Aug. 15, 1933. D. A. CHRISTIAN 1,922,232

TELEPHONE SYSTEM

Filed April 13, 1931 3 Sheets-Sheet 1

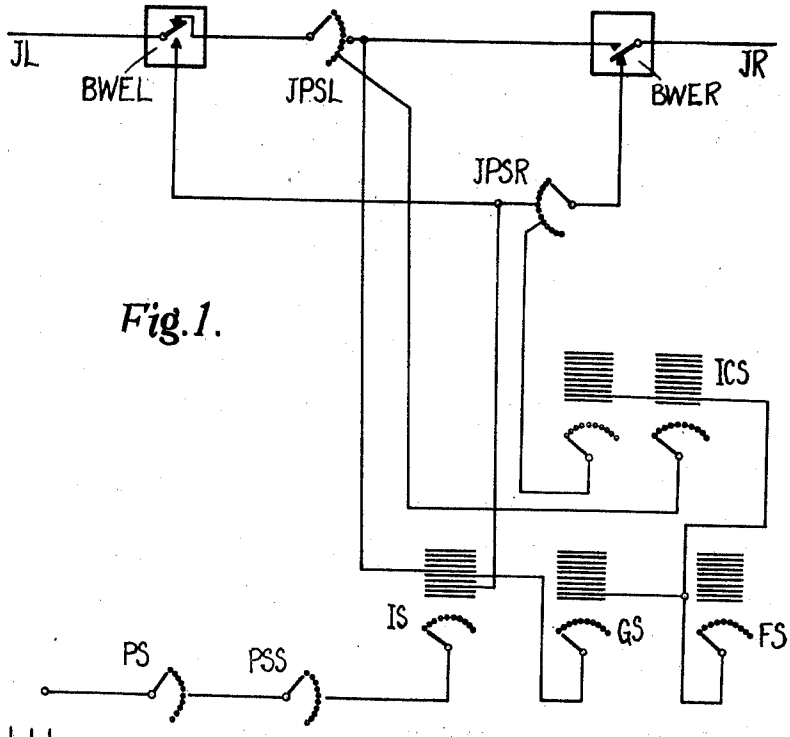

Fig. 1.

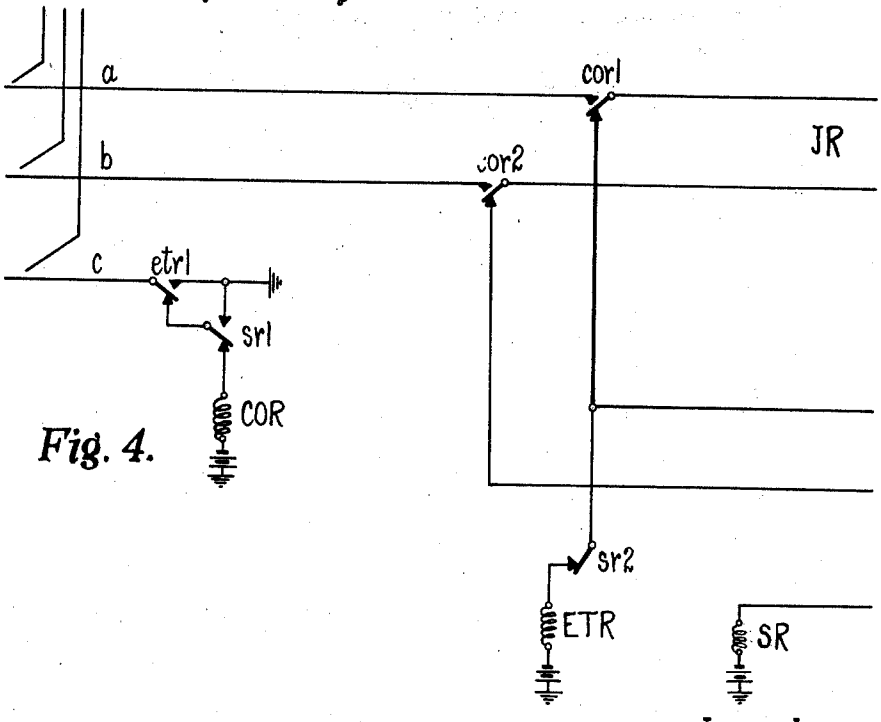

Fig. 4.

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TELEPHONE SYSTEM

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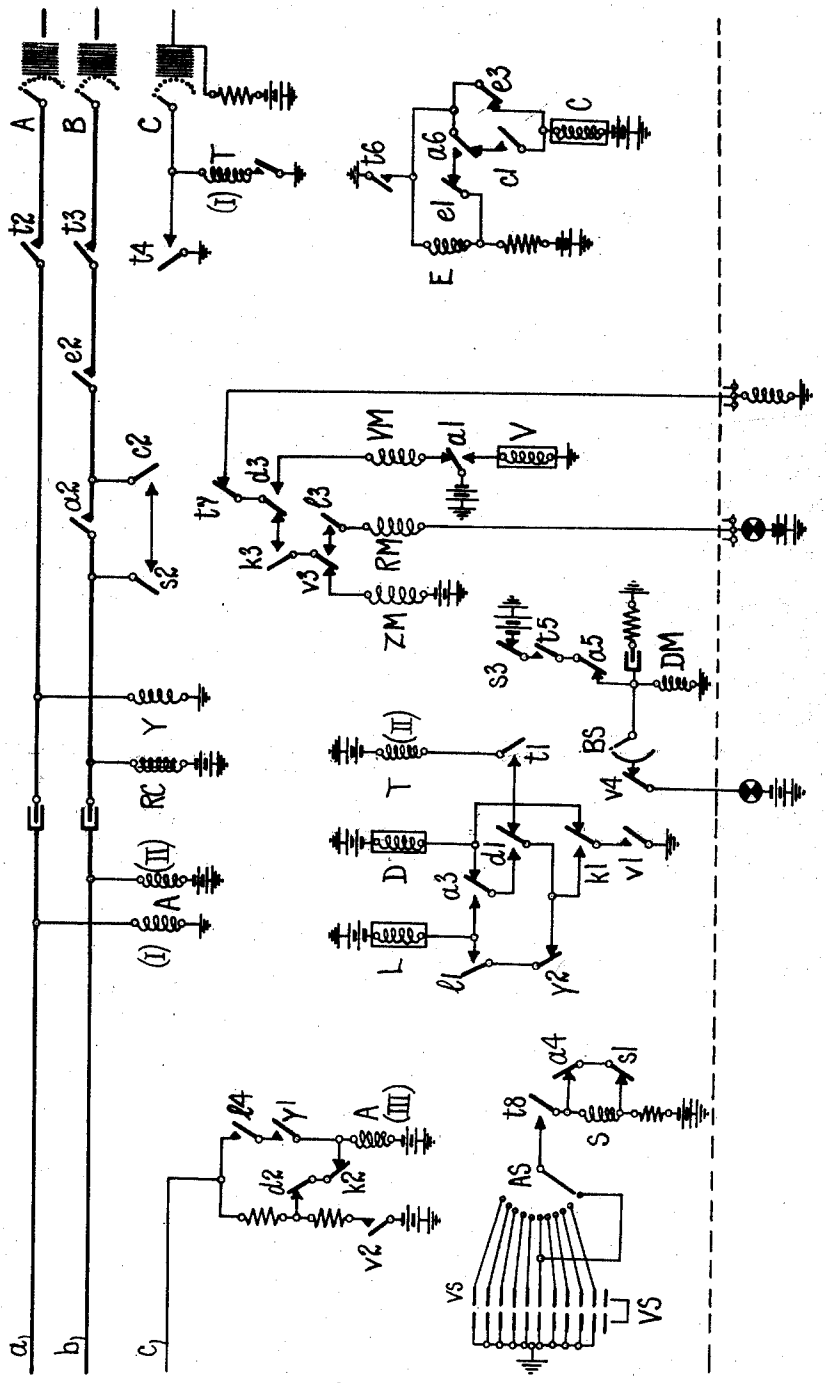

Fig. 2.

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TELEPHONE SYSTEM

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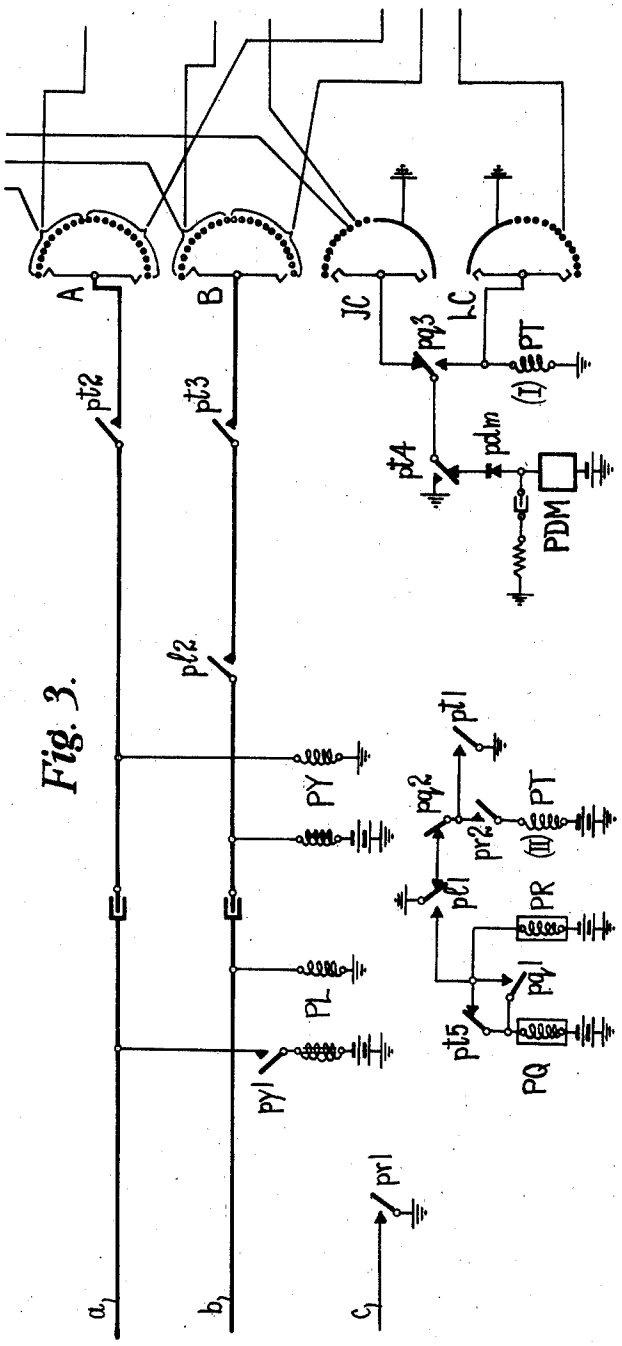

Fig. 3.

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UNITED STATES PATENT OFFICE

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TELEPHONE SYSTEM

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30 Claims. (Cl. 179—18)

The present invention relates to telephone systems and is more particularly concerned with setting up connections between different exchanges over junctions.

In urban areas it is common to have a main central exchange linked by junctions to a number of subexchanges which in turn may be linked by junctions to satellite exchanges, the junction layout being determined by the traffic requirements of the area. In rural areas a different problem is often encountered in that a number of exchanges are frequently found lying more or less along a line as in the case of small towns or villages along the banks of a river. It is then uneconomical to provide junctions between each exchange and every other exchange in the area or between a central point and every other exchange, and as the junctions between two adjacent exchanges follow the same route as junctions to more distant exchanges in the same direction, an obvious method of linking up the several exchanges of such an area is to connect each exchange with the adjacent exchanges on either side of it by means of junctions and to extend connections to more distant exchanges over a number of serially-connected junctions.

The problem that then presents itself where automatic switching arrangements are concerned is the most satisfactory way of setting up a connection between any two exchanges in the area. Several methods are available but some have serious drawbacks to their adoption. To mention one such method, a first digit dialled may determine in which direction the connection is to be extended and further digits would then take effect in setting switches in the serially-connected exchanges until the required subscriber's line is reached. It will be seen at once that such a method involves different digits being dialled at different exchanges to call a particular exchange and if there are a number of exchanges in the area, a large number of digits would in some cases be required to set up a connection. Digit translating arrangements could of course be provided in order that a subscriber may be called by dialling the same digits irrespective of the exchange at which the call originates, but this would prove costly, particularly where special facilities such as rural party lines requiring an extra digit have to be catered to.

According to one feature of this invention each exchange of the system is connected with the adjacent exchanges on each side of it by junctions and provision is made for associating free junctions between adjacent exchanges to the end that as far as may be possible having regard to junction occupation there is always a waiting free route between the exchanges at each end of a chain of exchanges.

The junctions may be associated so that there is a chain of free junctions in readiness for a connection but no actual connection between one junction and the next adjacent junction exists until a junction call is made. As many serially connected junctions may then be taken into use as are requisite to extend the route to a desired exchange, and the other waiting junctions are free to be used in the preparation of another through route.

For the preparation of a route junctions incoming at an exchange may terminate in searching switches which are maintained in connection with free outgoing junctions for the extension of a route so far as there are free outgoing junctions. No seizure of a junction however need be made and in one arrangement according to the invention it is arranged that an effective connection of adjacent junctions is made depending on an operation at the exchange at which a call originates.

According to a further feature of the invention it is arranged that successive junctions are taken into use consequent on the receipt at an exchange at the incoming end of a junction of a single current impulse. For the connection of serially related junctions a train of impulses may be transmitted from the exchange at which the call originates, each impulse of the train effecting the connection of a further junction to the route. When a junction is taken into use no circuit is closed thereover until an impulse of a route setting digit is transmitted and it may be arranged that the "make" period of an impulse energizes a line relay at the incoming end of the junction, the de-energization of the line relay consequent on the transmission of the "break" of the next impulse effecting the switching through of the junction to the next adjacent exchange. In the case of the desired exchange the operation of the line relay at this exchange takes place consequent upon the prolonged closure of the circuit over the junction on the cessation of impulse transmission thereon, and time is given for a slow operating relay to operate and prevent connection of a further junction section. This relay may close a circuit for the searching switch at the incoming end of the junction whereby it is caused to advance in search of a free outlet to local switches. The slow operating relay at intermediate exchanges would be

rendered unoperative when an extension of the junction route is made.

In order to obviate, for the calling of a particular exchange, the dialling by a subscriber of trains comprising different numbers of impulses according to the position of the calling and called exchanges in the chain it is arranged that a certain maximum number of impulses is always dialled for the route setting train and certain of these impulses are suppressed at the originating exchange, the number of impulses transmitted being determined by the number of junctions to be connected in series.

According to another feature of the invention novel and simple means for translating a dialled digit into a routing digit and transmitting the latter are provided.

For this purpose it may be arranged that the first digit dialled by a subscriber determines the exchange with which connection is desired and the number of impulses required for the interconnection. The first digit is received at a selecting switch which in accordance with the value of the digit searches for a free outlet in the direction of the required exchange, i. e. to the left or right or over local switches, and marks a counting device or the like. The second digit is predetermined and comprises at least the maximum number of impulses that will be required for the interconnection of the extreme exchanges, this may be for example the digit "9". The impulses of this digit cause the counting device to operate and count the impulses and at the same time the impulses are transmitted over the selected outlet. When the counting device reaches the position marked by the first dialled digit further impulse repetition over the selected outlet is suppressed. In the case of a local call all the impulses of the route setting train may be suppressed.

In the preferred form the counting device consists of a simple stepping switch which may be embodied in the first selector at an exchange. Contacts in a bank of the switch are cross connected to a set of contacts corresponding to groups of selector outlets, the group in which an outlet is selected being marked, and a test relay connected to the wiper of the counting switch coacting with the cross connected contacts is arranged to operate when a marked contact is reached and short circuit the impulse receiving contact in the outgoing wires. This short circuit is removed at the end of the digit by suitable means to enable further impulse trains to be transmitted without translation for the setting of switches in the desired exchange.

In a system in which a simple connecting circuit is employed and connections are completed over a connector operated under the control of or in conjunction with a controlling device, the connector may be stepped automatically when the controlling device is taken into use to a group of contacts over which it may search for a free junction in one direction in response to the first digit received. If however the first digit received determines that the connection is to be completed over a junction in the other direction the connector may be stepped to a further group of contacts associated with junctions in the required direction over which it searches automatically. In the case of a local call the connector would be released from the position to which it was stepped automatically and the succeeding digit would be absorbed.

In a system of this kind when a controlling device is taken into use at each exchange involved in a connection it may be arranged that a junction is only marked available for use when a controlling device is associated with the searching switch (preselector) at its incoming end. Alternatively to this arrangement search for a free controlling device may take place when the demand arises and a second dialling signal is given after the second digit has been dialled.

The above described arrangements contemplate the use of one-way junctions but we may provide for both-way junction working by arranging changeover contacts of a relay at each end of a section so that the junction is always connected to incoming preselectors at each end.

When such a junction is taken into use the relay controlling the change over contacts at the outgoing end of a desired junction is operated to change over the contacts to extend the connection to the next junction section. Incoming preselectors at the originating exchange, as regards the direction of the call considered, which may be resting in contact with the junction taken into use, would then step in search of another free junction and preselectors at the end of a junction incoming from the opposite direction at the distant exchange, would act in a similar manner.

If an incoming preselector is unable to find a free junction section, it may come to rest on contacts associated with a busy signal circuit so that when it is taken into use the calling subscriber will receive a busy signal.

The arrangements of the invention lend themselves to the adoption of multi-metering, i. e. metering of calls according to the exchange to which the call is made. A convenient method of determining the fee to be charged for a call is to prepare the metering circuit over contacts operated as determined by the first digit dialled.

The arrangements lend themselves to mixed automatic and manual exchanges in an area. In the case of a terminal manual exchange, the operator thereat may dial the required number of impulses to extend the junction sections to the wanted exchange, instead of the exchange determining digit, a controlling device then being unnecessary. At an intermediate manual exchange, the incoming preselectors terminating junction sections, which preselectors would still be provided, may have access to the answering equipment for the purpose of dealing with local calls. The multiple jacks would take the place of levels in the selecting switches in an automatic exchange and would be multipled to the junction outlets from the incoming preselectors.

Reference will now be had to the accompanying drawings which show by way of example a method of carrying out the invention. Fig. 1 shows in diagrammatic form the arrangement of switches and connections at an exchange having junctions outgoing to the left and the right of the figure, the junctions being used for traffic in both directions. Fig. 2 shows a first selector at an exchange, the selector having combined with it a counting switch which is marked by the exchange determining digit and controls the transmission of impulses for the connecting up of junction sections until the desired exchange is reached. Fig. 3 shows a preselector connected to the incoming end of a junction which preselects a junction to the next exchange and when the junction to which it is connected is taken into use it extends the connection either to the next junction section or to local switches. Fig. 4 shows an equipment for connection between the

end of a junction and the junction preselector when the junction is to be used for traffic in both directions.

Referring now to Fig. 1, the switches indicated diagrammatically at the foot of the drawings from left to right are subscriber's preselector PS connected to the line from a subscriber SUB, second preselector PSS, first selector IS, intermediate selector GS, and final selector FS. In the upper part of the drawings are indicated junctions outgoing to or incoming from the left and the right. The junction JL incoming from the left of the figure is connected over an equipment BWEL when it is to be used for both way working to the junction preselector JPSL, part of the banks of which are multipled and connected to the equipment BWER and to contacts in levels of the first selectors such as IS. Another part of the banks of the preselector JPSL is connected to incoming selectors such as ICS, the bank contacts of which are multipled to those of intermediate selectors such as GS and connected to final selectors such as FS. The junction JR on the right of the figure is connected over the equipment BWER to the junction preselector JPSR, the bank contacts of which are connected in a similar manner to those of JPSL. If one way junction working only is to be employed, junction JL if incoming from the left would be connected directly to JPSL, the bank contacts of which concerned with junction connections would be connected directly to junctions such as JR outgoing to the right of the figure, the junction being marked engaged at its outgoing end when taken into use. Incoming junctions from the right such as JR and preselector JPSR would then be connected in a similar manner, the multipled connections between the incoming preselectors and the first selectors represented by IS and the connections to incoming selectors represented by ICS being made as before.

The system as shown in this figure is arranged for subscribers numbers on a 5 figure basis, the first digit denoting the required exchange stepping a first selector taken into use over PS and PSS to a level giving access to junctions leading in the direction of the required exchange or to outlets to local switches according to the digit dialled. The second digit is always 0 and a number of impulses of this digit are counted off as determined by the first digit dialled to effect the completion of the junction connection to the required exchange if the call is one to be completed over a junction. The 3rd, 4th and 5th digits effect the setting of the intermediate or incoming selector as the case may be and the final selector. Selectors ICS, GS and FS are of a kind usually employed for the purposes they serve having regard to the system of impulsing testing and supervision at the exchange where they are situated and the preselectors PS and PSS may be switches of any suitable known type.

Fig. 2 shows a first selector of the two motion type in which impulses are received on an impulse relay A connected in the incoming side of a feeding bridge and are repeated over contact *a*1 to the vertical magnet VM of the selector and after seizure of a free outlet in the level to which the selector is set by impulses, the impulses are repeated over contact *a*2 and the outgoing *b* wire. The test for a free selector and free outlet is battery potential on the test wire.

Y is the answering supervisory relay operated when the called subscriber replies by the application of battery to the *a* wire either over the retard coil RC and the subscriber's loop or from a connection made at a subsequent feeding bridge. V is the release relay, D a dialling relay and T the test relay. The rotary and release magnets are designated RM and ZM respectively. Vertical off-normal contacts are denoted by *k* with a numerical suffix. Associated with the first selector is a single motion counting switch of the direct drive type having 2 wipers designated AS, BS. Wiper AS co-acts with an arc of contacts which are cross-connected as required to a set of contacts *vs* which are bridged to a corresponding set of earthed contacts by a wiper VS which partakes only in the vertical motion of the selector, the contacts *vs* corresponding to levels in the selector. Wiper BS wipes over an off-normal segment in a homing circuit for the counting switch. Relay S is the test relay for the counting switch and relay E prevents current flow over the outgoing *b* wire until the first impulse of the second train is received. Relays which are slow to release have their windings enclosed within rectangles.

The selector tests free by reason of a battery connection over winding (III) of relay A, contacts *k*2, and *d*2 to the incoming test wire *c*. Relay A energizes in this circuit to earth connected at the subscriber's preselector and at contact *a*1 operates the slow releasing release relay V. When the connection is switched through at the preselector, windings (I) and (II) of relay A become energized. On the operation of relay V a circuit is closed at contact *v*1 for relay D and at *v*2 a circuit is closed over a resistance to the incoming *c* wire to guard against the subsequent opening of contacts *d*2 and *k*2. Contact *v*3 opens a point in the circuit of the release magnet ZM, and closes a point in the circuit of the rotary magnet RM; contact *v*4 opens a point in the homing circuit for the single motion switch. Relay D operating prepares a holding circuit for itself at contact *d*1 and opens a point in the test in circuit at contact *d*2 de-energizing winding (III) of relay A. Contact *d*3 prepares the vertical magnet circuit. A further contact of relay D may connect a dialling signal transformer to the line if desired.

The calling subscriber now dials the first digit of the wanted number and relay A responds to the impulses of the digit.

These impulses are repeated at contact *a*1 in a circuit including winding VM of the vertical magnet, contacts *d*3 and *k*7, and the switch is stepped vertically in accordance with the number of impulses received. At the first step taken by the switch the vertical off-normal contacts are operated, contact *k*1 opening the operating circuit of relay D which thereafter depends for its operation on a circuit over the back of contact *a*3 and the front of contacts *d*1, *k*1 and *v*1. Contact *k*2 opens in the test-in circuit against the release of relay D, and contact *k*3 closes a further point in the circuit of the rotary magnet. When relay A re-operates at the end of the first impulse, contact *a*3 closes in its front position a circuit for relay L which thereupon operates and locks up over contacts *l*1, *y*2, *k*1 and *v*1 and a contact *l*2 prepares the circuit of the test relay T over its winding (I), and at contact *l*3 prepares the circuit of magnet RM. Other contacts of relay A have no function at this stage. At the end of the impulse train relay A remains steadily operated and relay D releases closing a circuit for magnet RM

at contact *d*3. The rotary magnet is operated from battery connected to it over an interrupter and the selector wipers are rotated over the level in search of a free outlet. When such an outlet is found relay T operates by means of its winding (I) and locks up over its winding (II) and contacts *t*1, *d*1, *k*1 and *v*1. The rotary magnet circuit is opened at contact *t*7 and contact *t*4 connects earth directly to the test wiper to mark the outlet engaged. Contacts *t*2 and *t*3 close in the *a* and *b* wires and contact *t*5 prepares a circuit for magnet DM of the single motion switch. Contact *t*6 closes a circuit over contact *c*3 for relay C which thereupon operates and prepares a holding circuit for itself at contact *c*1.

Referring for a moment to the connections between the contacts *vs* and the bank of wiper AS, the contacts corresponding to levels of the selector are connected to contacts in the bank of wiper AS, the contact corresponding to the level from which outlets to a local group selector such as GS (Fig. 1) are taken being connected to the normal contact of the switch on which wiper AS rests when the switch is not in use. The vertical wiper VS connects earth to the contact in the bank of wiper AS corresponding to the level to which the switch has been stepped and in the case of calls to be completed locally earth is also connected over the normal contact to wiper AS.

As regards the outlets from the selector itself, outlets to a group selector for the completion of local calls are connected in one level and outlets to junctions going out in one direction such as junctions JL (Fig. 1) are connected in levels corresponding to the digits denoting exchanges in that direction, contacts in the several levels concerned being commoned if necessary. Outlets to junctions going out in the other direction such as junction JR are connected in levels corresponding to digits designating exchanges in that direction.

Continuing with the description of the operations of the first selector it will first be assumed that the call is one to be completed locally. In this case earth will be connected by wiper VS to the normal contact in the bank of wiper AS as well as to contact 5 it being assumed that the initial digit of subscribers in the exchange under consideration is 5, consequently on the operation of relay T, contact *a*4 being open relay S operates and at contact *s*1 opens a point in a short circuit connected over the front of contact *a*4 about its winding. Relay C being operated a short circuit is closed over contacts *s*2 and *c*2 about contact *a*2 preventing repetition of the second digit over the selector *b* wire and contact *s*3 opens to prevent operation of magnet DM of the single motion switch. On the commencement of the first impulse of the second train a short circuit is removed from relay E at contact *a*6 and this relay operates and prevents the short circuit being re-imposed on the termination of the impulse by opening contact *c*1; contact *e*2 closes in the outgoing *b* wire and contact *e*3 opens in the operating circuit of relay C leaving this relay dependent on the back of contact *a*6 for its continued operation. This train of impulses is without any effect on the circuits shown in this figure if the call is a local one and at the end of the train relay C releases. The short circuit is now removed from contact *a*2 and the impulses of subsequent trains are repeated by it to complete the setting up of the connection. When the called subscriber replies to the call relay Y operates and at contact *y*2 releases relay L. Relay L is however slow in releasing and during its release period current in the *c* wire is increased due to the parallel connection of battery over winding (III) of relay A, contacts *y*1 and *l*4 and the subscriber's meter is operated.

At the end of the conversation and when the calling subscriber replaces his receiver on its hook relay A releases and at contact *a*1 opens the circuit of relay V. After a brief interval relay V releases releasing relay T at contact *v*1 and contact *t*4 initiates the release of subsequent switches and relay Y releases. Contact *t*6 releases relay E, and contact *t*8 releases relay S and contact *t*7 closes the circuit of the release magnet ZM. The selector wipers are now restored to their normal position and the restoring of the vertical off-normal contacts opens the circuit of magnet ZM at contact *k*3.

If a call is to be made over a junction the first digit dialled will be that corresponding to the exchange to which the wanted subscriber is connected. The selector will be stepped to a level depending on this digit, the level containing outlets to junctions leading in the direction of the wanted exchange. Accordingly after the end of the first train of impulses earth will be connected by wiper VS to the corresponding contact in the bank of wiper AS (not contact 5) but relay S will not operate at this time as wiper AS is resting on its normal or home contact. When a free outlet has been found relay T operates and closes a circuit in which relay C operates as before but as relay S is unoperated relay A repeats impulses of the second train over the junction seized at contact *a*2, The second digit is 0 and on the first impulse break taking place relay E operates and leaves relay C dependent for its continued energization on the back of contact *a*6. Contact *e*2 closes and at the end of the impulse a circuit is closed over the *b* wire at contact *a*2 to cause the preselector connected to the incoming end of the junction at the next exchange to prepare to switch the junction through. This operation will be more fully described later with reference to Fig. 3. Relay S being unoperated, each time relay A releases a circuit is closed from battery over contacts *s*3, *t*5, *a*5 magnet DM to earth. The counting swich is in consequence stepped until wiper AS is stepped onto the contact earthed over wiper VS whereupon when relay A reoperates a short circuit is removed from relay S and the relay operates opening the magnet circuit at contact *s*3 and short-circuiting contact *a*2 at contact *s*2. The remaining impulses of the ten are not transmitted over the junction but are repeated at contact *a*6 for the maintenance of relay C. After the last impulse of the ten has been received by relay A relay C releases and opens the short circuit about contact *a*2 which is now closed and impulses of further trains are repeated at contact *a*2 for the setting of switches at the distant exchange for the completion of the connection.

When the connection is released by the calling subscriber the counting switch is rotated to normal by the energization of its magnet DM in a homing circuit over wiper BS and the off-normal segment, contact *v*4 and an interrupter.

It will be noted that the counting switch permits a definite number of impulses to be transmitted over the junction as the second digit, the number being determined by the first digit dialled. As the second digit is always "0" any number of impulses from 1 to 10 can be transmitted and each impulse effects the connection of a further junction section until a route to the wanted exchange is built up.

As the digit for determining the wanted exchange is fixed it will be clear that a different number of impulses of the second train will have to be cut off at different calling exchanges and this is readily effected by suitably cross connecting the contacts *vs* to the contacts in the bank of wiper AS.

It has been stated that the test for a free outlet is battery potential on the test wire and in the case of one way junction working the test contact in the multiple will be connected to battery over a suitable resistance, the junction being marked engaged by the connection of earth to the test wiper by a contact of the test relay.

The incoming ends of junctions terminate in junction preselectors the function of which is to preselect free junctions to the adjacent exchange. Each preselector normally stands with its wipers on contacts associated with a free junction but the junction is not seized until the preselector is taken into use. Such a preselector is shown in Fig. 3 which switch corresponds to the switches designated JPSL and JPSR in Fig. 1. The banks of the switch are divided into two parts, the earlier contacts in the banks being associated with outlets to outgoing junctions and the later contacts with outlets to an incoming selector such as ICS in Fig. 1 for the completion of local calls. The preselector is provided with a feeding bridge with a line relay PL connected to the incoming *b* wire and an answering supervisory PY connected to the outgoing *a* wire. PT is the test relay and PR is a relay which operates on receipt of the first impulse, PQ is a slow operating relay which does not operate on an impulse being received by PL and only operates if the latter relay is operated for a period longer than the make period during impulsing of relay A in the first selector; it therefore only operates when the junction circuit is closed for a prolonged period at the end of a train of impulses which effects a prolonged energization of relay PL. The switch magnet is designated PDM. Two test wipers designated JC and LC and corresponding contact banks are provided. The contacts corresponding to outlets to junctions are commoned and earthed in the bank of wiper LC and contacts corresponding to outlets to incoming selectors are commoned and earthed in the bank of wiper JC.

In the normal position of the switch the wipers rest on one of the earlier bank contacts connected to an outlet to a free junction. If the junction is seized an engaging earth is connected to the test contact in the bank of wiper JC and magnet PDM operates and steps the switch until contacts connected with an outlet to a free junction are reached, the magnet interrupting its own circuit at contact *pdm*. The incoming junction can only be seized when a subscriber dials the second digit "0", and depending on the position of the junction with regard to the originating exchange it is seized consequent on the transmission of the first or a subsequent impulse of this digit before relay S in the first selector at the originating exchange operates and cuts off further impulses of the ten.

An outgoing junction in the required direction having been picked up by the first selector the second digit comprising ten impulses is received by the selector and at the first break of the dial contacts relay A releases and relay E operates. Contact *a*2 opens before contact *e*2 closes but relay PL in the incoming junction preselector has not been operated previously so the impulse break is without effect. When the dial contacts re-close at the end of the impulse relay A re-operates and contact *a*2 closes in the *b* wire and battery over the retard coil connected thereto is fed over wiper B, the junction *b* wire and relay PL to earth; relay PL operates and contact *pl*1 changing over a circuit is closed for the slow releasing but quick operating relay PR. Contact *pr*2 closes and on the release of relay PL due to the next impulse break relay PT operates by means of its winding (II) and locks up over contacts *pr*2 and *pt*1, relay PR holding its armature attracted during the break period of an impulse. Relay PQ does not operate as the make period of an impulse is not long enough. Contact *pl*2 closes during the make period of an impulse but at the first impulse relay PT has not operated, consequently it is without effect. When relay PT operates the outgoing junction is marked engaged by the connection of earth over contact *pt*4 to the test wiper JC, the junction is switched through at contacts *pt*2 and *pt*3, and the circuit of relay PQ is opened at contact *pt*5. If further impulses are received by relay PL subsequent break periods are without effect but at the next make period contact *pl*2 closes a circuit for the relay connected to the *b* wire at the preselector connected to the incoming end of the junction taken into use over the preselector of Fig. 3 and the further preselector is operated in a similar manner. After the requisite number of impulses have been transmitted relay S in the first selector operates and short circuits the impulse repeating contact *a*2 thereby causing relay PL and like relays in succeeding incoming preselectors to remain operated. At an intermediate exchange this is without effect as relay PT has already operated thereby preventing operation of relay PQ. At the wanted exchange no impulses are received but the operation of relay S at the first selector closes the *b* wire circuit and all the relays PL connected to the junction circuit so far built up are energized for a prolonged period. At the wanted exchange the operation of relay PL effects the operation of relay PR as before and due to the former relay's prolonged energization relay PQ operates, locks up over contact *pq*1 and at contact *pq*2 opens a point in the circuit of winding (II) of relay PT. Contact *pq*3 disconnects wiper JC and connects the switch magnet PDM to earth over wiper LC and the commoned contacts in the early part of the bank. The switch is thereupon stepped until the first of the later contacts is reached, winding (I) of relay PT being short-circuited by the earth over wiper LC, and continues stepping until an outlet to a free incoming selector is met denoted by absence of earth on the test wire. The magnet PDM is of the kind in which stepping of the wipers occurs on the retraction of the magnet armature and when the wipers are stepped on to contacts of a free outlet relay PT is no longer short circuited and on the closure of contact *pdm* the relay operates in series with magnet PDM, the resistance of this circuit being too high to permit of re-operation of the magnet. Contact *pt*1 closes a locking circuit for relay PT over its winding (II) and contact *pt*4 connects earth over contact *pq*3 to wiper LC to mark the outlet engaged. The junction is switched through to the incoming selector and further trains of impulses are repeated by relay PL in the ordinary manner. The reply of the called subscriber causes relay PY to be operated and contact *py*1 connects battery over the incoming junction *a* wire to op-

erate the answering supervisory relays at preceding exchanges.

When the calling subscriber clears relay PL releases releasing relays PR, PQ and PT and PY and the release of succeeding switches is initiated. If the test connection is a local one the release of relays PQ and PT connects magnet PDM over wiper JC to the earthed contacts and the switch is stepped until the first contacts connected to an outlet to a free junction is met and the switch comes to rest with its wipers on such contacts.

If the junctions are worked in both directions then a special equipment such as that denoted by BWEL or BWER (Fig. 1) is connected between the incoming end of a junction and the junction preselector. The equipments BWEL and BWER are identical and one of them is shown in Fig. 4; for convenience this will be assumed to be the equipment designated BWER in Fig. 1 and the junction wires on the right of Fig. 4 (upper part) will be assumed to be the junction JR. The wires on the left will be connected to JPSL and IS and those on the right (lower) to JPSR. In the case of a call incoming over the junction JR the operation of the test relay in the preceding circuit connects earth over relay Y or PY as the case may be to the junction *a* wire and this connection extends over contacts *cor*1 and *sr*2 and relay ETR to battery. Relay ETR is of high resistance and operates but the answering supervisory relay in series with it does not. Contact *etr*1 disconnects relay COR and connects earth to the junction multipled in the banks of JPSL and IS (Fig. 1) to mark the junction engaged and to cause JPSL to step on and preselect another free junction. The connection of battery to the incoming junction *b* wire operates relay PL in JPSR as previously described. When the junction is worked as a both way junction a third incoming wire is connected to the incoming preselector this wire being connected to battery over relay SR in the equipment BWER and on the operation of relay PR earth is connected to this wire at contact *pr*1 to operate relay SR. Relay SR operating contact *sr*1 opens a further point in the circuit of relay COR and prepares an alternative earth connection to the junction in the multiple which circuit is completed on the release of relay ETR at contact *sr*2. The setting up of the connection now proceeds as before described.

If a call is incoming from junction JL over the equipment BWEL and preselector JPSL or over a first selector in the exchange in which the equipment under consideration is situated earth will be connected to the wire *c* on the left of the Fig. 4 by the operation of the test relay in the preceding switch and relay COR operates. The earth connection to wire *c* marks the junction engaged and contacts *cor*1 and, *cor*2 switch the connection through over junction JR to the next exchange.

On the release of a connection relay SR or COR as the case may be are released and the equipment is restored to its normal condition.

What I claim as new and desire to secure by Letters Patent is:

1. In a telephone system, a plurality of exchanges, junctions connecting the exchanges in tandem or serial relationship, and means in each intermediate exchange for associating free junctions incoming from the adjacent exchanges on each side to maintain a free route through the exchange.

2. In a telephone system, a plurality of exchanges, junctions connecting the exchanges in tandem or serial relationship, and pre-selecting switching devices in each intermediate exchange for automatically associating each free junction with a free junction leading to an adjacent exchange.

3. In a telephone system, a plurality of exchanges connected by junctions in tandem or serial relationship, means in each intermediate exchange automatically operated for associating free junctions from one of the adjacent exchanges with free junctions from the other of the adjacent exchanges to maintain a free route through the series of exchanges, and subscriber-controlled means for effectively interconnecting associated junctions.

4. In a telephone system, a plurality of exchanges connected by junctions in tandem or serial relationship, means in each tandem exchange for automatically associating free junctions from one of the adjacent exchanges with free junctions from the other of the adjacent exchanges to maintain a free route through the chain of exchanges, subscriber controlled means for seizing a junction and for transmitting a series of impulses thereto, and means controlled by the impulses for effectively interconnecting associated junctions.

5. In a telephone system, a plurality of serially related free junctions, means for taking the first junction of the series into use and for transmitting a series of impulses thereto, and means responsive to said series of impulses for progressively interconnecting adjacent junctions.

6. In a telephone system, a plurality of free junctions, automatic switches for associating said junctions in tandem or serial relationship, means for transmitting a series of impulses to the first junction in the chain, and means responsive to said impulse series for progressively connecting the junctions, said means comprising means in each switch operated responsive to a single one of the impulses of the series.

7. In a telephone system, a plurality of exchanges connected by junctions in tandem or serial relationship, means in each tandem exchange for associating together free junctions extending to the respective adjacent exchanges, means controlled by a calling party in an intermediate exchange for selecting a free junction extending to one of the adjacent exchanges, and means controlled by the calling party for effectively connecting the selected junction with the associated junction in said adjacent exchange.

8. In a telephone system, a plurality of automatic exchanges connected by junctions in tandem or serial relationship, means in each exchange for associating free junctions extending to adjacent exchanges, subscribers' lines terminating in the exchanges, subscriber-controlled means for transmitting series of impulses over the line, means responsive to the first series of impulses transmitted over a line for selecting a free junction extending from the exchange terminating the line, and means responsive to the second series of impulses transmitted over the line for progressively connecting a plurality of associated junctions to extend a connection from the line to a wanted exchange.

9. In a telephone system, a plurality of automatic exchanges connected by junctions in tandem or serial relationship, means in each exchange for automatically associating free junctions extending to adjacent exchanges, a subscriber's line terminating in one exchange, means

for transmitting series of impulses over the line, means responsive to the first series of impulses transmitted over the line for selecting a free junction to an adjacent exchange and for designating a particular one of the plurality of exchanges as a wanted exchange, and means responsive to the second series of impulses and dependent on the value of the first series of impulses for progressively connecting associated junctions in various exchanges to extend a connection from the line to the designated exchange.

10. In a telephone system, a plurality of exchanges connected by junctions in tandem or serial relationship, a hunting switch for each junction, said switches being arranged to pre-select a free junction extending to an adjacent exchange, means for transmitting impulses over the junctions, and means responsive to the receipt of an impulse over a junction for operating the associated switch to seize the pre-selected junction.

11. In a telephone system in which exchanges are connected by junctions in tandem or serial relationship, means for seizing a junction in any exchange, means for transmitting a series of impulses over the seized junction, and means responsive to said impulses for progressively connecting other junctions to the seized junction, one junction being connected for each impulse of the series.

12. In a telephone system, a plurality of exchanges connected by junctions in a chain, means for seizing a junction and for transmitting a series of current impulses thereover, means responsive to the first impulse of the series for connecting the seized junction to a junction extending to an adjacent exchange, and means responsive to each succeeding impulse of the series for connecting the junction last connected with to a junction extending to an exchange located farther along in the chain.

13. In a telephone system, a switch, means for transmitting series of impulses to the switch, means in the switch operated responsive to the first series of impulses for setting the switch, and means in the switch for repeating a portion of the second series of received impulses, the repeated portion depending on the initial setting of the switch.

14. In a telephone system, a selector repeater switch, means for transmitting series of impulses to the switch, means responsive to the first series of impulses for setting the switch in selective relation to a group of junctions, means in the switch for automatically selecting an idle one of said junctions, and means in the switch for repeating a portion of the second series of impulses over the selected junction, the number of impulses repeated depending on the initial setting of the switch.

15. In a telephone system, a selector repeater switch, means for transmitting series of impulses to the switch, means responsive to the first series of impulses for setting the switch and for determining the portion of the second series of impulses to be repeated, and means responsive to the second series of impulses for repeating the portion determined by said first means and for disabling said determining means to permit the repeating of all impulses of subsequent series transmitted to the switch.

16. In a telephone system, a selecting switch and an associated auxiliary switch, means in the first switch for responding to a plurality of series of impulses, means responsive to the first series of impulses for setting the first switch in selective relation to a group of junctions and for marking a contact accessible to the second switch, means in the first switch for automatically selecting and seizing an idle junction in the selected group, and means responsive to the second series of impulses for operating said second switch and for simultaneously repeating the impulses over the seized junction until the second switch connects with said marked contact.

17. In a telephone system, a selecting switch and an associated auxiliary switch, means for transmitting series of impulses to the first switch, means responsive to the first series of impulses for setting the first switch in selective relation to a group of junctions and for marking a contact accessible to the second switch, means in the switch for automatically connecting with an idle one of said junctions, means responsive to the second series of impulses for operating the second switch one step for each impulse of the series and for simultaneously repeating the impulses over said one junction, a relay operated responsive to the second switch connecting with said marked contact, and means controlled by said relay for disabling the last said means.

18. A telephone system as claimed in claim 17 in which the auxiliary switch is not operated and no impulses of the second series are repeated in case the contact marked by the first switch is the contact normally engaged by the second switch.

19. In combination, a junction terminating in a hunting switch, two groups of junctions accessible to said switch, means for closing a circuit over the first junction, and means controlled by the duration of said circuit closure for determining the group in which the switch will seize a junction.

20. A switch having access to two groups of outlets, a line relay for the switch, means for transmitting impulses of different length to the switch to operate said relay, and means controlled by the duration of the operation of said relay for determining the group of outlets over which a connection will be extended.

21. A switch having access to two groups of outlets, two test wipers for testing the outlet groups, respectively, means for transmitting impulses of different lengths to the switch, and means dependent on the length of the impulse for rendering one or the other of said wipers effective.

22. A switch having access to two groups of outlets, means for operating the switch to select an outlet in one group, means for transmitting a long or a short impulse to the switch, means responsive to a short impulse for operating the switch to seize the selected outlet, and means responsive to a long impulse for operating the switch to select and seize an outlet in the other group.

23. A switch having access to two groups of outlets, means for transmitting a single impulse or a series of impulses to the switch, means in the switch responsive to the receipt of a single impulse for operating the switch to connect with an idle outlet in one group, and means in the switch responsive to the receipt of the first impulse of a series for operating the switch to seize an outlet in the other group and for rendering the switch effective to repeat subsequent impulses of the series over the seized outlet.

24. In a hunting switch, a line relay and a test relay, means for energizing the line relay

for either a short interval or a long interval, means controlled by the line relay for preparing a circuit for the test relay upon energizing and for completing said circuit upon releasing provided the line relay has been energized for a short interval, and means including a relay energized provided the line relay has been energized for a long interval for preventing the completion of said circuit.

25. In a telephone system comprising a plurality of exchanges, two-way junctions connecting the exchanges in tandem or serial relationship, hunting switches associated with both ends of the junctions, means for maintaining said switches in selective relation with idle junctions extending to adjacent exchanges, means for seizing a junction at one end, means responsive to said seizure for disconnecting the associated switch at said one end, means for transmitting a current impulse over the seized junction, and means controlled by said impulse for causing the associated switch at the other end of the junction to seize the pre-selected junction extending to the adjacent exchange.

26. In a telephone system, a plurality of unconnected serially related junctions, means for taking the first junction of the series into use, means for transmitting a series of evenly spaced impulses over the first junction, and means responsive directly to the impulses for progressively connecting the associated junctions.

27. In a telephone system, a plurality of serially related junctions, a switch terminating each junction and associating it with the next adjacent junction of the series, means for taking the first junction of the series into use, means for transmitting a series of impulses over the first junction, and means responsive to said impulses for progressively operating said switches to connect associated junctions while the impulses are being transmitted.

28. In an automatic switch adapted to respond to two series of impulses, means for positioning the switch responsive to the first series of impulses, and means for repeating a variable number of the impulses of the second series dependent upon the positioning resulting from the first series of impulses.

29. In a switching device, means for responding to two series of impulses, means for repeating a variable number of impulses of one series, and means controlled by the other impulse series for controlling said first means.

30. In a switching device, means for responding to a plurality of series of impulses, means for setting the device responsive to the first series of impulses, means for repeating a variable number of impulses of the second series of impulses, and means for repeating all impulses of subsequent impulse series.

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