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R. TAYLOR ET AL

2,409,164

TELEPHONE SYSTEM

Filed Sept. 25, 1943

3 Sheets-Sheet 1

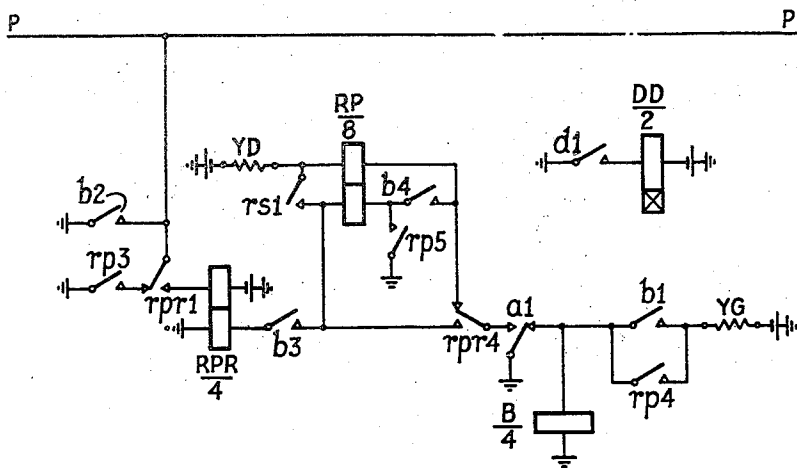
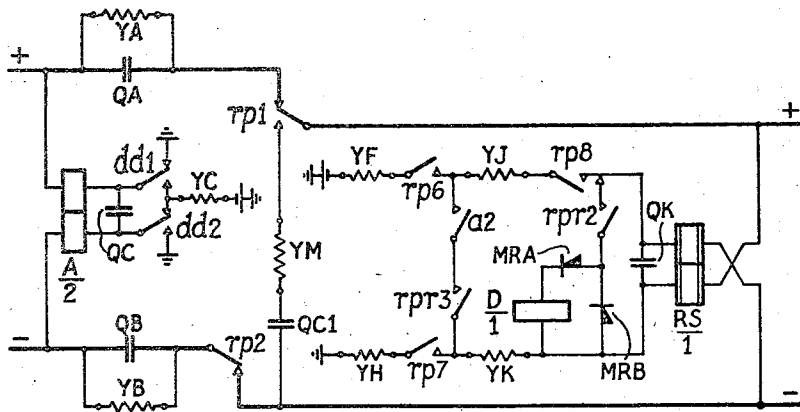


Fig. 1

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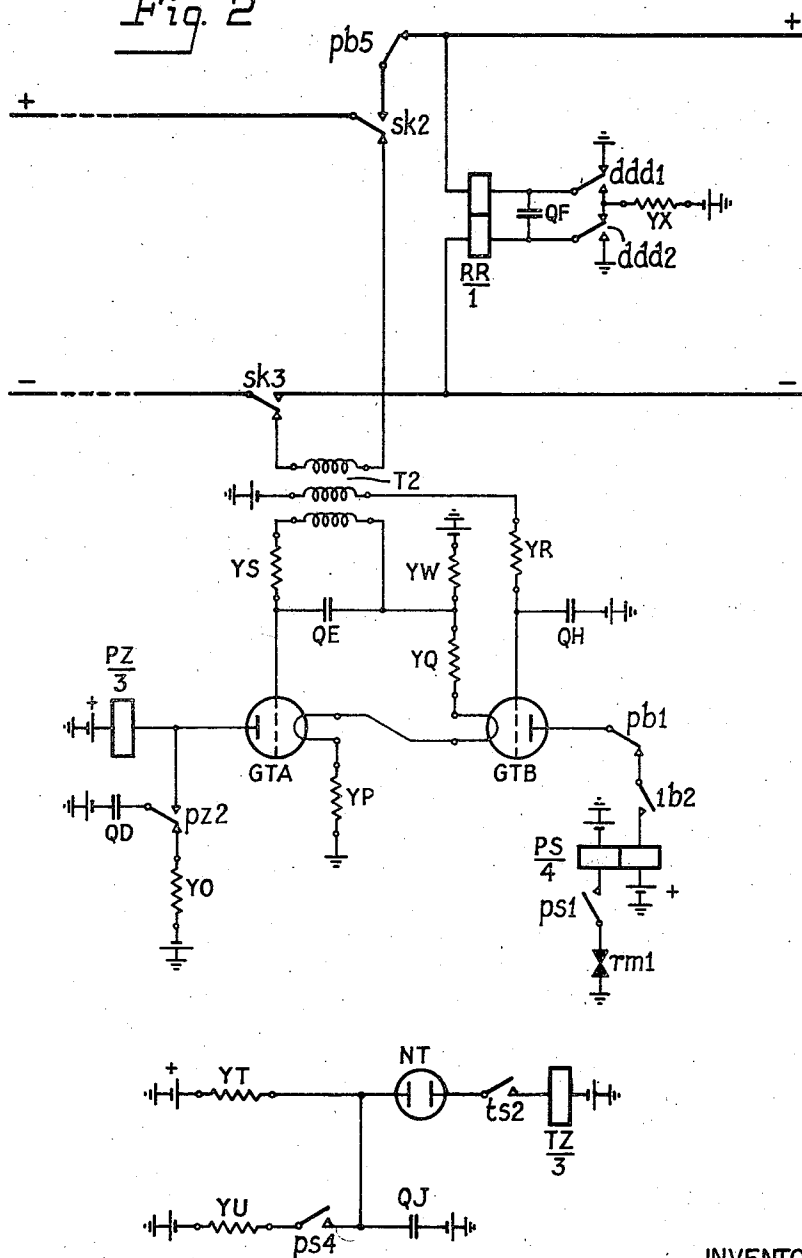
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Fig. 2



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3 Sheets-Sheet 3

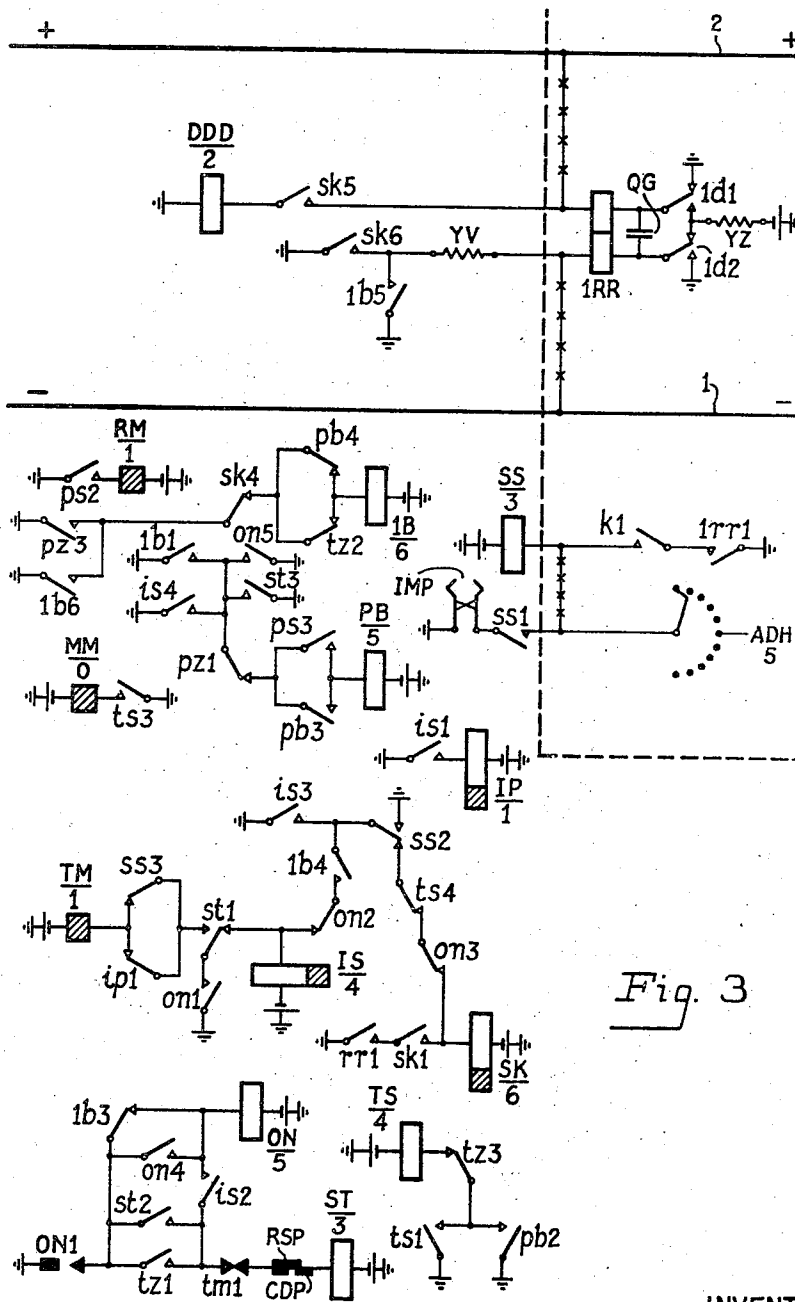


Fig. 3

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TELEPHONE SYSTEM

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Application September 25, 1943, Serial No. 503,750
In Great Britain November 10, 1942

10 Claims. (Cl. 179—18)

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The present invention relates to telephone systems and is more particularly concerned with systems in which it is desired to effect the setting of automatic switches or the like by trains of impulses transmitted over considerable distances. In arrangements of the type normally employed in automatic telephone systems in which control is effected by repeatedly interrupting the flow of direct current over the speaking circuit, difficulties are experienced as the length of line increases owing to the distorting effect produced by the inductance and capacity of the line and its associated equipment. For this reason it is generally necessary to make arrangements whereby the various transmission bridges employed under speaking conditions are cut out while impulsing is in progress, and this involves certain difficulties in securing the re-introduction of the transmission bridges when dialling is finished. Where only short lines are concerned it is possible to make the necessary alteration at the beginning of each train of impulses in response to the receipt of the first impulse, but with long lines this arrangement introduces so much distortion into the first impulse that it cannot be satisfactorily employed. The chief object of the present invention is to provide improved long distance impulsing arrangements of the type in which impulsing conditions are initially set up and speaking conditions are only introduced after all dialling is finished.

According to one feature of the invention, in a telephone system having connections set up over a junction in response to numerical impulses transmitted thereover, the conditions appropriate to impulse transmission are established in response to the seizure of the junction and speaking conditions are introduced when impulse transmission is completed in response to a signal transmitted from a register device at the incoming end of the line.

According to another feature of the invention, in a telephone system having connections set up over a junction in response to numerical impulses transmitted thereover, at the outgoing end of the junction conditions suitable for impulse transmission are established in response to the seizure of the junction, said conditions persisting until a signal is transmitted back from the incoming end due to a register device thereat completing its operation.

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 com-

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prising Figs. 1-3. Of these, Fig. 1 shows the equipment at the outgoing end of a long line which is for instance accessible to a subscriber from a particular level of the first selector, while Figs. 2 and 3, which should be placed side by side, show the equipment at the incoming end of the line and certain elements appropriate to a register translator circuit of known type. It is assumed that the calling party is served by an automatic system with direct dialling while the trunk line extends to an area served by a register translator system and advantage is taken of the presence of the register translators to obtain a signal indicating the end of dialling.

The general method of signalling employed is substantially similar to that disclosed in our co-pending application Ser. No. 499,194, filed August 19, 1943, in which however the dialling took place from an operator's position and the operator performed a specific operation, viz. restoration of the dialling key, when impulse sending was completed. The receiving equipment employs two oppositely-connected grid-controlled gas discharge tubes which are triggered into operation by the rise and fall of the current flowing over the line and impulsing is effected by shunting out the battery supply rather than by opening the line circuit.

Considering now the operation in detail, when the outgoing equipment of Fig. 1 is taken into use, relay A is operated by the loop across the speaking conductors and at contacts *a1* operates relay RP by way of its upper winding. Relay RP thereupon at contacts *rp1* and *rp2* opens the speaking leads and connects the line termination comprising resistance YM in series with condenser QC1 across the outgoing side of the circuit to preserve balance in case the line includes voice repeaters, at contacts *rp3* earths the P conductor, at contacts *rp4* energises relay B in series with resistance YG, at contacts *rp5* prepares a locking circuit for itself and at contacts *rp6*, *rp7* and *rp8* connects battery and earth by way of resistances YF, YH, YJ and YK and relay RS to the outgoing line which is bridged at the distant end by the primary winding of the transformer T2. Relay B on energising, at contacts *b1* completes a locking circuit for itself, at contacts *b2* applies a multiple earth to the P conductor, at contacts *b3* prepares a circuit for relay RPR and at contacts *b4* completes a locking circuit for relay RP. When the current flow over the line has practically reached its steady value, relay RS operates and at contacts *rs1* energises relay RPR which thereupon at contacts *rpr1* locks up by way of

its upper winding, at contacts *rpr2* prepares a circuit for the supervisory relay D, at contacts *rpr3* completes a shunt across the line by way of contacts *a2* and at contacts *rpr4* short-circuits the lower winding of relay RP. In view of the shunting of current off the line, relay RS now releases leaving relays RP and RPR locked up.

In the incoming equipment of Figs. 2 and 3, the tubes GTA and GTB are gas discharge tubes of the type in which a grid controls the striking of the tube but thereafter exercises no further control, the tube being extinguished only by a change in the anode circuit. These tubes are preferably of the hot-cathode argon-filled type. It will be seen that a circuit is normally completed for the filaments of the tubes in series in a circuit including resistances YP, YQ and YW. The grids of the tubes are connected to separate windings of transformer T2 in such a manner that tube GTA is caused to strike by a fall in the line current and tube GTB by a rise in the line current. The purpose of the arrangement shown whereby the negative bias of the tube GTA is derived by way of resistance YW is to ensure that the tubes will strike with substantially the same bias in spite of the fact that their filaments, being in series, are at slightly different potentials. The condensers QE and QH serve to integrate the effect of the impulses from the windings of the transformer T2 since they are charged through the high resistances YS and YR and the potential thereon is enabled to build up over an appreciable interval. By this arrangement some degree of immunity is given against false operation by surges as explained in greater detail in our application Serial No. 446,900 filed June 13, 1942, now Patent No. 2,350,652, dated June 6, 1944.

The effect of the pulse caused by the initial application of potential to the line circuit on the operation of relay RP is to reduce the negative bias on the grid of the tube GTB but it does not operate at this time owing to the fact that its anode circuit is at present open at contacts *lb2*. When relay RPR operates and the current over the line again falls to zero, the negative bias on the grid of the tube GTA is reduced and this thereupon strikes and energises relay PZ. Relay PZ on operating, at contacts *pz2* connects the discharged condenser QD in series with its winding whereupon the tube is at once extinguished by the substitution of negative for positive potential and as the condenser becomes charged through the relay, the current falls until relay PZ can no longer remain operated. With this arrangement the period of operation of relay PZ may be readily adjusted to any desired value by suitable choice of the value of condenser QD. The immediate extinction of tube GTA tends to prolong its life and thus reduce maintenance costs. Relay PZ also at contacts *pz3* completes a circuit for relay IB which accordingly operates and locks up at contacts *lb6*. Relay IB also at contacts *lb5* completes a circuit for the lower winding of relay IRR in the so-called first code selector of the local register translator system which is permanently associated with the incoming line. The arrangement of this switch may be substantially as shown in British patent specification No. 469,184, the lines with crosses indicating the connections for switches used in the local system only. Relay IRR then initiates the operation of a so-called A digit hunter which selects a free A digit switch which will respond to the first incoming digit.

In accordance with usual practice, the A digit switch then selects a register translator of the desired group and this responds to subsequent digits and sends out suitable digits for operating the local switches, some or all of these digits being different from the digits which were received. Since the calling subscriber will already have dialled at least one digit before obtaining access to the equipment shown in Fig. 1, the operation of the A digit hunter is likely to occupy more time than can be safely counted on as an interdigital pause and in order therefore to avoid the need for a second dial tone, an impulse regenerator, for instance of the type disclosed in United States Patent No. 2,188,461 to McClew and Woodland, is provided, preferably associated with the incoming equipment as shown. This regenerator serves to store the incoming impulses and to transmit them at the appropriate time. As fully described in the specification referred to, it comprises essentially a circle of movable pins which are selectively displaced by an operating arm in response to the incoming impulses and are restored to normal when corresponding trains of impulses have been sent out.

Considering now the dialling of the first digit into the equipment shown, relay A responds in the usual manner and intermittently short-circuits relay B at contacts *a1* but not for sufficiently long to cause its release. Each time relay A releases, the shunt across the line is removed at contacts *a2* and current is therefore enabled to flow thereover. Relay RS accordingly operates intermittently and short-circuits relay RP but this short-circuiting is not for sufficiently long to cause its release.

At the commencement of the first impulse when the line current rises, the gas discharge tube GTB strikes and operates relay PS. This relay locks up over its left-hand winding by way of contacts *ps1* and the interrupter contacts *rml* of the stepping magnet RM of the regenerator, at contacts *ps2* completes a circuit for this magnet, at contacts *ps3* energises relay PB and at contacts *ps4* discharges condenser QJ in the so-called speed timing circuit. Relay PB on operating, at contacts *pb1* extinguishes the tube GTB, at contacts *pb2* energises relay TS and at contacts *pb3* locks up. Relay TS locks up at contacts *ts1*, prepares a circuit for relay TZ at contacts *ts2* and at contacts *ts3* energises the marking magnet MM of the regenerator. Relay PS is de-energised as soon as the stepping magnet RM has completed its operation and thereupon opens the circuit of the magnet which will have advanced the operating member of the regenerator one step. This member, moreover, is tilted clear of the undisplaced pins by the operation of magnet MM. When the line current falls at the end of the impulse, tube GTA strikes and operates relay PZ which at contacts *pz1* releases relay PB so that the tube GTB is again rendered responsive.

Further impulses are received in a similar manner and the operating arm of the regenerator is moved a corresponding number of steps. As soon as it leaves its initial position, the off-normal contacts ON1 are closed but without immediate effect. At the end of the train of impulses, relay PS fails to re-operate and condenser QJ is therefore enabled to charge to the striking value of the neon tube NT whereupon relay TZ is operated. This arrangement is described in detail in our application Serial No. 434,762 filed March 14, 1942, now Patent No. 2,334,591 dated Nov. 16,

1943. Relay TZ thereupon at contacts *tz3* releases relay TS which in turn releases the marking magnet MM whereupon the operating arm displaces the pin opposite which it is then standing. Relay TZ also at contacts *tz1* completes a circuit over the transmitting magnet contacts *tm1* and the reset pin RSP for relay ST which on operation at contacts *st1* prepares a circuit for the transmitting magnet TM and at contacts *st2* completes a locking circuit for itself. When the A digit hunter finds a free A digit switch, which will normally be before the end of the first train of impulses, relay SS is operated due to the energisation of relay K (not shown) and thereupon at contacts *ss1* completes the out impulsing circuit and at contacts *ss2* energises relay IS. Relay IS at contacts *is1* operates relay IP, at contacts *is2* operates relay ON, at contacts *is3* completes a locking circuit for itself and at contacts *is4* prepares an additional holding circuit for relay PB. Relay IP on operating opens a further point in the circuit of the transmitting magnet TM, while relay ON at contacts *on1* closes another point in this circuit, at contacts *on2* opens the initial and locking circuits of relay IS and at contacts *on4* completes a locking circuit for itself. Relays IS and IP release slowly in turn and a circuit is then completed at contacts *ip1* for the transmitting magnet TM which operates the resetting pin RSP to restore the pin such as CDP left displaced after the regenerator was last used. Magnet TM also opens the circuit of relay ST which therefore releases and at contacts *st1* again energises relay IS which in turn operates relay IP. The release of magnet TM leaves the mechanism free to operate and the springs IMP are then interrupted at the standard speed until the reset pin RSP has been moved past the undisplaced pins and engages the pin which was displaced in response to the first digit. At this time a number of impulses corresponding to the digit received will have been transmitted to the A digit switch. If by the time the sending out of the first digit is completed further impulses have been received in the manner described, relay ST is then again operated over contacts *on4* and *is2* and after a pause represented by the release times of relays IS and IP, magnet TM again operates. Subsequent digits are transmitted in a similar manner.

When all the impulses received have been sent out again, the off-normal contacts *on1* will open and relay ON will then de-energise and operate relay IS by way of contacts *ss2* and *on2* but no further circuit will be completed for relay ST. Shortly after this time the register translator will complete its sending operation and when it has done so relay SS will be released. A circuit will then be completed for relay SK from earth over contacts *is3*, *ss2*, *ts4* and *on3*. Relay SK at contacts *sk1* prepares a locking circuit for itself, at contacts *sk2* and *sk3* disconnects the primary winding of the transformer T2 and switches the speaking leads through, at contacts *sk4* releases relay IB, at contacts *sk5* prepares an alternative circuit for relay IRR and at contacts *sk6* completes an alternative circuit for this relay.

At the outgoing end of the line the application of battery and earth to the line through the winding of relay RR completes a circuit for relay RS, which thereupon at its contacts *rs1* short-circuits relay RP for a sufficiently long period to cause its release. Thereupon at contacts *rp8* the supervisory relay D in series with rectifier MRA and shunted by rectifier MRB is connected up in place of the initial battery and earth connec-

tions and relay RS now remains operated together with relays A, B and RPR.

When the called party replies, relay ID (not shown) operates and reverses the connections to relay IRR thereby operating relay DDD which at contacts *ddd1* and *ddd2* similarly reverses the connections to relay RR. Thereupon relay D at the outgoing end is operated and in turn operates relay DD which at contacts *dd1* and *dd2* reverses the connections of relay A to the line to give the usual supervision. The release of relay IB at the incoming end of the line released relay IS and accordingly at the incoming end only relays RR, DDD, IRR and SK remain operated.

When the calling party hangs up, relay A releases and is shortly followed by relay B in consequence of the short-circuiting effect of contacts *a1*. On the release of relay B the circuits for both windings of relay RPR are opened at contacts *b2* and *b3* and this relay accordingly releases. Thereupon at contacts *rpr2* it opens the bridge across the line by way of relay RS and thus releases relay RR in the incoming equipment. This then brings down relay SK which releases relay IRR and also relay DDD if this has not already been released by the called party hanging up.

Considering now the case in which the subscriber omits or delays to dial, a state will be reached in which the regenerator is normal and relays IB, IRR, SS, IS and IP are operated. In due course the time pulse equipment associated with the A digit switch or register translator will come into operation and cause the release of relay SS. Thereupon relay SK is operated with the result that the speaking conductors are switched through and the connecting up of relay RR causes the operation of relay RS which then releases relay RP. The speaking conductors are thus switched through so that the calling party is enabled to hear NU tone from the equipment associated with the A digit switch in the distant exchange. Relays IB, IS and IP are now de-energised and release takes place as previously described when the calling party hangs up.

If it should happen that the regenerator is not in normal condition when the register translator switches through, for instance because the subscriber has dialled more than the required number of digits, the release of relay SS when the register translator is released causes the regenerator to discharge its stored digits as quickly as possible since contacts *ss3* shunt contacts *ip1* and thus cut out the normal inter-digital pause defined by the release times of relays IS and IP. When the regenerator is again normal relay ON releases and by closing contacts *on3* permits the operation of relay SK to establish speaking conditions.

In the somewhat unlikely event of the A digit hunter failing to find an A digit switch and the subscriber abandoning the call after dialling one or more digits, the impulse regenerator will be left off-normal and it is important that the trunk line shall be guarded during this time and the regenerator restored to normal as soon as possible. The position at the distant end of the line is that relay SS is not operated and one or more digits are stored in the regenerator and relays IB and ST are operated. When the subscriber hangs up in these circumstances, the effect is to cause a sustained application of potential to the line, that is to say the shunting of current off the line by relay A at the end of a normal impulse does

not take place. Hence though relay PS is operated and the regenerator is advanced a further step relay PZ is not operated and relay PB therefore remains energised. Consequently, when relay TZ in the speed timing circuit subsequently operates, relay IB is released by the opening of contacts *tz2* since contacts *pb4* are already open. Thereupon relay IRR in the first code selector is released at contacts *ib5* and relay ON is now operated over contacts *ib3*. Since relay ST is already operated and contacts *ss3* are closed, magnet TM now operates and a quick discharge of the stored digits is initiated. At the end of the final train when relay ON releases owing to the opening of contacts *on1*, relay SK is operated and remains operated for the slow release time of relay IS. Since, however, relay PB is still locked up to contacts *is4*, the line circuit is open at contacts *pb5* and therefore relay RS at the outgoing end releases when relay SK switches through. The position at the outgoing end of the line is that when the calling party hangs up, relays A, B and RPR release in turn and the removal of earth from the P conductor at contacts *b2* enables the preceding switches to release. When relay RPR is normal, however, earth is again applied to the P conductor over contacts *rp3* and *rpr1* and since current flow over the line has persisted since relay A released, relay RS remains operated and maintains relay RP by way of its lower winding and contacts *rs1* and *rp5*. On the operation of relay SK as just described however, relay RS releases and permits relay RP to release whereupon the equipment at the outgoing end is ready for further use. At the incoming end relay SK releases after its slow period and the equipment at that end also is then restored to normal.

A further case remains to be considered, namely that in which the subscriber hangs up prematurely. If he has not dialled at all, the effect of hanging up will be to release relays A, B and RPR at the outgoing end and to advance the operating arm of the regenerator one step. Assuming that relay SS is already operated and hence relays IS and IP, relays ST and ON are energised when relay TZ operates. Relay PB also operates due to the flow of current over the line and remains locked and owing to the operation of contacts *pb4* relay IB is released when contacts *tz2* open. Thereupon relays IRR and SS are released and owing to the closing of contacts *ss3* the regenerator at once sends the single stored impulse and relays ON and ST release. On the release of relay ON relay SK is enabled to operate during the slow release period of relay IS and produces the results previously described. The junction has been guarded at the outgoing end by the operation of relay RP and when switching through takes place, relay RS releases and brings down relay RP and the equipment is then ready for further use.

If the subscriber has already dialled one or more digits the regenerator will already be transmitting when he hangs up but the operations are substantially the same as before.

It will be appreciated that the impulsing arrangement shown whereby battery is shunted off the line is preferable to the more usual method of opening the line as it permits the rise and fall of current to follow substantially similar curves and thus enables the two gas discharge tubes to operate under substantially identical conditions.

It should be mentioned that the condensers QC, QK, QF and QG connected across the wind-

ings of the various line relays form with these relays a crude type of low pass filter which very largely blocks the high frequency components of surge currents which might otherwise produce unwanted effects. Moreover with the arrangement shown it is possible for these filter circuits to be operative at all stages of the setting up and maintenance of the connection and particularly during the change from impulsing to speaking conditions which may itself give rise to the possibility of surges.

We claim:

1. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said trunk line, means effective upon such seizure to condition said trunk line for the transmission of impulses thereover, means in said one exchange operated to transmit impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges associated with said trunk line for registering said impulses and controlling the extension of a connection in accordance therewith, and means thereafter controlled by said impulse registering means to alter the connections of said trunk line in said one exchange thereby to condition said trunk line for the transmission of speech thereover.

2. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said trunk line, means effective upon such seizure to condition said trunk line for the transmission of impulses thereover, means in said one exchange operated to transmit impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges normally conditioned to receive said impulses and to control the extension of a connection in accordance therewith, and means thereafter controlled by said last means to alter the connections of said trunk line at both ends thereby to condition said trunk line for the transmission of speech thereover.

3. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said trunk line, means effective upon such seizure to alter the connections of said trunk line in said one exchange thereby to condition said trunk line for the transmission of impulses thereover, means in said one exchange operated to transmit impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges associated with said trunk line for registering said impulses and controlling the extension of a connection in accordance therewith, means thereafter controlled by said impulse registering means for transmitting a signal over said trunk line to said one exchange, said second means effective to maintain said trunk line conditioned for the transmission of impulses thereover until said signal is transmitted, and means in said one exchange operated responsive to the transmission of said signal for again altering the connections of said trunk line in said one exchange thereby to bring said conditioning thereof to an end.

4. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said trunk line, means effective upon such seizure to condition said trunk line for the transmission of impulses thereover, means in said one exchange operated to transmit impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges associated with said trunk line

for registering said impulses and controlling the extension of a connection in accordance therewith, means thereafter controlled by said impulse registering means to transmit a signal over said trunk line to said one exchange, and means in said one exchange operated responsive to said signal to condition said trunk line for the transmission of speech thereafter.

5. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said line, means effective upon such seizure to condition said trunk line for the transmission of impulses thereafter, means in said one exchange for transmitting impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges associated with said trunk line for registering said impulses and controlling the extension of a connection in accordance therewith, and means thereafter controlled by said impulse registering means to condition said trunk line for the transmission of speech thereafter.

6. In a telephone system as claimed in claim 5, a particular relay connected to said trunk line when it is conditioned for the transmission of impulses and also when it is conditioned for the transmission of speech, and a condenser shunting said relay and forming therewith a low pass filter for suppressing the high frequency component of surge currents on said trunk line.

7. A telephone system as claimed in claim 5, wherein said impulse transmitting means including a source of potential connected to said trunk line in said one exchange and means in said one exchange for shunting said source to interrupt the flow of current over said line from said source.

8. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said line, means ef-

fective upon such seizure to condition said trunk line for the transmission of impulses thereafter, means in said one exchange for transmitting impulses over said trunk line after it has been thus conditioned, means in the other of said exchanges for receiving and storing said impulses, a register, means operated to associate said register with said trunk line, means effective when said register has been associated with said trunk line to cause said impulse storing means to transmit the stored impulses to said register, and means thereafter controlled by said register to condition said trunk line for the transmission of speech thereafter.

9. In a telephone system, two exchanges interconnected by a trunk line, means in one of said exchanges operated to seize said line, means effective upon such seizure to condition said trunk line for the transmission of impulses thereafter, means in said one exchange for transmitting impulses over said trunk line after it has been thus conditioned, a pair of grid controlled gas discharge tubes in the other of said exchanges operated alternately by said impulses, means controlled by said tubes for registering said impulses and controlling the extension of a connection in accordance therewith, and means controlled by said impulse registering means after said impulses have been registered to condition said trunk line for the transmission of speech thereafter.

10. A telephone system as claimed in claim 9, wherein one of said tubes has a normally disabled anode circuit, means whereby the other of said tubes operates responsive to said seizure of said trunk line, and means controlled by such operation of said other tube for enabling the anode circuit of said one tube.

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