May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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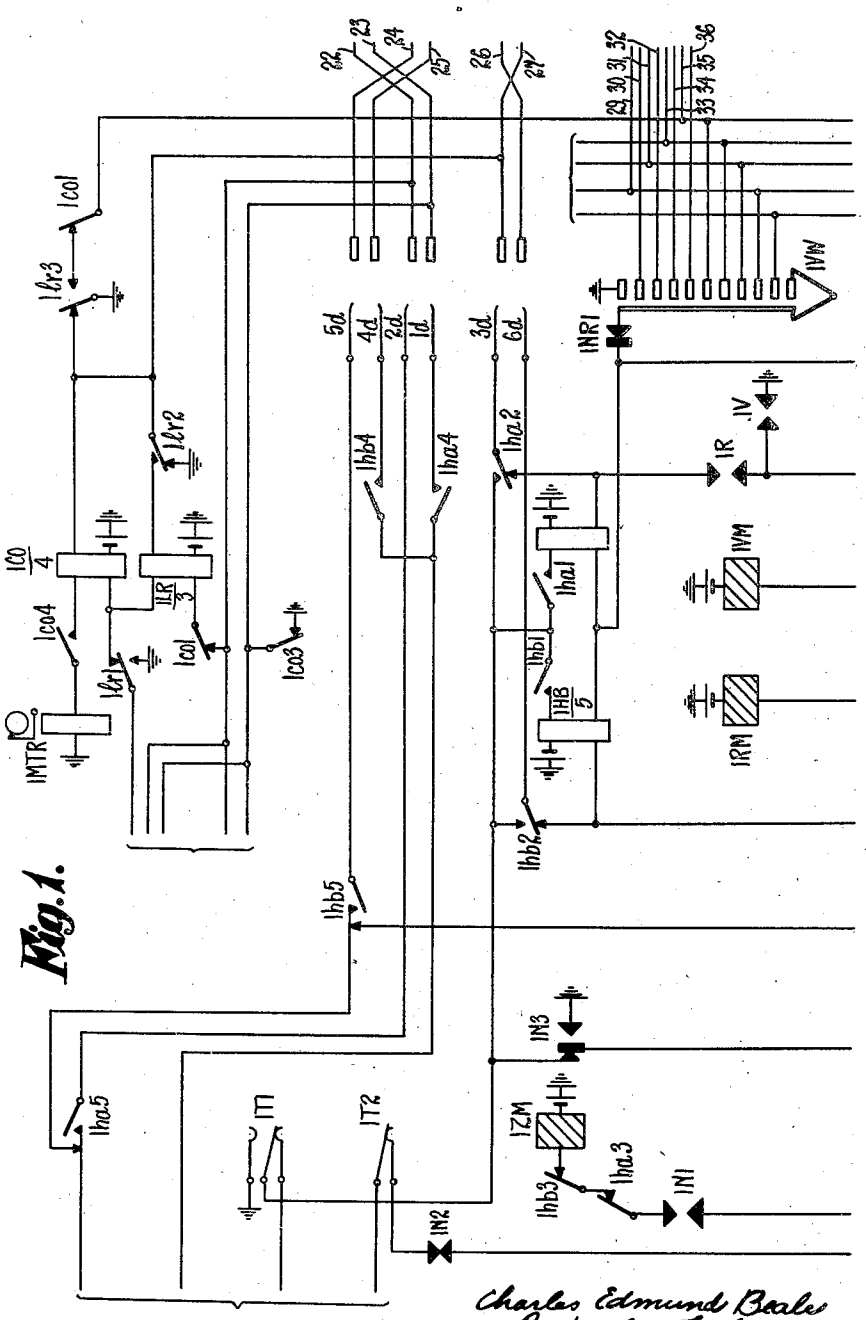


Fig. 1.

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TELEPHONE SYSTEM

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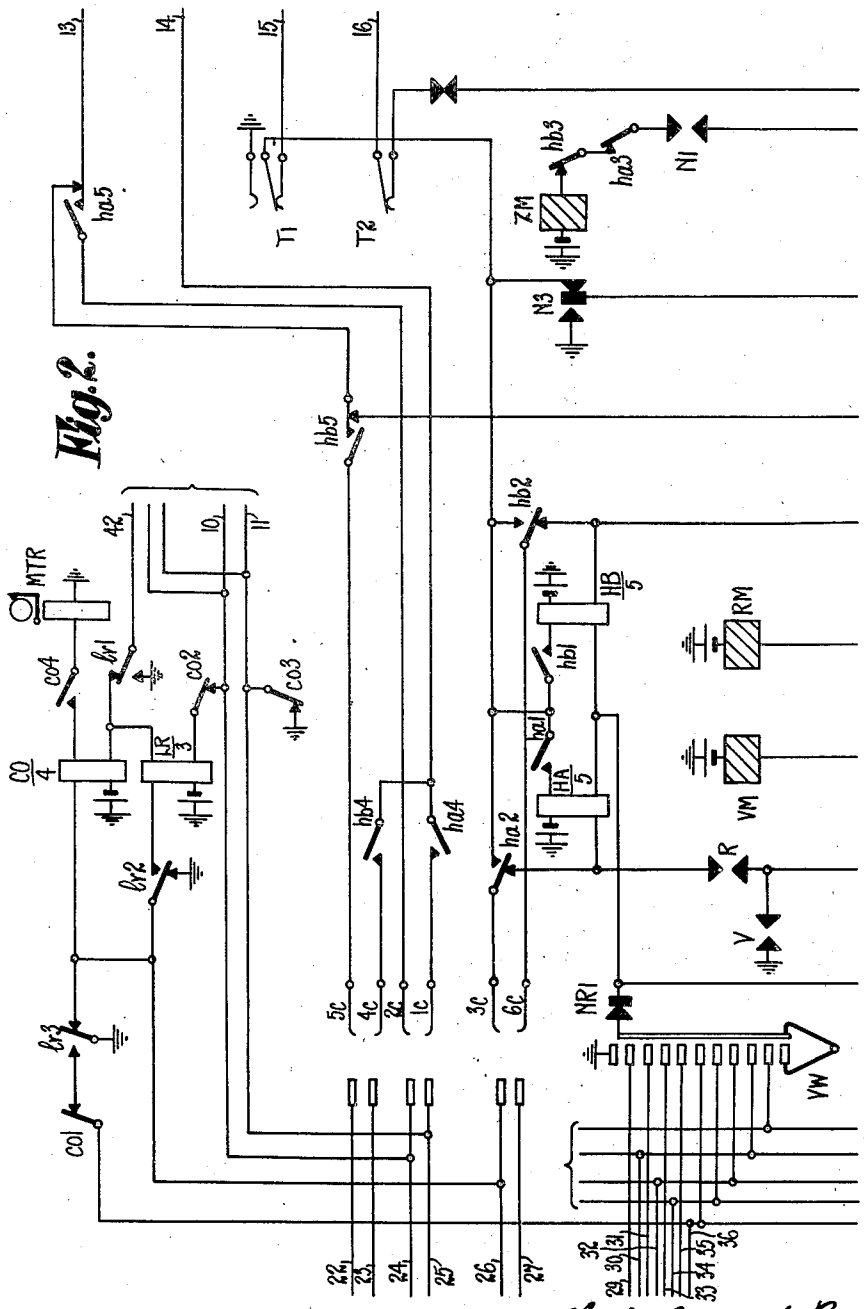


Fig. 2.

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TELEPHONE SYSTEM

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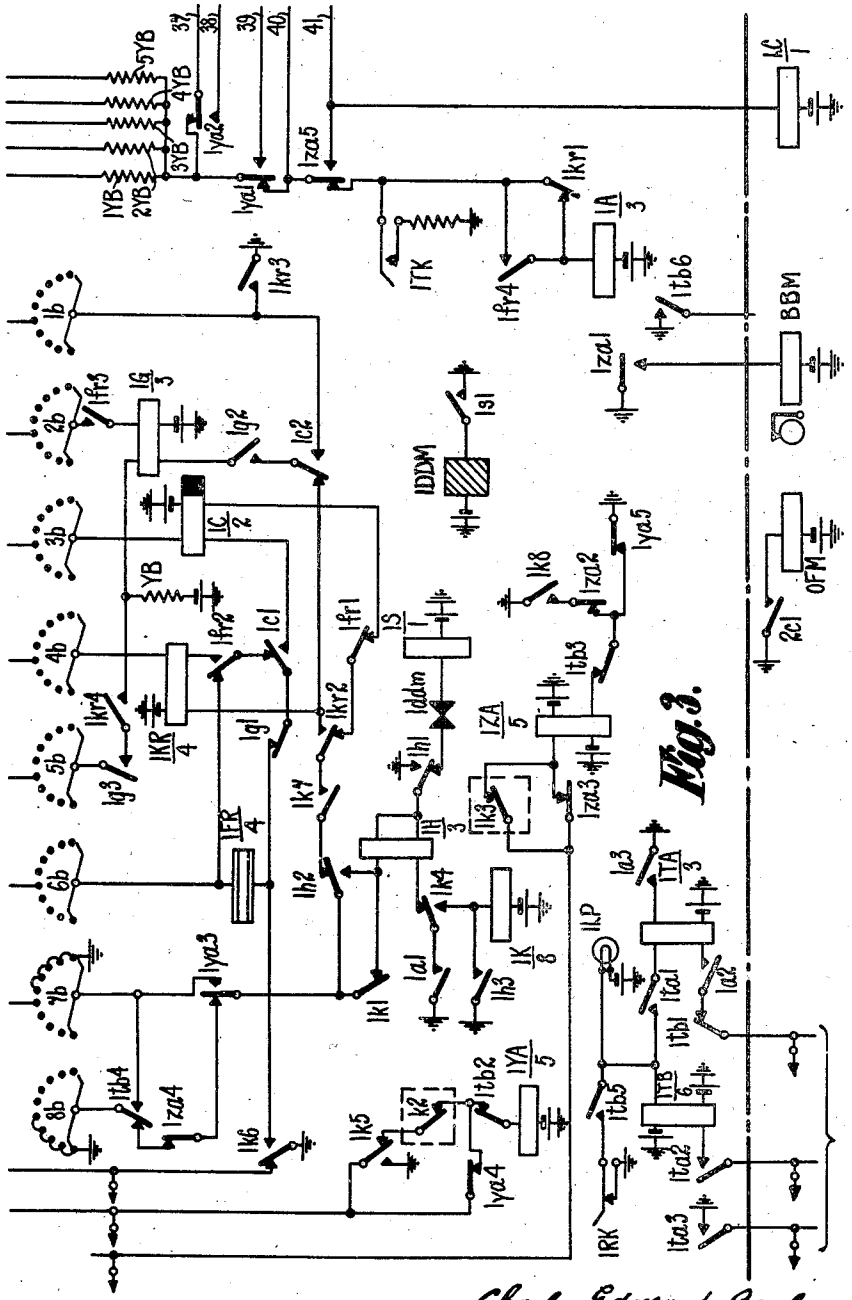


Fig. 3.

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TELEPHONE SYSTEM

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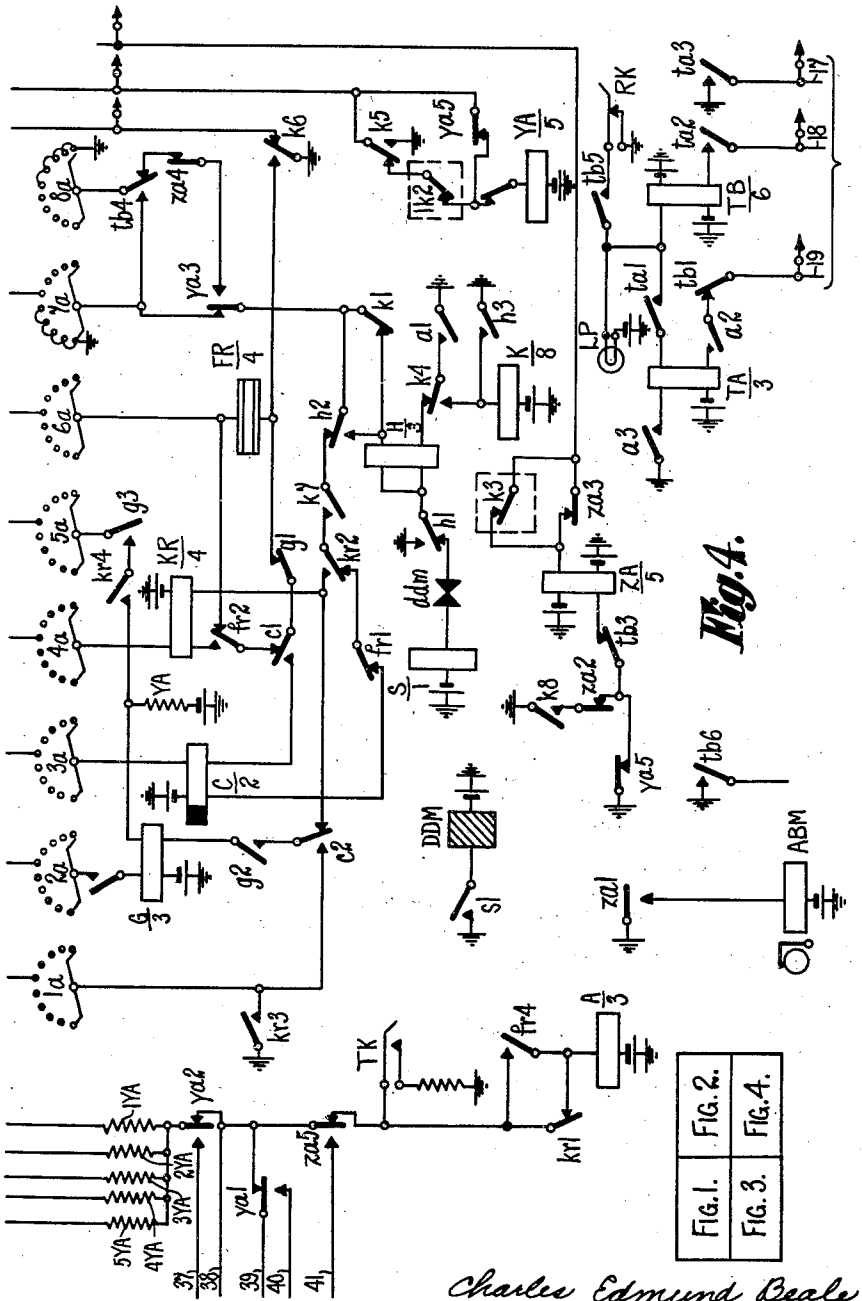


Fig. 4.

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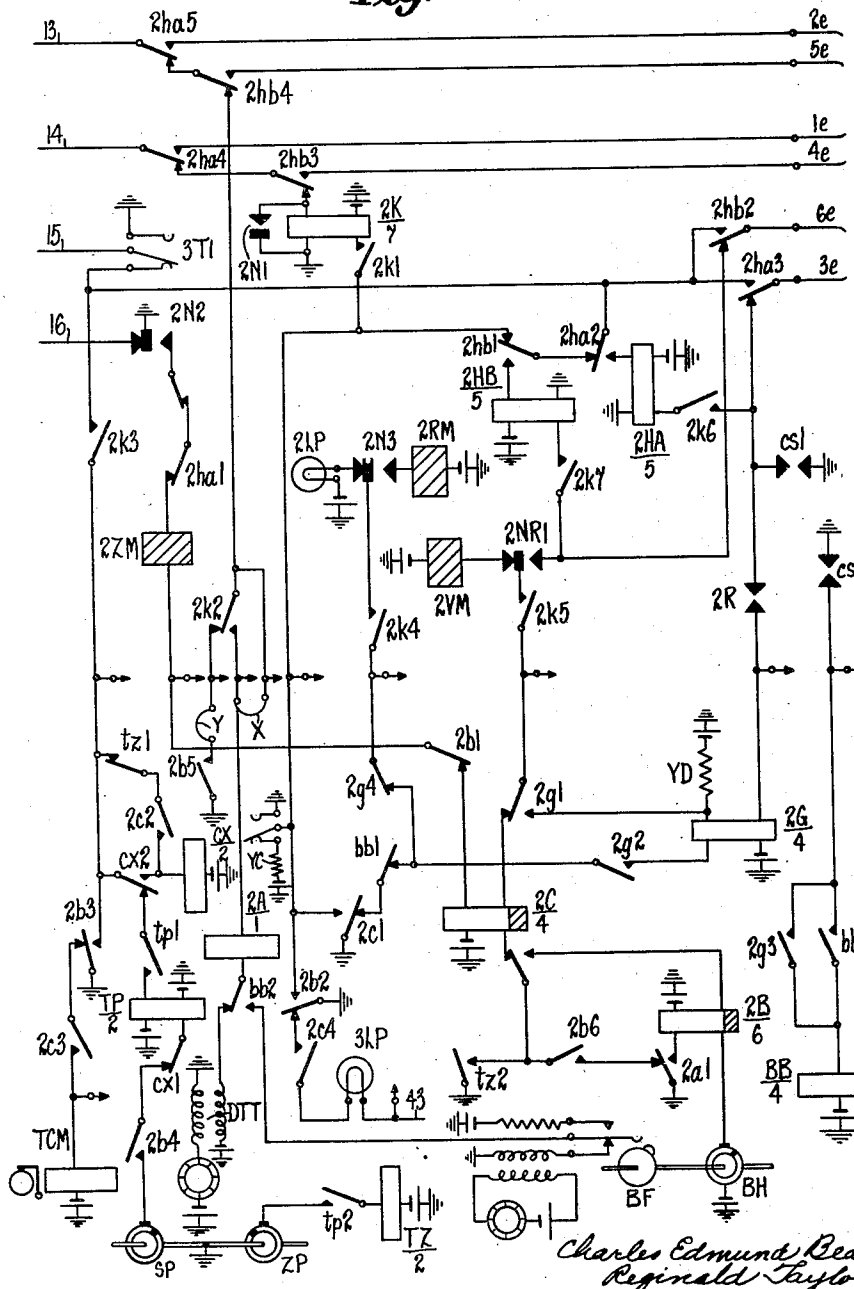
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May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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Fig. 5.



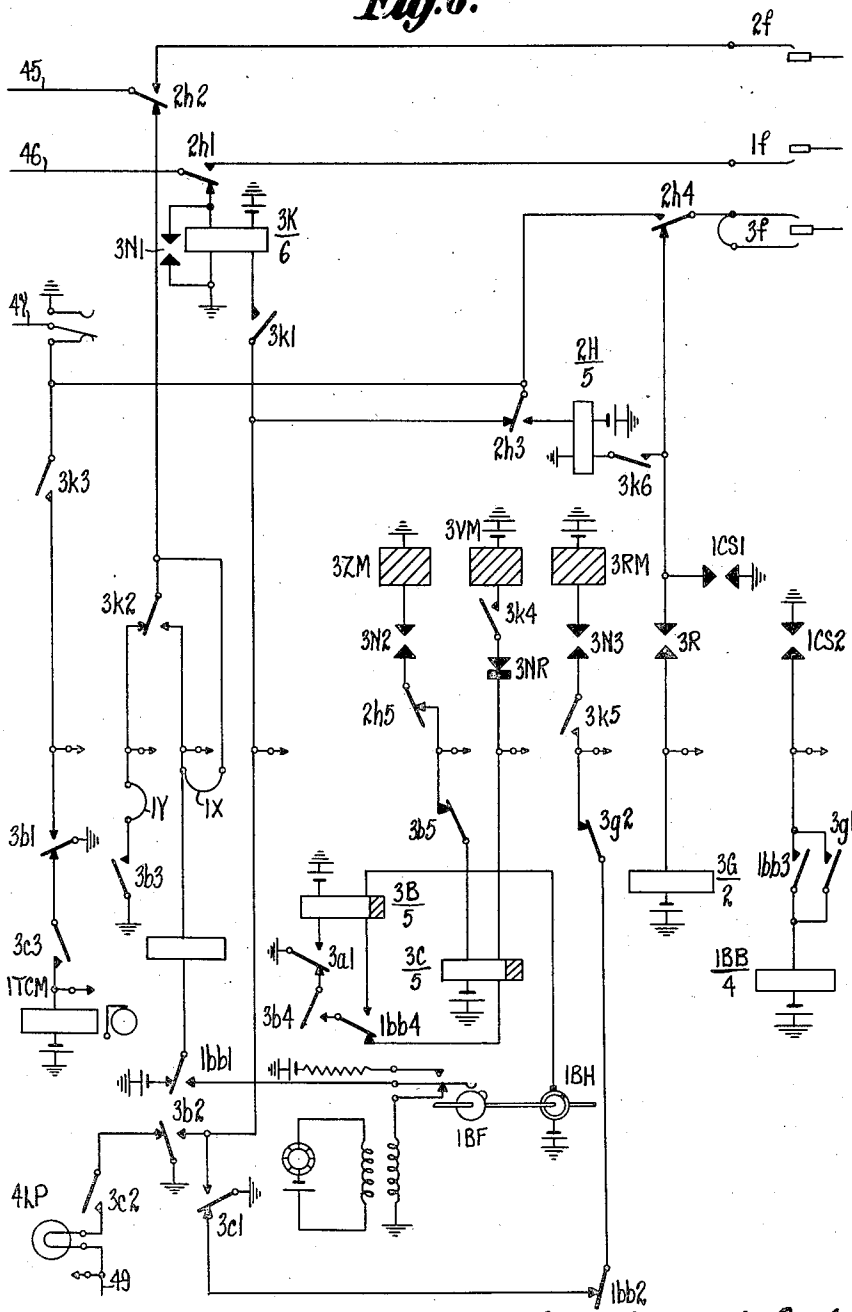
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May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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Fig. 6.



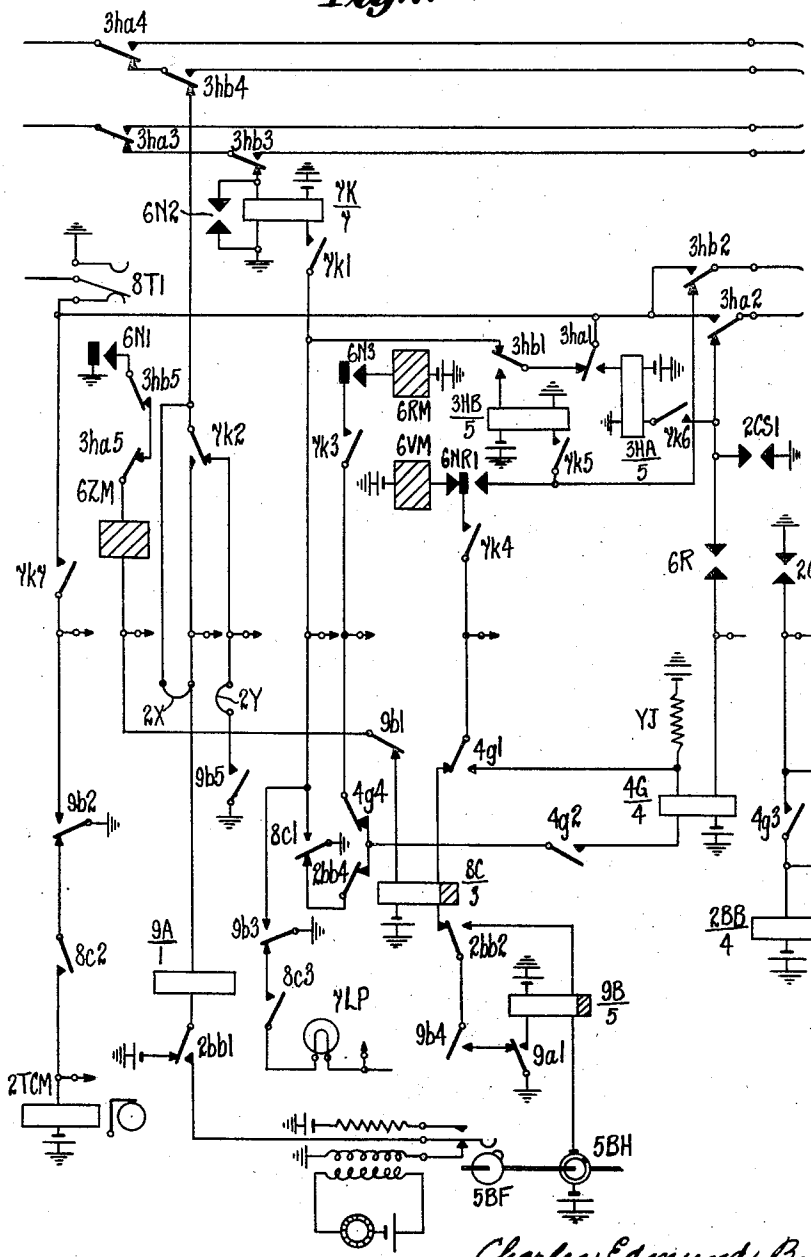
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Chas. M. Candy
By attorney

May 30, 1933. C. E. BEALE ET AL 1,912,122

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Fig. 7.



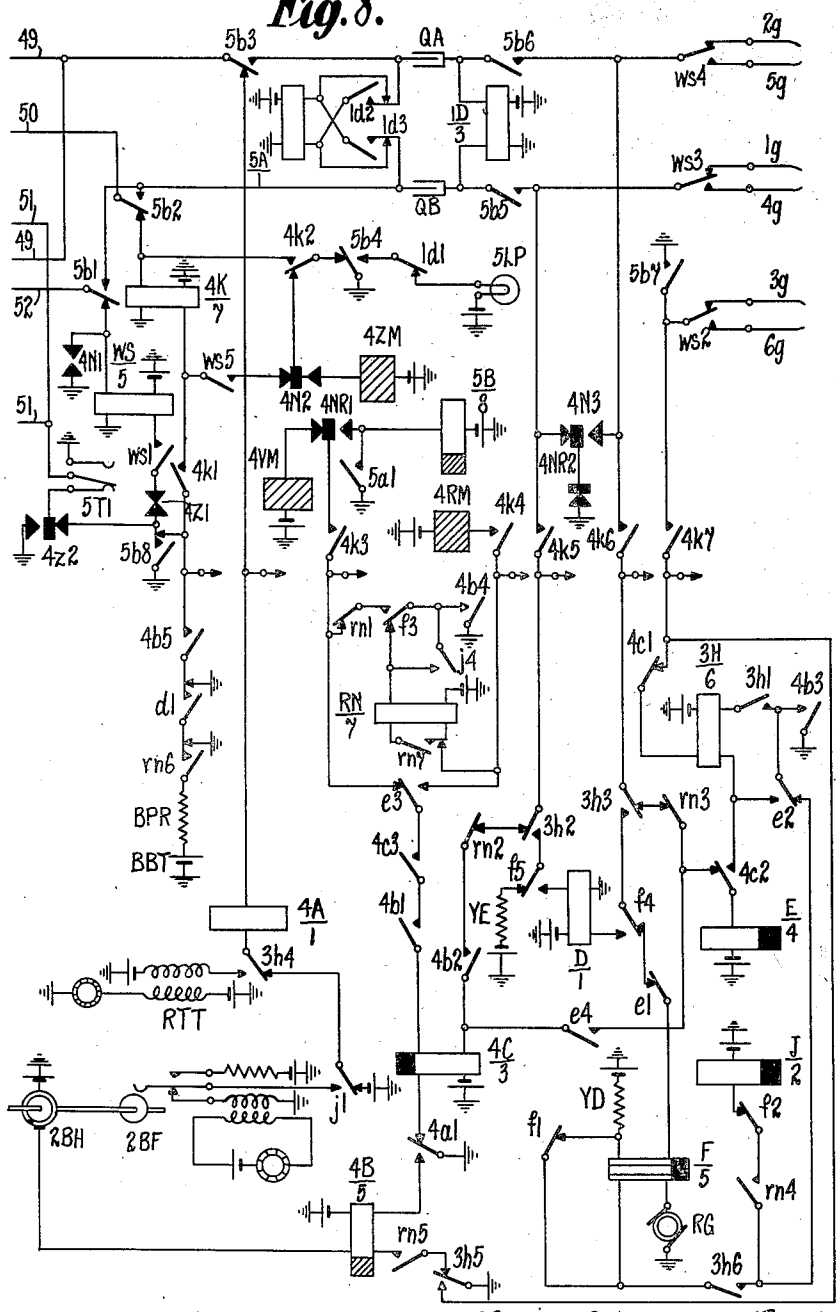
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May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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Fig. 8.

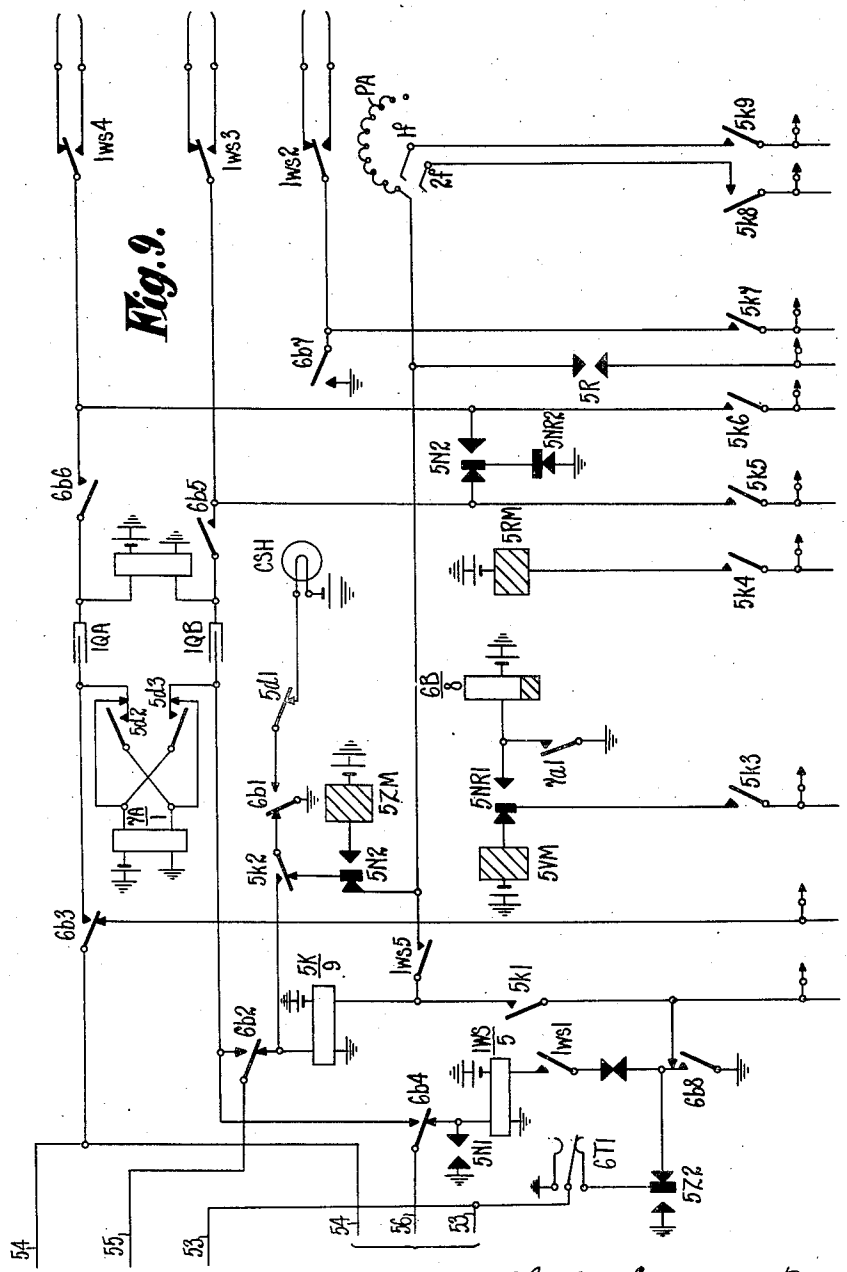


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TELEPHONE SYSTEM

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TELEPHONE SYSTEM

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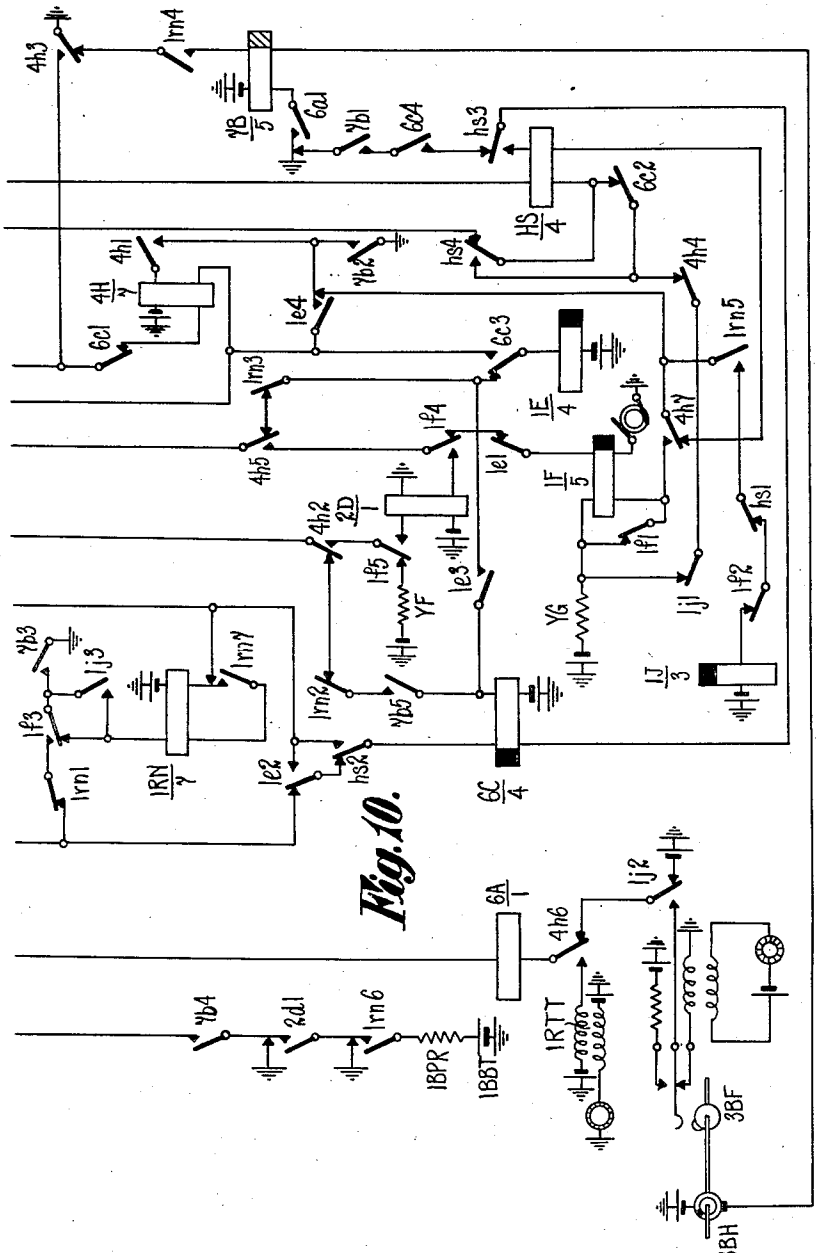


Fig. 10.

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May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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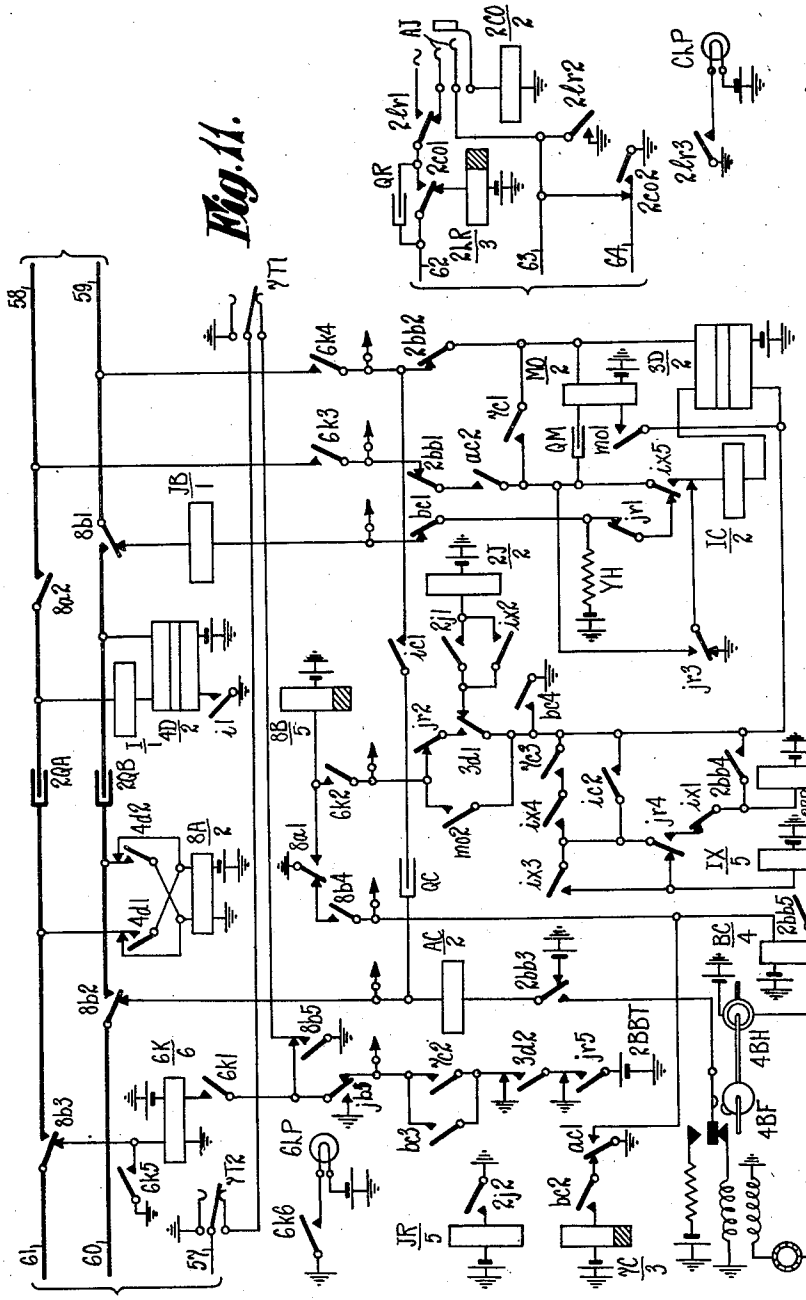


Fig. 11.

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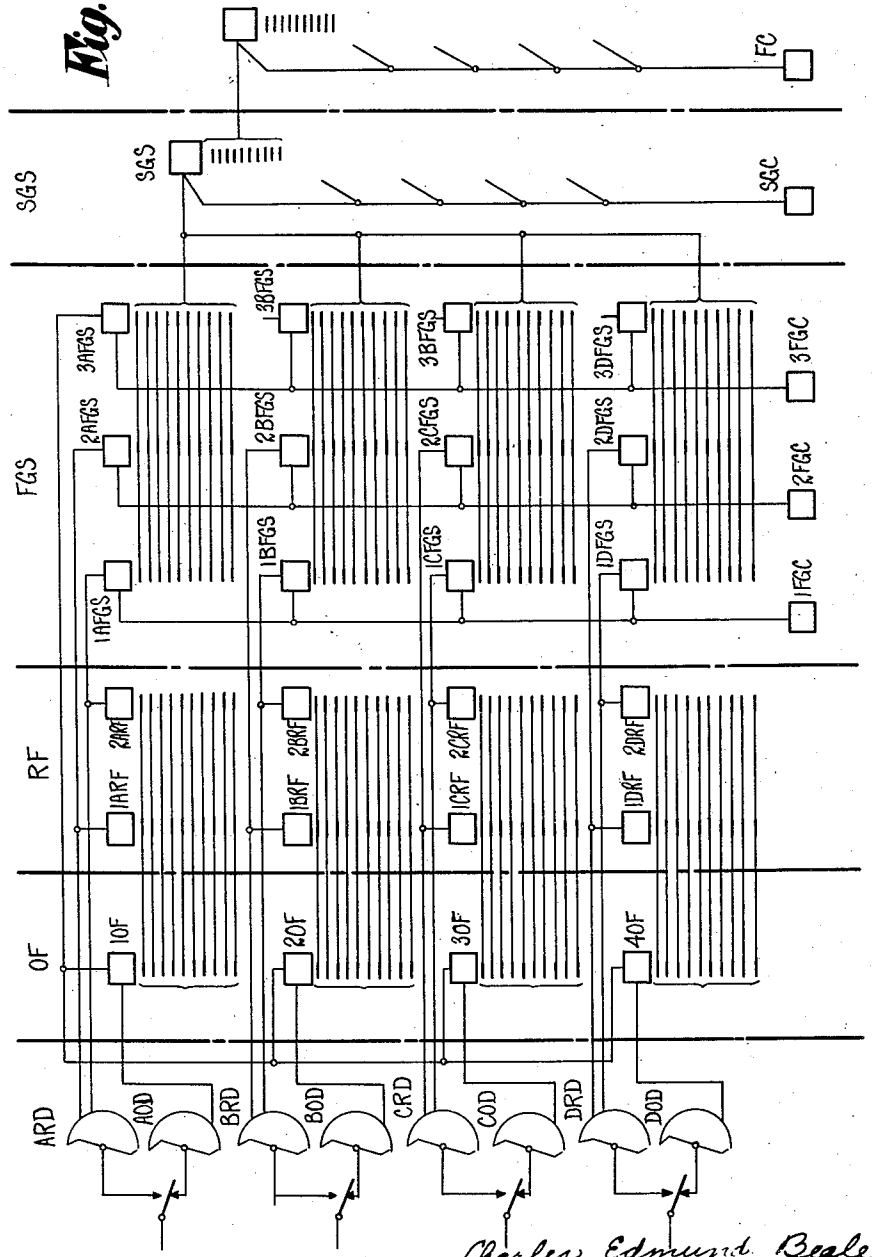
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May 30, 1933. C. E. BEALE ET AL 1,912,122

TELEPHONE SYSTEM

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Fig. 12.



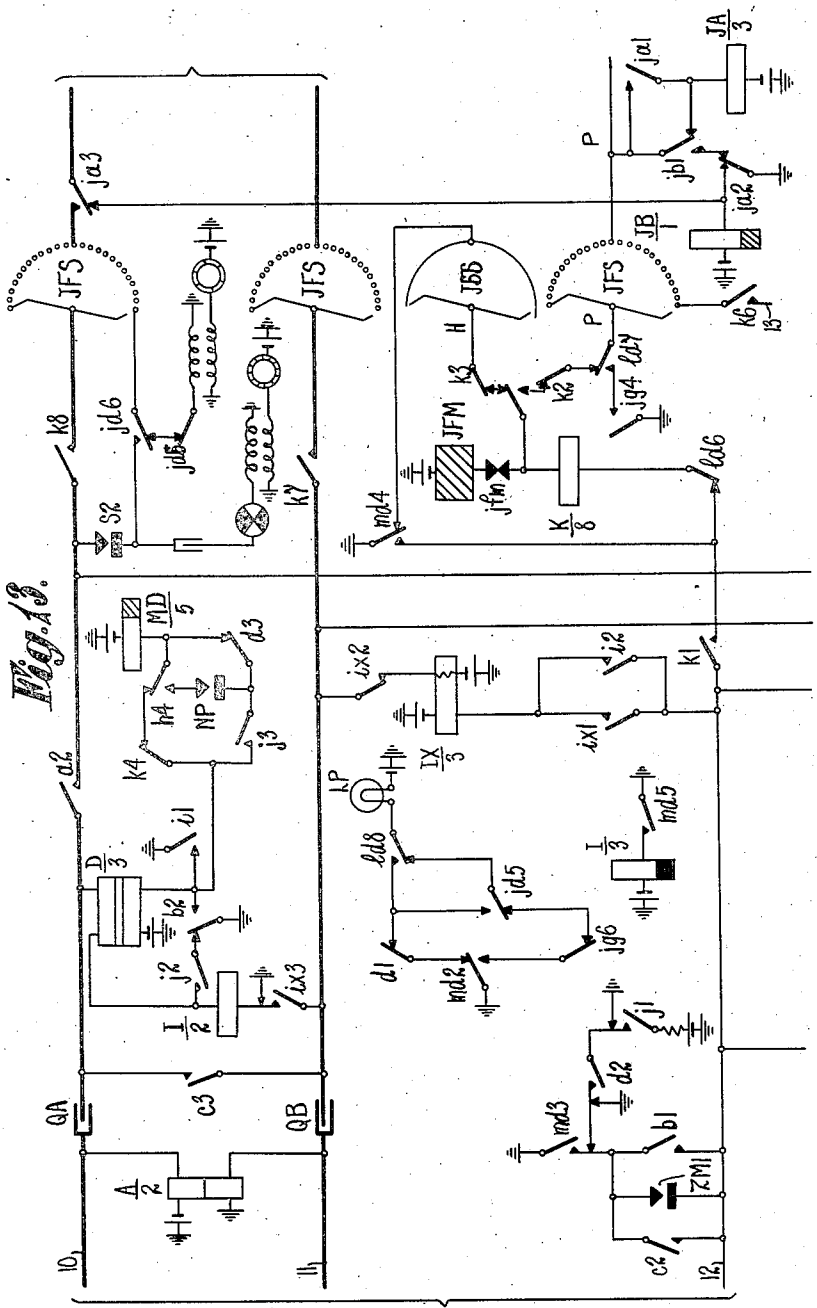
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TELEPHONE SYSTEM

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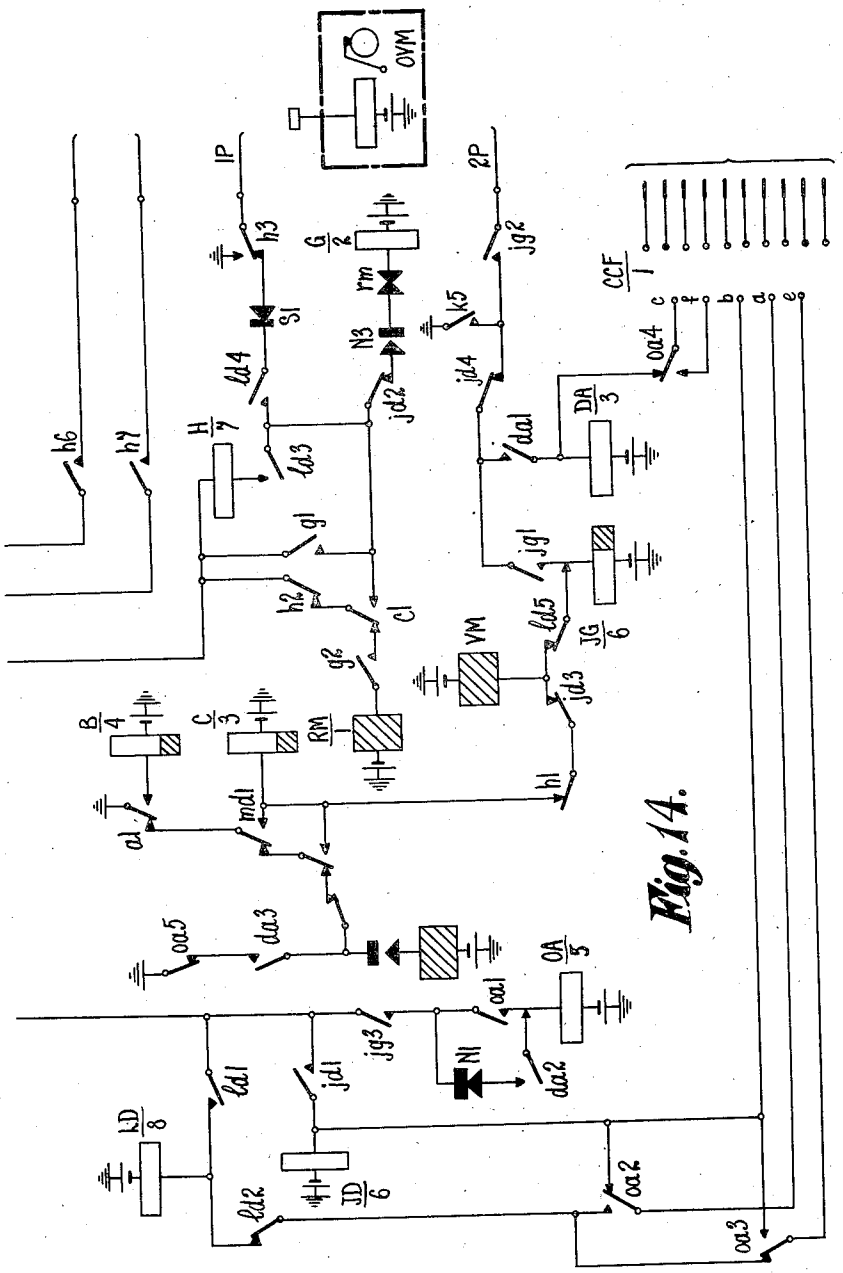


Fig. 14.

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Patented May 30, 1933 1,912,122

UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

Application filed September 28, 1931, Serial No. 565,605, and in Great Britain October 2, 1930.

The present invention relates to telephone systems and more particularly to arrangements whereby automatic switches may be controlled by equipment provided in common to a group of switches.

According to one feature of the invention in a group of automatic switches associated with common controlling apparatus, the extension of the speaking loop to one of the said switches causes the operation of two relays in series over the loop, one of said relays being located in the common controlling apparatus, while the other is individual to the switch.

According to a further feature of the invention a telephone system comprises a plurality of groups of lines, each group being served by regular and overflow finders in which the regular and overflow finders are brought into use over different wipers of a further switch.

According to another feature of the invention an impulse repeater is associated with common controlling apparatus which apparatus is adapted to be associated with a repeater by the operation of a relay individual to the repeater.

According to yet another feature of the invention a group of final selector switches are adapted to co-operate with incoming numerical switches associated with common controlling apparatus at a distant exchange over a two wire junction and are provided with means for placing a busy condition on the junctions associated with numerical switches when the common apparatus associated with said switches is taken into use.

The invention will be better understood from the following description of a preferred embodiment, reference being had to the accompanying drawings.

Figs. 1, 2, 3 and 4 show the arrangement of the finder switches,

Fig. 5 shows a first group selector with two sets of wipers,

Fig. 6 shows a second group selector with one set of wipers,

Fig. 7 shows a second group selector with two sets of wipers,

Fig. 8 shows a final selector with two sets of wipers,

Figs. 9 and 10 show a P. B. X. final selector,

Fig. 11 shows an impulse repeater, and

Fig. 12 shows a layout diagram, while

Figs. 13 and 14 show a discriminating selector repeater for use with incoming numerical selectors associated with common controlling apparatus.

The common equipment is preferably associated with a vertical group of switches, one controlling the first selector on each of say ten shelves, another controlling the second selector on each of say ten shelves, etc. This method has the advantage over the arrangement of associating the equipment with a horizontal group of switches in that each shelf of ten selectors has access to ten different common control equipments and thus the possibility of extensive trouble caused by a single fault is eliminated.

The switches are of the two-directional step-by-step type of well-known construction. The finder switches and first selector switches are connected together, the finder switches being controlled by common equipment which is associated with the switch to be controlled by means of a distributor switch whilst the selector switches are controlled by common equipment which is common to all the switches in a group. The two groups of common equipment are interconnected by operating circuits extending from one to the other.

The first selector switch includes other features such as arrangements for double hunting with preferential switching, for giving overflow busy from the common equipment, and in the case of permanent loops for releasing the common equipment and connecting back number unobtainable tone from the selector. The final selector switch is also provided with two sets of wipers, but in this case the set of wipers taken into use depends upon the route over which it is seized. Ringing, metering, and busy tone are connected up in the common equipment. The bridge relays for supplying speaking current to the calling and called subscribers are not connected up until the called subscriber replies but are then connected up by a relay in the switch which relay is held operated dependent upon the calling loop.

In the repeater the bridge placed across the outgoing loop after an impulse train has terminated is located in the common control equipment and can consequently be of low impedance, thus avoiding the tendency of giving an extra impulse to the line relay at the distant end of the trunk line which has existed in previous repeaters.

Moreover the impulse repeating relay is located in the common control equipment so that this relay can be made of low impedance for responding accurately to impulses whilst the relay in the repeater for supplying speaking current can be made of high impedance so as to reduce transmission loss.

Furthermore, the common control equipment is adapted to be disconnected from the repeater both when a called subscriber replies and when a called operator replies, different signals being received by the repeater in the two cases.

Figs. 1, 2, 3 and 4 show a line finder of known type except that overflow finders are incorporated therewith and minor modifications have been made for working with common control group selectors.

Subscribers' lines are divided into groups of 200 and each group is provided with a number of individual finders and when these are all busy, overflow finders are brought into use. Sufficient individual finders are provided to cater for all traffic except the peak, during which the overflow finders are brought into use. Two, three, four or five overflow finders, each one from a different 200 line group, are connected to one group selector and a number of similar combinations will constitute an overflow group. This overflow group caters for the traffic peaks from several different 200 line groups of subscribers. The peaks of traffic from say four 200 line groups will not coincide and advantage is taken of this to save an appreciable number of first selectors. The number of different line finders connected to one overflow group selector is determined by the traffic. The trunking schematic diagram shown in Fig. 12 illustrated this feature.

In this figure ARD and AOD illustrate the two wipers of the distributor switch over which the regular overflow finders respectively are brought into use. The wiper ARD is connected to the regular finders such as 1ARF and 2ARF which in turn are directly connected to the first group selectors 1AFGS and 2AFGS associated with common controlling apparatus 1FGC and 2FGC respectively. The wiper AOD is connected to the overflow finder 1OF which together with overflow finders 2OF, 3OF and 4OF from other line groups is connected to the first group selector 3AFGS. The remaining group selectors 3BFGS, 3CFGS and 3DFGS are similarly connected to overflow finders from other groups and are controlled by the common apparatus 3FGC.

It will, of course, be appreciated that the economies in selectors obtained by adopting the overflow finder group principle, are quite independent of the common control system.

The first group selector may be either of the 10/10 or 10/20 type. A permanent loop condition releases the common equipment and the selector only is held. The proposal is to step the selector and hunt for a free N. U. tone equipment on level 1. It is proposed to fit one common equipment for ten first selectors. The overflow busy signal is given from the common control equipment, because this condition should not affect more than 1 call in 500, with the standard grade of service.

The second group selectors may be of the 10/10 or 10/20 type. The associated common equipments will not contain relays for "throwing back" P. G's, but overflow busy will be given from them. It is proposed to fit one common equipment for 20 selectors. Similar type selectors on any rank are, of course, interchangeable.

The regular final selectors are of the 200 line type and provide battery feed for the calling and called parties. Ringing, metering, and busy tone are controlled by the common equipment. As the common equipment is held until the called party answers, it is proposed to fit one common group for six final selectors.

The P. B. X. final selectors may have from 2 to 10 lines in groups and employ a common control equipment from which is given P. B. X. hunting facilities, ringing, metering, and busy tone. As the common equipment is held until the called party answers, it is proposed to fit one common equipment for six final selectors.

Repeaters for use between two automatic exchanges fitted with common control simplify the following problems which exist in the present design of repeaters:—

(*a*) Introducing a high impedance bridge across the outgoing loop after an impulse train is finished, has tended to given an extra impulse to the distant A relay.

(*b*) The local A relay should have low impedance for dialling and high impedance for supplying speaking battery.

(*c*) Difficulty of giving supervision when the call is extended to a manual board, since reversing battery sets up metering conditions.

The proposed circuit shows how these problems are met in a simple manner. At the same time operating limits wider than are at present possible are provided. As the common equipment is held until the called party answers, it is proposed to fit one common equipment for four repeaters.

Referring now particularly to Figs. 1, 2,

3 and 4 in which Figs. 2 and 4 represent a subscriber's line circuit, a line finder and a distributor associated with the so-called A group and Figs. 1 and 3 represent similar circuits associated with the B group.

When a subscriber in the "A" group originates a call relay LR will operate from battery, lower winding of relay LR, armature *co*2, conductor 10, circuit containing calling subscriber's line and instrument, conductor 11, armature *co*3 to earth and at armature *lr*3 applies earth to the combined "start common and level marking" wire on the finder vertical bank, at armature *lr*1, earth is also applied to the private normal conductor 42 to guard the line against incoming calls. Relay A in the distributor is therefore energized, the circuit being battery, winding of relay A, armatures *kr*1, *za*5, *ya*2, non-inductive resistance 5YA, armatures *co*1 and *lr*3 to earth.

The distributor rotary line switch is preselecting and operates in the following manner. If a contact on the regular guard bank, that is, the bank with which wiper 7*a* engages is earthed, relay S of the distributor operates in series with relay H but without operating relay H, and at armature *s*1 completes a circuit for the distributor driving magnet DDM which in operating at interrupter springs *ddm* breaks the circuit of relay S. This interaction between relay S and the driving magnet continues until a free contact on the regular guard bank is reached. It should be mentioned here that relays YA and ZA in the "A" group distributor circuit, Figs. 2 and 4, and relays 1YA and 1ZA in the "B" group distributor circuit, Figs. 1 and 3, are normally operated and for this reason their armatures are shown on the drawings in an operated position. It will be seen that relay YA will only remain operated as long as there is a disengaged finder in the "A" group so that if all the finders are busy, relay YA will release since earth will be removed from all conductors such as conductor 16, and at armature *ya*2 will transfer the start common to the 1A relay in the "B" group of finders. If all the finders in the "B" group are busy, the start common is transferred back to the relay A of the "A" group by the release of relay 1YA in the "B" group distributor circuit and the overflow finders are brought into use.

Assuming now that a disengaged finder is encountered in the "A" group, wiper 7*a* will now no longer find earth on the bank contact but battery via resistance YC in the first group selector, Fig. 5. Thus relay H will operate over the circuit: battery, resistance YC, Fig. 5, armatures 2*hb*1, 2*ha*2, busying jack 3T1 of the first group selector, private conductor 15, busying jack T1 of the finder switch, contacts N3, bank contacts and wiper 7*a* of the distributor switch ADS, armatures *ya*3 and *k*1, both windings of relay H in series, armatures *k*4 and *a*1 to earth. Current will also flow from battery, winding of relay S, interrupter springs *ddm*, armature *h*1, lower winding of relay H, armatures *k*4 and *a*1 to earth but the resistance of the lower winding of relay H is such as to prevent the operation of relay S in this circuit. Relay H operates and locks over its upper low resistance winding via armatures *h*2 and *h*1 in series with the resistance YC in the first group selector, and at armature *h*3 energizes relay K which operates and locks via armatures *k*4 and *a*1. At armature *k*6 a circuit is completed for relay 2A in the first group selector common equipment, Fig. 5, which therefore operates from dial tone battery, armature *bb*2, winding of relay 2A, strap X, armatures 2*hb*4 and 2*ha*5 in the first group selector, negative talking conductor 13, armatures *ha*5 and *hb*5 in the finder switch, contact and wiper 6*a* of the distributor switch, armatures *fr*2, *c*1, *g*1 and *k*6 to earth. At armature 2*a*1 relay 2B is energized and in operating applies earth via armatures 2*b*2, 2*hb*1, and 2*ha*2 to the private conductor 15 thereby short circuiting relay H of the distributor which releases. The same earth is now utilized to operate slow acting relay C of the distributor via armatures *h*2, *k*7, *kr*2, *fr*1, winding of relay C to battery. At armature *c*1 the short circuit is removed from the winding of relay FR of the distributor and in addition the circuit for the vertical magnet VM of the finder is also completed from battery, winding of the vertical magnet VM, bank contact and wiper 3*a* of the distributor ADS, low resistance winding of relay C, armatures *c*1, *g*1 and *k*6 to earth. It should be noted that the first selector shown in Fig. 5 is adapted for use either in association with a finder switch as described or as an incoming selector. When used in the first capacity strap Y is removed and strap X is added while in the second capacity strap X is removed and stray Y is added. Relay FR also operates in series with relay 2A of the first group selector common equipment and at armature *fr*1 breaks the circuit of the winding of relay C. When the vertical magnet operates its contacts B will operate relay G of the distributor from battery, winding of relay G, armature *fr*3, wiper 2*a* and bank contact of switch ADS, vertical magnet interrupter springs, contacts V to earth and at armature *g*1 will break the circuit of the vertical magnet and relay C. This type of interaction between the relay and the magnet is well-known to those skilled in the art and it will continue until the finder has raised its wipers to the marked level, whereupon the earth which has been applied to the level marking wire at armature *lr*3 in the subscriber's line circuit will now be transmitted via vertical wiper VW, normal rotary springs

NR1, bank contact and wiper 1*a* of switch ADS, armatures *c*2 and *g*2, winding of relay G, resistance YA to battery, thus maintaining relay G operated. Relay C which has hitherto remained operated over its low resistance winding in series with the vertical magnet will now release since its circuit is broken at armature *g*1 so that relay G will also release when its circuit is broken at armature *c*2.

The rotary magnet RM of the line finder is now operated from battery, winding of rotary magnet, bank contact and wiper 4*a* of the switch ADS, low resistance winding of relay KR, armatures *fr*2, *c*1, *g*1 and *k*6 to earth and will step the wipers of the finder switch into engagement with the first set of bank contacts on the particular level, at the same time connecting relay G via rotary magnet springs R and armature *ha*2 to the finder switch wiper 3*c*. Relay KR will also operate over this circuit and lock up over armature *kr*2 to earth at off-normal spring contacts N3.

Assuming that the line circuit associated with this first set of contacts is not that of the calling subscriber the contact upon which wiper 3*c* is resting will be earthed, either via armature *lr*2 in the line circuit if the particular line is disengaged or if the line be engaged via the private wiper of the line finder which is being used on that call. In either case this earth will serve to operate relay G which at armature *g*1 will break the rotary magnet circuit. This interaction between relay G and the rotary magnet will continue until the contacts associated with the calling line are reached.

If it be assumed that these contacts are now in engagement with wipers 1*c*, 2*c* and 3*c* relay HA will now switch during the time that the rotary magnet springs R are closed the circuit being, earth, armature *kr*3, wiper 1*a* and bank contact of the switch ADS, lower winding of relay HA, rotary magnet springs R, bank contact and wiper 2*a* of switch ADS, armature *fr*3, winding of relay G to battery, but the resistance of this winding of HA is such as to prevent the operation of relay G in this circuit. At armature *ha*2 earth on the private conductor 15 is now extended by wiper 3*c* and bank contact of the finder switch and armature *lr*2 of the calling subscriber's line circuit to operate relay CO over its lower winding and also to hold relay LR over its upper winding. Relay CO at armature *co*1 disconnects the earth from the start common wire which releases relay A in the distributor, thus initiating the release of all distributor relays but the first group selector associated with the finder switch will now be held under the control of the calling subscriber since the circuit for relay 2A in the first group selector common equipment will now be dial tone battery, armature *bb*2, winding of relay 2A, strap X, armatures 2*hb*4 and 2*ha*5, negative conductor 13, armature *ha*5, wiper 2*c* and bank contact of the finder switch, conductor 10, circuit containing calling subscriber's line and instrument, conductor 11, bank contact and wiper 1*c* of the finder switch, armature *ha*4, positive talking conductor 14, armatures 2*ha*4 and 2*hb*3, left hand winding of relay 2K to earth. Relay K thereupon operates and locks up over its right hand winding via its make first armature 2K1 to earth at armature 2*b*2.

It will be seen that at the time when relay HA of the finder switch is operated the corresponding winding of relay HB will be short circuited on one side by the earth via armature *kr*3 and wiper 1*a* and bank contact of switch ADS and on the other side by the earth which will be connected to that contact on which wiper 6*c* is now resting since the line associated with this contact is not the calling line. If, however, the calling line is associated with the level with which wipers 4*c*, 5*c* and 6*c* engage then relay HB will switch and relay HA remains short circuited. Relay HB in switching performs exactly the same functions as relay HA except that the other set of line wipers are extended to the first group selector.

When the conversation is finished the switching relay HA or HB, as the case may be, released and a circuit is completed for the release magnet of the finder switch from battery which may be via the well known release alarm relay, winding of release magnet ZM, armatures *hb*3 and *ha*3, off normal contacts N1, armature *k*6 of the distributor switch to earth in order to restore the finder switch to normal.

If a fault causes the start relay A of the distributor switch to remain operated for longer than some predetermined period (usually three seconds) the time pulse which operates in conjunction with relays TA and TB in a manner well known to those skilled in the art, will transfer the start common to the other group of finders.

It should be mentioned that the A group of finders serves 100 subscribers forming the A group on the lower five levels and the 100 subscribers forming the B group on the upper five levels. The B group of finders serves the 100 subscribers forming the B group on the lower five levels and the 100 subscribers forming the A group on the upper five levels.

As has previously been stated, when all finders in the A group are busy, relay YA of the A group distributor circuit will release and at armature *ya*2 will transfer the start common wire to relay 1A in the B group distributor circuit. Relay 1A will therefore be operated on subsequent calls originated in the A group, and the finder in the B group

will therefore carry all traffic while the regular A finders remain busy, but should all the B finders also become busy relay 1YA will restore and transfer the A group start common back to its own distributor. Further calls originated in the A group will now be dealt with by the overflow group of finders but if these also become busy the relay ZA will release so that in the event of other calls being originated during this period, relay LC will be energized to operate the lost call meter (not shown). The sequence of operations is identical for calls originated in the B group except that the procedure is reversed.

Referring to the subscriber's line circuit Fig. 2, when the subscriber originates a call his meter will be short circuited by earth on the private conductor via armature *co*4, and the upper winding or relay CO, but when the call is finished a local circuit may be traced as follows, earth, winding of the subscriber's meter, armature *co*4, upper winding of relay CO, armature *lr*2, upper winding of relay LR, lower winding of relay CO to battery. This circuit is of high resistance and the meter consequently does not operate. Also in this condition the windings of relay CO will now be acting in opposition, so that it quickly releases, thus breaking the already mentioned local circuit. When the booster battery is applied to the private conductor for metering purposes the short circuit on the meter will thereupon be replaced by full booster battery (which, as is well-known, is usually a 50 volt battery with its negative pole earthed) and the meter will then operate. When booster battery is replaced by guarding earth again the meter will release and it will be seen therefore that several applications of booster battery to the private conductor which may conceivably take place in zone metering areas will give a corresponding number of registrations on the subscriber's meter. While booster battery is connected to the private conductor the two windings of relay CO will assist each other; they oppose only during the release of the connection. If zone metering is not required the line circuit shown can, of course, be simplified considerably.

Referring now to the first group selector shown in Fig. 5 when the subscriber's loop is extended from the finder switch relay 2K will operate over the circuit previously outlined and will lock up over its right hand winding from battery, right hand winding of relay 2K, make first armature 2*k*1, armature 2*b*2 to earth. It will be remembered that relay 2A and consequently relay 2B are already operated by the earth sent forward from the finder distributor. Relay 2B, by earthing the common private at armature 2*b*3, busies all first selectors in the group.

The first impulse from the subscriber's dial releases relay 2A which will step the vertical magnet 2VM of the first group selector over the circuit, battery, winding of the magnet 2VM, normal rotary springs 2NR1, armatures 2*k*5 and 2*g*1, right hand low resistance winding of relay 2C, armatures *bb*3, 2*b*6 and 2*a*1 to earth. Relay 2C also operates over this circuit and, in the well known manner remains operated during the train of impulses. It should be pointed out that only the vertical magnet of the group selector taken into use is operated as in all associated selectors the "2K" relay is not energized.

When the vertical impulses are finished relay 2C will release and complete a circuit for the rotary magnet 2RM of the first group selector from battery, winding of the rotary magnet 2RM, off normal contacts 2N3, armatures 2*k*4 2*g*4, *bb*1 and 2*c*1 to earth which will therefore step the wipers of the group selector into engagement with the bank. If both of the private contacts with which wipers 3*e* and 6*e* engage are earthed, relay 2G will operate when the rotary magnet springs 2R make near the end of the rotary step the circuit being battery, right hand winding of relay 2G, rotary magnet springs 2R, armature 2*ha*3, wiper 3*e* to earthed private contact. Further, the other coil of relay 2G will be short-circuited, on one side by the other earthed contact via wiper 6*e*, armature 2*hb*2, normal rotary springs 2NR1, armatures 2*k*5 and 2*g*1, and on the other side by earth via armatures 2*c*1, *bb*1 and 2*g*2 so that although relay 2G will operate in order to break the rotary magnet circuit at armature 2*g*4 yet its left hand holding winding will be inoperative. This interaction between relay G and the rotary magnet will continue until a free trunk to the next rank of switches, characterized by an unearthed private contact, is found.

If the wipers 3*e* and 6*e* encounter disengaged contacts simultaneously then as the rotary magnet is energized and the rotary magnet springs R are closed there will be a circuit completed for the switching relay 2HA from earth, lower winding of relay 2HA, armature 2*k*6, rotary magnet springs 2R, right hand winding of relay 2G to battery. Relay 2HA will lock operated over its upper winding to the earthed private conductor via armature 2*ha*2, but relay 2G will not be able to operate owing to the comparatively high resistance of the lower winding of the relay 2HA. The negative and positive talking conductors and the private conductor are switched to the next selector ahead and the common equipment of the first group selector will be released since the circuit for relay 2A is now broken at armature 2*ha*5.

If the private contacts associated with wiper 3*e* were busy and that associated with

wiper 6*e* were free, then relay 2G would operate and lock over its left hand winding whereupon relay 2HB would operate over the following circuit, earth, right hand winding of relay 2HB, armature 2*k*7, normal rotary springs 2NR1, armatures 2*k*5, and 2*g*1, resistance YD to battery. Relay 2HB will lock over its left hand winding to the private conductor via armatures 2*k**b*1 and 2*k**a*2 in order to switch the appropriate talking conductors and private conductor to the next selector rank.

If all trunks on the particular level dialled be engaged, the switch wipers will be rotated to the eleventh rotary position whereupon the cam springs CS will be operated. Relay 2G will operate via cam springs CS1 and rotary magnet springs 2R and relay BB will then operate via cam springs CS2 and armature 2*g*3 thereupon locking independent of armature 2*g*3 via armature *b**b*4. The earth via springs CS1 will also be extended to the eleventh step private contact to which is connected the overflow meter for that particular selector level, so that this meter will be operated in order to register the overflow condition. At armature *b**b*2 busy flash is connected to the calling conductors via the winding of relay 2A and a circuit is completed for connecting busy hold battery to the winding of relay 2B via armatures *b**b*3, 2*b*6 and 2*a*1 which will hold relay B operated each time the circuit of its left hand winding is broken due to the intermittent release of relay 2A in response to the busy flash.

If a subscriber fails to dial within a predetermined period the time pulse earth supplied by the "S" pulse cam will operate relay TP over its right hand winding via armature 2*b*4 and *cx*1 so that this relay will operate and lock over its left hand winding from battery, left hand winding of relay TP, armatures *tp*1, *cx*2 and 2*b*3 to earth. At armature *tp*2 the relay TZ is connected to the "Z" pulse cam so that upon the next operation of this cam it will supply earth to operate relay TZ which at armature *tz*2 will complete the vertical magnet circuit from earth, armatures *tz*2, *b**b*3, right hand winding of relay 2C, armatures 2*g*1 and 2*k*5, normal rotary springs 2NR1, winding of the vertical magnet 2VM to battery in order to step the wipers one vertical step. Upon the cessation of the "Z" pulse, the vertical magnet and relay 2C will release and the rotary cut-in of the wipers on the bank will take place, the switch thereupon hunting for a free number unobtainable tone equipment connected to the contacts of the first level.

Referring now to Figure 6, this shows a second group selector of the 10-level 10-trunk type and it is assumed that the call is extended from the first selector to a group selector of this type.

When the subscriber's loop is extended from the first selector, relays 3K and 3A will operate in series over the circuit, earth, left hand winding of relay 3K, armature 2*k*1, conductor 46, circuit comprising subscriber's line and instrument via the first group selector, the line finder switch and the line circuit, conductor 45, armature 2*k*2, strap 1X, winding of relay 3A, armature 1*b**b*1 to battery, relay 3K thereupon locking up to the earth sent forward on the private conductor 47, via its own make first armature 3*k*1. Relay 3A completes a circuit for relay 3B via armature 3*a*1 which operates and at armature 3*b*1 busies all associated selectors, and at armature 3*b*2 holds relay K. The train of impulses constituting the next dialled digit will step the switch wipers to the desired level after which relay 3C will release and allow the rotary magnet 3RM to step the wipers into engagement with the bank. If the first trunk is busy relay 3G will operate and break the rotary magnet circuit and this interaction will continue until a free trunk is found whereupon the characteristic absence of earth on the contact with which wiper 3*f* will now be resting will enable relay 2H to switch in series with relay 3G the circuit being, battery, winding of relay 3G, rotary magnet springs 3R, armature 3*k*6, lower winding of relay 2H to earth. When relay 2H operates it switches through to a final selector such as the one illustrated in Fig. 8, and releases the common equipment. If all trunks on the level dialled are busy the wipers will be rotated to the eleventh rotary position on that level and the cam springs operated to register on the overflow meter at cam springs 1CS1 and to operate relay 1BB at springs 1CS2. Relay 1BB in operating at armature 1*b**b*1 will connect busy flash to the calling line via the winding of relay 3A and at armature 1*b**b*4 apply the busy hold condition to the right hand winding of relay 3B. It should also be noted that in this circuit the switch magnets are all associated with the common apparatus over off-normal contacts.

Fig. 7 shows a first group selector of the 10-level 20-trunk type the circuit operations of which are similar to those of the first group selector shown in Fig. 5, with the exception that there is no dial tone equipment or facility for the transmission of number unobtainable tone if the subscriber delays to dial. A detailed description will, therefore, not be given of this circuit.

Referring now to the final selector shown in Fig. 8, it will be seen that either relays WS and 4A or relays 4K and 4A will operate in series over the calling subscriber's loop dependent upon the selector level from which the connection is extended, this final selector being of the type which is commonly referred to as a 200 line final selector. If relay WS operates the switch will function over one group of 100 lines whereas if relay WS does

not operate the switch will function over the other group of 100 lines.

Assuming the connection is extended in such manner as to operate relays WS and 4A in series then relay WS will lock up over its right hand winding via its own make-first armature *ws*1 and release magnet springs 4*z*1 and 4*z*2 to the earth sent forward on the private conductor 51. This earth is replaced upon the operation of relay 4B in the common equipment by the earth from armature *d*1 via armature 4*b*5. Relay WS also completes a circuit for relay 4K over the circuit battery, right hand winding of relay 4K, armature *ws*5, off normal contacts 4N2, armatures 4*k*2 and 5*b*4 to earth. Relay 4K thereupon operates and locks up over its right hand winding via its make-first armature 4*k*1 to the earth via armatures 4*b*5 and *d*1. Relay 4A at contact 4*a*1 causes the operation of relay 4B which at contact 4*b*2 closes a circuit for relay 4C from battery, right hand winding of relay 4C, armatures 4*b*2, *rn*2, 3*h*3, 4*k*5, contacts 4N3 and 4NR2 to earth in order to prepare the vertical magnet circuit at armature 4*c*3. The vertical impulses will step the switch to the desired level and maintain relay 4C operated. Relay 4C will however release upon the completion of the vertical impulse train in order to complete a circuit for relay E from battery, winding of relay E, armatures 4*c*2, *rn*3, 3*h*3, 4*k*6, off normal contacts 4N3, normal rotary contacts 4NR2 to earth. Relay E in operating at armature *e*4 will allow relay 4C to re-operate after which relay E will hold from battery, winding of relay E, armatures 4*c*2, *e*2, 4*b*3 to earth, the slug on relay E holding the relay operated while the armature 4*c*2 is changing over.

The next train of impulses constituting the final digit of the required number will step the rotary magnet to the desired line maintaining relay 4C energized over the circuit battery, winding of the rotary magnet 4RM, armatures 4*k*4, *e*3, 4*c*3, 4*b*1, left hand low resistance winding of relay 4C, armature 4*a*1 to earth, the first impulse also operating relay RN from battery, right hand winding of relay RN, armature *rn*7, in parallel with the rotary magnet 4RM and armature 4*k*4. Relay RN will immediately lock up from battery, right hand winding of relay RN, armature *rn*7, left hand winding of relay RN, armatures *f*3 and 4*b*4 to earth. When the rotary impulses are finished relay 4C will release and initiate the release of relay E but assuming the required subscriber is disengaged during the release of this latter relay there will be a circuit for relay H from earth, armatures 4*b*3 and *e*2, lower winding of relay 3H, armatures 4*c*1, 4*k*7 and *ws*2, private wiper and bank contact to battery via the subscriber's cut off relay. Relay H will operate its make-first armature 3*h*1 over this circuit and immediately lock up via this armature to the earth at armature 4*b*3. In addition the cut off relay in the required subscriber's line circuit will operate in order to clear the line of attachments before ringing is connected up when relay E has released. The circuit for the application of ringing current will be earthed ringing generator RG, right hand winding of relay F, armatures *e*1, *f*4, 3*h*3, 4*k*6, *ws*4, wiper and bank contact, circuit comprising subscriber's bell and condenser, bank contact and wiper, armatures *ws*3, 4*k*5, 3*h*2, *f*5, resistance YE to battery. In addition at armature 3*h*4 ringing tone is transmitted to the calling party via the winding of relay 4A in order to inform him that the required subscriber's bell is being rung. After relay E has released relay J will operate from battery, winding of relay J, armatures *f*2, *rn*4, *e*2 and 4*b*3 to earth and when the called party replies relay F will operate its armature *f*1, thus removing the short circuit from its left hand holding winding whereupon the relay is enabled to operate fully, the circuit now being battery, resistance YD, left hand winding of relay F, armatures 3*h*6, *e*2, 4*b*3 to earth. At armatures *f*4 and *f*5 relay D will be connected across the called subscriber's loop circuit while at armature *f*2 the circuit for relay J will be broken. It will be seen that at this time relay RN is dependent upon armature *j*2, and since relay D will operate immediately while relay J will release slowly, booster battery will be applied to the private conductor 51 via armatures *rn*6 and *d*1 for a period sufficient to operate the calling subscriber's meter. Relay RN being released relay 5B in the final selector will now operate from battery, winding of relay 5B, normal rotary springs 4NR1, armatures 4*k*3, *rn*1, *f*3 and 4*b*4 to earth. The operation of relay 5B closes a circuit for the operation of relay 5A over the speaking conductors which relay supplies speaking current to the line and at armature 5*a*1 closes a locking circuit for relay 5B. Conversation may now take place between the subscribers. Further the operation of relay 5B causes the release of the common equipment and also of relay 4K.

At the completion of the conversation, the release magnet 4ZM of the final selector operates as soon as armature 5*b*4 reverts to normal due to relay 5B releasing when its circuit is broken at armature 5*a*1 by the release of relay 5A. At the release magnet springs 4Z1 the holding circuit for relay WS is broken to enable this relay to restore, while at the release magnet springs 4Z2 the private conductor 51 is earthed to guard the final selector during the releasing period.

If the required party had been busy, earth on the private bank contact would have prevented relay 3H from operating and after the slow release period of relay E relay J would

have operated over the circuit previously outlined in order to connect busy flash to the calling line via armatures *j*1, 3*h*4 and the winding of relay 4A.

If the calling party had dialled an unallotted number, the bank contacts associated with which being connected to a number unobtainable tone equipment, then after relay 3H has switched battery on the negative speaking conductor relay F operates in order to trip the ringing but will not operate relay D. The operation of relay F will release relay J which in turn releases relay RN. Relay 5B in the final selector is therefore operated to release the common equipment and to connect the calling party through to number unobtainable tone, but since relay D does not operate booster battery is not connected to the release trunk since it is not desired that such a call should be metered.

Referring now to Figs. 9 and 10 this figure illustrates a so-called P. B. X. final selector which is arranged to serve single lines over one set of wipers and groups of 2 to 10 lines over the other set of wipers. Dependent upon the selector level from which this final selector is seized either relays 1WS and 6A or 5K and 6A will operate in series with the calling subscriber's circuit. Assuming that relays 1WS and 6A operate, then relay 1WS will immediately lock up via its own make-first armature 1*ws*1, release magnet springs 5Z1 and 5Z2, springs of busying test jack 6T1 to private conductor 53, which is at this moment earthed by the previous selector. At armature 1*ws*5 a circuit is completed for relay 5K which operates over its right hand winding from battery, right hand winding of relay 5K, armature 1*ws*5, off normal springs 5N2, armatures 5*k*2 and 6*b*1 to earth, and locks up from battery, right hand winding of relay 5K, make-first armature 5*k*1, armature 7*b*4, armature 2*d*1 to earth since relay 7B will be operated at armature 6*a*1 upon the operation of relay 6A. This earth will also hold relay 1WS when the earth sent forward from the previous selector is removed from the private conductor 53. Relay 7B in operating at armature 7*b*5 also serves to operate relay 6C from battery, right hand winding of relay 6C, armatures 7*b*5, 1*rn*2, 4*h*2, 5*k*5, off normal springs 5N2, normal rotary springs 5NR2 to earth. When the subscriber dials the final train of impulses the switch wipers are stepped to the required level, relays 6C and 7B remaining operated and at the completion of impulsing relay 6C will release and energize relay 1E over the circuit, battery, winding of relay 1E, armatures 6*c*3, 1*rn*3, 4*h*5, 5*k*6, off normal springs 5N2, normal rotary springs 5NR2 to earth. At armature 1*e*3 this earth will be connected to the winding of relay 6C thus operating this relay while relay 1E thereafter holds via armatures 6*c*3, 1*e*4 and 7*b*2 to earth. At armature 1*e*2 the impulsing circuit is changed over from the vertical magnet to the rotary magnet so that the next train of impulses will operate the rotary magnet 5RM, the circuit for each impulse being battery, winding of the rotary magnet 5RM, armatures 5*k*4, 1*e*2, *hs*2, left hand low resistance winding of relay 6C, armatures *hs*3, 6*c*4, 7*b*1, 6*a*1 to earth. If it be assumed that relay 1WS is not operated and therefore that one of the hundred regular subscribers is required, the P. B. X. function of the selector will not enter into the subsequent operation which will be substantially the same as has previously been explained in connection with the regular final selector illustrated in Fig. 8, but if relay 1WS is operated then the P. B. X. function of the switch will be brought into operation. In this case it should be mentioned that all the lines in any P. B. X. group except the last line of the group will have their P. B. X. arc contacts connected to earth and in addition the P. B. X. arc wiper 1*f* is arranged to lead one contact space on P. B. X. arc wiper 2*f*.

If it be assumed that the first line of a P. B. X. group be dialled, then wiper 1*f* will come to rest on the P. B. X. contact associated with the first line of the group and wiper 2*f* on the P. B. X. contact associated with the last line of the preceding group which, as had just been stated, will not be earthed.

It will be seen therefore that when relay 6C releases at the end of rotary stepping relay HS will operate from battery, resistance YG, armatures 1*j*1, 4*h*4, 6*c*2, left hand winding of relay HS, armature 5*k*9 and wiper 1*f*, P. B. X. arc contact, armature 1*ws*5, 5*k*1, 7*b*4 and 2*d*1 to earth so that assuming that the first line is busy, when relay 1E restores a circuit will be completed for the rotary magnet from battery, winding of rotary magnet 5RM, armatures 5*k*4, *hs*2, left hand low resistance winding of relay 6C, armature *hs*3, right hand low resistance winding of relay HS, armatures 4*h*7, 1*e*4, 7*b*2 to earth, and so rotate the switch wipers into engagement with the next line in the group.

If, however, the first line in the group had been disengaged relay 4H would have switched before relay 1E had released in a manner similar to that described in connection with the regular final selector illustrated in Fig. 8.

When the rotary magnet has operated, the circuit of relay 1E will again be completed from battery, winding of relay 1E, armature 6*c*3, rotary magnet springs 5R, armatures 1*ws*5, 5*k*1, 7*b*4, 2*d*1 to earth so that relay 1E operates and breaks the rotary magnet circuit at armature 1*e*4, in order to allow the rotary magnet to restore. This interaction between the rotary magnet 5RM and relay 1E will continue until either a disengaged line in the group is reached or, in the case of all the lines in the group being busy, the wipers have

been rotated to the last line in the group. In the former case relay 4H will switch during the release time of relay 1E in a manner similar to that already described while in the latter case, relay 4H will be unable to switch owing to an earthed private contact. Since relay HS will also release in view of the fact that wiper 1*f* will now not be connected to earth (last line of a group), relay 1J will therefore operate when relay 1E finally releases, the circuit being battery, winding of relay 1J, armatures 1*f*2, *hs*1, 1*rn*5, 1*e*4, 7*b*2 to earth in order to complete the circuit for the transmission of busy flash and tone to the calling party, at armature 1*j*2.

In the case of a disengaged line being found, subsequent circuit operations will be similar to those already described for the regular 200 line final selector illustrated in Fig. 8.

The purpose of the second wiper 2*f* will now be explained. When only one line of the P. B. X. is available, for instance in the case of business houses when the majority of the staff have left, a subscriber wishing to make a connection will have to dial direct on to the available line and no P. B. X. hunting will be required. In this case P. B. X. hunting will be prevented owing to the left hand winding of relay HS being short circuited over the two wipers 1*f* and 2*f*.

Referring now to Fig. 11 which shows a repeater for use between two automatic exchanges, when the repeater is seized relay 6K will operate in series with relay AC in the common equipment and lock up from battery, right hand winding of relay 6K, make-first armature 6*k*1, armature 8*b*5, busy test jack springs 7T1 and 7T2 to the earth applied to private conductor 57 by a preceding selector. When this earth is removed, relay 6K locks up to earth via armatures *jb*1, *bc*3 and 3*d*2 to earth since by this time relay BC in the common equipment will have operated over its upper winding to the earth at armature *ac*1. Since all repeaters connected to this common equipment have their private conductors connected together, they also are guarded by earth from the common contact. At armature 6*k*3 battery will be applied to the positive conductor 58 of the outgoing junction to the distant exchange to operate the "K" relay in the incoming selector connected to the other end of the junction, the circuit being from battery, resistance YH, armatures *jr*1, *iw*5, *ac*2, 2*bb*1, 6*k*3, to the positive conductor 58. In the incoming selector the consequent operation of the "K" relay will result in battery being connected to the negative conductor 59 of the junction and this battery will serve to operate relay IC in the common equipment of the repeater via the following circuit, battery on the negative conductor 59, armatures 6*k*4, 2*bb*2, upper or line winding of the polarized relay 3D, winding of relay IC, armatures *iw*5 and *jr*3 to earth. It should be noted that in an incoming selector to this type of operation the strap "X" is removed. At armature *ic*2 a circuit will be completed for relay IX from battery, winding of relay IX, armatures *jr*4, *ic*2 and *bc*4 to earth, relay IX thereupon locking up from battery, winding of relay IX, armatures *iw*3, *ic*2, *bc*4 to earth. At armature *iw*5 relay IX connects relay IC and the upper or line winding of relay D in series across the loop outgoing to the distant exchange and at armature *iw*2 relay 2J is enabled to operate via armatures 3*d*1 and *bc*4 to earth then locking via armature 2*j*1 independent of armature *iw*2. The operation of relay 2J will result in the operation of its relief relay JR at armature 2*j*2. It should be pointed out that the B relay in the common equipment of the incoming selector at the distant exchange will connect earth to the negative conductors of all selectors associated with the common equipment in order to energize the JB relays in the repeaters associated therewith and so busy the repeaters by the operation of the "JB1" armatures. The subscriber now dials and relay AC will impulse and at armature *ac*2 repeat the impulses over the conductors to the distant exchange. On the first release of relay AC armature *ac*1 serves to operate relay 7C which at armature 7*c*1 short circuits relay IC and the line winding of relay D in order to provide a dialling loop of minimum impedance. It will be seen that no talking condensers are connected to this impulsing circuit and as a result the repetition of impulses is an improvement on the standard method. In addition, the impulsing is improved due to the fact that relay AC is designed for impulsing only instead of being a compromise between an efficient impulsing relay and a high impedance talking relay as is the case in the standard repeater.

When the switch train in the distant exchange has been set up and the final selector operated, ringing tone will be transmitted from this selector and will pass through the common equipment to the calling subscriber via armatures 6*k*4 and *ic*1, condenser QC and armature 8*b*2.

When the called party replies the final selector in the train of switches at the distant exchange will reverse battery over the junction in the well-known manner and accordingly operate the polarized relay 3D in this repeater. At armature 3*d*2 booster battery is applied to the release trunk until the release of relay JR which will take place after the release of relay 2J consequent upon the operation of armature 3*d*1. The release of relay JR will disconnect booster battery from the release trunk at armature *jr*5 and will also, at armature *jr*2 result in the operation of relay 8B in the repeater, the circuit being battery winding of relay 8B armatures 6*k*2, *jr*2, 3*d*1

and *bc*4 to earth. At armatures 8*b*2 and 8*b*3 the battery feeding relay 8A in the repeater is connected to the calling line, armature 8*b*2 also disconnecting the AC relay in order to release the common equipment. Relay 4D of the repeater will respond to reverse battery from the distant final selector and by reversing the calling feed at armatures 4*d*1 and 4*d*2 provide the necessary supervision for use in the case of a calling manual operator.

When the calling party restores his receiver a momentary earth energizes relay BC in the common equipment via armatures 8*a*1 and 8*b*4 to ensure that the local private conductor is maintained busy until the distant exchange switches have released.

If a busy condition is encountered during the setting up of the switch train in the distant exchange, busy flash will be transmitted over the junction to the repeater. During the first busy flash period, since no current will then be flowing over the junction, relay IC in the repeater will release and allow relay IX to restore. At the cessation of the busy flash period relay IC re-operates and operates relay 2BB the circuit being battery, winding of relay 2BB, armatures *ix*1, *jr*4, *ic*2 and *bc*4 to earth. At armature 2*bb*3 busy flash is connected to the calling lines via the winding of relay AC, at armature 2*bb*5 busy hold conditions are applied to the lower winding of relay BC, and at armatures 2*bb*1 and 2*bb*2 the loop to the distant exchange is opened in order to allow the switches set up at that exchange to restore.

If the call had been for a manual board off a selector level instead of for a subscriber the answering equipment shown would be used. Relay 2LR operates through the repeater loop to the momentary earth extended from the preceding selector on the private conductor. When relay 2LR operates, it signals the manual operator via armature 2*lr*3, connects ringing tone to the calling party via armature 2*lr*1 and ring-tone condenser QR, and at armature 2*lr*2 earths the private conductor 64 and provides earth for locking itself through the distant loop. When the operator answers by plugging into the answering jack AJ relay 2CO operates and connects ringing current to the line for the release period of relay 2LR in order to operate relay MO over its upper winding in the repeater common equipment. Relay MO will lock over its lower winding via armatures *mo*1 and *bc*4 and at armature *mo*2 operates relay 8B of the repeater in order to free the common equipment. By this method supervision may be given without reverse battery causing metering conditions. The selectors which terminate the junction may be provided with time pulse relays for throwing back P. G's to the selector if required. The common equipment would then be identical with that provided for first selectors with the exclusion of dial tone.

Figs. 13 and 14 show a discriminating selector repeater adapted for use with incoming selectors at a main exchange where the selectors are controlled by common apparatus.

Referring now to Figs. 13 and 14 when the calling subscriber's line is extended over the conductors 10 and 11 to the discriminating selector repeater relay A is operated and at armature *a*1 completes a circuit to relay B and at armature *a*2 prepares a point in the impulsing circuit to the switch which is selected subsequently. Relay B in operating at armature *b*1 connects earth to the release trunk conductor 12 to busy the circuit and hold operated the preceding switch, at armature *b*2 energizes the polarizing winding of the shunt field relay D and operates relay MD, at armature *b*3 completes a driving circuit to the junction finder switch JFS which will be described in detail later, and at armature *b*4 completes a point in the energizing circuit to the vertical magnet VM. Relay MD in operating at armature *md*1 prepares a further point in the circuit of the vertical magnet independent of contact *b*4, at armature *md*2 completes a circuit for lighting the supervisory lamp LP which is not of sufficient duration to enable the time alarm device connected in series therewith to be operated, at armature *md*3 connects an earth to the release trunk conductor 12 independent of contact *d*2, at armature *md*4 disconnects the homing circuit to the junction finder JFS and prepares the switching circuit for relay K and at armature *md*5 operates relay J. Relay J in operating at armature *j*1 completes a point in the circuit for the application of booster battery metering potential to the release trunk conductor 12, at armature *j*2 prepares a circuit for holding relay I which is effective later, and at armature *j*3 provides an alternative locking circuit to relay MD. Owing to the operation of relay B the driving magnet JFM is connected in circuit with the test wiper P and in case the first set of contacts should prove busy wiper P will encounter earth which serves to energize the driving magnet in a self interrupted circuit to advance the wipers on to the next set of bank contacts. It will be noticed that the switching relay K is short circuited under these conditions by earth connected to both sides of its winding. In this manner the magnet is intermittently energized to advance the wipers into engagement with an idle junction line as indicated by the absence of earth on the contact engaged by wiper P.

When an idle line is found the driving circuit to the magnet is discontinued and as relay K is no longer short circuited it operates in series with the driving magnet JFM and

at armature *k*1 locks to earth on the release trunk conductor 12. It should be explained that the resistance of relay K is sufficiently high to prevent the operation of the driving magnet JFM in series therewith. Moreover at armature *k*2 direct earth is connected to the test wiper P so as to busy the junction guard relays JA and JB the function of which will be described later. At armature *k*3 opens a further point in the homing circuit to the switch JFS, at armature *k*4 opens the initial energizing circuit to relay MD, at armature *k*5 prepares a locking circuit for relays JG and DA, at armature *k*6 prepares the start circuit over conductor 13 to the ringing and tone generator not shown, and at armatures *k*7 and *k*8 prepares the impulsing circuit by way of the wipers and bank contacts of the junction finder to the junction selected.

Returning now to the operation of the junction guard group of relays, it will be seen upon the application of earth to the test wiper P, relay JA is operated and locked, and in turn operates the slow to release relay JB which prepares a circuit for the subsequent application of earth to the test contact at a later period. Moreover relay JA in operating at armature *ja*3 switches through the upper lead of the junction to complete a circuit for relays I and D in series. It should be explained that relay K in operating extends battery by way of a resistance conveniently wound on relay IX to the lower junction conductor to effect the operation of a relay K in the incoming selector not shown, but assumed to be substantially identical to that described in Fig. 5. Relay K in operating in the incoming selector connects battery through the line relay A in the common equipment over the upper junction lead to effect the operation of relay I in series with the shunt field relay D which is not operated when connected up in this sense. Consequently relay A in the common equipment of the incoming circuit and relay I in the discriminating selector repeater are operated in series the former completing a circuit relay B in the common equipment which connects earth by way of all the selectors associated with the common equipment to the upper junction conductors extending therefrom, whereupon the JB relays associated with the outgoing end of the junctions terminating in these selectors are operated to connect earth to the corresponding contact of the bank engaged by wiper P of the switches JFS so as to mark these junctions as busy.

Relay I in operating in the discriminating selector repeater at armature *i*1 supplements the earth connected up by armature *b*2 and at armature *i*2 operates relay IX over its left hand winding. Relay IX in operating locks by way of its armature *ix*1, at armature *ix*2 disconnects resistance battery from the lower junction conductor, and at armature *ix*3 connects relays D and I in bridge with the junction circuit. Under these conditions a distinctive tone indicative of the dialling condition is fed back over the junction line from the incoming selector at the main exchange and when the calling subscriber hears this tone he will then proceed to dial the first digit of the wanted number. In case, however, all the junctions extending from the junction finder JFS are busy the wipers of the switch will be automatically rotated into engagement with the last set of bank contacts which are unwired as regards a junction connection, and in order to afford the calling subscriber the opportunity of completing his connection in case the call is to be set up over the local train of switches, means are provided for the transmission of a dialling signal by way of the resting armatures *jg*5 and *jg*6, bank contact and wiper of the switch JFS to the upper speaking conductor. No further circuit changes will take place until the reception of the first series of impulses whereupon relay A is operated in synchronism and at each de-energization completes the following circuit for energizing the vertical magnet VM in parallel with relay C to battery, and in parallel therewith by way of armatures *h*1 and *jd*3, winding of the vertical magnet VM to battery. In addition a still further branch path may be traced from the winding of the vertical magnet by way of armatures *ld*5 and *jg*1 to effect the operation of relay JG, which thereupon disconnects itself from the impulsing circuit and locks to earth at armature *k*5. In this manner the vertical magnet is energized to raise the shaft and wipers to the desired level corresponding to the number of impulses in the series, and it should be explained that relays C and B are each provided with copper slugs surrounding their cores so as to enable them to hold operated continuously throughout the impulsing period. Relay C in operating at armature *c*1 prepares a circuit to relay G, at armature *c*2 connects earth to the release trunk conductor 12 and at armature *c*3 short circuits relays D and I to provide a more effective impulsing circuit to the switch ahead which is controlled by armature *a*2. During the first vertical step the off normal springs are operated thereupon at springs N1 opening a point in the circuit to relay OA which is not effective at this time, at springs N2 closes a point in the circuit to the release magnet ZM, and at springs N3 completes a circuit for operating relay G which locks by way of its armature *g*1, and at armature *g*2 completes a point in the energizing circuit to the rotary magnet RM. At the conclusion of the train of impulses the wipers of the discriminating selector repeater and those of the incoming switch at the distant exchange will be raised to similar levels, and as relay A is now held

operated for an extended period relay C will release after a short interval and at armature *c*1 completes a circuit to the rotary magnet RM, by means of which the wipers are advanced into engagement with the first set of bank contacts. It should be explained that the lower testing wiper 2P is reserved for discrimination as to the type of connection desired depending upon the number of digits dialled, and for this purpose the first contact in each level is wired out to a cross connecting frame so that by suitable jumpering the class of call, either local or distant may be selected, and moreover a digit absorbing feature is available whereby the first digit in any series may be absorbed. The wiring of the first bank contacts to the cross connecting frame CCF is associated with wiper 2P shown in detail, in the drawings and these may be jumpered to the terminal points designated *a*, *b*, *c*, *e* or *f* depending upon the class of the call desired.

Assuming now that the first contact in the level selected by wiper 2P is cross connected to the terminal point *a*, relay JD will be operated and locked, and at armature *jd*2 opens the circuit of relay G to terminate the automatic rotation of the wipers, at armature *jd*3 opens the circuit of the vertical magnet so that it will not be affected by subsequent trains of impulses, at armature *jd*4 releases relay JG, at armature *jd*5 prepares a point in the circuit to the supervisory lamp LP and at armature *jd*6 completes a circuit for the transmission of a busy signal to the calling party in case a free junction is unavailable at this time. Subsequent series of impulses are therefore repeated by relay A to the main exchange to control the setting of the switches thereat for the completion of the connection.

In case the first contact selected by wiper 2P is cross connected to the terminal point *b*, the same sequence of operations will be produced.

In case the first contact selected by wiper 2P is cross connected to the terminal point *c*, a circuit is completed for relay DA which operates and locks to bring about the digit absorbing feature. Moreover, at armature *da*2 a circuit is completed for the operation of relay OA when the switch reaches its normal position, at armature *da*3 the release magnet ZM is energized to restore the shaft and wipers to normal. When the normal position is reached relay OA is operated and locked by way of its armature *oa*1 in an independent circuit, at armatures *oa*2 and *oa*3 alters the normal conditions produced by the connections to the terminal points, and at armature *oa*4 extends the terminal point *c* to the terminal point *f*, so that in case the second digit dialled is the same as the first, the proper relay JD or LD may be operated to determine whether the call is local or distant, and at armature *oa*5 the release circuit is opened.

In case the first contact selected by wiper 2P is cross connected to the terminal point *e*, relay LD is operated and locked to prepare the circuit for a local call. Moreover at armature *ld*2 the original energizing circuit is opened, at armatures *ld*3 and *ld*4 the switching relay H is connected in circuit with the upper test wiper 1P, at armature *ld*5 the original energizing circuit is opened to relay JG, at armature *ld*6 relay K is released to free the junction circuit, at armature *ld*7 earth is maintained to the test contact in the finder switch bank until such time as relay JG is restored after its disconnection by relay K, and at armature *ld*8 a further point is prepared in the circuit to the supervisory lamp LP. Under these conditions therefore the common equipment associated with the incoming selector at the main station is also released, thus disconnecting earth from the upper junction lead of all associated junctions, to restore all JB relays, thus removing the busy condition from these junctions. Moreover, owing to the disconnection of earth fed forward over wiper P of the junction finder JFS in question, relay JA is released and is followed after a short interval by relay JB. In this manner earth is connected over armatures *ja*2 and *jb*1 to mark the junction finder as busy, so that the apparatus at the main exchange may be completely restored before the junction line is made available at the satellite exchange.

Referring now particularly to the case where relays DA and OA are operated in response to the first series of impulses, it will be assumed that the switch is operated by the second series of impulses into a position where earth is extended over wiper 2P to the terminal *a*. In this case relay LD is operated and locked so that the call may be completed locally and as relay H is now connected in circuit with the upper test wiper IP it will remain short circuited until such time as this wiper encounters a free outlet, or alternatively until the wipers are moved into their eleventh rotary position.

Considering first the case in which a free outlet is found relay G will not again be operated to the absence of earth on the test contact and as the short circuit is removed from the winding of the switching relay H this relay will operate in series with relay G. The resistance of relay H is sufficiently high to prevent the operation of relay G under these conditions. Relay H moreover at armature *h*1 opens the circuit to the vertical magnet VM so that it shall not be influenced by further impulsing, at armature *h*2 opens the initial energizing circuit to relay G so as to prevent further rotary impulsing, at armature *h*3 connects direct earth to the test wiper IP to busy the selected switch, at armature *h*4 opens

the initial energizing circuit to relay MD which is however held operated by way of the resting armature *d*3 and operated armature *j*3, at armature *h*5 opens a point in the circuit to the release magnet ZM, and at armatures *h*6 and *h*7 extends the impulsing circuit by way of the wipers and bank contacts to the switch ahead.

Considering now the condition when all the outlets in the level selected are busy the wipers of the switch will then be rotated into the eleventh position where cam springs are operated, thereby at springs S1 disconnecting the switching relay H from the test wiper IP and at springs S2 completes the circuit for the transmission of a busy signal over the upper speaking conductor to inform the calling subscribed that the connection desired is unavailable. Relay H is permitted to operate under these conditions to fulfil the functions already described, and in addition at armature *h*3 connects direct earth to the test wiper IP so as to effect the operation of an overflow meter OVM which is multipled to all eleventh step contacts for the purpose of registering overflow calls on all levels.

Considering now a successful completion of the desired connection, when the called subscriber replies, current flow in the outgoing speaking leads either over the junction lines or over a local connection is reversed, whereupon the shunt field relay D is operated, at armature *d*1 opens a point in the circuit to the supervisory lamp LP, at armature *d*2 prepares a point in the metering circuit and at armature *d*3 opens the holding circuit to relay MD. Relay MD therefore releases after a short interval and in turn opens the circuit to relay J, and during the slow release period of this latter relay booster battery potential is connected to the release trunk conductor 12 to effect the operation of the calling subscriber's meter in a manner which is now generally well recognized. Upon the full release of relay J, earth is again connected to the release trunk conductor 12 and a further point is opened in the locking circuit to relay MD. It should be explained that relay MD is provided with a copper slug to introduce a delay in the connecting up of the meter circuit, thereby avoiding the possibility of false metering in case the shunt field relay D should inadvertently flick owing to condenser surges in the line circuit. In the case of local connections subscribers are requested to dial "0" to obtain access to the enquiry operator and in order that they shall not be metered for this facility, the switch is provided with what are known as normal post springs designated in the drawings NP, and arranged to be operated when the "0" level is dialled. The operation of these springs provides an alternative holding circuit to relay MD so as to cancel the metering feature.

At the end of the connection when the calling subscriber clears relay A releases and is followed shortly after by relay B, and in case the connection has been completed over the wipers of the discriminating selector relay H will follow the release relay B and complete a circuit for the release magnet by way of the resting armatures *a*1, *md*1, *b*4, *h*5 and operated off normal springs N2, winding of release magnet ZM to battery. It will be seen from the drawings that the release magnet is equipped with a set of springs designated *zm*1 arranged to connect earth to the release trunk conductor 12 during the release movement so as to prevent the switch again being seized until the wipers and apparatus are fully restored to normal.

In case the connection has been extended over a junction line relay K follows the release of relay B and completes a homing circuit to the junction finder switch JFS by way of earth at armature *md*2, homing plate and wiper H, armatures *k*3 and *b*3, interrupter springs *jfm*, driving magnet JFM to battery. The wipers are therefore automatically rotated into the home position, where the homing circuit is opened. Upon the disconnection of earth from wiper P and bank contact of the switch JFS, the junction guard relay JA is released and at its resting armature *ja*2 again applies earth to the test contact for a short interval represented by the slow releasing period of relay JB, to ensure that the apparatus at the main exchange is completely restored to normal before the junction is again taken into use.

In case the called subscriber should clear and the calling subscriber continues to hold the connection for an undue length of time, a circuit will be completed by way of the resting armatures *md*2, *d*1 and alternatively *jd*5 or *ld*8 for lighting the supervisory lamp LP which is in circuit with a delayed alarm device. If the condition persists the delayed alarm device will operate after the period for which it is set to provide a common alarm, which in conjunction with the lighting of the individual lamp LP enables the faulty connection to be located. Alternatively in case the switch is seized, but the calling subscriber fails to dial within a specified period of time the supervisory lamp LP will again be lit in series with the delayed alarm device over a circuit formed by way of the operated armature *md*2, and resting armatures *jg*6, *jd*5 and *ld*8.

In case the calling subscriber should clear his connection during a busy flash condition or alternatively when the call is completed by way of a manual board, battery will be connected to one or both of the junction conductors from the apparatus at the distance exchange to hold the connection.

Considering now the circuit operations involved, relay A in releasing re-operates relay

C to maintain a guarding earth to the release trunk conductor 12, and upon the release of relay B earth is connected by way of the operated armature *j2* to the centre point of the windings of relays I and D so that these may be energized in parallel to battery connected over the lower junction conductor. Relay I in operating holds relay MD to maintain the connection and this condition will persist until the flash period is ended or alternatively the operator clears her connections. Similar conditions will also obtain in case a local connection is established by way of a manual board.

We claim:

1. In a telephone system, a group of automatic switching apparatus units, controlling apparatus common to the units of said group, a relay for each of said units for connecting the corresponding unit to said controlling apparatus, and a line relay in said controlling apparatus operated in series with any one of said connecting relays.

2. In a telephone system, a group of automatic switches, common controlling apparatus associated therewith, a relay in each switch in said group for connecting the associated switch with said common apparatus, and a common line relay in said apparatus adapted to be operated in series with the relay in any one of said switches.

3. In a telephone system, a group of selector switches, a common apparatus unit adapted to control said group of switches, a plurality of test wipers for each of said switches, and a test relay located in said apparatus unit adapted to test over a plurality of test wipers of the switch to which said unit is associated.

4. In a telephone system, a selector switch, other selector switches, a common apparatus unit adapted to control all of said switches, means for operatively associating said first switch and said common apparatus unit for a predetermined interval, and means responsive after the lapse of said predetermined interval for operating said first switch to transmit a distinctive signal to a calling subscriber.

5. In a telephone system, a selector switch, other selector switches, a common apparatus unit adapted to control all of said switches, means for operatively associating said first switch and said common apparatus unit for a predetermined period, and means responsive when impulses for setting said switch are not received before said predetermined period has elapsed for causing said switch to transmit a distinctive signal to a calling subscriber.

6. In a telephone system, a selector switch, other selector switches, a common apparatus unit for controlling all of said switches, means for operatively associating the common apparatus unit with said first switch responsive to the initiation of a call by a subscriber, means controlled by the calling subscriber for transmitting impulses to said first switch, and means in said apparatus unit responsive when said impulses are not received within a predetermined time limit for causing said switch to be operated to a predetermined position to transmit a distinctive signal to said calling subscriber.

7. In a telephone system, a connector switch, other connector switches, a common apparatus unit adapted to control all of said switches, a test conductor incoming to said first switch, a source of booster battery potential for controlling metering, and means in said common controlling apparatus for controlling the application of said booster battery potential to said test conductor.

8. In a telephone system, a connector switch, other connector switches, a common controlling apparatus unit associated with said first switch and adapted to control all of said switches, two sets of wipers for said first switch, one set for extending connections to groups of lines extending to private branch exchanges, and the other set for extending connections to individual lines, two routes over which said first switch may be seized, the set of wipers to be used in extending the connection being dependent upon the path over which said first switch is seized.

9. In a telephone system, a connector switch, two paths over which said switch may be seized, one set of wipers for said switch having access to groups of lines extending to private branch exchanges, a second set of wipers for said switch having access to individual lines, the set of wipers used in extending the connection being dependent upon the path over which the switch is seized, other similar connector switches, and a common controlling apparatus unit associated with said first switch and adapted to control all said switches.

10. In a telephone system, a connector switch, other connector switches, a common controlling apparatus unit associated with said first switch and adapted to control all of said switches, two sets of wipers for said first switch, one set for extending connections to groups of lines extending to private branch exchanges, the other set for extending connections to individual lines, two routes over which said first switch may be seized, the set of wipers to be used in extending the connection being dependent upon the path over which said switch is seized, contacts for controlling the hunting movement of said switch over a group of lines, and means controlled when said switch is seized over a particular one of said routes for connecting up said contacts.

11. In a telephone system, a connector switch, other connector switches, a common controlling apparatus unit associated with

said first switch and adapted to control all of said switches, groups of lines accessible to said first switch, means responsive to a plurality of series of impulses for operating said first switch to select the first line in one of said groups of lines, and a relay in said apparatus unit for controlling said first switch to hunt over the remaining lines in the selected group.

12. In a telephone system, a connector switch, other connector switches, a common controlling apparatus unit associated with said first switch and adapted to control all of said switches, means for operating said first switch to select a line, a relay in said common controlling apparatus unit adapted to be operated when the line selected by said switch fails to test idle, and means responsive to the operation of said relay for transmitting a busy signal to a calling line.

13. In a telephone system, an impulse repeater, a connecting relay in said repeater, other similar repeaters, a common controlling apparatus unit adapted to control all of said repeaters, and means responsive when said first impulse repeater is selected for operating said relay to temporarily associate the common controlling apparatus unit in operative relation with said first repeater.

14. In a telephone system, an impulse repeater, a relay in said repeater operated when the repeater is seized, other similar repeaters, a common controlling apparatus unit adapted to control all of said repeaters, a line relay in said apparatus unit adapted to be operated in series with the winding of the relay in said first repeater to associate the common controlling apparatus unit with the first impulse repeater.

15. In a telephone system, a group of impulse repeaters, a relay for each of said repeaters, a common controlling apparatus unit for controlling the repeaters in said group, and a line relay in said apparatus unit adapted to be operated in series with the relay in any one of said repeaters, and means responsive to the operation of the line relay in said apparatus unit and the relay of one of said repeaters for connecting the apparatus unit and the said one repeater in operative relation.

16. In a telephone system, a group of impulse repeaters, a controlling apparatus unit common to said groups of repeaters, means for associating said unit with one of said repeaters, means for transmitting impulses to said one impulse repeater, a trunk line, and a relay in said common apparatus unit for repeating the impulses received by said one impulse repeater over said trunk line.

17. In a telephone system, an impulse repeater, other impulse repeaters, a common controlling apparatus unit associated with said first repeater and adapted to control all of said repeaters, a low impedance loop circuit extending from said common apparatus unit, and means including said loop circuit for repeating impulses received by said first impulse repeater.

18. In a telephone system, an impulse repeater, other impulse repeaters, common controlling apparatus associated with said first repeater and adapted to control all of said repeaters, a trunk line extending from said first impulse repeater to a distant exchange, a low impedance circuit extending from said common controlling apparatus to said trunk line, means in said unit for receiving impulses transmitted to said first impulse repeater, and means including said impulse receiving means for interrupting the low impedance circuit to repeat said received impulses over said trunk line.

19. In a telephone system, an impulse repeater, other impulse repeaters, a common controlling apparatus unit associated with said first repeater and adapted to control all of said repeaters, a trunk line extending to a distant exchange, means in said common controlling apparatus unit for repeating impulses received by said first impulse repeater over said trunk line to extend a connection to a subscriber in said distant exchange, and means for disconnecting the common controlling apparatus unit from said first repeater after said connection has been extended, said means responsive to a signal transmitted back over said trunk line when the subscriber at the distant exchange answers.

20. In a telephone system, a plurality of groups of subscribers' lines, a corresponding finder group for each of said groups of lines, each of said finder groups being divided into sub-groups, said sub-groups arranged to serve the calling lines in a particular group in a definite order, the first sub-groups of finders of all the finder groups being selected before the second sub-groups of finders are selected.

21. In a telephone system, a group of finder switches divided into two sub-groups, an allotting switch adapted to preselect an idle finder switch, a first test wiper in said allotting switch for testing for an idle finder in one of said sub-groups, and a second wiper in said allotting switch for testing for an idle finder in the other sub-group, the testing of the second test wiper being effective only when all the finders in the first sub-group are busy.

22. In a telephone system, a plurality of groups of subscribers' lines, a corresponding finder group for each of said groups of lines, each of said finder groups divided into sub-groups, a common start conductor for a group of subscribers' lines for starting the operation of the finder switches in said sub-groups, and means for extending said common start conductor to successive sub-groups of finders in a definite order as the sub-groups become busy.

23. A system as is claimed in claim 1 in which said line relay is adapted to respond to impulses independently of the connecting relay individual to the switching apparatus.

24. A system as is claimed in claim 2, in which means is provided for opening the circuit of the two relays to release the common controlling apparatus from said switch when the switch is set.

25. A system as is claimed in claim 2, in which the switches are provided with controlling magnets and in which the controlling magnets of any switch are associated with the common controlling apparatus over contacts operated by the movement of the switch.

26. A system as is claimed in claim 3, in which the test relay is adapted to test first over one test wiper and is operated if a busy condition is encountered to close a test circuit over the second test wiper.

27. In a telephone system, a selector switch, other selector switches, a common controlling apparatus unit associated with said first switch and adapted to control all of said switches, a plurality of test wipers for said first switch, a rotary magnet for advancing the wipers of said first switch step by step, a test relay in the common controlling apparatus unit adapted to be operated over a circuit including one of said test wipers when a busy condition is encountered thereby to transfer the testing circuit to the second of said test wipers, a locking winding on said test relay adapted to be short circuited when said second test wiper encounters a busy condition to release said relay, and means responsive to the release of said relay for closing a circuit for operating said rotary magnet to advance said wipers.

28. In a telephone system, a plurality of switches accessible from a distant exchange over a like plurality of trunk lines. a controlling apparatus unit common to said switch, a connecting relay in each of said switches, a line relay in said unit adapted to be operated in series with any one of said connecting relays, a circuit completed when one of said switches is seized over its associated trunk line for operating the associated connecting relay in series with said line relay, and means responsive to the operation of said line relay for completing circuits over contacts of the unoperated connecting relays in the remaining switches to busy the trunk lines individual thereto at the distant exchange.

In testimony whereof I have signed at Liverpool, England, this 16th day of September, 1931.

CHARLES EDMUND BEALE.

In testimony whereof I have signed at Southampton, England, this 15th day of September, 1931.

REGINALD TAYLOR.