Oct. 25, 1949. C. E. BEALE ET AL 2,486,100

VOICE FREQUENCY SIGNALING CIRCUITS
FOR TELEPHONE SYSTEMS

Filed March 24, 1945 11 Sheets-Sheet 1

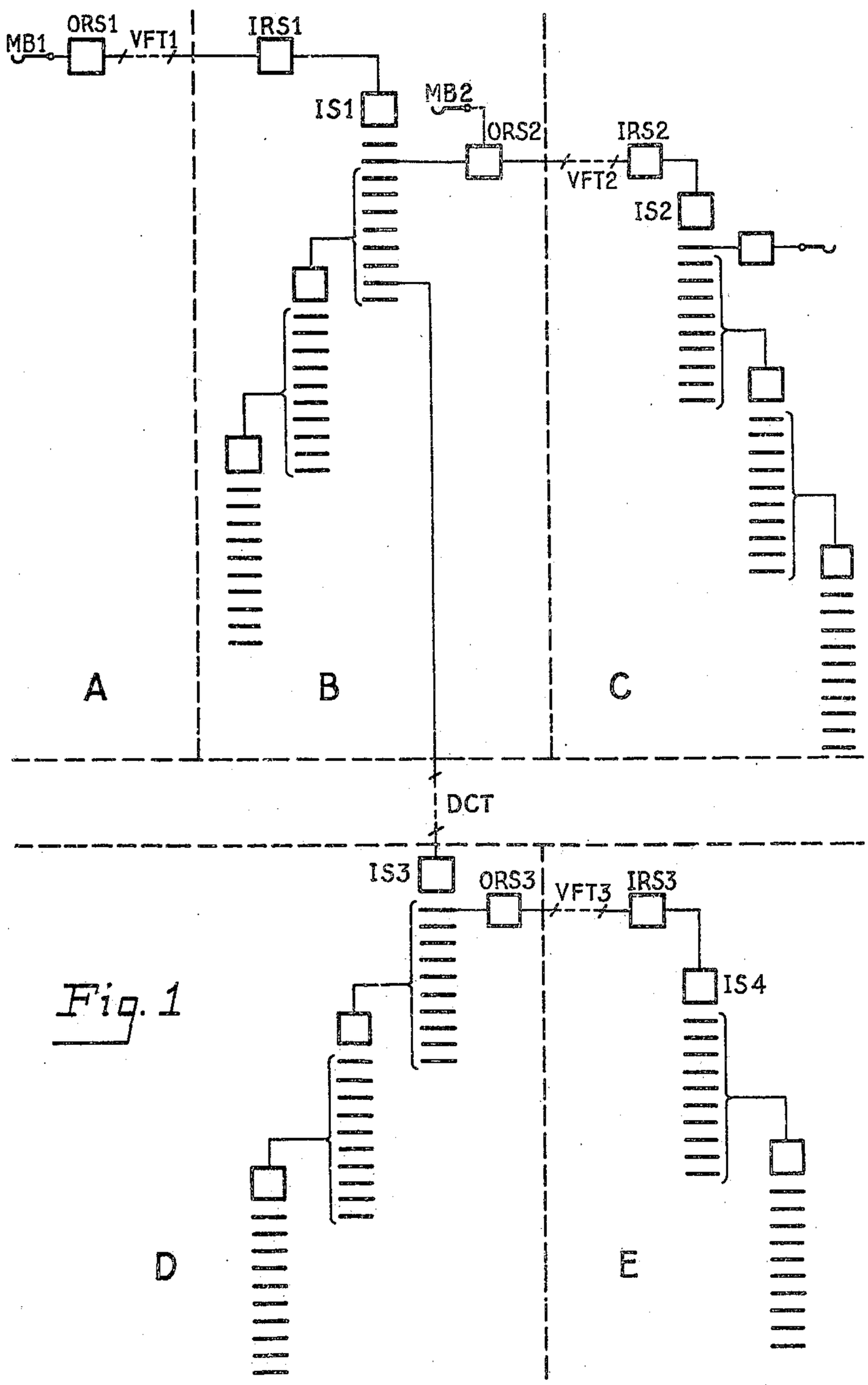

Fig. 1

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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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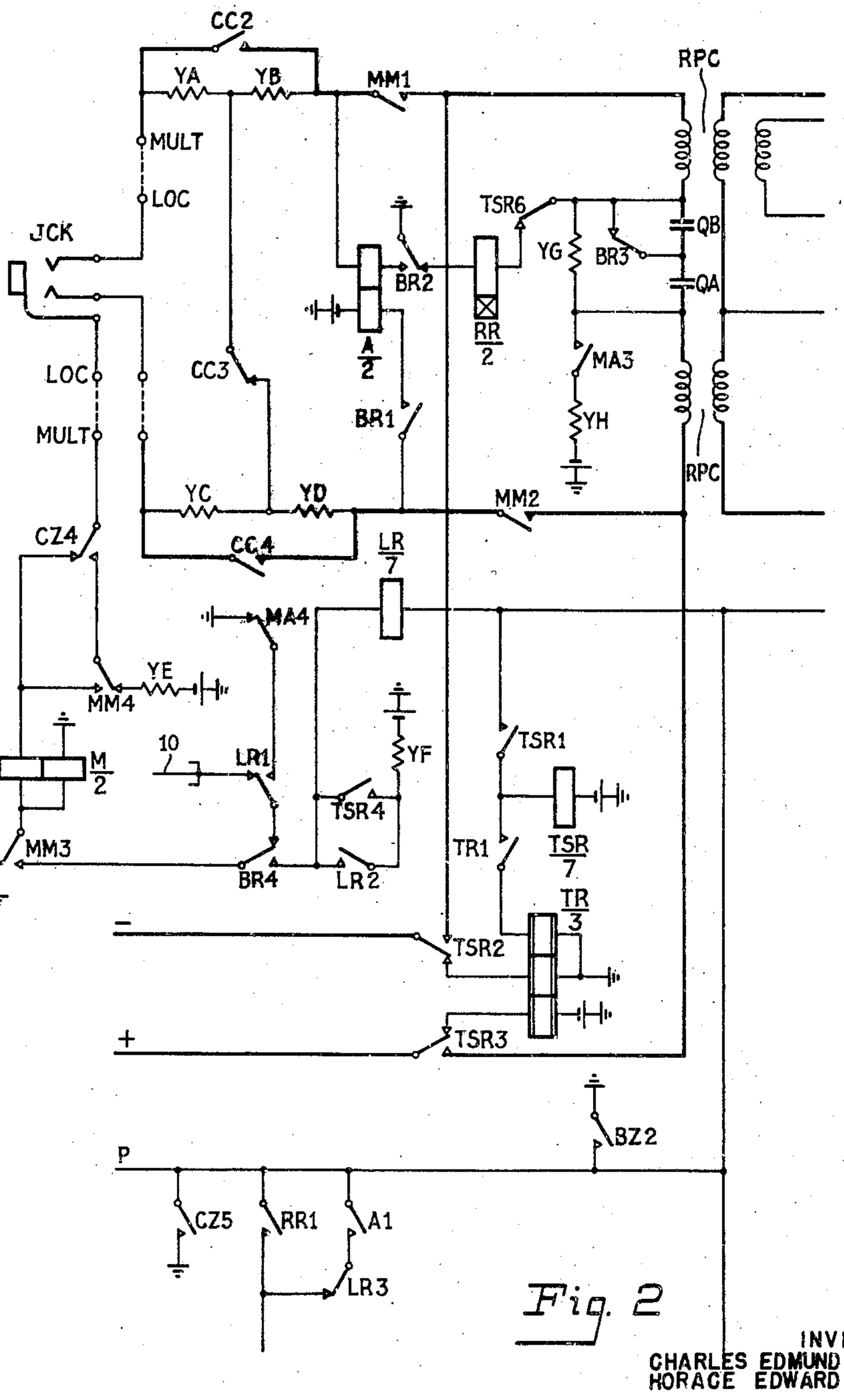

Fig. 2

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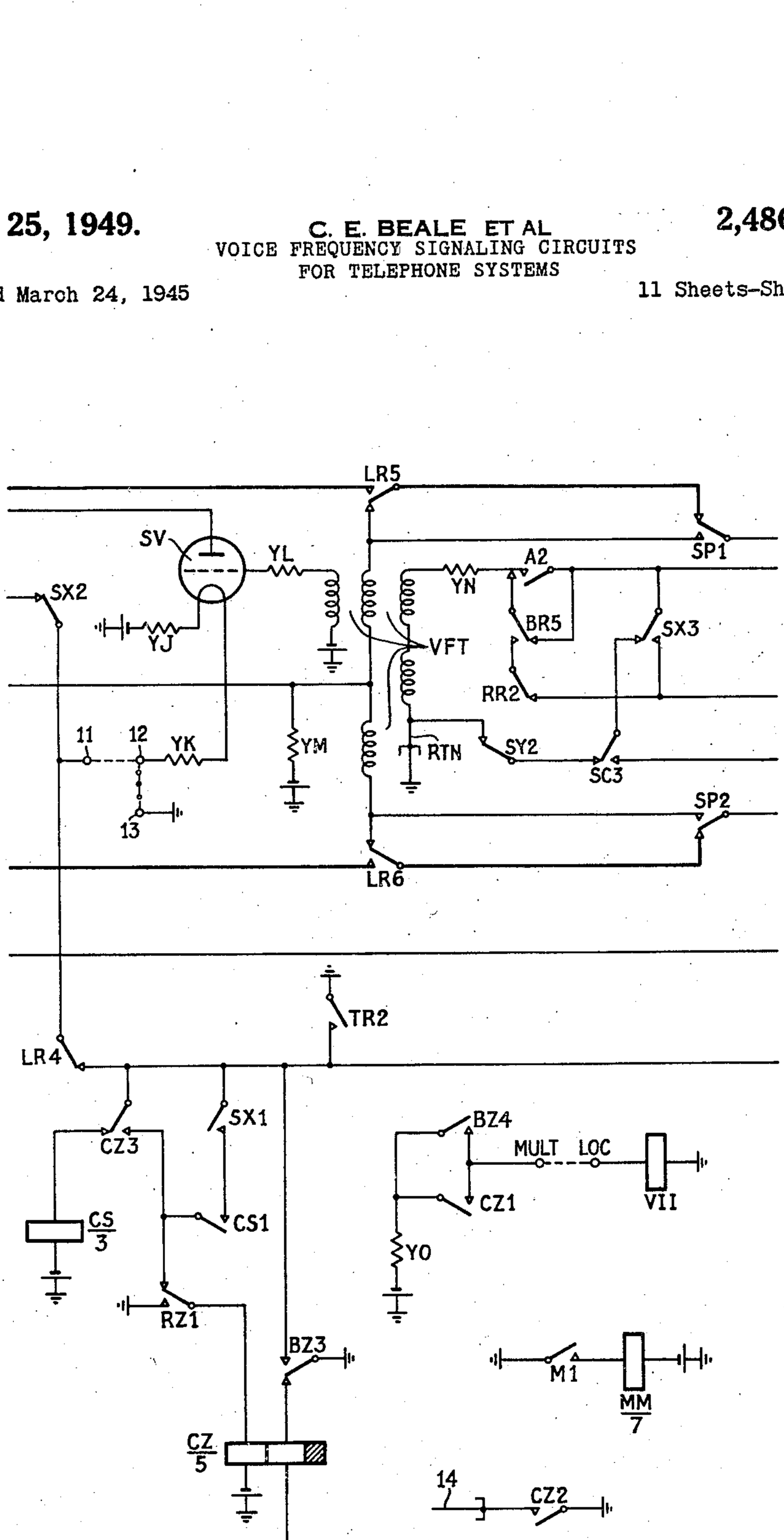

Fig. 3

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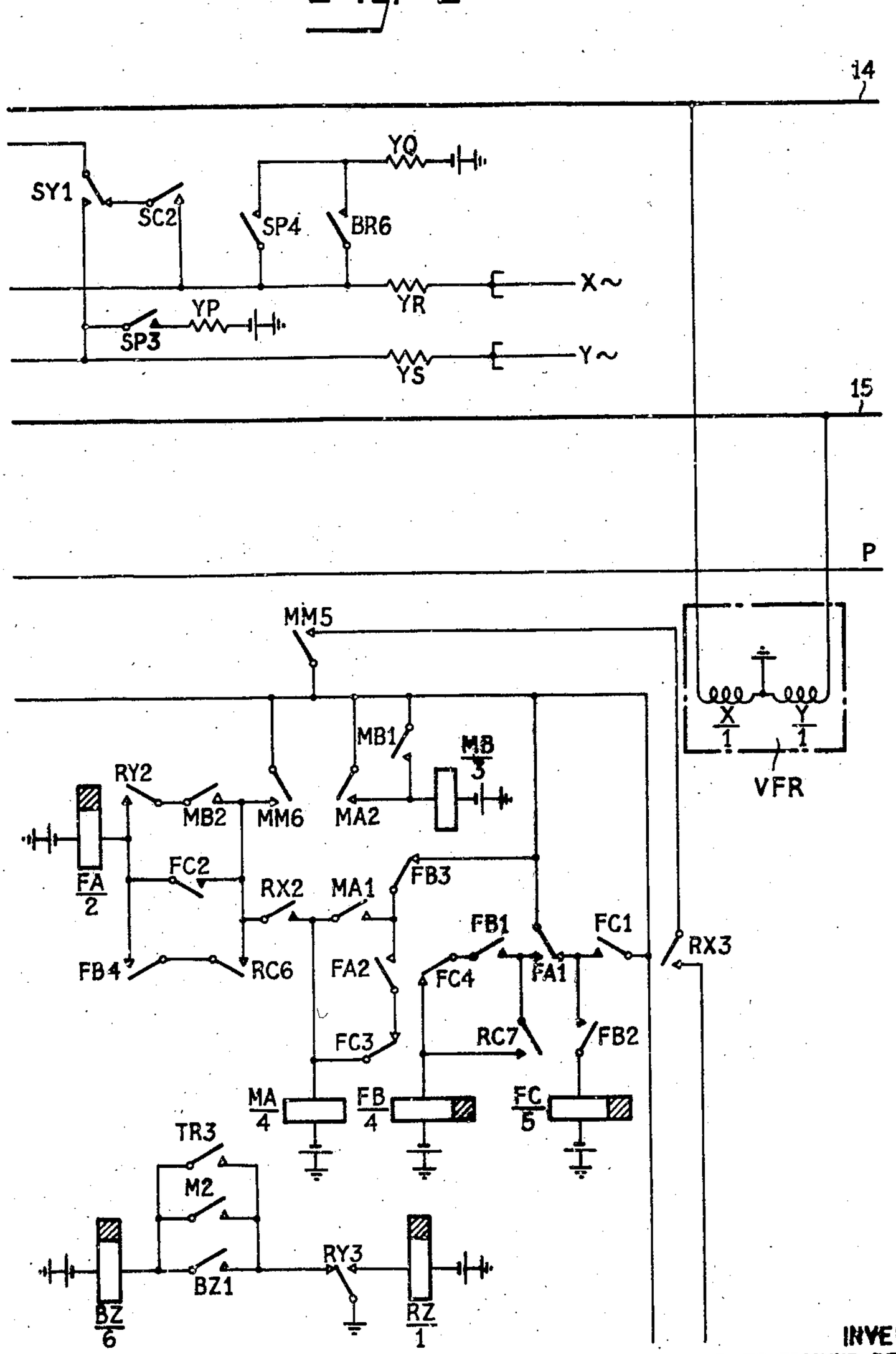
Fig. 4



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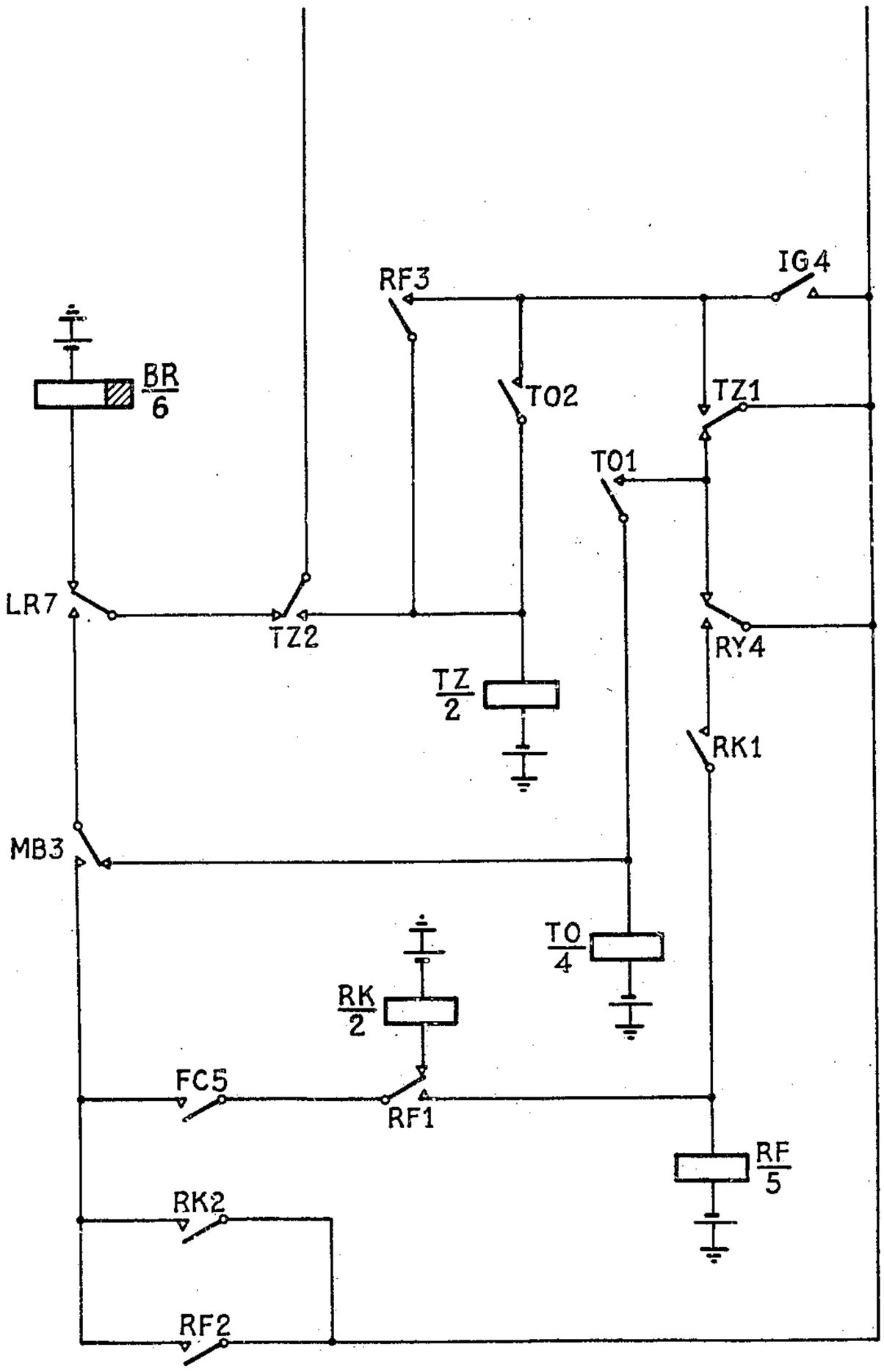

Fig. 5

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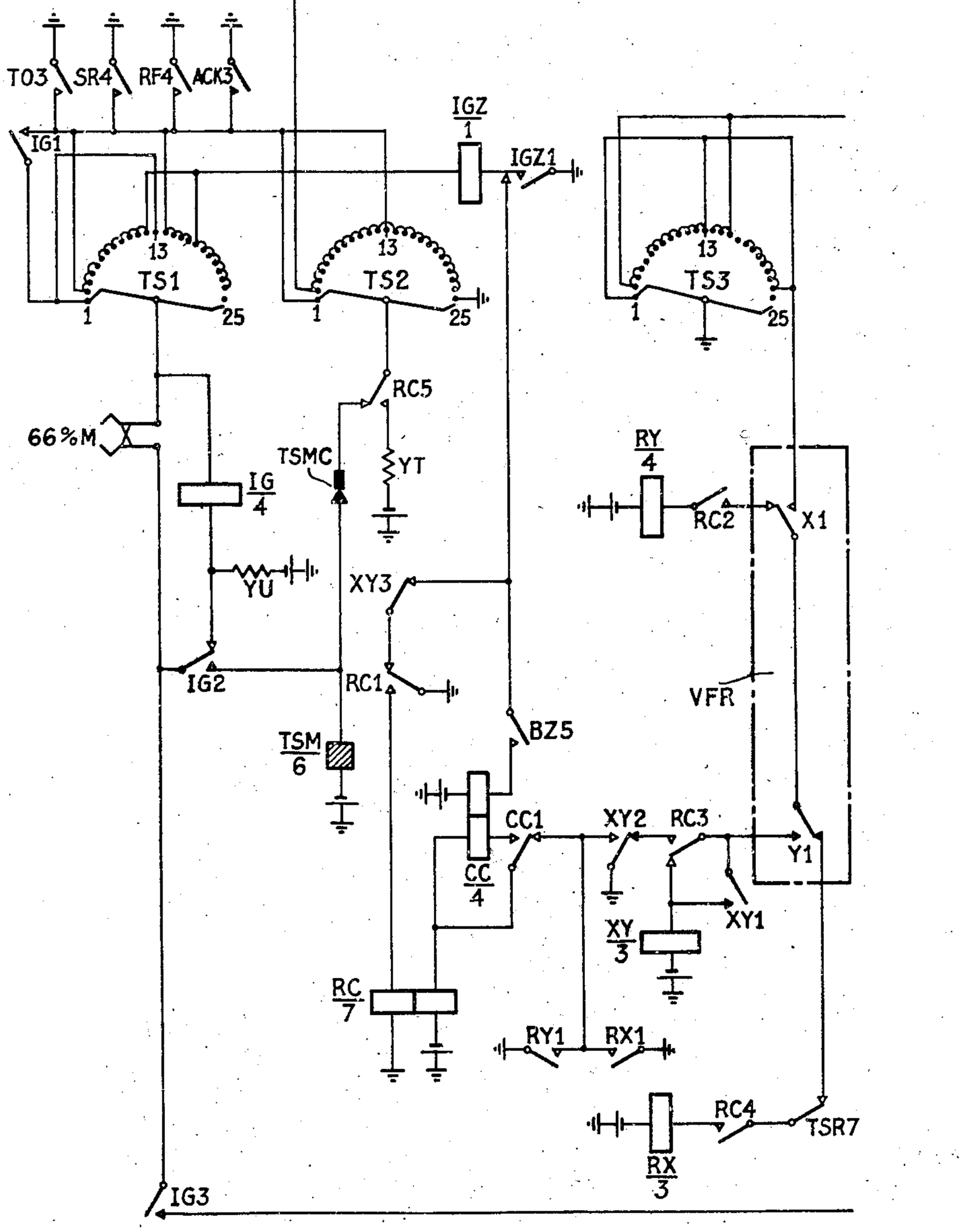
Fig. 6



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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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Fig. 7

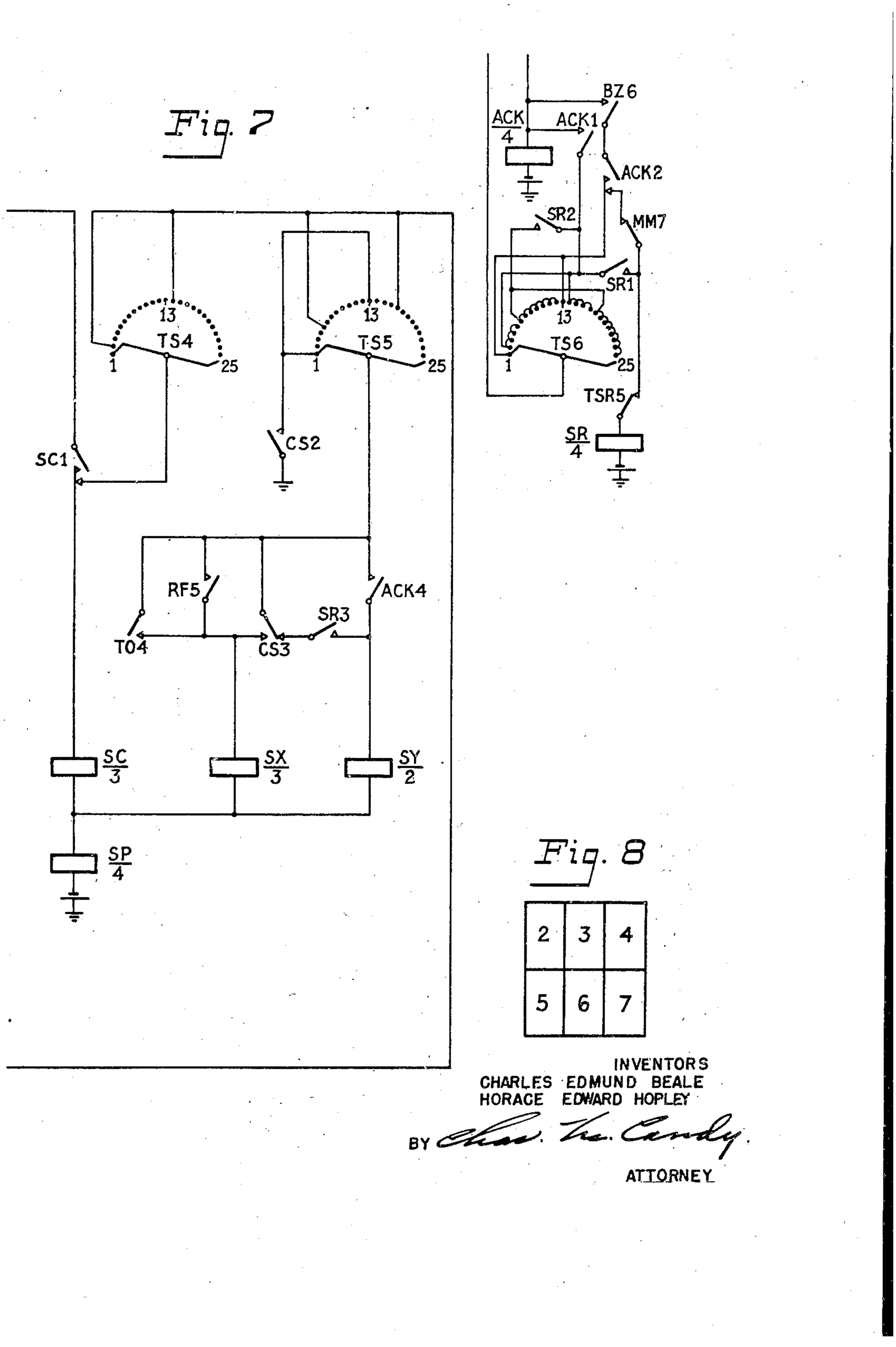

Fig. 8

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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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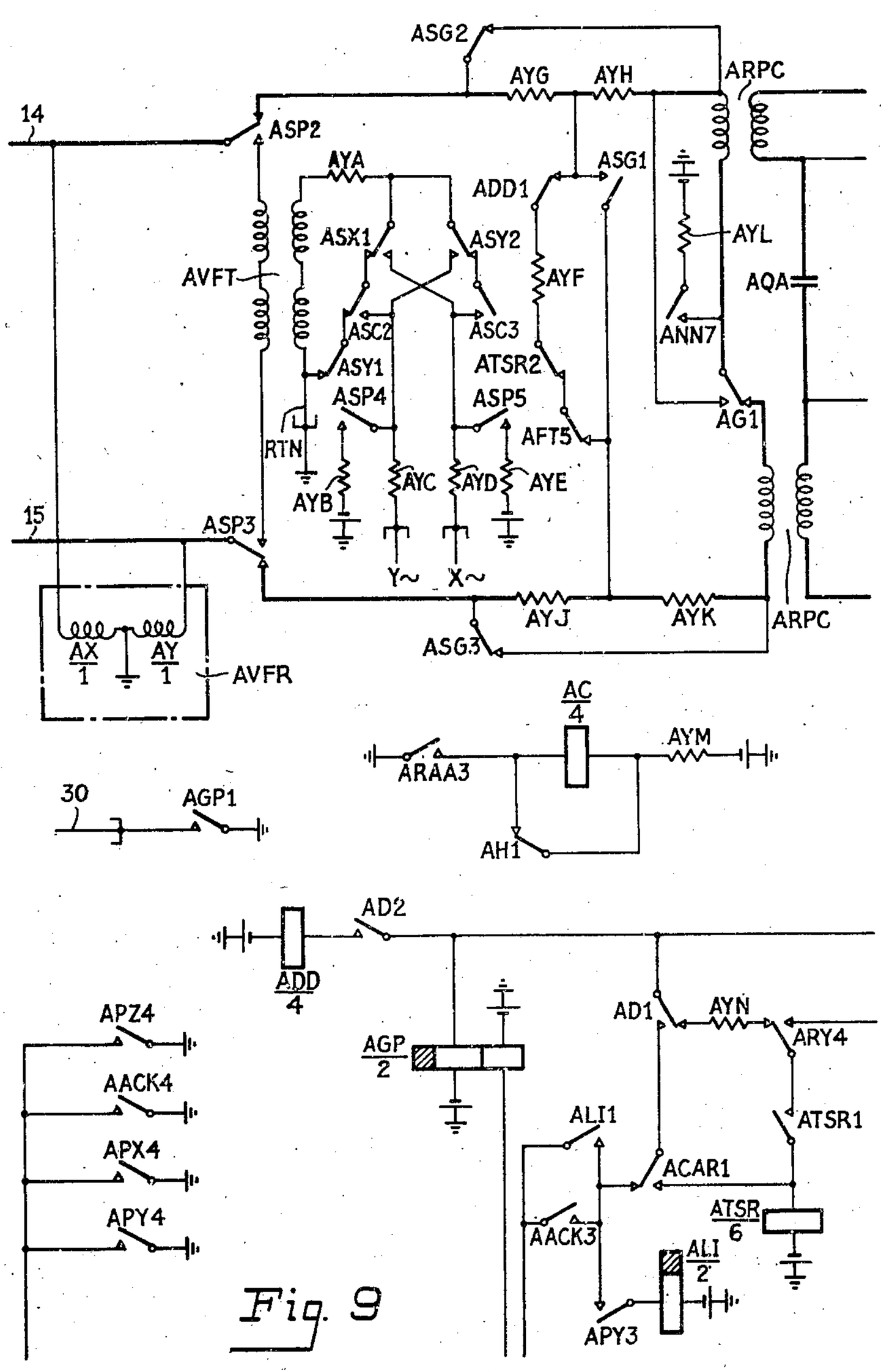

Fig. 9

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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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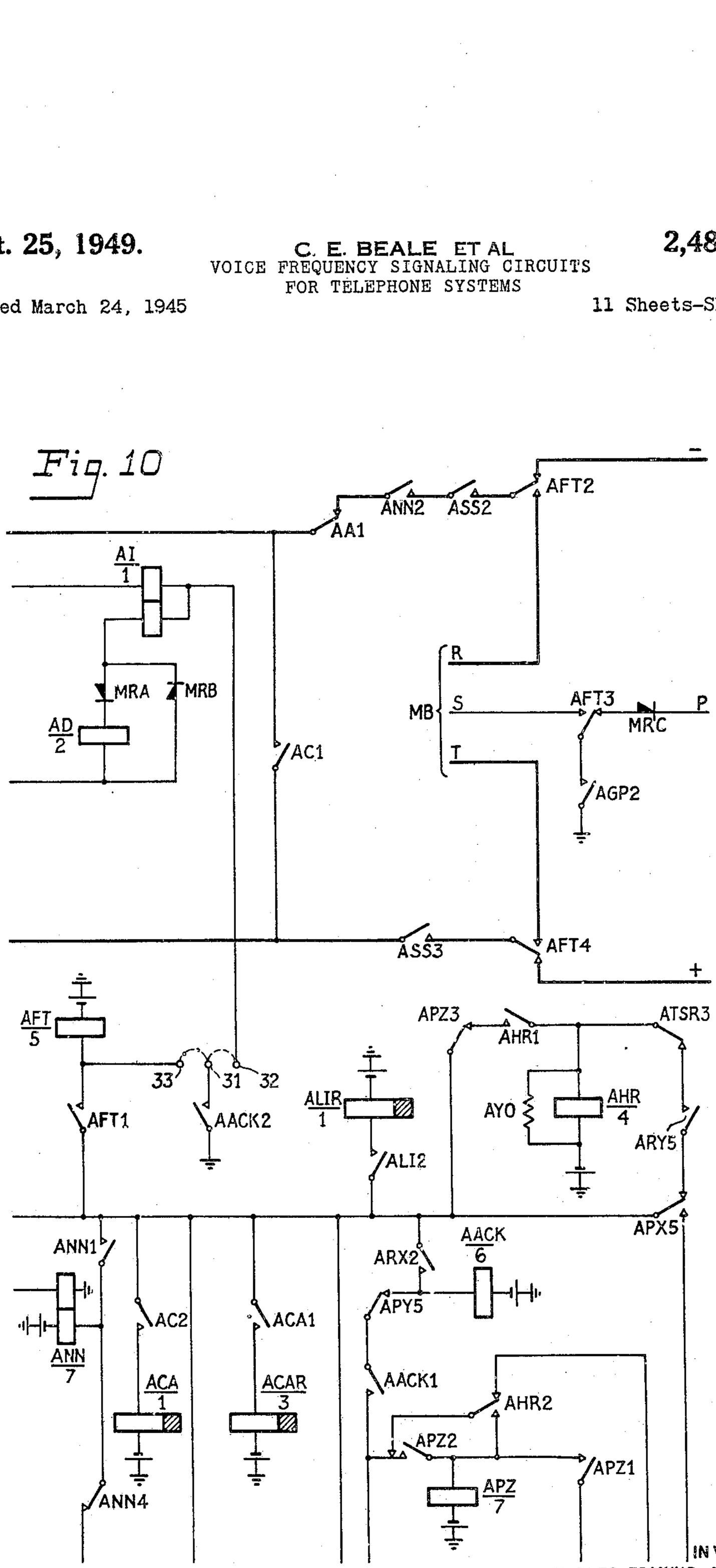
Fig. 10



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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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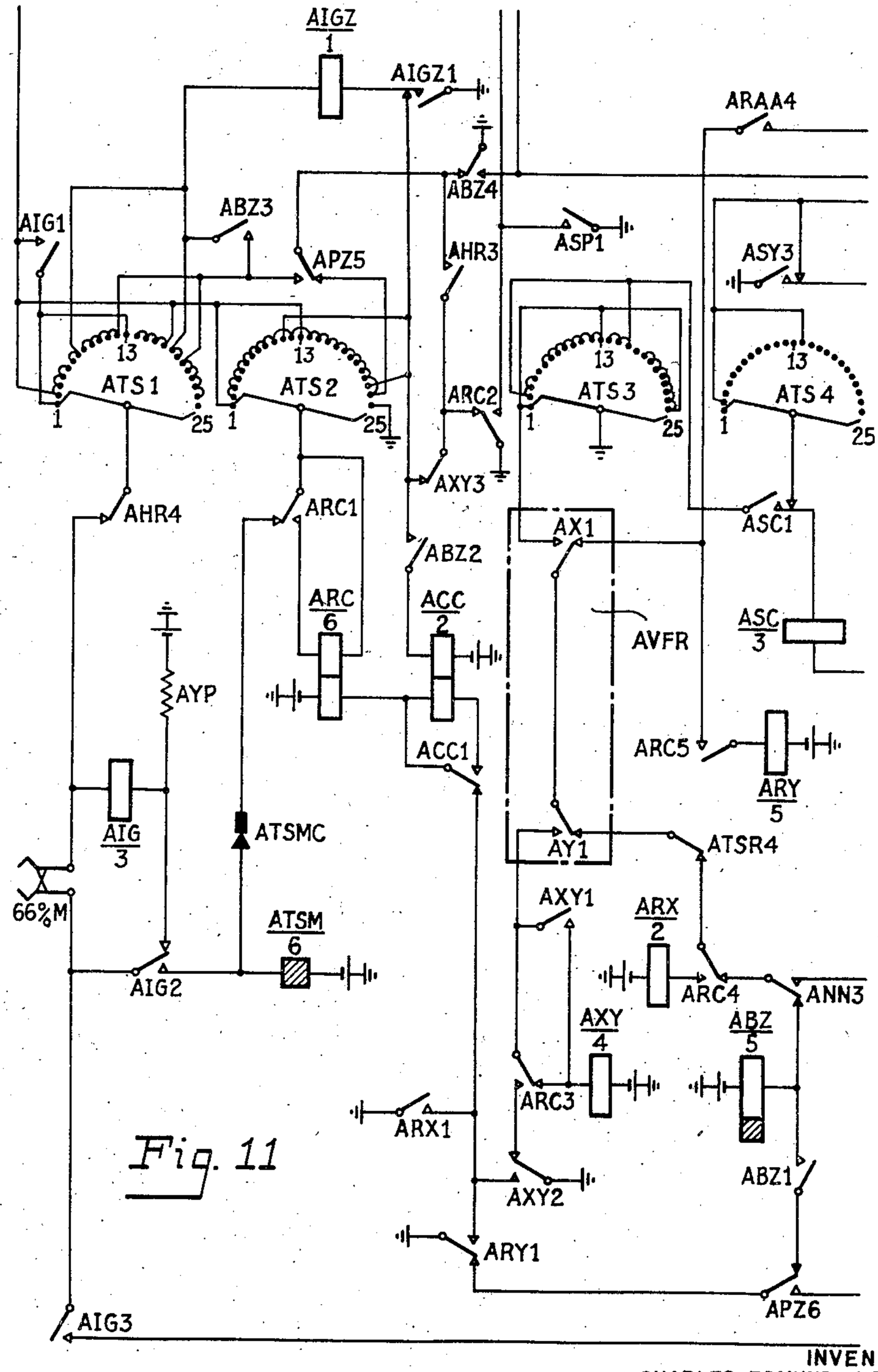

Fig. 11

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VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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Fig. 12

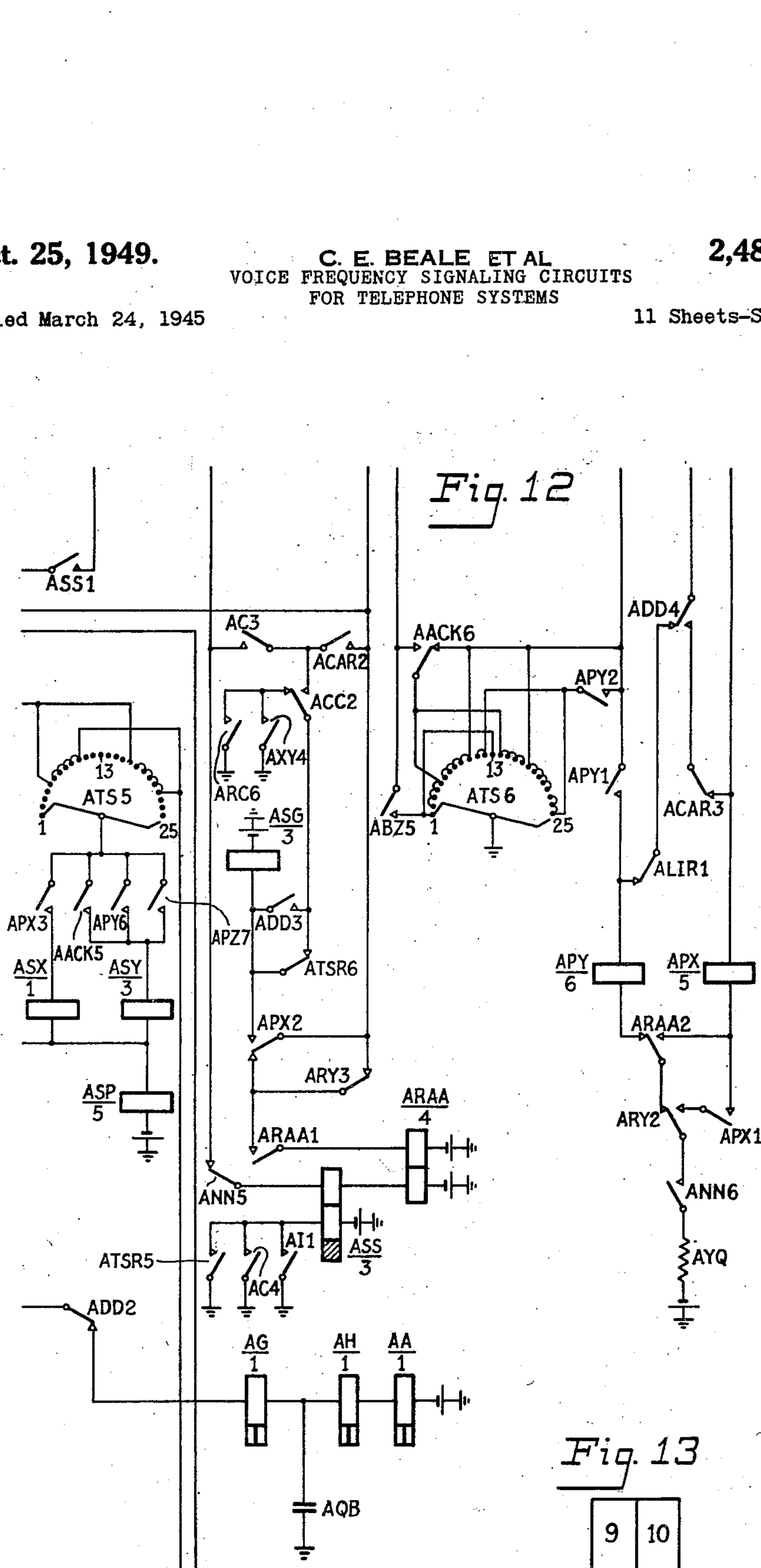

Fig. 13

9	10
11	12

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Patented Oct. 25, 1949

2,486,100

UNITED STATES PATENT OFFICE

2,486,100

VOICE FREQUENCY SIGNALING CIRCUITS FOR TELEPHONE SYSTEMS

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Application March 24, 1945, Serial No. 584,620
In Great Britain May 5, 1944

11 Claims. (Cl. 179—27)

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The present invention relates to telephone systems and is more particularly concerned with systems involving comparatively long trunk routes so that owing to the probability that voice amplifiers or repeaters will be used it is desirable for the signals over some portions at least to be in the form of voice frequency impulses. Such a method of signalling has the advantage that the signals will readily pass through such repeaters but it has the disadvantage that since the signals are in the same frequency range as the actual speech currents, there is a danger that supervisory and like signals will be simulated by speech currents and special steps have therefore to be taken to prevent unreliable operation from this cause. The present invention is particularly applicable to a system which makes use of supervisory signals composed of two different voice frequencies in accordance with the code which has been recommended by international agreement, the most important feature of which is that immunity from interference by actual speech is primarily attained by prefixing each signal with a guard portion consisting of the two specific frequencies applied simultaneously for a definite period of time so that simulation by normal speech is extremely unlikely. This prefix signal serves to condition the responding apparatus for the operative signal which comprises a predetermined duration of one or other frequency alone and follows after a predetermined spacing interval.

The main object of the invention is to provide in a simple form a V. F. signalling system giving all the normal facilities without danger of false operation so as to permit so-called national dialling, that is to say the setting up of a call to any telephone in a national network by a suitable dialling operation by an operator.

According to one feature of the invention, in a telephone system employing voice frequency signals for the setting up and supervision from an operator's position of connections over automatic switches and arranged for a signal indicating that the called party has cleared to be transmitted repeatedly until the operator takes down the connection, the interval between repetitions of the signal is arranged to be altered in response to an operation by the called party and also in response to an operation on the part of the operator and thereupon produces circuit changes in the outgoing equipment associated with the operator's position.

According to another feature of the invention, in a telephone system employing voice frequency

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signals for the setting up and supervision from an operator's position of connections over automatic switches and arranged so that after the transmission of a particular signal from one end of the connection has been initiated it is repeated at predetermined intervals until the appropriate acknowledgment signal is received from the other end, if a repeated signal is transmitted forward at a time when a repeated signal is being transmitted back the acknowledgment signal for terminating the transmission of the forward signal comprises an alteration in the interval between repetitions of the backward signal.

A further feature of the invention is that in a telephone system employing voice frequency signals for the setting up and supervision from an operator's position of connections over automatic switches and arranged for a signal indicating that the called party has cleared to be transmitted repeatedly until the operator takes down the connection, if the called party again removes his receiver momentarily the repeated clearing signal initiated when the receiver is first replaced is modified by the lengthening of the interval between repetitions by a predetermined amount which effects the intermittent lighting of the operator's supervisory lamp.

The invention will be better understood from the following description of one method of carrying it into effect which should be taken in conjunction with the accompanying drawings comprising Figs. 1–13. Of these, Fig. 1 is a typical lay-out diagram illustrating the various facilities which the invention is intended to provide, Figs. 2–7 when arranged as indicated in Fig. 8 form a detailed circuit diagram of an outgoing V. F. relay set and Figs. 9–12 when arranged as indicated in Fig. 13 form a circuit diagram of a corresponding incoming V. F. relay set.

Referring first to Fig. 1, exchange A is shown equipped with an operator's position MB1 having access to an outgoing relay set ORS1 from which connection is made over a two-conductor V. F. trunk line VFT1 to an incoming relay set IRS1 in exchange B. This is directly associated with an incoming selector IS1 from which access may be obtained to the local switches of exchange B or over level 9 to a further outgoing relay set ORS2 giving access to exchange C. This relay set is also accessible from an operator's position MB2 in exchange B.

It is assumed that the link VFT2 between exchanges B and C is operated on a voice frequency basis and consequently arrangements are desirable whereby on a call from exchange A to ex-

change C the impulses transmitted by the originating operator pass through the incoming and outgoing relay sets of exchange B without intermediate conversion into D. C. impulses as is the case when the incoming selector IS2 is operated from the operator's position MB2.

This selector also gives access over level 2 to exchange D over a D. C. link DCT so that no special relay sets at the ends of the line are required and for calls terminating in exchange D no question of end-to-end sending can arise. The incoming selector IS3 in exchange D however gives access over level O to exchange E over a V. F. trunk VFT3 so that an outgoing relay set ORS3 is necessary and works in association with an incoming relay set IRS3 in exchange E. In this case end-to-end working on a V. F. basis may be adopted for the setting of the switches such as IS4 in exchange E as soon as the outgoing repeater ORS3 in exchange D has been taken into use. A possible limitation on this method of working is if the D. C. link between exchanges B and D incorporates impulse repeaters with their associated transmission bridges but the general tendency will be to use D. C. links only for short lines where it is possible to dispense with impulse repetition.

As previously mentioned it is contemplated that use will be made of two voice frequencies for signalling, preferably 600 cycles/sec. which will be referred to as Y frequency and 750 cycles/sec. which will be referred to as X frequency. The prefix signal comprising both frequencies applied together will be referred to as XY or a compound signal.

In order to simplify the understanding of the signalling arrangements and form a means of ready reference, the signals employed are set out in the following table:

	Forward	Backward
Seizing signal	80 ms. X	
Impulsing	70 ms. X each impulse.	
Called subscriber answer.		250 ms. XY, 35 ms. space, 80 ms. X. Repeated at intervals of 600 ms. until acknowledged.
Acknowledgment	250 ms. XY, 35 ms. space, 80 ms. Y.	
Clear forward	250 ms. XY, 35 ms. space, 80 ms. Y. Repeated at intervals of 700 ms.	
Release		250 ms. XY, 35 ms. space, 600 ms. Y.
Clear back		250 ms. XY, 35 ms. space, 80 ms. Y. Repeated at intervals of 600 ms.
Ring Forward, trunk offering, breakdown or forward transfer.	250 ms. XY, 35 ms. space, 80 ms. X. Repeated at intervals of 700 ms. until acknowledged.	
Acknowledgment		250 ms. XY, 35 ms. space, 80 ms. Y.

It will be appreciated that as a matter of convenience round figures for the durations of the signals have been given above and that in practice the lengths may be varied within assigned limits and still produce correct operation of the equipment. It should also be mentioned that as will appear subsequently, in certain circumstances the ring forward, etc. signal is acknowledged in a slightly different manner.

Considering now the detailed operation of the outgoing relay set shown in Figs. 2–7, which may be considered as the relay set ORS2 in exchange B, Fig. 1, it will first be assumed that a call is being

set up from the operator's position MB2. When the operator plugs in, relay M is operated over the sleeve of the jack JCK and at contacts M1, Fig. 3, operates relay MM, and at contacts M2, Fig. 4, operates relay BZ. Relay MM at contacts MM1 and MM2, Fig. 2, connects the speaking leads through to the repeating coil RPC, at contacts MM3 connects flicker earth over lead 10 to the jack sleeve, at contacts MM4 prepares an alternative circuit over the sleeve, at contacts MM5, Fig. 4, prepares a circuit for relay ACK, at contacts MM6 prepares a circuit for relay FA and at contacts MM7, Fig. 7, opens a point in the circuit of relay SR. Relay BZ at contacts BZ1 completes a locking circuit for itself, at contacts BZ2, Fig. 2, earths the P conductor extending to the selector banks, at contacts BZ3, Fig. 3, earths the common holding lead, at contacts BZ4 energises relay VII, at contacts BZ5, Fig. 6, energises relay CC by way of its upper winding and at contacts BZ6, Fig. 7, prepares a locking circuit for relay ACK. In a manner not shown but well understood, relay VII co-operates with similar relays individually associated with other trunks to give a visual indication of the next idle trunk to be taken into use. Relay CC at contacts CC1 short-circuits its lower winding to make itself slow to release, and at contacts CC2, CC3 and CC4, Fig. 2, removes the loss pad comprising resistors YA, YB, YC and YD from the line.

The application of earth to the common holding lead energises relay CS, Fig. 3, which thereupon at contacts CS1 prepares a circuit for relay CZ and at contacts CS2 and CS3, Fig. 7, completes a circuit over wiper TS5 in normal position for relays SX and SP in series. The resulting operation of relay SP at contacts SP1 and SP2, Fig. 3, shunts contacts LR5 and LR6 and at contacts SP3 and SP4 connects up battery over the high value resistors YP and YQ for contact wetting purposes. Relay SX at contacts SX1, Fig. 3, completes the circuit for relay CZ at contacts SX2 opens the anode circuit of the stopper valve SV to prevent the X seizing signal being fed back to the operator and at contacts SX3 connects X frequency to the outgoing line by way of resistor YR, contacts BR5 and the transformer VFT, at the same contacts removing the termination. Relay CZ at contacts CZ1 completes an alternative circuit for relay VII, at contacts CZ2 earths lead 14 to start the impulse machine, at contacts CZ3 disconnects relay CS and completes a locking circuit for itself, at contacts CZ4 includes contacts MM4 in the sleeve circuit and at contacts CZ5 connects a multiple earth to the P conductor extending from the selector banks. Relay CS now releases and brings down relays SX and SP to terminate the transmission of X frequency which will have persisted for a period of approximately 80 ms. The position is therefore that a seizing signal of X frequency has been transmitted to the distant exchange and the relays now operated in the outgoing relay set are relays M, MM, BZ, CC and CZ and the operator is informed that the trunk has been duly seized by the flickering of her supervisory lamp.

The operator now throws the dialling key, thereby momentarily connecting battery to the tip conductor so that it is extended over contacts CC2, MM1, upper left-hand winding of repeating coil RPC, contacts TSR6, relay RR, contacts BR2 to earth. Relay RR operates at this time and at contacts RR1 completes a circuit for relay BR and at contacts RR2 opens a point in the X frequency sending circuit which is without

effect at the present time. Relay BR at contacts BR1 and BR2 disconnects relay RR and connects relay A to the tip and ring conductors, at contacts BR3 inserts the condenser QB into the repeating coil circuit to improve impulsing, at contacts BR4 disconnects the flicker earth and prepares a circuit for relay LR, at contacts BR5 prepares a point in the circuit for transmitting X frequency impulses and at contacts BR6 completes a contact wetting circuit by way of resistor YQ. Relay A now operates over the loop connected across the speaking conductors by way of the dial springs and at contacts A1 maintains relay BR after the release of relay RR, and at contacts A2 prepares for the sending of X frequency impulses.

When the dial is operated, the impulse springs intermittently open the line circuit and relay A de-energises accordingly. On each release, X frequency is connected to the transformer VFT by way of the contacts RR2, BR5 and A2 and though the circuit of relay BR is intermittently opened at contacts A1, it is sufficiently slow to remain operated during the various trains of impulses. It will be appreciated that during this time the line is disconnected at contacts LR5 and LR6 so as to prevent speech or line noise transmitted from the operator's position from mutilating the outgoing impulses. The one-way connection over the stopper valve SV, however, permits tones to be transmitted backwards for the operator's information.

When the operator restores her dialling key after dialling the complete number, low resistance battery is momentarily connected to the sleeve circuit and is extended over contacts CZ4, MM4, low resistance left-hand winding of relay M, contacts MM3 and BR4 to relay LR which is connected to earth at contacts BZ2. Relay LR therefore operates and at contacts LR1 prepares the supervisory circuit, at contacts LR2 completes a locking circuit for itself to battery by way of resistor YF, at contacts LR3 disconnects relay BR, at contacts LR4, Fig. 3, opens the anode circuit of the stopper valve and the filament circuit also if the dotted strapping between terminals 11 and 12 is used, at contacts LR5 and LR6 disconnects transformer VFT and switches the speaking conductors through, and at contacts LR7, Fig. 5, prepares a circuit for relays RK and TO. Relay BR releases after its slow period and disconnects relay A which therefore releases in turn. The connection has now been completely set up and if the subscriber is rung automatically the relays energised during the operation in the outgoing relay set are relays M, MM, BZ, CC, CZ and LR. If the ringing is controlled by the operator additional circuit changes take place and these will be described in detail later.

When the wanted party replies, an answer signal is transmitted back comprising a compound prefix, that is to say X and Y frequencies together for the duration of approximately 250 ms., followed by a space of 30–40 ms. and then an X pulse of approximately 80 ms., and the outgoing relay set thereupon sends forward an acknowledgment signal which if correctly received stops the transmission of the answer signal. The compound prefix operates both relays X and Y in the voice frequency receiver VFR, Fig. 4, and at their contacts X1 and Y1, Fig. 6, they complete a circuit from earth, wiper TS3 in position 1 and contacts RC3 for relay XY. This relay thereupon at contacts XY1 completes a locking circuit for itself, at contacts XY2 prepares a circuit for relay RC and at contacts XY3 opens the circuit of relay CC. This relay therefore releases after the slight delay due to its short-circuited lower winding and re-inserts the loss pad so as to give a splitting effect and thus prevent the voice frequency signal from extending back to the operator's position. It will be appreciated that relay CC has to be slightly slow to prevent splitting being effected by fortuitous splashes of combined X and Y frequencies of short duration which occur in normal speech. On the release of relay CC, relay RC is operated at contacts CC1 and thereupon at contacts RC1 opens a further point in the circuit of relay CC and short-circuits its left-hand winding to make itself slow to release, at contacts RC2 and RC3 prepares a circuit for relay RY, at contacts RC4 prepares a circuit for relay RX, at contacts RC5 opens a point in the homing and kick-off circuit of the switch TS, at contacts RC6, Fig. 4, prepares a circuit for relay FA and at contacts RC7 prepares a circuit for relay FB. During the space between the prefix and the operative part of the signal, relay XR releases but relay RC remains held. When the X signal is subsequently received, relay X alone operates and a circuit is thus completed from earth on wiper TS3 for relay RX. This at contacts RX1 completes a holding circuit for relay RC, at contacts RX2, Fig. 4, energises relay MA and at contacts RX3 energises relay ACK.

At the end of the X pulse, relays X, RX and RC release in turn and relay CC is then reoperated. Relay MA at contacts MA1 completes a locking circuit for itself, at contacts MA2 energizes relay MB, at contacts MA3, Fig. 2, connects battery by way of resistor YH to the ring conductor to give through supervision and at contacts MA4 removes the short-circuit from the right-hand winding of relay M so as to extinguish the supervisory lamp. Relay MB at contacts MB1 locks up for the remainder of the connection, at contacts MB2 prepares a circuit for relay FA and at contacts MB3, Fig. 5, prepares a circuit for relay RK. Relay ACK at contacts ACK1 and ACK2 completes locking circuits for itself over positions 1—5 of wiper TS6, at contacts ACK3, Fig. 6, completes a circuit over wiper TS2 in normal position and interrupter contacts TSMC for magnet TSM so that the switch TS is stepped off-normal, and at contacts ACK4, Fig. 7, prepares a circuit for relays SY and SP in series. With switch TS in second position, a circuit is completed from earth over contacts ACK3, wiper TS1 and relay IG to battery by way of resistor YU. When this circuit is initially completed, relay IG may be short-circuited by way of contacts IG2 and the impulse springs 66% M which are machine-driven at a speed of approximately 10 impulses per second. Hence when the springs next open, relay IG operates and thereupon at contacts IG1 earths the home position contact in the bank of wiper TS1 to prepare a locking circuit for itself, at contacts IG2 removes the short-circuit from its own winding and connects the impulse springs to magnet TSM, at contacts IG3 prepares a circuit for relays SC and SP in series and at contacts IG4, Fig. 5, prepares a circuit for relay TZ. When the magnet springs next close, relays SC and SP are operated and relay SP splits the line and connects up transformer VFT. Relay SC at contacts SC1 completes a locking circuit for itself and relay SP over contacts 2—4 in the bank of wiper TS3 and at contacts SC2 and SC3, Figs. 4 and 3, connects up X and Y frequencies

to the transformer VFT so that a compound signal is transmitted over the line. This persists for a period of approximately 250 ms. that is to say while the switch TS is stepping to position 5 and relays SC and SP then de-energise to disconnect the signal.

During the succeeding break period of the impulse springs, no signal is sent to line but when the springs next close with switch TS now in position 5, earth is extended over contacts IG3, wiper TS5 and contacts ACK4 to operate relays SY and SP. Relay SY thereupon at contacts SY1 connects Y frequency to transformer VFT and at contacts SY2 removes the termination, relay SP performing the same functions as before. This pulse of Y frequency lasts approximately 80 ms. and the switch TS continues to step under the control of the impulse springs, earth from position 6 onwards being derived from contact RC1 by way of the low resistance relay IGZ. When the switch reaches position 6, the locking circuit for relay ACK is opened and it releases.

Arrangements are made for transmitting the called subscriber answer signal repeatedly but in normal operation it is only transmitted once since the acknowledgment signal stops the transmission. In case the first acknowledgment signal fails to get through, however, the succeeding called subscriber answer signal will again cause the operation of relay ACK when the switch TS has reached its home position and hence the transmission of the acknowledgment signal as just described is repeated. The connection is now fully set up and the subscribers may converse and at this time the relays operated in the outgoing repeater are M, MM, BZ, CC, CZ, LR, MA and MB.

It will first be assumed that at the end of the conversation the operator clears first. When she removes the plug from the jack JCK, relay M is de-energised and releases relay MM. Thereupon at contacts MM4 guarding battery by way of resistor YE is applied to the sleeve of the jack and at contacts MM7, Fig. 7, a circuit is completed for relay SR from earth by way of contacts BZ3, wiper TS6 in position 1 and contacts ACK2 and TSR5. Relay SR thereupon at contacts SR1 and SR2 prepares locking circuits for itself over the off-normal positions of the switch, at contacts SR3 prepares a circuit for relays SY and SP in series and at contacts SR4 earths the first contact in the bank of wiper TS2. This has the effect as previously described of causing the switch TS to advance to position 2 and a circuit is then completed for relay IG immediately or when the interrupter springs 66% M next open and the switch then proceeds to step to the next home position at the rate of approximately 10 steps per second. Relays SC and SP are operated as before over wiper TS4 in position 2 and are locked up over contacts SC1 until wiper TS3 reaches position 5. During this stepping operation, a compound pulse of approximately 250 ms. duration is transmitted, followed by a pause during the open period of the impulse springs. When these springs close while the switch is standing in position 5, earth is extended from contacts SR4, wiper TS1, springs 66% M, contacts IG3, fifth contact and wiper TS5, contacts CS3 and SR3, relays SY and SP to battery. Relay SY therefore as previously described causes a pulse of Y frequency to be transmitted which is approximately 80 milli-seconds duration since relay SY releases when switch TS steps to position 6. The switch TS continues to step so that a period of approximately 700 ms. then elapses before it reaches its next home position. If the conditions remain the same when this position is reached, the initial circuit for relay SR is again completed and the switch TS continues its operation to send a further cycle of the clear forward signal.

If however the first clear forward signal is effective, the release signal, comprising the usual compound prefix followed by a Y frequency pulse of approximately 600 ms. is sent back from the incoming relay set in a manner which will be described subsequently. At the outgoing end the compound signal can only become effective when switch TS is advanced beyond position 5 and then the operation of relays X and Y together brings up relay XY with the results previously described, that is to say, relay CC is released to effect splitting and thereupon relay RC is operated and holds up during the pause. When relay Y is subsequently operated alone in response to the long Y pulse, relay RY energises over contacts XY2, RC3, Y1, X1 and RC2. Thereupon at contacts RY1 it provides a maintaining circuit for relay RC, at contacts RY2, Fig. 4, prepares a circuit for FA which will not be effective at this time since relay MM has already released, at contacts RY3 opens the circuit of relay BZ and at contacts RY4, Fig. 5, prepares a circuit for relay RF. Owing to the length of the Y pulse, the circuit of relay BZ is held open sufficiently long to cause the relay to release and it thereupon at contacts BZ2 and BZ3 removes earth from the P conductor and the common holding lead, thus bringing down relays LR, SR, MA and MB while owing to the opening of contacts BZ5 relay CC is prevented from re-operating. Relay RY also at contacts RY3 energises relay RZ which at contacts RZ1 completes a circuit for the left-hand winding of relay CZ. When the signal ceases, relays Y, RY, RC and RZ release in turn and the switch TS homes in a self-interrupted circuit in series with the right-hand winding of relay CZ. Relay CZ therefore maintains a guard on the P conductor until all the equipment has been restored to normal and is in condition to be taken into use for another call.

It may be mentioned at this point that the function of relay IGZ, Fig. 6, which is of low resistance, is to prevent a clipped pulse being given to the switch magnet TSM by the operation of relay XY on the receipt of a compound signal. It will be appreciated that while the switch is stepping from position 6 to position 12 which is the period during which an incoming pulse can be effective, relay IGZ is operated in series with the magnet and at its contacts IGZ1 provides a full earth to ensure proper operation of the magnet even if the initial earth is removed at contacts XY3.

Considering now the case in which the called party releases first, in this case a clear back signal is received at a time when relays M and MM are still operated. As already pointed out in the signal table given earlier, the clear back signal comprises a short Y pulse following the usual compound prefix after a short interval. The compound signal causes the operation of relay XY, the release of relay CC and the operation of relay RC and the subsequent Y pulse again brings up relay RY. In this case however the signal is not of sufficient length to permit the release of relay BZ, while contacts RY2 in this instance cause the operation of relay FA since relays MM and MB are both operated. Relay FA at contacts

FA1 completes a circuit for relay FB over contacts RC7 and at contacts FA2 prepares an alternative circuit for relay MA. Relay FB thereupon at contacts FB1 completes a locking circuit for itself, at contacts FB2 prepares a circuit for relay FC, at contacts FB3 releases relay MA and at contacts FB4 closes an alternative circuit for relay FA. The release of relay MA energizes the supervisory lamp at contacts MA4 and thus gives the operator clearing supervision. At the end of the signal, relays RY and RC de-energise in turn thus opening the circuit of relay FA which releases after its slow period. Thereupon at contacts FA1 it opens the circuit of relay FB and operates relay FC. This latter relay at contacts FC1 completes a locking circuit for itself dependent on relay FB, at contacts FC2 again energises relay FA, at contacts FC3 opens a point in the alternative circuit for relay MA, at contacts FC4 opens a point in the locking circuit of relay FB, and at contracts FC5, Fig. 5, opens a point in the circuits of relays RK and RF. Relay FA is now again operated and therefore again prepares the alternative circuit for relay MA which is at present held open at contacts FC3. The normal interval between repetitions of the clear back signal is such that though relay FB may release, relay FC is held up by its slug until relay FB completes its circuit when it is again operated by contacts RC1 when the next compound pulse is received. No circuit is therefore again completed for relay MA and the supervisory lamp remains steadily lighted.

If however the called party is trying to attract the attention of the operator by flashing his switchhook, the interval between repetitions of the clear back signal is lengthened as will be explained in connection with the description of the incoming relay set and this lengthening is sufficient is permit relay FC to release. Relay MA is then again operated over contacts FB3, FA2 and FC3 so that a flashing is given on the supervisory lamp to indicate that the subscriber wishes to speak to the operator.

In the case of a normal release, when the operator responds to the steady lighting of the supervisory lamp by withdrawing the plug, relays M and MM release and relay SR is operated as previously described. This thereupon produces the same effect as previously described, namely the transmission of the clear forward signal, but it will be noted that the switch TS cannot be advanced if relay RC is operated owing to the effect of contacts RC5. This means that the switch TS can only initiate its sending cycle during intervals between repetitions of the clear back signal. The switch TS then advances through one cycle to transmit the usual clear forward signal comprising compound-space-short Y. The effect of this is to stop the transmission of the clear back signal and cause the substitution therefor of the release signal, that is to say, the transmission of a long Y pulse instead of a short one after the compound prefix. This signal has the effect of releasing relay BZ and thus initiating the restoration to normal of all the equipment in the outgoing relay set.

Consideration will now be given to the effect of special signals which may be transmitted by the operator and the first to be dealt with will be the ring forward signal which will be required if it is arranged for the operator to control ringing and may also need to be transmitted in the face of clear back, that is to say, to recall the wanted party to the line after he has hung up. Dealing with the latter case first, when the operator

throws her ringing key, battery is connected to the tip conductor to operate relay RR which thereupon at contacts RR1 extends earth from contacts BZ2 over contacts TZ2, LR7, MB3, FC5 and RF1 to operate relay RK. Relay LR is of course operated on the completion of dialling and relay MB also will be operated because it is assumed that the wanted party has previously been on the line. Moreover relay FC is steadily operated since it is assumed that the normal clear back signal is being received. Relay RK thereupon at contacts RK1 prepares a circuit for relay RF which is effective on the next Y pulse sent back, that is to say when relay RY is operated, and at contacts RK2 completes a locking circuit for itself. Relay RF at contacts RF1 disconnects relay RK and completes a locking circuit for itself, at contacts RF2 closes a further point in its locking circuit, at contacts RF3 prepares a circuit for relay TZ, at contacts RF4, Fig. 6, prepares a circuit for stepping the switch TS off-normal when relay RC releases at the end of the Y pulse, and at contacts RF5 prepares a circuit for relays SX and SP in series. The operation of the switch TS transmits a compound signal in the usual manner in response to the successive operation of relays IG, SC and SP and when the switch reaches position 5, relay SX is operated instead of relay SC so that a short X pulse is transmitted. Moreover on the operation of relay IG, earth is extended over contacts IG4 and RF3 to operate relay TZ which at contacts TZ1 and TZ2 completes locking circuits for itself dependent respectively on relays RR and RF.

The ring forward signal is adapted to be transmitted repeatedly if necessary but is terminated when accepted by the incoming equipment which as later described lengthens the interval between repetitions of the clear back signal in the same way as is done when the subscriber wishes to recall the operator. This permits relay FC to release whereupon relay RF is restored and the transmission of the signal is terminated when the switch TS reaches its next home position. If the ringing key is still operated, relay TZ remains held and thus prevents the transmission of a false signal. The release of relay FC also permits relay MA to re-operate so that the supervisory lamp is extinguished but relay MA is again released on the next clear back signal and the supervisory lamp then remains lighted until the called party replies, at which time the transmission of the clear back signal is terminated.

For the initial ringing when no clear back signal is being received, the circuits are arranged so that the ring forward signal is terminated in response to a separate acknowledgment signal comprising compound-space-Y, i. e. the same as the clear back signal except that it is not repeated. The difference in the outgoing relay set is that since the called party has not yet replied, relay MB will not be operated. Hence when the ringing key is thrown and relay RR is operated, a circuit is completed for relay TO. This at contacts TO1 completes a locking circuit for itself, at contacts TO2 prepares a circuit for relay TZ, at contacts TO3 at once kicks the switch TS off-normal since in this case there is no incoming signal, and at contacts TO4 prepares a circuit for relays SP and SX. Relay TZ is again operated on the energisation of relay IG and again performs its function of preventing the transmission of a false or repeated signal if the ringing key remains operated. The ring forward signal comprising compound-space-X is therefore transmitted as before and

normally an acknowledgment signal will be received after the first transmission. It will be noted that after relay TZ operates, the locking circuit of relay TO is dependent on relay RY and hence when the acknowledgment signal comprising compound-space-Y is received, relay RY is operated and brings down relay TO so that the forward signal is terminated at the end of the cycle.

Similar conditions apply if the wanted party is busy and the operator desires to offer the call and possibly effect breakdown of the existing connection. In this case the operator will be receiving busy tone sent back from the distant exchange but this will not produce any relay operations in the outgoing relay set. At the incoming relay set the signal compound-space-X is preferably arranged to cause earth to be connected to both speaking leads and this in accordance with existing practice serves to produce different effects such as ringing, offering or breakdown according to the state of the connection existing at the time.

The same signal, namely compound-space-X, sent from the operator's end also serves for forward transfer in an area where this facility is preferred to toll offering. No difficulty arises however as the two facilities are in practice mutually exclusive and both would not be provided in the same area. The difference is effected by alteration in the strapping of the incoming relay set and this will be dealt with in due course.

A further facility provided by the system remains to be described, namely, the completion of so-called transit calls, that is those involving end-to-end V. F. signalling, which are distinguished by the fact that the outgoing relay set illustrated is seized from another incoming relay set, either in the same exchange or over a two-wire junction. If the relay set shown is thus seized over a selector level, relay TR is operated over the incoming loop and at contacts TR1 operates relay TSR in series with its own third winding, at contacts TR2 applies earth to the common holding lead and at contacts TR3, Fig. 4, energises relay BZ. The application of earth to the common holding lead by relay TR serves to secure early sending of the seizing signal which is transmitted in the manner previously described in response to the operation of relay CS. Relay TSR at contacts TSR1 locks up, thereby short-circuiting the third winding of relay TR, at contacts TSR2 and TSR3 disconnects relay TR and switches the incoming speaking leads through to the repeating coil RPC, at contacts TSR4 energises relay LR, at contacts TSR5, Fig. 7, opens a point in the circuit of relay SR, at contacts TSR6 disconnects relay RR and at contacts TSR7, Fig. 6, disconnects relay RX. Relay LR switches the speaking leads through and disconnects the stopper valve SV and the relay set is now unable to transmit any signals owing to the fact that all the relays which are in a position to set the switch TS in operation have been rendered ineffective. Moreover the relay set will not respond to any signals of which X is the significant portion, though the compound prefix will result in the energising of relays XY and RC and the release of relay CC. In this case of course, the splitting effect normally produced by relay CC occurs in a portion of the circuit which is not included in the connection. Signals involving Y frequency are able to operate relay RY but short signals produce no effect and it is only the long release signal which is able to de-energise relay BZ and thus restore the equipment to normal.

It will be noted that with the dotted strapping between terminals 11 and 12 for the filament of the stopper valve SV the circuit is dependent on the operation of relay LR so that current is saved if the stopper valve has no longer any useful function to perform. It may happen however that some portions of the system are already on a register controller basis in which case it is usual to arrange for a pip of tone to be transmitted to indicate that a register controller has been taken into use and hence that dialling may be resumed. In this case it is preferable to have the valve permanently ready for action and hence the chain-dotted strapping between terminals 12 and 13 is used.

Considering now the circuit changes in the incoming relay set shown in Figs. 9–13, this is initially prepared for operation in response to the short seizing signal of X frequency only. This signal causes the operation of relay AX in the voice frequency receiver AVFR whereupon a circuit is completed from earth over the home position contact of wiper ATS3, Fig. 11, and contacts AX1, AY1, ATSR4, ARC4 and ANN3 for relay ABZ. This relay at contacts ABZ1 locks up dependent upon relays ARY and APZ, at contacts ABZ2 energises relay ACC, at contacts ABZ3 prepares a stepping circuit for the switch ATS, at contacts ABZ4 earths the common holding lead, and at contacts ABZ5, Fig. 12, prepares a circuit for relays APX and APY. Relay ACC at contacts ACC1 short-circuits its lower winding to make itself slightly slow to release and at contacts ACC2 re-arranges the circuit of relay ASG. The connection of earth to the holding lead energises relays AGP, ASS and ARAA. Relay AGP thereupon at contacts AGP1 earths lead 30 to start the impulse machine and at contacts AGP2 earths the outgoing P conductor by way of rectifier MRC. Relay ASS at contacts ASS1, Fig. 12, prepares a circuit for relay ANN and at contacts ASS2 and ASS3, Fig. 10, prepares the outgoing loop. Relay ARAA at contacts ARAA1 locks up over its upper winding, at contacts ARAA2, prepares a circuit for relay APX, at contacts ARAA3, Fig. 9, prepares a circuit for relay AC which is at present short-circuited, and at contacts ARAA4, Fig. 11, closes another point in the circuit of relay ANN.

When relay AX de-energises at the end of the seizing signal, relay ANN is operated from earth over contacts ARY1, APZ6, ABZ1, ANN3, ARC4, ATSR4, AY1, AX1, ARAA4, ASS1 and ANN4. Relay ANN thereupon locks up over its X contacts ANN1 at contacts ANN2 completes the outgoing loop, at contacts ANN3, Fig. 11, prepares the impulsing circuit, at contacts ANN4 opens its initial circuit, at contacts ANN5, Fig. 12, opens the initial circuit of relays ASS and ARAA4, at contacts ANN6 closes a further point in the circuit of relay APX and at contacts ANN7, Fig. 9, applies battery through the high resistance AYL to the line conductors for contact wetting purposes. The outgoing loop includes relays AI and AD and relay AI now operates but relay AD which is polarised by the rectifiers MRA and MRB is not able to operate at this time. Relay AI at its contacts AI1, Fig. 12, provides a holding circuit for relay ASS so that this relay remains operated, while relay ARAA is already locked up over its upper winding. The effect of the seizing signal is therefore to cause the operation of relays ABZ, AGP, ACC, ASS, ARAA, ANN and AI.

Impulses for setting the associated incoming selector and subsequent switches are transmitted in the form of X pulses of approximately 70 ms. duration which cause the operation of relay AX. On the receipt of the first of these pulses, earth is extended from wiper ATS3 in the home position over contacts AX1, AY1, ATSR4, ARC4, ANN3 and ADD2 to high speed relay AG which operates very quickly in view of the fact that the condenser AQB is in a charged condition. Relay AG at contacts AG1 immediately splits the line and short-circuits the upper left-hand winding of the repeating coil ARPC so as to prevent the voice frequency signal extending forward over the selectors. After a short interval represented by the discharge time of the condenser AQB, relays AH and AA which are also of the high speed type are operated. Relay AA at contacts AA1, Fig. 10, opens the outgoing loop to repeat the impulse in D. C. form to the incoming selector, while relay AH at contacts AH1, Fig. 9, removes the short-circuit from relay AC which is accordingly operated. Relay AC at contacts AC1, Fig. 10, shunts relays AI and AD in order to give an impedance-free impulsing loop, at contacts AC2 energises relay ACA, at contacts AC3, Fig. 12, energises relay ASG and at contacts AC4 maintains relay ASS in spite of the de-energisation of relay AI. Relay ACA at contacts ACA1 energises relay ACAR which thereupon at contacts ACAR1, Fig. 9, prepares a circuit for relay ATSR, at contacts ACAR2 completes an additional circuit for relay ASG and at contacts ACAR3 opens a point in the circuit of relay APX to prevent premature operation of this relay under certain operating conditions. Relay ASG at its contacts ASG1, ASG2 and ASG3 inserts the loss pad comprising resistors AYG, AYH, AYJ and AYK so as to ensure that the voice frequency impulses cannot be transmitted over the outgoing circuit. Relays AX, AG, AH and AA are similarly operated for the succeeding impulses of the train and relay AC, though intermittently short-circuited, remains operated until the end of the series and thus maintains relays ACA, ACAR and ASG. At the end of the train of impulses relays AC, ACA, ACAR and ASG release in turn and the original conditions are then restored with relays ABZ, AGP, ANN, ASS, ARAA, ACC and AI operated. Succeeding trains of impulses are repeated in a similar manner.

It may be pointed out that if one of the selectors should switch to a short-circuited line, there would be danger of a lock-up resulting as the incoming relay set would be unable to receive the release signal since the short-circuit would prevent the operation of relay AY. The circuits are therefore arranged to take care of this difficulty in that in such a case relay AI would be unable to operate on the release of relay AC at the end of the train of impulses and hence there is no circuit for maintaining relay ASS. On the release of this relay after its slow period, the outgoing circuit is opened at contacts ASS2 and ASS3 and therefore the short-circuit is opened. Consequently the relay set is then in a position to respond to the release signal which will be sent subsequently when the call is found to be in difficulties.

In the normal course, however, no further operations take place in the incoming relay set until the called party replies, assuming that automatic ringing is employed so that the operator does not send the ring forward signal. Thereupon the usual reversal over the speaking leads serves to operate relay AD which then at contacts AD1, Fig. 9, prepares a circuit for relay ATSR and at contacts AD2 operates relay ADD. This relay at contacts ADD1 removes the termination represented by resistor AYF, at contacts ADD2, Fig. 12, opens a point in the impulsing circuit, at contacts ADD3 prepares a multiple circuit for relay ASG and at contacts ADD4 completes a circuit for relay APX from earth on wiper ATS6 in home position, contacts ABZ5, APZ2, AHR2, ADD4, ACAR3, relay APX, contacts ARAA2, ARY2 and ANN6 and resistor AYQ. Relay APX thereupon at contacts APX1 prepares a locking circuit for itself, at contacts APX2 completes a circuit for relay ASG, at contacts APX3 prepares a circuit for relays ASX and ASP in series, at contacts APX4, Fig. 9, completes a circuit for stepping the switch ATS off-normal, and at contacts APX5, Fig. 10, completes a locking circuit for itself. Relay ASG operates as previously described to split the line and magnet ATSM is energised in series with its interrupter contact ATSMC and thus advances the wipers of the switch to position 2. Thereupon a circuit is prepared for relay AIG which becomes effective when the impulse springs 66% M next open. Relay AIG operates and at contacts AIG1 earths the first contact in the bank of wiper ATS1 to maintain itself operated if the conditions remain the same when the wiper again encounters this contact, at contacts AIG2 opens a point in the initial short-circuit and connects the impulse springs to the magnet ATSM and at contacts AIG3 prepares a circuit for relays ASC and ASP. The switch is accordingly advanced at a speed of approximately 10 steps per second and when the impulse springs close while the wipers are in position 2, a circuit is completed from earth over contacts APX4, wiper ATS1, contacts AHR4, impulse springs 66% M, contacts AIG3, second contact and wiper ATS4, contacts ASC1, relays ASC and ASP in series to battery. Relay ASC thereupon at contacts ASC1 locks itself and relay ASP over contacts 2, 3 and 4 in the bank of wiper ATS3 and at contacts ASC2 and ASC3, Fig. 9, applies X and Y frequencies to the transformer AVFT to effect the transmission of a compound pulse. Relay ASP at contacts ASP1, Fig. 11, energises the right-hand winding of relay AGP though this is without effect at the present time, at contacts ASP2 and ASP3, Fig. 9, connects the secondary of the transformer AVFT to the incoming speaking leads 14 and 15 and at contacts ASP4 and ASP5 connects up battery through the high value resistors AYB and AYE for contact wetting purposes. When the switch reaches position 5, relays ASC and ASP release and restore the conditions to normal and during the open period of the impulse springs the usual space is timed. When the impulse springs next close, the circuit previously traced to the bank of wiper ATS4 is extended over contacts ASY3 to the 5th contact in the bank of wiper ATS5 and contacts APX3 to operate relays ASX and ASP. Relay ASP produces the results previously described and relay ASX at contacts ASX1, Fig. 9, connects up X frequency to the transformer AVFT. This pulse is terminated when the impulse springs open and after a dura-

tion of approximatelv 80 ms. The circuit for the switch magnet is maintained over contacts AXY3 and ARC2 however and the switch continues to step until it reaches its home position. If relay APX is still operated at this time, the switch then commences a further movement and thus the answer back signal is adapted to be transmitted repeatedly.

If however the operations are proceeding correctly an acknowledgement signal comprising compound-space-Y will be sent forward and its satisfactory receipt will serve to terminate transmission of the answer back signal. The compound prefix of the acknowledgement signal causes the operation of relays AX and AY so that when the switch ATS has passed position 5, earth over wiper ATS3 serves to operate relay AXY. This relay at contacts AXY1 completes a locking circuit for itself, at contacts AXY2 prepares a circuit for relay ARC, at contacts AXY3 opens the circuit of relay ACC and at contacts AXY4, Fig. 12, prepares another circuit for relay ASG. Relay ACC releases after its slow period and the alternative circuit for relay ASG is then completed over contacts ACC2 so that relay ASG operates to split the line. Moreover, at contacts ACC1, relay ARC is operated over its lower winding and thereupon at contacts ARC1 short-circuits its upper winding to make itself slow to release and opens the self-interrupting circuit for magnet ATSM, at contacts ARC2 opens another point in the circuit of relay ACC and energises relay AGP over its right-hand winding, at contacts ARC3, ARC4 and ARC5 prepares circuits for relays ARX and ARY and at contacts ARC6 completes a further circuit for relay ASG. During the pause at the end of the compound prefix, relay AXY de-energises but relay ARC remains held. Upon the receipt of the subsequent Y signal, relay ARY is operated over contacts AXY2, ARC3, AY1, AX1 and ARC5 and at contacts ARY1 completes a holding circuit for relay ARC and opens the circuit of relay ABZ, at contacts ARY2, Fig. 12, alters the circuit of relay APX, at contacts ARY3 releases relay ARAA since contacts APX2 are operated, at contacts ARY4, Fig. 9, prepares a locking circuit for relay ATSR and at contacts ARY5, Fig. 10, prepares a circuit for relay AHR. At the end of the Y signal, relay RY releases followed by relay ARC whereupon relay ACC reoperates. Owing to the fact that contacts ARAA2 are now restored, relay APX falls away so that a new cycle of the switch ATS to cause repeated sending of the answer back signal is not initiated. Conversation between the parties may now take place and relays ABZ, ACC, ANN, AGP, ASS, AI, AD and ADD are operated in the incoming relay set.

At the end of the conversation when the called party hangs up, relay AD releases and brings down relay ADD. Thereupon a circuit is completed from earth on wiper ATS6, position 1, contacts ABZ5, APZ2, AHR2, ADD4 and ALIR1, relay APY, contacts ARAA2, ARY2 and ANN6, resistor AYQ to battery. Relay APY operates and at contacts APY1 and APY2 prepares locking circuits for itself over the off-normal positions of switch ATS, at contacts APY3, Fig. 9, prepares a circuit for relay ALI, at contacts APY4 kicks the switch ATS off-normal, at contacts APY5, Fig. 10, opens a point in the locking circuit of relay AACK and at contacts APY6 prepares a circuit for relays ASY and ASP in series. The operation of switch ATS then takes place in the usual manner to effect the transmission of a compound-space-Y signal by the energisation of relay ASC in positions 2, 3 and 4 and the energisation of relay ASY in position 5. Relay ASY at contacts ASY1 opens the termination including the transformer AVFT, at contacts ASY2 applies Y frequency to this transformer, and at contacts ASY3 provides a momentary locking circuit for itself. Since the initial circuit for relay APY is maintained, this signal will be transmitted repeatedly each time the switch ATS passes over half its bank.

If the called party again removes his receiver in order to attract the operator's attention, relays AD and ADD are again operated and since relay APY is now energised except at the instant the switch ATS is in normal position, relay ALI, Fig. 9, is now energised over contacts AD1, ACAR1 and APY3. Relay ALI at contacts ALI1 locks up independently of relay AD and at contacts ALI2, Fig. 10, energises relay ALIR which in turn at contacts ALIR1, Fig. 12, brings down relay APY when the switch ATS next reaches its home position. Relays ALI and ALIR which are both slow to release then deenergise in turn and only when contacts ALIR1 are again closed can relay APY re-operate to initiate the transmission of the next signalling cycle. The effect therefore is to lengthen the normal interval between repetitions of the signal and as already explained in connection with the description of the outgoing relay set, Figs. 2–7, the timing of relays FA, FB and FC therein is such that with this lengthened interval, relay MA is again operated and thus the operator's supervisory lamp is extinguished so that a flashing signal is produced. The transmission of the signal will cease when the called party maintains his receiver off the hook as relay ADD is then steadily energised and no further circuit is completed for relay APY.

The calling operator may clear either before or after the called party has hung up and the effects at the incoming end will now be dealt with.

Considering first the case in which the calling party clears after the called party has cleared, the clear forward signal is then transmitted and on becoming effective causes the release signal to be sent back instead of the clear back signal. In fact this means lengthening the significant Y portion of the signal in a manner which will be explained shortly. For the reasons already explained the clear forward signal comprising compound-space-Y will be transmitted in the interval between repetitions of the clear back signal. On receipt of the compound prefix, relays AX and AY operate and bring up relay AXY which as previously described releases relay ACC which then energises relay ARC. This relay remains energised during the space and relay ARY is then operated by the short Y pulse. Relay ARY at contacts ARY2 releases relay APY and at contacts ARY5 energises relay AHR since contacts APX5 are now normal. Relay AHR at contacts AHR1 completes a locking circuit for itself, at contacts AHR2 completes a circuit for relay APZ when the switch ATS reaches its home position, at contacts AHR3, Fig. 11, prepares a homing circuit for the switch ATS and at contacts AHR4 opens the circuit of relay AIG which therefore deenergises. Relay APZ at contacts APZ1

and APZ2 prepares locking circuits for itself in positions 1 to 10 of wiper ATS6, at contacts APZ3 releases relay AHR, at contacts APZ4, Fig. 9, completes the usual circuit for stepping the switch ATS from its home position, at contacts APZ5 alters the connections to the bank of wiper ATS1, at contacts APZ6 opens the circuit of relay ABZ and at contacts APZ7 prepares a circuit for relays ASY and ASP in series. The switch therefore advances to initiate a further cycle and a compound signal is transmitted in the usual manner by the operation of relays ASC and ASP and the transmission of the Y signal is initiated when the interrupter springs close with the switch ATS in position 5. In this case however, owing to the operation of contacts APZ6 earth is connected to contacts 6 to 10 in the bank of wiper ATS5 and consequently a long Y signal of approximately 600 ms. duration is transmitted which is sufficiently long to release relay BZ in the outgoing relay set. The release of relay ABZ, Fig. 11, allows relays AGP, ANN and ACC to fall away and on the resulting opening of the outgoing loop, relay AI releases and brings down relay ASS. Relay APZ releases when the switch ATS reaches position 11 and the switch then homes in the usual manner over contacts AXY3 and ARC2 in position 11 and contacts APZ5 and ABZ4 in position 12.

If the called party is still on the line when the calling party clears, in this case the clear forward signal is transmitted at a time when no signal is being sent back and its effect is to operate relay ARY which in turn brings up relay AHR. In this case however, since the switch ATS is in its normal position, relay APZ is operated immediately and the release signal is therefore transmitted back and the equipment in the incoming relay set restored to normal as just described. In this case there is no need for the clear back signal to be sent since it is the operator who actually controls the release of the connection. It will be understood that the purpose of the relay AIGZ is similar to that of the relay IGZ in Fig. 6, namely, to prevent a clipped pulse being given to the magnet ATSM on the operation of contacts AXY3.

The operations in the incoming relay set which occur when the ring forward signal is transmitted will now be dealt with. It will be remembered that this signal comprises compound-space-X and it serves for initial ringing or recall and also for toll offering, breakdown and forward transfer. The receipt of the compound signal operates relay AXY in the usual manner whereupon relay ACC is released and relay ARC is operated. The following X pulse effects the operation of relay ARX which thereupon at contacts ARX1 completes the usual locking circuit for relay ARC and at contacts ARX2, Fig. 10, energises relay AACK. This relay at contacts AACK1 and AACK3 prepares locking circuits for itself over contacts 1 to 5 in the bank of wiper ATS6, at contacts AACK2 connects earth to terminal 31, at contacts AACK3, Fig. 9, prepares a circuit for relay ALI, at contacts AACK4 completes a circuit for stepping the switch ATS off-normal and at contacts AACK5 prepares a circuit for relays ASY and ASP.

If the signal is being sent at a time when no supervisory signal is being transmitted back, the switch ATS will perform one cycle to send the acknowledgment signal comprising compound-space-Y and if this signal gets through correctly the sending of the compound-space-X signal from the outgoing end will be terminated and hence when the switch ATS again reaches its home position there will be no signal to re-energise relay AACK.

If however, the ring forward signal is sent at a time when clear back is being transmitted, the switch ATS will already be in operation owing to the energisation of relay APY and the energisation of relays ARC, ARX and AACK can only be effected when wiper ATS3 has passed position 5, though it will be appreciated that the transmission of the ring forward signal can only be initiated in intervals between the repetitions of the clear back signal. Since with the assumption made relay APY is already operated due to the transmission of clear back, contacts AACK3 complete a circuit for relay ALI which in turn operates relay ALIR. These relays co-operate in the manner previously described to introduce a delay period during which relay APY remains de-energised and hence a lengthening of the interval between repetitions of the signal is produced. This lengthening of the interval is sufficient to cause the release of relay FC with the results previously described, namely that relay RF is released to terminate the ring forward signal. Accordingly the acknowledgment of the ring forward signal in the face of clear back is merely an increase in the intervals between repetition of the signal and this serves to stop transmission.

If the ring forward signal is being transmitted for the purpose of initiating operator-controlled ringing terminals 31 and 32 will be strapped and contacts AACK2 will apply earth to the two speaking conductors. This unbalances a differential relay and in known manner causes the wanted party to be rung.

If the ring forward signal is being transmitted in the face of busy tone because the wanted party is engaged, it will be intended to bring about toll offering and in this case also terminals 31 and 32 are strapped. The effect of the operation of contacts AACK2 at this state of the connection is to cause the switch concerned to cut into the busy line and the subsequent transmission if necessary of the same signal will break down the existing connection. If the ring forward signal is transmitted when either no signal or busy tone is being sent back so that the switch ATS is not already operating, the locking circuit of relay AACK is opened when the switch ATS reaches position 6 and the relay accordingly de-energises since at this time the acknowledgment signal has been completed. When the wanted party comes on the line, the usual reversal takes place to operate relays AD, ADD and APX so that the called party answer signal is sent until terminated by the acknowledgment signal in the usual manner. If however, ring forward is sent in the face of clear back, relay AACK is only operated as long as relay ARX and after the lengthening of one interval by relays ALI and ALIR to acknowledge and terminate the ring forward signal, clear back continues to be sent as before. The earthing of the two speaking conductors by contacts AACK2 in this case produces re-ringing and when the wanted party comes on the line again, the usual reversal causes the re-operation of relays AD and ADD and hence the release of relay APY. The clear back signal is therefore terminated and hence as previously described, relay FC is released and relay MA is again operated to give a supervisory signal to the operator.

If the signal is to be used to effect forward transfer in systems where toll offering and break-

down are not employed, terminal 31 is strapped to terminal 33. Consequently the operation of contacts AACK2 energises relay AFT which thereupon at contacts AFT1 completes a locking circuit for itself, at contacts AFT2, AFT3 and AFT4 transfers the outgoing circuit of the manual board over conductors R, S and T, and at contacts AFT5 removes the termination. When the operator on the distant manual board throws her speaking key, she effects a reversal to operate relay AD which then initiates the transmission of the usual called subscriber answer signal. When she restores the key, relay AD releases and thus initiates the transmission of the clear back signal, which persists during the time that the wanted party is being rung. When he replies, relay AD is again operated to release relay APY and terminate the clear back signal so that as just described relay MA is re-operated to extinguish the supervisory lamp at the calling operator's position. Accordingly with this arrangement both key supervision for the operator and switch hook supervision for the subscriber are provided. It will be appreciated that with the arrangements as shown with forward transfer facilities due to the strapping of terminals 31 and 33, operator controlled ringing or re-ringing would not be available. This facility could readily be provided however by a simple addition to the circuits if it were found desirable.

One further facility provided by the incoming relay set remains to be described, namely, the operation in the case of transit calls, that is to say, calls in which the voice frequency setting pulses are to be transmitted direct to another exchange without conversion into D. C. pulses. The arrangement is that when a group selector switches to an outgoing V. F. relay set, a momentary reversal is encountered due to the connections of relay TR, Fig. 2. Relay AC in the relay set is arranged to release before the C relay in the group selector and it is while the latter relay holds up that the reversal is operative. On the release of relay AC, this reversal is enabled to become effective on relay AD but at this time relay ACAR is stil operated and possibly also relay ACA. Relay AD therefore at contacts AD1 extends earth over contacts ACAR1 to operate relay ATSR. This relay thereupon at contacts ATSR1 prepares a locking circuit for itself over back contacts AD1, at contacts ATSR2 removes the termination, at contacts ATSR3, Fig. 10, opens a point in the circuit of relay AHR, at contacts ATSR4, Fig. 11, opens a point in the impulsing circuit and also in the circuit of relay ARX, at contacts ATSR5, Fig. 12, completes an alternative holding circuit for relay ASS and at contacts ATSR6 prevents further operation of relay ASG after the opening of contacts ADD3. The reversal lasts for approximately 50 ms. and thereafter relays AD and ADD release and relay ATSR remains locked up over resistor AYN. On the receipt of the next train of impulses which it will be remembered are 70 ms. pulses of X frequency, no effect can be produced on the impusing relays nor can relay ASG be operated which would have the effect of splitting the line. Consequently the incoming pulses are transmitted direct over the outgoing speaking leads and extend to an incoming relay set in a distant exchange. The timing of relay ACAR is such that it holds up until both relays AD and ADD have released and consequently there is no danger of the false operation of relay APX since its circuit is held open at contacts ACAR3. The operation of contacts ATSR4 ensures that the relay set is non-responsive to X pulses whether preceded by a compound prefix in the case of supervisory signals or not as in the case of setting pulses, while short Y pulses are also ineffective to operate relay AHR since contacts ATSR3 are open. When the release signal is received, however, since this involves a long Y pulse, contacts ARY1 are maintained open for sufficiently long to release relay ABZ which then initiates the release of the incoming relay set during the long pulse. Relays ATSR and ANN are held up in series over contacts ARY4 and since relay ATSR maintains relay ASS the speaking circuit is not opened until the release signal is completed. It will be appreciated that if this were not done the release signal would be cut off and possibly prevented from becoming operative on the outgoing relay set at the originating exchange. When relay ARY finally falls away, relays ATSR and ANN both release followed by relays ASS and AGP, the latter relay having been held up over its right-hand winding by contacts ARC2. When the incoming relay set is used in these circumstances no operation of the switch ATS takes place.

It should be explained that there is a remote possibility that a subscriber might remove his receiver just as a connection was extended to his line in which case a reversal would be produced similar to that encountered when an outgoing relay set is taken into use. In such a case however the reversal would persist for more than 80 ms. and hence when the initial circuit of relay ATSR was opened by contacts ACAR1 no locking circuit would be completed for it since contacts AD1 would be operated and thus false operation is prevented.

It will be noted from the table that the interval between repetitions of signals which are sent more than once is different for transmission in the two directions being slightly longer in the outgoing or forward direction. Hence if it should happen that signals sent in opposite directions originally overlapped so as to mask one another, they would get out of phase after a few cycles and would then be able to produce their desired effect.

We claim:

1. In a telephone system employing voice frequency signals for controlling the setting up and supervision from an operator's position of connections over automatic switches, means for repeatedly transmitting at intervals a signal indicating that the called party has disconnected, said signal being terminated by breaking of the connection at the operator's position, means including a relay set controlled by an operation by the called party and also responsive to an operation on the part of the operator for altering the intervals between said signals, and means associated with the operator's position controlled by said alterations in said intervals.

2. In a telephone system employing automatic switches in which voice frequency signals are used to set up connections over said switches and to supervise the same, electromagnetic means controlled from one end of the connection for initiating the transmission of a particular backward signal and for repeating the same at predetermined intervals until an acknowledgement is received from the other end of the connection, means for repeatedly transmitting a forward signal while said backward signal is being transmitted, electromagnetic means for acknowledging the forward signal by altering the intervals between repetitions of the backward signal, and switching means for terminating the transmis-

sion of said forward signal in response to said alterations in said intervals of said backward signal.

3. In a telephone system employing automatic switches in which voice frequency signals are used to set up connections over said switches and to supervise same, means including a relay set for repeatedly transmitting at intervals a signal indicating that the called party has disconnected, said signal being terminated by breaking of the connection at the operator's position, and means in said relay set controlled by the called party again removing his receiver for lengthening the interval between repetitions of said signals by a predetermined amount, said altering of the intervals effecting the intermittent lighting of the operator's supervisory lamps.

4. In a telephone system employing voice frequency signals for the setting up and supervision of connections over a line having an outgoing relay set at one end and an incoming relay set at the other end, said outgoing relay set converting received direct current impulses into voice frequency impulses for transmission over the line to the incoming relay set, said incoming relay set converting said voice frequency impulses into direct current impulses and transmitting them for operating automatic switches to extend connections, means for seizing the outgoing relay set over different paths, means in the incoming relay set for transmitting signals comprising voice frequency impulses of different durations over the line to the outgoing relay set, electromagnetic means in the outgoing relay set responsive to said signals when said outgoing relay set is seized over one of said paths, and relay means in said outgoing relay set operated responsive to seizure over another of said paths for controlling said outgoing relay set to respond only to the signals of greater than a predetermined duration and further extending the signals of less than said predetermined duration through said outgoing relay set to a distant point.

5. In a telephone system employing voice frequency signals for setting up different connections including a line having equipment therein responsive to received voice frequency impulses to convert said impulses into direct current impulses and transmit them over certain of said extended connections, relay means operated responsive to completion of a long circuit to certain other of said connections for returning a momentary particular signal to said equipment, and circuit means responsive to said momentary particular signal for disabling said equipment to convert said voice frequency impulses to direct current impulses and to cause said equipment to pass said voice frequency impulses over said other connections without conversion.

6. In a telephone system employing voice frequency signals for the setting up and supervision from an operator's position of connections over automatic switches, means including a relay set controlled by the response of a called party for reversing the connection to signal the operator, means including a relay set accessible to said operator for transferring a partially established connection to another operator at the distant end in case a wanted party cannot be obtained, means including a key controlled by the distant operator when connecting herself to a connection for producing a signal at the first operator's position in the same manner as said signal is produced by the response of a called party, relay means controlled by the disconnection of the distant operator for giving a disconnect signal to said first operator, and relay means controlled by a response of a called party while said disconnect signal is being given for terminating said signal.

7. In a telephone system as claimed in claim 1 in which said last means includes a slow acting relay maintained in the operated position while said signal is being transmitted at normal intervals and released when the intervals are altered to signal the operator.

8. In a telephone system as claimed in claim 2 in which said switching means includes a slow acting relay operated responsive to the said alterations in said intervals, and circuit means controlled by the operation of said slow relay for terminating the transmission of the forward signal.

9. In a telephone system as claimed in claim 3 in which there is a slow acting relay intermittently operated responsive to said lengthening of said intervals, and circuit means controlled by said intermittent operation of said slow relay to cause said intermittent lighting of the operator's lamp.

10. In a telephone system as claimed in claim 1 in which there are rotary stepping switches and in which the timing of said intervals is accomplished by the operation of said switches at a predetermined speed under control of said relay set.

11. In a telephone system having means including a relay set with automatic switches for controlling the setting up and supervision from an operator's position of connections over automatic switches, means including a second relay set for repeatedly transmitting at intervals over such a connection a voice frequency signal indicating that the called party has cleared, said voice frequency signal being terminated by breaking of the connection at the operator's position, relay means in said second relay set controlled by an operation by the called party and also responsive to an operation on the part of the operator for altering the intervals between said voice frequency signals, and supervisory means associated with the operator's position controlled by said alterations in said intervals.

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