Aug. 19, 1941. A. WIRTH ET AL 2,253,218

TELEPHONE SYSTEM

Filed Feb. 9, 1939 5 Sheets-Sheet 1

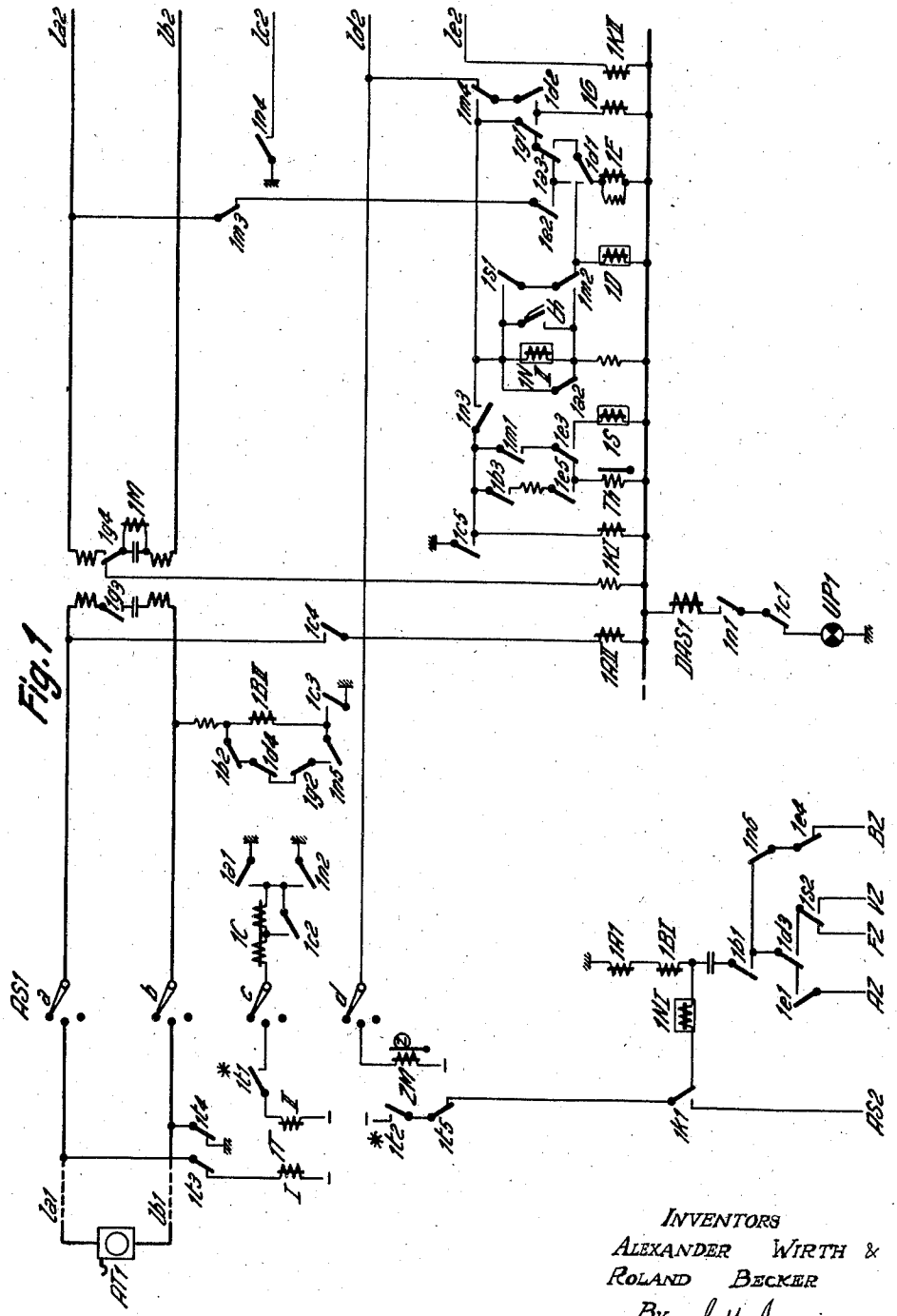


Fig. 1

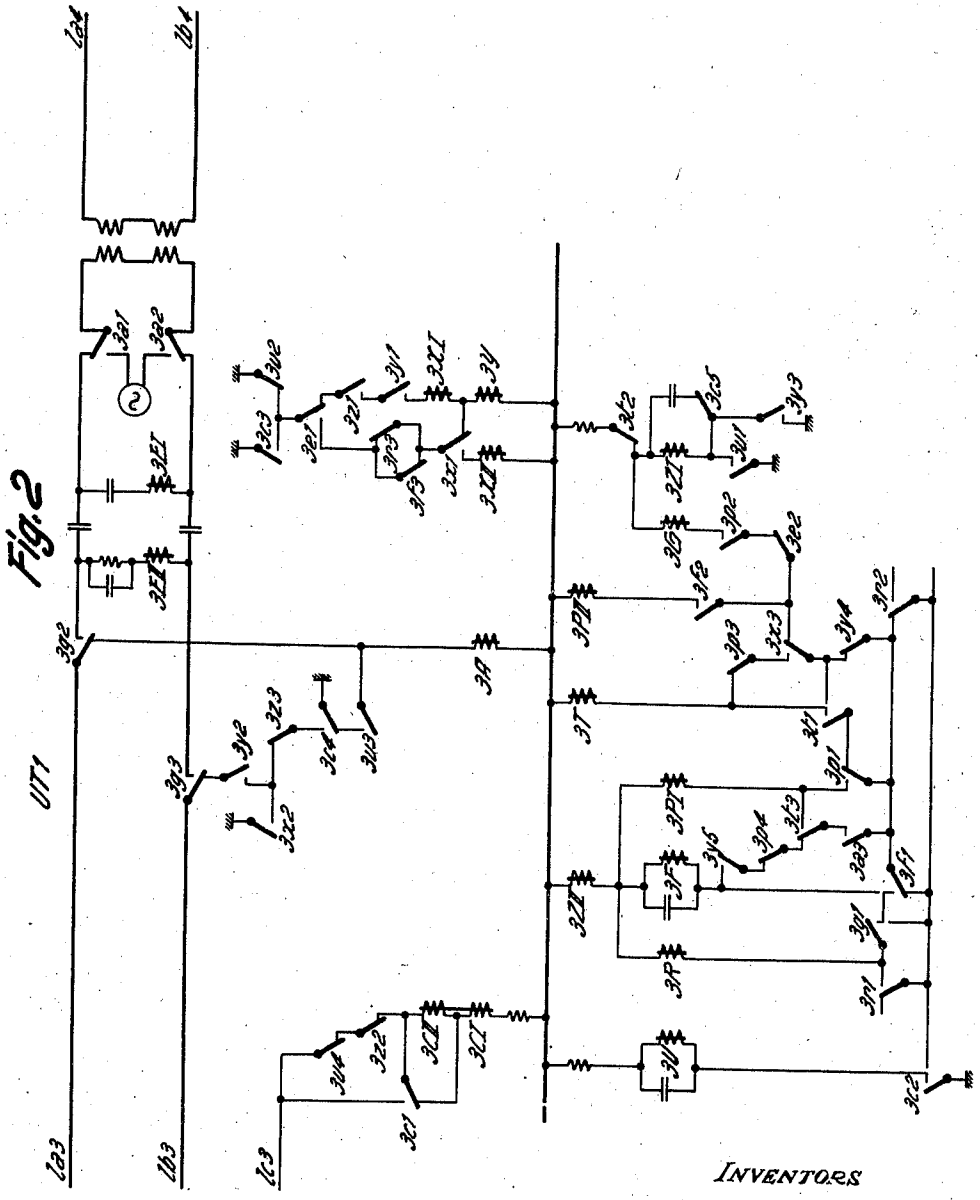
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TELEPHONE SYSTEM

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Fig. 2



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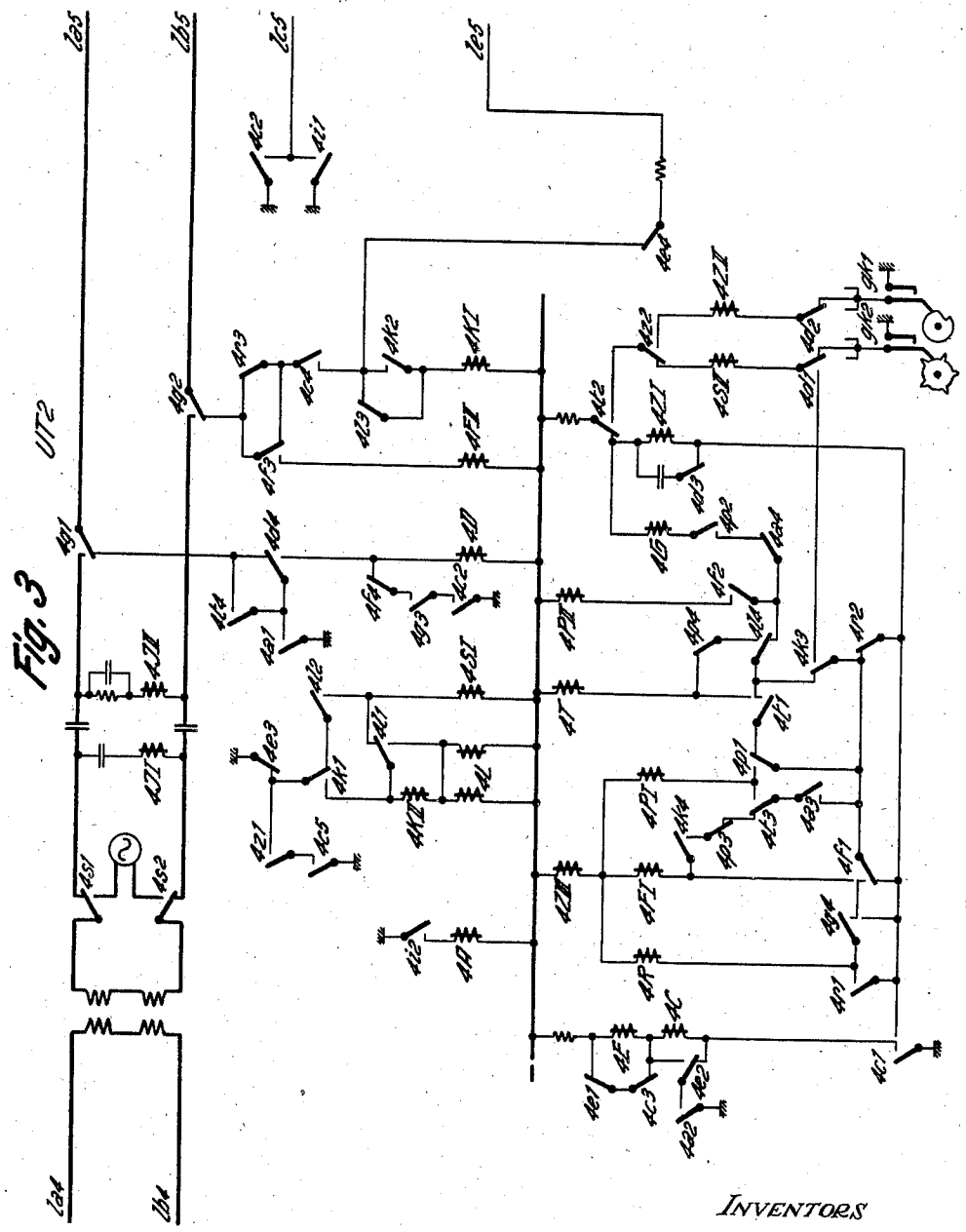


Fig. 3

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TELEPHONE SYSTEM

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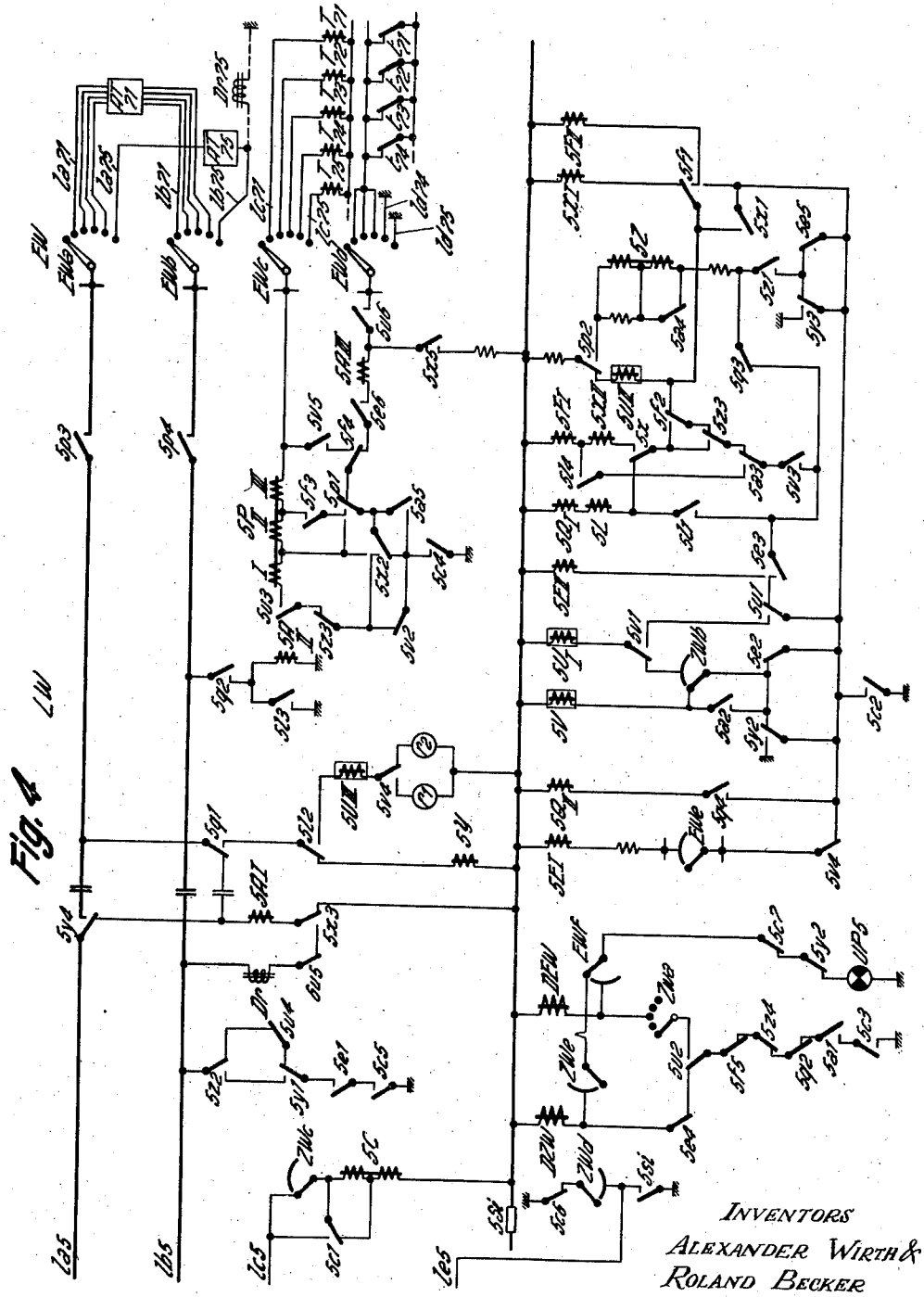


Fig. 4

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TELEPHONE SYSTEM

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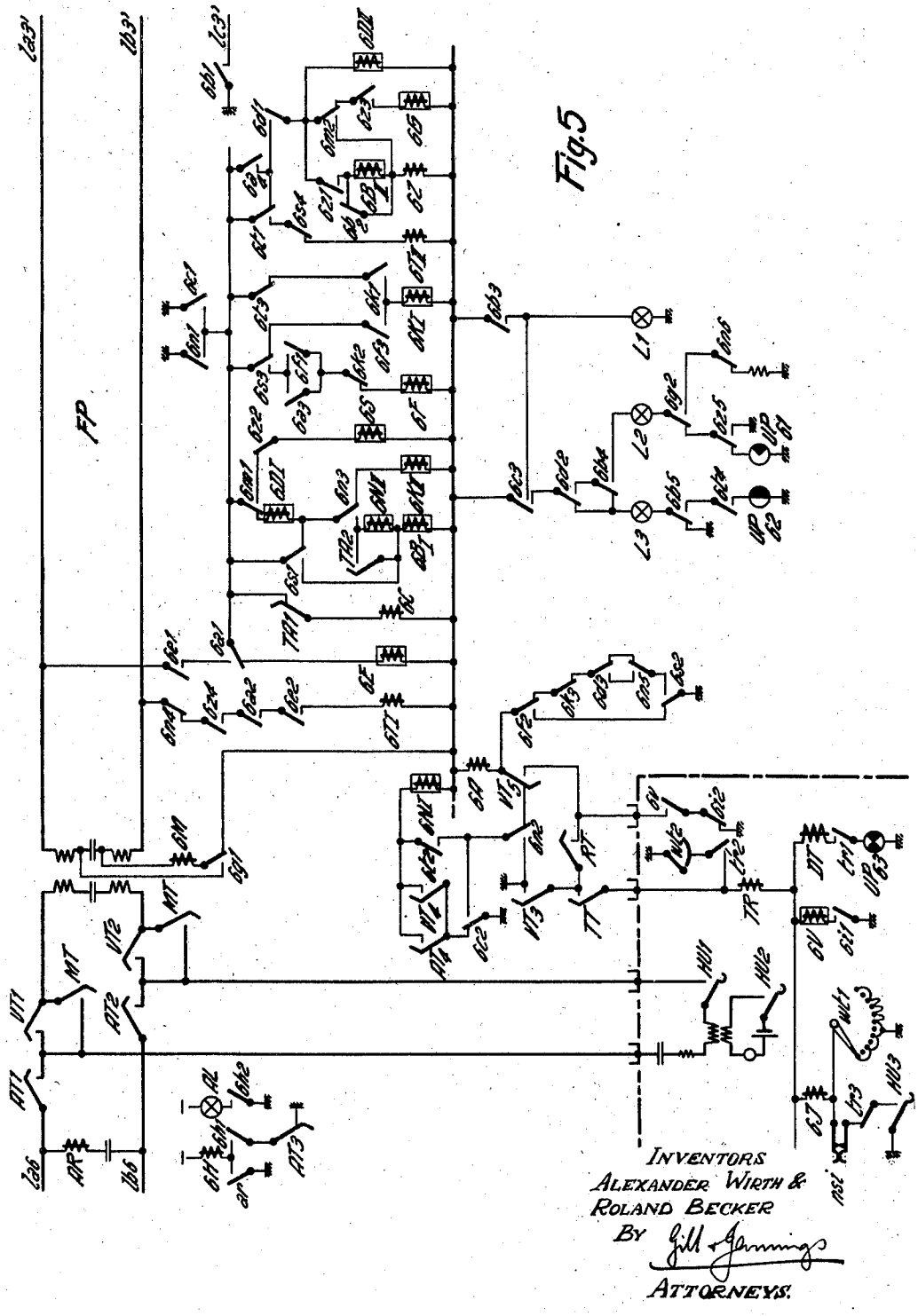


Fig.5

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2,253,218

TELEPHONE SYSTEM

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In Germany February 8, 1938

14 Claims. (Cl. 179—18)

This invention relates to selector-operated telephone systems and in particular to systems comprising a number of exchanges connected by trunk lines. The invention provides new and improved means for controlling the line selectors and, in particular, for sending calling current to a wanted subscriber and also means for sending signal currents to a calling subscriber.

According to one feature of the invention, the final selector has associated with it switch means for sending out different backward signals in accordance with the condition of the selected subscriber's line. These switch means actuate switch means provided in a repeater connected to the exchange which makes the connection so as to switch in idle and busy signals. On receipt of the backward signal which characterises that the selected subscriber's line is free, the switch means in the repeater cause a control current impulse to be emitted; the switch means in the final selector make the apparatus for the intermittent supply of calling current to a selected "free" subscriber operative only when this particular control current impulse is received. With this arrangement, the alternating calling current is therefore not immediately and automatically sent out by the line selector when the wanted subscriber has been found to be free. It is sent out only when a particular control current impulse has been received. It is thus possible to control the final selectors in the same way both when the connection is made by a subscriber and when it is made by an exchange operator. In connections which are made by an operator, it is usual for the calling current to be sent to the wanted subscriber only after the operator has carried out a particular switching measure. In accordance with the invention, the wanted subscriber is called only when the calling subscriber has lifted his receiver and the connecting devices are in order. When this is not the case, the control current impulse cannot be sent out or transmitted by the repeater which is connected to the calling subscriber. It is also possible, after the final selector has been set, to transmit further switching operations over the speech line of the connection. For example, current impulses may be sent from the wanted subscriber's exchange to the calling subscriber's exchange which characterise the former exchange and serve to determine the charge to be made to the calling subscriber for the connection. In this case, the emission or the transmission of the control current impulse may be delayed until these additional switching operations have been transmitted. The calling subscriber then receives an appropriate signal upon the reception of the backward signal which indicates that the wanted subscriber is disengaged. The wanted subscriber is, however, not yet called. The supplementary switching operations are first transmitted and then the control current impulse which institutes the calling of the wanted subscriber.

In accordance with a further feature of the invention, an exchange is provided with switch means which, on receipt of the backward signal which indicates that the selected subscriber is engaged, send out a control current impulse which, in the final selector, cause a connection to be made to the busy subscriber's line. This considerably simplifies and accelerates the making of connections through an operator as the operator is automatically connected to a busy line and can inform the subscriber of the existence of an urgent connection.

In accordance with a further feature of the invention, the trunk lines have associated with them switch means which, on receipt of certain backward signals, cause the speech lines to be connected. It is thus possible, in a simple manner, to send the backward signals through the trunk lines and through the speech lines which run within an exchange. The speech lines are connected only while talking conditions persist, i. e. when the subscriber replies or when a connection is made to a busy subscriber, and are disconnected for example when the called subscriber replaces his receiver.

In accordance with a further feature of the invention, the repeaters at the ends of the trunk line have associated with them alternating current relays which are galvanically connected to the speech line in an exchange and which may be actuated by a direct current received through this speech line. This makes it possible during talking conditions to connect in each repeater only one relay to each speech line, so that the speech currents are very little attenuated.

In accordance with a further feature of the invention, there are provided in the final selector both circuits for testing whether the selected subscriber's line is idle or busy and also a circuit for testing whether a line running to the same subscriber is free. In this group testing circuit is connected a winding of the current impulse relay of the final selector which, when the selected line is engaged, and also when one of a number of lines belonging to the same subscriber is free, causes the final selector to be stepped. This makes it simple to select a free line from a num-

ber of lines leading to the same subscriber. If an urgent connection is made by an operator when all the lines are engaged, one of the lines which is carrying a not urgent connection is automatically connected to the operator.

These and further features of the invention are explained in the following description of the accompanying drawings, in which:

Figure 1 shows the circuit of a calling subscriber, a finder and a repeater connected thereto;

Figure 2, the circuit of a repeater at the outgoing end of a trunk line;

Figure 3, the circuit of a repeater at the incoming end of a trunk line;

Figure 4, the circuit of a final selector; and

Figure 5, the circuit of an operator's position on a trunk exchange.

Figures 1, 2, 3 and 4 together show the circuits made during a connection between a calling subscriber and a called subscriber; Figures 5, 2, 3 and 4 together show the circuits made during a connection between the trunk exchange and a wanted subscriber. If no trunk line is used, i e. when the wanted subscriber and the calling subscriber belong to the same exchange, the circuits shown in Figures 2 and 3 are not used.

Connections between two subscribers belonging to different exchanges

When the subscriber AT1 (Figure 1) removes his receiver, his calling relay 1T (which is a 2-step relay) is energised through the winding I and makes its first step so that the contacts *1t1*, *1t2* are closed. The contact *1t2* closes a circuit through the windings I of the relays 1N, 1B, 1A of an idle finder switch AS1. The relays respond. The contact *1n1* closes a circuit for the driving magnet DAS1 of the finder switch to which is connected an interrupter UP1. The magnet DAS1 is intermittently energised and steps the wipers of the finder switch. When the wiper *c* finds the calling subscriber's contact, the following circuit is closed:

—, winding II of relay 1T, contact *1t1*, wiper *c* of the finder AS1, relay 1C, $<^{\text{contact } 1a1,}_{\text{contact } 1n1,}$ +

The testing relay 1C responds and its contact *1c1* opens the circuit of the magnet DAS1 while its contact *1c2* short circuits its own high ohmic winding. The amplification of the current thus obtained causes the relay 1T to make its second step and open its contacts *1t3*, *1t4* and *1t5*. The contacts *1c3* and *1c4* connect the windings II of the relays 1A and 1B to the speech wires so that these relays remain energised in spite of the opening of the circuit through their windings I. The contact *1c5* closes a circuit for the winding I of the relay 1K which responds and by means of its contact *1k1* prepares a circuit for another idle finder switch AS2. Also, the contacts *1c5* and *1n3* close a circuit for the winding II of the relay 1N so that this relay also remains energised. The contact *1n4* maintains a circuit through the lead *lc2* to the next selector, for example to a group selector. Finally, the contacts *1c5*, *1n3*, *1g1*, *1a3* and *1d1* close a circuit for the relay 1E which responds. The contact *1e1* connects the source of alternating current AZ which emits the exchange signal to the windings I of the relay 1A and 1B over the contacts *1d3* and *1b1*. The exchange signal is therefore transmitted inductively to the calling subscriber's speech wires. When the subscriber has received the exchange signal, he can start the dial.

The first impulse emitted when the subscriber dials de-energises the relays 1A and 1B. The contact *1b2* short circuits the winding II of the relay 1B so that this relay cannot respond again. At the same time, the resistance in the feed circuit is reduced. The contact *1b1* opens the circuit of the source of alternating current which sends out the exchange signal.

Each time the relay 1A drops, an impulse is sent through the wire *la2* by the contact *la3*:

+, contacts *1c5*, *1n3*, *1g1*, *1a3*, *1e2*, wire *1a2*

In the next selector, which may for example be a group selector, the wire *la2* has connected to it an impulse receiving relay which sets the selector in accordance with the received impulses.

It is assumed, that when the calling subscriber dials, a current impulse train is emitted which sets a group selector connected to the wires *la2*, *lb2* and *lc2* in the repeater UT1 (Figure 2) from which a trunk line *la4* leads to another exchange. When this happens, a circuit is closed through the wire *lc3* in which the relay 3G is energised. Consequently, the contact *3c2* energises a relay 3U which, by means of its contacts *3u1*, energises the winding I of a relay 3Z.

The calling subscriber AT1 now sends out current impulses which set the selectors of the distant exchange. These impulses are transmitted by means of the contact *1a3* of the finder AS1 (Figure 1) over the trunk line *1a4*, *1b4* to the wire *1a2* which is connected to the wire *la3* in the group selector GW (not shown). The impulses are received in the repeater UT1 (Figure 2) by the relay 3A. At each impulse, the relay 3A actuates its contacts *3a1* and *3a2* and causes alternating current to be supplied to the trunk line *la4*, *lb4*. The impulses are thus transmitted through the trunk line as alternating current impulses.

In the repeater UT2 (Figure 3) at the incoming end of the trunk line *la4*, *lb4*, these impulses are received by the relay 4J. The winding I of the relay 4J lies in series with a condenser bridged across the speech wires. The winding II of the relay 4J is directly bridged across the speech wires. The alternating currents arriving through the trunk line *la4*, *lb4* reach it through the condensers lying in the speech wires. This ensures that the relay 4J is energised with reliability with alternating current. At each response, the relay 4J closes by means of its contact *4j2* a circuit for the relay 4A.

When the first alternating current impulse is received, the seizing circuit through the wire *lc5* of the final selector LW (Figure 4) is closed by the contact *4j1* so that the relay 5C responds. Furthermore, the relay 4C of the repeater UT2 (Figure 3) is energised by the contact *4a2* and locks in a circuit closed at its contact *4c1*. The contact *4c3* opens a short circuit for the relay 4E which therefore responds. The winding I of the relay 4Z is also energised by the contact *4c1*. Each current impulse is transmitted through the wire *la5* by the contact *4a1* so that the winding I of the relay 5A in the final selector LW is energised. A selector EW of the final selector LW is set on to the contact connected to the wanted subscriber's line by the two impulse trains sent out by the calling subscriber. During the setting of this selector, the relays 5V and 5U are energised. When the last train has been received, the relay 5V releases after a delay and, by means of its contact *5v2*, closes the testing circuit for the relay 5P.

Desired subscriber's line is busy

If the selected line is busy, the relay 5P cannot respond. The relay 5U drops after a delay as a result of the response of the relay 5E. When, after the relay 5U has dropped, the relay 5V drops, a backward signal circuit through the wires *lb*5 is closed by the contact 5*u*4 in which the winding I of the relay 4K in the repeater UT2 is energised. The relay 4K responds and its contact 4*k*1 closes a circuit for the winding I of the relay 4S and also locks the winding II of the relay 4K in a circuit which runs through a slow-acting relay 4L. When the relay 4L responds, its contact 4*l*1 opens the circuit for the relay 4S and short circuits the winding II of the relay 4K. The contact 4*k*2 however maintains the winding I energised in the backward signalling circuit.

The relay 4S (winding I) responds for the duration of the delay in response of the relay 4L and its contacts 4*s*1 and 4*s*2 connect alternating current to the trunk line *la*4, *lb*4. The alternating current impulse sent out is received by the relay 3E in the repeater UT1 at the outgoing end of the trunk line. On response of the relay 3E, the relay 3Y is energised by the contact 3*e*1 and its contact 3*y*1 prepares a locking circuit which is closed when the relay 3E drops. This locking circuit runs through the winding I of the relay 3X, which is also energised. The short backward impulse energises the relays 3X and 3Y and the contacts 3*x*2 and 3*y*2 close the backward signalling circuit through the wire *lb*3 which is connected to the wire *lb*2 through the group selector (not shown). The relay 1M which is connected to the line *lb*2 is thus energised and its contact 1*m*1 energises the relay 1S. The contacts 1*s*1 and 1*m*2 short circuit the winding II of the relay 1N. This relay, after a delay, releases and its contact 1*n*3 opens the energising circuit for the relay 1E which likewise drops. The contact 1*m*5 removes the short circuit from the winding II of the relay 1B. The relay 1B responds in the calling subscriber's feed circuit and the contacts 1*b*1, 1*n*6 and 1*e*4 switch in the source of alternating current BZ which sends out a "busy" signal to the windings I of the relays 1A and 1B. The calling subscriber then hears the busy tone. The seizing circuit running through the wires *lc*2 is interrupted at the contact 1*n*4 whether the calling subscriber replaces his receiver or not. The seizing circuit through the wire *lc*3 is also interrupted in the group selector (not shown) and the relay 3C in the repeater UT1 at the outgoing end of the trunk line drops. The circuit of the relay 3U is interrupted at the contact 3*c*2. The relay 3A is energised for the duration of the delay in release of the relay 3U by the contacts 3*c*4 and 3*u*3 and its contacts 3*a*1 and 3*a*2 connect the source of alternating current to the trunk line *la*4, *lb*4 for 250 milliseconds. The relays 4J and 4A in the repeater UT2 are consequently energised. The contacts 4*a*2 and 4*e*2 short circuit the relay 4C which, after a delay, drops. At the end of the alternating current impulse, the relay 4E also drops and the seizing circuit through the wire *lc*5 is opened. When the relay 4C drops, the relays 4Z and 4K are deprived of current.

The opening of the circuit through the wire *lc*5 causes the relay 5C in the final selector LW to drop. The contact 5*c*7 then closes a circuit for stepping the switches EW and ZW into the rest position. The contact 5*c*6 and the wiper ZW*d* close a locking circuit which runs through the wire *le*5 and energises the winding I of the relay 4K in the repeater UT2. The relays 4K and 4L consequently respond and the relay 4S is energised for the delay in response of the relay 4L so that by means of the contacts 4*a*1 and 4*e*2, it sends out a short alternating current impulse.

This short alternating current impulse causes the energisation of the relays 3Y and 3X in the repeater UT1 which were deprived of current when the relay 3C dropped. The contact 3*yc* closes an energising circuit for the winding I of the relay 3Z. The contact 3*z*2 disconnects the relay 3C from the wire *lc*3 so that the repeater UT1 cannot be seized by the group selector.

It is not until the switch ZW of the final selector LW has been stepped back into the rest position that the locking circuit through the wire *lc*5 is interrupted at the wiper ZW*d*. The relay 4K in the repeater UT2 is deprived of current and disconnects the relay 4L. The relay 4S is energised for the duration of the delay in response of the relay 4L, and sends back a second short alternating current impulse through the trunk line. This impulse is received by the relay 3E in the repeater UT1 which, by means of its contact 3*c*1, opens the circuit for the relay 3Y. The contact 3*y*3 opens the circuit for the relay 3Z which, by actuating its contact 3*z*2, again connects the seizing relay 3C to the line *lc*3. The repeater UT2 may now again be seized by a group selector.

The repeater UT1 is made unseizable in the same way when the line selector LW is out of order for one reason or another and must not be actuated. If, for example, the fuse 5S*i* has blown, the locking circuit through the wire *le*5 is maintained closed by the contact 5*si*.

Desired subscriber's line is idle

If the selected subscriber's line is idle, the testing relay 5P responds before the relay 5U has dropped and the contacts 5*p*3 and 5*p*4 connect the speech lines while the contact 5*p*2 prepares a circuit for the relay 5Z which is closed at the contact 5*u*1 when the relay 5U drops. At the same time, the backward signalling circuit is closed through the wire *lb*5 by the contact 5*u*4 and is opened again by the contact 5*z*2 when the relay 5Z responds. This backward signalling circuit causes the relay 4K in the repeater UT2 to respond and the contact 4*k*1 energises the relay 4L. The winding I of the relay 4S is energised for the duration in the delay in response of the relay 4L and by actuation of the contacts 4*s*1 and 4*s*2 sends an alternating current impulse through the line *la*4, *lb*4. Current flows over the wire *lb*5 for only 50 milliseconds, at the end of which time the relay 4K again drops. A circuit for the relay 4S is closed again by the contacts 4*k*1 and 4*l*2 for the duration of the delay in release of the relay 4L so that the relay 4S sends back a second alternating current impulse through the trunk line. A circuit is also closed for the relay 4T by the contacts 4*k*3 and 4*l*4 for the duration of the delay in release of the relay 4L. The relay 4T responds and its contact 4*t*1 closes a locking circuit. The contact 4*t*2 opens the circuit of the winding I of the relay Z and closes a circuit through the windings II of the relay 4Z.

In the repeater UT1 at the outgoing end of the

trunk line the relay 3Y is first of all energised and then the relay 3X is energised by the relay 3E on receipt of the first alternating current impulse which is sent through the trunk line to indicate that the selected subscriber's line is idle. The contacts *3x2* and *3y2* close the backward signalling circuit through the wire *lb3* in which circuit the relay 2J of the metering device ZUG (Figure 2) responds. On receipt of the second alternating current impulse, the relay 3E first de-energises the relay 3Y and then the relay 3X. The backward signalling circuit through the wire *lb3* is thus again opened. The relay 1M in the finder AS1 (Figure 2) is energised. The relay 1S is energised by the contact *1m4*. At the end of the backward signal, the relay 1D is energised by the contacts *1s1* and *1m2* and its contact *1d1* opens the circuit of the relay 1E and closes a locking circuit. The contact *1e2* now sends an impulse through the wire *1a2* for the duration of the delay in release of the relay 1E. The relay 1D opens the short circuit of the winding II of the relay 1B at the contact *1d4* so that the relay 1B again responds. The source of alternating current VZ which emits the calling signal is connected by the contacts *1b1*, *1d3*, and *1s2* to the windings I of the relays 1A and 1B for the duration of the delay in release of the relay 1S so that this signal is inductively transmitted to the calling subscriber's line. When the relay 1S has dropped, the source of current FZ which sends out an intermittent calling signal is connected to the windings I of the relays 1A and 1B so that that signal is transmitted to the calling subscriber. The calling subscriber is thus informed that the wanted subscriber's line is free.

In the repeater UT1, the impulse is received by the relay 3A and is transmitted through the trunk line as an alternating current impulse by the contacts *3a1* and *3a2*. The winding I of the relay 3P and the winding II of the relay 3Z are energised by the contacts *3a3* and *3t3* and the contact *3p1* closes a locking circuit.

In the repeater UT2 at the incoming end of the trunk line, the alternating current impulse is received by the relay 4J which energises the relay 4A. The contact *4a1* transmits a direct current impulse through the wire *la5*. The winding I of the relay 4P and the winding III of the relay 4Z are energised by the contacts *4a3* and *4t3*. The contact *4p1* closes a locking circuit.

In the final selector LW, the current impulse is received by the relay 5A which by means of the contact *5a2* energises the relay 5V. At the end of the impulse, the relay 5L and the winding I of the relay 5Q are energised by the contacts *5v3* and *5z3*. The relay 5L closes a locking circuit by means of its contact *5l1*. The contacts *5q1*, *5q2* and *5l2* and *5l3* close the ringing circuit in which ringing alternating current is sent to the selected subscriber first from the source *r1* and then, after the relay 5V has dropped, from the source *r2* which acts intermittently.

The connection of the devices of the final selector LW for the automatic calling of the desired subscriber is thus dependent upon the receipt of a current impulse which is emitted automatically by the finder AS1 on receipt of the backward signal which characterises that the desired subscriber's line is idle. It is thus ensured that the desired subscriber is called only when the calling subscriber has removed his receiver and the connecting apparatus is in order. In other circumstances, the finder does not send out the impulse and the connecting apparatus cannot transmit it.

On the other hand, it is possible to delay the emission of the calling signal until certain switching operations involving the use of the trunk line have been effected. If, for example, the charge for the connection depends upon distance, and the "zone" in which the called exchange lies relatively to the calling exchange is determined by a signal sent back by the called exchange when the connection has been made, a charge determining device (not shown) may be arranged between the finder AS1 (Figure 1) and the repeater UT1 (Figure 2) which receives the current impulse emitted by the finder AS1 but does not immediately repeat it. The relay 4T in the repeater UT2 (Figure 3) was energised by the "busy" backward signal and its contact *4t2* had interrupted the circuit through the winding I and had closed a circuit through the winding II of the relay 4A. This circuit runs over the contact *gk1* of a current impulse transmitter serving a number of repeaters and having two continuously rotated cams. One of these cams actuates the contact *gk2* so that several trains of impulses are sent out which characterise the exchange in which the repeater is arranged. The contact *gk1* which is actuated by the other cam is always closed when the cam discs are out of their rest position. If the repeater UT2 is connected to the transmitter by the contact *4t2* when the cams are out of their rest position, a locking circuit is closed through the contact *gk1* and the winding II of the relay 4Z.

When the cams pass through their rest position, the contact *gk1* is opened and the relay 4Z drops. The contact *4z2* now closes the current impulse circuit which contains the winding II of the relay 4S and is controlled by the contact *gk2*. The relay 4S, through its contacts *4s1* and *4s2*, emits a number of alternating current impulses, for example three trains, which characterise the exchange of the called subscriber.

When the second alternating current impulse which indicates that the selected subscriber is disengaged was received in the repeater UT1 at the outgoing end of the trunk line, the relay 3T was energised and locked by its contact *3t1*. By means of its contact *3t2* it opened the circuit through the winding I of the relay 3Z. The contact *3z1* is therefore now open and the current impulse trains which characterise the called subscriber and which are received by the relay 3E can now influence only the relay 3Y and not the relay 3X. Each of the received impulses is transmitted by the contacts *3c4*, *3z2* and *3y2* to the line *lb3*.

The charge determining device arranged between the lines *la2*, *lb2*, *lc2* and *la3*, *lb3*, *lc3*, receives these impulse trains which are transmitted through the wire *lb3*, and, in known manner, determines therefrom the charge which is to be recorded by the calling subscriber's meter when the wanted subscriber replies. As soon as the last of the impulses has been received, the charge determining device sends out the impulse which makes the calling circuit in the final selector LW.

As the impulse which the finder AS1 (Figure 1) automatically sends out on receipt of the "idle" backward signal, is not immediately re-

peated, it is possible to delay the automatic calling of the selected subscriber. This provides time in which to transmit impulse trains which characterise the called exchange. The transmission of the signal to the calling subscriber is initiated in the finder AS1 solely as a result of the receipt of the backward "idle" signal. The calling subscriber thus immediately receives a signal which indicates to him that the wanted subscriber is being intermittently rung although the wanted subscriber has not yet been rung.

The impulse trains which characterise the wanted subscriber's exchange do not always have to be sent out by a transmitter in the repeater UT2 at the incoming end of the trunk line. If the arrangement is such that connections can be made through the trunk line *1a4*, *1b4* only to a specific exchange and, for example, not to other exchanges beyond that exchange, a transmitter which corresponds to the transmitter *gk1*, *gk2* (Figure 3) may also be associated with the repeater UT1 at the outgoing end of the trunk line. Such a transmitter would be switched in in the same way on energisation of the relay 3T.

During the automatic calling of the wanted subscriber from the final selector (Figure 1), the relays 1C, 1A, 1B, 1K, 1N, and 1D are energised in the finder AS1 (Figure 1). In the repeater UT1 the relays 3C, 3P, 3T and 3Z are energised, and in the repeater UT2 the relays 4C, 4E, 4P, 4T and 4Z. When the called subscriber replies, the winding III of the relay 5U is energised by the final selector LW. The contact *5a1* unlocks the relay 5L but the winding II of the relay 5U remains energised. The called subscriber's feed circuit now runs through the relay 5Y and the winding II of the relay 5A. The contact *5y1* closes the backward signalling circuit through the wire *1b5* and the contact *5y3* unlocks the relay 5Z which drops. Current is thus sent through the backward signalling device *1b5* for the duration of the delay in the release of the relay 5Z so as to signal back that the called subscriber has removed his receiver.

If the connection is to be metered the relay 5A also responds in the feed circuit of the called subscriber. In this case, the relay 5Z drops after a delay of 50 milliseconds. If the connection is one for which no charge is to be made, the wire *1b75* of the called subscriber AT75 is earthed over a choke coil DR75. When, upon the called subscriber having replied, the relay 5L drops, only the relay 5Y can be energised. The relay 5A is not energised through its winding II because, owing to the parallel connection of the choke coil DR75 it does not receive sufficient current.

When, on response of the relay 5Y, the backward signalling circuit is closed at the contact *5y1* and the relay 5Z is unlocked by the contact *5y3*, this circuit is maintained for about 250 milliseconds because one winding of the relay 5Z is short circuited by the contact *5a4* and the dropping of the relay 5Z is therefore greatly delayed.

At the beginning of the transmission of current through the backward signalling device *1b5*, the relay 4K in the repeater UT2 is energised and switches in the relay 4L. The relay 4S responds for the duration of the delay in response of the relay 4L and sends an alternating current impulse through the trunk line *1a4*, *1b4*. At the end of the backward signal, the relay 4K first of all drops and then the relay 4L. The relay 4S is energised again for the duration of the delay in release of the relay 4L and sends a second alternating current impulse through the trunk line. In the case of a connection which is to be metered, these two alternating current impulses follow at an interval of 50 milliseconds; in the case of a connection which is not to be metered, they follow at an interval of 250 milliseconds. When the relay 4K in the repeater UT2 responds the relay 4T is unlocked by the contact *4k3* and drops. When the relays 4K and 4L have dropped, the following circuit is closed for the relay 4G:

+, contacts *4c1*, *4r2*, *4k3*, *4l4*, *4p2*, relay 4G, contact *4t2*, —

The relay 4G responds and its contacts *4g1* and *4g2* connect the speech wires. The contact *4g3* energises the relay 4D and the contact *4g4* the relay 4R which is locked by its contact *4r1*.

In the repeater UT1 at the outgoing end of the trunk line, the first alternating current impulse of the backward signal which is received by the relay 3E causes the energisation of the relays 3Y and 3X. Through the contacts *3x2* and *3y2*, current is sent through the backward signalling wire *1b3*. The second alternating current impulse of the backward signal causes first the relay 3Y and then the relay 3X to drop. The transmission of current through the backward signalling wire *1b3* is thus interrupted again. If the connection is one which is to be metered, current flows over the wire *1b3* for 50 milliseconds; if it is one which is not to be metered, the flow of current lasts for 250 milliseconds.

On the response of the relay 3Y, the circuit through the relay 3T was opened at the contact *3y4*. When the relays 3Y and 3X have dropped, the following circuit is closed for the relay 3G:

+, contacts *3c2*, *3r2*, *3y4*, *3x3*, *3e2*, *3p2*, relay 3G, contact *3t2*, —

The relay 3G responds and, by means of contact *3g1*, energises the relay 3R which locks itself. The contacts *3g2* and *3g3* connect the speech wires. In the finder AS1, the relay 1M is energised by the flow of current through the wires *1b3*, *1b2*.

The contact *1m4* closes a circuit for the relay 1G which responds and, by means of its contact *1g1*, opens the circuit through the relay 1D and locks the relay 1G. As in the case of a connection which has to be metered, the energisation of the relay 1M persists only for 50 milliseconds. The relay 1M drops before the relay 1D opens. The following circuit is now closed through the wiper *d* of the finder AS1 through which the meter ZM of the calling subscriber is energised.

+, contacts *1c5*, *1n3*, *1g1*, *1d2*, *1m4*, wiper *d* of the finder AS1, meter ZM, —

This circuit is opened again when the relay 1D drops. The meter ZM is thus moved forward one step in order to record the charge.

On response of the relay 1G the contacts *1g3* and *1g4* connect the speech wires *1a1*, *1a2*, *1b2*. The speech wire *1b2* is thus disconnected from the battery.

In the case of a connection which is not to be metered, the relay 1M in the finder AS1 is energised for a time sufficient to allow the relay 1D to drop. When the relay 1D drops, the contact *1d* is opened so that at the end of the backward

signal the circuit for the meter ZM of the calling subscriber is not closed at the contact 1*m*4. The connection of the speech line by means of the relay 1G is effected in the same manner as in the case of connections which have to be metered.

If a charge determining device is provided which is influenced by the impulse trains which characterise the called exchange, this device receives the backward signal which indicates that the called subscriber has removed his receiver. When this happens, it first of all sends a long impulse through the wire *lb*3, which, as in the case of a connection which is not to be metered, energises the relay 1G without influencing the calling subscriber's meter. The charge determining device then sends metering impulses through the wire *ld*2 which step the meter ZM in accordance with the charge to be made. If the charge depends also upon the duration of the connection, metering current impulses may be sent out periodically by the device during the connection, for example, at the end of the third and each subsequent minute etc.

When the calling subscriber replaces his receiver, the relays 1A and 1B in the finder AS1 (Figure 1) are de-energised. The contact 1*a*2 short circuits the relay 1N which drops. The contact 1*n*2 opens the circuit through the relay 1C. All the relays are thereby de-energised. When the contact 1*n*4 opens, the circuit through the wire *lc*2 is also opened so that the group selector is released. The circuit through the wire *lc*3 is thus opened.

In the repeater UT1, the relay 3C drops, so that all the relays return to their rest position. The relay A is energised by the contacts 3*c*4 and 3*a*3 for the duration of the delay in release of the relay ZU and by means of its contacts 3*a*1 and 3*a*2, sends a long alternating current impulse through the trunk line.

In the repeater UT2, the relay 4C is short circuited by the relays 4J and 4A which receive the long alternating current impulse. The relay 4C drops and opens the circuit through the other relays. On receipt of a long alternating current impulse, the relays 4J, 4A and 4E also drop. The circuit through the wire *lc*5 is opened so that in the final selector LW the relay 5C drops and, in known manner, causes the final selector to be released.

If the connection has been made to a subscriber such as the subscriber AT71 who has a number of lines, the final selector LW automatically selects a free line from among them. When the wipers EW of the selector are set on the first line *la*71, *lb*71 of this subscriber's line, the relay 5V which was energised during the setting is de-energised. The contact 5*v*2 closes the testing circuit for the relay 5P through the contact 5*u*3 which is still closed. The relay 5P only responds if the line is "idle." The contact 5*v*4 closes an energising circuit for the winding I of the relay E which responds and closes its contact 5*e*6. If, at this moment, the testing relay 5P has not responded because the first line *la*71, *lb*71 is busy, the following circuit is closed through the winding III of the relay 5A:

+, contacts 5*c*4, 5*x*2, 5*p*1, 5*f*4, 5*e*6, winding III of relay 5A, contact 5*u*6, wiper EW*d*, line *ld*71, contacts *t*72 and *t*73 or *t*74, —

The relay 5A is energised in this circuit. The contact 5*a*1 closes a circuit for the stepping magnet DEW and the contact 5*a*2 again energises the relay 5V. The wipers of the final selector are stepped on to the next contact.

Let it be assumed that subscriber AT71 has four lines *la*71, *lb*71, to *la*74, *lb*74. In the contact bank wiped by the wiper EW*d*, the contacts which correspond to the first three of these lines are connected together and are connected to the battery by the contacts *t*71–*t*74 connected in parallel of the separating relays T71–T74 of the four lines. With this arrangement, as long as one of the lines *l*71–*l*74 is idle, one of the relays T71–T74 is not energised and the wiper EW*d* is connected to the battery so that the relay 5A is energised and causes the wipers to be stepped. The contact associated with the last line *l*74 and wiped by the wiper EW*d* is connected to earth so that the wiper cannot be stepped beyond it.

If, when the selector is set on the first line *l*71, all the lines are busy, the relay 5A is not energised and when the relay 5U has dropped, the backward signal indicating that the subscriber is busy is given through the contact 5*a*4.

If there is an idle line, the wipers are stepped until the testing relay 5P responds, whereupon, in the described manner, the backward signal indicating that the called subscriber is free is given.

Connection between a distant exchange and a subscriber belonging to another exchange

The relay AR in the distant exchange FP (Figure 5) is energised by a call over the long distance line *la*6, *lb*6 which switches in the locking relay 6H. The contact 6*h*2 switches in the lamp AL and the operator asks for the required number by setting over the switch AT.

To make the connection to the wanted subscriber, the operator actuates the switch VT so that the winding I of the relay 6N is energised by the contact VT4. The winding II of the relay 6N is locked by the contacts 6*n*1 and 6*n*3 in which a relay 6B is also energised. The relays 6C and 6E are also energised. The contact 6*b*1 closes the seizing circuit through the wire *lc*3'. This circuit may lead to a group selector which selects the repeater UT1 at the outgoing end of a trunk line so that the relay 3C is energised. The further impulse trains which the operator sends out by means of the numerical switch *ns*1 and the relays 6J and 6A are received by the relay 3A which transmits the impulses through the trunk line *la*4, *lb*4 by means of the contacts 3*a*1 and 3*a*2.

In the repeater UT2 at the incoming end of the trunk line, the current impulses are received by the relay 4J and are repeated by the relay 4A. The relays 4C, 4E and 4Z are energised on receipt of the first impulse. The final selector LW is set in known manner by the impulses received from the relay 5A. During receipt of the last impulse train, the relays 5U and 5V in the final selector are energised. When, on receipt of the last impulse the slow-to-release relay 5V releases, a circuit for the relay 5E is closed at the contact 5*v*4. The relay 5E responds and opens the circuit through the relay 5U at the contact 5*e*2. The testing circuit for the relay 5P is maintained for the duration of the delay in the release of the relay 5U.

If the wanted subscriber is free, the relay 5P responds and the contact 5*p*2 prepares a circuit for the relay 5Z. When the relay 5U drops, the backward signalling circuit through the line *lb*5 is closed by the contact 5*u*4. At the same time, the contact 5*u*1 closes a circuit for the relay 5Z which responds after a delay and by actuating its contact 5*z*2 opens the backward sig-

nalling circuit. In the repeater UT2, the relay 4K is energised over the line *lb*5 by the backward signalling impulse which lasts 50 milliseconds, and switches in the relays 4S and 4L. The relay 4S is energised for the duration of the delay in response of the relay 4L and, by means of its contacts 4*s*1 and 4*s*2, sends back a short alternating current impulse through the trunk line *la*4, *lb*4. At the end of the backward signalling impulse received through the line *lb*5, the relay 4K drops and, for the duration of the delay in release of the relay 4L, again closes the circuit for the relay 4S which sends out a second backward signalling impulse through the trunk line. The contacts 4*k*3 and 4*l*4 cause the relay 4T to be energised. The relay 4T is then locked by the contact 4*t*1 and the contact 4*t*2 opens the circuit through the relay 4Z. A circuit is thus prepared for the transmitter which sends out the impulse trains which characterise the called subscriber's exchange. The relay 4Z is, however, very slow in releasing because of a condenser which is connected in parallel with its winding I.

In the repeater UT1, the first backward signalling impulse received from the relay 3E causes the energisation of the relays 3X and 3Y. The backward signalling circuit through the line *lb*3 is closed by the contacts 3*x*2 and 3*y*2; the second backward signalling impulse which occurs after 50 milliseconds causes de-energisation of the relays 3Y and 3X which drop one after the other. The contact 3*y*2 opens the backward signalling circuit through the line *lb*3. The relay T is energised by the contacts 3*y*4 and 3*x*3 and is locked by its contact 3*t*1 while its contact 3*t*2 de-energises the relay 3Z. The condenser which is connected in parallel with the winding I of the relay 3Z is disconnected on energisation of the relay 3C so that the relay 3Z drops without delay.

At the distant exchange FP, the 50 millisecond backward signalling impulse is received by the relay 6M which, by means of its contact 6*m*1, energises the relay 6S. The relay 6N which is now energised, as are the relays 6C, 6E and 6B, because of its delayed release does not drop in spite of the opening of the locking circuit through its winding II.

When, at the end of the backward signalling impulse, the relay 6M drops, the relay 6D is energised through its winding I by the contact 6*m*1, the short circuit of the winding I being opened at the contact 6*s*1. The contact 6*d*1 closes a locking circuit through the winding II of the relay 6D. The contact 6*d*3 closes a circuit for the relay 6A which, by means of its contact 6*a*1, sends out an impulse through the line *la*3'. The relay 6F is energised by the contacts 6*a*3 and 6*s*3 and its contact 6*f*2 opens the circuit through the relay 6A. After the delayed release of the relay 6S, the circuit through the relay 6F is opened at the contact 6*s*3. For the duration of the delay in the dropping of the relay 6F, a circuit is maintained by the contacts 6*s*2 and 6*f*2 through the relay 6A which sends out a second impulse through the line *la*3'. Also, the winding I of the relay 6K is energised by the contacts 6*s*3 and 6*f*3 and is locked by its contact 6*k*1. On receipt of the 50 millisecond backward signal which indicates that the wanted subscriber is disengaged, two impulses are sent out from the distant exchange. The relays 6C, 6E, 6B, 6N, 6D and 6K in that exchange are now energised and the lamp L2 flickers.

The two impulses sent out from the exchange FP are received in the repeater UT1 by the relay 3A which transmits them over the trunk line by means of its contacts 3*a*1 and 3*a*2. On receipt of the first impulse, the contacts 3*a*3 and 3*t*3 close a circuit for the winding I of the relay 3P and the winding II of the relay 3Z. The relay 3P is locked by its contact 3*p*1. The relays 3C, 3U, 3T, 3P and 3Z are now energised.

In the repeater UT2, the two alternating current impulses are now received by the relay 4J which causes the relay A to repeat the impulses over the line *la*5. On receipt of the first impulse, the contacts 4*a*3 and 4*t*3 close a circuit for the winding I of the relay 4P and for the winding III of the relay 4Z. The contact 4*p*1 closes a locking circuit. The dropping of the relay 4Z is prevented by the energisation of the winding III of the relay 4A, so that the common transmitter cannot send out the current impulse trains which characterise the exchange of the wanted subscriber by means of the contact *gk*2. As the connection is made by the operator who estimates the charge, the emission of these impulses is not necessary. They are only necessary when a connection to another exchange is made by an ordinary subscriber. In this case, a charge determining device may be arranged in the path of the connection which prevents the transmission of one or two control impulses following upon the backward signal which characterises that the wanted subscriber is disengaged, so that the relay 4A drops in the repeater UT2. If, however, one or two control impulses immediately follow the transmission of that signal, the relay 4Z is again energised so that the relay A cannot drop.

In the final selector LW, the two control impulses sent out by the exchange FP are received by the relay 5A which energises the relay 5V. On receipt of the first impulse, the contacts 5*v*3, 5*a*3, 5*z*3 and 5*x*4 close a circuit through the relay 5L and the winding I of the relay 5Q. Both relays respond and are locked by their contacts 5*l*1 and 5*q*4. The contacts 5*q*1, 5*q*2, 5*l*2 and 5*l*3 close the calling circuit in which calling alternating current is sent to the wanted subscriber in the first place from the source *r*1 and, when the relay 5V has dropped, from the intermittently operating source *r*2. On receipt of the second impulse, the winding I of the relay 5F is energised by the contacts 5*v*3, 5*a*3 and 5*l*4 and is locked by its contact 5*f*1. The contact 5*f*3 short circuits the windings I and II of relay SP so that the selected subscriber's line cannot be seized by another high grade connection.

When the called subscriber removes his receiver, the relay 5U is energised through its winding III. The contact 5*u*1 opens the locking circuit for the relay 5L. The contacts 5*l*2 and 5*l*3 switch in the source of alternating current and the feeding relays 5Y and 5A. The relay 5Y in the feed circuit is energised and its contact 5*y*1 closes the backward signalling circuit through the line *lb*5. The contact 5*y*3 opens the locking circuit for the relay 5Z which, after dropping, in the backward signalling circuit is again interrupted by the contact 5*z*2. The contact 5*y*4 has connected the speech line.

In the repeater UT2, the relay 4K is energised at the beginning of the 50 millisecond backward signalling impulse which denotes that the called subscriber has removed his receiver. The contact 4*k*1 energises the relay 4A and the relay 4S is energised for the duration of the delay in the response of the relay 4A and sends out a short

alternating current impulse through the trunk line *la*4, *lb*4. On response of the relay 4K, the contact 4*k*3 opens the locking circuit for the relay 4T which drops. At the end of the backward signalling impulse which is received through the line *lb*5, the relay 4K is deprived of current and the relay 4L, after a delay, drops. The relay 4S is again energised for the duration of the delay in release of the relay 4L and sends out a second short alternating current impulse. When the relays 4K and 4L drop, a circuit is closed for the relay 4G. The contacts 4*g*4, 4*g*1 and 4*g*2 connect the speech lines so that all the branches are cut off from the speech lines. The contact 4*g*4 closes a circuit for the relay 4R which is locked by its contact 4*r*1.

In the repeater UT1, on receipt by the relay E of the first alternating current impulse of the backward signal which indicates that the called subscriber has removed his receiver, the relay 3Y is first energised and then the relay 3X. The backward signalling circuit through the line *lb*3 is closed by the contacts 3*x*2 and 3*y*2. The contact 3*y*4 unlocks the relay 3T which drops. The second alternating current impulse, received at an interval of 50 milliseconds, causes first the relay 3Y and then the relay 3X to be deenergised by the relay 3E. The contact 3*y*2 opens the backward signalling circuit. When the relays 3Y and 3X drop, a circuit is closed for the relay 3G. The contact 3*g*1 energises the relay 3R which is locked. The contacts 3*g*2 and 3*g*3 connect the speech lines and sever all branches from the speech lines.

In the exchange FP, the 50 millisecond backward signalling impulse transmitted over the line *lb*3′ is received by the relay 6M. The contact 6M2 energises the relay 6Z. When the relay 6M drops, the relay 6G is energised and its contact 6*g*1 connects the speech lines while its contact 6*g*2 disconnects the lamp L2. When the called subscriber replaces his receiver, the relays 5Y and 5A in the final selector LW are de-energised. The contact 5*y*1 earths the line *lb*5 and the contact 5*y*4 connects the line *la*5 to the battery. By means of this flow of direct current, the winding II of the relay 4J in the repeater UT2 which is at other times energised by alternating current impulses received through the trunk line, is energised. The relay 4J is bridged across the lines *la*5 and *lb*5 and, therefore, the winding II responds to a direct current. By means of its contact 4*j*2, it energises the relay 4A, the contact 4*a*4 of which opens the circuit for the relay 4G. The winding I of the relay 4K is thus again connected to the line *lb*5 and is energised by the direct current flowing through this line. The contact 4*k*1 energises the relay 4L so that the relay 4S is also energised for the duration of the delay in the response of the relay 4L and sends a short alternating current impulse through the trunk line.

In the repeater UT1, this alternating current impulse which denotes that the called subscriber has replaced his receiver is received by the relay 3E which, at its contact 3*e*2 opens the circuit for the relay 3G. The contact 3*e*1 energises the relay 3Y and then the relay 3X. The line *lb*3 is earthed by the contact 3*x*2, 3*y*2 and 3*g*3 while the line *la*3 is connected to the battery by the contact *g*2.

The relay 6M in the exchange FP which is bridged across the lines is energised by the direct current and its contact 6*m*2 opens the circuit through the relay 6G. The contact 6*g*1 again applies potential to the relay 6M so that it is kept energised by the flow of current through the line *lb*3′. The contact 6*g*2 closes the circuit of the lamp L2 which lights up. The operator is thus informed that the subscriber has replaced his receiver.

By depressing and releasing his receiver hook, the subscriber will cause the lamp L2 to flicker. Each time the hook is released, the relay 5Y in the final selector LW is energised and its contacts 5*y*1 and 5*y*4 disconnect the battery from the line *la*5, *lb*5. In the repeater UT2, the relays 4K and 4L drop one after the other. The relay 4S is momentarily energised and sends an alternating current impulse through the trunk line. The relay 4G is again energised and connects the speech lines. In the repeater UT1, the alternating current impulse is received by the relay 3E which de-energises the relays 3Y and 3X. When these relays drop, the relay G is energised and connects the speech lines. At the exchange FP, the relay 6M is de-energised and its contact 6*m*2 closes a circuit for the relay 6G, the contact 6*g*1 of which connects the speech line while the contact 6*g*2 disconnects the lamp. The lamp L2 thus flickers in phase with the movements of the receiver hook.

If the operator wishes to call back the called subscriber after he has replaced his receiver, she momentarily actuates the calling key RT so that the contacts VT3 and VT5 are closed and the relay 6A energised. The contact 6*a*1 then sends an impulse through the line *la*3′. In the repeater UT1, the impulse is received by the relay 3A and is repeated over the trunk line as an alternating current impulse by the contacts 3*a*1 and 3*a*2. In the repeater UT2, the alternating current impulse is received by the relay 4J and is repeated over the line *la*5 by the relay 4A. In the final selector LW, the relay 5*a* responds and energises the relay 5V. The contacts 5*v*3, 5*a*3, 5*z*3, 5*f*2 and 5*x*4 close a circuit for the relay 5L for the duration of the delay in response of the relay 5V and the contact 5*l*2 connects the source of calling alternating current to the speech line. When the subscriber replies, the same operations take place as have been described above.

The wanted subscriber's line is busy

If the wanted subscriber is engaged, the relay 5P in the line selector LW does not respond before the relay 5U. The contact 5*u*4 closes the backward signalling circuit through the line *lb*5. In the repeater Ut2, the relay 4K is energised and switches in the relay 4L. The relay 4S is energised for the duration of the delay in response of the relay 4L and sends out a short alternating current impulse through the trunk line.

In the repeater UT1 at the outgoing end of the trunk line, this alternating current impulse causes the relay 3E and then the relays 3Y and 3X to be energised. The backward signalling circuit through the line *lb*3 is closed by the contacts 3*x*2 and 3*y*2.

At the exchange FP, the relay 6M is held energised by means of this continuous backward signal which indicates that the wanted subscriber is engaged. The contact 6*m*1 unlocks the relay 6N which drops after a delay and at the same time closes a circuit for relay 6S. When the relay 6N drops, the relay 6A is energised by the contacts 6*s*2, 6*n*5, 6*d*3, 6*k*3 and 6*f*2 and its contact 6*a*1 sends out an impulse through the line *la*3′. The contacts 6*a*3 and 6*s*3 energise the relay 6F and

the contact 6*f*2 de-energises the relay 6A. The relay 6F is locked by its contact 6*f*1.

In the repeater UT1, the impulse is received by the relay 3A and is repeated as an alternating current impulse by the contacts 3*a*1 and 3*a*2. The contacts 3*a*3, 3*t*3, 3*p*4 and 3*y*5 close a circuit for the relay 3F and the winding II of the relay 3Z. The relay 3F is locked by its contact 3*f*1.

In the repeater UT2, the alternating current impulse is received by the relay 4J which energises the relay 4A. The contact 4*a*1 sends an impulse through the line *la*5. The contacts 4*a*3, 4*t*3, 4*p*3 and 4*k*4 close a circuit for the winding I of the relay 4F and the winding III of the relay 4Z. The relay 4F is locked by its contact 4*f*1.

In the line selector LW, the relay 5A is energised momentarily and energises the relay 5V. A circuit for the winding II of the relay 5U and for the winding I of the relay 5X is closed by the contacts 5*v*3, 5*a*3, 5*z*3 and 5*f*2 for the duration of the delay in release of the relay 5V. The contact 5*x*1 closes a locking circuit for the relay 5X. The contact 5*u*4 opens the backward signalling circuit through the line *lb*5.

In the repeater UT2, the relays 4K and 4L drop one after the other. The relay 4S is energised for the duration of the delay in release of the relay 4L and sends an alternating current impulse through the trunk line. The contact 4*f*2 now energises the winding II of the relay 4P. In the repeater UT1, the relay 3E is energised by the alternating current impulse and de-energises the relays 3Y and 3X. The contact 3*y*2 opens the backward signalling circuit through the line *lb*3, and the winding II of the relay 3P is now energised by the contact 3*f*2. In the exchange FP, the relay 6M drops and opens the circuit through the relay 6S. The contacts 6*m*1 and 6*m*3 energise the winding I of the relay 6D and the winding II of the relay 6K. The contact 6*d*1 locks the winding II of the relay 6D and the contact 6*k*1 locks the winding I of the relay 6K. The lamp L2 is caused to flicker by the interrupter UP61.

The response of the relay X of the final selector LW causes the winding I of the relay 5P to be short-circuited when the relay 5V drops. If the selected subscriber's line is engaged by a less important connection, the relay 5P responds through its windings II and III and the contact 5*p*2 opens the circuit through the relay 5U. The relay 5U drops and then its contact 5*u*4 closes the backward signalling circuit through the line *lb*5 and its contact 5*u*1 closes a circuit for the relay 5Z which, after a delay, responds and opens the backward signalling circuit again at the contact 5*z*2.

In the repeater UT2, the relay 4K is energised at the beginning of the short, 50 millisecond backward signalling impulse and energises the relay 4L. The relay 4S is momentarily energised and sends the alternating current impulse through the trunk line.

At the end of the backward signalling impulse received through the line *lb*5, the relays 4K and 4L drop one after the other. The relay 4S is momentarily energised a second time and emits a second alternating current impulse. The relay 4G is now energised by the contact 4*p*2. The contacts 4*g*1 and 4*g*2 connect the speech lines. The contact 4*g*4 energises the relay 4R1 which is locked by the contact 4*r*1.

In the repeater UT1, the relays 3Y and 3X are energised by the first alternating current impulse by means of the relay 3E. The contacts 3*x*2 and 3*y*2 close the backward signalling circuit through the line *lb*3. The relays 3Y and 3X are again de-energised by the relay E on receipt of the second backward signalling impulse which arrives after 50 milliseconds. The relay 3J is now energised by the contact 3*p*2. The contact 3*g*1 energises the relay 3R which is locked by its contact 3*r*1. The contacts 3*g*2 and 3*h*3 connect the speech lines so that the backward signalling circuit is opened. In the exchange FP, the relay 6M is energised by the 50 millisecond backward signalling impulse. The contact 6*m*2 closes a circuit for the relay 6Z. When the relay 6M drops, the relay 6G is energised and its contact 6*g*1 connects a speech line. The contact 6*g*2 closes a circuit for the lamp L2 which burns dimly. This denotes to the operator that she is connected to the wanted subscriber. The speech lines are connected in the repeaters and all the branches are cut off from the speech lines. In the final selector LW, the connection is effected by the contact 5*v*4, a condenser and the contacts 5*q*1, 5*p*3 and 5*p*4. The operator can thus speak to the subscriber who is engaged on an ordinary call and tell him that there is a long distance call for him.

Had the subscriber been engaged on a long distance call, the windings II and III of the relay 5P could not have been energised. Consequently, the backward signal which has just been described and which causes the speech lines to be connected in the repeaters is suppressed. At the exchange FP, the lamp L2 flickers and indicates to the operator that the wanted subscriber is busy on a long distance call. When the operator has informed the subscriber to whom she was connected of the existence of a long distance connection, she puts back the exchange key VT into the rest position and thereby brings the connection into a state of waiting. The relay 6A is energised over the contacts 6*c*2, 6*n*2, and VT5. The contacts 6*c*1, 6*a*1 and 6*e*1 earth the line *la*3' and potential is applied to the line *lb*3 by the winding I of the relay 6T and the contacts 6*e*2, 6*a*2, 6*z*4 and 6*n*4. In the repeater UT1, the winding II of the relay 3E is bridged across the speech lines *le*3, *lb*3. The direct current flowing through the speech wires energises the relay 6T at the exchange FP and the relay 3E in the repeater responds. The contact 6*t*2 closes a circuit through the winding I of the relay 6N which is locked by its contact 6*n*3. In addition, the contact 6*t*1 closes a locking circuit through the winding II of the relay 6T. In the repeater UT1 in which the relay 3E (which is otherwise only energised by alternating current impulses received through the trunk line *la*4, *lb*4) has been energised by alternating currents, the circuit through the relay 3G is opened at the contact 3*e*2. The contact 3*g*2 again connects the relay 3E to the line *la*3. As the delay in response of the relay 6N in the exchange FP is shortened so that the relay responds at the moment when the relay 6A in the repeater UT1 is still energised, the relay 3A is momentarily energised by the current flowing through the line *la*3 and sends an alternating current impulse through the trunk line.

In the repeater UT2, this alternating current impulse is received by the relay 4J which energises the relay 4A. The contact 4*a*4 de-energises the relay 4G which disconnects the speech lines. The contact 4*a*1 sends a direct current impulse through the line *la*5.

In the line selector LW, the relay 5A is momen-

tarily energised and consequently energises the relay 5V. The contact 5*v*2 opens the circuit through the relay 5P and the relay 5P drops. The contact 5*p*2 opens the circuit through the relay 5Z and closes a circuit for the relay 5U. For the duration of the delay in release of the relay 5V and of the relay 5Z, a circuit is made through the contacts 5*v*3, 5*a*3, 5*z*3 and 5*x*4 for the winding II of the relay 5X and the winding I of the relay 5F. The relay 5F responds and its contact 5*f*1 closes a locking circuit through the winding II. The energising circuit for the winding I of the relay 5X is thereby opened so that this relay drops. In the final selector, the relays 5C, 5E, 5U and 5F are now energised.

In the repeater UT2, the relays 4C, 4E, 4Z and 4R are energised. The relay 4F is de-energised owing to the dropping of the relay 4G. In the repeater UT1, the relays 3C, 3U, 3Z and 3R are energised. The relays 3P and 3F have been de-energised by the dropping of the relay 3G.

When the wanted subscriber terminates the call on which he is engaged (the connection for the long distance call having been prepared), the relay 5P of the final selector LW can respond through its windings I, II and III. The "idle" signal, the control impulses which switch in the automatic calling apparatus and the backward signal which indicates that the called subscriber has removed his receiver are then transmitted in turn in the same way as they were when a connection was made to a free subscriber.

If the operator wishes to sever the existing connection to the wanted subscriber, she sets the exchange switch VT and actuates her starting key TT for a short while. The relay TR in the exchange FP is thus energised and closes a circuit for the driving magnet DT of a switch. The wiper *wt*1 of this switch causes the relay 6J to be actuated so that it first emits a number of current impulses and then, after a pause one further current impulse. These current impulses are transmitted through the line *la*3' by the contact 6*a*1 of the relay 6A.

In the repeater UT1, the current impulses are received by the relay 3A and are repeated as alternating current impulses. In the repeater UT2, the alternating current impulses are received by the relay 4J and are repeated by the relay 4A. In the line selector LW, the relays 5A and 5V are energised by the impulses of the first train. On receipt of this train, the contacts 5*c*4, 5*x*2, 5*p*2, 5*f*4 and 5*v*5 earth the testing wire of the subscriber's line so that the testing relay of the final selector which holds this subscriber engaged is short-circuited and caused to drop. In the pause following the receipt of the impulse train, the relay 5V drops so that the relay 5P can respond and, by means of its contact 5*p*2, interrupt the circuit of the relay 5U. By the further current impulse which is then received, the relays 5A and 5V are energised. For the duration of the delay in release of the relay 5V, a circuit is now closed through the relay 5L and the winding I of the relay 5Q by the contacts 5*v*3, 5*a*3, 5*z*3, 5*f*2 and 5*x*4. Both relays respond and their contacts 5*q*1, 5*q*2 and 5*l*2, 5*l*3 cause the calling circuit to be sent to the wanted subscriber. As the subscriber has not yet removed his receiver, the relay 5U (winding III) at once responds and unlocks the relay 5L. The relay 5Q is kept energized by its winding II. When the relay 5L drops, the relay 5Y and the winding II of the relay 5A are energized in the feed circuit of the wanted subscriber. On response of the relay 5P (as a result of the dropping of the relay 5U), the contact 5*u*4 closes the backward signalling circuit through the line *lb*5 for the duration of the delay in response of the relay 5X. On response of the relay 5Y, the contact 5*y*3 unlocks the relay 5Z and the contact 5*y*1 closes the backward signalling circuit a second time for the duration of the delay in the response of the relay 5Z. All the speech lines are then connected and all the branches are cut off from them.

In the repeater UT2, a relay 4K is energized at the beginning of the first backward signalling impulse and energises the relay 4L. The relay 4S is momentarily energised and sends out the alternating current impulse. At the end of the first backward signalling impulse received through the line *lb*5, the relays 4K and 4L drop one after the other. The relay 4S is momentarily energised and sends out a second alternating current impulse. The contacts 4*c*1, 4*f*1, 4*k*3, 4*l*4 and 4*p*4 energise the relay T which is locked by its contact 4*t*1. The alternating current impulse now received through the trunk line and sent out from the exchange FP after the impulse train which severs the existing connection energises the relay 4A. The contacts 4*a*3 and 4*t*3 then energise the relay 4P which is locked by its contact 4*p*1. At the beginning of the backward signalling impulse which is sent through the backward signalling line *lb*5 on response of the relay 5Y in the final selector, the relays 4K and 4L again respond one after the other so that the relay 4S sends out an alternating current impulse. The contact 4*k*3 unlocks the relay 4T which drops. At the end of this impulse, the relays 4K and 4L drop one after the other. The relay 4S is momentarily energised and sends out an alternating current impulse. When the relay 4L drops, the relay 4G is energised by a contact 4*l*4 and connects the speech lines.

In the repeater UT1, the relays 3Y and 3X are first energised and then again de-energised by the two alternating current impulses which are received through the trunk line 50 milli-seconds after the existing connection has been severed. The backward signalling circuit through the line *lb*3 is closed for 50 milliseconds. On de-energisation of the relays 3Y and 3X, a momentary circuit is made by the contacts 3*y*4 and 3*x*3 for the relay 3T which responds and is locked by its contact 3*t*1.

The control impulse which is sent out by the exchange FP after the train which severs the existing connection, energises the relay 3A so that the contacts 3*a*3 and 3*t*3 energise the winding I of the relay 3P. The relay 3P responds and is locked by its contact 3*p*1. The next two alternating current impulses which denote that the wanted subscriber has removed his receiver energise the relays 3Y and 3X. These relays are then de-energised. The backward signalling circuit through the line *lb*3 is thus closed a second time for 50 milliseconds. On being energised, the relay 3Y unlocks the relay 3T. When the relays 3Y and 3X de-energise, the circuit through the relay 3B is then closed so that this relay responds and connects the speech line.

In the exchange FP, the relay 6M, the contact 6*m*1 of which energises the relay 6S, is energised by the first 50 millisecond backward impulse received after the existing connection through the line *lb*3 has been severed. The contact 6*s*4 unlocks the relay 6T which drops. At the end of the impulse, the relay 6D (winding I) is energised by the contact 6*m*1, the short circuit of the winding

I being opened at the contact 6s1. The relay 6D responds, is locked by its contact 6d1, by means of its contact 6d2, opens the circuit through the lamp L3 and closes a circuit through the lamp L2 in which the latter is caused to flicker.

At the beginning of the second impulse, which denotes that the wanted subscriber has removed his receiver, the relay 6M is again energised. The contact 6m2 energises the relay 6Z which is then locked. At the end of the impulse, the relay 6G is energised so that its contact 6g1 connects the speech lines and its contact 6g2 switches off the lamp. Ordinary talking conditions now exist. When the subscriber replaces his receiver, the lamp L2 is again switched on in the manner described.

Connection to a busy subscriber having a number of lines

If the exchange FP is to make a connection to a subscriber having a number of lines, for example, the lines *l*71–*l*74 which lead to the subscriber AT71 the switch EW of the final selector LW is set on to the first of these lines by the impulses sent out by the exchange. If, on receipt of the last impulse, the relay 5*v* drops, the contact 5*v*4 energises the winding I of the relay 5E so that the contact 5*e*2 opens the circuit through the relay 5U. A testing circuit is made for the relay 5P for the duration of the delay in the release of the relay 5U. If the relay 5P cannot respond because the first of the lines is busy, a circuit is closed through the wiper EW*d*. The contacts associated with the various lines of the subscriber AT71 in the contact bank wiped by the wiper EW*d* are connected together except for the contact associated with the last of the line. The contacts which are connected together are connected to the battery by parallel connection of the contacts *t*71–*t*74 of the separating relays of all the lines as long as one of the lines is idle. The relay 5A is energised in the following circuit:

+, contacts 5*c*4, 5*x*2, 5*p*1, 5*f*4, 5*e*6, winding III of the relay 5A, contact 5*u*6, wiper E*wd*, contacts *t*74, —

The contact 5*a*1 then energises the driving magnet DWE and causes the wipers of the switch EW to be moved forward by one step.

At the same time, the contact 5*a*2 energises the relay 5V so that the contact 5*v*4 opens the circuit through the relay 5E which drops. When the relay 5V drops, the testing of the second line is effected. The wipers of the switch EW are stepped until an idle line is found. The relay 5U is still energised by the contacts 5*e*2 and 5*v*1 so that it does not allow its armature to drop. When an idle line is found, the further switching operations are effected in the manner already described.

If however, all the lines are busy, the circuit for the winding III of the relay 5A cannot be made when the first line is tested because all the relays T71–T74 are energised. When the relay 5U drops, the backward signalling circuit through the line *l*b5 is closed at the contact 5*u*4. The backward signal which denotes that the wanted subscriber is busy causes the relay 6N in the exchange FP to drop in the manner described and an impulse to be emitted which is transmitted through the trunk line. In the line selector LW, this impulse is received by the relay 5A, which energises the relay 5V. A circuit for the winding II of the relay 5U and for the winding I of the relay 5X is closed for the duration of the delay in release of the relay 5V. Both the relays respond and the contact 5*x*1 closes a locking circuit. The contact 5*x*2 short circuits the winding I of the relay 5P, so that only the windings II and III of the relay 5P are in the testing circuit. If the first line of the subscriber AT71 is kept engaged by a connection of less importance, the relay 5P cannot respond and the further operations take place in the manner already described. If, however, the first line is engaged by a long-distance call, the relay 5P cannot respond through its windings II and III. The winding III of the relay 5A lies in the following circuit:

+, contacts 5*c*4, 5*v*2, 5*x*2, 5*f*4, 5*e*6, winding III of relay 5A, contact 5*x*5, —

The relay 5A is energised in this circuit and causes the wipers of the switch gear EW to be stepped and the relay 5V to be energised. The contact 5*v*2 opens the circuit through the relay 5A. When the relay 5V drops, the second line of the subscriber AT71 is tested. If this line is also engaged by an important (long distance) call the selector is again stepped.

If all the lines are engaged on important calls, the relay 5P cannot be energised through its windings II and III on any of the lines. When the wiper of the switch gear EW has been stepped on to the contact of the last line, no further stepping takes place. The contact associated with this line and which is wiped by the wipers EW*d* is permanently earthed. The exchange official receives no backward signal, and is thus informed that all the lines are engaged on important calls.

If, however, the wipers of the switch EW reach a line which is engaged on an unimportant call, the relay 5P responds, connects the speech lines and causes a backward signal to be given in the manner described, so that the exchange operator is connected to this line. The further operations take place in the manner already described.

Instead of being emitted automatically from the exchange FP, the various control current impulses may be sent out by the operator. In particular, it may be advisable for the receipt of the backward signal which denotes that the wanted subscriber is engaged simply to cause the appropriate lamp to be switched in, so that the control impulse which, in the line selector, causes the connection to be made to the busy line, must be sent out by the operator of the exchange FP.

We claim:

1. In an automatic telephone system, a plurality of subscriber's lines, a connector with means for transmitting a backward signal according as the wanted subscriber's line is idle and with means for emitting ringing current to an idle subscriber's line, means connected to a calling subscriber's line for receiving said backward signal and thereby for transmitting a ringing signal to said subscriber and for emitting a control impulse to said connector, and means for receiving said control impulses and thereby bringing said ringing current emitting means into operation.

2. In an automatic telephone system, a plurality of subscriber's lines and a toll exchange, a connector with means for transmitting a backward signal according as the wanted subscriber's line is idle and with means for emitting ringing current to an idle subscriber's line, means connected to said toll exchange for receiving said backward signal and thereby switching in an

optical signal and emitting control impulses and means for receiving said control impulses and thereby bringing said ringing current emitting means into operation.

3. In an automatic telephone system according to claim 2, further means associated to said connector and responsive to said control impulses sent by said toll exchange for making said wanted subscriber's line inaccessible to other toll calls.

4. In an automatic telephone system, a calling exchange, a calling subscriber's line connected to said calling exchange, a called exchange, a wanted subscriber's line connected to said called exchange, a trunk line connecting said exchanges, a connector associated to said called exchange and provided with means for transmitting a backward "idle" signal to the calling exchange when the wanted subscriber's line is idle, a repeater connected to said calling subscriber's line within said calling exchange and provided with means responsive to said backward "idle" signal for transmitting a forward control impulse, a counting device situated at said calling exchange between said repeater and said trunk line and provided with means for delaying the transmission of said forward control impulse to said trunk line, means arranged at said called exchange for emitting ringing current to said wanted subscriber's line and means responsive to said forward control impulse for bringing into operation said ringing current emitting means.

5. In an automatic telephone system a plurality of subscriber's lines, a connector with means for transmitting a backward "idle" signal when the wanted subscriber's line is idle and for transmitting a backward "busy" signal when said subscriber's line is busy, ringing current emitting means associated to said connector, a repeater connected to a calling subscriber's line and provided with means responsive to said backward "busy" signal for transmitting an audible "busy" tone to said calling subscriber and for releasing the connector and with further means responsive to said backward "idle" signal for transmitting an audible "ringing" tone to said calling subscriber and a forward control impulse to said connector, and means associated to said connector and responsive to said forward control impulse for bringing into operation said ringing current emitting means.

6. In an automatic telephone system a calling exchange with at least a calling subscriber's line, a called exchange with at least a wanted subscriber's line, a trunk line connecting said exchanges having repeaters at its ends, a connector situated at said called exchange having means for transmitting a short backward "idle" signal when said wanted subscriber's line is idle and a second short backward signal when the wanted subscriber replies and means for emitting ringing current to said wanted subscriber's line, a repeater situated in said calling exchange and connected with said calling subscriber's line having means responsive to said first short backward "idle" signal for transmitting an audible ringing tone to said calling subscriber and a forward control impulse to said connector and for preparing means for switching through the speech lines, said repeater having further means responsive to said second backward signal for making effective said prepared means for switching through the speech lines, means associated to said repeaters of said trunk line and responsive to said first backward "idle" signal for preparing means for switching through a conversation circuit, further means associated to said repeaters of said trunk line and responsive to said second backward signal for making effective said prepared switching through means and means associated to said connector and responsive to said forward control impulse for bringing into operation said ringing current emitting means.

7. In an automatic telephone system a trunk exchange, a called exchange, at least a called subscriber connected to said called exchange, a trunk line connecting said exchanges, repeaters arranged at the ends of said trunk line, a connector arranged at said called exchange and provided with means for transmitting a short backward signal when the wanted subscriber is idle and a further short backward signal when said subscriber replies, with means for emitting ringing current to said wanted subscriber's line with means for transmitting a permanent backward signal when said wanted subscriber is busy and with means for switching through to a busy subscriber's line, means associated to said repeaters of said trunk line and responsive to two short backward signals for switching through a conversation circuit, means associated to said trunk exchange and responsive to said permanent backward busy signal for transmitting a forward control impulse, means associated to said connector and responsive to said forward control signal for making ineffective said permanent backward signal transmitting means and for making effective said switching through means and means controlled by said switching through means for said connector for transmitting a short backward signal to said trunk exchange.

8. In an automatic telephone system a calling exchange, at least a calling subscriber, a called exchange, at least a called subscriber connected to said called exchange by a group of subscriber's lines, a trunk line connecting said exchanges, repeaters arranged at the ends of said trunk line, a connector arranged at said called exchange and provided with means for testing a selected subscriber's line actuable when said line is idle, with means for testing said group of subscriber's lines actuable when a line of said group of lines is still idle, with means controlled by said group testing means for automatically stepping said connector onto an idle line of said group of subscriber's lines, with means for transmitting a backward "idle" signal when said connector is stepped onto an idle subscriber's line and with means, for emitting ringing current to said selected line, means associated to said calling exchange and responsive to said backward "idle" signal for transmitting an audible ringing tone to said calling subscriber and for transmitting a forward control impulse and means associated to said connector and responsive to said control impulse for bringing into operation said ringing current emitting means.

9. In an automatic telephone system according to claim 8, an impulse receiving relay associated to said connector having a winding which is controlled by said group testing means.

10. In an automatic telephone system a toll exchange, a called exchange, at least a wanted subscriber connected to said called exchange by a group of subscriber's lines, a trunk line connecting said exchanges, a connector associated to said called exchange having means for automatically stepping its switch arms onto the contacts of an idle line of said group of lines of a wanted subscriber, means for making ineffective said stepping means when all lines of said group

are busy, means controlled by said last named means for transmitting a backward busy signal, means associated to said toll exchange and responsive to said backward signal for transmitting a forward control impulse, means associated to said connector and responsive to said control impulse for making said stepping means effective so as to step said switch arms onto the contacts of a line engaged only by an ordinary call.

11. In an automatic telephone system according to claim 10, repeaters arranged at the ends of said trunk line having means responsive to two backward signals for switching through a conversation circuit and means associated to said connector for transmitting a second backward signal when said switch arms have reached a line of said group of subscriber's lines being engaged only by an ordinary call.

12. In an automatic telephone system a calling exchange, a called exchange, at least a wanted subscriber connected to said called exchange, a trunk line connecting said exchanges provided with repeaters at its ends, a connector arranged at said called exchange and provided with means for transmitting a short backward signal when the selected subscriber's line is idle, for emitting ringing current to said subscriber and for transmitting a further short backward signal when the wanted subscriber replies, each of said repeaters comprising a transformer one winding of which being connected to said trunk line, an alternating current receiving relay connected to the other winding of said transformer, switching-through means for connecting the speech lines of the associated exchange to said receiving relay and said winding and means responsive to said two backward signals for controlling said switching-through means.

13. In an automatic telephone system a calling exchange, a called exchange, at least a wanted subscriber connected to said called exchange, a connector arranged in said called exchange and provided with means for transmitting a direct current backward signal when said wanted subscriber is idle, with means for emitting ringing current to said wanted subscriber, and with means for transmitting a second direct current backward signal when said called subscriber replies, a trunk line connecting said exchanges and repeaters at the ends of said trunk lines provided with a transformer one winding of which being connected with said trunk line, with means for transmitting alternating current impulses over said trunk line, with an alternating current receiving relay operable also by direct current and connected with the other winding of said transformer, with means for connecting said winding and said receiving relay with the speech line of the associated exchange, with means responsible to said two direct current backward signals for controlling said alternating current transmitting means and said connecting means and with means controlled by said receiving relay when operated either by alternating current or by direct current for making ineffective said connecting means.

14. An automatic telephone system according to claim 13 in which said receiving relay comprises two windings being arranged in parallel and separated by condensers, one of said windings being directly switched across said speech line when said connecting means are effective, the other of said windings being arranged in series with a condenser and with a winding of said transformer.

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