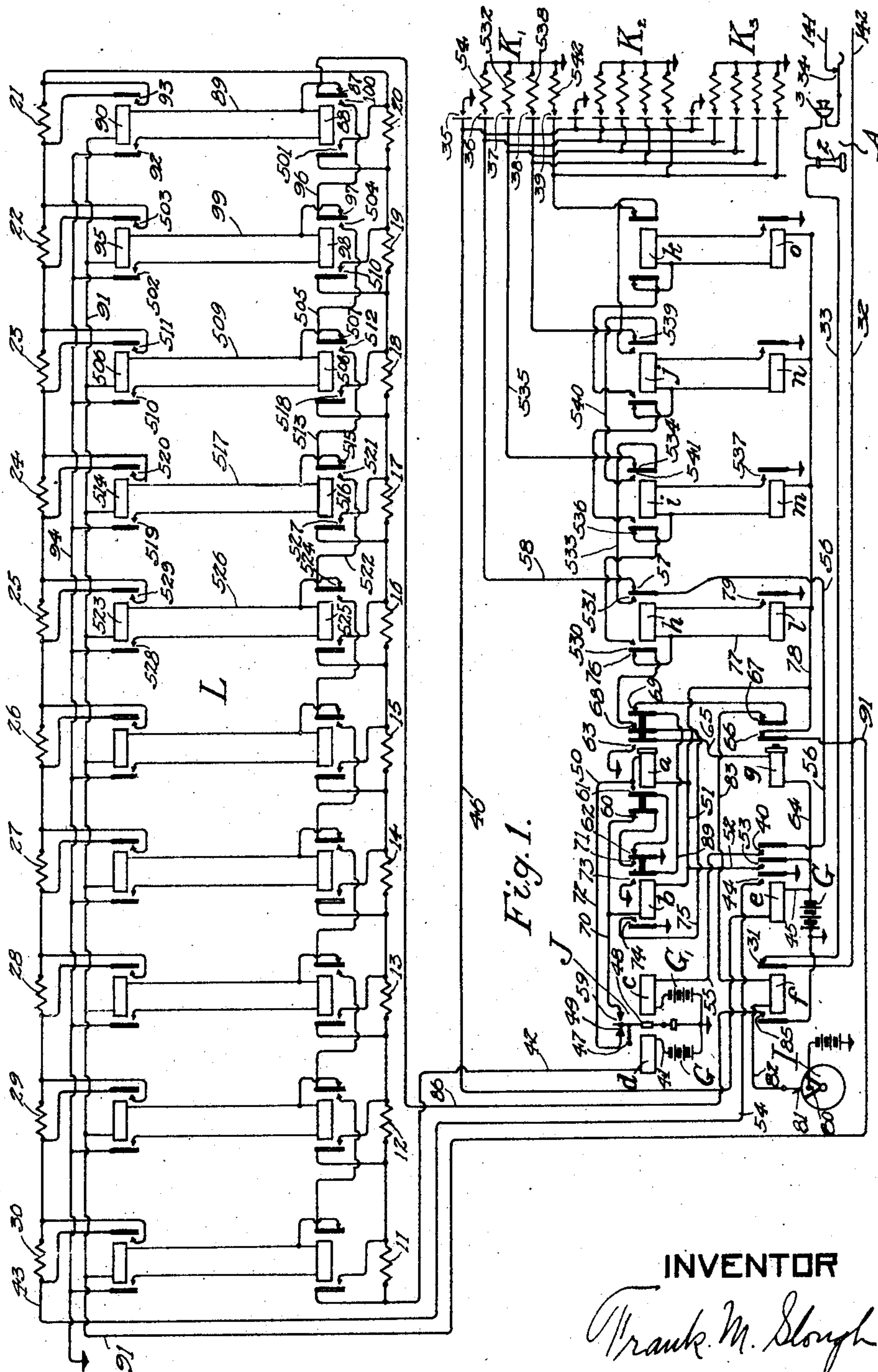


F. M. SLOUGH.
ELECTRIC TRANSLATOR.
APPLICATION FILED JUNE 23, 1917.

1,391,586.

Patented Sept. 20, 1921.

3 SHEETS—SHEET 1.



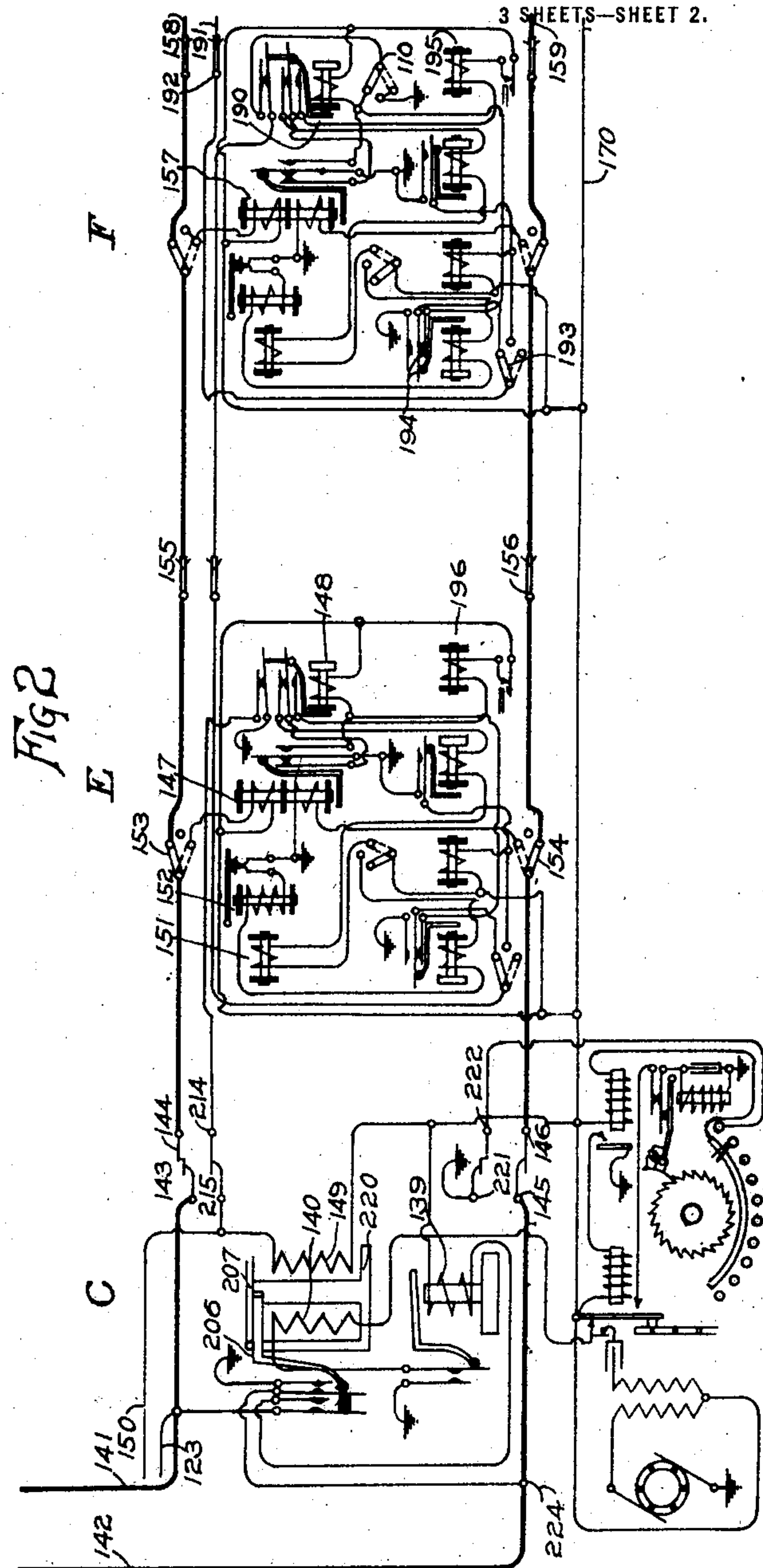
INVENTOR

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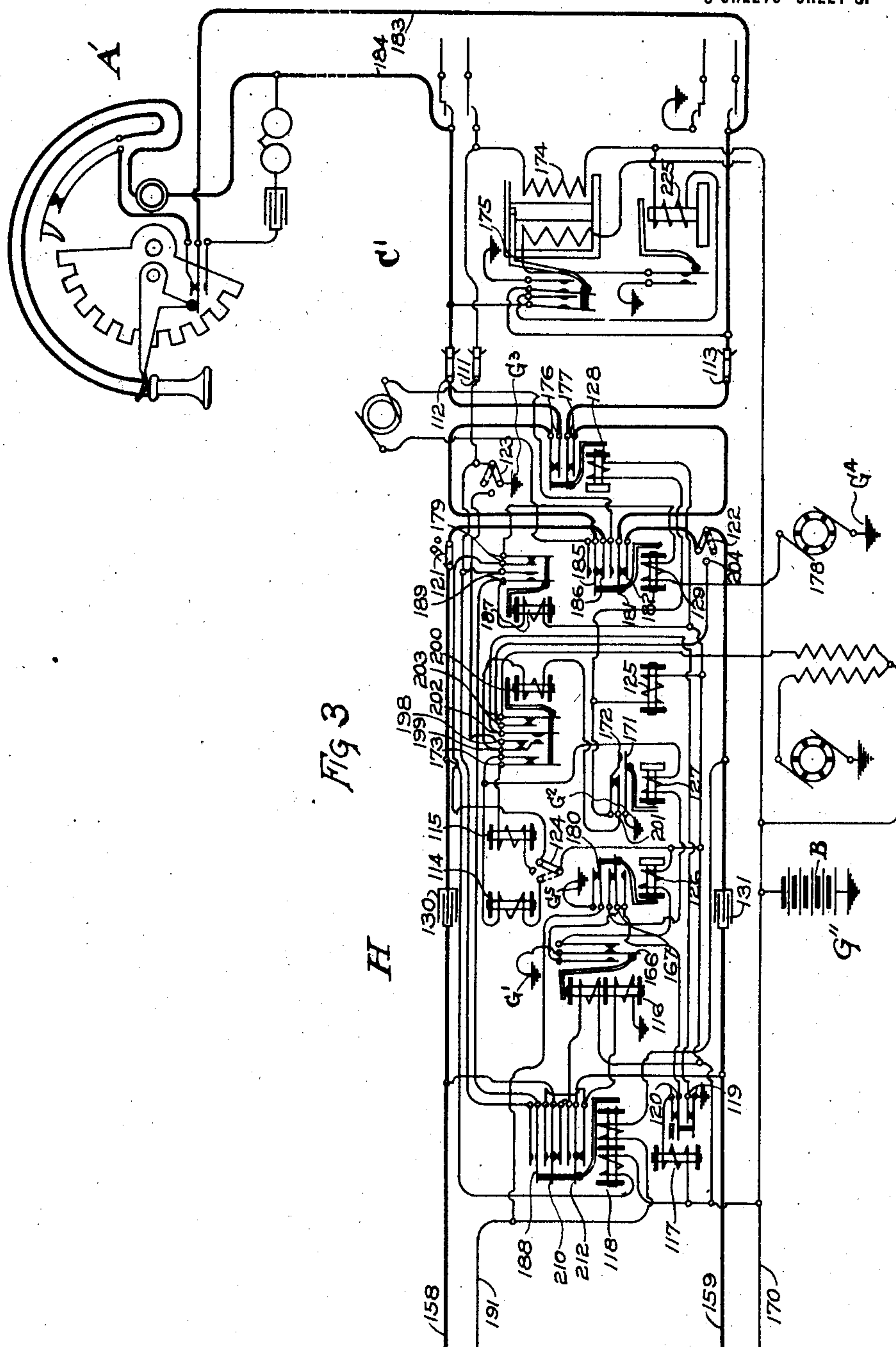


INVENTOR

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1,391,586.

3 SHEETS—SHEET 3.



Frank. W. 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.

ELECTRIC TRANSLATOR.

1,391,586.

Specification of Letters Patent. Patented Sept. 20, 1921.

Application filed June 23, 1917. Serial No. 176,502.

To all whom it may concern:

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

My invention relates to a system for controlling the movements of selective switches, such as are commonly used in automatic telephone systems, and more particularly to selective switches operated by a succession of current impulses.

It is one of the objects of my present invention to provide means which will control the operation of automatic step-by-step switches to select a given one of a number of telephone lines by the mere closure of a multi contact switch, which may be a manual or an automatic switch. This is accomplished in the present instance by providing means whereby the closure of such a switch introduces into the electric circuit of what I term the translator, resistance coils arranged in a definite way with respect to the circuits of the said translator, and each having certain values of ohmic resistance.

This and other objects and the features of my invention will be more clearly understood by reference to the following description in which the complete operation of a system embodying the features of my invention is described.

In the accompanying drawings, Figures 1 to 3 inclusive taken together show a complete circuit connection between a calling station A shown in Fig. 1 and a called station A' shown in Fig. 3, in a system embodying the principles of my invention. The typical automatic telephone system represented herein is of the well-known type of system embodying individual or line switches for the stations, selectors and connectors, the connection shown being established through the medium of the line switch C, first selector E, second selector F and connector H. As shown herein, the station A comprises the usual receiver 2 and transmitter 3.

The means whereby this station A is enabled to call other stations of the system, for instance the station A', are shown in Fig. 1 wherein are shown keys K_1 , K_2 and K_3 of a series of keys, the others not being

shown, each key of which in the embodiment illustrated when operated will close five pairs of contacts individual to the operated key. Also in connection with these keys in Fig. 1 is illustrated the electric translator system comprising electric circuits and apparatus, the object of which is to translate the several units of resistance included in the circuit of the translator by the operation of the keys just mentioned into the desired succession of current impulses to operate the selective switches necessary to be operated in order to call the desired station A'.

The electric translator shown in Fig. 1, comprises relays h , i , j and k , together with their associated controlling relays l , m , n and o to include at the proper time in the operation of the system, the proper resistance coil to perform the proper selective function.

What I term a balance relay, is shown at J and comprises electromagnets d and c , each capable of operating the armature placed between them, the effect of the one electromagnet upon the armature being capable of being balanced or over-balanced by the effect of the other.

The relays a and b are associated with the balance relay J in such a way that the closure of one of the pairs of contacts of the balance relay J will operate the relay a , and the closure of the other pair of contacts of the balance relay J will operate the relay b . Furthermore, the relays a and b have their circuits interlocked so that one of the relays having been operated it remains operated until after the other relay is fully operated.

The circuits of the electromagnets c and d are arranged to include resistance coils and a source of current, the electromagnet c being adapted to contain in its circuit the different resistance coils of which ever of the keys K_1 , K_2 , K_3 , etc., as may be operated under the control of the controlling relays; and the effect of the electromagnet c upon the armature of the balance relay J is adapted to be counter-balanced by the effect of the electromagnet d in the circuit of which is included variable resistance containing resistance coils 11 to 30 inclusive, of the current impulse operated step-by-step rheostat L shown in the upper part of Fig. 1. This contains a plurality of relays, each

capable of short circuiting a resistance unit in the circuit of the electromagnet *d* of the balance relay J.

An interrupter I is also shown in Fig. 1 and performs the double function of simultaneously operating the step-by-step rheostat L to decrease the effective resistance of its resistance coil, and also to cause the contacts 31 of the relay *f* to be operated to produce current impulses in the circuit of the line of the telephone station A.

The circuit conductors from the station A which are adapted to be intermittently broken at the contacts 31 are extended to the conductors 141 and 142 of Fig. 2, leading to the line switch C of the typical automatic telephone system shown in Figs. 2 and 3, and these contacts are adapted to be operated under the control of the translator of Fig. 1 to produce the same effect as would a dial of the usual automatic station.

The invention will perhaps be better understood from the detailed description of the operation following:

Assuming that the operator of the station A desires to converse with station A', or for any other reason desires to make telephonic connection with the station A', the operator A will remove the receiver 2 from the switchhook causing the switchhook to close contacts 34 in the circuit of the line conductors 141 and 142 leading to the line switch C of Fig. 2, establishing a bridge across the line conductors 141 and 142 through the receiver and transmitter of the station, and through contacts 31 of the relay *f* of the translator. The closure of this bridge across establishes an energizing circuit for the line relay 139 of the line switch C. The relay 139, upon energizing, operates to close a circuit of the operating winding 140 of the magnet 220, which upon energizing, attracts the plunger arm 207 and cutoff armature 206, whereby the line conductors 141 and 142 are extended through the line switch bank springs 143 and 144, and 145 and 146 to the selector E, and the line relay 139 is disconnected from the line. When the connection is extended to the selector E its line relay 147, which is normally bridged across the line circuit of the switch in series with the battery, becomes energized and operates to close the circuit of the relay 148. The relay 148, upon energizing, operates to close the circuit of the holding winding 149 of the line switch C before the line relay 139 breaks the circuit of the operating winding 140, and to extend a guarding ground potential over the conductor 150 to the connector private bank contacts of the calling line, upon which is located the station A. The apparatus of the first selector E is now adapted to be operated by the opening and closing of contacts 31 of the relay *f* under the control of the translator to produce results later to be described.

We will assume that the operator desiring to call a certain number consisting of four digits, operates the key K₁ closing contacts 35, 36, 37, 38 and 39. The closing of the contacts 35 will cause a circuit to be closed, including the source of current G, the conductor 45, the winding of the relay *e*, the conductor 46, and the contacts 35 to the ground pole of the source of current G. Current flowing over this circuit from the source G will energize the relay *e*, causing it to attract its armatures for purposes later to be described.

Up to this time the retractile spring 47 attached to one side of the armature 48 of the balance relay J has caused it to close contacts 49.

When the relay *e* is operated a circuit is closed including the winding of the relay *a* which may be traced as follows:—from the ground pole of battery, the armature 48 of the balance relay J, the normally closed contacts 49 thereof, circuit conductor 50, the winding of the relay *a*, circuit conductor 51, circuit conductor 52, and the now closed contacts 53 of the relay *e* to the negative pole of battery G. The relay *a* will therefor be energized, attracting its armatures, affecting circuits to be later described.

The contacts 44 of the relay *e* being closed, complete a circuit for the winding of the electromagnet *d* traced as follows:—from the negative pole of the source of battery G, circuit conductor 41, the winding of the electromagnet *d*, circuit conductor 42, the resistance units 11 to 30 inclusive serially connected by conductors extending between them, to circuit conductor 43, circuit conductor 54, and the contacts 44 of the relay *e* to the ground pole of battery. The electromagnet *d* will be energized to a degree which depends upon the amount of resistance contained in the circuit of its winding, and which contains resistance units 11 to 30 inclusive. The effect of this energization would be to keep closed the contacts 49 of the balance relay J were it not for the other circuit changes which will now be related. Also the relay *a* having been energized as before described, attracts its armatures operating contacts and causing circuit changes as follows. The contacts 60 will be broken, and the breaking of these contacts will have no effect upon the circuits as constituted at this stage of the operation.

Contacts 61 will be closed forming a locking circuit for the relay *a* including contacts 62 of the relay *b* as follows:—from the ground pole of battery, contacts 62 of the relay *b*, contacts 61 of the relay *a*, the winding of the relay *a*, circuit conductors 51 and 52, and contacts 53 of the relay *e* to the negative pole of battery G. This locking circuit will maintain for the moment the relay *a* operated even though the contacts 49

may be broken, or until the contacts 59 of the balance relay J are closed as will be later described. The contacts 63 of the relay *a* will also be closed completing a circuit for the slow releasing relay *g* as follows:—
 5 from the ground pole of battery, the source of battery G, circuit conductor 64, the winding of the electromagnet *g*, circuit conductor 65, and now made contacts 63 of the relay *a*
 10 to the ground pole of battery. This will cause current to flow over the circuit and energize the relay *g*, which will attract its armatures breaking the pairs of contacts 66 and 67 which at this stage of the operation
 15 will have no positive effect upon the circuits. The contacts 68 of the relay *a* will also be broken, and will have no positive effect at this stage of the operation. Likewise the contacts 69 of the relay *a* will be broken, the
 20 breaking of these contacts having no positive effect at this stage of the operation.

It will be seen later that the relays *a* and *d* are operated a number of times at different stages of the operation of the system, and
 25 that on subsequent operations the contacts which have been impotently operated at the present time will be effective to control circuit changes.

At the time the relay *e* was operated, also
 30 the contacts 40 were closed completing a circuit including the winding of the electromagnet *c* and the resistance coil 54 over a circuit as follows:—from the ground pole of battery, the source of current G_1 , conductor 55, the now closed contacts 40 of the
 35 relay *e*, circuit conductor 56, the normally closed contacts 57 of the relay *h*, circuit conductor 58, contacts 36 of the key K_1 , and the resistance coil 54 to the ground pole of battery. Current will flow over this circuit including the winding of the electromagnet *c*,
 40 and will energize the electromagnet *c* to a degree depending upon the resistance of the coil 54. The first resistance coil of each group represents the tens of thousands digit of the called-for number, and therefore the
 45 resistance coil 54 being the first of the group included in the circuit by the operation of the key K_1 indicates in which tens of thousands group the connector of the called-for line resides. We will assume that the ohmic
 50 resistance of the resistance unit 54 is such that it represents the digit 5, and therefore in order to produce the desired result it will
 55 cause the calling interrupter contacts 31 to be opened five times, which it will now do in a manner to be described.

The electromagnet *c* being energized over the circuit just described will close contacts
 60 59 of the balance relay J overpowering the effect of the electromagnet *d*, for the time being. The conductor 59 being closed will complete a circuit for the relay *b* traced as follows:—from the ground pole of battery,
 65 the armature 48 of the balance relay J, con-

tacts 59 thereof, circuit conductor 70, the winding of the relay *b*, circuit conductor 52, and the now closed contacts 53 of the relay *e* through the source of current G to ground. Current flowing over this circuit will cause
 70 the energization of the relay *b*, operating contacts as follows: The contacts 62 will be opened in the locking circuit of the relay *a* which has been traced, restoring this relay to normal. This relay being restored to
 75 normal will restore its normally closed contacts, and open the pairs of contacts 61 and 63; the first being in the locking circuit just mentioned, and the second being in the circuit of the relay *g*, and thereby restoring the
 80 relay *g* to normal. The relay *g* being restored to normal will restore its normally closed contacts 66 and 67 to normal positions of closure.

A locking circuit for the relay *b* will be
 85 formed by the closing of contacts 71 of the relay *b*, the locking circuit being traced as follows:—from the ground pole of battery, the now closed contacts of the relay *b*, the
 90 normally now closed contacts 60 of the relay *a*, the winding of the relay *b*, circuit conductor 52, now closed contacts 53 of the relay *e* to the source of current G to the ground pole of the said source. This circuit will maintain energized the relay *b* whether or not
 95 the contacts 59 should be opened or previously opened, and until contacts 49 are closed as will be later described to break this locking circuit.

The contacts 74 of the relay *b* will be
 100 closed completing a circuit for the relay *l* as follows:—from the ground pole of battery, the contacts 74 of the relay *b*, circuit conductor 75, the normally closed contacts 68 of the relay *a*, the normally closed contacts
 105 76 of the relay *h*, conductor 77, relay *l*, circuit conductor 78, circuit conductors 51 and 52, the now closed contacts 53 of the relay *e*, and the source of current G to the ground pole of battery. Current from the said
 110 source will flow over this traced circuit energizing the relay *l*, which will close its contacts 79 conditioning a circuit for the relay *h*, but which circuit will not now be operative to energize the relay *h*, due to the fact
 115 that the ground pole of battery is applied on both sides of the winding of the relay *h*, thereby short circuiting this relay. The contacts 73 of the relay *b* are also closed completing a circuit including the interrupter I
 120 and source of current, and the winding of the relay *f*, said circuit being traced as follows:—from the ground pole of battery, the source of current, the interrupter I whose
 125 segment 80 is arranged to revolve and intermittently make contact with a brush 81, the intermittently closed circuit being continued over conductor 82, the winding of the relay *f*, circuit conductor 83, the normally closed contacts 67 of the relay *g*, the
 130

normally closed contacts 69 of the relay *a*, circuit conductor 84, and the now closed contacts 73 to the ground pole of the source of battery.

5 The circuit of the relay *f* thus being closed through the interrupter *I*, the relay *f* will be operated as long as this circuit remains closed intermittently each operation causing a momentary opening of the contacts 31, 10 which will cause circuit changes to be later related. Also each operation of the relay *f* will cause a momentary closure of the contacts 85, completing a circuit for successive relays of what I have termed the electrical 15 current impulse operated rheostat *L*. The effective first circuit closure between the revolving segment 80 and the brush 81 produces the first opening of the contacts 31, and also the first closing of the contacts 85, 20 which latter closure will complete a circuit traced as follows:—from the ground pole of battery, the now closed contacts 85 of the relay *f*, circuit conductor 86 which conductor may be termed the impulse wire, the now 25 closed contacts 87 of the relay 88, circuit conductor 89, the winding of the relay 90, circuit conductor 91, the normally closed contacts 66 of the relay *g*, circuit conductors 51 and 52, the now closed contacts 53 of the 30 relay *e*, and the source of current *G*, to the ground pole of battery. Current will flow over this circuit through the relay 90 operating the relay 90, and closing contacts 92 and 93. The closure of contacts 92 will condition a circuit for the relay 88, but this circuit will not at present be operative to energize the relay 88, because of the short circuit now introduced about the winding of the relay 88 by the placing of a connection 40 to ground on each side of the winding, by the contacts 85 of the relay *f* on the one side, and by the contacts 92 over circuit conductor 94 on the other side.

Contacts 93 upon being closed will short 45 circuit the resistance unit 21 serially connected in circuit with the electromagnet *d* of the balance relay *J*, and the short circuiting of this resistance in the circuit of the electromagnet *d* will increase the energization thereof a definite predetermined amount. However, under the assumptions we have made, the energization will not be sufficiently increased in the electromagnet *d* to close its contacts 49. Therefore, at this 55 time no consequent circuit change will be instituted.

The interrupter *I* continuing to revolve will cause a breaking of the circuit between the segment 80 thereof and the brush 81, 60 and therefore will cause the circuit of the relay *f* to be interrupted and a deenergization of the relay *f* will ensue; the relay *f* restoring its contacts to their normal position, the contacts 31 being restored to a

closed condition, and the contacts 85 being 65 restored to their normal position.

The circuit changes due to the reclosing of the contacts 31 will not now be described, but it will be understood that the contacts 31 are operating as would the usual calling 70 dial of an automatic telephone; and that such circuit changes as would be produced in an automatic system by the usual calling dial will be produced by the contacts 31 as will be therefore related later. 75

The release of the contacts 85 will remove the ground which has been described as being placed about the one side of the relay 88, and the energizing circuit of the relay 88 will be operative, the circuit being traced 80 as follows:—from the ground pole of battery, conductor 94, contacts 92 of the relay 90, the winding of the relay 88, circuit conductor 89, the winding of the relay 90, circuit conductor 91, the normally closed contacts 66 of the relay *g*, circuit conductor 51, circuit conductor 52, now closed contacts 53 85 of the relay *e*, and source of current *G* to the ground pole of battery. The relays 88 and 90 are thus operated, their windings being 90 serially connected with the source of current. The relay 88 being operated will attract its armatures, operating contacts as follows:—contacts 87 will now be broken interrupting the circuit of the impulse wire 95 86, the impulse wire extending by means of the now closed contacts 100 to operative connection with the relay 95 through conductor 96, the normally closed contacts 97 of the relay 98, and circuit conductor 99. 100

The contacts 501 of the relay 88 will now be closed short circuiting the resistance unit 20 in the circuit of the electromagnet *d* of the balance relay *J*, thereby increasing the energization of this relay a definite predetermined amount. Under our present assumptions however, it is arranged that this energization shall not be sufficiently increased at this time to cause the electromagnet *d* to close the contacts 49. 110

The interrupter *I* continuing its rotary movement will again close a circuit between its segment 80 and its brush 81, and complete a circuit for the relay 95 as follows:— 115 from the ground pole of battery, the source of current, the segment 80 and brush 81 of the interrupter *I*, conductor 82, the winding of the relay *f*, circuit conductor 83, the normally made contacts 67 of the relay *g*, the normally made contacts 69 of the relay *a*, 120 circuit conductor 84, and now closed contacts 73 to the ground pole of battery. Current flowing over this circuit will as has been described before, operate as it did before, the relay *f* which will attract its 125 armatures again interrupting the contacts 31, and again close contacts 85, this being the second operation of these contacts.

The contacts 85 being again closed will complete a circuit over the impulse wire 86, which as has been described is now extended by conductor 96, contacts 97, the conductor 99 to the winding of the relay 95, and will operate this relay just as was the relay 90 operated of the pair of relays 88 and 90, and the relay 95 being operated will attract its armatures closing contacts 502 and 503. Contacts 502 will condition a circuit for the relay 98, just as did the contacts 92 condition a circuit for the relay 88; but just as in the aforesaid case, the relay 98 will not now be operated because of the short circuit being placed about its winding at this time by the connection of the ground pole of battery at either side of the winding by the contacts 85 of the relay *f* on the one side, and by the circuit conductor 94 and contacts 502 on the other side.

The contacts 503 being operated will short circuit a resistance unit 22 in the circuit of the electromagnet *d*, thereby increasing the energization of this electromagnet a definite predetermined amount, but under our assumptions insufficient to cause it to close the contacts 49.

The interrupter I continuing to rotate will now break the connection between its segment 80 and the brush 81 in the circuit of the relay *f*, thereby again restoring the contacts of the relay *f* to normal the contacts 31 therefore being again closed, and the contacts being therefore again opened.

The contacts 85 being again opened will remove the short circuited ground connection from about the one side of the winding of the relay 98, and will permit the relay 98 to be energized over a circuit as follows:—from the ground pole of battery, conductor 94, contacts 502 of the relay 95, the winding of the relay 98, conductor 99, the winding of the relay 95, circuit conductor 91, normally closed contacts 66 of the relay *g*, circuit conductors 51 and 52, now closed contacts 53 of the relay *e*, and the source of current *G* to the ground of the said source. Current will flow over this circuit energizing the relay 98 which will attract its armatures operating contacts as follows:

Contacts 97 will be operated interrupting the circuit of the impulse wire 86 as extended by the conductor 96, and will again extend it by means of contacts 504, and conductors 504 and 505 to the winding of the relay 506, through the normally made contacts 507 of the relay 508, and circuit conductor 509.

The contacts 510 being closed will short circuit the resistance unit 19 in the circuit of the electromagnet *d*, thereby increasing the energization of the electromagnet *d* a definite predetermined amount, but which

amount according to our present assumptions will be insufficient to cause it to close contacts 49.

The interrupter I continuing to rotate will again cause a connection to be made between its segment 80 and its brush 81 again completing the energizing circuit of the relay *f* which as has been previously described energizes the relay *f* which will attract its armatures, and for the third time opening the contacts 31 and closing contacts 85.

Contacts being again closed will complete a circuit from the ground over the impulse wire extended by conductors 96 and 505 through the winding of the relay 506 over contacts 507 of the relay 508, circuit conductor 509, the winding of the relay 506, circuit conductor 91, contacts 66 of the relay *g*, circuit conductors 51 and 52, now made contacts 53 of the relay *e*, and the source of current *G* to the ground pole of said source.

This circuit being completed current will flow over the same energizing the relay 506 which will attract its armatures and close contacts 510 and 511. The contacts 510 being closed will condition a circuit for the winding of the relay 508, which circuit will be at present impotent to operate the relay 508, because of short circuiting ground being placed about the winding of the relay 508 in a manner like that described for the relays 98 and 88 in the like stage of their operation.

Contacts 511 being closed will short circuit resistance unit 23 in the circuit of the electromagnet *d*, thereby increasing the energization of this electromagnet a definite predetermined amount, and which amount under our present assumptions will be insufficient to cause it to close the contacts 45 of the balance relay J.

The interrupter I continuing to revolve will cause its segment and brush to separate opening the circuit of the relay *f* which will restore its contacts to their normal position, contacts 31 being restored to their normal closing position and the contacts 85 being restored to their normal opened position. Contacts 85 being opened will remove the short circuiting ground from the one side of the winding of the relay 508, and the relay 508 will be operated over a circuit including the winding of its associated relay 506, said circuit otherwise being like unto that of the relays 98 and 88, and which circuits have been previously so well described it is believed unnecessary to describe it, particularly for the relay 508. The relay 508 being operated will operate its contacts. Contacts 507 being broken the impulse wire 86 as extended by conductors 96 and 505 will be again extended by contacts 512 and conductor 513 to the winding of the relay 514 over contacts 515 of the relay

516 and circuit conductor 517. The contacts 518 of the relay 508 being closed will short circuit the resistance unit 18 in the circuit of the electromagnet *d* and will energize the electromagnet *d* a definite predetermined amount, but which increased energization according to our present assumptions will be insufficient to close contacts 45.

Interrupter I continuing to revolve will again cause its segment 80 to make a connection with the brush 81, again closing the circuit of the relay *f* which will be again energized, again operating its contacts; the contacts 31 being opened for the fourth time, and the contacts 85 being again closed. Contacts 85 being again closed will complete a circuit for the relay 514 over the impulse wire as extended as described, and the relay 514 will be operated closing its contacts 519 and 520. The contacts 519 being closed will condition a circuit for the relay 516, said circuit being at present inoperative because of the short circuiting connections to ground on either side of its winding. The contacts 520 being closed will short circuit the resistance unit 24 in the circuit of the electromagnet *d*, and therefore the energization of this electromagnet will be again increased a definite predetermined amount, but which amount will be insufficient according to our present premises to cause the electromagnet *d* to close the contacts 49 of the balance relay J.

The interrupter I continuing to revolve will again cause its segment 80 to break connection with its brush and thereby cause the breaking of the circuit of the relay *f* restoring its contacts to their normal position, contacts 31 being restored to a closed position, and the contacts 85 being restored to an opened position. The opening of the contacts 85 will remove the ground on one side of the winding of the relay 516 and the relay 516 will be operated, the circuit of this winding including the serially connected winding of the relay 514, but which circuit need not now be traced it being like unto the circuit of the relay 508, also of the relays 98 and 88 which circuits have been previously well described.

The relay 516 being operated will operate its contacts, the contacts of the relay 516 connecting the extended impulse wire to the relay 514 being broken, and the impulse wire 86 as extended by conductors 96, 505 and 513 will again be extended by contacts 521 and conductor 522 to the winding of the relay 523 over contacts 524 of the relay 525 and circuit conductor 526. The contacts 527 of the relay 516 being closed will establish a short circuit about the resistance unit 17 in the circuit of the electromagnet *d*, and the electromagnet *d* will have its energization increased a definite predetermined amount depending upon the definite predetermined

ohmic resistance of the resistance unit 17, but the increased energization of the electromagnet *d* will not be sufficient according to our present premises to cause it to close the contacts 49 of the balance relay J.

The interrupter I continuing to revolve will again cause its segment 80 to make contact with its brush 81 again reestablishing the circuit of the relay *f*, and for the fifth time will separate its contacts 31 and will close its contacts 85. The contacts 85 being closed will reestablish the ground connection to the impulse wire 86 which is now connected in circuit with the winding of the relay 523 by the extended circuit of the said impulse wire as previously described, and relay 523 will be operated causing it to attract its armatures, and closing contacts 528 and 529. The contacts 528 being closed will condition a circuit for the relay 525, but which conditioned circuit will at present be unable to operate the relay 525 because of the presence of the short circuited ground connection on both sides of the relay 525 in a manner which has been previously described for the other like relays 516, 508 and 98.

Contacts 529 being closed will short circuit the resistance unit 25 which is included in the circuit of the electromagnet *d* of the balance relay J, and will therefore increase the flow of current through the balance *d* increasing its energization a definite predetermined amount, the increased energization depending upon the particular predetermined value of ohmic resistance in the resistance coil 25.

Under our present premises we will assume that the short circuiting of this resistance unit in addition to the short circuiting of resistance units 17, 18, 19, 20, 21, 22, 23 and 24, all in the circuit of the balance relay *d*, produces an aggregate increased current flow through and thereby increased the energization of the electromagnet *d* sufficient to cause the balance relay *d* to overcome the effect of the electromagnet *c* and to withdraw the armature from the position of proximity to the pole of electromagnet *c*, and to cause the armature to close the contacts 49 of the balance relay J. The closing of the contacts 49 as will be seen signifies the ending of the first train of current impulses instituted by the opening and closing of the contacts 31, which contacts as has been seen have been opened five times in rapid succession.

The contacts 49 of the balance relay J now being closed complete a circuit including the winding of the relay *a*, the circuit being traced as follows:—from the ground pole of battery, now closed contacts 49 of the balance relay J, circuit conductor 50, the winding of the relay *a*, conductor 51, conductor 52, the now closed contacts 53 of the

relay *e*, and the source of current *G* to the ground pole of battery.

Relay *a* will now be energized attracting its armatures, switching contacts for purposes which will now be described. The contacts 60 of the relay *a* will be broken interrupting the locking circuit of the relay *b*, and the relay *b* will therefore be deenergized restoring its contacts to their normal position. The contacts 61 will now be closed and will complete a locking circuit for the relay *a* including the contacts 62 of the relay *b* which are now restored to their normal position of closure. This locking circuit has been previously described, and therefore the description will not need to be repeated.

Contacts 63 of the relay *a* will also be closed, closing the circuit of the relay *g* which relay is a slow releasing relay, and the relay *g* will be energized over this circuit which extends from the source of current *G* through the winding of the relay *g*, the conductor 65 and the contacts 63 of the relay *a* to the ground pole of the source, and will attract its armatures breaking the contact 66 and the contact 67, the contacts 66 interrupting the common battery conductor 91 supplying connection to the negative pole of battery for the windings of the relays of the electrically operated rheostat *L*, and these relays which have been operated as has been described including the relays 88, 90, 98, 95, 508, 506, 516, 514 and 523 will all be restored to their normal or deenergized condition, restoring all of the contacts controlled thereby to their normal position.

The contacts 67 of the relay *g* being broken will interrupt the circuit of the interrupter *I* and the impulse relay *f*, so that the relay *f* will cease to operate under the control of the interrupter *I*, and contacts 31 of the relay *f* will be restored to their normal position of closure, and the contacts 85 will be restored to their normally opened position.

The contacts 68 of the relay *a* upon being broken will remove the short circuit which had been placed about the relay *h* by the contacts 79 of the relay *l*, and the contacts 74 of the relay *b* and the relay *h* will thereupon be operated over a circuit traced as follows:—from the ground pole of battery, contacts 79 of the relay *l*, the winding of the relay *h*, the circuit conductor 77, the winding of the relay *l*, circuit conductors 78, 51 and 52, the contacts 53, and the source of current *G* to the ground pole thereof. Current from the said source will flow over the said circuit through the winding of the relay *h* energizing this relay which will attract its armatures, operating its contacts 76 and 57, which contacts will be broken, and operating contacts 530 and 531 which will be closed for purposes to be described.

The contacts 68 of the relay *a* are preferably given such an adjustment as to cause

their opening prior to the operation of the rest of the contacts of the relay *a* when the relay *a* is operated.

The relay *h* being operated will cause its contacts 531 to be closed thereby including the resistance coil 532 in the circuit of the electromagnet *c*. The electromagnet *c* will therefore be energized over the circuit just closed, and which is traced as follows:—from the ground pole of battery, the source of current *G*, the winding of the electromagnet *c*, circuit conductor 55, contacts 40 of the relay *e*, circuit conductor 56, the now made contacts 531 of the relay *h*, circuit conductor 533, the normally made contacts 534 of the relay *e*, circuit conductor 535, the contacts 37 of the key *K*, and resistance unit 532 to the ground pole of battery. Current flowing over circuit including the said resistance coil will be of such a strength as to cause the contacts 49 of the balance relay *J* to be opened, and the contacts 59 to be again closed.

The contacts 59 being closed will complete the above described circuit for the relay *b* including the said contacts 59 of the balance relay *J*, and the relay *b* will be operated as before, and as above will release the relay *a* which in turn will release the relay *g*. The release of the relay *a* is caused by the breaking of the contacts 62 in the locking circuit thereof previously described, and the release of the relay *g* is accomplished by the breaking of the contacts 63 of the relay *a*. The other contacts of the relays *a* and *g*, as well as the now operated relay *b*, will be operated as will be now related. The relays *a* and *g* are slow releasing relays, and take a relatively long time to restore their contacts to normal after the relays have been once energized, and therefore these relays will restore their contacts but slowly.

Contacts 69 of the relay *a* and 67 of the relay *g*, and the closure of the contacts 73 of the relay *b* again places the impulse relay *f* under the control of the interrupter *I* over the circuit which has previously been traced for this interrupter and relay, and the relay *f* will again be operated intermittently by the relay *i* until a balanced condition of the relay *J* again occurs as will be described.

The contacts 66 of the relay *g* being closed will again restore the connection from the negative pole of battery to the relays of the electrically operated rheostat *L* by means of the conductor 91 whose circuit has been previously described, and these relays will therefore again be conditioned for operation.

The closure of the contacts 74 of the relay *b*, and the closure of the contacts 68 of the relay *a* completes a circuit for the relay *m*, the circuit being traced as follows:—from the ground pole of battery, contacts 74

of the relay *b*, conductor 75, the normal contacts 68 of the relay *a*, the now closed contacts 530 of the relay *h*, the normally closed contacts 536 of the relay *i*, the winding of the relay *m*, circuit conductor 78, circuit conductors 51 and 52, the closed contacts 53 of the relay *e* to the source of current *G*, and from thence to the ground pole of the said source. The relay *m* will be operated by current flowing over the circuit just traced, and will close its contacts 537 conditioning a circuit for the operation of the relay *i*, but which relay will not now be operated due to the presence of the short circuited ground connection on the opposite side of the relay *i*, from the contacts 537 through the contacts 74 of the relay *b*. These circuits are now in condition to translate the value of the second resistance unit included in circuit of the key *K*₁, namely, the resistance unit 532 into the corresponding number of impulses, which in the present case we will assume to be but one impulse, or in other words, that the second digit of the called-for number is to be the numeral 1.

The relays *a* and *g* being slow releasing, as has been said, have caused the contacts 31 of the impulse sending circuit to be closed for a relatively long time, thereby performing a circuit changing function required in the operation of automatic apparatus as illustrated in Figs. 2 and 3 as will be subsequently related.

The interrupter *I* now revolving will cause contact to be made between its segment 80 and its brush 81, closing a circuit including a source of current and the winding of the relay *f* which circuit has previously been traced, and will cause the operation of the relay *f*, which being operated will attract its armatures breaking the contacts 31 in the impulse sending circuit of the station *A*, and closing the contacts 85, thereby connecting the ground pole of battery to the impulse wire 86 leading to the electrically operated step-by-step rheostat *L*; and just as was the case as previously described in the first operation of this rheostat the relay 90 will first be operated over a circuit traced as follows:—from the ground pole of battery, contacts 85 of the relay *f*, circuit conductor 86, contacts 87 of the relay 88, circuit conductor 89, the winding of the relay 90, and the circuit conductor 91 to the negative pole of battery through contacts 66 of the relay *g*, circuit conductors 51 and 52, and contacts 53 of the relay *e*. Current flowing over this circuit will cause the operation of the relay 90, and will close its contacts 92 and 93; the first named contacts conditioning a circuit for the relay 88, just as in the before described case, and the second pair of contacts short circuiting the resistance unit 21.

We will assume that the consequent cur-

rent flowing over the circuit of the electromagnet *d* including the resistance coils 11 to 30 inclusive of the rheostat is not sufficiently increased by the short circuiting of the resistance coil 21 to cause the electromagnet *d* to close the contacts 49 of the balance relay *J*, and therefore the interrupter *I* continuing to revolve will open its circuit connection between its segment 80 and brush 81 restoring the relay *f* to its normal deenergized condition, whereupon the contacts 31 will be restored to their normal position, and the contacts 83 will be opened. This will cause the operation of the relay 88 in series with the relay 90 as before described after the previous operation of these relays, and as before described the resistance unit 20 will be short circuited by contacts 501 of the relay 88 and thus cause a sufficiently increased flow of current over the circuit including the un-short-circuited resistance units of the group 11 to 30 inclusive to cause a sufficient energization of the electromagnet *d* to take place and cause it to close the contacts 49 of the balance relay *J*.

From now on the operation of the relays mentioned will be as before described after the sending of the first train of impulses, the relay *i* being previously operated just as was the relay *h* followed by an operation of the relay *n* just as was the case of the relay *m* previously described, and the resistance coil 538 will next be included in circuit with the electromagnet *c* instead of the resistance coil 532, and after a relatively long closure of the contacts 31. The circuits have been sufficiently described in connection with other previous operations that it is believed unnecessary to again repeat this operation.

The resistance unit 538 is subsequently included in circuit with the electromagnet *c*, the circuit being traced through contacts 539 of the controlling relay *j*, circuit conductor 540, now closed contacts 541 of the relay *i*, circuit conductor 533, now closed contacts 531 of the relay *h*, circuit conductor 56, now closed contacts 40 of the relay *e*, the winding of the electromagnet *c*, and the source of current *G*₁ to the ground pole of said source.

The connection of this resistance unit we will assume controls the operation of the impulse sending relay *f* so as to cause two operations of this relay, and therefore two openings of the contacts 31 in the impulse sending circuit of the station *A* before a sufficient number of resistance units in the circuit of the counter-balanced electromagnet *d* have been short circuited to cause this counter-balanced electromagnet *d* to overcome the power of the electromagnet *c* in whose circuit is included the resistance unit 538 and to close the contacts 49, thereby dis-

establishing the energizing circuits of the operated relays of the rheostat L, and of the relays *b* and *f* for the time being.

There will be produced as before described, two openings of the contacts 31 in the impulse sending circuit, and the ohmic resistance of the resistance unit 538 is such as to control the translator apparatus to produce just two such openings.

10 In like manner we may assume that the fourth resistance unit 542 of the group included by the key K_1 will after a sufficient closure of the contacts 31 control the operation of the relay *f*, say for four full operations of this relay after which the balance relay J will again be operated to close the contacts 49 having previously been described closing the contacts 59, and the circuit operation from this time on including the dis-
20 establishing of the battery supply circuit of the rheostat L, and the subsequent operation of the relay *o* in a manner similar to the operation of the relays *n* and *m* will now be understood. The operator therefore having
25 transmitted four trains of impulses corresponding to the tens of thousands, the thousands, the hundreds and the units of the called-for number will restore the key K_1 .

I have previously described how the operator of the station A desiring to make telephonic connection with the station A', and having removed the receiver 2, from the switchhook causing the switchhook to close contacts 34 in the circuits of the line conductors 141 and 142, thereby caused the circuit of the station A to be extended to the first selector E of Fig. 2, and it has heretofore been stated that hereafter the apparatus of the first selector E was thereupon established to be operated by the opening and closing of the contacts 31 of the relay *f* under the control of the translator. Subsequently the operation of the system to cause the opening and closing of the contacts 31
45 of the relay *f* to produce successive trains of current impulses was described.

A general description of the operation of the apparatus of Figs. 2 and 3 will now be explained to show how the connection is
50 extended from the calling to the called station.

When the contacts 31 of the relay *f* were first operated for the first digit of the called number which is assumed in this description to be 5124, the contacts 31 of the relay *f* are separated twice momentarily, thereby causing the selector line relay 147 to be twice momentarily deenergized. Each time the relay 147 deenergizes, it closes a circuit
60 through the vertical magnet 151. Since the digit called is 5, the vertical magnet 151 operates five times to raise the switch shaft and its wipers five steps, after which the side switch passes to second position, and
65 causes the rotary magnet 152 to operate in

the usual manner to rotate the shaft wipers onto the contacts of an idle trunk line leading to a second selector F. The said switch thereupon passes to third position and, through the medium of its wipers 153 and 154, disconnects the line relay 147 from the line circuit and extends the line conductors through the shaft wipers 155 and 156 and the contacts upon which they have been rotated to the second selector F. The line relay 157 of the second selector thereupon becomes energized in the same manner in which the line relay of the first selector was energized when connection was first extended to it.

When the contacts 31 of the relay *f* of the sending station is operated for the second digit, 1, of the called number, the selector F operates in the same manner as explained for the selector E in connection with the previous digit to extend the connection over the trunk conductors 158 and 159 to an idle connector H which has access to the group of lines to which that of the station A' belongs. When the connection is thus extended to the connector H, its line relay 116, which is normally bridged across the conductors 158 and 159 in series with the battery, becomes energized. The relay 116 upon energizing, closes the circuit of the relay 126. When the calling station causes the contacts 31 to be operated for the third digit, 2, of the called number, the circuit of the line relay 116 of the connector is broken twice momentarily. The relay 126 being a slow-acting relay does not have time to deenergize during the momentary interruptions of its circuit by the line relay, and therefore, each time the relay 116 deenergizes, a circuit is closed from ground G' through the spring 166 and its back contact, spring 167 and its front contact, relay 127, vertical magnet 114 and side switch wiper 124 to the battery lead 170, and thence through battery B to ground G''. Since the digit called is 2, the vertical magnet receives 2 impulses over this circuit and operates to raise the switch shaft and wipers 111, 112 and 113 two steps. The relay 127, which is energized in series with the vertical magnet, is a slow-acting relay and, upon being energized by the first impulse, remains in its energized position until after the last impulse is delivered to the vertical magnet. The relay 127, upon energizing, completes a circuit extending from ground G² through the springs 171 and 172 and private magnet 125 and relay 128 in multiple to the battery lead 170. The relay 127 deenergizes and breaks the circuit of the private magnet 125 and the relay 128 shortly after the last impulse is delivered to the vertical magnet. The private magnet, upon energizing and deenergizing, causes the side switch to pass from first to second position.

When the contacts 31 of the relay *f* of the calling station are caused to be operated for the last digit 4, the circuit of the line relay 116 is broken four times. Since the side switch is now in second position, each time the line relay deenergizes, a circuit is closed from ground *G'* through the spring 166 and its back contact, spring 167 and its front contact, relay 127, springs 173, rotary magnet 115 and the side switch wiper 124 to the battery lead 170. The rotary magnet 115 operates in response to the four impulses received over this circuit to rotate the switch shaft four steps to carry the wipers 111, 112 and 113, onto the bank contacts of the desired line No. 5124.

The relay 127 is energized in series with the rotary magnet 115 and operates in the same manner as for the previous digit to maintain the circuit of the private magnet 125 and the relay 128 closed during the entire time the rotary magnet is operating. The circuit of the private magnet 125 and the relay 128 is broken shortly after the last impulse is delivered to the rotary magnet, and the private magnet 125 upon deenergizing permits the side switch to pass to third position. The side switch wiper 123, upon reaching third position completes a circuit from ground to *G₃* through said side switch wiper, shaft wiper 111, connector, private bank contacts and the cutoff winding 174 of the switch *C'* to the battery lead 170. The winding 174, upon energizing, attracts the armature 175 which operates to disconnect the battery from the line at the switch *C'*.

The passage of the side switch wipers 121 and 122 to third position, and the closing of the contacts 176 and 117 by the deenergization of the relay 128 finally completes a connection between the calling and the called lines. The passage of the side switch wiper 124 to third position completes the circuit of the ringing relay 129. This circuit extends from ground *G₄*, through the interrupter 178, relay 129, springs 179, and the side switch wiper 124 to the battery lead 170. The relay 129, upon energizing disconnects the calling line from the called line, and connects the ringing current generator *M* with the called line through the ringing relay springs 181 and 185 and their front contacts, contacts 177 and 176 of the relay 128 and the wipers 113 and 112. The relay 128 which controls the contacts 177 and 176, is a slow-acting relay and therefore does not permit its contacts to close, until shortly after the side switch has passed the third position and closed the circuits of the cutoff winding 174 of the line switch *C'*. It will thus be seen by the aid of the relay 128 it is impossible for ringing current to be applied to the called line until after the cutoff winding 174 has had sufficient time to en-

energize and disconnect the line relay 225 from the line. Since the circuit of the ringing relay 129 includes the interrupter 178, said relay is energized only intermittently, thus ringing the called subscriber's bell intermittently. When the called-for subscriber removes his receiver in response to the call, the talking circuit of the called station is bridged across the line and as soon thereafter as the ringing relay 129 deenergizes, said station is provided with talking current over a circuit extended from ground *G₅* at the connector release relay 126, through the springs 180, the right-hand winding of the back-bridge relay 118, side switch wiper 122, ringing relay springs 181 and 182, springs 177, thence to and through the station *A'* and back over the line 184, wiper 112, springs 176, springs 185 and 186, side switch wiper 121 and the left-hand winding of the back-bridge relay 118 to the battery lead 170. The relay 118 upon energizing, closes the circuit of the relay 187. This circuit extends from ground *G₃* through the side switch wiper 123, springs 188 and relay 187 to the battery lead 170. The relay 187 upon energizing, operates to open the circuit of the ringing relay 129 at the springs 179 and, by closing contact between the springs 189 forms a locking circuit for itself independent of the relay 118, so as not to deenergize again when the called subscriber hangs up his receiver. In the drawings the complete talking circuit between the calling and the called lines is outlined by heavy conductors.

After the conversation is completed, the entire connection is released by the hanging up of the receiver at the calling station. During the time the connection is being maintained, the release relays 190 and 148 of the selectors *F* and *E*, respectively, are maintained energized over a circuit extending from ground *G₅* at the connector through the springs 180, conductor 191, private wiper 192 of the selector *F*, side switch wiper 193 and spring 194, whence the circuit branches, one branch passing through the relay 190 to battery, while the other branch passes through the side switch wiper 110 and on to the selector *E* and through its relay 148 to the battery lead 170. When the calling subscriber hangs up his receiver, the circuit of the line relay 116 of the connector is broken. The relay 116, upon deenergizing, breaks the circuit of the relay 126. The relay 126, upon deenergizing, closes the circuit of the release magnet 117, said circuit extending from ground *G'* through the spring 166 and its back contact, spring 167 and its back contact, spring 120 and release magnet 117 to the battery lead 170. The magnet 117, upon energizing, immediately restores the shaft and side switch of the connector to normal position, and the switch

shaft, upon reaching its lowest position, separates the springs 120, thereby permitting the release magnet to deenergize. The relay 126, upon deenergizing, also disconnects ground G^5 from the back-bridge relay 118 and also breaks the holding circuit of the relays 190 and 148 of the selectors F and E, respectively. The disconnection of ground from the relay 118 permits said relay to deenergize and cause the current in the calling line to be restored to its normal direction, even though the called subscriber has not yet hung up his receiver. The breaking of the circuits of the relays 190 and 148 permits the said relays to deenergize so as to close the circuits of their respective release magnets 195 and 196, which, upon energizing, cause the switches F and E to be restored to normal position. The relay 148, upon deenergizing, also breaks the holding circuit of the holding winding 149 of the switch C, causing said switch to be restored to normal position.

In the foregoing it has been assumed that the line of the station A' was idle when called from the station A. In case said line had been busy, the connector H would not have completed connection therewith, and the calling subscriber would have been given a busy signal in the manner set forth in the patent to F. Newforth, Jr., No. 1,078,690, and which need not be described herein, it being well understood in the art how the busy signal in an automatic system is produced.

In the foregoing description it was assumed that the operator at station A desiring to call a line upon which is located the station A' operated the key K_1 . Now if some other station than the station A' of the system was desired to be called, the operator would depress one of the other keys, such as the key K_2 or the key K_3 , thereby associating with the circuits of the translator resistance coils having different ohmic resistance characteristics in one or more of the resistance units of the group included, and therefore, successive trains of impulses differing from the trains of impulses created by the depressal of the key K_1 will be produced, and a different line will thereby be selected; and therefore the operator by selecting the particular key to call a given station can predetermine the characteristics of the successive trains of impulses produced by the translator, and which controls the operation of the automatic apparatus illustrated in Figs. 2 and 3 to select the desired line.

While I have illustrated my invention in connection with a particular type of automatic telephone system, it will, of course, be understood that the features of my invention are capable of broader use and that my invention contemplates the use of the

various novel features of my invention in connection with an automatic system of any known type, or in connection with a semi-automatic system.

What I claim as my invention is:—

1. In an electrical translator, the combination with a resistance unit, a controlling relay, means to include in a circuit with a source of current the said resistance unit and the said controlling relay, an intermittent circuit breaker, an electrically operated step-by-step rheostat, means under the control of said controlling relay to include the said circuit breaker and said rheostat in circuit with a source of current whereby said electrically operated rheostat is operated under the control of said circuit breaker, the said resistance unit limiting the extent of operation of said rheostat by said circuit breaker, contacts adapted to be intermittently made and broken during the operation of said rheostat, a selective switch, and means to include said selective switch and said contacts in circuit with the source of current whereby said contacts control the operation of said switch.

2. In an electrical translator, the combination with a resistance unit, a controlling relay in the circuit of said resistance unit, the said circuit including the source of current, an electrically operated step-by-step rheostat, said controlling relay being under the joint control of said resistance unit and said step-by-step rheostat, said controlling relay controlling the operation of said rheostat, a pair of contacts adapted to be intermittently operated during the operation of said rheostat under the control of said controlling relay, the said resistance unit limiting the extent of operation of said rheostat by its control of the said controlling relay to an extent depending upon the ohmic resistance of the said resistance unit, a selective switch, and means to variably operate said selective switch under the control of the said contacts.

3. In an electrical translator, the combination with a selective switch, a pair of contacts included in the circuit of said selective switch together with a source of current to operate the said selective switch, a step-by-step rheostat, means to operate the step-by-step rheostat, means to cause said contacts to be operated during the operation of said rheostat, a controlling relay, a resistance unit, and means whereby the said controlling relay limits the operation of said rheostat, the said means including the said resistance unit.

4. In an electrical translator, the combination with a resistance unit, an electrically operated rheostat, means to operate the same, a pair of contacts adapted to make and break a circuit including a selective switch and a source of current, the degree of

operation of the said rheostat depending upon the ohmic resistance of the said resistance unit and the number of operations of said contacts and the degree of operation of said selective switch depending upon the extent of operation of said rheostat.

5. In an electrical translator, the combination with a pair of contacts adapted to make and break a circuit, a selective switch and a source of current included in the said circuit, said pair of contacts variably controlling the said switch, a resistance unit, a step-by-step operated rheostat, means to cause the said rheostat to operate under the control of said resistance unit, the degree of operation of said rheostat depending upon the ohmic resistance of said resistance unit, and the number of operations of said contacts depending upon the degree of operation of said rheostat.

6. In an electrical system, the combination with a resistance unit having a definite ohmic resistance, a pair of contacts, and means to cause said resistance unit to control the operation of said contacts a certain number of times depending upon the ohmic resistance of the said resistance unit.

7. In an electrical system, the combination with a resistance unit having a definite ohmic resistance, a pair of contacts adapted to intermittently make and break a circuit including an electrical responsive device, and a translator to translate a measure of the ohmic resistance of the said resistance unit into a definite number of operations of said pair of contacts to variably operate the electrical responsive device.

8. In an electrical system, the combination with a resistance unit having a definite ohmic resistance, a pair of contacts adapted to intermittently make and break a circuit including an electrical responsive device, a translator to translate a measure of the ohmic resistance of the said resistance unit into a definite number of operations of said pair of contacts to variably operate the electrical responsive device, a second resistance unit, an automatic switch to effectively include the second resistance unit in the circuit of the said translator to control the same and to exclude the first resistance unit from the said circuit, and means to cause the continued operation of said pair of contacts to cause a second train of operations thereof under the control of the second resistance unit.

9. In an electrical translator, the combination with an electrically operated step-by-step rheostat, means to operate the same, a pair of contacts controlled by the said means during the operation of the said rheostat, and controlling means including a resistance unit and a balancing device to cause the said rheostat to operate causing a definite number of operations of the said contacts,

the number depending upon the ohmic resistance.

10. In an electrical system, the combination with an automatic telephone system including selective switches to select a desired line, a pair of contacts adapted to control the operation of the said switches, a resistance unit, and an electrical translator, said translator controlling the operation of the said contacts under the primary control of the said resistance unit.

11. In an automatic telephone system, the combination with a selective switch containing a movable contact and a plurality of fixed contacts, a plurality of telephone lines connected to the fixed contacts, means to variably operate the said movable contact to make connection with a desired fixed contact, a pair of controlling contacts for the said selective switch controlling the movement of the said movable contact, an electric translator, a plurality of resistance units, switch contacts to include a desired one of the said resistance units in circuit with the said translator whereby the said translator controls the operation of the said contacts variably according to the particular resistance unit used, to variably control the operation of said selective switch.

12. In an electrical system, the combination with a plurality of groups of resistance units, each group consisting of a plurality of resistance units, each resistance unit having a definite predetermined ohmic resistance, an electric translator, a pair of contacts adapted to be operated thereby, a selective switch under the control of the said contacts to make connection between a first circuit and a desired one of a plurality of other circuits, switching means to associate all of the resistance units of a group in circuit with the said translator, means to include in sequence the different resistance units of the associated group in circuit with said translator, whereby the translator is variably operated under the control of each of the resistance units in turn, the degree of operation in each case depending upon the ohmic resistance of the particular unit, the operation of the said switching means thereby causing successive trains of operations of the said contacts.

13. In a telephone system, the combination with a plurality of telephone lines extending by their limbs from stations to an exchange, a plurality of fixed switch contacts for the said lines at the said exchange, a movable contact adapted to be brought into connection with any of the said fixed contacts whereby connection is adapted to be made between the said movable contact and any of the said lines, a source of current, an electromagnet and a pair of contacts controlling the same to cause variable operation of the said switch, an electrical translator adapted

to variably control the said contacts, a plurality of resistance units for the said translator, and means to include a desired one of the said resistance units in circuit with the said translator to variably operate the same, whereby a desired connection can be made between the said movable contact and a desired line.

14. In an electrical system, the combination with a pair of contacts adapted to make and break a circuit, a selective switch, a source of current in the said circuit, an electrical translator, and electrically operated rheostat therefor, means to operate the same, a plurality of resistance units adapted to be associated with the said translator, means to cause one of the said resistance units to control the extent of operation of the said rheostat to be included in the circuit of the said translator to control the extent of operation of the said rheostat by the said translator, the said pair of contacts being adapted to be operated a proportional number of times to the extent of operation of the said rheostat, circuit connections and apparatus limiting the extent of the operation of said rheostat to a degree depending upon the ohmic resistance of the said resistance unit, the said selective switch being variably operated depending upon the ohmic resistance of the particular resistance unit included in circuit with the said translator.

15. In an automatic telephone system, the combination with a telephone line leading from a calling station to an exchange, selector and connector switches at the exchange adapted to make connection with other lines leading thereto, a plurality of resistance units, each having definite ohmic resistances, a translator to translate in sequence the ohmic resistance of the different resistance units, each into a definite number of operations of the said pair of contacts, a source of current associated with the said automatic system adapted to produce under the control of said contacts during the said successive operations of the same successive trains of current impulses, and electromagnetic means associated with the said selector and connector switches to variably operate the said switches, the degree of operation of said switches depending upon particular values of ohmic resistances of the said resistance units.

16. In an electrical system, the combination with a resistance unit having a definite ohmic resistance, a pair of contacts adapted to intermittently make and break a circuit including an electrical responsive device, a translator to translate a measure of the ohmic resistance of the said resistance unit into a definite number of operations of said pair of contacts to variably operate the electrical responsive device, a second electrical responsive device, a second resistance unit,

and means to subsequently supersede the first resistance unit with the second resistance unit, and to subsequently translate the measure of the ohmic resistance of the second resistance unit into a succeeding definite number of operations of said pair of contacts to operate the said second electrical responsive device.

17. In an electrical system, the combination with a plurality of resistance units having definite ohmic resistances, a pair of contacts to intermittently make and break a circuit including a step-by-step responsive device, a translator, and means to successively interpose the said translator between successive resistance units and the said contacts whereby the said step-by-step device is successively operated under the successive control of the different resistance units.

18. In a telephone system, the combination with a plurality of groups of resistance units, each having a definite ohmic resistance, a switch contact in the circuit of each resistance unit, each resistance unit of the group having a different resistance from other resistance units in the group, means to close the switch contacts of a resistance unit in each group, a pair of contacts adapted to intermittently make and break a circuit including a step by step responsive device, a translator, automatic means responsive to the closure of said switch contacts to successively operatively associate the said translator and the different resistance units whose switch contacts have been previously closed, and means to cause the said translator to operate the said pair of contacts under the successive control of the different associated resistance units.

19. In an electrical system, the combination with a resistance unit having a definite ohmic resistance, a pair of contacts in a circuit including a source of current and a current impulse operated device, a translator interlinking with said resistance unit and the said pair of contacts, the said translator operating under the control of said resistance unit to cause the said contacts to operate a definite number of times depending upon the ohmic resistance of the said resistance unit, and to cause the said current impulse operated device to operate a predetermined number of steps.

20. In a telephone system, the combination with a plurality of groups of resistance units, each having a definite ohmic resistance, a switch contact in the circuit of each resistance unit, each resistance unit of the group having a different resistance from other resistance units in the group, means to close the switch contacts of a resistance unit in each group, a pair of contacts adapted to intermittently make and break a circuit including a step by step responsive de-

vice, a translator, automatic means responsive to the closure of said switch contacts to successively operatively associate the said translator and the different resistance units
5 whose switch contacts have been previously closed, means to cause the said translator to operate the said pair of contacts under the successive control of the different associated resistance units, a movable contact associated with the said step by step device, a
10 plurality of stationary contacts therefor, and means responsive to the intermittent closures of the said contacts under the control of the said resistance units to operatively connect the said movable contact in an electrical circuit with a desired one of the
15 said stationary contacts.

21. In an electrical system, a progressively operable switch arranged to occupy a plurality of selective positions, two circuits co-operating in the control of said switch, means for directly including resistance units in one circuit, means to include resistance units in the other circuit as said switch
25 is being advanced, and means for stopping said switch when the resistance values of one circuit bears a certain relation to the resistance values of the other circuit.

22. In an electrical system, a progressively

operable switch arranged to occupy a plurality of selective positions, and circuits and resistance units arranged as a Wheatstone bridge to directly control the setting of said switch.

23. In an electrical system, a plurality of circuits, means including link circuits and directly operable switches for inter-connecting a pair of circuits and other circuits and resistance units arranged as a Wheatstone bridge to directly control the setting of
40 said switches.

24. In an electrical system, a plurality of circuits, means including link circuits and directly operable switches for inter-connecting a pair of circuits, control circuits, resistance units, means for directly including said resistance units in certain of said circuits, means to include resistance units in another of said control circuits as said switches are being advanced and means
50 for stopping said switches when the resistance values of one circuit bear a certain relation to the resistance values of the other circuits.

In witness whereof, I hereunto subscribe my name this 22nd day of June, A. D. 1917.

FRANK M. SLOUGH.