

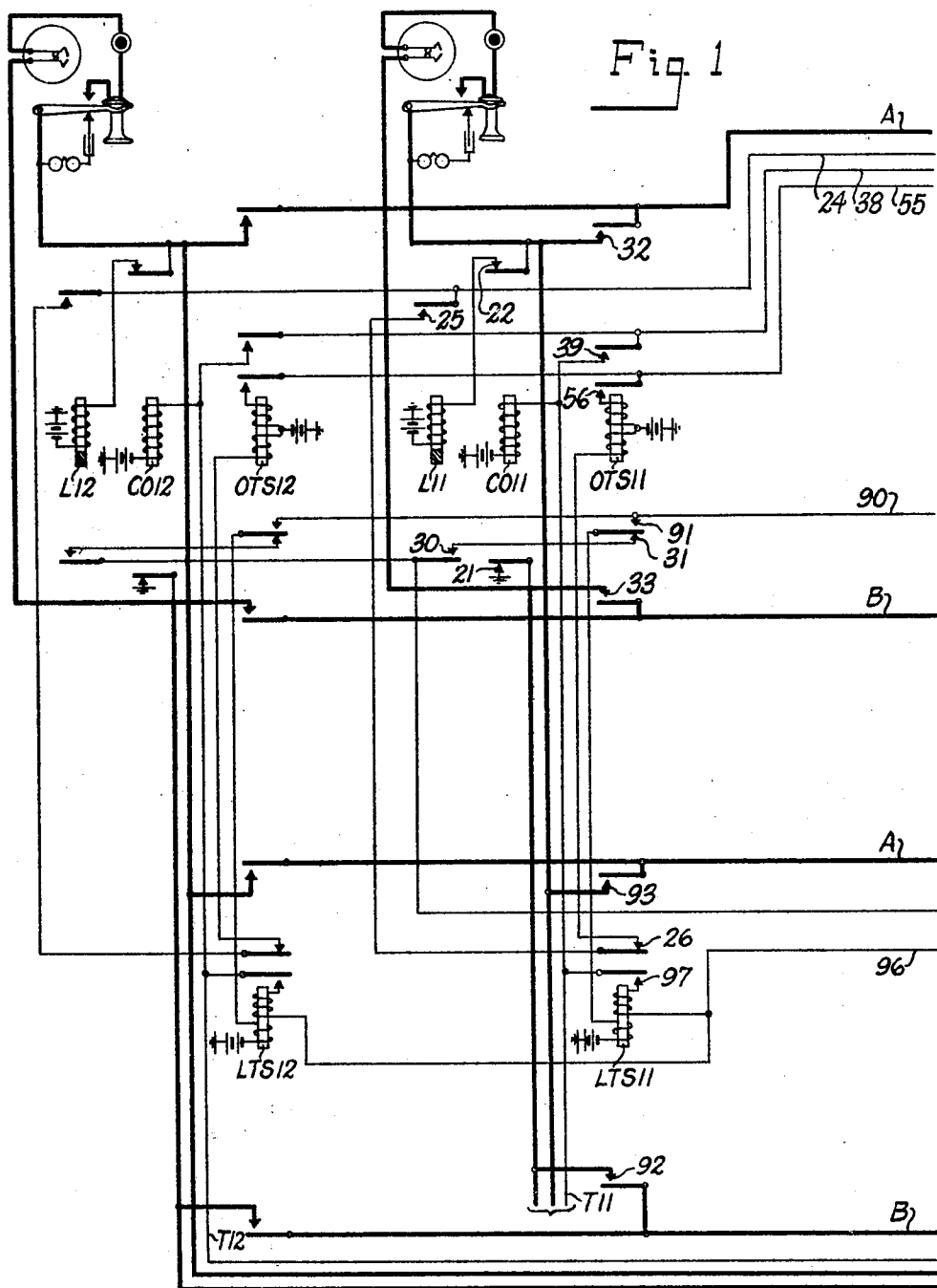
Jan. 20, 1931.

R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928 9 Sheets-Sheet 1



Inventor
Rudolph F. Stehlik

R. B. Richardson Atty.

Jan. 20, 1931.

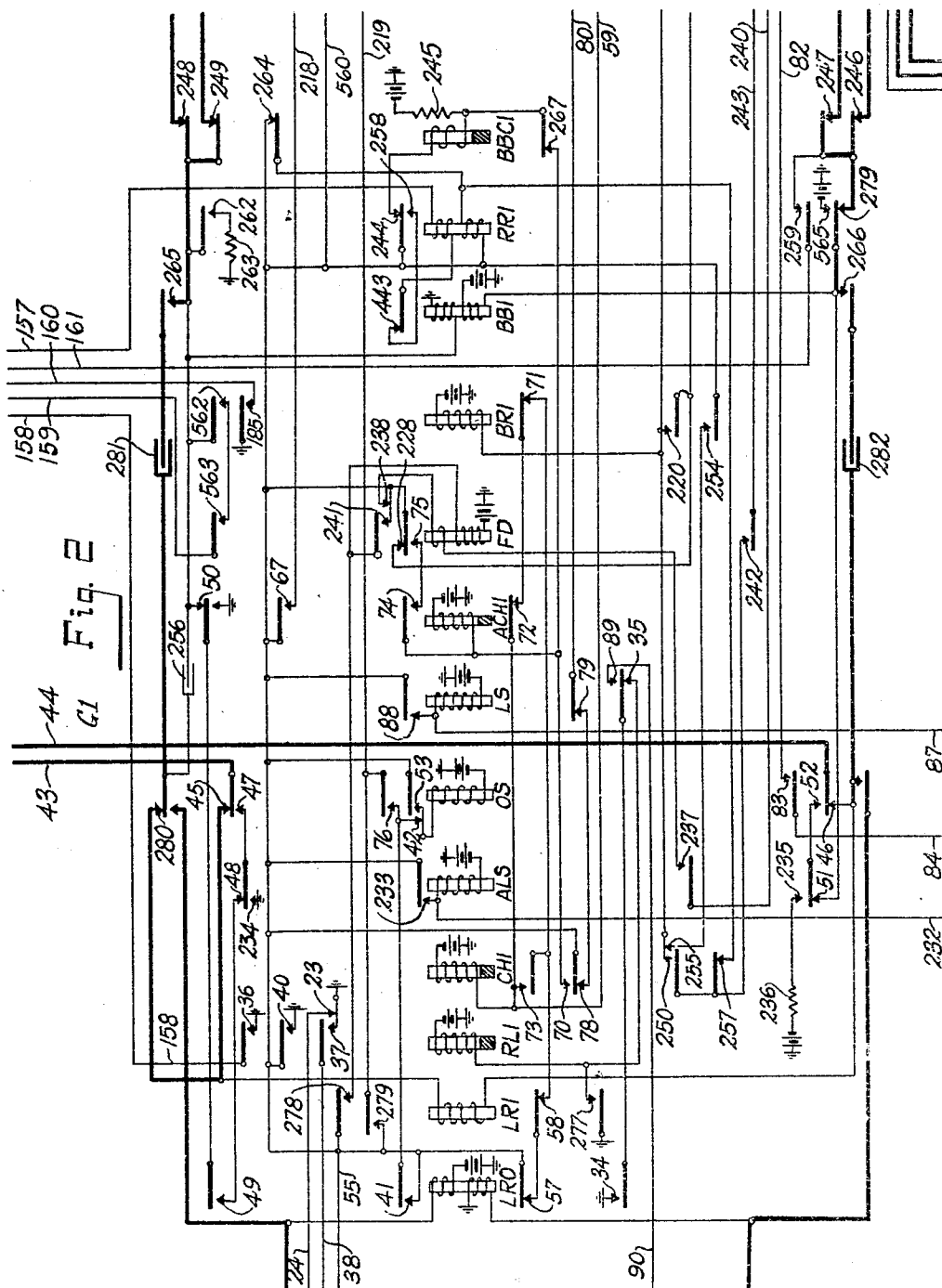
R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928

9 Sheets-Sheet 2



Inventor
Rudolph F Stehlik

RS Richardson Attg

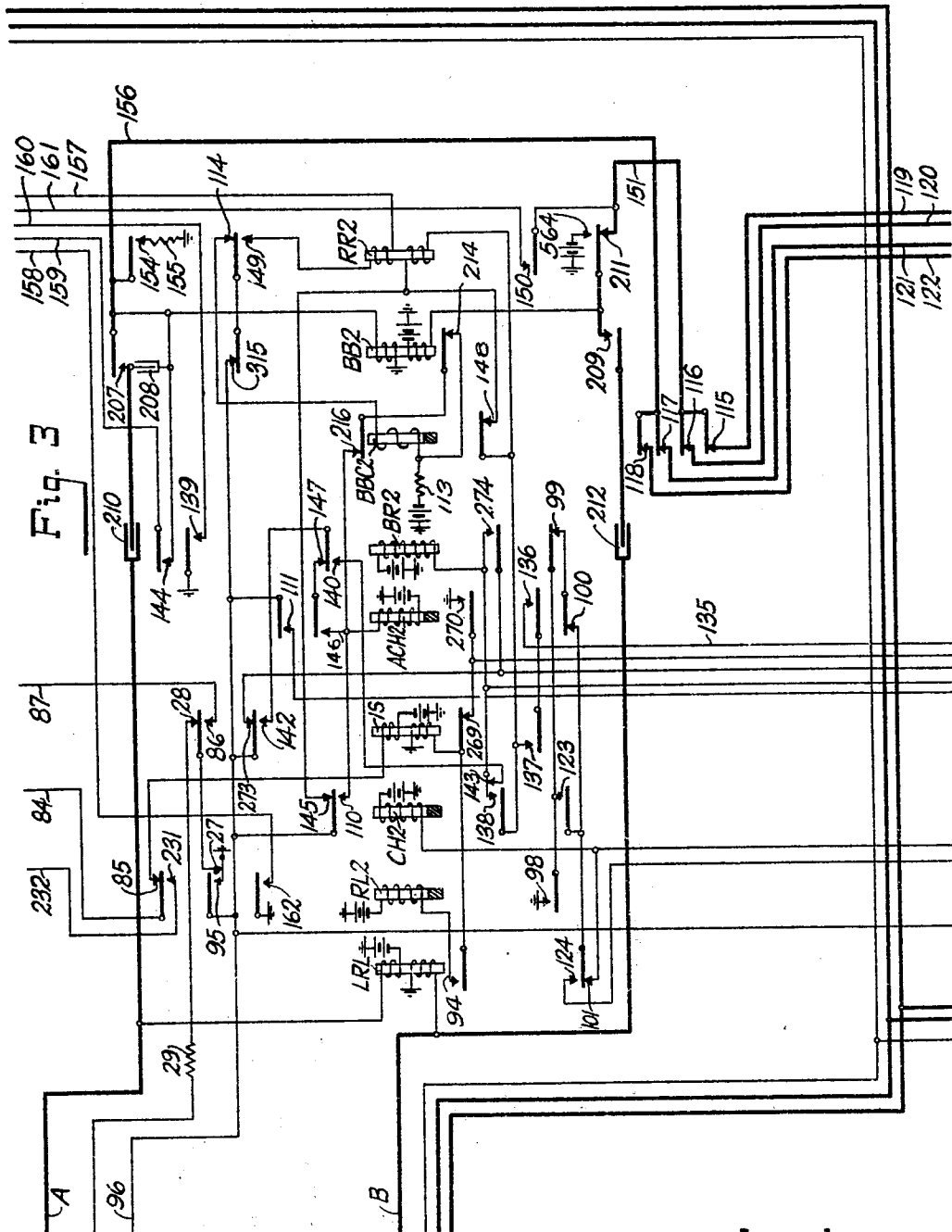
Jan. 20, 1931.

R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928 9 Sheets-Sheet 3



Inventor
Rudolph F Stehlik

P. B. Richardson Atty.

Jan. 20, 1931.

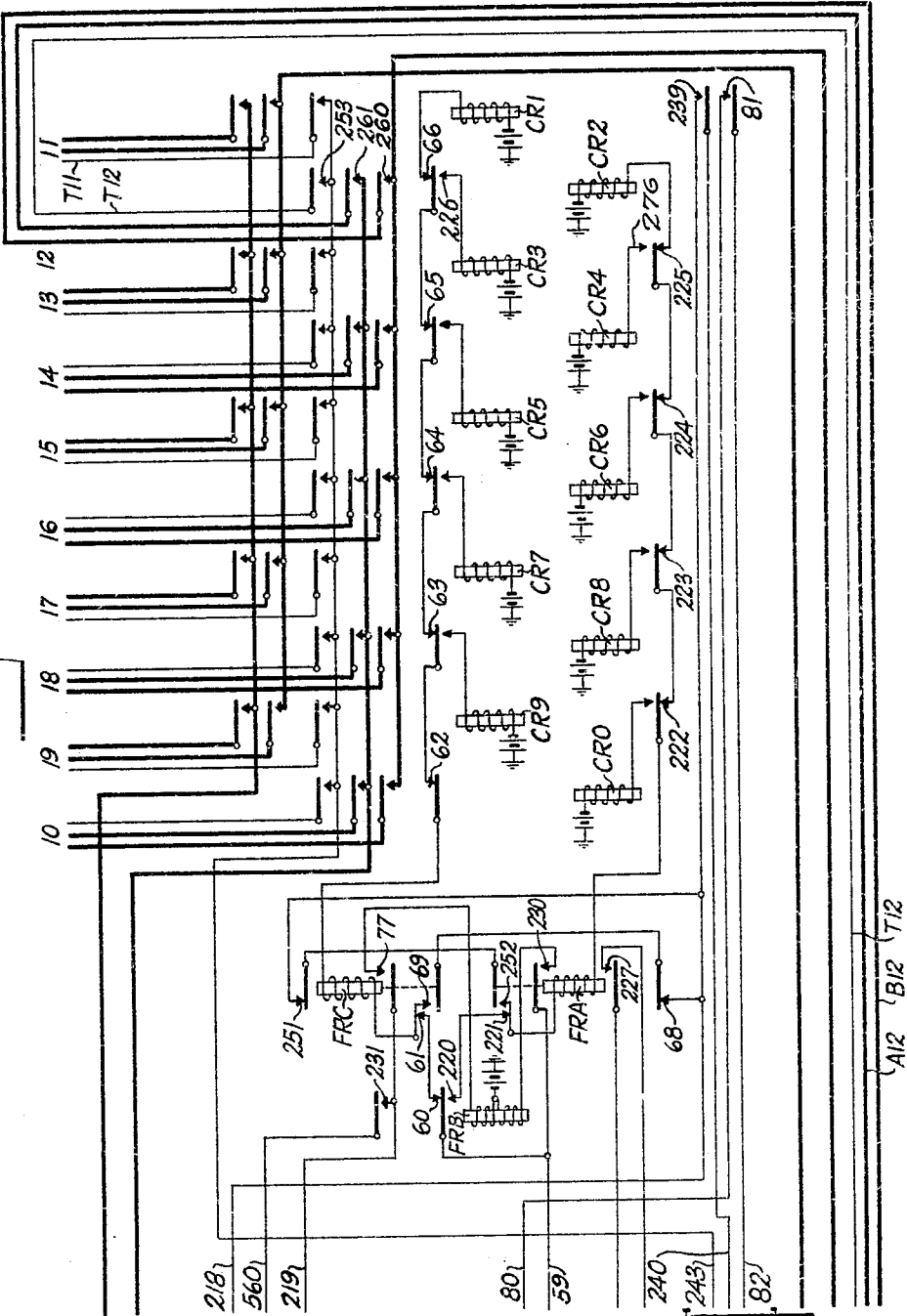
R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

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Fig. 4



Inventor
Rudolph F. Stehlik

R. F. Stehlik Atty.

Jan. 20, 1931.

R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928

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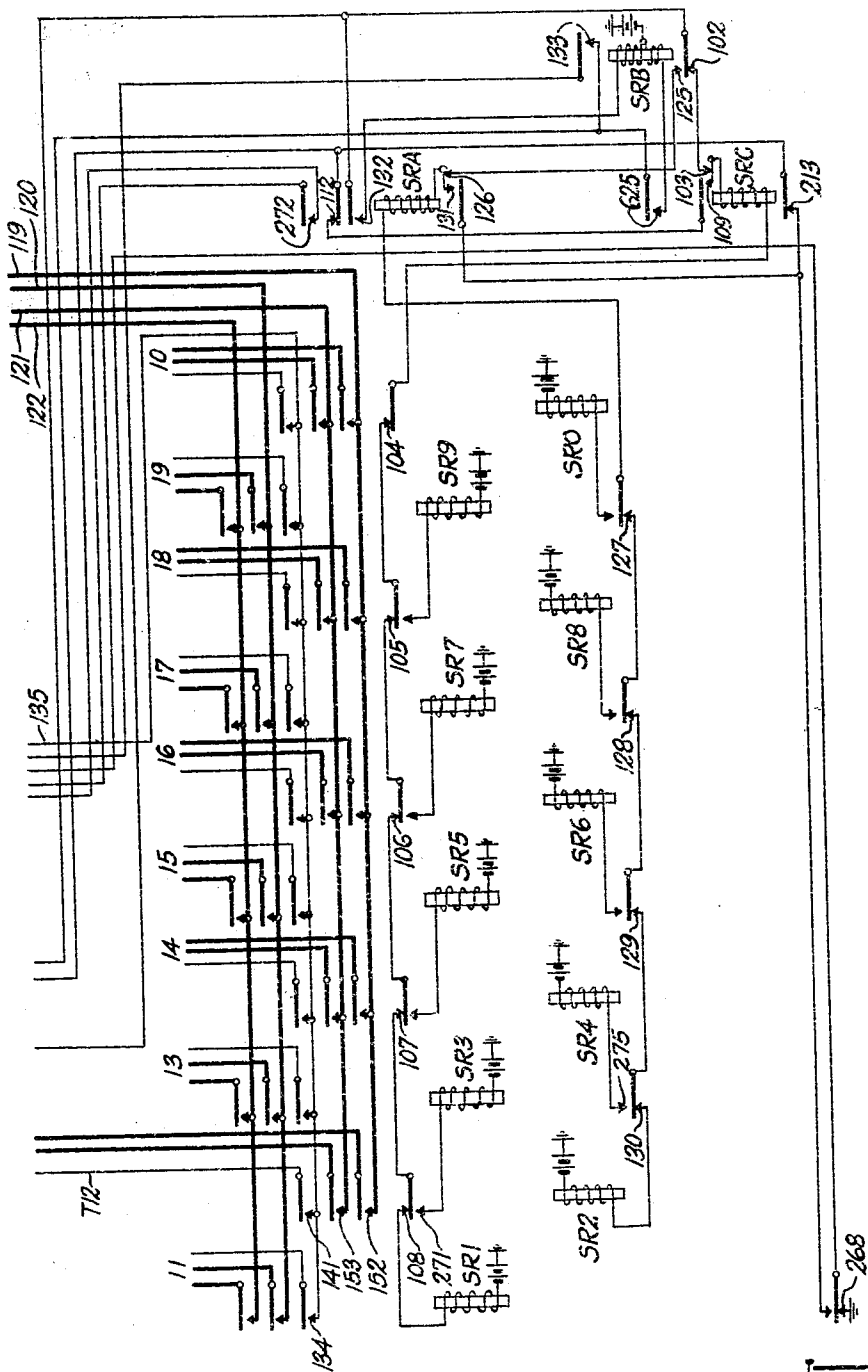


Fig. 5

Inventor
Rudolph F. Stehlik

R. F. Stehlik Atty

Jan. 20, 1931.

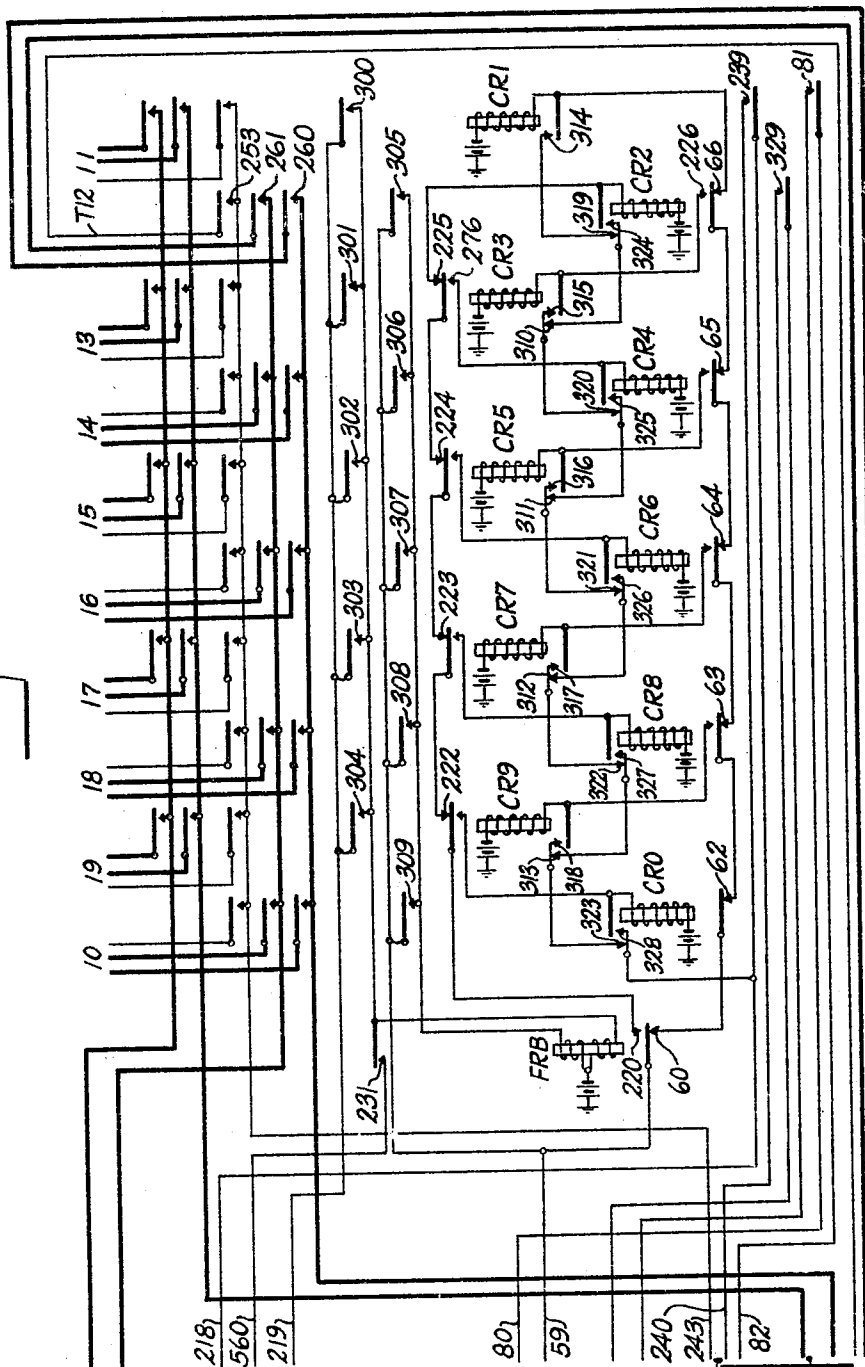
R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

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Fig. 6



Inventor
Rudolph F. Stehlik

Attorney
R. B. Richardson

Jan. 20, 1931.

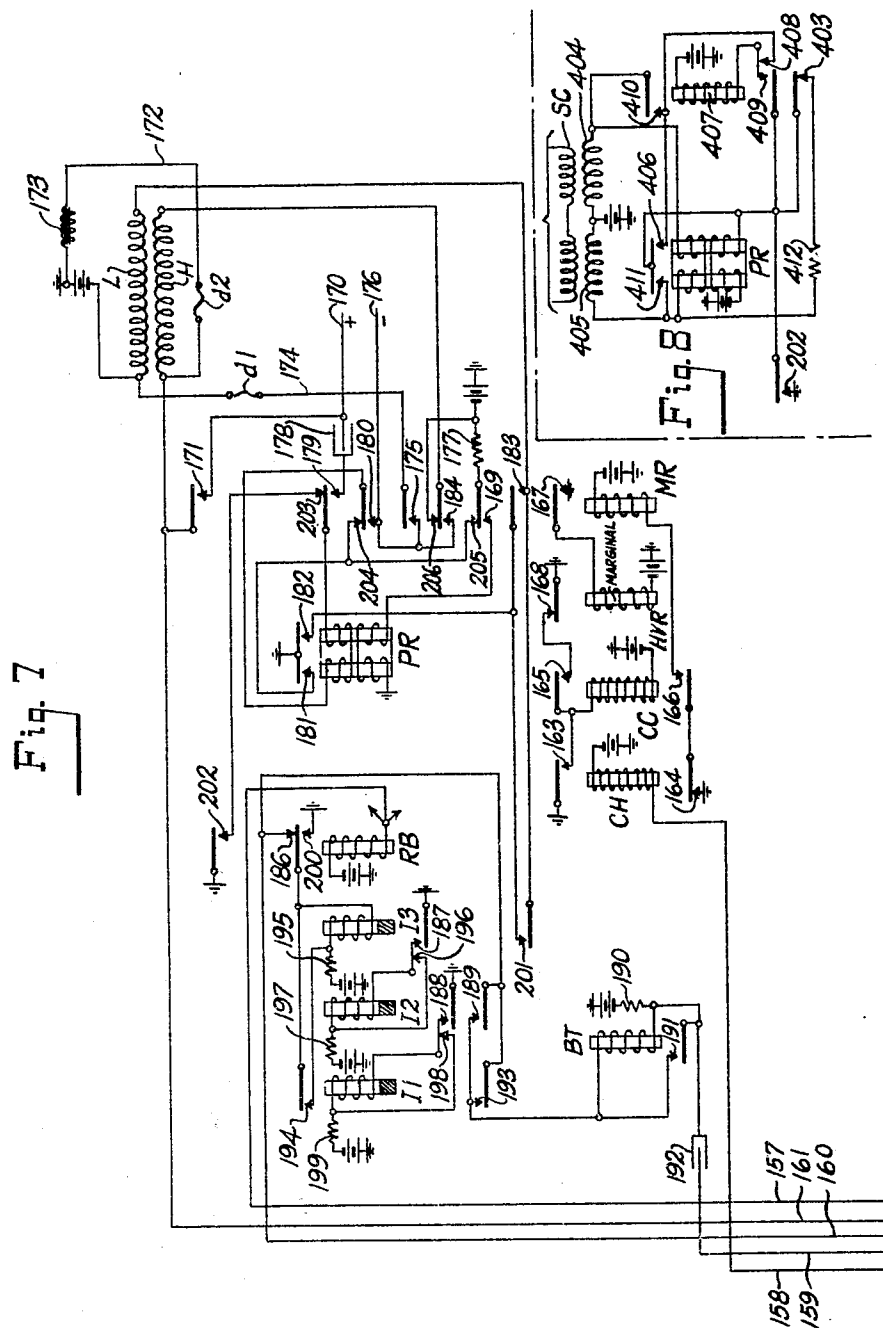
R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928

9 Sheets-Sheet 7



____Inventor____
Rudolph F Stehlik
Richardson Atty.

Jan. 20, 1931.

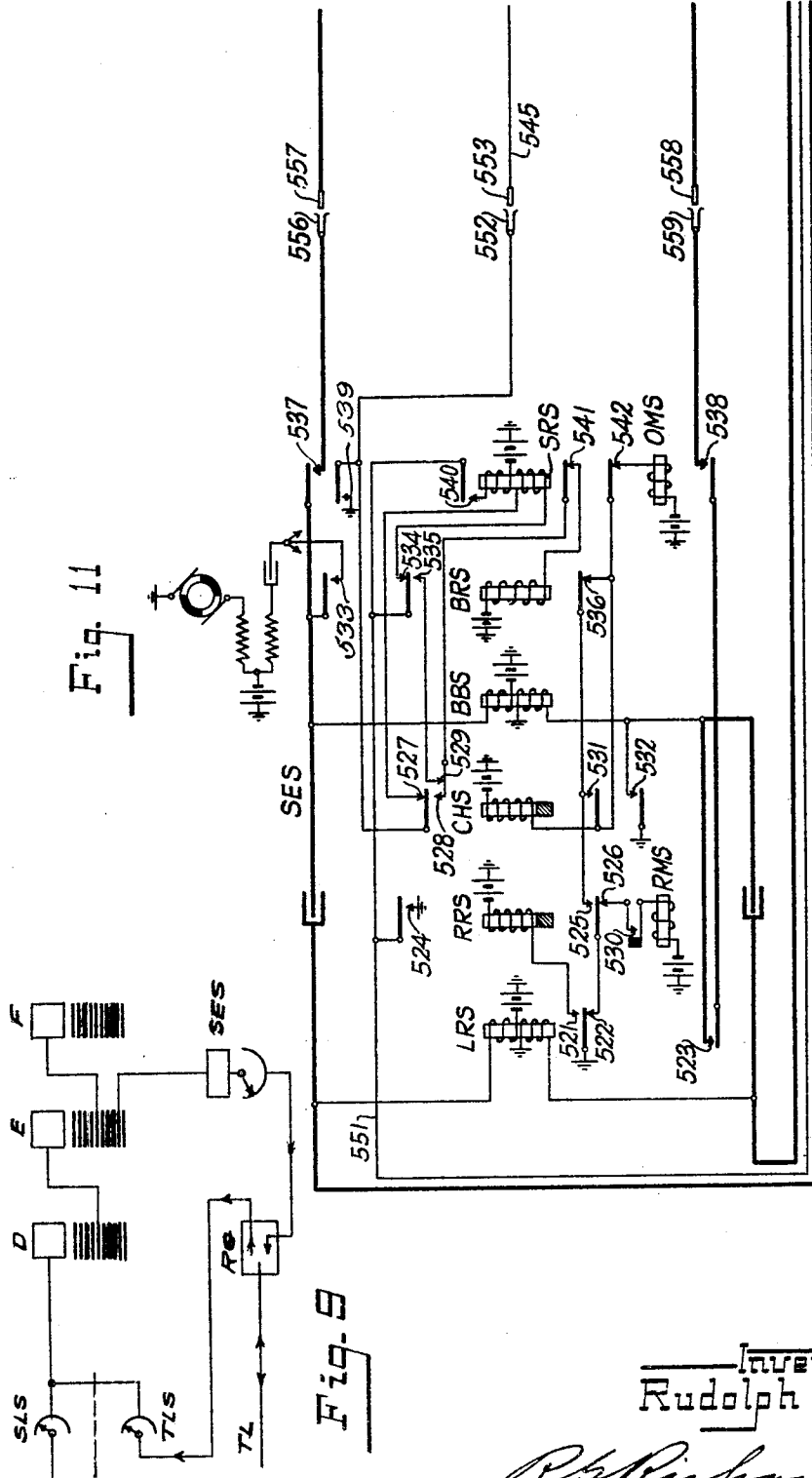
R. F. STEHLIK

1,789,606

AUTOMATIC TELEPHONE SYSTEM

Filed March 23, 1928

9 Sheets-Sheet 8



Inventor
Rudolph F. Stehlik

Attorney
R. F. Richardson

Jan. 20, 1931.

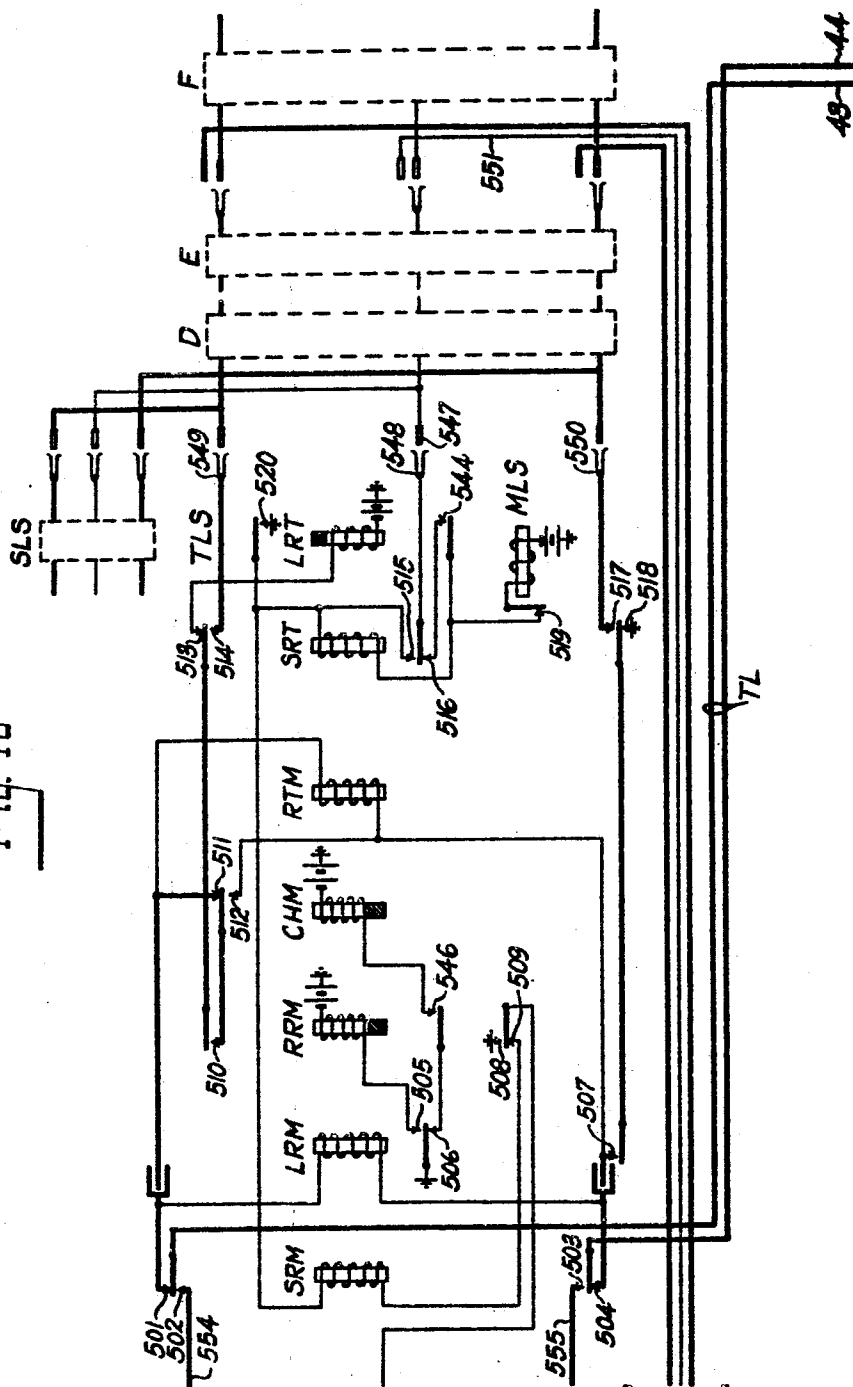
R. F. STEHLIK

1,789,606

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Fig. 10



Inventor
Rudolph F. Stehlik

R. F. Stehlik Atty

UNITED STATES PATENT OFFICE

RUDOLPH F. STEHLIK, OF CHICAGO, ILLINOIS, ASSIGNOR TO RESERVE HOLDING COMPANY, OF KANSAS CITY, MISSOURI, A CORPORATION OF DELAWARE

AUTOMATIC TELEPHONE SYSTEM

Application filed March 23, 1928, Serial No. 264,262, and in Belgium August 13, 1927.

The present invention relates to improvements in or relating to automatic telephone systems and more particularly concerns the provision of a small private automatic exchange although it will be understood that features of the invention are capable of much wider interpretation.

The arrangement described consists of a private automatic branch exchange having an extension to a main exchange and adapted to be operated solely by relays.

One of the objects of the invention is the production of a small automatic exchange operated solely by relays which would be much cheaper than those hitherto employed, while a subsidiary feature is to provide a private or automatic branch exchange with an extension to a main exchange which is operated solely by relays and which is very cheap to install.

Among important features of the invention may be mentioned the provision of arrangements by which a call set up over one primary trunk may be transferred to another primary trunk if the call is a local call, but if there is no other trunk available then the call can be set up locally over the first primary trunk.

It is possible, according to the invention, to utilize a group of relays associated with the primary trunk to effect a call from a local subscriber to the main exchange, from a local subscriber to another local subscriber by transferring to another primary trunk, from a local subscriber to another local subscriber by the original primary trunk if there is no other trunk available and a call from a main exchange subscriber to a local subscriber. It will thus be appreciated that the group of relays associated with the first primary trunk contains a number of novel features in varying combinations, which consist of a relay group capable of dealing not only with all the functions mentioned but dealing with two, three or more in varying combinations. Again, it will be appreciated that a second primary trunk circuit is provided which is capable not only of receiving an originating call but also of receiving and dealing with a call transferred to it. The

transfer is effected when a discriminating digit is dialled indicating that the call is not for the main exchange, no discriminating digit being required in the case of a call from the main exchange, and accordingly further features of the invention arise out of the fact that according to the route over which a group of relays is seized it is adapted to operate differently according as to whether it is seized directly or seized after some series of impulses have already been transmitted.

Among further novel features may be mentioned a counting relay chain in which a single controlling relay, which energizes after the termination of one impulse and remains energized until the end of the next impulse, controls the operation of the chain of relays.

Another feature of the invention consists of relays which between them perform the functions of ringing, giving a busy tone and charging the local battery. These and other features of the invention will be better understood by referring to the accompanying description in which, Figs. 1 to 11 show diagrammatically the circuits by which various connections can be set up. Fig. 1 shows the line cut-off and switching relays of subscribers in the local exchange, Fig. 2 shows the battery feed group associated with the first choice primary trunk, Fig. 3 shows the battery feed group associated with the second choice primary trunk, Fig. 4 shows the relay recorder associated with the first primary trunk, Fig. 5 shows the relay recorder associated with the second primary trunk, Fig. 6 shows an alternative recorder to that shown in Fig. 4, Fig. 7 shows the battery charging, ringing, and busy arrangements, Fig. 8 shows an alternative of the busy arrangements.

Fig. 9 shows diagrammatically the general layout arrangement at the main exchange, that is the relationship between Figures 10 and 11.

Fig. 10 shows the repeater at the main exchange to which access is had from a sub-exchange, and from which access is had to the sub-exchange, while

Fig. 11 shows a selector switch having

access to the relay group from the normal type selector.

In order to follow the layout, the figures should be arranged as follows: Fig. 1 to the extreme left, Fig. 2 to the right of the upper portion of Fig. 1, Fig. 3 to the right of the lower portion of Fig. 1, Fig. 4 to the right of Fig. 2, Fig. 5 beneath Fig. 3, Fig. 7 can be placed either above Fig. 2 or Fig. 3, according as to which battery feed relay group is being used, Fig. 10 should be placed on the left hand upper side of Fig. 2, while Fig. 11 should be placed to the left of Fig. 10, Fig. 6 is an alternative which can be substituted for Fig. 4.

Referring to the drawings the invention will be better understood by describing in the first place the setting up of a call assuming that both the battery feed groups are idle.

It will be assumed that subscriber No. 11 lifts his receiver with a view to establishing connection with subscriber No. 12, that is to say, it is desired to establish a simple local connection.

It should be mentioned that all the subscribers connected to the small private branch exchange have the first digit in their number as one. This is to distinguish them from subscribers connected to the main exchange, where the subscribers' numbers always begin with a digit other than one. The first digit therefore discriminates between a call for a local subscriber and a call for a main exchange subscriber. When subscriber No. 11 lifts his receiver the following circuit is completed: earth, contact 21, subscriber's loop, contact 22, line relay L11 to battery. The line relay energizes and completes the following circuit: earth, normally closed contact 23 of release relay RL1 located in battery feed group G1, conductor 24, contact 25, contact 26, of relay LTS11, lower winding of relay OTS11 to battery. A second circuit is completed at the same time as follows: earth, normally closed contact 27 of relay RL2 of the battery feed group G2, contact 28, resistance 29, contact 30, contact 31 of relay OTS11, lower winding of relay LTS11 to battery. The resistance 29 is so chosen that in the circumstances described relay OTS11 will energize before LTS11 thereby opening contact 31 and preventing relay LTS11 from energizing. Consequently the call is now extended from the subscriber's line over contacts 32 and 33 of relay OTS11 to the line relay LRO of the battery feed group G1. Line relay LRO accordingly energizes and at contact 34 completes a circuit for relay RL1 as follows: earth, contact 34, contact 35 of relay LS, relay RL1 to battery. Relay RL1 accordingly energizes and at contact 36 completes a circuit for the charging relay set shown in Fig. 7 for a purpose to be described later. Relay RL1 also

closes contact 37 and opens contact 23; the opening of this contact prevents the feed group G1 being taken into use by any other calling subscriber, at contact 37 relay RL1 connects earth to the release trunk 38 so as to energize the cut-off relay CO11 over contact 39 of relay OTS11. Relay RL1 also provides a holding circuit for relay OTS11 from earth over contact 40, conductor 55, contact 56, relay OTS11 to battery; this relay is therefore held energized independently of the initial energizing circuit. The cut-off relay CO11 on energizing opens contacts 22 and 21, whereby disconnecting line relay L11 which de-energizes and opens the circuits by which the feed groups G1 and G2 were originally tested and G1 seized. Further operations however take place in the battery feed group G1. The energization of relays LRO and RL1 jointly complete a circuit for relay OS as follows: earth, contact 40, contact 41, normally closed contact 42, relay OS to battery. Relay OS energizes and disconnects the relay LR1 from the conductors 43 and 44 extending to the main exchange at contacts 45 and 46 and connects up in place thereof the relay BB1 in the following circuit: conductor 43, contact 47, contact 48, contact 49, contact 50, the upper winding of relay BB1 to earth. The lower winding of relay BB1 is connected from battery over contact 51, contact 52 to conductor 44 so that battery feed is now connected from the relay group G1 to the conductors 43 and 44 to energize the line relay LRM at the main exchange (Fig. 10), which line relay is similar to relay LR1 in that it has neither battery nor earth connections and is normally connected across the conductors 43 and 44 so that it energizes in series with relay BB1.

The subscriber now commences to operate his calling device to send a series of impulses corresponding to the first digit. This digit only includes one impulse as the number dialled will be No. 12 and accordingly line relay LRO de-energizes once only. Relay OS at contact 53 closes a locking circuit for itself independent of contact 42 and contact 41 so that it is directly controlled by contact 40 and relay RL1. When relay LRO de-energizes it opens contact 49 so that battery ceases to be fed by relay BB1 over the conductors 43 and 44 to the main exchange and the line relay LRM thereat de-energizes. Relay LRO also closes at contact 57 a circuit for relay CH1 as follows: earth, contact 40, contact 57, contact 58, contact 71, contact 72, relay CH1 to battery. A branch of this circuit extends over conductor 59, contact 60 of relay FRB, normally closed contact 61 of relay FRC, winding of relay FRC, contacts 62, 63, 64, 65, 66 of the counting relays CRO, CR8, CR6, CR4, CR2 to relay CR1. Relays CH1, FRC and CR1 all energize. Relay CH1 on energizing completes a cir-

cuit for relay ACH1 as follows: earth, contact 40, contact 70, relay ACH1 to battery. Relay FRC and relay CR1 are locked-energized in the following circuit: earth, contact 40 of relay RL1, contact 67 of relay ACH1, conductor 218, contact 68 of relay FRA, contact 69 of relay FRC, relay FRC, contacts 62, 63, 64, 65 and 66, relay CR1 to battery; contact 61 is opened but owing to the completion of the locking circuit over conductor 218 and contact 67 this is of no effect. Relay CH1 at contact 73 closes a circuit for its further energization independent of contacts 71 and 72, contact 72 being opened when relay ACH1 energizes. On the cessation of the first impulse relay LRO again energizes, contact 49 closes, re-energizing the line relay at the main exchange, and contact 34 closes to prevent relay RL1 de-energizing. Relay RL1 being slow to release does not de-energize on the momentary opening of the circuit. On the energization of relay LRO contact 57 is opened thus opening the circuit of relay CH1, which accordingly de-energizes after a short interval. Before this takes place, however, due to the energization of relay LRO after the first impulse a circuit is completed as follows: earth, contact 40, contact 41, contact 76, conductor 219, contact 77 of relay FRC, upper winding of relay FRB to battery. Relay FRB energizes in this circuit, opens contact 60 and connects at contact 220 conductor 59 to relay FRA. As however, conductor 59 is not again connected to earth, the energization of relay FRB in this case is without effect. When relay CH1 de-energizes, the following circuit for relay IS of the second battery feed group G2 is completed: earth, contact 40, contact 78, contact 79, conductor 80, contact 81, conductor 82, contact 83, conductor 84, contact 85 of relay RL2 of the second battery feed group G2 and the upper winding of relay IS to battery. This circuit is completed because the first digit only included one impulse and consequently relay CR1 was energized at the cessation of a train. If a train had consisted of more impulses it will be understood from the further description, that relay CR1 would not be energized and this circuit would not have been completed. The purpose of completing this circuit is that, now it is known that the call is for a local subscriber, it is possible to utilize a second battery feed group which has no access to the main exchange and so leaves the battery feed group G1, which has access to the main exchange, free for a further call. It will be borne in mind that it is assumed that the battery feed group G2 is still not taken into use. On relay IS energizing the following circuit is completed: earth, normally closed contact 27, contact 86, conductor 87, relay LS of battery feed group G1 to battery. Relay LS accordingly energizes, locks itself energized at contact 88, and at contact 89 completes the following circuit: earth, contact 34, contact 89, change-over lead 90, contact 91 of relay OTS11, lower winding of relay LTS11 to battery. Relay LTS11 accordingly energizes in this circuit and at contacts 92 and 93 connects the line relay LRL in circuit with the subscriber's loop. Relay LS on energizing opens the circuit of relay RL1 at contact 35 which relay accordingly de-energizes and by opening contact 40 permits relays OS and LS to de-energize. It also removes earth from conductor 55 and permits relay OTS11 to de-energize. Relay OTS11 accordingly disconnects the relay group G1 thereby permitting the relays thereat to restore to normal, including the relays FRC and CR1. Due to the sluggishness of the release of relay RL1, while this has been taking place the connection has been transferred and the relay LRL of the battery feed group G2 is energized over the subscriber's loop, completing a circuit for relay RL2 at contact 94 as follows: earth, lower winding of relay IS, contact 94, relay RL2 to battery. Relay RL2 accordingly energizes and opens contact 27, thereby opening the energizing circuit of relay LS, this occurring in the event of the relay RL1 at the battery feed group G1 de-energizing before relay RL2 energizes. Generally speaking relay RL2 will energize first owing to the sluggishness of relay RL1 in falling away so that it is really the opening of the locking circuit of the relay LS at contact 27 which causes the de-energization of relay LS, as previously mentioned. Relay RL2 at contact 95 connects earth to the release trunk conductor 96, thereby maintaining cut-off relay CO11 energized in the following circuit after earth has been removed at contact 37 from the release trunk conductor 38 in the group G1: earth, contact 95, conductor 96, upper winding of relay LTS11, contact 97, relay CO11 to battery. As soon as relay RL2 energizes it completes a circuit for relay BBC2 as follows: earth, contact 95, contact 315, contact 114, relay BBC2, over resistance 113 to battery. BBC2 energizes in this circuit and opens contacts 115, 116, 117 and 118 thereby disconnecting the speaking conductors from the calling subscriber during the transmission of impulses. Both relay LTS11 and CO11 are maintained energized in the locking circuit described above and everything is now in order for the subscriber to dial a second digit, in this case the digit 2. On the first impulse, when the subscriber's loop is opened the relay LRL de-energizes and completes a circuit as follows: earth, contact 98 of relay RL2, contact 99 of relay BR2, contact 100, contact 101, relay CH2, to battery, while a branch circuit extends over the back contact 102 of relay SRB,

normal contact 103 of relay SRC, relay SRC, contacts 104, 105, 106, 107, 108 of relays SRO, SR8, SR6, SR4, SR2 and relay SR1 to battery. Relays SRC and SR1 energize in series. Relay CH2 on energizing completes at contact 110 an energizing circuit for relay ACH2 which also energizes and at contact 111 completes a locking circuit for relays SRC and SR1 as follows: earth, contact 95, contact 111, contact 112, contact 109, relay SRC, contacts 104, 105, 106, 107, and 108, relay SR1 to battery. On the completion of the first impulse when relay LRL again energizes, the following circuit is completed: earth, contact 98, contact 123, contact 124, contact 625 of relay SRC, lower winding of relay SRB to battery. Relay SRB energizes and closes a locking circuit for its lower winding over contact 133 and as there are two impulses in the series which has been transmitted, relay CH2 and relay ACH2 remain energized. The second impulse accordingly commences and relay LRL again de-energizes and this time a circuit is completed for relays SRA and SR2 as follows: earth, contact 98, contact 123, contact 101, contact 125, contact 126, relay SRA, contact 127, 128, 129, 130 of relays SR9, SR7, SR5, SR3 to relay SR2. Relays SR2 and SRA energize in this circuit, and are locked energized in the following circuit: earth, contact 270 of relay ACH2, contact 268 of relay SR1, contact 131, relay SRA, contacts 127, 128, 129, 130 to relay SR2 to battery. At contact 132 a circuit is completed for the upper winding of relay SRB over the previously described circuit, including contacts 101, 123, 98 to earth. Relay SRB is maintained energized over its upper winding, on this circuit because relay SRA has opened contact 112 and thereby opened the locking circuit for relay SRC and relay SR1, and hence, opened the circuit for the lower winding of relay SRB. Relays SRC and SR1 accordingly de-energize. The locking circuit for relays SRA and SR2 is now however completed as follows: earth, contact 95, contact 111, contact 213 of relay SRC, contact 131, relay SRA, contacts 127, 128, 129 and 130, relay SR2 to battery. It will be clear that relay SR2 should not close its front contact before relay SRA has opened contact 112, as it is important that relay SR3 should not energize, which it might do if relay SRA was slow in opening contact 112. This can readily be arranged by those versed in the art of relay design. Relay SR2 is accordingly energized and remains energized as there are no further impulses to be sent to select subscriber No. 12. As the relays SR1 and SR2 are successively energized, the test leads T11 and T12 of the subscribers Nos. 11 and 12 are successively tested. The relay SR1 was energized when the test lead was connected to earth over the upper winding of relay LTS11, and accordingly a circuit was completed as follows: earth, contact 95, release trunk conductor 96, upper winding of relay LTS11, contact 97, conductor T11, contact 134 (Fig. 5), conductor 135, contact 136 of relay ACH2, contact 137 of relay IS, contact 138 of relay CH2, relay BR2 to battery. Relay BR2 accordingly energizes and at contact 139 connects earth over conductor 160 to the busy tone circuit, while at contact 140 it prepares a locking circuit for itself, which however is of no effect as the closure of contact 134 is only momentary, relay SR1 de-energizing at the beginning of the second impulse and relay SR2 energizing and closing contact 141. The closure of contact 141 by relay SR2 completes a test circuit for the line of subscriber No. 12. If this subscriber is busy at this time it will have earth connected to its test lead T12 and accordingly relay BR2 will be energized over contact 141 in a similar circuit to that described with relation to the closure of contact 134. As there are no more impulses the relay CH2 de-energizes after a short interval. Relay ACH2 which would normally de-energize after a short interval responsive to the de-energization of relay CH2, does not de-energize at this time, as it is locked energized in the following circuit: earth, contact 95, contact 142 of relay IS, contact 147, contact 146, relay ACH2 to battery. The de-energization of relay CH2 completes the locking circuit for relay BR2 as follows: earth, contact 95, contact 142, contact 140, contact 143 of relay CH2, relay BR2 to battery. Relay BR2 connects busy tone from conductor 159 over contact 144 so as to signal subscriber No. 11 that the number he requires is engaged. In such a case the subscriber will then restore his receiver opening the circuit for the line relay LRL, which in turn opens the circuit for relay RL2, and the opening of contact 95 causes all relays which are dependent upon this circuit to de-energize, and the second battery feed group G2 and the second recorder restore to normal and become available for another call. Assuming, however, that the subscriber No. 12 was not engaged then relay BR2 would not be energized by the closure of contact 141 and the following circuit would be completed when relay CH2 de-energized—earth, contact 95, contact 145 of relay CH2, lower winding of relay RR2, contact 137, contact 136, conductor 135, contact 141, test lead T12, relay CO12 to battery. In this circuit relays RR2 and CO12 energize and relay CO12 disconnects the relay L12 from across the called subscriber's line so as to prepare a clear circuit for ringing. Ringing relay RR2 on energizing opens contact 114 and thereby permits relay BBC2 to de-energize so that it closes at its contact 148 a short circuit for the lower winding of relay RR2. Relay RR2

at contact 564 short circuits the lower winding of relay BB2 to battery, thereby rendering relay BB2 sluggish in operation, and unresponsive to alternating current. It also at contact 154 shunts the upper winding of relay BB2 over resistance 155 to assist in the above effect. Relay RR2 however does not de-energize due to its lower winding being short-circuited as it is locked energized over its upper winding in the following circuit: ringing battery, relay RB (Fig. 7), conductor 157, upper winding of relay RR2, contact 149, contact 315, contact 95 to earth. At the same time the generator ringing current is connected to the called subscriber's line in the following circuit: battery, contact 206, winding H of the transformer, conductor 161, contact 150, conductor 151, contact 115, which is now closed, since relay BBC2 is de-energized, conductor 119, contact 152, conductor B12, the loop of called subscriber No. 12, back to conductor A12, contact 153, conductor 121, contact 117, conductor 156, contact 154, resistance 155 to earth. It will be noted that this ringing circuit is not completed until relay BBC2 de-energizes which can only take place a short time after its energizing circuit is opened. This gives ample time for relay CO12 to energize and cut-off the relay L12. Ringing continues until the called subscriber answers, when a circuit is completed for relay BB2 as follows: earth, upper winding of relay BB2, conductor 156, contact 117, conductor 121, contact 153, conductor A-12, subscriber's loop, conductor B12, contact 152, conductor 119, contact 115, conductor 151, contact 150, conductor 161, winding H of the transformer, contact 206 of relay MR (Fig. 7) to battery. Relay BB2 energizes in this circuit, opens contact 315 in the circuit of the upper winding of relay RR2, which accordingly de-energizes, closes contact 207 so as to short-circuit the small capacity condenser 208 through which busy tone can be connected to calling subscriber's line, and closes contact 209 to complete the speaking circuit. The speaking circuit may now be traced as follows: starting from calling subscriber's station No. 11 over the conductor A, contact 93, condenser 210, contact 207, conductor 156, contact 117, conductor 121, contact 153, conductor A12 to subscriber No. 12 and back over conductor B12, contact 152, conductor 119, contact 115, conductor 151, contact 211, contact 209, condenser 212, contact 92, conductor B, back to subscriber's station No. 11. The battery of the talking circuit is fed on the calling subscriber's side by the line relay LRL, which it should be noted is connected across the conductors A and B, while battery is fed on the called subscriber's side, by the relay BB2, which is connected across the conductors 151 and 156. The subscribers can now carry on conversation, and when finished, the calling and called subscribers restore their receivers. On the calling subscriber restoring his receiver, the line relay LRL de-energizes and opens contact 94, which opens the circuit of the relays RL2 and IS thereby causing them to de-energize. Relay RL2 opens contact 95, thereby permitting relay ACH2 to de-energize. Relay ACH2 de-energizes and opens contact 111, thereby opening the locking circuit for relays SRA and SR2, which accordingly de-energize. The opening of contacts 153 and 152 opens the circuit of relay BB2, which de-energizes and consequently everything is restored to normal. Assuming however, that the calling subscriber hangs up his receiver after the called subscriber has hung up, then the relay BB2 de-energizes and opens the talking circuit at contacts 209 and 207, and at the same time closes contact 315, the energizing circuit for relay BBC2 being thereby completed from battery, relay BBC2, contacts 114, 315, and 95 to earth. This circuit is, however, not effective as relay BBC2 is short circuited in the following circuit on the de-energization of BB2; earth, contact 95, contact 142, contact 147, contact 146, contact 216, contact 214 to left hand terminal of winding of BBC2, winding of BBC2, contact 114, contact 315, contact 95 to earth. Accordingly, the circuit of relay CO12 is not opened. It is therefore essential before the called party can be effectively released that the calling subscriber should hang up, which is of course usual practice in the principal automatic telephone systems.

It will thus be seen that the foregoing description covers the case where both the feed groups are idle and a subscriber of the private exchange desires connection with another local subscriber. Briefly the operation may be summarized as follows: when the subscriber's calling device operated for the digits 1 and 2, the first digit determines that he wants a local connection and therefore the main exchange line 43, 44 is released, and at the same time the call is transferred to the second battery feed group G2. He then dials digit 2 and tests the line of subscriber No. 12, ascertains whether such subscriber is busy or idle and if busy receives the busy tone, and if idle rings his bell until he answers. On his answering the speaking connection is established and at the conclusion of the conversation everything is restored to normal.

It will now be assumed that subscriber No. 11 calls subscriber No. 12 and that the second battery feed group G2 is busy, having been taken into use for some other call. In such a case the release relay RL2 will be energized, consequently when contact 81 is closed and the change-over relay CH1 de-energizes, a circuit is completed for relay ALS as follows: earth, contact 40, contact 78, contact 79,

conductor 80, contact 81, conductor 82, contact 83, conductor 84, contact 231, conductor 232, relay ALS to battery. Relay ALS energizes in this circuit and completes a locking circuit for itself at contact 233; at the same time it opens contacts 48 and 51 and closes contacts 234 and 235. At contacts 47 and 234, it connects exchange conductor 43 to earth, and at contacts 52 and 235 it connects exchange conductor 44 over resistance 236 to battery; it also at contact 51 disconnects the relay BB1, consequently battery is continued to be served to the main exchange over conductor 44 which is therefore rendered busy, but as the selector at the main exchange is only stepped to the first level which is dead, no other switches are taken into use, simply the conductors 43 and 44, and the switches associated therewith at the main exchange are all rendered busy and inaccessible to other calls. Contact 49 it will be noted is now cut out of the impulsing circuit at contact 48 so that the next series of impulses cannot effect any further impulsing at the main exchange. Relay ALS at contact 237 also completes a circuit as follows: earth, contact 40, contact 238, upper winding of relay FD, contact 237, conductor 240, contact 239 of relay CR1, conductor 218, contact 68 of relay FRA, contact 69 of relay FRC, relay FRC contacts 62, 63, 64, 65, 66, relay CR1 to battery. Relay FD at present cannot energize as its winding is short-circuited over conductor 218, and contact 67, of relay ACH1. Relay ACH1 however will shortly de-energize, depending on its sluggishness, as its circuit is opened at contact 70 due to the de-energization of relay CH1, so that the contact 67 is eventually opened and the energizing circuit through the upper winding of relay FD becomes effective. Relay FD energizes, locks itself energized at contact 241 and opens contact 238. The opening of contact 238 opens the circuit of relays FRC and CR1 thereby causing them to be de-energized so that the recording relays are restored to normal in readiness to receive the next series of impulses. Relay FD at contact 75 prepares a locking circuit for relay ACH1, at contact 563 prepares the busy tone circuit over conductor 159, and at contact 242 prepares the test circuit as will be described later.

It will be noted that relay BB1 de-energized on the energization of relay ALS, due to the contacts 48 and 51 being opened and accordingly a circuit is completed for relay BBC1 over contacts 40 and 244, relay BBC1, resistance 245, to battery. Relay BBC1 on energizing in this circuit opens contacts 246, 247, 248 and 249 so as to prevent any disturbance to existing connections which may be in use when the next series of impulses are transmitted and it will be clear that relay BBC1 remains energized throughout the series of impulses. The de-energization of

relay BB1 after the digit 1 has been dialled simply maintains BBC1 energized. Everything is now in order for the dialling of the second digit, which in this case consists of two impulses. Relay LRO responds and opens contact 49, which has now no effect owing to the opening of contact 48. It also momentarily opens contacts 34 and 41, but these have no effect, in the first case due to the sluggishness of relay RL1, and in the second case due to contacts 77 and 42 being opened. However a circuit is closed over contact 57 for relay CH1 as follows: earth, contact 40, contact 57, contact 58, contact 71, contact 72, relay CH1 to battery. Relay CH1 energizes and at contact 73 completes a locking circuit for itself independent of contacts 71 and 72. At contact 70 relay CH1 completes a circuit as before for relay ACH1 from earth, contact 40, contact 70, relay ACH1 to battery, while at contact 250 a circuit is prepared for relay BR1 as follows: battery, relay BR1, contact 250, contact 242, test conductor 243, which is successively connected to test conductors T11, T12, etc., as relays CR1, CR2 are energized. Relay ACH1 closes contact 67 and completes a locking circuit for itself at contact 74 as follows: earth, contact 40, contact 75 of relay FD, contact 74, relay ACH1 to battery. Relay ACH1 opens contact 72 thereby preventing the relay CH1 from energizing again after it has once de-energized, although of course it is locked energized throughout the train of impulses, over contact 73. The impulse conductor is also connected over contact 73 to conductor 59 over contact 60 and contact 61 to energize relay FRC and thence over contacts 62, 63, 64, 65 and 66 to energize relay CR1. Relays FRC and CR1 energize in this circuit and relay FRC locks energized in the circuit: earth, contact 40, contact 67, conductor 218, contact 63, contact 69, relay FRC, contacts 62, 63, 64, 65 and 66, relay CR1 to battery. At the end of the first impulse relay LRO again energizes and closes contact 41, whereby a circuit is completed for relay FRB as follows: earth, contact 40, contact 41, contact 76, conductor 219, contact 77, upper winding of relay FRB to battery. Relay FRB energizes, opens contact 60 and closes contact 220 and at contact 231, completes a locking circuit for its upper winding. The next operation takes place when relay LRO de-energizes on the second impulse, when a circuit is completed as follows: earth, contact 40, contact 57, contact 58, contact 73, relay CH1 to battery, thereby keeping relay CH1 energized, while a branch extends over conductor 59, contact 220, contact 221, relay FRA, contacts 222, 223, 224, 225, relay CR2 to battery. Relay FRA energizes and opens contact 68 thereby causing the relays FRC and CR1 to de-energize; at contact 230 a circuit is completed for the lower winding of

relay FRB, which therefore is maintained
 operated independently of contact 77 which
 opens when relay FRC de-energizes. Relay
 CR2 also energizes and opens contact 66,
 5 thereby again disconnecting relay CR1 and
 prepares a circuit over 226 for relay CR3.
 Relay FRA locks energized in the following
 circuit: earth, contact 40, contact 67, con-
 ductor 218, contact 251 (relay FRC having
 10 de-energized), contact 252, relay FRA, con-
 tacts 222, 223, 224, 225, relay CR2 to battery.
 Relays FRA and CR2 are therefore main-
 tained energized, and as this is the final im-
 pulse of the series a test is made to ascertain
 15 whether the called line is busy or not. As-
 suming that the called line is busy then there
 will be an earth connection on conductor T12
 as previously described. A circuit for busy
 relay BR1 will therefore be completed as fol-
 20 lows: earth on conductor T12, contact 253,
 conductor 243, contact 242, contact 250, relay
 BR1 to battery. Relay BR1 therefore ener-
 gizes and locks energized in the following
 circuit: earth on contact 40, contact 254, con-
 25 tact 255, relay BR1 to battery; this circuit
 being completed when relay CH1 de-ener-
 gizes at the end of the series of impulses.
 Relay BR1 thereupon connects earth to the
 busy start conductor 160 at contact 185 where-
 30 by a busy tone is received over conductor
 159, contact 563 and contact 562 as will be
 described later. It passes through the con-
 denser 256 to the A speaking conductor from
 whence it extends over contact 32 of relay
 35 OTS11 to the calling subscriber's telephone
 and informs him that the number he requires
 is busy. He thereupon restores his receiver
 causing LRO to de-energize, which in turn
 causes the de-energization of relay RL1 and
 40 the opening of contact 40, whereupon relays
 ALS, OS, ACH1, FD, BR1 and BBC1 de-
 energize, also relays FRA and CR2 de-ener-
 gize; FRB it should be mentioned de-ener-
 gized on the cessation of the second impulse
 45 as its locking circuit over the upper wind-
 ing was opened at contact 77 when relay FRC
 deenergized and its energizing circuit over
 the lower winding was opened at contact 57
 when the line relay LRO energized on the
 50 termination of the second impulse. The re-
 moval of earth from the hold conductor 55,
 on the opening of the contact 40 brings about
 the release of relay OTS11, while the opening
 of contacts 37 and 39 enables relay CO11 to
 55 de-energize. Everything is now restored to
 normal and can be taken into use by another
 subscriber. If however the called subscriber
 had been idle then on the relay CH1 de-
 energizing a circuit would have been com-
 60 pleted as follows: earth, contact 40, relay
 RR1, contact 257, contact 242, conductor 243,
 contact 253, test conductor T12, relay CO12
 to battery. Relay RR1 and cut-off relay
 CO12 energize in this circuit. Relay RR1
 65 at contact 565, short-circuits the lower wind-

ing of relay BB1 to battery; this renders
 relay BB1 sluggish in operation and unre-
 sponsive to alternating currents. It also at
 contact 262 shunts the upper winding of
 relay BB1, over resistance 263 to assist in
 the above effect. Relay RR1 further opens
 70 contact 244, thereby permitting relay BBC1
 to de-energize; it closes contact 258, thereby
 completing a circuit from earth and contact
 40 over contact 258, contact 443, upper wind-
 75 ing of relay RR1 to conductor 157 which is
 connected to battery. Ringing relay RR1 is
 therefore locked energized and at the same
 time ringing current is received back over
 conductor 161, which passes over contact 259,
 80 contact 246 to the B speaking conductor, con-
 tact 260, conductor B12 through the bell at
 the station of subscriber No. 12, back over
 conductor A12, contact 261, contact 249, con-
 tact 262, resistance 263 to earth. On the de-
 85 energization of relay BBC1 the lower wind-
 ing of ringing relay RR1, is short-circuited
 at contact 264, but the relay is locked ener-
 gized over contacts 443 and 258. The sub-
 scriber's bell rings and on lifting his receiver
 90 in response thereto a circuit is completed
 for relay BB1 as follows: earth, upper wind-
 ing of relay BB1, contact 249, contact 261,
 conductor A12, loop to a subscriber's instru-
 95 ment, conductor B12, contact 260, contact 246,
 contact 259, to battery on conductor 161.
 Relay BB1 accordingly energizes and opens
 contact 443 to open the locking circuit of the
 upper winding of relay RR1 causing this
 100 relay to de-energize. Relay BB1 also closes
 contacts 265 and 266, whereby a speaking cir-
 cuit is completed over the A and B speaking
 conductors. At contact 267 the circuit of
 relay BBC1 is shunted, to prevent this relay
 105 from again energizing after the called sub-
 scriber has answered. When the subscribers
 have finished talking and the calling sub-
 scriber restores his receiver, a release takes
 place substantially as previously described,
 the only difference being in this case that
 110 when the busy signal is received the relay
 BR1 does not require to be de-energized, nor
 does relay BBC1, otherwise the relays RL1,
 ACH1 and FD de-energize as before. Relay
 BB1 which serves to feed battery to the called
 115 subscriber's loop, de-energizes due either to
 the called subscriber hanging up, if he hangs
 up first, or due to contacts 261 and 260 being
 opened on the de-energization of relay CR2,
 so that the battery feed group G1 is restored
 120 to normal independently of the called sub-
 scriber hanging up his receiver.

The next case to be considered is on the as-
 125 sumption that when subscriber No. 11 at-
 tempts to call subscriber No. 12 the first bat-
 tery feed group G1 is already in use for an-
 other call. Under these conditions, when the
 line relay L11 pulls up no circuit will exist
 for energizing relay OTS11. The energizing
 130 circuit for relay OTS11 it will be recollected

passes through contact 23 which however is now open as relay RL1 will be operated, relay RL1 being operated all the time the battery feed group G1 is in use. A circuit will therefore be completed for relay LTS11 as follows: earth, contact 27 of relay RL2 in battery feed group G2, contact 28 of relay IS, resistance 29, contact 30, contact 31, lower winding of relay LTS11 to battery. Relay LTS11 energizes in this circuit and closes a locking circuit for itself over contact 97, which locking circuit becomes effective when relay RL2 is energized, as will be described later. On relay LTS11 operating, it opens contact 26 as to prevent the energization of relay OTS11 if battery feed group G1 should become vacant, closes contacts 92 and 93, thereby connecting relay LRL to the subscriber's loop. Relay LRL accordingly energizes and at contact 94 completes a circuit for relay RL2 as follows: earth, contact 268 of relay SR1, contact 269 of relay IS, contact 94, relay RL2 to battery. Relay RL2 accordingly energizes and completes a locking circuit for relay LTS11 as follows: earth, contact 95, conductor 96, upper winding of relay LTS11, contact 97, relay CO11 to battery. Relay CO11 energizes, disconnects the line relay L11 and earth at contacts 22 and 21 respectively and is held energized throughout the connection. Relay L11 deenergizes and opens contacts 25 and 30 so as to open the original energizing circuit for relay LTS11. Relay RL2 closes contact 231, completing a circuit between conductors 232, and 84, thereby preventing a call being transferred to group G2 as long as RL2 is energized. Similarly it will be noted that IS cannot be energized through its upper winding as long as RL2 is energized. Relay RL2 at contact 162 connects earth to conductor 158, whereby, as described later, the arrangements for starting charging of the battery are prepared. It also closes contact 98 in readiness for the transmission of impulses. Subscriber No. 11 now operates his impulse sender to send a single impulse. Therefore relay LRL de-energizes and a circuit is completed as follows: earth, contact 98, contact 99, contact 100, contact 101, contact 102, contact 103, relay SRC, contacts 104, 105, 106, 107, and 108 of relays SRO, SR8, SR6, SR4 and SR2 respectively to relay SR1 and battery. Relays SR1 and SRC accordingly energize and lock energized over the following circuit: earth, contact 95, contact 111, contact 112, contact 109, relay SRC, contacts 104, 105, 106, 107 and 108, relay SR1 to battery. A branch of the impulsing circuit extends from earth, contact 98, contact 99, contact 100, contact 101, relay CH2 to battery. Relay CH2 energizes and completes the following circuit for relay ACH2: earth, contact 95, contact 110, relay ACH2, to battery. Relay ACH2 energizes in this circuit, and closes contact 111 thereby preparing the locking circuit for re-

lays SRC and SR1 as above described. At the end of the impulse, relay LRL again energizes and a circuit is completed as follows: earth contact 98, contact 123, contact 124, contact 625, lower winding of relay SRB to battery. Relay SRB energizes and closes contact 133 to complete a locking circuit for its lower winding and also closes contact 125 and opens contact 102. As, however, there are no further impulses in the series, the energization of relay SRB actually brings about no other operation incidental to the closure of this contact. After a short pause, as there are no more impulses, relay CH2 de-energizes and after a further short pause relay ACH2 de-energizes. When this occurs it will be noted that the circuit for relay RL2 is opened at contact 268, due to the energization of relay SR1, and at contact 270 due to the de-energization of relay ACH2. However, relay RL2 is held energized in the following circuit: earth, lower winding of relay IS, contact 94, relay RL2, to battery. Relay IS energizes in this circuit, opens contact 269 to prevent its lower winding being again short-circuited by either relay ACH2 or relay SR1, opens contact 28 and closes contact 86, which in this particular example is without any material effect, and closes contact 137. On the de-energization of relay ACH2, contact 111 is opened, which opens the locking circuit of relays SRC and SR1. Accordingly these relays de-energize and contact 268 is closed. This now, however, has no effect on short-circuiting the lower winding of IS as contact 269 is opened. On relay SRC de-energizing, contact 625 is opened and accordingly SRB de-energizes and the recorder restores to normal. Everything is now in readiness for the transmission of the next digit, which consists of two impulses. The first impulse brings about the de-energization of relay LRL and a circuit is accordingly completed as follows: earth, contact 98, contact 99, contact 100, contact 101, contact 102, contact 103, relay SRC, contacts 104, 105, 106, 107 and 108, relay SR1 to battery. Relays SRC and SR1 accordingly energize as before, SRC at contact 109 completing a locking circuit for itself over contact 111, relays CH2 and ACH2 being also energized, as previously described. Now, however, relay ACH2 is locked energized in the following circuit: earth, contact 95, contact 142, contact 147, contact 146, relay ACH2 to battery. The test circuit is now completed for relay BR2 as follows: battery, relay BR2 contact 138, contact 137, contact 136, conductor 135, contact 134 to test conductor T11. Relay BR2 energizes but this is only for the duration of the first impulse. At the end of the first impulse, relay LRL again energizes and contact 124 is closed, whereby relay SRB is energized in a circuit already described. When relay LRL de-energizes at the beginning of the second impulse, a circuit is com-

pleted for relay SRA as follows: earth, contact 98, contact 123, contact 101, contact 125, contact 126, relay SRA, contacts 127, 128, 129, 130, relay SR2 to battery. Relay SRA at contact 132 completes a circuit for the upper winding of relay SRB independent of contact 625 so that relay SRB is maintained energized in the following circuit: earth, contact 98, contact 123, contact 101, contact 132, upper winding of relay SRB to battery. This circuit only lasts during the second impulse, however, and as soon as this impulse ceases relay SRB de-energizes. If the called subscriber No. 12 were busy at this time, a circuit for relay BR2 would have been completed as follows: earth on conductor T12, contact 141, conductor 135, contact 136, contact 137, contact 138, relay BR2 to battery. Relay BR2 would accordingly energize when the impulse ceased. On the de-energization of relay CH2 due to no further impulses being received, relay BR2 would lock energized in the following circuit: earth, contact 95, contact 142, contact 140, contact 143, relay BR2 to battery. Relay BR2 by closing contact 139 and thereby connecting earth to conductor 160, would start the busy signalling arrangements, whereby busy tone would be received over conductor 159, pass through condenser 208, condenser 210, contact 93, to the calling subscriber No. 11, thereby indicating to him that the subscriber he requires is engaged on another call. If, however, the subscriber No. 12 is free, relay BR2 will not energize and when relay CH2 is de-energized as described a circuit will be completed as follows: earth, contact 95, contact 145, the lower winding of relay RR2, contact 137, contact 136, conductor 135, contact 141, conductor T12, cut-off relay CO12 to battery. Relays CO12 and RR2 accordingly energize in this circuit: Relay CO12 cuts off the line relay L12 and earth from the conductors extending to the station of subscriber No. 12, while relay RR2 opens contact 114, thereby opening the energizing circuit of relay BBC2, which was completed as follows when relay RL2 energized: earth, contact 95, contact 315, contact 114, relay BBC2, resistance 113 to battery. Relay RR2 also at contact 564, short-circuits the lower winding of relay BB2 to battery, and at contact 154 shunts the upper winding of relay BB2 to earth over resistance 155. This renders relay BB2 very sluggish in operation and unresponsive to alternating currents. The de-energization of relay BBC2, short-circuits the lower winding of relay RR2 at contact 148, but this relay does not de-energize as it is locked energized in the following circuit: earth, contact 95, contact 315, contact 149, upper winding of relay RR2, to battery on conductor 157. The completion of this circuit, as will be described later, causes alternating current to be connected in series with battery on conductor 161 so that a ring-

ing circuit is completed as follows: battery, ringing current over conductor 161, contact 150, conductor 151, contact 115, conductor 119, contact 152, conductor B12, subscriber's loop and subscriber's station No. 12 through the bell of that station, conductor A12, contact 153, conductor 121, contact 117, conductor 156, contact 154, resistance 155 to earth, while a branch circuit extends through the upper winding of relay BB2 to earth. Ringing continues until the called subscriber removes his receiver and loops the speaking conductors whereupon a battery circuit is completed through the windings of relay BB2 causing this relay to energize. At contact 315 of this relay the circuit of the upper winding of relay RR2 is opened thereby causing this relay to de-energize, as its lower winding is short circuited at contact 148. At contact 214 relay BB2 opens the circuit in which the relay BBc2 is short-circuited during the ringing period. It closes contacts 207 and 209, thereby cutting out the condenser 208, and completing a speaking loop, battery being fed to the called subscriber over the windings of relay BB2. When the subscribers have finished talking the calling subscriber replaces his receiver and thereby allows relay LRL to de-energize. This is followed by the de-energization of relay RL2 which in turn opens the circuit of relays CH2 and ACH2. Relay ACH2 opens contact 111, causing relays SRA and SR2 to de-energize. Relay SR2 on de-energizing opens contacts 152 and 153, permitting relay BB2 to de-energize and opens contact 141, permitting relay CO12 to de-energize. Everything is thereby restored to normal. It should be mentioned that the release is substantially similar in the case where the calling subscriber hangs up after receiving the busy signal. It will be noted that this description is substantially identical with the description of the first arrangement in which the subscriber, after dialling the first digit one is switched over on the second group G2, except that in this case the dialling of the digit one as a first digit is necessary in order to operate the relay IS, and bring the battery feed group G2 to the same condition as would be effected by the original energization of IS over the group G1. It might be opportune at this time to consider the case where the first group G1 is busy but the subscriber No. 11 requires an exchange number. When he initiates his connection he is switched through to the group G2 exactly in the same way as described when he desired connection with subscriber No. 12 and the group G1 was busy, but in this case the first digit does not consist of one impulse but a number greater than one, for example four. In this case the first impulse brings about exactly the same operations as previously described, namely, at the beginning of the impulse re-

lays SR1 and SRC are energized, relays CH2 and ACH2 are energized and remain energized throughout the train of impulses, while relay SRB is energized on the termination of the first impulse. On the beginning of the second impulse a circuit is completed as follows: earth, contact 98, contact 123, contact 101, contact 125, contact 126, relay SRA, contacts 127, 128, 129 and 130, relay SR2 to battery. Relays SRA and SR2 energize in this circuit, relay SRA opens contact 112, thereby permitting relays SRC and SR1 to de-energize. Relay SR2 at contact 108 opens the circuit of relay SR1 and at contact 271 connects up relay SR3 in its place. Relay SRA completes a locking circuit for itself as follows: earth, contact 95, contact 111, contact 213, contact 131, relay SRA, contacts 127, 128, 129, 130, relay SR2 to battery. At contact 132 relay SRA completes a circuit for the upper winding of relay SRB, contact 101, contact 123, contact 98 to earth for the duration of the second impulse, while at contact 272 a circuit is completed for relay BR2 as follows: earth, contact 95, contact 273, contact 272, relay BR2 to battery. Relay BR2 energizes and locks energized in the following circuit: earth, contact 95, contact 273, contact 274, relay BR2 to battery. Therefore relay BR2 remains energized irrespective of the number of impulses dialled. The subscriber, however, will not listen to the busy signal as his calling device is still in operation. On relay BR2 energizing, it opens contact 99. On the cessation of the second impulse relay SRB de-energizes due to contact 101 being opened, and opens the locking circuit of relays SRA and SR2. On the beginning of the third impulse, relays SRC and SR3 are energized in the same way as relays SRC and SR1 were energized by the first impulse. Relay SRA does not energize and relays SRC and SR3 are locked energized over contacts 109 and 112 in the same circuit as for the first impulse. On the cessation of the third impulse, relay SRB is energized over contact 625 and its lower winding and at the beginning of the fourth impulse relay SRA, and relay SR4 which is now connected up at contact 275 in place of relay SR2, energize, and relays SRC and SR3 de-energize. At the end of the fourth impulse, relay SRB de-energizes and after a pause relay CH2 de-energizes and opens contact 123. After a further short pause relay ACH2 de-energizes and opens contact 111 whereby relays SRA and SR4 de-energize and the relays are therefore all restored to normal. The subscriber without listening for the busy tone may continue to dial, but this is without effect as contact 99 is now open so that the first impulse cannot pass to the counting relays over the circuit: earth, contact 98, contact 99, contact 100,

contact 101, contact 102, contact 103, relay SRC, contacts 104, 105, 106, 107 and 108 to relay SR1 to battery. It is clear therefore that no further impulses can be effective so that when eventually the subscriber lifts up his receiver he hears the busy tone which has been connected up by busy relay BR2 connecting earth at contact 139 to conductor 160 and receiving busy tone back over conductor 159, contact 144, condenser 208, condenser 210, contact 93 to his instrument over the subscriber's line circuit. He thereupon knows that he cannot get the number he requires and accordingly restores his receiver whereupon relays LRL and RL2 de-energize in turn, permitting relays BR2 and BBC2 and BB2 to de-energize, relay LTS11 and relay CO11 also being de-energized as previously described.

It will be noted that when either the relay RL1 or the relay RL2 energizes, earth is connected to the conductor 158 leading to the ringing, busy and charging relay group RBC, shown in Fig. 7. Relay RL1 effects this by closing contact 36, while relay RL2 effects it by closing contact 162. When this occurs the relay CH is energized. Relay CH closes contact 163, and completes a circuit for relay CC, which, upon energizing completes a locking circuit for itself over contacts 165 and 168.

Nothing further, however, takes place until earth is removed from the conductor 158, whereupon relay CH de-energizes and in conjunction with relay CC completes a circuit for relay MR over contacts 166 and 164. Relay MR accordingly energizes and remains energized until either earth is again connected to charging conductor 158 due to a subscriber making a call, whereupon contact 164 is opened and relay MR de-energizes, or the high voltage relay HVR, the circuit of which is closed over contact 167 of the relay MR, energizes. This high voltage relay is a relay which only energizes when the voltage of the battery reaches a predetermined voltage above normal when the battery is being charged, so that it would only energize when the battery is sufficiently charged and when it does so it opens contact 168, thereby opening the locking circuit for relay CC which in turn opens the circuit for relay MR. Thus it will be appreciated that in either of the two conditions, namely, of a subscriber calling, or of the battery being fully charged, charging of the battery will not take place. This arrangement has the advantage that charging never occurs while any party is engaged in conversation, while at the same time the battery is maintained fully charged in between conversations. Relay MR, as has already been indicated, is for the purpose of starting charging and a brief description of the charging arrangements will now be given.

It will be assumed in the first case that

there is a direct current power supply available. In such a case the fuses *d1* and *d2* will be inserted and the charging circuit may then be traced as follows: positive pole of power supply connected to conductor 170, contact 171, fuse *d2*, conductor 172, retard coil 173 to positive pole of battery, while negative pole of battery is connected over fuse *d1*, conductor 174, contact 175 to conductor 176 connected to negative pole of power supply. If, however, the local supply is of alternating current, then it is necessary to provide a current rectifying arrangement and this is obtained by means of the polarized relay PR.

It will be noted that when relay MR energizes it closes contact 169, whereby a circuit is completed for relay PR as follows: earth, battery, resistance 177, contact 169, lower windings of the polarized relay PR to earth. These windings do not bring about any operation of the relay by themselves, but simply serve as polarizing windings. Another circuit is completed as follows: conductor 170, condenser 178, contact 179, upper windings of polarized relay PR, contact 180 to conductor 176. Alternating current, therefore flows through these windings and causes the armature of the polarized relay to alternately close contacts 181 and 182 in accordance with the frequency of the alternating current supply. Contact 181 is at present without effect but contact 182 connects direct earth over contact 183 of relay MR and the low tension winding L of the transformer to the negative pole of the exchange battery. In these circumstances, that is, when charging by alternating current, the fuses *d1* and *d2* are removed. The high tension winding H of a transformer is then connected direct across the conductors 170 and 176 of the power supply over contacts 171 and 184 respectively. This causes an alternating current of the same frequency and of suitable voltage to be generated in the low tension winding L of the transformer. Normally this would simply serve to ensure alternating current to flow through the battery. However by suitably designing the windings of relay PR, contact 182 is closed only for one half cycle namely the half cycle in which the direction of current is such as to charge the battery; during the other half-cycle, contact 182 is open and consequently no charge can take place. Consequently an efficient charging of the battery results.

It will be also noted that when either relay BR1 or relay BR2 energizes, earth is connected over contacts 185 and 139 respectively to the busy start conductor 160. The effect of this is to energize the relay 13 over contact 186 of relay RB. Relay 13 energizes and closes contact 187 to energize relay 12. Relay 12 energizes and at contact 188 closes a circuit for relay 11 and at contact 189 completes a circuit from earth on conductor 160

over contact 189 to busy tone relay BT, resistance 190 to battery. Relay BT energizes and by closing its contact 191 short-circuits itself so that it immediately de-energizes and re-energizes intermittently, thereby causing the condenser 192 to be intermittently charged and discharged thus sending a tone over conductor 159. The relay 11 upon energizing closes contact 193 in parallel with contact 189 and at the same time closes contact 194. Contact 194 completes a short circuit about the relay 13, the resistance 195 preventing the battery being short-circuited. Relay 13 accordingly de-energizes after an interval as it is slow to release and is made additionally slow by having its winding short circuited. On releasing, it opens contact 187 to short-circuit at contact 196 the winding of relay 12. As make-before-break springs are provided in order to render this short circuit effective to reduce the time of release of relay 12, a resistance 197 is provided to prevent the battery being connected direct to earth. In a similar way, relay 12 when it releases, opens contact 188 and closes contact 198, whereby the relay II is short-circuited. Resistance 199 is provided for the same purpose as resistance 197 that is to guard against short-circuiting the battery while contacts 188 and 198 are momentarily closed. For a while contacts 189 and 193 are opened and the intermittent operation of the relay BT ceases, thereby giving a pause in the busy tone, but as soon as contact 194 opens, relay 13 energizes and causes the re-energization of relay 12, which in turn causes the reenergization of relay II, then the relays successively release as previously described, and consequently the busy tone is given intermittently, the cycle of the operation of relays 11, 12, and 13 continuing as long as earth is connected to the busy start conductor 160. It will thus be seen that the connection of earth to the busy start conductor 160 causes the intermittent connection of a busy tone current to conductor 159 which conductor is insulated from all battery and earth connections by condenser 192.

It will have been noted that whenever either of the ringing relays RR1 or RR2 are energized the upper winding of these relays is connected to conductor 157 which extends through the ringing relay RB to battery. Whenever this occurs the relay RB energizes and at contact 200 completes a circuit for the relay 13, which in turn causes the operation of relays 12 and 11 in the manner previously described. These relays therefore, operate intermittently and while the closure of contacts 189 and 193 is without effect, seeing that there is no earth on the busy start conductor 160, the contact 201 is intermittently opened and closed. At the same time contact 202 of the relay RB completes a circuit over contact 203 through the upper windings of the relay PR, contacts 204, and 205 of relay

MR, resistance 177 to battery. The relay therefore operates in a direction to connect earth over contact 181 to short-circuit its operating winding causing it to deenergize to open contact 181 and remove the short-circuit, and consequently the polarized relay reenergizes. The swinging of its armature causes an intermittent closure of contact 182 so that as exchange battery is permanently connected in series with the low tension winding L of the transformer direct current is caused to flow intermittently through the winding L over contacts 182 and 201. This causes alternating current in series with battery to be transmitted over contact 206 to the generator conductor 161 which is connected up to the speaking conductors whenever relays RR1 or RR2 are operated; such current is intermittent according as to whether contact 201 is open or closed.

An alternative arrangement for generating ringing current from the exchange battery is shown in Fig. 8 and although this arrangement is described for ringing only, it will be clear that by the employment of a suitable switching relay such as MR, it could readily be made applicable for charging. It is sufficient, however, to understand the operation if it is simply described from the point of view of generating ringing current. When contact 202 is closed a circuit is completed for relay PR as follows: earth, contact 202, lower winding of the polarized relay PR to battery. The polarized windings of PR are energized in this circuit. The operating windings are energized in the following circuit: earth, contact 202, contact 403, resistance 412, operating windings of relay PR, winding 404 of transformer to battery. At the same time it should be mentioned that a branch circuit extends through winding 405 to battery so that a larger current flows through the winding 405 than through the winding 404. The current through 404 is, however, sufficient to cause the polarized relay to operate its armature and close the right-hand contact 406, whereupon a circuit is completed for relay 407 as follows: earth, contact 202, contact 406, contact 408, relay 407 to battery. Relay 407 energizes and locks energized over contact 409 and earth on contact 202, at the same time opening contact 403 and closing contact 410. The closure of contact 406 it will be noted, causes earth to be connected over contact 410 to the right-hand side of the winding 404. Consequently a current now flows from battery through the left-hand winding 405, upper windings of the polarized relay PR, contact 410, contact 406, contact 202 to earth. That means to say that a reduced current flows through winding 405 and a current in the opposite direction flows through the upper windings of relay PR, while at the same time due to earth being connected directly to the right-

hand side of winding 404 an increased current flows through this winding. The increasing of the current in 404 and reduction of current in 405, mutually assist each other in their inductive effect on the secondary coil SC. The polarized relay PR, due to the reversal of current in its windings, operates to close contact 411 thereby connecting earth over contact 202 to the left-hand side of the upper windings of the polarized relay thereby increasing the current through the winding 405, reducing the current through 404 and reversing the current through the windings of polarized relay PR. This reversal causes a repeated operation of the armature and by this means a very effective generation of alternating current is obtained which is created in the secondary coil SC which is connected in the ringing circuit where it can be taken into use at the appropriate instant by the calling subscriber to ring the bell of the required subscriber.

A description will now be given of a connection to the main exchange. It will be assumed again that both the battery feed groups are idle and that the subscriber seizes the group G1 in the same manner as previously described, but in this case seeing that the call is to a main exchange, the first series of impulses dialled would not consist of one impulse but would consist of a greater number of impulses. As an example, we will assume that the number is 4; after the first impulse when the relay CR1 has been operated in series with the relay FRC, it is locked energized over contacts 69 and 68, conductor 218, contact 67 of relay ACH1, contact 40, to earth; as the impulses do not cease at the first digit dialled, relays CH1 and ACH1 remain operated. At the end of the first impulse relay FRB energizes over contact 77 of relay FRC and its lower winding and at the beginning of the second impulse, contact 57 is closed and accordingly a circuit extends from: earth, contact 40, contact 57, contact 58, contact 73, conductor 59, contact 220 of relay FRB, contact 221 of relay FRA, relay FRA, contacts 222, 223, 224, 225 of relays CR9, CR7, CR5, CR3 respectively, relay CR2 to battery. Relays CR2 and FRA accordingly energize in this circuit, relay FRA opening contact 68 so as to cause FRC and CR1 to de-energize, relay CR1 being also cut out of circuit by relay CR2 at contact 66 and relay CR3 being connected up in its place at contact 226. Relay FRA on energizing closes contact 227, thereby completing a circuit for busy relay BR1 as follows: earth, contact 40, contact 228, contact 227, relay BR1 to battery. Relay BR1 therefore energizes and locks energized in the circuit over contacts 220 and 228, independently of contact 227, but does not connect the busy signal at contact 562 as contact 563 of relay FD is open. Accordingly relay FRB does not de-energize

when contact 77 is opened on the de-energization of relay FRC as it is maintained energized over its lower winding, contact 230 of relay FRA to earth on conductor 59. On the termination of the second impulse when earth is removed from conductor 59, relay FRB de-energizes. When the next impulse commences a circuit is completed for relays FRC and CR3 as follows: earth, contact 40, contact 57, contact 58, contact 73, conductor 59, contact 60, contact 61, relay FRC, contacts 62, 63, 64, 65, 226, relay CR3 to battery. Relays CR3 and FRC accordingly energize, relay FRC opens contact 251, thereby releasing relays FRA and CR2, while relay CR3 opens the contact 225 and closes contact 276, thereby connecting up relay CR4. At the end of the third impulse, relay FRB energizes in the following circuit: earth, contact 40, contact 41, contact 76, conductor 219, contact 77, upper winding of relay FRB to battery. At the beginning of the fourth impulse a circuit is completed as follows: earth, contact 40, contact 57, contact 58, contact 73, conductor 59, contact 220, contact 221, relay FRA, contacts 222, 223, 224, 276, relay CR4 to battery. Relays CR4 and FRA lock energized in series over contact 252, contact 251, conductor 218, contact 67, contact 40 to earth, opening, at contact 68, the energizing circuit for relays CR3 and FRC which accordingly de-energize. Relay FRB is maintained energized as previously described for the second impulse. As there are no more impulses relay CH1 de-energizes after a short interval and opens contact 73; it also opens contact 70 and allows relay ACH1 to de-energize. During this period four impulses have been sent to the main exchange by relay LRO opening contact 49, four times. Subsequent impulses are incapable of operating the counting relay as contact 71 is now opened and therefore neither the relay CH1 nor the counting relays can be again operated. Furthermore the de-energization of relay ACH1 opens contact 67 so that relays FRA and CR4 also de-energize, restoring the counting relays to normal. The subscriber can therefore continue to send impulses to operate switches at the main exchange in the usual way as will be described later with reference to Figures 9, 10 and 11. To release the connection when he has completed the main exchange call he simply hangs up his receiver, opening the circuit of relay LRO which de-energizes and opens contact 49 thereby releasing switches at the main exchange. Relay LRO also opens the circuit of relay RL1 which de-energizes and opens contact 40 thereby releasing relays OS, BR1 and OTS11. As all the other relays are released it will be clear that the group G1 is restored to normal and is ready to be taken into use by another subscriber.

The next operation to be described is that

in which the main exchange subscriber requires a local subscriber. In that case he will dial the number for the private branch exchange and seize a repeater thereat, as described with reference to Figures 9, 10 and 11, whereby battery is fed over conductors 43 and 44 so that a circuit is completed for relay LR1 as follows: battery on conductor 43, contact 45, relay LR1, contact 46, conductor 44 to earth at the main exchange. Relay LR1 on energizing closes contact 277 thereby energizing relay RL1, opens contact 58 and closes contacts 278 and 279. Relay RL1 closes contact 40 whereby a circuit is completed for relay BBC1 as follows: earth, contact 40, contact 244, relay BBC1, resistance 245 to battery. Relay BBC1 accordingly energizes and opens contacts 246, 247, 248, 249 and 264. At contact 40 a second circuit is closed as follows: earth, contact 40, contact 278, lower winding of relay FD, to battery. Relay FD accordingly energizes and locks energized in the following circuit: from battery, lower winding of relay FD, contact 241, contact 40 to earth. At contact 563 relay FD prepares the busy signalling circuit. At contact 242 a test circuit is connected up, which at present has no effect, contact 228 is opened and contact 75 closed. The subscriber in the main exchange does not dial the first digit but dials the second digit of a subscriber in the sub-exchange, for instance supposing he requires subscriber No. 12 he will dial 2. Accordingly, on the first impulse being received in the sub-exchange, battery will cease to be fed over conductors 43 and 44, and relay LR1 will be de-energized. A circuit will therefore be completed as follows: earth, contact 40, contact 57, contact 58, contact 71, contact 72, relay CH1 to battery, a branch extending over conductor 59, contact 60 of relay FRB, contact 61, relay FRC, contacts 62, 63, 64, 65 and 66, relay CR1 to battery. Relays FRC and CR1 energize in this circuit and lock energized over contact 69, contact 68, conductor 218, contact 67, contact 40 to earth. Relay CH1 on energizing closes contact 70 whereby a circuit is completed for relay ACH1 as follows: earth, contact 40, contact 70, relay ACH1 to battery. Relay ACH1 therefore energizes and closes contact 67. Relay FRC also closes contact 77 so that at the end of the first impulse when relay LR1 again energizes a circuit is completed as follows: earth, contact 40, contact 279, conductor 219, contact 77, upper winding of relay FRB to battery. Relay FRB accordingly energizes, closes contact 231 and contact 220, and opens contact 60, so that when relay LR1 deenergizes for the next impulse a circuit is completed as follows: earth, contact 40, contact 57, contact 58, contact 73, conductor 59, contact 220, contact 221, relay FRA, contacts 222, 223, 224 and 225, relay

CR2 to battery. Relays FRA and CR2 accordingly energize, contact 68 is opened thereby permitting relays FRC and CR1 to de-energize, and contact 252 is closed so as to lock relays FRA and CR2 energized over contact 251, conductor 218, contact 67, contact 40 to earth. Relay FRB is maintained energized over its lower winding, contact 230 of relay FRA, to earth on conductor 59. On the cessation of the second impulse, relay FRB de-energizes and shortly after, as there are no more impulses to be received, relay CH1 de-energizes. If subscriber No. 12 had been busy there would have been prior to this, a circuit completed for relay BR1 as follows: earth on conductor T12, contact 253, conductor 243, contact 242, contact 250, relay BR1 to battery, and when relay CH1 de-energized a locking circuit would be completed for relay BR1 as follows: earth, contact 40, contact 254, contact 255, relay BR1 to battery. Relay BR1 therefore connects earth over contact 185 to conductor 160, to start the busy signalling arrangements whereby busy tone is connected over conductor 159, contact 563 of relay FD, contact 562, through condenser 256, contact 280, contact 45, to the instrument of calling subscriber in the main exchange. If however the called subscriber had been idle then a circuit would be completed for relay CO12 as follows: earth, contact 40, lower winding of relay RR1, contact 257, contact 242, conductor 243, contact 253, test conductor T12, relay CO12 to battery. Relay RR1 and relay CO12 energize in series, relay CO12 disconnecting the line relay L12 and earth from the line of subscriber No. 12 and ringing relay RR1 completing the ringing start circuit as follows: earth, contact 40, contact 258, contact 443, upper winding of relay RR1, conductor 157 to battery through the start relay of the ringing circuit, so that alternating current and battery in series are connected over conductor 161, contact 259, contact 246, contact 260, conductor B12 of subscriber's instrument No. 12, conductor A12, contact 261, contact 249, contact 262, resistance 263 to earth. The subscriber's bell is therefore rung and when he lifts his receiver a circuit is completed for relay BB1, the upper winding of which is connected in a branch of the circuit just described to resistance 263. Relay BB1 on energizing opens contact 443 to cause relay RR1 to de-energize. Ringing is discontinued due to the opening of contacts 258 and 259 and contact 279 is closed to connect up the lower winding of relay BB1. Relay BB1 closes contacts 265 and 266 in the speaking circuit which now may be traced as follows: conductor 43, contact 45, contact 280, condenser 281, contact 265, contact 249, contact 261, conductor A12, subscriber's station, conductor B12, contact 260, contact 246, contact 279, contact 266, condenser 282, contact 46, conductor 44 to

the main exchange. When the subscribers have finished talking the calling subscriber in the main exchange hangs up his receiver. In addition to causing the subscriber at the sub-exchange to release he removes battery from conductors 43 and 44 thereby causing relay LR1 to de-energize. Relay LR1 on de-energizing opens at contact 278 the circuit of relay FD and at contact 277 the circuit of relay RL1. Relay RL1 de-energizes and at contact 40 opens the circuit of relay ACH1 which is also opened by relay FD at contact 75 so that relay ACH1 de-energizes and opens contact 67, thereby permitting relays FRA and CR2 to de-energize. The opening of contacts 260 and 261 permits relay BB1 to de-energize, while the opening of contact 253 permits the relay CO12 to de-energize. It will thus be appreciated that all the relays are now restored to normal and the battery feed group G1 is available for further calls.

It should be understood that various modifications may be made in the counting relay arrangement shown in Fig. 4, without departing from the spirit of the invention. An alternative form is shown in Fig. 6, in which the relays FRA and FRC are eliminated, the functions of these relays being performed by contacts on the individual relays of the chain. The resemblance between these two figures will be clear when it is understood that contacts 300, 301, 302, 303, 304, are equivalent to contact 77 of the relay FRC, contacts 305, 306, 307, 308, 309, are equivalent to contact 230 of relay FRA, contacts 310, 311, 312, 313 are equivalent to contact 61 of relay FRC, contacts 314, 315, 316, 317, 318 are equivalent to contact 69 of relay FRC, contacts 319, 320, 321, 322, 323 are equivalent to contact 221 of relay FRA and contacts 324, 325, 326, 327, 328 are equivalent to contact 252 of relay FRA. The other contacts on the relays in Fig. 6 are given the same reference letters as in Fig. 4 so that the relationship between these sets of counting relay chains may be readily traced. It will be recollected that conductor 59 has earth connected to it as soon as the line relay LRO de-energizes on the first impulse. Conductor 218 has earth connected to it continuously as long as relay ACH1 is energized and conductor 219 has earth connected thereto in between the interruptions. Conductors 80 and 82, 218 and 240 and the conductors connected by contact 329 serve exactly the same function as the conductors with the same reference numbers and those connected up by contact 227 of Fig. 4.

To understand the operation we will consider that four impulses are being transmitted. As soon as the line relay LRO de-energizes at the first impulse a circuit is completed as follows: earth on conductor 59, contact 60, contacts 62, 63, 64, 65, 66, relay

CR1 to battery. Relay CR1 accordingly energizes and closes a locking circuit for itself at contact 314 in the following circuit: earth on conductor 218, contact 323, 313, 322, 312, 321, 311, 320, 310, 319, 314, relay CR1 to battery. At the same time it closes contact 300 so that when at the end of the first impulse earth is connected to conductor 219 a circuit is completed for lower winding of relay FRB as follows: earth, conductor 219, contact 300, lower winding of relay FRB to battery. Relay FRB accordingly energizes, opens contacts 60 and closes contacts 220 and 231. At the beginning of the next impulse earth is again connected to conductor 59 and this now extends over contacts 220, 222, 223, 224, 225, relay CR2 to battery. Relay CR2 energizes, opens contact 319 thereby permitting relay CR1 to de-energize, and completes a locking circuit for itself as follows: earth, conductor 218, contacts 323, 313, 322, 312, 321, 311, 320, 310, 324, relay CR2 to battery. Relay CR2 opens contact 66 and closes contact 226; it also closes contact 305 thereby completing a circuit for the upper winding of relay FRB as follows: earth on conductor 59, contact 305, upper winding of relay FRB to battery. It should be noted that relay FRB is maintained energized from the end of the first impulse until the beginning of the second impulse over its lower winding and then when contact 300 opens due to relay CR1 de-energizing, relay FRB is maintained energized until the termination of the second impulse over its upper winding in the circuit above described. When earth is removed from conductor 59 at the end of the second impulse this latter circuit is opened and relay FRB de-energizes, the earth coming between the second and third impulses on conductor 219 at this time has no effect as all of the contacts 300, 301, 302, 303 and 304 are open. At the beginning of the third impulse earth is again connected to conductor 59 and now passes over the original circuit contacts 60, 62, 63, 64, 65, passing this time however over contact 226 to relay CR3 to battery. Relay CR3 energizes, opens contact 310 to release relay CR2 and closes contact 315 to establish a locking circuit for itself as follows: earth, conductor 218, contacts 323, 313, 322, 312, 321, 311, 320, 315, relay CR3 to battery. Relay CR3 opens contact 225 and closes contact 276, it also closes contact 301 to prepare a further energizing circuit for the relay FRB. Consequently at the termination of the third impulse earth connected to conductor 219 completes a circuit over contact 301 for the lower winding of relay FRB to battery. Relay FRB energizes, opens contact 60 and closes contact 220 and contact 231. At the beginning of the fourth impulse earth is again connected to conductor 59 and this time passes, as in the case of the second impulse, over contact 220,

contacts 222, 223, 224 but this time over contact 276, relay CR4 to battery. Relay CR4 energizes and locks energized in the following circuit: earth, conductor 218, contacts 323, 313, 322, 312, 321, 311, 325, relay CR4 to battery: it opens contact 320 to cause relay CR3 to de-energize and closes contact 306, thereby completing a circuit for the upper winding of relay FRB. Relay FRB therefore is maintained energized by earth on conductor 59 and de-energizes at the end of the impulse. It will be clear from the foregoing how subsequent impulses will operate relays CR5, CR6, CR7, etc. To release the counting relays so that they can restore to normal it is only necessary to remove earth from conductor 218.

In order that it may be understood how calls are transmitted from a main exchange subscriber to the subexchange over the trunk line TL comprising conductors 43 and 44, and also the manner in which calls may be transmitted from a sub-exchange over the trunk line TL to a main exchange subscriber, reference should be had first of all to Fig. 9. The different operations will be later described with reference to Figs. 10 and 11.

We assume in the first place that a call comes over the trunk TL. This call comes in to the relay group RG which has associated with it a trunk line switch TLS. When battery is fed from a trunk line over the relay group the trunk line switch TLS operates to select a first selector D at the main exchange, consequently this first selector D responds to the first series of impulses and hunts to find an idle second selector E. The second selector E responds to the next series of impulses and then hunts to find an idle connector F which responds to the next two series of impulses and establishes connection with the line of the wanted subscriber. It will be noted that the operations of the first selector D, second selector E and the connector F are standard and well known in the art. If the call, however, is from a subscriber at the main exchange, then when he lifts his receiver his line switch SLS operates to select an idle first selector such as D. Selector D responds to the first series of impulses dialled by him and then hunts automatically to select a second selector E. The second selector then responds to the next series of impulses, and as it will be assumed that the call is for a sub-exchange subscriber, the selector will step to a certain level and then select a sub-exchange selector SES. The sub-exchange selector SES is arranged to respond to one series of impulses only, and according as to whether a trunk line selected such as TL is busy or not, either to give a busy signal or to extend the call over the trunk line via the relay group RG, which converts the normal subscriber's impulses into impulses suitable for operating the sub-

exchange apparatus. The last digit of the sub-exchange number which has exactly the same number of digits as a main exchange number, is then received in the manner already described at the sub-exchange for selecting the wanted subscriber's line thereat.

Referring now to Figs. 10 and 11 in which the circuits briefly described are shown, it will be noted that a call coming over the conductors 43 and 44, which is indicated by connecting battery across these conductors at the sub-exchange, as has been previously described, will effect the energization of the line relay LRM. Relay LRM accordingly energizes, closes contact 505 and completes the circuit for the release relay RRM. RRM energizes and closes contact 510 whereby a circuit is completed as follows: battery, relay LRT, contact 513, contact 510, contact 511, retard relay RTM, contact 507, contact 518, to earth. Relay LRT accordingly energizes. Relay RRM on energizing also opens contact 509 thereby disconnecting the switching relay SRM, and closes contact 508 connecting earth to conductor 545, thereby guarding the trunk line against being taken into use by a sub-exchange selector SES. Relay RRM also closes contact 546. Relay LRT on energizing closes contacts 520 and 544 and a test circuit is thereby completed as follows: test contact 547 of selector D, wiper 548, contact 516, contact 544, contact 519, magnet MLS to battery. If the selector on which the wipers 548, 549 and 550 are resting is busy, then earth will be connected on test contact 547 which is connected to the wiper 548 and therefore a circuit is completed for the stepping magnet MLS, which will step intermittently as long as the wiper 548 engages an earth contact. It will be assumed however that the first selector D is idle, in which case the switching relay SRT will be energized in the following circuit: earth, contact 520, relay SRT, contact 519, magnet MLS to battery. It will be seen that relay SRT is short-circuited and cannot energize in this circuit as long as there is an earth on wiper 548 so that relay SRT only energizes when an idle selector is found. Also the resistance of relay SRT is so chosen that magnet MLS cannot energize in series therewith. Relay SRT energizes, opens contacts 513 and 518 thereby permitting relay LRT to de-energize, and closes contacts 514 and 517 thereby extending the connection to the first selector D. The further operation of the selectors D, E and F is well known and will not be described. It is sufficient to say that when the selector D is seized the line relay energizes and connects up the release relay, which in turn connects earth to contact 547 thereby completing a locking circuit for relay SRT independent of contact 520 this circuit being completed before contact 520 is opened due to relay LRT being slow to

release. The locking circuit is then completed as follows: earth, contact 547, wiper 548, contact 515, relay SRT, contact 519, magnet MLS to battery. The next series of impulses is received by the line relay of the selector D. The selectors D and E are of the well known type which operate in a vertical and then in a rotary direction so that the first series of impulses causes the wipers of the first selector D to stop at a level, dependent upon the number of impulses in the series, thereafter hunting takes place automatically to find a second selector E, the first selector D is cut through and the second selector E operates in a similar manner for the second series of impulses and thereafter automatically selects a connector F. The connector F differs in operation from the selectors in that it not only responds to the third series of impulses, but it also responds after the third series of impulses to the fourth series of impulses for its movement in a rotary direction so that its wipers are set on to the line of the wanted subscriber. Thereafter the subscriber's line is tested to see whether it is busy or idle and if busy, a busy signal is given to the calling subscriber or if not busy, then the wanted subscriber is rung and on answering the connection is switched through. On the termination of the conversation the connection is released due to battery being removed from across the conductors 43 and 44, thereby permitting the relay LRM to release and open contact 507. Relay RRM releases shortly after, opens contact 510 and removes the guard earth at contact 508.

It will be clear that every impulse received over the conductors 43 and 44 permitted relay LRM to release and complete a circuit for the change-over relay CHM over the following circuit: earth, contact 506, contact 546, relay CHM to battery. Relay CHM energizes, opens contact 511 and closes contact 512, so completing an impulsing circuit independent of retard relay RTM. The intermittent opening of contact 507 transmits the impulse to the line relay of the first selector and afterwards to the second selector and the connector. The impulsing circuit can therefore be traced as follows starting from wiper 549, contact 514, contact 510, contact 512, contact 507, contact 517, wiper 550. As is well known the line relays of the successive switches D, E and F are connected across the conductors to which wipers 549 and 550 are successively connected.

Having dealt with a call from the sub-exchange we will now deal with a call from a main exchange subscriber to a sub-exchange subscriber. When a main exchange subscriber lifts his receiver his line switch SLS operates to select an idle first selector such as D. His first series of impulses causes the operation of the first selector in a similar manner to that just described, which in turn

selects an idle second selector such as E. The idle selector E responds to the next series of impulses in a similar manner but this time it is stepped to a level having access to sub-exchange selectors such as SES (Fig. 11).

When the call is extended to a sub-exchange selector such as SES then the line relay LRS energizes over the subscriber's loop, closes contact 521 and opens contact 522. The closure of contact 521 completes a circuit for release relay RRS. Relay RRS energizes and closes contact 524 to connect earth to the test conductor 551, thereby holding up the switches D, E and SLS and at the same time guarding these from intrusion by other subscribers. Relay RRS also closes contact 525 and opens contact 526. As has already been mentioned the switch SES is a single level switch having an operating magnet OMS and a release magnet RMS. This switch is adapted to respond to from 1 to 10 impulses to select a particular relay group, such as RG, having access to a sub-exchange. It will be assumed that the subscriber requires access to the sub-exchange already described with reference to Figs. 1 to 8, that is he selects the trunk line TL comprising conductors 43 and 44. Accordingly relay LRS responds to the third series of impulses dialled and the following operations take place. At the beginning of the first impulse relay LRS de-energizes and the following circuit is completed: earth, contact 522, contact 525, contact 536, contact 542, operating magnet OMS to battery, while a branch of this circuit extends as follows: earth, contact 522, contact 525, contact 536, relay CHS to battery. Relay CHS energizes and opens contacts 527 and 529, and closes contact 528 so that a circuit may be traced as follows: from the test wiper 552, contact 528, contact 541, busy relay BRS to battery. Relay CHS also closes contact 532 but this is without effect at this time. Relay CHS also closes contact 531 thereby shunting the contact 536 during the series of impulses and preventing the operating circuit being opened due to the relay BRS energizing when the wiper 552 passes over the contacts. After the series of impulses has terminated and the wiper 522 is in engagement with the contact 553 connected to the test conductor 545 of the relay group RG, the relay BRS will energize if test conductor 545 is connected to earth, that is, if the relay group RG and the trunk line TL are in use. If they are in use then relay BRS will energize, and when CHS de-energizes at the end of the train of impulses due to its circuit being opened at contact 522 relay BRS will be locked energized in the following circuit: earth, contact 524, contact 535, contact 529 of relay CHS, contact 541, relay BRS to battery. Relay BRS closes contact 533 thereby connecting the busy signal to the upper talking lead and informing the calling subscriber that he cannot get access to the sub-exchange subscriber he requires. He thereupon hangs up his receiver releasing the relay LRS which in turn releases relay RRS, the two jointly completing a circuit from earth, contact 522, contact 526, off normal contact 530, release magnet RMS to battery. Release magnet RMS accordingly energizes and restores the sub-exchange selector to normal, the circuit of BRS being opened at contact 524 at the same time that the preceding train of switches is released, and everything is now restored to normal. If however the trunk line TL had been idle, then there would have been no earth on conductor 545, and on the de-energization of relay CHS, relay BRS being in its normal position, a circuit would be completed as follows: earth, contact 524, contact 534, lower winding of switching relay SRS, contact 527, wiper 552, test contact 553, conductor 545, contact 509, relay SRM, relay SRT, interrupter contacts 519, magnet MLS to battery. In this circuit the relays SRS, SRM and SRT energize. Magnet MLS does not operate in this circuit as already described. Relay SRT energizes to open contacts 518 and 513, thus disconnecting the relay LRT. Relay SRM energizes to open contacts 501 and 504, thus disconnecting the line relay LRM, and closes contacts 502 and 503 so as to connect the conductors 43 and 44 of the trunk line TL to the conductors 554 and 555 respectively. Relay SRS on energizing closes contact 540 thereby completing a locking circuit for itself as follows: earth, contact 524, contact 540, upper winding of relay SRS to battery and at the same time closes contact 539, short-circuiting its lower winding and establishing an earth potential on the test wiper 552 and thereby on the test conductor 545 so as to guard against intrusion from other subscribers. Relay SRS opens contact 542 thereby preventing the further operation of the magnet OMS and closes contacts 537 and 538, whereby battery is fed over the trunk line TL to the sub-exchange selector in the following circuit: battery, upper winding of back bridge relay BBS, contact 537, wiper 556, contact 557, conductor 554, contact 502, conductor 43, contact 45 (Fig. 2), through the line relay LR1, contact 46, conductor 44, contact 503, conductor 555, contact 558, wiper 559, contact 538, contact 523, lower winding of relay BBS to earth. Line relay LR1 at the sub-exchange is energized in this circuit. It is not necessary to go into the subsequent operations of LR1 as these have been already described, but a description will now be given of the transmission of the next series of impulses.

It will be noted that when LRS de-energizes it opens contact 523, thereby opening the loop circuit for relay LR1 as previously described, permitting relay LR1 to de-energize and repeat the impulses in the manner al-

ready described. Relay LRS also completes a circuit for relay CHS as follows: earth, contact 522, contact 525, contact 536, relay CHS to battery. Relay CHS closes contact 532 thereby short-circuiting the lower winding of relay BBS to improve the impulsing circuit. Further impulses are received in a similar manner to that described, and connection is established with the line of the desired subscriber. As already described, if the desired line is busy, a busy tone is connected to the trunk line so that the calling subscriber hears the tone and hangs up his receiver. If the line is idle, the calling subscriber is rung and conversation proceeds, and when the conversation is finished the calling and called subscribers hang up their receivers. In either case on the calling subscriber hanging up his receiver the relay LRS de-energizes, opens contacts 521 and 523. By opening contact 523 it permits the relay LR1 at the sub-exchange to de-energize, while at contact 521 it opens a circuit for relay RRS. Relay RRS de-energizes, opens contact 524 to permit the selectors D and E, and the subscriber's line switch SLS to restore to normal, and it opens the locking circuit of the upper winding of relay SRS. Relay SRS accordingly de-energizes. Relay RRS also closes contact 526, thereby completing a circuit for the release magnet RMS from: earth, contact 522, contact 526, off normal contact 530, release magnet RMS to battery. Release magnet RMS thereby operates and restores the sub-exchange selector SES to normal. Everything is now restored to normal.

It should be understood that the invention is capable of considerable modification of the actual circuits shown and described. For instance the invention is applicable to a small isolated private automatic exchange in which case the relay groups and impulse recorders would somewhat resemble the relay group G2 with the omission of the relay IS. In that case of course, it would only be necessary to have one digit and consequently testing would take place during the first series of impulses instead of waiting for the second series to begin. There would be no inter-connection between the relay groups and the busy signal would only be given when a called line was tested and found to be busy. It is of course possible to have more than two speaking circuits, for instance there could be three speaking circuits having a third relay like OS. This would necessitate modifications in the inter-connecting arrangements and would somewhat increase the number of contacts on each relay, but otherwise it would be appreciated that it could be readily effected by those versed in the art.

A further alternative which may arise in certain circumstances is that in which a second exchange line is required, when the relay groups would be similar to G1 and again

there would be no necessity for transferring the call unless there was a third speaking circuit.

Again it should be understood that the size of the system is not necessarily limited to ten lines. As most impulse senders are arranged for transmitting ten digits this is convenient, but either with a counting relay chain and impulse sender of greater capacity a larger number of lines could be made accessible to the exchange, or without increasing the capacity of the impulse sender it could be arranged that one of the relays of the counting chain was a dead relay so that when such a relay was selected by dialling a digit it would be possible without restoring to normal, to receive further impulses on further counting relays, above ten.

What I claim is:

1. In a telephone system, a trunk having two sections at one end thereof, a switching device individual to one of said sections, means responsive to the initiation of a call over a line for extending the calling line of said trunk, whereby digit impulses may be transmitted from the calling line over both sections of the trunk line, means in the switch operated by the impulses, means independent of the value of the digit dialled for restoring said switch to its initial position responsive to the cessation of the first group of digit impulses, and means dependent upon the value of the first digit dialled for disconnecting one or the other of said sections from said trunk line whereby subsequent digit impulses are transmitted over one only of said sections for extending the desired telephone connection.

2. In a telephone system, a two-way trunk line, a switching device, means for seizing the trunk line and switching device from either end of the trunk line, means for transmitting digit impulses from the seized end of the trunk line for operating the switching device, and discriminating means for causing the switching device to absorb the first group of digit impulses transmitted to it if said device is seized from one end of the trunk line and for causing the switching device to select any one of a group of lines responsive to the first group of digit impulses transmitted to it if said device is seized from the other end of said trunk line.

3. In a telephone system, a two-way trunk line which may be seized at either end, a switching device, means for transmitting digit impulses from either end of the trunk to said switching device, discriminating means for determining from which end the digit impulses are received, means controlled by the discriminating means for rendering the switching device responsive to two groups of digit impulses to select any desired line of a group of lines if said digit impulses are received from one end of said trunk line and

for causing said switching device to respond to one group of digit impulses for selecting any line in said same group of lines if the digit impulses are received from the other end of said trunk line.

4. In a telephone system, a two-way trunk which may be seized at either end, a switching device, means for transmitting digit impulses from either end of the trunk to said switching device, discriminating means for determining from which end the digit impulses are received, and means controlled by the discriminating means for causing said switching device to respond to one or more groups of digit impulses depending upon from which end of the trunk the digit impulses are received.

5. In a telephone system, a two-way trunk which may be seized at either end, a switching device, means for transmitting digit impulses from either end of the trunk to said switching device, discriminating means for determining from which end the digit impulses are received, a second switching device, and means controlled by the discriminating means for causing said first mentioned switching device to respond to one or more groups of digit impulses depending upon from which end the digit impulses are received and upon the busy or idle condition of said second switching device.

6. In a telephone system, a two-way trunk which may be seized at either end, a first and a second switching device, means for transmitting digit impulses from an impulsing circuit at either end of the trunk to the first switching device, discriminating means for determining from which end of the trunk the digit impulses are received, means controlled by the discriminating means effective if the impulses are received over one end of the trunk for causing the first mentioned switching device to seize a desired line in a group of lines, and means effective if the impulses are received over the other end of said trunk for releasing said first mentioned switching device upon the cessation of the first group of impulses and connecting the impulsing circuit to said second mentioned switching device, said second mentioned switching device having access to said same group of lines.

7. In a telephone system, a branch exchange, a switching device, means for operating said switching device in accordance with one digit of a desired number to extend a connection to any line in the branch exchange from the main exchange, and means for operating said switching device in accordance with two digits in the desired number for extending a connection from a line in the branch exchange to any other line in the branch exchange.

8. In a telephone system, lines, a switch, means for seizing the switch over either of two paths, and for transmitting digit im-

pulses for operating said switch, discriminating means and means effective if the impulses are received over one path for causing said switch to select a called line responsive to the first group of digit impulses received by said switch, and means controlled by the discriminating means and effective if the impulses are received over the other path for causing said switch to respond to one or more groups of digit impulses depending upon the value of the first group of impulses.

9. In a telephone system, a main exchange and a sub-exchange, a switching device in the sub-exchange, means for operating the switching device from a calling line in the main exchange or from a line in the sub-exchange to set up a connection to any line in the sub-exchange, and discriminating means effective if the device is operated from the main exchange to set up a connection to a desired station in the sub-exchange over one path and effective if the switching device is operated from a line in the sub-exchange for setting up a connection to the same desired called station over a different path.

10. In a telephone system, a branch exchange including a trunk having two sections at one end, a counting device connected to one of said sections, said other section extending to a main exchange, a second trunk in said branch exchange, said second trunk also having a counting device connected thereto, each of said devices having access to local lines within said branch exchange by means entirely within the branch exchange, means responsive to the initiation of a call over a line in the branch exchange for extending the calling line to the first mentioned trunk whereby digit impulses may be transmitted over both sections of said first mentioned trunk, means effective regardless of the value of certain first digits dialled for restoring the seized counting device upon the cessation of the transmission of said current impulses, means effective if said impulses were of certain values for rendering the seized counting device non-responsive to subsequent digit impulses, means effective if the digit impulses transmitted were of a different value for opening the section of the trunk line that extends to the main exchange and for seizing the second mentioned trunk if the same is idle and for releasing said first mentioned trunk if the second trunk is seized, and means for completing the telephone connection over the second trunk if the same has been seized and over the first trunk if the second trunk was not seized.

11. A counting relay group comprising two groups of counting relays, a controlling relay individual to one of said groups, a second controlling relay individual to the other of said groups, means for operating one of said controlling relays responsive to the commencement of the odd numbered impulses

and releasing the same responsive to the commencement of the even numbered impulses, means for operating the second controlling relay responsive to the commencement of the even numbered impulses and releasing the same responsive to the commencement of the odd numbered impulses, a changeover relay operated over contacts controlled by one of said controlling relays and locked over contacts controlled by the other of said controlling relays, and means controlled by said changeover relay for alternately connecting the impulsing circuit first to one and then to the other of said groups of counting relays.

12. In a telephone system, a two-way trunk line extending between two exchanges, two impulse responding relays connected across said trunk line, one at each end of said trunk line, means responsive to the seizure of said trunk line at either end thereof for disconnecting the relay connected to that end of the trunk line and for connecting in place thereof a source of potential for operating the relay at the other end.

13. In a telephone system, a polarized relay, means effective under predetermined conditions for connecting said polarized relay across a source of alternating current whereby said relay vibrates in synchronism with said source of alternating current, a battery, means for connecting said battery across the source of alternating current through contacts on said relay, whereby said relay acts as a vibrating rectifier to charge said battery, and means effective under other predetermined conditions for connecting said polarized relay across the battery in a self interrupting circuit for generating alternating current for ringing purposes.

14. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, and means responsive to the dialling of the first digit in the called number for substituting the second connector for the first.

15. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to the dialling of the first digit in the called number for substituting the second connector for the first, and means for operating the second connector responsive to the remainder of the number to complete the connection.

16. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to the dialling of the first digit in the called number for substituting the second connector for the first, and means for rendering said last means ineffective if the second connector is busy.

17. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to the dialling of the first digit in the called number for substituting the second connector for the first, means for rendering said last means ineffective if the second connector is busy, and means for thereafter operating the first connector responsive to the remainder of the number to complete the connection.

18. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to a busy condition of said first connector for causing the calling line to seize the second connector instead of the first, and means in said second connector for absorbing the first digit of the called number.

19. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to a busy condition of said first connector for causing the calling line to seize the second connector instead of the first, means in said second connector for absorbing the first digit of the called number, and means for operating said second connector responsive to the remainder of the called number to complete the connection.

20. In a telephone system, a calling line, two connectors accessible to said line, means responsive to the removal of the receiver for extending said line to the first connector, means responsive to a busy condition of said first connector for causing the calling line to seize the second connector instead of the first, means in said second connector for absorbing the first digit of the called number, and means dependent upon the value of the absorbed digit for immediately returning a busy signal to the calling line.

21. In a telephone system, a calling line, an emergency connector seized responsive to the removal of the receiver of the calling line, a regular connector, and means for transferring a call received at the emergency connector to the regular connector if the latter is idle, thereby maintaining said emergency connector in reserve.

22. In a telephone system, a calling line, an emergency connector seized responsive to the removal of the receiver of the calling line, a regular connector, means for transferring a call received at the emergency connector to the regular connector if the latter is idle, thereby maintaining said emergency connector in reserve, and means for operating said emergency connector to complete a connection in case the regular connector is busy.

23. In a telephone system, a calling line, a connector seized by said line responsive to

the removal of the receiver, a second connector seized by said line responsive to a busy condition of the first connector or in response to the dialling of the first digit, and means in
 5 said second connector for absorbing the first digit of the called number when seized in response to a busy condition of said first connector.

24. In a telephone system, a calling line, a connector seized by said line responsive to the removal of the receiver, a second connector seized by said line responsive to a busy condition of the first connector or in response to the dialling of the first digit, means in said
 10 second connector for absorbing the first digit of the called number when seized in response to a busy condition of said first connector, and means for rendering said last means ineffective if said second connector was seized in
 15 response to the dialling of the first digit.

25. In a telephone system, two connectors for alternative use in completing connections, circuit arrangements whereby the first connector is made first choice to calling lines, and
 20 means for automatically transferring calls received at the first connector to the second provided the second connector is idle.

26. In a telephone system, two connectors for alternative use in completing connections, circuit arrangements whereby the first connector is made first choice to calling lines, means for automatically transferring calls
 25 received at the first connector to the second provided the second connector is idle, and means for completing the calls over the first connector provided the second connector is busy.

27. In a telephone system, a primary trunk having access to a first and a second class of subscribers, a second primary trunk having access to only said second class of subscribers, means responsive to a call from a line for connecting said line to said first trunk, means for transferring said calling
 30 line to said second trunk if the call is for a subscriber of said second class, and means for rendering said last means inoperative and for completing the call over said first trunk if said second trunk is busy.

28. In a telephone system, a primary trunk having access to a first and a second class of subscribers, a second primary trunk having access to only said second class of subscribers, means responsive to a call from a line for connecting said line to said first trunk if idle, means for connecting said line to said second trunk providing said first trunk is busy, means for completing the call over said second trunk if the call is for a subscriber of said second class, and means for
 35 returning a busy signal to the calling line if the call is for a subscriber of said first class.

29. In a telephone system, a calling line, two counting relay chains accessible to said
 40 line, means responsive to the removal of the

receiver for extending the calling line to the first counting relay chain, and means responsive to the dialling of the first digit of a called number for releasing said first counting relay chain and for extending the calling line to the second counting relay chain.
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30. In a telephone system, a plurality of lines, a group of counting relays common to said lines, means responsive to the initiation of a call over one of said lines for extending the calling line to said group of counting relays, means in said group of counting relays for absorbing the first digit of the called number, and means for operating said counting relays responsive to the dialling of the remainder of the called number to complete the connection.
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31. A counting relay chain comprising a number of relays equal to the maximum number of impulses to be registered at one time, said relays being divided into two groups, a controlling relay for each group, a changeover relay, and means controlled by said changeover relay for alternately operating said controlling relays in series with successive relays of their respective groups.
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32. A counting relay chain comprising a number of relays equal to the maximum number of impulses to be registered at one time, said relays being divided into two groups, a controlling relay for each group arranged to be operated in series with successive relays of its group, an impulsing circuit having a branch extending to each of said controlling relays, a changeover relay, and means controlled by said changeover relay responsive to received impulses for connecting up one branch of said impulsing circuit to receive the odd-numbered impulses and for connecting up the other branch of said impulsing circuit to receive the even-numbered impulses.
 95 100 105

33. A counting relay chain comprising a number of relays equal to the maximum number of impulses to be registered at one time, said relays being divided into two groups, a controlling relay for each group, a changeover relay, and means controlled by said controlling relays for operating said changeover relay to a certain position at the termination of one impulse and maintaining it in said certain position until the termination of the succeeding impulse.
 110 115

34. In a telephone system, subscribers' lines, a trunk line, a link circuit having incoming and outgoing sections, means responsive to the initiation of a call for connecting the calling line to the incoming section of said link circuit, and means responsive to the dialling of the called number for connecting a called one of said lines or said trunk line to said link circuit, said called line being connected to the outgoing section and said trunk line being connected to the incoming section of said link circuit.
 120 125 130

35. In a telephone system, subscribers' lines, a trunk line, a plurality of link circuits having incoming and outgoing sections, means for connecting a calling line to the incoming section of one of said link circuits, means responsive to the dialling of a subscriber's number for connecting the called line to the outgoing section of said link circuit, and means responsive to a particular digit dialled for connecting said trunk line to the incoming section of said link circuit. 75
36. In a telephone system, a switching device accessible over either of two paths, means for operating said switching device in accordance with the digits of a desired number to extend a connection to a desired subscriber's line, and means effective only in case said switching device is seized over a particular one of said paths for absorbing the first digit in the called number. 80
37. In a telephone system, a switching device accessible over either of two paths, subscribers' lines accessible to said switching device, means effective when said switching device is seized over one of said paths for operating said switching device to extend a connection to a desired line in accordance with the first digit received, and means effective when said switching device is seized over the other of said paths for releasing said device at the termination of the first digit received. 85
38. In a telephone system, a calling line, two primary trunks accessible to said line, means for connecting the calling line to the first of said trunks, means for rendering said first means inoperative and for connecting the calling line to the second trunk in case said first trunk is busy, and means in said second trunk for absorbing the first digit of the called member. 90
39. In a telephone system, a calling line, two primary trunks accessible to said line, means for connecting said calling line to the second of said trunks responsive to a busy condition of the first trunk or responsive to the dialling of the first digit of the called number, and means in said second trunk for absorbing the first digit received by it only in case said second trunk was seized responsive to a busy condition of the first trunk. 95
40. In a telephone system, subscribers' lines, a trunk line, a link circuit seized responsive to the initiation of a call, a second link circuit, means for completing all local calls over said second link circuit if idle, and means for completing all trunk calls over said first link circuit and for completing local calls over said first link circuit in case said second link circuit is busy. 100
41. In a telephone system, subscribers' lines, a trunk line, two link circuits accessible to said lines, means for completing all trunk calls over the first of said link circuits, means for completing all local calls over the second of said link circuits when the same is idle, and means for completing local calls over said first link circuit in case said second link circuit is busy. 105
- In witness whereof, I hereunto subscribe my name this 15th day of February, A. D. 1928. 110
- RUDOLPH F. STEHLIK. 115
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