March 29, 1932. J. H. E. BAKER 1,851,482

AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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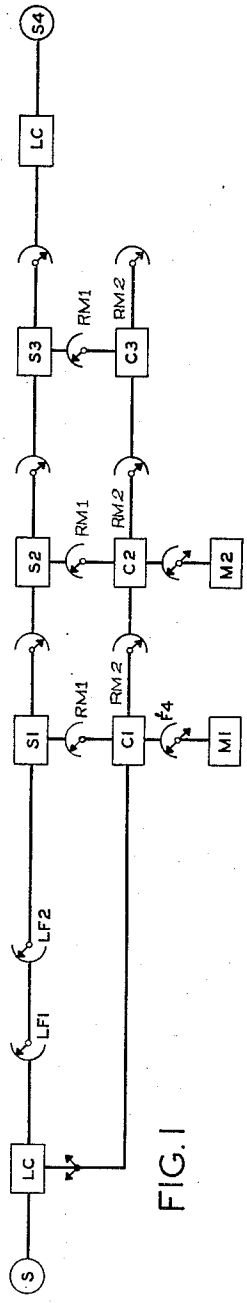

FIG. 1

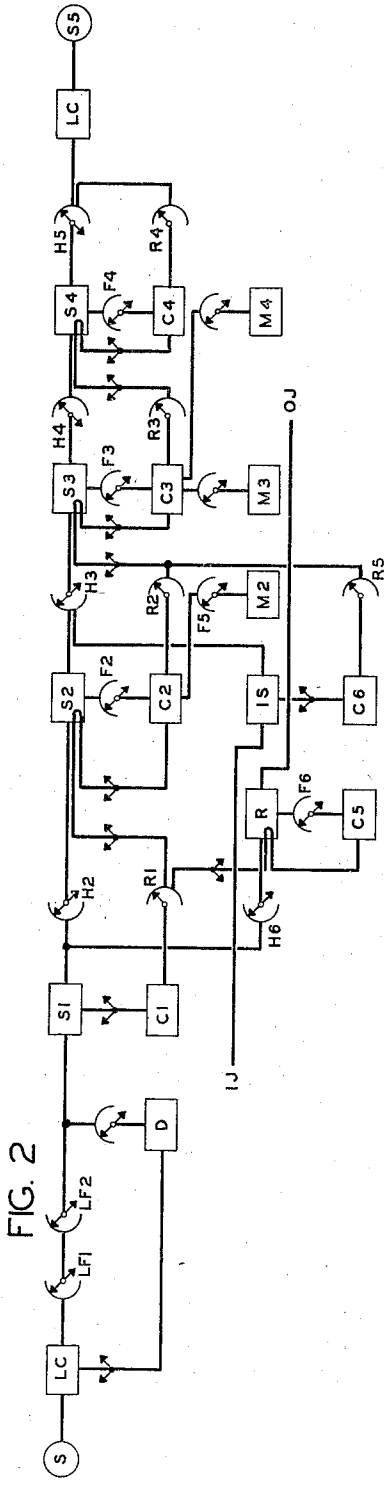

FIG. 2

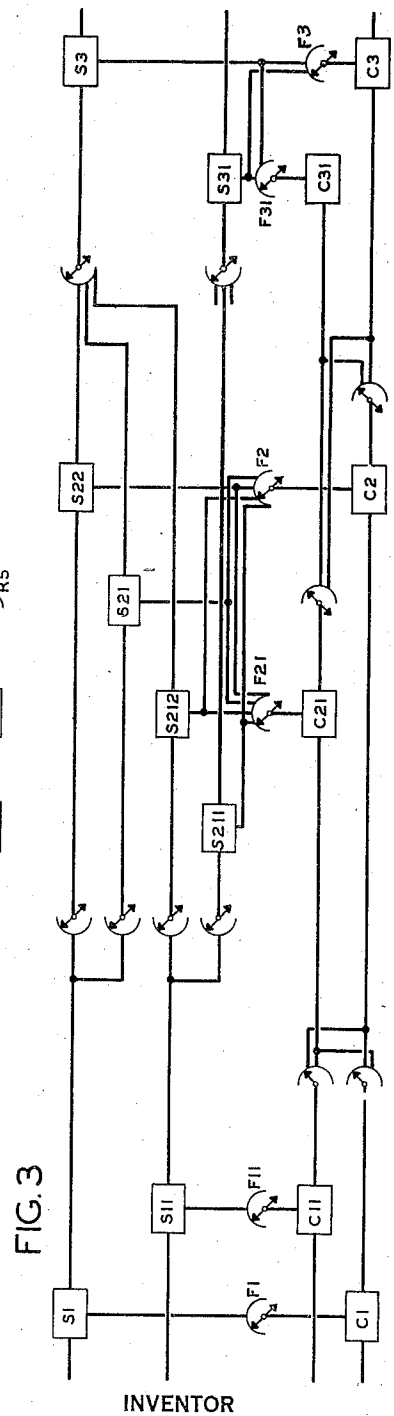

FIG. 3

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FIG. 4

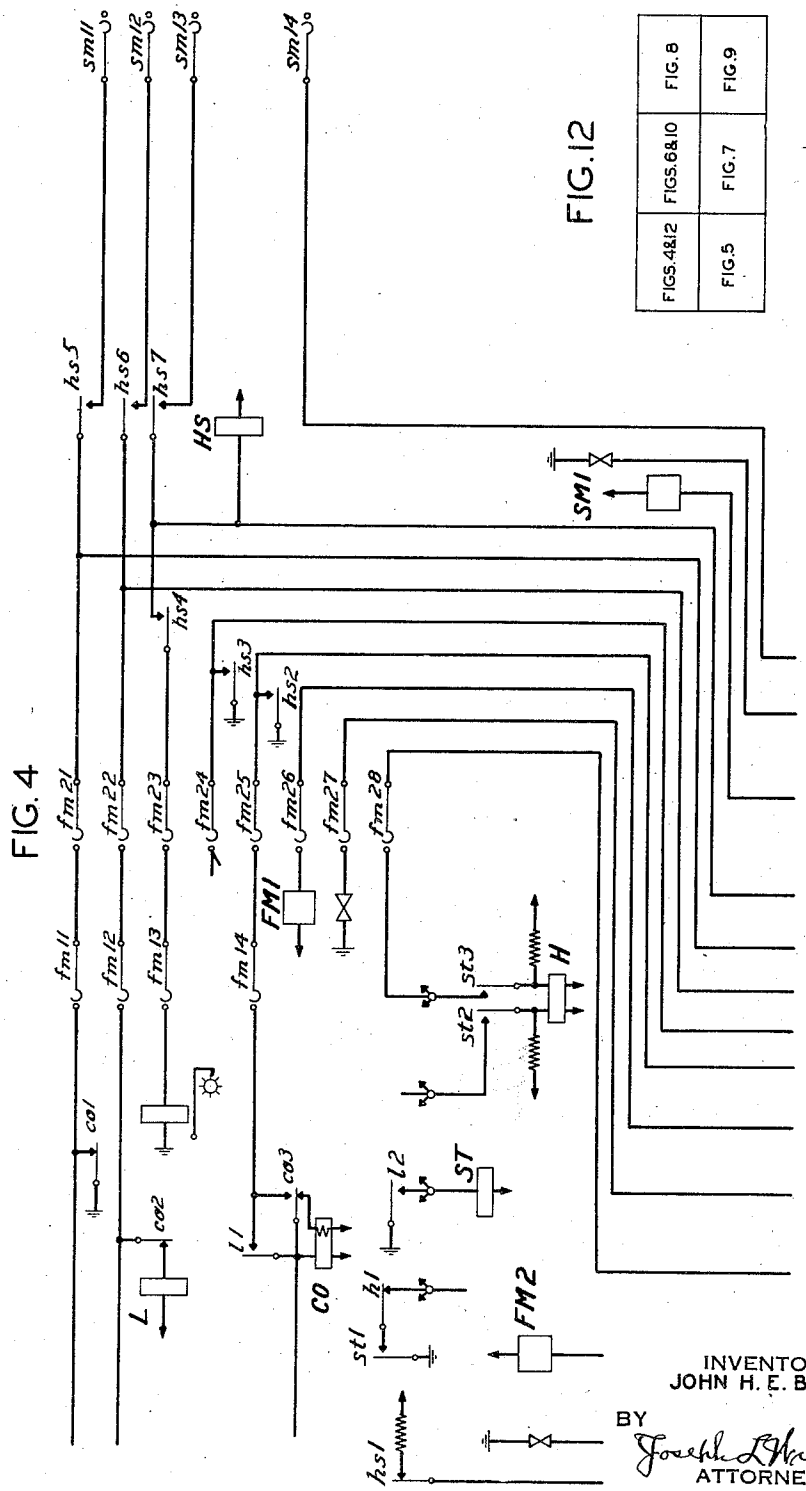

FIG. 12

FIGS.4&12	FIG.5	FIG.8
FIGS.6&10	FIG.7	FIG.9

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FIG. 5

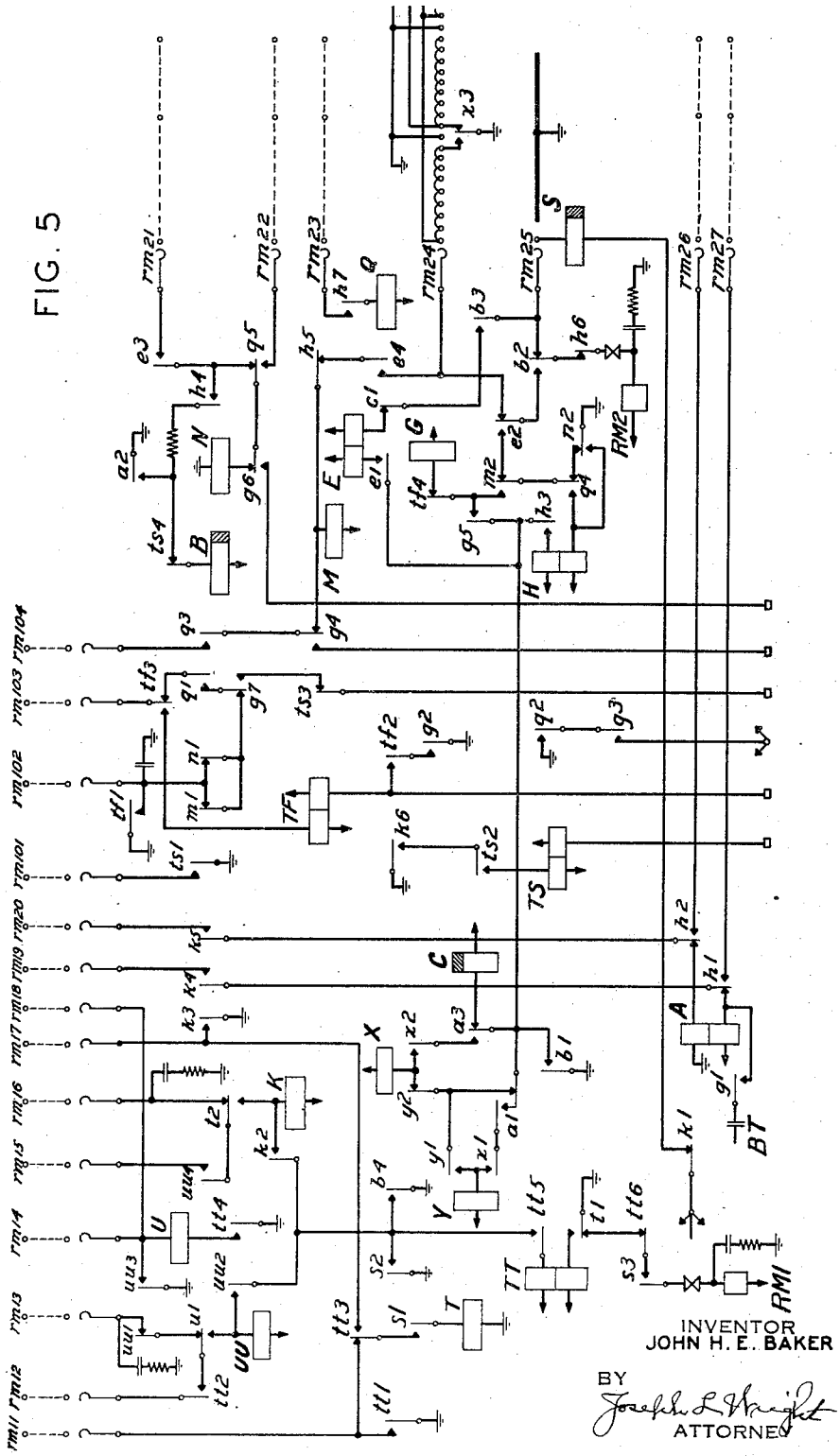

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FIG. 6

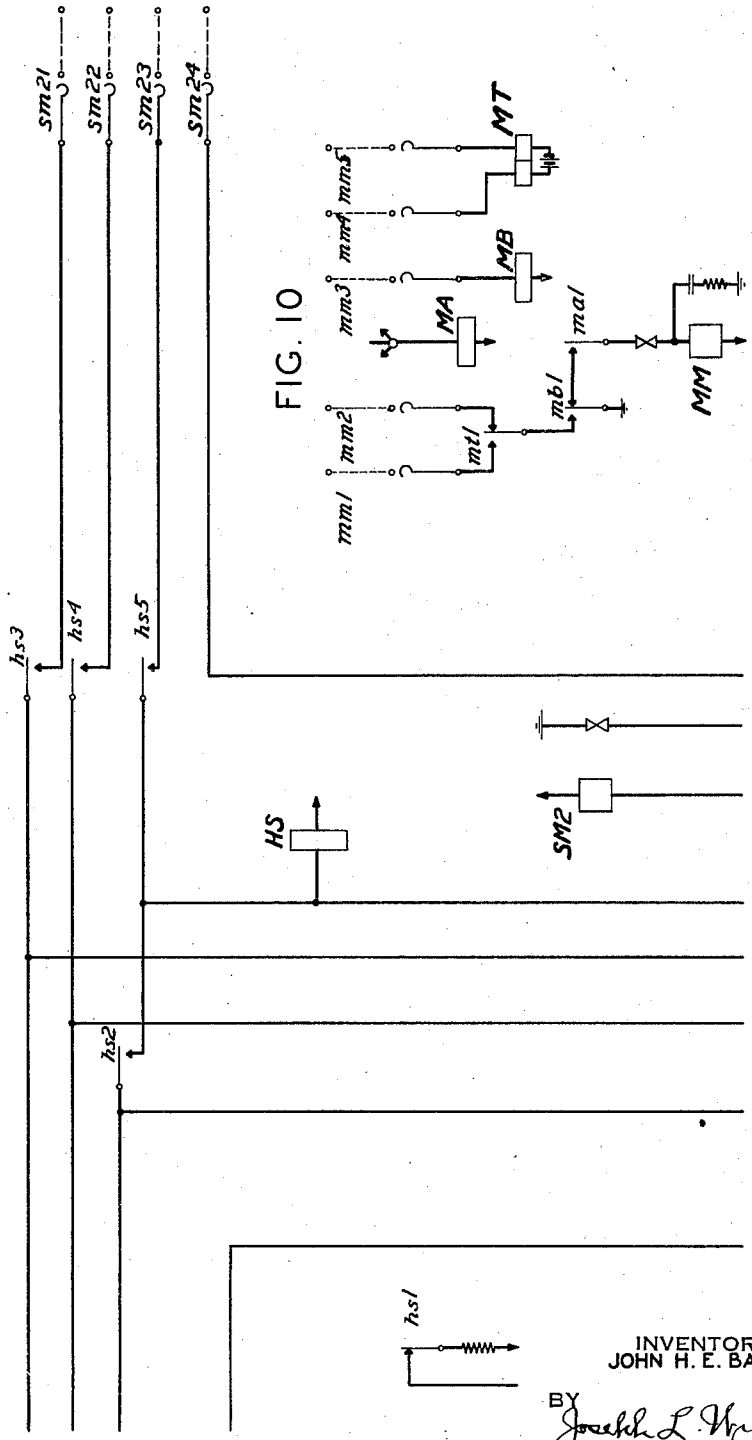

FIG. 10

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FIG. 7

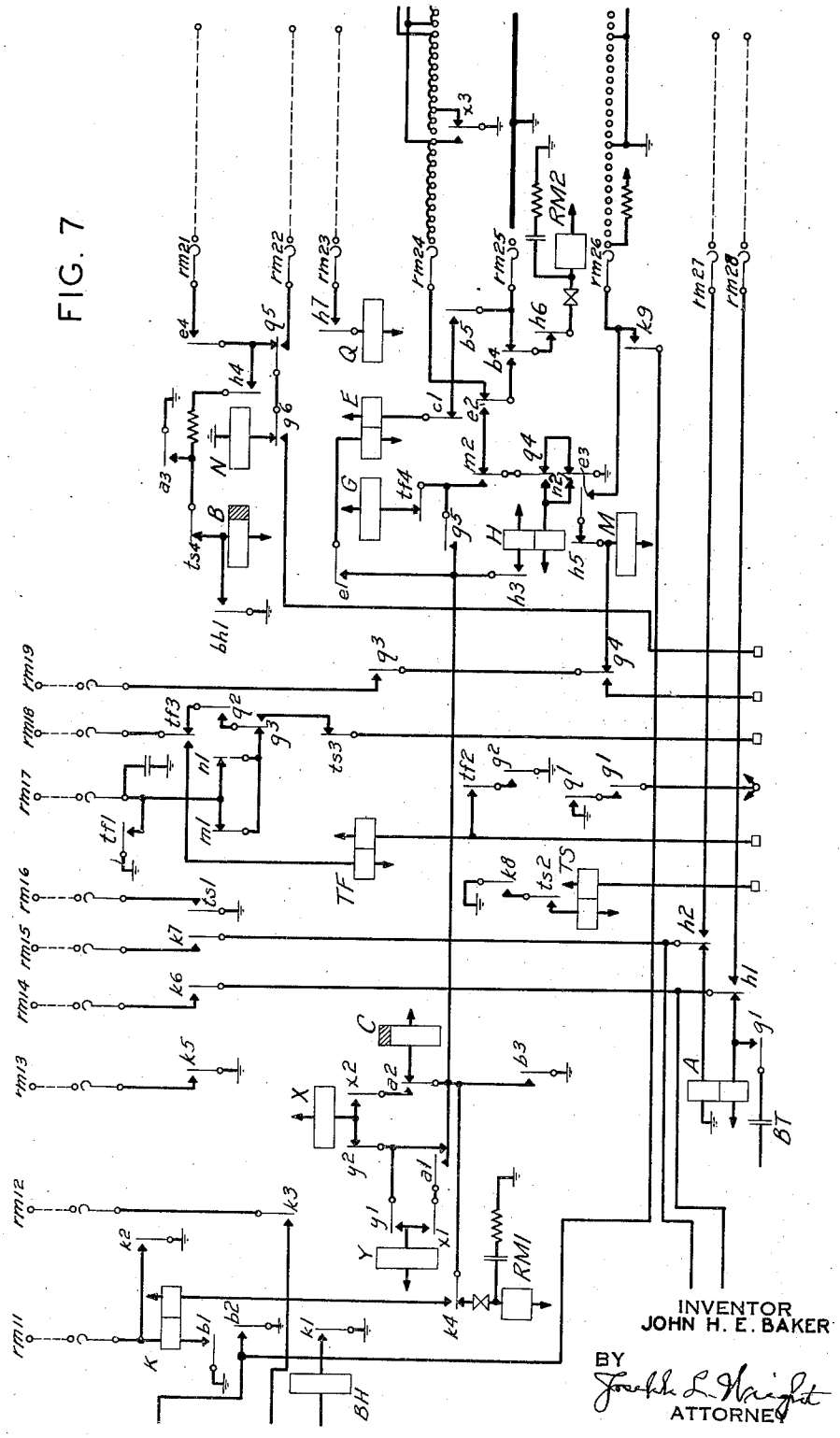

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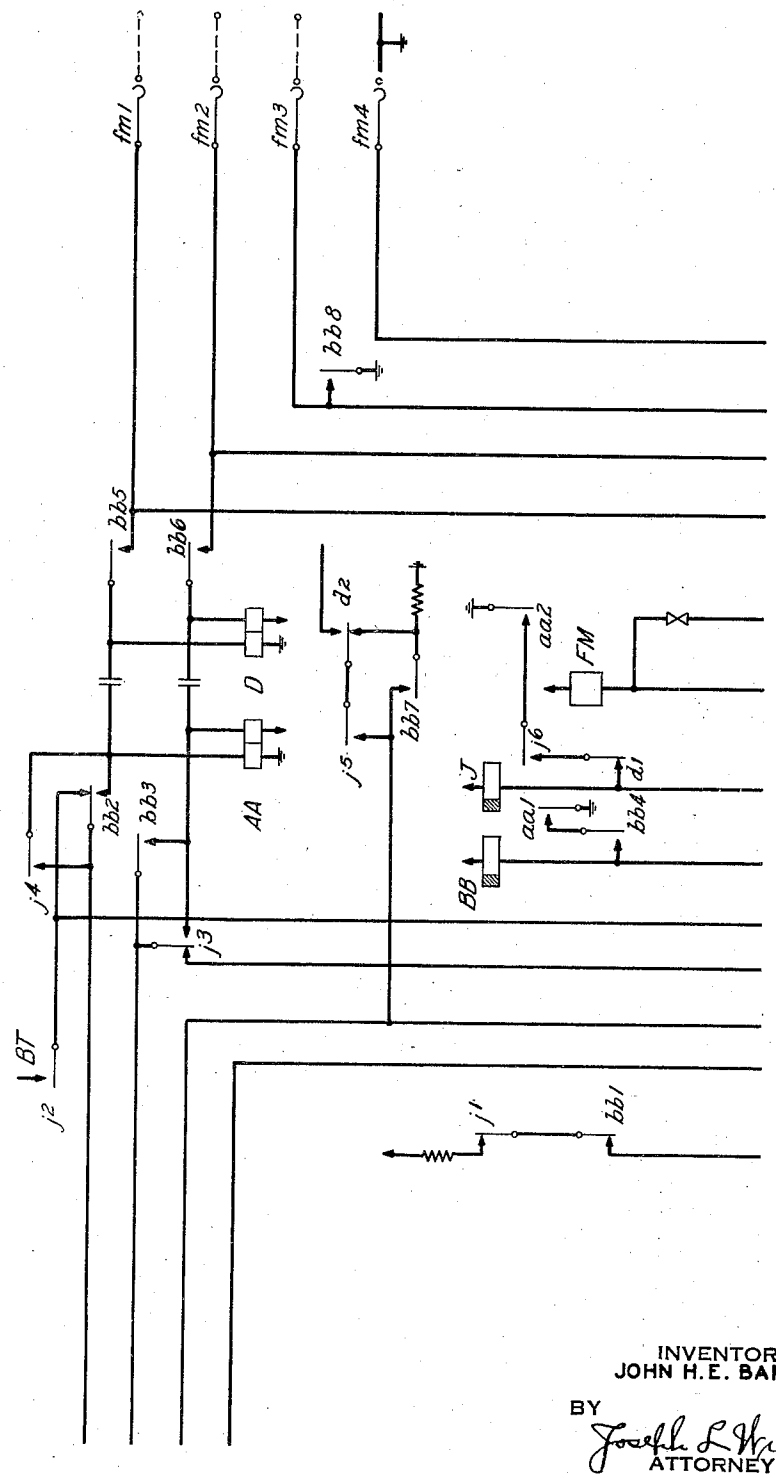
FIG. 8



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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

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FIG.9

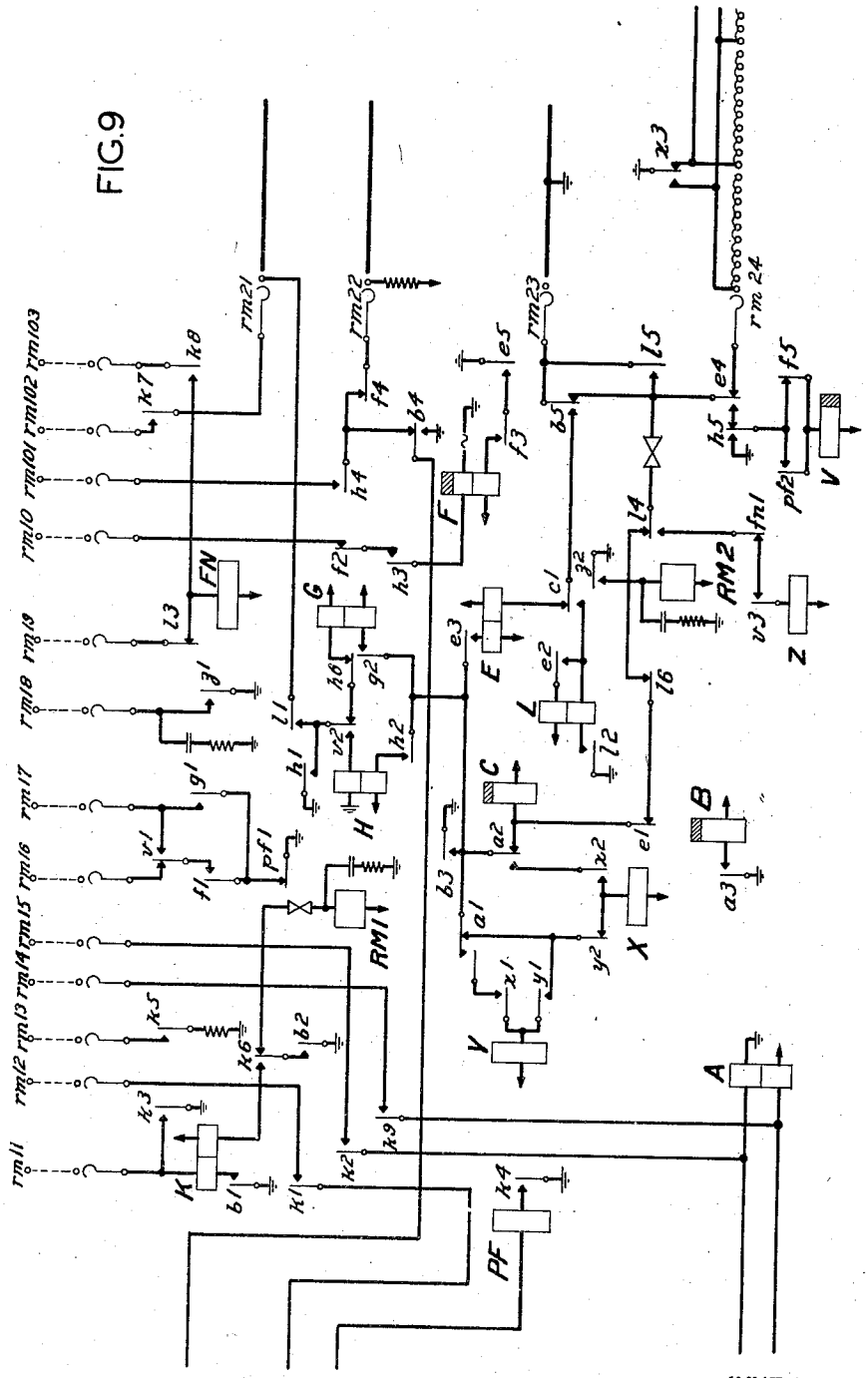

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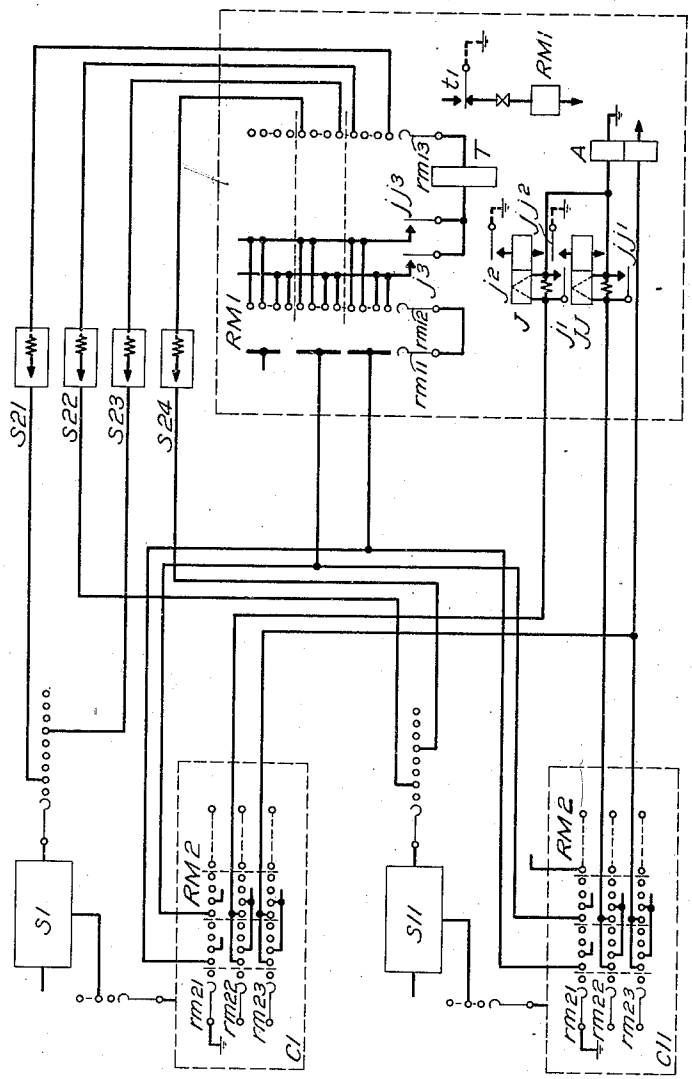
FIG. 11



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Patented Mar. 29, 1932 1,851,482

UNITED STATES PATENT OFFICE

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AUTOMATIC OR SEMIAUTOMATIC TELEPHONE SYSTEM

Application filed January 31, 1930, Serial No. 424,886, and in Great Britain February 14, 1929.

This invention relates to automatic and semi-automatic telephone exchange systems and has particular reference to systems of the kind in which bye-path circuits are employed for controlling the operation of the conversation switches thereat.

It has been the practice in such systems in the past to make a search from one switching stage for an idle conversation switch in the next stage having associated therewith an idle bye-path circuit. This search is made in the period between successive digits and owing to the limitations imposed by the allowable duration of this period and by the stepping speed of the switch, the number of outlets which can be provided in any one group is of necessity limited. The disadvantage has been overcome to some extent by the employment of pilot switches which receive the dialled impulses while the main bye-path switch is advancing towards the wanted group of outlets. It has also been proposed to provide the main switches with a plurality of sets of wipers and bank contact sets and to make the switch conduct a simultaneous hunt over such wiper sets.

It is the object of the present invention to provide means whereby this disadvantage is still further overcome and whereby at the same time economy of apparatus is obtained. In the previous arrangements also it has been necessary to associate a plurality of conversational switches with a single bye-path circuit with the result that when a bye-path circuit and one of its associated conversational switches was in use, the remainder of the associated conversational switches were artificially busied.

It is a further object of the present invention to obviate this disadvantage also.

According to one feature of the present invention, in extending a connection from one selecting stage to another, search is made for an idle bye-path circuit only. Since the number of bye-path circuits is less than the number of conversational switches, this arrangement reduces the number of outlets over which the bye-path switch is required to search between successive digits. Thus it becomes possible to provide arrangements whereby the wipers advance over entire groups of outlets between successive impulses. This may be further facilitated by simultaneous hunting in a plurality of levels and wiper-switching.

According to another feature of the invention, therefore, digital impulses are received directly by the bye-path switch of a selector stage.

In such an arrangement the bye-path circuit will be adapted to make connection to an idle conversational switch leading in the wanted direction and associated with the bye-path circuit. It is possible, therefore, to provide a very flexible arrangement of conversational and bye-path circuits in a selector stage, and according to a further feature of the invention each conversational switch in a selector stage is associated with the plurality of bye-path circuits.

With such an arrangement also, provision must be made for avoiding a cross between two connections which are being set up simultaneously. This defect may occur when a bye-path circuit having been seized from a preceding bye-path circuit searches for an idle conversational switch and then causes initiation of a connection between the last mentioned conversational switch and the predetermined preceding conversational switch. This danger may be taken care of, for example, by providing at each switching stage a suitable device which determines that a true connection has been made. Thus a single common testing circuit may be associated in common with all the bye-path circuits of a group in a selector stage. With such an arrangement, when a connection has ostensibly been set up from the said selector stage to the next stage, the test circuit is taken into use and a test is made of the formation of a loop through the two stages. Since only one testing circuit is provided, only one connection can be tested at a time so that there is no possibility of the test device being operated by a cross connection. The test may be made either by use of the common battery, or by independent battery connections.

Further flexibility is also possible with the arrangements described. Thus, each bye-

path in a group of bye-paths at one selector stage may be made accessible from a plurality of groups of bye-paths in the preceding selector stage and the said group will therefore be associated with a plurality of groups of conversational switches to which access is possible from the conversational switches associated with the said groups of bye-paths in the preceding stage. Similarly, a single group of bye-paths in one selector stage may be accessible from one or more groups of bye-paths in the preceding stage in response to a plurality of digital values; in this case the said group of bye-paths must be associated with a plurality of groups of conversation switches which have access to trunks leading in a plurality of directions and which are accessible from one or more groups of conversational switches in the preceding stage. It will be appreciated that the groups of bye-path circuits may vary in number. If, however, the banks of a bye-path switch were divided up exactly in accordance with the size of the groups of succeeding bye-paths to which it had access, alterations in the size in the groups due to changes in traffic distribution would be difficult. In order to obviate this an equal number of outlets may be provided for each group of bye-paths sufficient to provide for the maximum traffic possible. A number of outlets in each of some or all of the groups of outlets could then be permanently busied so as to provide groups of the required sizes. Further features of the invention will be apparent from the following description of certain embodiments of the invention and are set out in the appended statement of claims.

The bye-path circuits may comprise common control means for controlling the operation of the conversation switches.

The layout of three typical systems embodying the features of the invention are illustrated in Figs. 1, 2 and 3.

A short description of Figures 4–12 will now be given:

Figure 4 shows a first path circuit and indicates the first and second line finders together with a subscriber's line and starting circuits.

Figure 5 shows a first bye-path circuit including a hunting switch RM1 which serves to connect the bye-path to its associated paths and a switch RM2 of the selector type, the functions of which will be described later.

Figure 6 shows an intermediate path switch.

Figure 7 shows an intermediate bye-path which is similar to the first bye-path described above.

Figure 8 shows a final path circuit.

Figure 9 shows a final bye-path.

Figure 10 shows a test circuit, one of which is associated with all the bye-path circuits of the first stage and of the second stage.

Figure 11 shows diagrammatically a particular embodiment of the arrangement shown in Figure 5.

Referring first to Figure 1 of the accompanying drawings, a calling subscriber's line circuit LC signals all idle first bye-path circuits C1 of the group associated with the subscriber so that their RM1 switches hunt for a free first group finder such as S1. When S1 is found line finders LF2, LF1 operate in turn to make connection to the calling line. A bye-path switch RM2 individual to the control circuit C1 responds to the first series of impulses and on the cessation thereof hunts for an idle bye-path circuit C2 associated with second group finders such as S2 in the required group at the next switch stage, and subsequently the bye-path switch RM2 individual to the control circuit C2 responds to the second digit received over the bye-path circuit C1 and selects an idle bye-path circuit C3 having associated final finder switches S3 giving access to the group of subscribers' lines to which the wanted party S4 belongs.

In the meantime the control circuit C2 at the second switching stage is associated over a hunting switch RM1 with an idle second group finder S2 accessible to the engaged first group finder S1 which now advances under the combined control of the first and second control circuits C1 and C2 until testing means in C1 are satisfied. There is however the possibility of a cross-connection, and in order to test for this a single test circuit M1 is provided, associated in common with the group of bye-path circuits such as C1. When S1 stops hunting, M1 is connected to C1 and the connection is tested by means of an independent battery. If the connection is a cross, the testing means will not respond, and S1 will recommence hunting. M1 becomes available for use elsewhere and will be taken into use again when S1 again stops. When a true connection is effected the bye-path switch RM2 is no longer required and the first control circuit C1 and marker M1 are restored for use in extending another call. In the same manner when the control circuit C3 has been associated with an idle final finder S3 over a hunting switch RM1 and the second group finder S2 has extended connection to the final finder S3 with the help of common test circuit M2 the control circuit C2 is dropped.

The tens and units impulses are received by the bye-path switch RM2 which is individual to the control circuit C3. S3 is set to the wanted line by being stepped in synchronism with RM2 while the latter returns to normal. The subscribers' lines are connected in the banks of S3 in substantially inverse order to that usually employed so that S3 is now on the wanted line. Ringing or busy tone and feed bridges may be provided at the final stage.

In the system illustrated in Figure 2 the two first directively controlled conversation switches are backwardly hunting switches. Provision for calls over incoming and outgoing junctions is also shown.

A calling subscriber's line S is connected over a line circuit LC and first and second line finders LF1, LF2, controlled by an allotting switch D, to a free first selector circuit S1 the associated control circuit C1 of which is also idle. A bye-path switch R1 individual to the control circuit C1 responds to the first digit and hunts for an idle control circuit C2 having an associated idle second selector circuit such as S2 in the required group at the next switching stage. The test circuit extends over parallel paths in all the idle associated selector circuits so that if all the associated circuits are engaged the control circuit tests non-selectable. Subsequently the bye-path switch R2 individual to the control circuit C2 responds to the second digit received over the control circuit C1 and selects an idle control circuit C3 having an idle associated penultimate selector circuit such as S3.

In the meantime the control circuit C2 is associated over a hunting switch F2 with an idle second selector circuit S2, a backwardly-hunting finder H2 individual to which has access to the first selector circuit S1. The finder H2 now advances until it finds the predetermined first selector circuit S1, a test circuit M2 which is common to the switching stage and which is associated with the control circuit C2 over a hunting switch F5 ensuring that a true connection is made. When this connection is effected the bye-path switch R1 is no longer required and the control circuit C1 is restored for use in another call.

In the same manner when the control circuit C3 has been associated with an idle penultimate selector circuit S3 over a hunting switch F3 and an associated finder H3 has picked up the second selector circuit S2 under the control of a common test circuit M3, the control circuit C2 is dropped.

The bye-path switch R3 individual to the control circuit C3 responds to the third digit and selects an idle control circuit C4 having an idle associated final selector circuit such as S4. The tens and units digits received over the bye-path switch R3 actuate the bye-path switch R4 of the control circuit C4, and a hunting switch F4 associates this control circuit with an idle final selector circuit S4. A forwardly-hunting finder H4 individual to the penultimate selector circuit S3 then advances until it finds the predetermined final selector circuit S4 under the control of a common test circuit M4. A finder H5 hunts for the wanted line S5 marked by the bye-path switch R4. The control circuits C3 and C4 are dropped when the bye-pass connections have been replaced by connections over conversational switches.

In an outgoing call the first bye-path switch R1 selects an idle control circuit C5 having an idle associated repeater circuit such as R. Subsequently the control circuit C5 is associated with a repeater circuit R at the outgoing end of an outgoing junction over a hunting switch F6 and a backwardly hunting finder H6 individual to the repeater circuit R picks up the preselected first selector circuit S1.

Incoming calls enter over incoming junctions such as 1J terminating in incoming selector circuits 1S accessible to the finders H3, an incoming junction 1J only being taken into use if the incoming selector circuit 1S and its associated control circuit C6 are both free. The first digit actuates an associated bye-path switch R5 to extend the connection to a control circuit C3 at the penultimate stage after which the operations are very similar to those in a local call.

The talking current feed for both the calling and called parties may be located in the penultimate selector circuit S3.

Any suitable device for preventing cross-connections may be used in place of the test circuits M. For example, a form of potentiometer device somewhat resembling the common cross-connected field used in the register translator described in U. S. Serial No. 276,734 might conveniently be adapted to this purpose.

Referring now to Figure 3 of the drawings it is assumed that the first selector circuits are arranged in groups of 100, each group being controlled by a group of control circuits, although only one selector circuit and one control circuit of each such group is illustrated.

The first digit is received by one of the first stage control circuits C1 serving a group of first selector circuits S1, and finds an idle control circuit C2 at the second stage. The control circuit C2 can also be seized by a control circuit C11 serving another group of first selector circuits S11, but the path of access will be different. Both groups of first control circuits may have access to the same group of second control circuits in response to a plurality of digital values. Means are therefore provided to control the search made by the hunting switch F2 which associates the control circuit C2 with a selector circuit at the second stage so that it searches only among those selector circuits capable of extending calls in the required direction and having access to the calling first selector circuit. The control circuit C2 receives the second digit and searches for a third stage control circuit. At the second switching stage also, the selector circuits S211, S212 and S21, S22 respectively represent two selector circuits of a large group, whilst the control cir-

cuits C2, C21, each represent one circuit of a group associated with the selector circuits S211, S212, and S21, S22.

One advantage of the above arrangements is that when a control circuit is connected to a selector circuit, the remainder of the selector circuits is available for further calls, only the selector circuit actually chosen being held. In previous arrangements in which a control circuit is tied to a group of selector circuits, all the selector circuits of the group are artificially busied while the control is handling the stage digit.

The arrangement at the third switching stage is similar. The control circuits C3 and C31 may be taken into use over a plurality of paths depending upon which group of third selector circuits S3 or S31 are required to be hunted over by an associating finder F3 or F31 reach an idle selector circuit having access to a predetermined second stage selector circuit.

The subscriber initiates a call by lifting his receiver and looping the line in the usual manner thereby completing the circuit for his line relay L, Figure 4, which operates and in turn causes the common start relay ST to operate. *St* grounds the common start lead to the bye-paths available, operating relay S in one or more first bye-paths; earth, *st*1, *h*1, *k*1, Fig. 5, S, *rm*25, *b*2, *h*6, interrupter contacts, RM2, battery. Relay S in operating completes the circuit for switch RM1 which drives in search of a first path; ground *t*1 *tt*6, *s*3, rotary interrupters and RM1 to battery.

At the same time a circuit is prepared for the testing relay T which operates when a resistance to battery is encountered by the test wiper over the following circuit:—

Ground, relay T, *s*1, *tt*3, *rm*11, *hs*1, and resistance to battery.

T operates breaking the drive circuit for RM1 and operating TT, which locks to ground from *s*2. The second finder is now caused to hunt for a calling group of subscribers, a circuit being provided for magnet FM2 from ground, interrupter springs, *rm*12, *tt*2, *u*1, *uu*1, *rm*13, FM2, battery. A testing circuit is prepared at the same time for relay U which operates when battery is picked up by the test wiper from ground, *tt*4, relay U, *rm*14, *fm*28, *st*3, resistance to battery. When U operates the circuit is completed for relay UU from ground, interrupter springs of FM2, *rm*12, *tt*2, *u*1, winding of UU to battery. UU operates and locks via *uu*2, *s*2. A drive circuit is now established for the first finder FM1 which searches for the calling subscriber, the testing circuit for relay T, which was de-energized on the operation of relay TT, being completed at the same time. The drive circuit for FM1 is from ground, interrupter springs, *fm*27, *rm*15, *uu*4, *t*2, *rm*16, *fm*26, FM1 to battery. This drive is broken when battery is picked up by the test wiper of FM1 and relay T operates; ground, relay T, *s*1, *tt*3, *rm*17, *fm*25, *fm*14, *l*1, *co*3, non-inductive and inductive windings of relay CO in parallel, battery. CO operates, and locks via *co*2, releasing relays L, ST, and S, Figure 5. Relay K, Figure 5, now operates via *t*2, *uu*4, *rm*15, *fm*27, interrupter springs to earth, and locks via *k*2, *s*2. Relay A, Figure 5, now operates in a circuit from ground, upper winding of relay A, *h*2, *k*5, *rm*10, *fm*21, *fm*11, subscriber's loop, *fm*12, *fm*22, *rm*19, *k*4, *h*1, lower winding of relay A to battery. Relay A in turn operates relay B which maintains the locking circuit for relays UU and K at *b*4 when S releases. Relay A subsequently responds to impulses from the subscriber's dial. When relay A falls back for the first time a circuit is completed for relay X from ground, *b*1, *a*1, *y*2, X to battery. X operates and is maintained when relay A re-operates over a circuit from ground *b*1, *a*3, *x*2, winding of X to battery. At the same time, an operating circuit is completed for relay Y from ground *b*1, *a*1, *x*1, winding of Y to battery. When relay A falls back for the second time X releases and does not reoperate for the moment, its former operating circuit being broken at *y*2. Relay Y is maintained while relay A is back over a circuit from ground *b*1, *a*1, *x*1, winding of Y to battery. When A reoperates Y is released. When relay A falls for the third time the initial cycle of operations is recommended with the operation of X as before. It will be seen that relay X remains up for the first complete impulse, is back for the second complete impulse, re-operates and remains operated for the third complete impulse and so on. When relay B operated, a circuit was prepared for RM2. When X operates for the first time the circuit of RM2 is completed from ground *x*3, *rm*24, *e*2, *b*2, *h*6, interrupter springs, RM2 to battery. RM2 drives until the 11th contact of its bank is reached, the tenth contact being permanently earthed. If only one impulse is sent by the subscriber, relay X will not fall back and RM2 remains in the position which is taken up, but if a second impulse be dialled relay X releases and the drive circuit for RM2 is again completed, in which case RM2 will drive to contact 21 for instance. This sequence of operation continues, RM2 in each case taking an arbitrary number of steps for each complete impulse dialled by the subscriber until the digit is completed. According to the arrangement of outlets on the bank of RM2, the number of steps taken for a complete impulse may vary during the impulse train. During impulsing dialling relay C is operated via *a*3, *b*1, and remains up, but releases when A finally remains operated. A circuit is then completed for relay E from ground, *rm*25, *b*3, *c*1, right hand winding of E, to battery. E operates and locks to *b*1.

RM2 now drives to search for an idle intermediate bye-path, the drive circuit being completed from ground, *n*2, *q*4, *m*2, *e*2, *b*2, *h*6, rotary interrupters, RM2 to battery. A free second bye-path is characterized as usual by having resistance to battery on its test contact and when this is reached relay N operates from ground, winding of N, *g*6, *q*5, *e*3, *rm*21 to the test battery. Relay H operates from earth at *n*2 and locks to *b*1. Relay A in the first bye-path is now disconnected and the calling loop is extended at *h*1 and *h*2 to the A relay in the intermediate bye-path selected:

Relay A (Fig. 7) in the intermediate bye-path operates and in turn operates B. B grounds the incoming test lead thereby serving to hold relay B in the first bye-path over the following circuit:—

Ground, *b*2, Fig. 7, *rm*21, Fig. 5, *e*3, *h*4, *ts*4 winding of B to battery.

RM1 of the intermediate bye-path now searches for an idle path, the drive circuit for RM1 being completed from ground, *b*3, *k*4, rotary interrupters, RM1, to battery. When an idle path is found relay K operates from ground, *b*1, left hand winding of K, *rm*11, *hs*1, Fig. 6, resistance to battery. K breaks the drive at *k*4 and locks to *b*3. When K operates, a signal is sent back to the first bye-path by ground being put out from K1 through the winding of BH over *rm*23, Fig. 5, *h*7, and the winding of Q to battery. Relays BH and Q operate in series. The operation of Q in the first bye-path completes the drive circuit for the first path selector from ground, interrupter springs, *rm*103, *tf*3, *q*1, *g*7, *m*1, and *n*1 in parallel, *rm*102, SM1 to battery. The selector now searches for the path which has been taken into use by the intermediate bye-path. When this path is found a circuit is completed for relays N and M Fig. 5 in series as follows:—

Ground, winding of N, *g*6, *q*5, *rm*22, *k*3, (Fig. 7) *rm*12, *sm*4 Fig. 4, *rm*104, Fig. 5, *q*3, *g*4, winding of M to battery.

It will be observed that it is necessary for both relays M and N to operate for the selector drive to be broken. This is to provide for a case in which the selector switch while hunting might encounter an intermediate path that has just been taken into use by an intermediate bye-path, other than that to which connection has been established by the first bye-path associated with the searching selector switch. In such case relay M alone would operate, in series with the N relay in the other first bye-path in suitable condition. Similarly the first path selector switch of another train might encounter the intermediate path associated with the intermediate bye-path we are dealing with at the moment; in such case relay N in the first bye-path we have under consideration would operate. In neither of the cases considered would the drive of the first path selector be broken. Further it is conceivable that the condition might arise in which relays M and N operate simultaneously in series with relays M and N respectively in a bye-path or bye-paths in another train or trains which is or are being set up at the moment. In these circumstances, the drive for the first path selector is definitely broken, but a false or cross connection has been established. The possibility of this occurring is dealt with by the common test circuit, Fig. 10, which is brought into action as follows:—

When both M and N operate a circuit is completed for relay G from ground, *n*2, *q*4, *m*2, *tf*4, winding of G to battery. G operates and grounds the common test start lead by completing a circuit from ground, *q*2, *g*3, to relay MA in the test circuit. MA completes the drive circuit for switch magnet MM from ground, *mb*1, *ma*1, rotary interrupter springs, MM to battery and the switch drives until ground is encountered by *mm*3, and when MB operates from ground, rotary interrupter springs of SM1, *rm*103, *tf*3, *q*1, *g*7, *ts*3, *mm*3, winding of MB to battery.

When the switch stops a test is made for a true or a cross connection between the first and intermediate paths. This is done by extending the two test lead previously connected to relays M and N to a test relay MT in the test circuit connected to an independent battery. If a true connection has been established a circuit will be completed for this relay from one pole of the independent battery, one winding of MT, *mm*4, *g*4, Fig. 5, *q*3, *rm*104, *sm*4 Fig. 4, *rm*12 Fig. 7, *k*3, *rm*22, Fig. 5, *q*5, *g*6, *mm*5, second winding of MT to the other pole of the independent battery. MT operates completing a circuit for TS in the bye-path; ground, *mb*1, *mt*1, *mm*1, right hand winding of TS to battery. TS operates and locks to *k*6 breaking the circuit of MB at *ts*3, which permits the test circuit to drive off again in case its services are required by another first bye-path. TS breaks the circuit for relay B at *ts*4 permitting the first bye-path to be released and at the same time puts ground via *ts*1 over *rm*101 to operate HS in the first path. HS extends the subscriber's loop over *hs*5 and *hs*6 to the intermediate path and is itself maintained over *hs*7, *sm*13, *rm*13 Fig. 7, to ground at *k*5. If the connection established between the first and intermediate paths is not a true one there will be no loop to complete the circuit for relay MT. In these circumstances, a circuit is completed for relay TF from ground *mb*1, *mt*1, *mm*2, right-hand winding of TF to battery. TF operates and locks over *tf*2 and *g*2 to ground. At the same time TF breaks the circuit of MB at *tf*3 and releases G at *tf*4 thereby permitting the test circuit to be taken into use by another first bye-path. TF holds via *tf*3, *rm*103, to the interrupter

springs of SM1 and applies ground to SM1 via *tf*1 and *rm*102. SML operates, opening its interrupter springs, whereby TF and SM1 release in turn, and switch SM1 takes a further step. With G back the drive circuit for SM1 is now re-established and the selector searches again for the intermediate path associated with the intermediate bye-path that has been selected by its associated first bye-path. When relays M and N again operate the same sequence of operations takes place and the test circuit is taken into service to test for a true connection with an intermediate path. When this is eventually established, the first bye-path is released as mentioned before. While the first path selector is searching for the immediate path, impulses may be received by relay A in the intermediate bye-path. RM2 drives and takes up a position corresponding to the impulses received by relay A in a manner exactly similar to that in which RM2 in Figure 5 was positioned, relay X being used to control the drive in precisely the same manner as relay X in the first bye-path. At the conclusion of impulsing, relay C releases as usual and a circuit is completed for relay E from ground, *rm*25, *b*5, *c*1, right-hand winding of E to battery. E operates and locks and completes the drive circuit for RM2 from ground, *n*2, *q*4, *m*2, *e*2, *b*4, *h*6, rotary interrupters RM2 to battery. RM2 now searches for an idle final bye-path and is stopped by the operation of relay N when an idle final bye-path is reached and the circuit is completed for N from ground, winding of N, *g*6, *q*5, *e*4, *rm*21 to test battery. Relay N operates and breaks the drive of RM2 and operates relay H which locks to ground over *h*3 and *b*3. Relay H extends the subscriber's loop at *h*1 and *h*2 to the relay A in the final bye-path. Relay A in the intermediate bye-path is thereby released but the bye-path is held by closing a holding circuit at *h*4 for relay B which holds to ground applied to the test lead by relay B of the final bye-path which operates after relay A. When relay B, Fig. 9, operates, the drive circut for RM1 is completed via *k*6, *b*2, and RM1 now searches for an idle final path. When an idle final path is found, relay K operates from ground, *b*1, left hand winding of K, *rm*11, *bb*1, in the final path, *j*1 and resistance to battery. Relay K breaks the drive of RM1 and locks to ground over K6 and *b*2. A signal is sent back to the intermediate bye-path that a final path has been found by the application of ground at *k*4 to relay PF which operates in series with relay Q in the intermediate bye-path. Relay Q also operates and completes the drive circuit for switch SM2 from ground, interrupter springs, *rm*18, *tf*3, *q*2, *g*3, *m*1, and *n*1 in parallel, *rm*17, SM2, to battery. SM2 searches for the final path associated with the final bye-path that has been selected by the intermediate bye-path, its drive being broken by the simultaneous operation of relays M and N in a manner precisely similar to that described relative to the first path and bye-path. When these two relays operate the circuit is completed for relay G in the manner previously described and ground is put on the common start lead of the test circuit associated with this stage. The test circuit switch is driven to the intermediate bye-path and the test for a true connection between the intermediate path and the final path is made exactly in the manner detailed when dealing with the first and intermediate paths. If a false connection has been established SM2 is caused to take one step and the searching is resumed, but if the connection is true, relay HS in the intermediate path is operated and the subscriber's loop is extended over *hs*3 and *hs*4 to the final path. During the establishment of connections between the intermediate path and the final path relay A in the final path responds to impulses from the subscriber's dial. Relay X remains operated during the first complete impulse, falls back during the next complete impulse, and remains operated during the next complete impulse in the manner described heretofore and RM2 takes up a position corresponding to the impulses dialled in the same way as the corresponding switches in the first and intermediate bye-path. At the conclusion of the first impulse train, relay C releases and the circuit is completed for relay E from ground *rm*23, *b*5, *c*1, winding of E to battery. E operates and locks to ground over *e*3 and *b*3. A second train of impulses is now received by the relay A which responds and these impulses are repeated to RM2 over the following circuit:—

Ground, *b*3, *a*2, *e*1, 16, RM2 to battery, RM2 takes further steps corresponding to the impulses received. During the second train of impulses a circuit for L is established from ground, *rm*23, *b*5, *c*1, *e*2, upper winding of L to battery. Relay L operates its contact C2 only over this circuit. At the conclusion of the second impulse train relay C releases removing the short circuiting ground from the main winding of L which now operates fully.

The final selector switch is now driven to its home position over the following circuit:—

Ground, *fm*4, *rm*103, K8, 13, *rm*19, interrupter springs FM to battery.

A circuit is now completed for relay V from ground, *rm*23, 15, *e*4, *h*5, *f*5, winding of V to battery. V operates and a circuit is completed for relay Z from ground, *rm*23, 15, interrupter springs of *rm*2, 14, *fn*1, *v*3, winding of Z to battery. Z operates applying a ground to the final selector switch magnet FM over *z*1 and *rm*18 and also applying ground to RM2 at *z*2. RM2 energizes caus-

ing its interrupter springs to open and thereby releasing Z, which removes the ground from both magnets causing them to take a step. When the interrupter springs re-make Z re-operates again, energizing both magnets and this process continues until RM2 reaches its home position when the circuit for relay Z is finally broken. It will be observed that since switches FM and RM2 have taken the same number of steps under control of relay Z the position that FM now occupies will be complementary to the position taken up by RM2 in response to the impulses received by the final bye-path. The numbering of FM will be approximately an inversion of the usual arrangements, the wiring being suitably disposed to cater for this. After RM2 reaches its home position relay V releases slowly. While V remains up a testing circuit is established for relay H. If the called subscriber's line is free relay H will operate from ground, upper winding of H, *v*2, *l*1, *rm*21, *k*7, *rm*102, *fm*3, test resistance to battery. H operates and locks and completes the circuit for ringing the called subscriber from ground, ringing tone, upper winding of relay F, *h*3, *f*2, *rm*10, *fm*1, subscriber's bell *fm*2, *rm*101, *h*4, *f*4, *rm*22 and ringing return resistance to battery. When the subscriber answers and loops his line, F operates and locks to *l*5. When H operates, relay V was re-energized from ground, *h*5, *f*5, winding of V to battery. When F operates this circuit is broken provided that relay PF has released denoting that the previous bye-path is released and that path connections throughout the train have been established. If PF has released, V releases slowly and while operated a circuit is completed for relay J from *pf*1, *f*1, *v*1, *rm*17, winding of J to battery. J operates and extends the calling subscriber's loop at *j*3, *j*4, to relay AA which operates and provides a locking ground for J via *aa*2, *j*6, and *d*1. After V has released a circuit is completed for relay BB from ground, PF1, *f*1, *v*1, *rm*16, winding of BB to battery. BB introduces relay D to the called subscriber's loop. D operates breaking the circuit of J which releases slowly. While J is releasing a booster battery is applied over *d*2 and *j*5 to the hold lead thereby operating the calling subscriber's meter. After J has released this booster battery is replaced by a resistance to ground which serves to hold the HS relays in the first and intermediate paths. The loop of the final bye-path is broken by the operation of J at *j*3 and subsequently by BB also at *bb*2 so that A in the bye-path releases releasing B and allowing the bye-path to return to normal. The switch train now includes paths only, which are held under control of the calling party. If the called subscriber's line happens to be busy, the operations are as follows:—

While relay V is releasing after RM2 has returned to its home position relay H fails to find a test battery and does not operate. On the release of relay V a circuit is completed, however, for relay G from ground on the called subscriber's test lead, *fm*3, *rm*102, *k*7, *rm*21, *l*1, *v*2, *h*6, upper winding of G to battery. G operates and locks via *g*2, *b*3. Providing that PF has released denoting that connection has been established between the intermediate and final paths the circuit is completed for relay J in the final path from ground, *pf*1, *g*1, *rm*17, winding of J to battery. J operates extending the calling subscriber's loop to relay AA in the final path and breaking the loop to the final bye-path. At the same time, busy tone is applied to AA in the final path over *j*2, *bb*2, *j*4, winding of relay A to ground, thereby causing it to be transmitted back to the calling subscriber. With the breaking of the loop of the final bye-path, relay A in that bye-path releases releasing relay B and allowing the final bye-path to revert to normal. The train of paths is now held by the calling subscriber and is released when he restores his receiver allowing AA and J in the final path to release and remove the holding ground from the hold wire.

The arrangement shown in Fig. 11 will now be described.

This arrangement shows in diagrammatic form the circuits for the system shown in Figure 5.

Two first conversational switches are indicated at S1 and S11; these switches belong to different groups, and one of the bye-path circuits associated with each group is shown at C1 and C11 respectively. Both of these bye-path groups, and if described other groups also, have access to the same bye-paths in the second selector stage in response to a plurality of digit values. One second bye-path is shown at C2. It will be appreciated that the second bye-paths must be associated in common with conversational switches for a plurality of directions from a plurality of groups in the first stage. Thus C2 is associated in the simple case shown with the conversational switches S21 and S23 leading in different directions from S1, and S22 and S24 leading in different directions from S11. It is necessary therefore to control switch RM1 in C2 so that it tests only one group of conversational switches, that including S21 for instance.

Each bye-path comprises as before an RM1 switch which is adapted to select a conversational switch, and an RM2 switch which is operated by one or two digits. Relays J, JJ are provided in the second bye-paths individual to the first stage groups. Thus, if C2 is taken into use from C1, in response to any one of a plurality of digits, a circuit is formed; earth upper winding of A, left-hand winding of J, *rm*22,

calling loop, *rm*23, lower winding of A, battery. Relays A and J operate, and J shorts its left-hand winding at *j*1, and locks at *j*2. Similarly if C2 was taken into use from C11, JJ would operate and lock. Operation of J or JJ connects test relay T to different sets of contacts of wiper *rm*12 at *j*3 or *jj*3 so that RM1 will select an idle conversational switch in the correct group.

As before stated, C2 can be reached via one contact in each of several groups of contacts in the banks of the RM2 switches of the previous bye-paths; the leads from corresponding digit groups in marking levels of the various RM2 switches having access to C2 are connected together and to a commoned set of contacts in the bank of wiper *rm*11 in C2.

The groups of contacts commoned in the bank of *rm*11 are those connected to conversational switches for use in setting up calls in one particular direction from all the groups of the first selector stage having access to C2.

Earth is connected to the marking wiper of each RM2 switch. The circuit for test relay T in C2 is as follows:—

Earth, *rm*21 in the first bye-path, *rm*11 in the second bye-path, *rm*12, *j*3 (or *jj*3, etc.), winding of T, *rm*13, to battery in the idle conversational switch to be taken into use; it will thus be seen that RM2 in C2 only tests those conversational switches which are accessible from the correct group of first stage conversational switches, and which give access to the required connections.

The setting up of connections between the selected conversational switches of successive bye-paths and other operations in setting up a call may take place in the manner described with reference to Figures 6–11.

It will be appreciated that by the arrangement just described, bye-path circuits are made common to very large groups of conversational switches, and that considerable economy in the total number of bye-paths may thereby be effected.

It might be possible in a simple arrangement like that shown and with suitable traffic conditions to do away with the J, JJ relays, and to connect the corresponding leads from the banks of the *rm*21 wipers to separate groups of contacts in the bank *rm*11 instead of to one larger group. This, however, is not possible usually since some conversational switches in one stage may be accessible from a plurality of groups in the preceding stage.

As before stated a bye-path, reached in response to a plurality of digits, is associated with a plurality of groups of paths leading in different directions. When the bye-path switch responds to a further digit to select a succeeding bye-path, it must select one which is associated with paths accessible from the selected preceding group of paths. Thus the bye-path switch must be controlled, by marking means or the like, to make a selection among a sub-group of the group of bye-paths accessible in response to the digit involved.

What is claimed is:

1. In an automatic or semi-automatic telephone exchange system, a selector stage comprising a group of conversational selector switches, a group of bye-path circuits associated with the conversational switches, means whereby each conversational switch is adapted to be connected to any one of a plurality of bye-path circuits during the setting up of a connection, and means in said bye-path circuits controlled by digital impulses transmitted directly thereto.

2. In an automatic or semi-automatic telephone exchange system, a selector stage comprising a group of conversational selector switches, a group of bye-path circuits associated therewith, means in said bye-path circuits controlled by digital impulses transmitted directly thereto, means whereby each bye-path circuit is adapted to be connected to any one of a plurality of conversational switches, and further means which are adapted to operate when a bye-path circuit is taken into use from a preceding selecting stage to control the operation of said first mentioned means so that said first mentioned means connects the bye-path circuit to any idle conversational switch associated therewith.

3. In an automatic or semi-automatic telephone exchange system a plurality of selector stages each comprising conversational switches and bye-path circuits smaller in number than the said switches and means whereby each bye-path circuit is adapted to be connected to any one of a plurality of conversational switches during the setting up of a connection, a bye-path switch in each bye-path circuit adapted to be controlled by digital impulses transmitted directly thereto, and direct test connections from the bye-path switches of one selector stage to the bye-path circuits of the succeeding stage whereby a bye-path switch is adapted to select an idle succeeding bye-path only and means for transmiting digital impulses directly to said succeeding bye-path circuit.

4. In or for an automatic or semi-automatic telephone exchange system, a selector stage comprising conversational switches and bye-path circuits associated therewith, characterized in this, that the conversational switches are of the purely hunting type and are adapted to hunt for a condition imposed at the succeeding selector stage.

5. A telephone system having an automatic switching selector stage comprising conversational switches and bye-path switches associated therewith, wherein the outlets of the bye-path switches are divided

into equal groups, and a plurality of outlets in one group are permanently busied.

6. A telephone system comprising a plurality of automatic switching selector stages each stage comprising conversational selector switches and groups of bye-path switches associated with and individual to said selector stages and wherein one group of bye-path switches in a selector stage is accessible from a plurality of groups of bye-path switches associated with the preceding selector stage and means is provided whereby such accessibility is adapted to be effected in response to impulses representing a plurality of digit values.

7. A telephone system comprising first and second selector switching stages and bye-path circuits associated respectively with said stages, the bye-path circuits associated with said second switching stage comprising switching means and a hunting switch, and wherein said switching means is adapted to be variably operated in accordance with bye-path circuits associated with said first selecting stage from which the connection was established, and wherein said hunting switch is adapted, in response to said variable operation to test only those selectors in the second switching stage which are accessible from selectors of said first selecting stage.

8. A system in accordance with claim 7 wherein marking potentials are adapted to be placed on the bank contacts of said hunting switch.

9. A telephone system comprising first and second automatic switching selector stages, each having a plurality of selectors and bye-path circuits adapted to be associated respectively with said stages and wherein testing means, adapted to control the movements of a selector in said first stage, is adapted to be operated in a circuit completed through the circuits of a selector and associated bye-path circuit of said second stage.

10. A system in accordance with claim 9 wherein said testing means is located in the bye-path circuits, said means comprising two relays adapted to operate simultaneously to cause the hunting movement of the selector being controlled to cease.

11. A telephone system comprising first and second selector stages, each stage having a plurality of selectors and bye-path circuits adapted to be associated therewith, a single testing circuit adapted to be associated with any one of the bye-path circuits of said first stage during the setting up of a connection for testing the connections made by the selector switch associated with that bye-path circuit and wherein the testing circuit is adapted to test for a complete loop through the selector and bye-path circuit of the first stage and selector and bye-path circuits of the second stage.

12. A system in accordance with claim 11 wherein, in the event that the test of said testing circuit fails, the selector in said first stage is adapted to repeat its hunting movement.

13. A system in accordance with claim 11 wherein, in the event that the test of said testing circuit is successful said testing circuit is immediately released.

14. A telephone system comprising a plurality of selector stages each comprising a plurality of selectors and bye-path switches adapted to be associated therewith and wherein one of said selectors is adapted to be stepped from normal to a particular position in synchronism with the stepping of the bye-path switch associated therewith from a selected position to normal.

15. A telephone system comprising a plurality of selector switch stages each having a plurality of bye-path switches and wherein one of said bye-path switches is adapted to take a plurality of steps in response to each impulse of a digit and wherein the number of steps per impulse is subject to variation.

16. A telephone system comprising a plurality of selector stages each having a plurality of selectors and a plurality of bye-path switches and wherein said selectors are of the backwardly hunting type.

17. A telephone system comprising first, second and third selector stages, each stage having bye-path switches adapted to be associated with selector switches in that stage and wherein a bye-path switch in said second stage which is adapted to be seized from said first stage in response to any one of a plurality of digits comprises means whereby it is adapted to be controlled to select a bye-path switch in said third stage which is associated with paths accessible from the group of paths selected by said bye-path switch in the second stage.

18. A telephone system comprising a plurality of selector stages each comprising a group of conversational selector switches and a group of bye-path circuits means whereby each conversational switch in a group is adapted to be associated with any one of said bye-path circuits and means in each of said bye-path circuits adapted to be controlled by digital impulses transmitted directly thereto.

In witness whereof I hereunto subscribe my name this fifteenth day of January, 1930.

JOHN HENRY ELVIDGE BAKER.