 103, 6, 6 of Fig. 1, and the now closed contacts 88 of the relay 79 and conductor 89 to the negative pole of battery E_4.

Over this circuit current will flow from the source E_4 energizing the relay 188 which will now attract its armatures, just as was the case with the relay 180 of the first pair of relays 180—177 conditioning a circuit for the subsequent operation of the second relay 189 of the pair and short circuiting the resistance 152 in the circuit of the magnet 92. The relay 189 is for the present inoperative because of the short circuit about its winding, comprising in part the contacting brush and segment of the interrupter I, just as was the case in the relay 177 of the first pair of relays, and the relay 189 will be subsequently operated whenever the interrupter I interrupts the circuit of the short circuiting conductor leading to the ground pole of battery.

Assuming that the energization due to the short circuit of the resistance 152 is still insufficient to operatively change the position of the armature 90 of the balanced relay Y, the interrupter I breaking the circuit of the conductor leading to it will cause the relay 189 to operate in a manner which will now be understood, and in turn the circuit of the conductor 175 will be extended to the pair of relays 194 and 195 which will in turn short circuit their associated resistances 151 and 156, and this action will continue with successive pairs of relays—such as 196—197, 198—199 until enough of the associated resistance coils all of which are serially connected in the circuit of the winding of the magnet 92 of the balancing re-

lay Y have been cut out of this circuit thereby increasing the flow of current sufficient to cause the balancing relay Y to operatively move the armature 90 of the balancing relay Y to open the contacts 93 thereof.

At this stage of the operation the current from over the line energizing the electromagnet 91 produces approximately the same effect on the armature 90 as the electromagnet 92 included in circuit with the resistance coils 146 to 161 inclusive. In other words, enough of the resistance coils 146 to 161 have been cut out of circuit to produce an over-balanced condition of the relay Y, the number of coils necessary to be cut out depending upon the resistance of the line and circuit conductors, and apparatus contained therein. Exact balance is not required.

The opening of the contacts 93 removes the restraining short circuit about the winding of the relay 126 previously noted, and the relay 126 will attract its armatures for the purposes to be related later; the energizing circuit for the relay 126 leading from the ground pole of battery, circuit conductor 208, the now closed contacts 131 of the relay 108, the winding of the relay 126, circuit conductor 127, the winding of the relay 108, circuit conductor 109, the now closed contacts 106 of the relay 101, circuit conductors 128, 129, 130, 103, 6, 6 of Fig. 1, the now closed contacts 88 of the relay 79, and circuit conductor 89 leading to the negative pole of battery E_4. Over this circuit current will flow energizing the relay 126. The contacts 174 leading to the group of relays X will now be opened, these contacts being interposed in the circuit conductors leading to the group of relays X from the interrupter I so that the group of relays X will be from now on in the operation of the system unaffected from the interrupter I.

Conductor 124 is now disconnected by the breaking of the contacts 125 of the relay 126 from the winding of the relays 126 and 108, and is extended by means of circuit conductor 201 and now made contacts to form a permanent energizing circuit for the relay 172 as will be described, this occurring whenever the contacts 93 of the balancing relay are again closed as will be later described.

An energizing circuit is now closed for the signal lamp 203 as follows:—from the ground pole of battery, now closed contacts of the relay 126, the signal lamp 203, circuit conductors 205, 6, 6 of Fig. 1, the now closed contacts 88 of the relay 79, and circuit conductor 89 to the negative pole of battery E_4. Current will flow over this circuit energizing the signal lamp 203 and apprising the operator that she is operatively connected to the telephone line to which she had previously made connection with the plug P_1 of the cord circuit F; and apprising her that the balancing function is complete.

The operator will now upon observing the signal lamp 203 which is now lighted, advise the calling subscriber to depress his register button, such as 226 if it is the station B calling, and this being done the short circuit about the winding R_2 formed by contacts 31 of the button 226 will be removed, and the button 226 being in part an armature for the electromagnet R_2, the key will remain depressed as long as battery from over the line flows through the winding of the resistance electromagnet R_2; and the contacts 31 will remain open as long as current flows over the line. The depressing of this button will add to the resistances included in the line conductor 32 by an amount equivalent to the resistance *y* of the electromagnet R_2, and this resistance being different for the different stations on the line, the resistance of the electromagnet will be a measure to indicate which of the stations is calling; the method of translating this measure will be now described. The line resistance being thus increased, the current through the windings of the electromagnet 91 which is in circuit with the line will be decreased, and the contacts 94 of the balanced relay Y will be again closed.

This completes a circuit for the relay 164 as follows:—from the ground pole of battery, conductor 95, conductor 96, armature 90, the now closed contacts 94 of the balanced relay Y, conductor 97, now closed contacts 123 of the relay 99, circuit conductor 122, normally closed contacts 227 of the relay 228, circuit conductors 229 and 230, the winding of the relay 164, circuit conductor 231, 129, 130, 103, 6, 6 of Fig. 1, now closed contacts 88 of the relay 79, and thence over conductor 89 to negative pole of battery E_4. Current flowing over this circuit will cause the relay 164 to be energized and will attract its armatures, and close contacts 219 and open contacts 163. The closure of the contacts 219 will condition a circuit for the operation of the relay 228 whenever the short circuit placed about the winding of the relay 228 has been removed by the further operation of the contacts of the balancing relay Y. This short circuit comprises the ground pole of battery placed on either side of the winding by means of contacts 94 of the balancing relay Y, and contacts 219 of the relay 164. The relay 228 is therefore inoperative until this short circuit is removed as will be later described, when the contacts 94 of the balancing relay Y are opened. The contacts 163 now being broken cause a sudden increase to be effected in the resistance of the associated circuit of the

winding of the electromagnet 92 of the balancing relay Y, this sudden increase in resistance being the operative inclusion of the resistance coils 232 to 247 inclusive. The circuit of the conductor 162 normally leading through contacts 163 of the relay 164 to the ground pole of battery being interrupted, the circuit of the conductor 162 now leads to ground through all of the resistance coils 232 to 247 inclusive.

In the system of my invention the sum of these resistance coils 232 to 247 inclusive is arranged to be sufficiently high that it will more than counter-balance the effect upon the balanced relay Y, produced by the inclusion of any of the resistances R_1, R_2, R_3 and R_4 in the circuit of the electromagnet 91 of the balancing relay Y. Therefore, the balancing relay Y will now be affected by the inclusion of this added resistance in the circuit of the electromagnet 92 to so decrease the energization of the electromagnet 92 that the electromagnet 91 will be overpowering in its effect upon the armature 90, the contacts 94 of the balancing relay Y will be opened, and then the contacts 93 will be closed. The opening of the contacts 94 removes the short circuit which has been described as having been placed about the winding of the relay 228 so that the relay 228 is operated, its winding being placed in serial circuit with the winding of the relay 164 across the poles of battery. The energizing circuit now being from the ground pole of battery, contact 165, closed contacts 219 of the relay 164, conductor 220, the winding of the relay 228, conductor 230, the winding of the relay 164, conductor 231, and from thence to negative pole of battery over conductor 129, 130, 103, 6, 6 of Fig. 1, contacts 88 of the relay 79, and circuit conductor 89.

The relay 228 being operated will break the contacts 227, thus opening the extended circuit of the contacts 94 so that they will no longer be effective in the operation of the system, and the contacts 221 will be closed completing a circuit from the negative pole of battery from the common battery supply conductor 6 to the winding of the relay 172 as follows:—negative battery supply conductor 6, conductors 129—222, the contacts 221, circuit conductor 223, the winding of the relay 172, and from thence over conductors 224 and 225, normally made contacts 248 of the relay 249, conductor 201, closed contacts of the relay 126, conductor 124, through the just closed contacts 93 of the balancing relay Y, the armature 90 thereof, circuit conductor 96, conductor 95 to the ground pole of battery. This will cause the relay 172 to be operated extending the circuit leading from the ground pole of battery through the interrupter I, to the group of relays Z. These relays are now in operative circuit arranged to be sequentially operated one at a time in a manner identical to the sequential operation of the group of relays X, and the details of this sequential operation it is therefore unnecessary to relate except with the circuit by which the interrupted connection to ground is carried through the interrupter and through the group of relays thereof traced as follows:—from the ground pole of battery, conductor 166, the segment 167 of the interrupter I, the brush 168 thereof, the conductor 169, the now closed contacts 132 of the relay 108, circuit conductor 170, now closed contacts 250 of the relay 172, normally closed contacts 251 of the relay 249, circuit conductor 252 leading to the armature 253 of the relay 254, and thence to normally closed contacts 255 thereof over circuit conductor 256, through the winding of the relay 257, the conductor 258, the conductor 183, and from thence to the common negative battery supply conductor 6 by means of conductors 129, 130 and 103.

In passing it will be seen that the common negative battery supply conductor 6 controlled by contacts 88 of the relay 79 of Fig. 1 controls the entire connection with negative battery of all the circuits local to Fig. 2, and these circuits will therefore be restored to normal whenever these contacts 88 are opened.

The circuit just traced for the relay 257 establishes a path for battery through the interrupter I, and this interrupter will operate this relay, and in turn the associated relay 254 and later, relays 259, 260, 261, 262, etc., or until enough of these relays of the group Z have been operated, and enough of the associated resistances 232, 247, 233, 246, 234, 245, etc. have been short circuited; and the resistance of the entire circuit in which they are included sufficiently decreased to allow a sufficient current to flow over this circuit and through the winding of the electromagnet 92 to cause this electromagnet to overpower the effect of the electromagent 91, at which time circuit changes will be effected as will be later related. One of these circuit changes is the removal of the short circuit heretofore existing about the winding of the relay 249, consisting in part of the circuit conductor 225, the contacts 248 of the relay 249, circuit conductor 201, contacts 202 of the relay 126, circuit conductor 124, contacts 93 of the balancing relay Y and the armature 90 thereof which is connected to the ground pole of the source of current. The armature 90 in response to the current flowing through the electromagnet 92, before described, breaks the contacts 93 and the short circuit about the winding of the relay 249 is removed and the relay 249 is thereby operated in series with the relay 172 and closed contacts thereof.

At the time the relay 249 was operated

contacts 248 were opened, thus disconnecting the initial operating wire 201 from the relays 249 and 172. Also the contacts 263 were closed at which time the signal lamp 264 will be lighted over a circuit comprising the common negative battery supply conductor 6, circuit conductors 103 and 130, the signal lamp 264, the conductor 268, contacts 263 of the relay 249, the conductor 265, and from thence to the ground pole of battery over conductor 208. Also the closure of the contacts 263 will condition for operation the signal lamps 19, 18, 17 and 16 whose circuit will be completely established upon the operation of the proper number of the relays of the group Z 257, 254, 259, 260, 261, 262, etc., as will be later related. The lighting of the signal lamp 264 is an indication to the operator that the subscriber has obeyed instructions and has depressed the registration button.

We will assume for the sake of description that when the resistances 232, 247, 233, 246, 234, 245, 235 and 244 have been short circuited by their associated relays that the elimination of the resistances of these coils is enough to cause the balancing relay Y to again be momentarily balanced, therefore, the amount of resistance contained in these coils is a rough measure of the amount of resistance added to the circuit of the telephone line by the inclusion of the resistance electromagnet R_2 of the substation, and therefore, again the number of operated relays associated with these resistance coils, each of which short circuits its associated resistance coil, is also a rough measure of the resistance y of the coil R_2.

Now lamps 19, 18, 17 and 16 are operatively connected across the terminals of the battery, the particular lamp connected depending upon the particular number of relays of the group Z which are opened. As the relays 257, 254, 259, 260, etc., are successively operated, the lamps 19 18 17 and 16 or some of them depending upon the number of relays operated will be successively flashed. With the assumption that the relays 257, 254, 259, 260, 261, 262, 266 and 267 alone are operated to cause the balanced condition of the relay Y then signal lamp 18 will be continuously connected across the terminals of battery over a circuit as follows:—from the ground pole of battery, conductor 208, conductor 265, the contacts 263 of the relay 249, circuit conductor 269, now made contacts 270 of the relay 254, the now made contacts 271 of the relay 260, the now made contacts 272 of the relay 262, the now made contacts 273 of the relay 267, the normally made contacts 274 of the relay 275, circuit conductor 276, the signal lamp 18, circuit conductor 277, circuit conductor 258, circuit conductor 183, circuit conductors 130, 103, the common negative battery supply conductor 6, and from thence to the negative pole of battery through the controlling contacts 88 of the relay 79 of Fig. 1.

It will be seen that if the relay 275 had also been operated it would be the lamp 17 which would remain lighted, and in like manner either of the other lamps 16 or 19 might have remained lighted depending upon the number of the relays of the group Z operated. At the time the lamps 19, 18, etc., are successively flashed there will be a momentary flow of current over divided circuits of these lamps, including conductors 10, 9, 8 or 7 as the case may be depending upon the number of relays operated, and the successive momentary current impulses transmitted over these conductors will be carried through the contacts 298, 278, 299 and 300, or a certain number of these contacts successively, operating relays 287, 280, 286 and 285 or a certain number of these relays. Such of these relays as may be operated will be locked in circuit through their own contacts, and over circuit conductors individual to the connecting circuit F.

Assuming as we have, that only the relays 257, 254, 259, 260, 261, 262, 266 and 267 are operated to balance the relay Y, then in such a case the relays 287 and 280 will be successively operated and locked in circuit, the relays 286 and 285 remaining inert. The first armature of the relay 287 will be operated closing contacts 282 which establishes a locking circuit for the relay 287 independent of the circuits of Fig. 2; and individual to the connecting circuit F traced as follows:—from the ground pole to battery E_1, the now closed contacts 74 of the relay 47, conductor 284, the now made contacts 282 of the relay 287, the winding of the relay 287, and circuit conductor 281 leading to the negative pole of battery E_4. Current flowing over this circuit will keep the relay 287 energized until the connection is taken down, and the relay 47 deënergized and its contacts 74 released. The relay 280 will also close its first pair of contacts 301 which will establish a like locking circuit over the same conductors as the locking circuit for the relay 287, and these two relays will in like manner remain energized for the balance of the connection. The relays 280 and 287 also attracted their right armatures switching circuits later to be described.

It will be seen that the particular substation on the line L_1 calling by the particular resistance coil R_1, R_2, R_3, or R_4 of the substation which has been inserted in the line circuit, determines the number of the relays of the group Z, and therefore the number of the relays 287, 280, 286 or 285 which will be operated and the number of the last named group operated conditions circuits as will be later described to properly regis-

ter the call against the particular calling station. At this stage of the operation of the system, the operator has before her glowing one of the lamps 16, 17, 18 or 19 to indicate which of the parties of the line is calling. Also included in the connecting circuit F being used, are operated a certain number of the individualized relays 285, 286, 280 and 287. Under the assumptions we are making in this description, the relays 287 and 280 are operated to control selective circuits as will be later described.

During this period the operator is in conversational circuit with the subscriber and having learned the number of the line desired, will thereupon make the usual busy test by touching the tip of the plug P_2 to the thimble of the jack J_2, and if the line is busy battery potential will be found upon the thimble of this jack and will be carried through a winding inductively linked with the operator's telephone set over a circuit comprising conductor 206, contacts 207, conductor 209, contacts 210 of the relay 82, circuit conductor 211, 3, 3 of Fig. 2, the winding of the busy test relay 212, and from thence to the ground pole of battery. If the line is busy the flow of current over this circuit in the ordinary way will attract the armature of this relay causing current to flow from the ground pole of battery, the now closed contacts 214 of the relay 212, conductor 215, the winding 216 of the induction coil 217, conductor 218 leading to the negative pole of battery E_6. This flow of current will be momentarily translated through the circuit comprising the winding 219 of the induction coil 217 and the operator's received 220, and cause a "click" to be heard by the operator apprising her that the line is busy. If the line is busy the operator will so apprise the subscriber and will withdraw the plug P_1 from the jack J_1 retoring all of the circuits to normal condition.

However, if the line is not busy the operator will insert the plug P_2 in the jack J_2 of the called-for line making connection therewith, and she will furthermore depress the ringing key K_1 to ring the called-for subscriber, and the depressal of this key will also operate contacts K assisting in the etablishing of the ringing condition as will be later decribed.

If the called-for line is a party line, which we will assume is not the case in this description, other of the ringing keys such as K_2, K_3 or K_4 will be depressed connecting different ringing generators as G_1, G_2, G_3 or G_4 will be connected to the circuit of the line depending upon which key is depressed. The ringing circuits illustrated are not new and are not claimed as such in this application, being the ordinary harmonic selective party line system associated with a common form of automatic ringing systems. The circuits thereof will be later briefly described.

When the plug P_2 was inserted into the jack J_2 a circuit was established local to the exchange as follows:—from the ground pole of battery, the winding of the relay 288, conductor 290, conductor 291, the thimble 292 of the jack J_2, the shank 293 of the plug P_2, conductor 294, the winding of the relay 82, and conductor 42 leading to the negative pole of battery E_1. Current will flow over this circuit energizing relays 82 and 288 which will attract their armatures switching circuits later to be described.

The relay 288 is the original cut-off relay of the called line L_2, and its armatures being attracted will break contacts 296 and 297 disconnecting the line relay 298 and its energizing circuit from the circuit of the line wires in the usual manner. Contacts 81 of the relay 82 will be broken opening the circuit of the relay 79, and thereby opening the circuit of the conductor 6 at the contacts 88; this connection 6 being what I have termed the common negative battery supply conductor for the local circuits of Fig. 2, and these circuits will therefore all be restored to normal.

The conductors 3, 4, 5, 6, 7, 8, 9 and 10 which lead through contacts 86, 87, 300, 299, 278, 298 and 88 of the relay 79 all being broken at these contacts and the circuits controlled over these conductors as shown in Fig. 2 will all be restored to normal.

The relays 287 and 280 previously mentioned as being operated through contacts 298 and 278 of the relay 79 will remain operated over the local locking circuit previously described.

The operator having depressed the particular selective key K_1, K_2, K_3, of K_4 to ring the desired party, for instance, the key K_1 to ring the bell of the substation H on the line L_2 which line is an individual line, the contacts 302 will be closed on the key K_1, and the contacts of the key K will also be momentarily closed. The last named contacts being closed a circuit will be formed as follows:—from the ground pole of battery through the contacts of the key K, circuit conductor 303, the winding of the ringing relay 208, the circuit conductor 304, the resistance coil 305, the normally made contacts 306 of the relay 44, circuit conductor 307, the now closed contacts 308 of the relay 82, circuit conductor 309, circuit conductor 77, now closed contacts 72 of the relay 59, the circuit conductor 76, the now closed contacts 73 of the relay 47, to the negative pole of battery. Current will flow over this circuit and energize the relay 208 which will attract its armatures to perform the ringing function. The contacts 333 will be closed to form a locking

circuit to the ground pole of battery for this relay independent of the circuit to ground comprising the conductor 303 and the momentarily closed contacts K of the ringing key.

When this is done a path for the ringing current will be completed from the generator G_1 to the bell of the called-for subscriber at substation H as follows:—from the ground pole of generator, circuit conductor 311, and from thence alternately over the circuit conductor 312 or 313 through the interrupter 314, or the generator G_1 and interrupter 314, and from thence over the circuit conductor 315 through contacts 302 of the key K_1 through the series contacts 316 of the other keys over circuit conductor 317, the winding of the trip relay 318, circuit conductor 319, the now made contacts 207 of the relay 208, circuit conductor 206 to the tip of the plug P_2 and the coöperating tip spring of the jack J_2 over the limb 322 of the line L_2 through the bell and condenser of the substation H over the line conductors 323 leading to the sleeve spring of the jack J_2, and from thence to the coöperating sleeve of the plug P_2, the circuit conductor 325 now closed right contacts of the relay 208 the resistance coil 329, and circuit conductor 42 to the negative pole of battery E_1.

The bell of the subscriber will continue to ring until the response of the called-for subscriber who responds by taking his receiver from the hook bridging the line conductors 322 and 323 by his telephone set comprising a transmitter and receiver 331, whereupon the relay 318 will effectively short circuit the winding of the relay 208 by means of the contacts of the relay 318, and the relay 208 will release its armatures, and the locking circuit for the relay comprising contacts 333 will be broken. The talking strands of the cord circuit will be connected through from the plug P_2 to the plug P_1, the circuit comprising in part the contacts 207 of the relay 208, and the condensers 334 and 335, and the conductors 39 and 40. Also a path for the supplying of talking battery to the substation transmitter of the substation H will now be complete traced as follows:—from the ground pole of battery, the left-hand winding of the relay 44, circuit conductor 337, and now closed contacts 338 of the relay 82, circuit conductor 209, the normally closed contacts 207 of the relay 208, the circuit conductor 206 leading to the tip of the plug P_2, the tip spring of the jack J_2, line conductor 322, the substation transmitter and receiver 331 of the substation H, line conductor 323, the sleeve spring of the jack J_2, the sleeve of the plug P_2, conductor 325, circuit conductor 341, the right-hand winding of the relay 44, conductor 42 leading to the negative pole of battery E_1. The relay 44 is the supervisory relay and will now be energized by current flowing over the circuit just traced and will attract its armatures switching circuits to be described. First the contacts 306 of the relay 44 will be broken preventing the operator from ringing on the subscriber's line while the subscriber is on the line, this in the well-known way by interrupting the circuit of the relay 208. Also the left contacts of the relay 44 will be closed completing a circuit including a particular one of the commutators c_4, c_3, c_2 and c_1 used to perform the register selection and register operation functions. Since I assume that it is the substation B on the calling line which initiated the connection and that by the act of the B subscriber depressing the button 226 of his instrument, the resistance coil R_2 automatically operated the relays 287 and 280 of the cord circuit the commutator c_3 will be effective to perform the above functions. The first circuit effected thereby is as follows:—from the negative pole of battery E_7, circuit conductor 343, circuit conductor 344, the commutator c_3, and as the commutator revolves we will assume that the brush thereof 346 comes first into contact with the segment 347, and thereafter the segment 348 and later 349, the insulating segment 350, and finally the conducting segment 351.

It will be seen that certain of the segments, namely, 351, 347 and 348 make contact with the brush 346 for a very short period of time, and that the segment 349 is wider and will therefore make contact for a relatively longer period of time. The insulating segment 350 will also make contact with the brush for a relatively long period of time. The circuits are so arranged as will be described so that no operative function will be performed therein during the revolution of the commutator until the large conducting segment 349 makes contact with the brush 346, and thereafter each of the segments will perform an operative function. For instance, assume now that the segment 347 makes quick passing contact with the brush 346, the circuit which I have started to describe will pass through this quick passing contact and through the brush 346, and over circuit conductor 352, the normally made contacts of the relay 286, the now made contacts 354 of the relay 280, the now made contacts 355 of the relay 287, circuit conductor 356, the now made contacts of the relay 44, circuit conductor 357, the normally closed contacts 358 of the relay 359, circuit conductor 360 through the winding of the relay 12, through contacts 362 and circuit conductor 83 to the ground pole of battery. Current will flow over this circuit including the winding of the relay 12, and it will attract its quick acting armature 363 only, and as this armature does not perform any

operative function so far as the circuits are concerned its operation will be futile.

The slow acting armature 364 being shielded by the quick acting armature 363, or being made slow acting in any other suitable manner, will not be attracted by the quick impulse of current passed through the short contact 347, nor will it be operative by impulse of current passed by the other contact 348, but later when the long contact 349 passes current to the brush 346 contact will be made for a long enough time to fully operate the armature 364 to cause it to close contact 365, thus conditioning the relay 359 for operation, but which relay at the present time will not be operated due to there being a short circuit placed about its winding by the segment 349 leading to the negative pole of battery.

The contacts 365 of the relay 12 will close another circuit however for the relay 15 traced as follows:—from the ground pole of battery, the winding of the relay 15, the normally made contacts 426 of the relay 359, the now closed contacts 365 of the relay 12 and circuit conductors 366, 344 and 343 to the negative pole of battery E_7. Current flowing over this circuit will operate relay 15 attracting its armatures and breaking contacts 62 which will interrupt the flow of battery current to the subscriber's instrument B and through the resistance electromagnet R_2 which has been described as at the time energized maintaining contacts 31 opened, and the supply of current being interrupted by the contacts 62, the electromagnet R_2 will be deënergized restoring the short circuiting contacts 31 to normal operative condition, and the substation instrument will be connected to the line wires instead of through the resistance of the coil R_2.

Now later upon the commutator c_3 advancing to the position wherein the brush 346 rests upon the wide insulating segment 350, the relay 359 will be operated over a circuit traced as follows:—from the negative pole of battery E_7, circuit conductors 343, 344, and 366, the now closed contacts 365 of the relay 12, circuit conductor 368, the winding of the relay 359, circuit conductor 360, the winding of the relay 12, now closed contacts 362 of the relay 82, circuit conductor 83, and from thence to the ground pole of battery. The relays 359 and 12 will thus be locked in operative circuit and both will maintain their armatures attracted. The circuit of the impulse transmitting wire from commutator c_3 is now extended to the relay 13 by means of now made contacts 369 of the relay 359, circuit conductor 370, normally closed contacts 371, circuit conductor 372, the winding of the relay 13, circuit conductor 361, the now closed contacts 362 of the relay 82, and from thence to the ground pole of battery. The contacts 426 of the relay 359 will now be opened restoring the relay 15 to normal position and reconnecting the source of battery supply to the subscriber's line. The quick acting armature of the relay 13 is the armature 373, and it will respond to the rapid impulses of current from the next passing short contacts 351, 347 and 348 while the slow acting armature 374 is inoperative. Thus the contacts 375 will be rapidly and intermittently closed three times when the commutator c_3 is in circuit with it, and the contacts 375 being thus rapidly closed will complete a circuit comprising the high voltage direct current generator G_5, and electroresponsive apparatus in the circuit of the line as will be later described. The circuit is traced as follows:—from the ground pole of the high voltage generator G_5 through the said generator entering by way of the opposite pole and line by way of the negative pole thereof, circuit conductor 376, the intermittently closed contacts 375 of the relay 13, the normally closed contacts 378 of the relay 379, the now closed contacts 381 of the supervisory relay 44, circuit conductor 45, and for the major portion of the current, the circuit conductor 46, the winding of the relay 47, circuit conductor 48, circuit conductor 41, the shank 49 of the answering plug P_1, the coöperating thimble 50 of the jack J_1 of the calling line, the circuit conductor 51, the winding of the cut-off relay 11, and the circuit conductor 52 to ground. This will cause a considerably increased current to flow over the circuit including the winding of the cut-off relay 11, and the relay 11 will operate its slow armature 55 once for each of the short segments 351, 347 and 348 of the commutator c_3. The armature 55 thus responding to the rapid impulses of current, contacts 382 will be intermittently and rapidly operated to operate in sequence the relays 383, 384, 385, 386, 387 and 388, and if there are enough impulses, 389 and 390.

The number of impulses, and therefore the number of these relays operated will depend upon which one of the commutators c_1, c_2, c_3 or c_4 is included in the impulse sending circuit just described.

We will now describe the circuits involved in the operation of the relays under the assumption that it is the commutator c_3 which is included in the impulse sending circuit. In such a case there will be three rapid impulses of current followed by a relatively long impulse of current followed in turn by a relatively long break in the current flow. This would cause three rapid closures of the contacts 382 followed by a long closure, and followed later by a long opening of the contacts 382. On the first of the rapid impulses, the relay 383 will be operated over

a circuit traced as follows:—from the ground pole of battery, contacts 382, armature 55, the normally closed contacts 391, the circuit conductor 392, the winding of the relay 383, circuit conductor 393, circuit conductors 21 and 20 leading to the negative pole of battery E. The relay 383 will be operated by current over this circuit and will attract its armatures, closing contacts 394 and 395. The contacts 395 being closed will condition a circuit for the relay 384, which circuit will be operative when the intermittently made contacts 382 are opened which will happen after the first rapid impulse.

The circuit then for the winding of the relay 384 can be traced from the ground pole of battery, contacts 56 of the relay 11, circuit conductor 396, the contacts 395 of the relay 383, circuit conductor 397, the winding of the relay 384, circuit conductor 392, the winding of the relay 383; circuit conductors 393, 21 and 20 leading to the negative pole of battery E. Therefore the relay 384 will operate by flow of current over this circuit, and will attract its armatures immediately after the operation of the relay 383, and will by contacts 399 extend the circuit controlled by the impulse sending contacts 382 to the next pair of relays 385 and 386. The second closure of the contacts 382 in response to the second rapid impulse of current through the relay 11 will cause the relay 385 to be operated over a circuit traced as follows:—from the ground pole of battery, the contacts 382 of the relay 11, the now made contacts 399 of the relay 384, the normally closed contacts 400 of the relay 386, the winding of the relay 385, circuit conductor 21 and circuit conductor 20 to the negative pole of battery E. The relay 385 will thus be operated attracting its armatures and closing contacts 402 and 406. The contact 402 being operated will condition a circuit for the relay 386, which relay will be operated immediately thereafter when the contacts 382 are opened. Current will flow over a circuit traced as follows including the winding of the relay 386, from the ground pole of battery, contacts 56 of the relay 11, circuit conductor 396, contacts 402 of the relay 385, circuit conductor 404, the winding of the relay 386, the winding of the relay 385, and circuit conductors 21 and 20 to the negative pole of battery E. The relay 386 will thereupon be operated attracting its armatures.

The first armature breaks contacts 405 in the circuit of the register *a* and prevents the register *a* from operating which it would otherwise do because of the previous closure of the contacts 406 of the relay 385. The contacts 405 break the circuit however before the slow acting register *a* can operate.

The circuit controlled by the impulse sending contacts 382 is now extended by means of contacts 407 to the relays 387 and 388. The third closure of the contacts 382 will thereupon operate relay 387 which will attract its armatures closing contacts 408 and 409, the contacts 408 conditioning the relay 388 for operation, and the contacts 409 conditioning the register *b* for operation. The register *b* however will not have time to operate because the third rapid impulse of current will be followed by an opening of the controlling contacts 382 which will permit the heretofore short circuited relay 388 to immediately operate breaking the contacts 410 in the circuit of the slow acting register *b*. The relay 388 being operated in the same manner as was the relay 386 and in the same manner as the relay 384 the operation of which relays has been previously described, will extend the impulse sending circuit controlled by the contacts 382 to the next pair of relays 389 and 390.

By referring now to the commutator c_3 it will be seen as has been said, after the contact has been made, that the three rapid contacts 351, 347 and 348 will be followed by a long contact. This will now produce a long operative closure of the contacts 382 of the relay 11, and will operate the relay 389 for a relatively long period of time over a circuit traced as follows:—from the ground pole of battery, contacts 382 of the relay 11, contacts 399 of the relay 384, the contacts 407 of the relay 386, the contacts 411 of the relay 388, the normally made contacts 412 of the relay 390, the winding of the relay 389, and circuit conductors 21 and 20 to the negative pole of battery. This will operate the relay 389 for a longer period of time than was the case with the relays 383, 385 and 387, and the relay 389 will close its contacts 413 and 414. The contacts 413 being closed will complete a circuit for the operation of the register *c* as follows:—from the ground pole of battery, the contacts 56 of the relay 11, circuit conductor 415, closed contacts 414 of the relay 389, circuit conductor 416, the normally closed contacts 417 of the relay 390, circuit conductor 418, the register *c*, and circuit conductor 20 to negative pole of battery E.

This circuit will be closed for a long enough period to enable the slow acting register *c* to operate, and this register will operate to register the connection against the account of the particular calling subscriber on the calling party line.

From the description given it will be easily seen how the operation of the other registers *a*, *b* or *d* on the line would take place were the commutators c_1, c_2 or c_4 brought into operation by the other substations A, C or D on the line L_1.

The commutator c_3 when the rapid contacts thereof were being made, as has been

described, operated rapid acting armature 373 producing rapid closure of the contacts 375. When the wide segment 349 makes contact with the brush 346, the contacts 375 will remain closed for the duration of this contact, and in addition the slow acting armature 374 will be operated to close the contact 419, and the closure of this contact will condition the relay 379 for operation, it being kept inoperative for the duration of the contact just mentioned by reason of the fact that the segment 349 completes a short circuit about the winding of the relay 379. Later however, the wide segment having passed the brush 346 there will be a relatively long insulated segment 350 pass under the brush 346, and the short circuit about the winding of the relay 379 is thereby removed and this relay will operate attracting its armatures for purposes to be later described.

The operating circuit for the relay 379 is as follows:—from the negative pole of battery E_7, the circuit conductors 343, 344 and 366, the now closed contacts 419 of the relay 13, the winding of the relay 379, circuit conductor 372, the winding of the relay 13, the now closed contacts 362 of the relay 82, and circuit conductor 83 to the ground pole of battery.

The contacts 371 in the impulse sending circuit from the interrupter brush 346 will now be opened disabling this interrupter until the operator takes down the connection.

The contacts 378 of relay 379 will be broken interrupting the circuit of the high voltage generator G_5 which as has been described previous to this time as connected in the circuit of the cut-off relay 11, to intermittently operate the contacts 382. Therefore, the contacts 382 will be opened for the balance of the connection, and the opening of these contacts will interrupt the short circuit which has been operative about the winding of the relay 390, and the relay 390 will be operated interrupting the circuit of the register *c* at contacts 417. Contacts 422 of the relay 379 will be closed to short circuit the resistance coil in the circuit of the relay 47, this being done by placing a negative battery potential on the opposite side of the resistance coil to which negative battery potential has been connected so that a short circuit of the winding ensues. The circuit by which this negative battery potential is placed about the winding 423 is traced as follows:—from the negative pole of battery E_3, circuit conductor 424, contacts 422 of the relay 379, contacts 381 and circuit conductor 45 leading to the resistance coil 423. The subscribers are now in conversational circuit.

An emergency listening key 501 is arranged in the usual manner so that the operator may be connected to the talking strands of the cord circuits 39 and 40 and thereby to the connected subscribers' telephones by listening leads 1 and 2 at any time during the connection. It will be seen that when this listening key is operated the extra contacts 502 provided therein will close a circuit to a particular one of the signal lamps A_1, A_2, A_3, and A_4 as may be at the time in circuit with said contacts. The circuit for the lamp under the condition which we have assumed, namely, that it is the substation B on L_1 that is calling, and therefore that the relays 280 and 287 of the cord circuit are operated during the conversational period, the lamp A_3 will thus be operatively connected to the contacts 502 over a circuit traced as follows:—from the ground pole of battery, contacts 502 of the key 501, circuit conductor 503, the now closed contacts 504 of the relay 287, the now closed contacts 505 of the relay 280, normally closed contacts 506 of the relay 286, circuit conductor 507, the signal lamp A_3, and circuit conductor 343 to the negative pole of battery E_7. The signal lamp therefore whenever the key 501 is depressed will light the lamp corresponding to the substation of the line calling. The group of lamps A_1, A_2, A_3, and A_4 are arranged to be common to a plurality of connecting circuits and made operative when a key of any of the connecting circuits is operated to indicate which of the parties of the party line initiated the call. After the conversation of the subscribers has been finished, the subscribers will restore their receivers to the hooks lighting the disconnected supervisory signal 84 in the usual manner over a circuit from the ground pole of battery, the lamp 84, the contacts 85 of the now retired supervisory relay 59, conductor 76, and contacts 73 of the relay 47 to the negative pole of battery E_1.

The operator will now disconnect the cord circuit by withdrawing the plugs P_1 and P_2 from the jacks J_1 and J_2 and all of the circuits will be restored to normal, since at the time, the exchange circuits are controlled by the cut-off relay 11, cut-off relay 288, the third strand relay 47, and the third strand relay 82. These relays having their circuits opened at the plug and jack switch will be restored to normal, and the circuits under their control will also be restored to normal.

I have in the above description described certain instrumentalities to attain the objects of my invention, and I am aware that numerous and extensive departures may be made from the same without violating the spirit of the invention, the objects of which are apparent from the foregoing description.

What I claim is:

1. In a telephone system, the combination

with a telephone line provided with a plurality of sub-stations, a main station, said telephone line extending by its limbs from a plurality of the substations to a main station, a plurality of signals at the main station, one for each of the said sub-stations, a plurality of resistances, one at each of the substations, each resistance being of different value from the other substation resistances, each of the said signals corresponding to a particular substation on the line, and apparatus at the main station under the control of one of the said resistances included in circuit with the line to operate the particular signal to identify the substation whereat said resistance is located.

2. In a telephone system, the combination with a telephone line provided with a plurality of substations, a main station, said telephone line, extending by its limbs from a plurality of the substations to a main station, the said telephone line being of appreciable ohmic resistance, a resistance unit for each of the substations adapted to be included in circuit with the line, the said resistance units differing in resistance value, a plurality of signals at the main station, each of which corresponds to a particular station on the line, and translating apparatus at the main station, said apparatus being controllable by the said line resistance to condition the said translating apparatus for selective operation of the said signals, said translating apparatus including means to cause a subsequently included resistance unit of one of the substations to control said translating apparatus whereby selective operation of the proper signal to identify the calling substation is effected.

3. In a telephone system, the combination with a telephone line extending by its limbs from a plurality of substations to a main station, a resistance unit adapted to be inserted in circuit with the line of the said substations, and step-by-step impulse operated electroresponsive means at the main station under the control of the said resistance unit.

4. In an electrical system, the combination of a main station, a plurality of distant stations, a connecting line connecting the said stations, an electro signal at the main station for each of the distant stations, a resistance unit at each of the distant stations, each resistance unit differing in resistance value from the other resistance units of the other stations, and step-by-step mechanism at the main station controlled by the inclusion of one of the said resistance units in circuit with the line to selectively operate the particular signal corresponding to the connected station resistance unit.

5. In an electrical system, the combination with a telephone line, a transmitting circuit including the two sides of said telephone line in series, a series of various resistances adapted to be included in said transmitting circuit, a balancing relay under the control of one of the said resistances, step-by-step mechanism under the control of said balancing relay, a plurality of electroresponsive devices, and apparatus associated with said balancing relay to variably control the operation of said step-by-step mechanism under the control of said included variable resistances.

6. In a telephone system, the combination with a telephone line, a substation for said line, a main station for said line, apparatus at the said substation, said substation apparatus and the said line containing a certain amount of ohmic resistance, a balancing relay at the main station adapted to be connected to the said line, and an electrically controlled step-by-step rheostat including a series of coöperating relays at the main station adapted to be operated under the control of said balancing relay, whereby the ohmic resistance of the said line and substation apparatus can be indicated.

7. In a telephone system, the combination with a telephone line, a substation for said line, a main station for said line, apparatus at the said substation, said substation apparatus and the said line containing a certain amount of ohmic resistance, a balancing relay at the main station adapted to be connected to the said line, an electrically controlled step-by-step rheostat at the main station adapted to be operated under the control of said balancing relay, whereby the ohmic resistance of the said line and substation apparatus can be indicated, an additional resistance adapted to be inserted in circuit with the said substation, and a second step-by-step rheostat thereafter adapted to be controlled by the balancing relay to indicate the value of the ohmic resistance of the inserted resistance.

8. In a telephone system, the combination with a telephone line, a substation therefor, a main station, automatic switching mechanism at the main station, means to associate the said line with the said automatic switching mechanism, an electromagnet at the substation, contacts normally associated with the said electromagnet and normally shunting the same, manually operated means to interrupt the said shunt circuit, an armature for the said electromagnet operated responsive to the breaking of the said circuit under the control of the said electromagnet to control the operation of the said switching mechanism.

9. In a telephone system, the combination with a telephone line, a substation therefor, a main station, a source of current at the main station and means at the main station to connect the said source of current to the telephone line, automatic switching mecha-

nism at the main station, a control relay therefor, means to variably operate the said switching mechanism under the control of the said control relay, a winding for the said control relay, means to include the said winding in circuit with the said source of current and the line conductors of the said telephone line, an electromagnet at the substation having a definite electrical resistance, contacts normally associated with the said electromagnet and normally shunting the same, manually operated means to interrupt the said shunt circuit to cause current from the said source flowing over the said telephone line conductors to energize the said electromagnet, an armature for the said electromagnet held operated responsive to the breaking of the said circuit, to maintain the said circuit broken, whereby the resistance of the said electromagnet is included in the circuit containing the said control relay, the said line conductors and the said source of current to operate the said relay, and an armature for the said control relay adjusted to respond to the inclusion of the said resistance in the said circuit to measurably control the operation of the said switching mechanism.

10. In a telephone system, the combination with a telephone line, a substation therefor, a main station, a source of current at the main station and means at the main station to connect the said source of current to the telephone line, automatic switching mechanism at the main station, a control relay therefor, means to variably operate the said switching mechanism under the control of the said control relay, a winding for the said control relay, means to include the said winding in circuit with the said source of current and the line conductors of the said telephone line, an electromagnet at the substation having a definite electrical resistance, contacts normally associated with the said electromagnet and normally shunting the same, manually operated means to interrupt the said shunt circuit to cause current from the said source flowing over the said telephone line conductors to energize the said electromagnet, an armature for the said electromagnet held operated responsive to the breaking of the said circuit, to maintain the said circuit broken, whereby the resistance of the said electromagnet is included in the circuit containing the said control relay, the said line conductors and the said source of current to operate the said relay, an armature for the said control relay adjusted to respond to the inclusion of the said resistance in the said circuit to measurably control the operation of the said switching mechanism, and means subsequently operative responsive to the operation of the said switching mechanism to open the circuit of the said line conductors to restore the said substation electromagnet contacts.

11. In a telephone system, the combination with a telephone line, a substation therefor, a main station, a source of current at the main station and means at the main station to connect the said source of current to the telephone line, automatic switching mechanism at the main station, a control relay therefor, means to variably operate the said switching mechanism under the control of the said control relay, a winding for the said control relay, means to include the said winding in circuit with the said source of current and the line conductors of the said telephone line, an electromagnet at the substation having a definite electrical resistance, contacts associated with the said electromagnet and normally shunting the same, manually operated means to interrupt the said shunt circuit to cause current from the said source flowing over the said telephone line conductors to energize the said electromagnet, an armature for the said electromagnet held operated responsive to the breaking of the said circuit, to maintain the said circuit broken, whereby, the resistance of the said electromagnet is included in the circuit containing the said control relay, the said line conductors and the said source of current to operate the said relay, an armature for the said control relay adjusted to respond to the inclusion of the said resistance in the said circuit to measurably control the operation of the said switching mechanism, and means operative responsive to the operation of the said control relay to open the line of the said line conductors to restore the said substation electromagnet contacts.

12. In a telephone system, the combination with a telephone line, substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, and resistance means at the said substation for controlling the operation of the said control relay.

13. In a telephone system, the combination with a telephone line, a substation therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at the said substation for controlling the operation of the said control relay, manually operated means at the said substation for including said resistance means in circuit with the said

telephone line and control relay, and electromagnetic means operated responsive to the operation of the said manually operated means to maintain the said resistance means in operative circuit with the said control relay.

14. In a telephone system, the combination with a telephone line, a substation therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at the said substation for controlling the operation of the said control relay, manually operated means at the said substation for including said resistance means in circuit with the said telephone line and control relay, electromagnetic means operated responsive to the operation of the said manually operated means to maintain the said resistance means in operative circuit with the said control relay, and subsequently operating means at the main station to open the circuit of the said telephone line, to restore the said resistance including means.

15. In a telephone system, the combination with a telephone line, a substation therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at the said substation for controlling the operation of the said control relay, manually operated means at the said substation for including said resistance means in circuit with the said telephone line and control relay, electromagnetic means operated responsive to the operation of the said manually operated means to maintain the said resistance means in operative circuit with the said control relay, subsequently operating means at the main station to open the circuit of the said telephone line, to restore the said resistance including means, and means responsive to the operation of the said switch to indicate the degree of operation thereof.

16. In a telephone system, the combination with a telephone line, a plurality of substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, and resistance means at each of the said substations on the line for controlling the operation of the said control relay.

17. In a telephone system, the combination with a telephone line, a plurality of substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at each of the said substations on the line for controlling the operation of the said control relay, manually operated means at each of the said substations for including the associated resistance means in circuit with the said telephone line, and electromagnetic means operated responsive to the operation of the manually operated means to maintain the said resistance means in operative circuit with the said control relay.

18. In a telephone system, the combination with a telephone line, a plurality of substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with the calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at each of the said substations on the line for controlling the operation of the said control relay, manually operated means at each of the said substations for including the associated resistance means in circuit with the said telephone line, electromagnetic means operated responsive to the operation of the manually operated means to maintain the said resistance means in operative circuit with the said control relay, and subsequently operating means at the main station to open the circuit of the said telephone line to restore the operated substation resistance including means.

19. In a telephone system, the combination with a telephone line, a plurality of substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with the calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at each of the said substations on the line for controlling the operation of the said control relay, manually operated means at each of the said substations for including the associated resistance means in circuit with the said telephone line, electromagnetic means operated responsive to the operation of the manually operated means to maintain the said resistance means in operative circuit with the said control relay, subsequently operating means at the main station to open the circuit of the said telephone line to restore the operated sub-

station resistance including means, and means responsive to the operation of the said switch to indicate the degree of operation thereof.

20. In a telephone system, the combination with a telephone line, a plurality of substations therefor, a main station, an automatic switch at the main station, means to associate the said automatic switch with the calling terminals of the said telephone line, a control relay for the said automatic switch adapted when operated to control the extent of operation of the said switch, resistance means at each of the said substations on the line for controlling the operation of the said control relay, manually operated means at each of the said substations for including the associated resistance means in circuit with the said telephone line, electromagnetic means operated responsive to the operation of the manually operated means to maintain the said resistance means in operative circuit with the said control relay, subsequently operating means at the main station to open the circuit of the said telephone line to restore the operated substation resistance including means, means responsive to the operation of the said switch to indicate the degree of operation thereof, and signal indicating means at the main station under the control of the said switch to indicate a calling substation.

21. In combination, an electrically operated step-by-step rheostat, a balance controlling circuit therefor having two branches, electric resistance in each branch, means to unbalance the said circuit by manually including a resistance in one of the branches, and means responsive thereto to cause the operation of the said rheostat, contacts for the said rheostat and operated thereby to again balance the said circuit by excluding resistance from the second branch thereof, and means responsive to the balancing by the said rheostat to discontinue the operation thereof.

In witness whereof, I hereunto subscribe my name this 31st day of October, A. D. 1918.

FRANK M. SLOUGH.