

Oct. 4, 1932.

L. B. HAIGH ET AL

1,881,273

TELEPHONE SYSTEM

Filed Feb. 12, 1932

7 Sheets-Sheet 1

FIG. 1

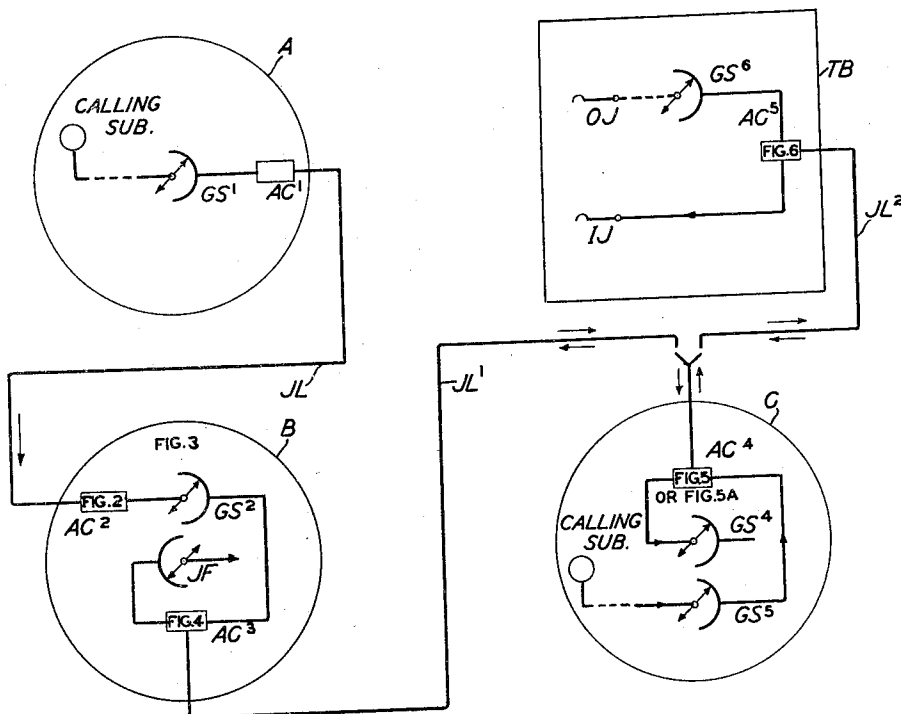
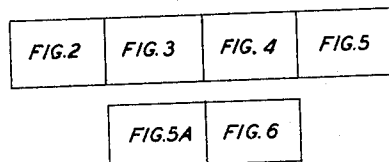


FIG. 7



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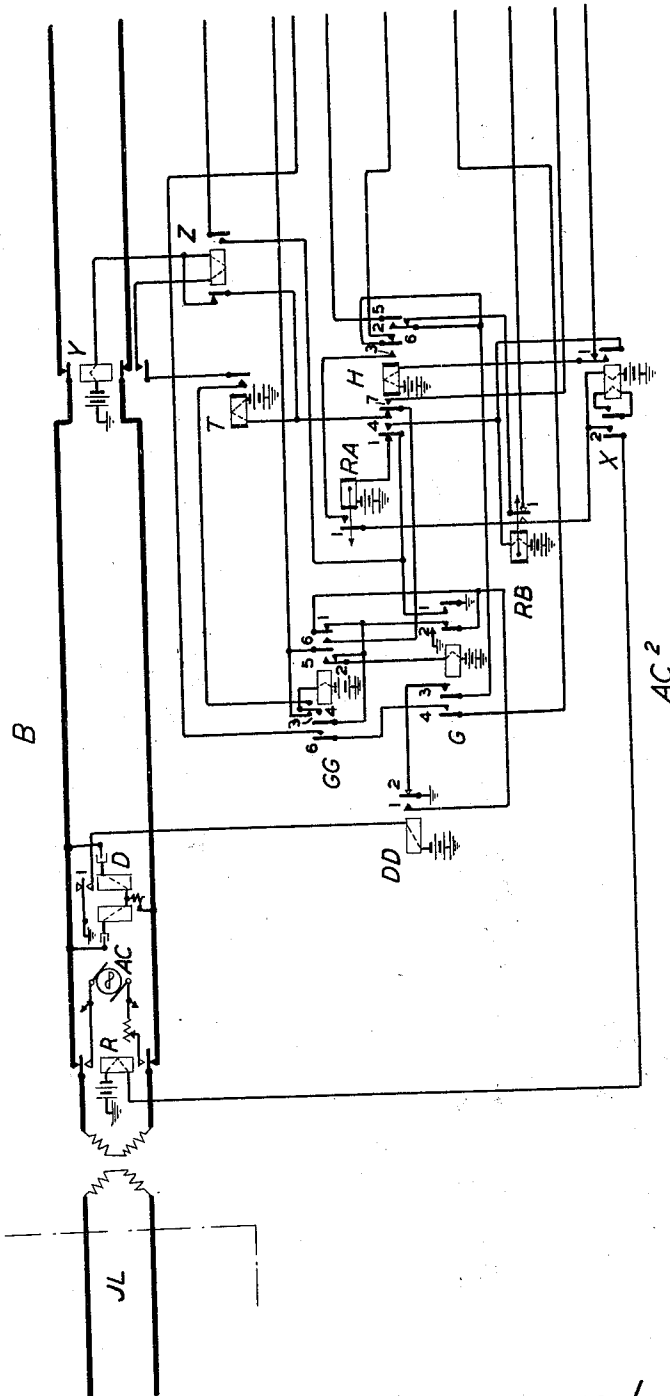
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FIG. 2



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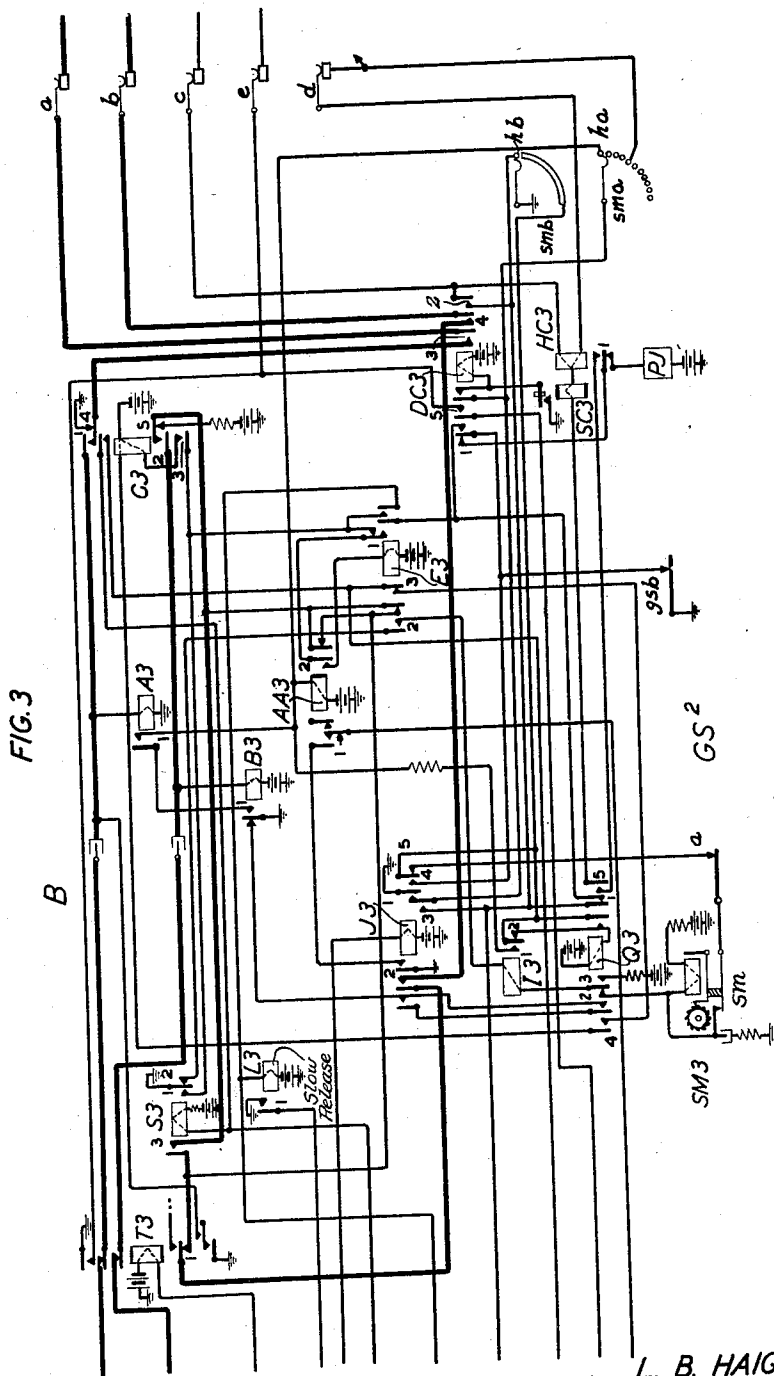
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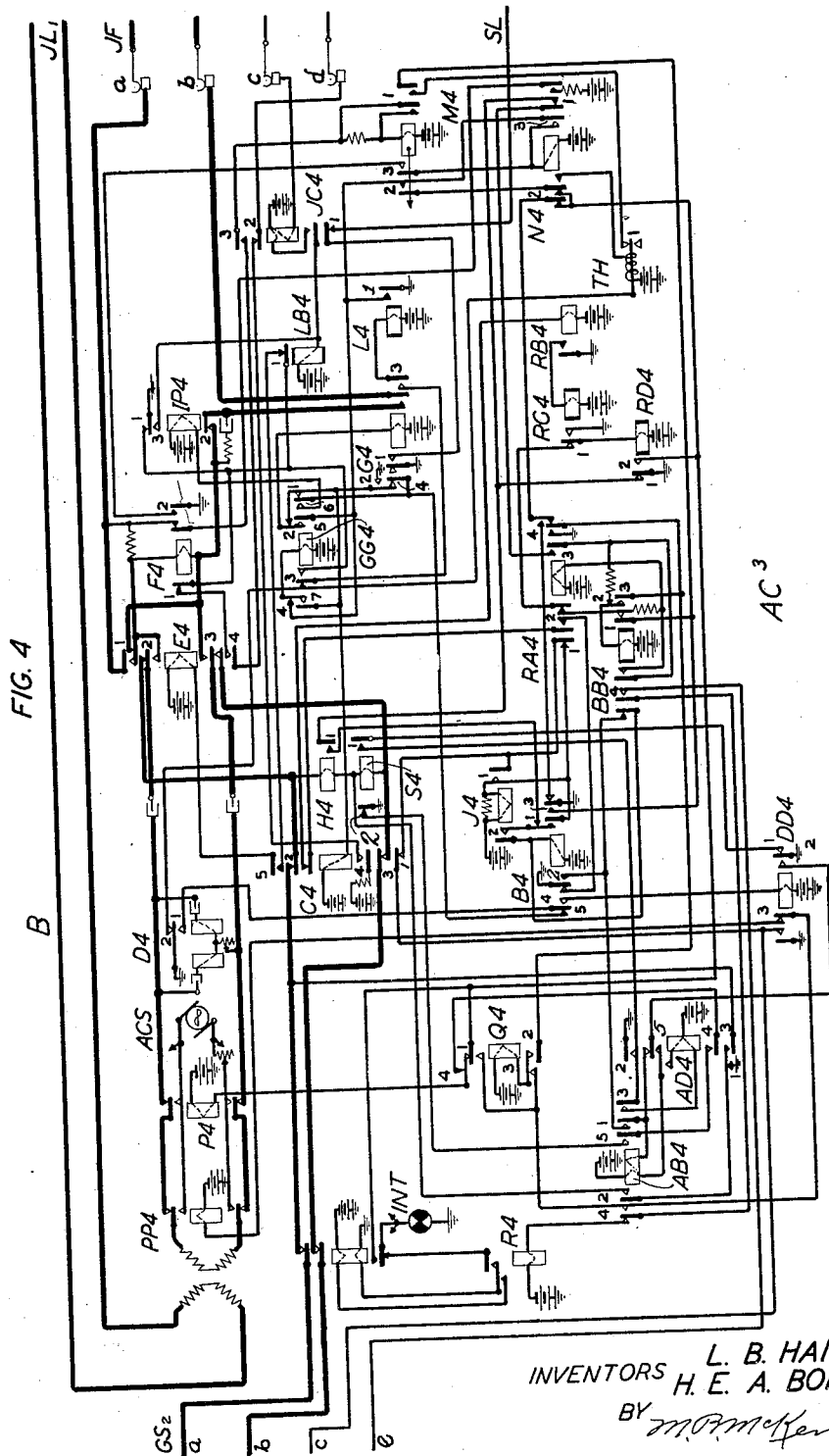
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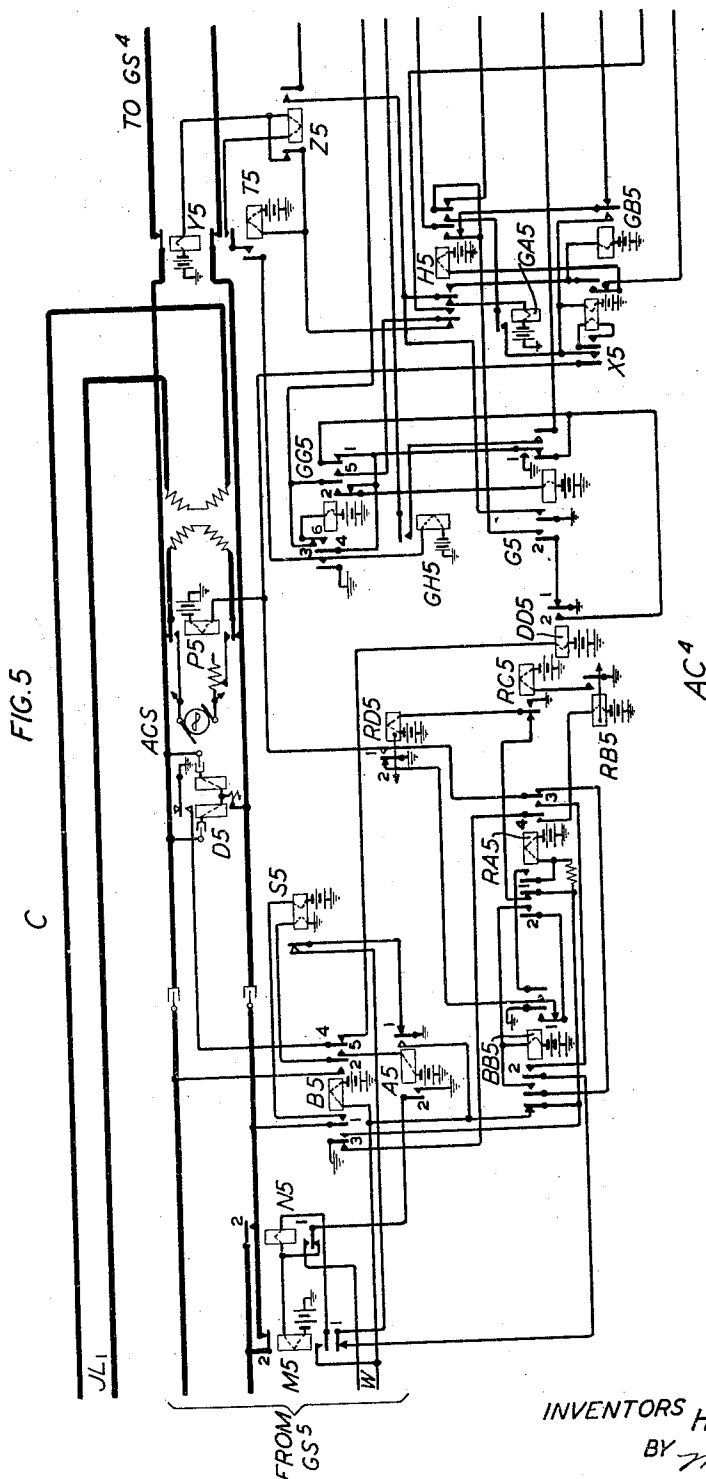
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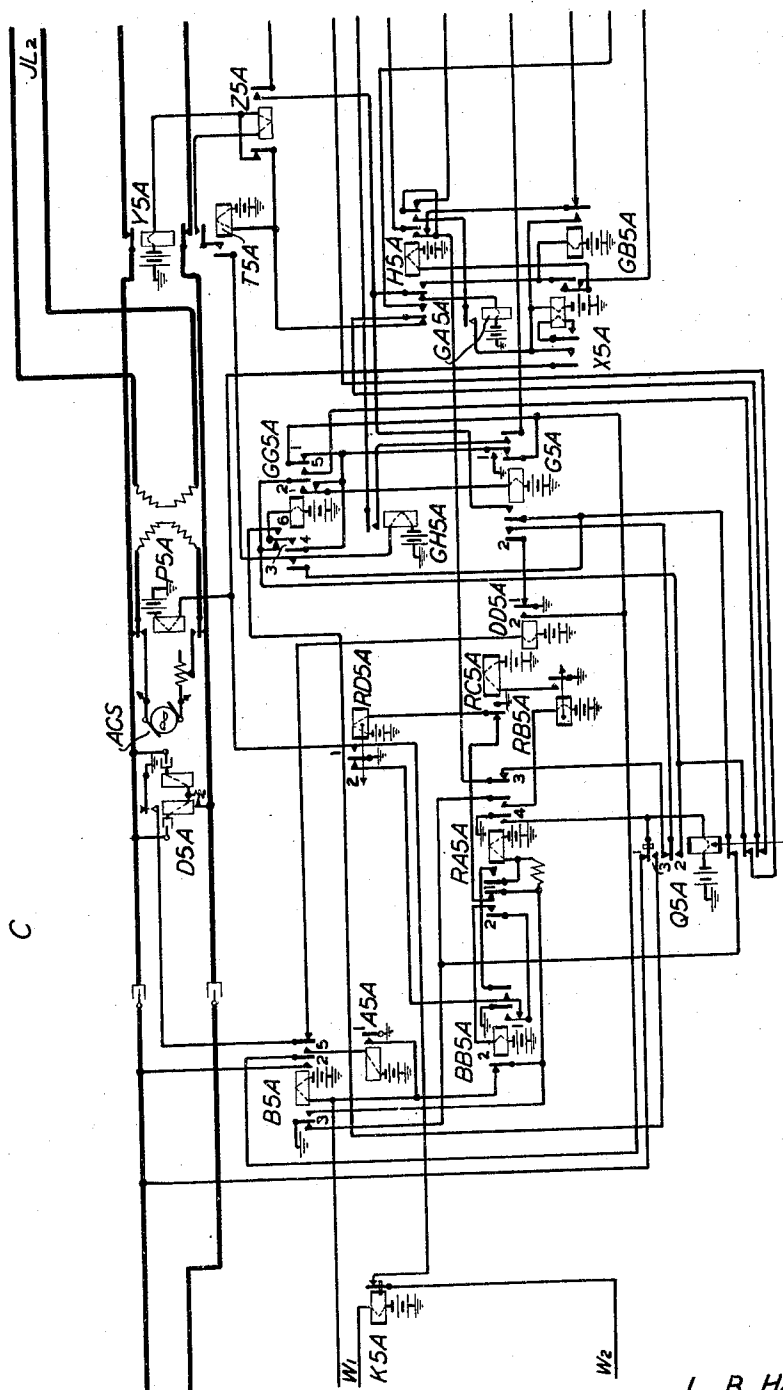
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FIG. 5A



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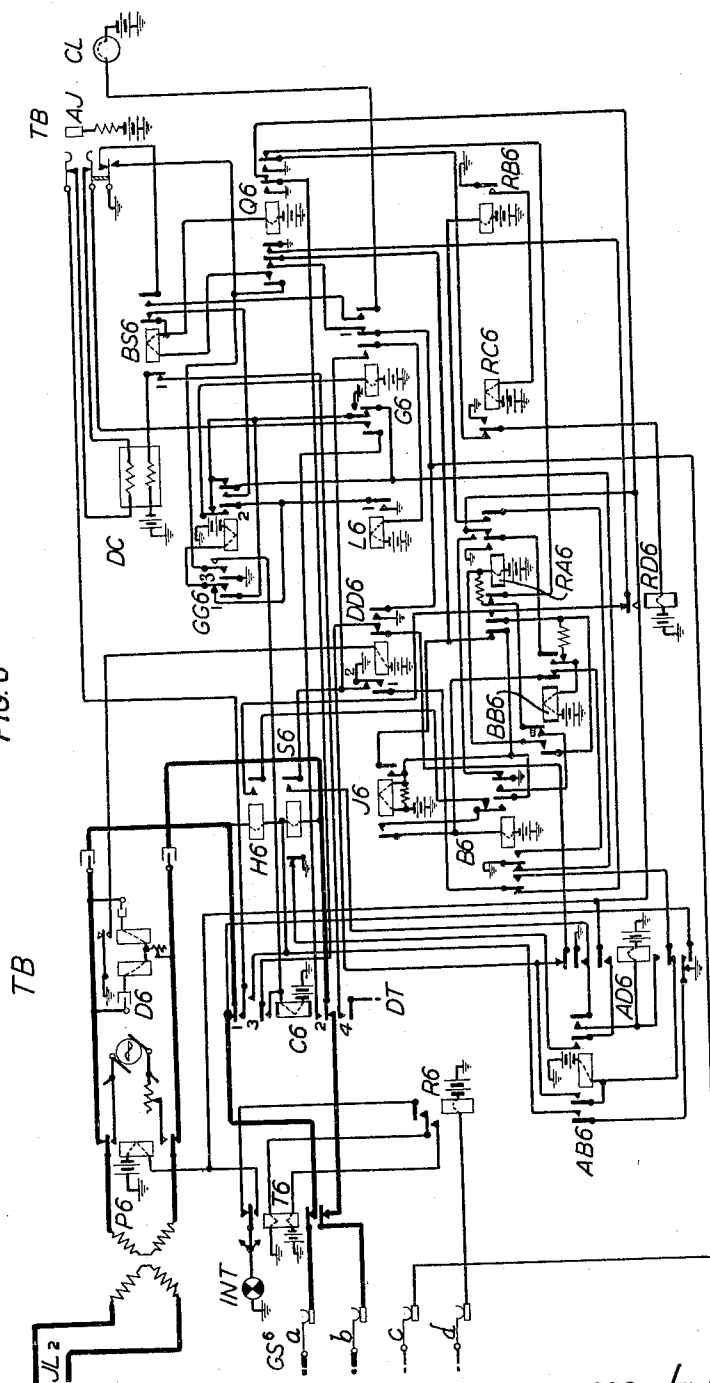
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FIG. 6



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TELEPHONE SYSTEM

Application filed February 12, 1932, Serial No. 592,490, and in Switzerland January 7, 1931.

This invention relates to telephone systems of the automatic or semi-automatic type and particularly to telephone systems comprising a plurality of different exchanges.

It is an object of the invention to provide improved arrangements for establishing connections between subscribers located in different exchanges of the network.

In order to provide an efficient system for interworking between exchanges which may be separated by long distances alternating currents are employed for signaling between such exchanges. Means may be provided at the outgoing end of the junction line for responding to signaling impulses received from a local direct current circuit and for transmitting corresponding signals of alternating current over the junction line. At the incoming end of the junction line, means may be provided for receiving the alternating current signals and for sending on the proper signals for operating a further direct current circuit which may extend the connection to the wanted line or to another junction.

These means, conveniently termed alternating current converting circuits, are therefore arranged at each end of a junction line and according to one feature of the invention an alternating current converting circuit at the incoming end of the junction may be seized from the outgoing end by means of a short pulse of alternating current, means being provided whereby the same circuit can be released at any time by a long pulse of alternating current, the same groups of relays being used for sending both signals.

An alternating current converting circuit may be provided at the incoming end of a junction line which may be so arranged that in response to alternating current pulses received over the junction, it sends out impulses of direct current over the talking wires to operate a direct current circuit and also sends out by-pass impulses over a different wire. These by-pass impulses may be received di-

rectly in a further alternating current converting circuit which may send on further alternating current impulses over a further junction line. Either or both the line and the by-pass impulses may be received by the second alternating current converting circuit, depending on the path of access, but if both are received only one set of these impulses will be used, the particular set being determined by a discriminating arrangement which may conveniently take the form of a relay in the second alternating current converting circuit which operates over an additional wire on the receipt of the by-pass impulses from the preceding converting circuit and disables the relay provided for the receiving of ordinary impulses over the line wires.

All signals except the release signal may take the form of short pulses of alternating current which will be sent out from the alternating current converting circuit at the outgoing end of the junction and these signals may be of the same duration.

Means may be provided in the alternating current converting circuit for converting these alternating current signals into either dialing pulses or ringing current according to the condition of the direct current circuit controlled by the incoming alternating current converting circuit.

Backward signals for indicating the progress of the connection may consist of alternating current pulses of short uniform duration and the arrangement may be such that indicating signals sent back from a direct current circuit at the incoming end of a junction will produce the usual opening or closing of the fundamental circuit whereupon such signals will be converted by the alternating current converting circuit into alternating current pulses which on being received at the outgoing end will create a corresponding opening and closing of the fundamental circuit at that end.

Means may also be provided for insuring that these signals are always kept in the same phase, and that if the frequency at which these impulses are sent becomes too great they are lost in pairs so that the signals still retain the same phase.

An alternating current pulse used for backward signaling is of a specified duration and means may be provided for insuring that this duration shall be the same regardless of the length of the impulse given by a closure or opening of the fundamental produced by the signals given from the direct current circuit. The circuit may be so arranged that if a closure of the fundamental is followed very rapidly by an opening, two alternating current pulses of the correct length are given and further means may be provided for insuring that the necessary time elapses between the two pulses to prevent their confusion.

The same signals of alternating current may be employed to indicate the reply and the clearing of the wanted party and the correct operation of the outgoing circuit is effected by its condition at the moment when the signal is received.

An alternating current relay which is provided in an alternating current converting circuit for responding to alternating currents is protected on one side by a filter arrangement which renders it insensitive to alternating current coming from that direction so that if the circuit is used for signaling in both directions, the alternating current relay so protected is responsive to signals in one direction only.

If two signaling pulses should be transmitted simultaneously in both directions over a junction the first alternating current receiving relay to be operated at either end of the junction disables the sending relay at that end, thereby arresting the transmission of signaling impulses from that end. Means may be provided, however, whereby these signaling impulses are not lost but are only delayed until a definite interval has elapsed after the pulse in the opposite direction has been completed.

Means may be provided whereby, if a call should be extended from the outgoing end of the junction to a toll operator at the incoming end and the calling subscriber restores, a long releasing pulse of alternating current is sent over the junction but the latter is held busy until the operator disconnects whereupon a backward pulse of alternating current is automatically transmitted over the junction which is thereby released at its outgoing end. Means may be provided whereby if the operator should disconnect before the calling subscriber restores, the backward pulse for releasing the junction is not transmitted until the usual releasing forward pulse is sent in response to the restoration of the calling subscriber's receiver.

The invention will now be described, by way of example, for one possible embodiment thereof taken in conjunction with the accompanying drawings in which:

Fig. 1 shows a lay-out diagram of the embodiment comprising an exchange A which may be located at the pivotal point of a multi-office network and may be surrounded by a number of principal controlling or parent exchanges such as B. Each of said parent exchanges B may have associated therewith a number of subsidiary exchanges such as C and may also comprise a toll board TB for purposes which will appear hereinafter.

Fig. 2 shows a one way alternating current converting circuit, such as AC2 adapted to receive calls from a subscriber in exchange A through switch GS' and associated circuit AC' over line JL.

Fig. 3 shows an associated circuit for extending said calls to an incoming group selector, such as GS2.

Fig. 4 shows a both way alternating current converting circuit such as AC3 arranged to receive calls from Fig. 3 through selector GS2 and calls from exchange C over line JL' through switch JF or to exchange C over line JL'.

Fig. 5 shows a both way alternating current converting circuit such as AC4 of exchange C and is arranged to receive calls from Fig. 4 over line JL' through switch GS4 to a desired subscriber's line or extend calls over line JL' to Fig. 4 in the other direction from a local direct current circuit over switch GS5 from a calling subscriber's line.

Fig. 5-A shows a both way alternating current converting circuit similar to AC4 of exchange C and is arranged to receive calls from the toll board TB over line JL² through switch GS4 to a desired subscriber's line or extend calls over line JL² to the toll board TB in the other direction from a local direct current circuit over switch GS5 from a calling subscriber's line.

Fig. 6 shows a both way alternating current converting circuit in the toll board TB such as AC5 similar to AC3 Fig. 4 in exchange B and is arranged to receive calls from exchange C over line JL² to called subscribers' lines over jack IJ or extend calls over line JL² to exchange C in the other direction from a calling subscriber over jack OJ and switch GS6.

Fig. 7 shows how the various figures may be arranged together.

The operation of the arrangement will now be described in a more general manner with reference to Fig. 1.

In the case of a call originating in exchange A the connection is extended over the usual train of automatic switches, one of which is represented by GS1, and if the call is for a distant exchange such as B

or C, these switches will extend the connection to the outgoing alternating current converting circuit AC1. This circuit will receive impulses of D. C. current from the calling line; and in response thereto will transmit a series of A. C. pulses over the junction line leading to an incoming alternating current circuit AC2 in exchange B which in response thereto will send out a series of D. C. impulses to a group selector switch such as GS2.

If the connection is destined for a subscriber on the exchange B, it will be extended to the wanted line from the switch GS2 by the usual train of automatic switches (not shown). If, however, the call is destined for a further exchange such as C, the connection will be extended by GS2 to the alternating current converting circuit AC3 which sends out a series of A. C. impulses to the alternating current converting circuit AC4 Fig. 5 located in exchange C which will extend the connection to a group selector switch GS4 which will in turn extend the connection over the usual automatic switches to the wanted line.

Calls outgoing from exchange C are controlled by a registering mechanism in the parent exchange B. To this end, when a subscriber attached to exchange C removes his receiver, a junction to exchange B is immediately seized by a hunting switch GS5 and the subscriber becomes connected to a registering mechanism in exchange B over GS5, alternating current converting circuit AC4 Fig. 5 alternating current converting circuit AC3 and a hunting switch JF.

Should the desired call be destined for another subscriber in exchange C means is provided whereby on the receipt of the appropriate dial impulses from the calling subscriber the junction is released and the call is subsequently entirely controlled and established in exchange C.

In certain circumstances when it is not desired to permit the automatic establishment of calls outgoing from exchange C, the latter is associated instead with a toll board TB in the parent exchange B and in order to permit of ready conversion at a later date to automatic interconnection the same principles of operation are employed.

Exchange C can be connected to the toll board TB by means of the both way alternating current converting circuit AC4 Fig. 5—A which is associated with the circuit AC5.

When a call is originated by a subscriber in exchange C, a junction to the toll board TB is seized immediately and a connection is extended over GS5, AC4 Fig. 5—A and AC 5 to the toll board where a calling lamp is lit only when the appropriate digits have been received after which connection will be completed over the jack IJ. If on the

other hand the call is local to exchange C, the calling lamp is never lit and the junction is liberated when the digits determining a local call have been received in exchange C.

A call incoming over a toll line will be received in the toll board TB and extended over the jack OJ and the switch GS6 to the circuit AC5 from where it will be extended to the circuit AC4 Fig. 5—A and thence over a switch GS4 to the wanted line.

The circuit operation will now be described in detail.

Referring first to Fig. 2, the circuit is seized by a short A. C. impulse received over the junction JL on a call from exchange A. This pulse operates relay D which is tuned to a particular frequency. Relay D closes at *dd1* an obvious circuit for relay DD, which operates relay G from ground at *dd1* over *gg1* and *gg2*. Relay G locks to ground at *g2* and operates relay RA from ground at *g1* over *h1*. At the end of the A. C. pulse relays D and DD release and the latter operates the slow releasing relay L³, Fig. 3: ground, *dd2*, *g3*, *h2*, relay L³, battery. Relay L³ connects at *l1* over *gg3* ground to relay GG, Fig. 2 which locks at *gg4* to *g2*. Relay G is now controlled over *gg5* and *l1*. Relay GG closes also a circuit for relay J³, Fig. 3: ground at brush *smb* of SM³, home contact *hb*, *g4*, *gg6*, relay J³, battery. Relay J³ closes a circuit for relay AA³: ground, *j1*, brush *sma* of SM³, *ha*, relay AA³, battery. Relay AA³ operates, and the impulse receiving circuit shown in Fig. 3 is now ready to receive the impulses.

Relay AA³ closes a circuit for relay H: ground *j2*, *aa1*, *x1*, relay H, battery. A circuit is now closed for relay X: ground, *dd2*, *g3*, *h3*, *ra1*, relay X, battery. At *x2* relay X transfers the same ground to relay R, which connects the A. C. source AC to the junction JL. Relay H disconnects relay RA and closes at *h4* the circuit of relay RB. The releasing time of relay RA determines the length of the back impulse. The function of relay X is to render relay H independent of relays J³ and AA³ during the releasing time of relay RA, so that the back impulse will always be of the same length, ensuring thereby that a correct impulse is given each time relay H has been operated.

Relay H closed also a circuit for relay S³, Fig. 3, ground, *dd2*, *g3*, *h5*, relay S³, resistance, battery. Relay S³ closed the circuit for relay E³: ground, *s1*, *e1*, *aa2*, relay E³, battery. Relay E³ locks over *aa2*, *e1*, *j3* and *j1* to ground.

The back impulse causes the register of exchange A to send out a train of impulses which are converted at said end into A. C. pulses of equal length. Relay D, Fig. 2, is operated in response to the said pulses and causes relay DD to operate correspondingly.

Each time relay DD opens *dd2*, relay S³,

Fig. 3, falls back and closes the circuit of the control switch SM^3 : ground, $s2$, $e2$, relay I , $q2$, magnet SM^3 , resistance, battery, and the switch takes a step, thus stepping its brushes sma and smb to a particular position corresponding to the number of pulses received. In this position the control switch marks a particular group of contacts in the bank of the selector $GS2$. During the impulses relay AA^3 is maintained from ground at smb over $i1$.

As soon as the control switch SM^3 had made its first step at the beginning of the impulse train a circuit is closed for the magnet PJ^3 of the selector: ground, smb , $j4$, $dc1$, $hc1$, magnet PJ^3 , battery. The selector starts to chase the switch SM^3 . After the first step of the group selector, it closes its off-normal contact gsb . Magnet PJ is now under the control of relay DC^3 and HC^3 . The selector continues to hunt for a free outlet in the marked group which may lead to a subsequent A. C. converting circuit, such as $AC3$, Fig. 4, or to a local circuit.

At the end of the impulse train, relay I^3 falls back, opening at $i1$ the circuit of relay AA^3 , which in turn opens at $aa2$ the circuit relay of E^3 , which de-energizes. At $aa1$ relay AA^3 also opens the circuit of relay H , Fig. 2, which releases and a new back impulse (controlled this time by the relay RB) is sent back to the distant register to prevent the transmission of a further impulse train until the next selection.

As soon as relay I^3 has released at the end of the impulse train a circuit for relay Q^3 is closed: ground, smb , $i2$, relay Q^3 , battery. Relay Q^3 transfers at q^3 relay I^3 from the step-by-step switch SM^3 to a resistance and also closes a circuit for relay C^3 : ground, $dd2$, $g3$, $h6$, $rd1$, $e3$, $q4$, relay C^3 , battery. Relay C^3 operates.

When the hunting selector reaches a free outlet in the marked group a circuit is closed for relay HC^3 : battery, terminal c , relay HC^3 , brush and terminal d , sma , ground at $j1$. Relay HC^3 opens at $hc1$ the circuit of magnet PJ^3 and the selector stops. Relay HC^3 introduces the double test relay SC^3 which operates over $q5$ and energizes at $se1$ relay DC^3 .

The latter locks to ground at $j1$ and connects at $dc2$ ground to the terminal c . Relay DC^3 closes the a and b wires at $dc3$ and $dc4$.

A circuit is now closed from ground over relay A^3 , $e1$, $dc3$, terminal a , over a high resistance bridge in the subsequent circuit, terminal b , $dc4$, $t1$, $s3$, $e2$, relay B^3 , battery. Relays A^3 and B^3 however do not operate as long as the said high resistance bridge is not replaced by a low resistance bridge. This takes place when the subsequent circuit is ready to receive the next impulse train. Relays A^3 and B^3 then operate and a circuit is closed for relay AA^3 at $b1$ and $a1$.

Relay AA^3 pulls up and consequently relays H , S^3 and E^3 operate as described. Relay H causes an impulse to be transmitted back to the distant register which starts to send out the next train of impulses. Relay I^3 is operated on the first release of relay S^3 and maintains relay AA^3 operated during the impulses.

It should be noted that as soon as relay E^3 has been operated relay C^3 remains locked over $c3$ and $s1$, so that it falls back on the first impulse. At $s3$ relay S^3 opens the b wire and retransmits further the opening caused by the first impulse. At the end of the first impulse relay S is again energized, but at this time ground on the a wire is connected over $c4$ and battery on the b wire over $c5$.

Relay S^3 remains energized at the end of the impulse train and relay I^3 falls back, opening the circuit of relay AA^3 as described so as to signal to the distant register as before. Relay AA^3 opens the circuit of relay E^3 , which again operates relay C^3 . The circuit is now ready to receive the next train of impulses. The cycle of operations is repeated in the same manner until all selections have been effected. When finally the wanted subscriber replies the supervisory relays A^3 and B^3 operate and energize relay AA^3 which operates relay H , and a signal indicating the reply of the called party is transmitted to the distant exchange.

When the calling subscriber releases a long releasing impulse is transmitted from the distant exchange and relays DC^3 and S^3 remain released for the duration of this impulse. Relay L^3 falls back, and so does relay J^3 due to the release of relay G . Relay J^3 opens at $j1$, the holding circuit of relay DC^3 which de-energizes and closes at $dc1$ the circuit for magnet PJ^3 : ground, gsb , $dc1$, $hc1$, magnet PJ^3 , battery. The group selector returns to normal where a circuit is closed for the control switch magnet SM^3 : ground, smb , $j5$, sm , magnet SM^3 , battery. The control switch returns also to normal.

It should be noted that if the impulse receiving circuit, Fig. 3, is restored before the control switch regains the normal position, relay J^3 can not be operated since its ground must be received over hb of switch SM^3 . Relay L^3 however is independent of the switch SM^3 and may be operated at any time by the A. C. converting circuit $AC2$, Fig. 2, and the circuit of Fig. 2 may therefore be seized or released independently of the selector circuit.

Referring now to Fig. 4, the following circuit is closed for relay J^4 when the circuit is seized on a call: ground in group selector, terminal c , $e1$, $ra1$ relay J^4 , battery, and relay J^4 locks at $j1$, independently of relay RA^4 . A circuit is also closed for relay H^4 , relay S^4 : ground on the a wire, $e2$, relay H^4 , $e3$, to battery on the b wire. Relay H^4 energizes relay

B⁴: ground, *rd1*, *h1*, *b1*, *j2*, relay B⁴, battery. Relay B⁴ locks at *b2* and operates relay RA⁴: ground, *b3*, *bb1*, relay RA⁴, battery, and in parallel to relay RA⁴ relay RD⁴, *bb1*, *ra2*, *rc1*, relay RD⁴, battery. Relay RA⁴ opens at *ra2* the circuit of relay RD⁴, but since relay RA⁴ is slow to operate, relay RD⁴ finds sufficient time to energize. Relay RD⁴ closes the circuit of relay P⁴: ground *rd2*, *q1*, relay P⁴, battery. Relay P⁴ connects the A. C. source ACS to the outgoing junction JL1. A short A. C. pulse, the length of which is determined by the releasing time of relay RD⁴ is sent out to the distant exchange, for example C, Fig. 1, to originate therein a call.

When relay RD⁴ falls off a circuit is closed for relay BB⁴: ground, *rd1*, *n1*, *ra3*, *bb2*, relay BB⁴, battery and relay BB⁴ locks at *bb3* to *ra4*.

When the distant exchange is ready to receive a digit, a short pulse is sent back and received by relay D⁴, which at *d1* operates relay DD⁴ over *b4*. Relay DD⁴ operates over *dd2* relay AB⁴ which lock at *ab1* to *b2*. Relay AB⁴ operates relay S⁴: ground, *ad1*, *ab2*, relay S⁴, to battery on the *b* wire. At the end of the back pulse relays D⁴ and DD⁴ release, relay DD⁴ closing the circuit for relay AD⁴: ground, *dd1*, *s1*, *ab3*, relay AD⁴, battery. Relay AD⁴ locks over *ab3* to *ad2*, and connects at *ad3*, relay S⁴ in bridge across AC3 *a* and *b* wires, thus giving a signal to the preceding circuit and the register respectively to send an impulse train.

In case the circuit has been seized by a local group selector the impulses are received over the *a* and *b* wires by relay S⁴, and in case of an incoming group selector over the 4th wire. In the latter case relay PP⁴ is used for sending out the impulses, this relay being operated in parallel with relay Q⁴ in the following circuit: ground, *dd1*, (Fig. 2), *gg6*, *h7*, *dc5* (Fig. 3), terminal *a* of GS2, *bb4* (Fig. 4), *ab4*, and from there over *dd3* (Fig. 4) to relay PP⁴ and in parallel over *q3* to relay Q⁴, which locks over *q2* to *ra4*, thereby disabling relay P⁴ at *q1*.

Therefore, when relay S⁴ responds to the openings of its circuit in the local circuit, on falling back on each impulse it closes the circuit of relay P⁴: ground, *s2*, *ab5*, *ad4*, *q4*, relay P⁴, battery. Relay P⁴ connects the A. C. source ACS to the outgoing junction JL1 as long as relay S is retracted.

At the end of the impulse train, a short back impulse is received on relay D⁴ which operates relay DD⁴. At *dd2* relay DD⁴ short-circuits relay AB⁴, which releases and by opening *ab2* introduces the high resistance bridge (relay H⁴) across the *a* and *b* wires to prevent the register sending the next train of impulses.

At the end of the back impulse relay D⁴ releases followed by relays DD⁴ and AD⁴.

When the distant circuit is ready, again a

further backward impulse is received. Relays AB⁴ and AD⁴ are reoperated and the next train of impulses is sent out as before.

Finally the reply of the called party is signaled back to the local link circuit of the originating exchange.

In the case of calls incoming over the junction line JL1 the circuit is seized by a short A. C. pulse received from the distant exchange. The pulse operates relay D⁴ which closes a circuit for relay G⁴: ground, *d1*, *b5*, *gg1*, *gg2*, relay G⁴, battery, and also a circuit for relay C⁴ in parallel to relay G⁴ from the same ground over *gg1*, relay C⁴, battery. Relay G⁴ locks at *g2* and closes at *g1* over *jc1* and the starting lead SL the starting circuit for the magnet (not shown) of the finder circuit JF, which starts to hunt for the calling junction. This junction is marked by a battery potential on terminal *d* applied thereto by relay C⁴ from battery, *c4*, *jc2*, terminal *d*. Relay C⁴ disconnects at *c1* relay J⁴ from the banks of the incoming group selectors in order to make the circuit busy for calls incoming in that direction. Relay C⁴ also closes a circuit for relay E⁴: ground, *ip1*, *bb1*, *c5*, relay E⁴, battery. At the end of the initiating A. C. pulse, relay D⁴ releases and closes a circuit for relay L⁴: ground, *d2*, *gg3*, *g3*, relay L⁴, battery. Relay L⁴ closes the circuit for relay GG⁴: ground *l1*, *gg4*, relay GG⁴, battery. Relay GG⁴ locks over *gg7* to *g2*, and transfers at *gg5* the control of relay G⁴ to relay L⁴.

When the finder JF has found the calling line a circuit is closed for relay JC⁴: ground at the local link circuit, terminal *c* of JF, relay JC⁴, battery. Relay JC⁴ opens at *jc1* the starting lead SL and removes at *jc2* battery potential from terminal *d*. The local link seizes a free register (not shown), and dialing tone is then transmitted to the calling subscriber. The impulses from the dial switch are converted at the distant exchange into A. C. pulses which are received by relay D⁴ and retransmitted over *d1*, *b5*, *gg6* to relay IP⁴, which opens at *ip2* the loop to the link circuit a corresponding number of times. Relay IP⁴ on responding to the first pulse also releases relay E⁴ and closes at *ip3* an obvious circuit for relay LB⁴, which is slow releasing and secures that relay E⁴ remains de-energized during the impulse train.

Each digit is received in the same way and transmitted to the register and subsequently all signals from the calling party at the distant exchange are transmitted to the local link circuit.

When the called party answers, the *b* wire is opened for a short period in the link circuit and relay F⁴ releases.

Relay F⁴ closes a circuit for relay M⁴: ground, *ip1*, *f1*, *e4*, *jc3*, relay M⁴, battery. Relay M⁴ closes a circuit for relay P⁴: ground, *l1*, *m2*, *n2*, *q1*, relay P⁴, battery and an A. C.

pulse is sent to the distant exchange. As soon as the "b" wire is reclosed relay F⁴ re-operates and relay M⁴ starts to release. Since relay M⁴ is slow-releasing a circuit will be closed for relay N⁴: ground *f2*, *m3*, relay N⁴, battery. Relay N⁴ locks at *n3*, to *l1* and so records that the answering has taken place.

At the end of the conversation, if the called party is first to restore his receiver, the link opens the *b*-wire again and relay M⁴ reoperates closing at *m2*, the circuit of thermostat TH. As soon as the thermostat closes *th1*, an A. C. impulse is sent to the distant exchange to signal the back release.

If the calling party hangs up first, a long A. C. pulse is sent out from the distant exchange. This pulse operates relays D⁴ and IP⁴ as before. Relay IP⁴ opens the loop to the local link and causes the circuit to release.

On the other hand relay IP⁴ opens the circuit of relay L⁴ which releases and opens at *l1* the circuit of relay G⁴. The latter relay releases, but relay GG⁴ remains locked over *d1*, *g4*, and *gg7*. At the end of the long pulse relay D⁴ releases followed by relay IP⁴ and GG⁴ and the circuit is again normal.

Referring now to Fig. 5, if the circuit is taken into use by a local group selector, such as GS5, ground is connected from the selector circuit (not shown) over the wire W to relay B⁵ which connects at *b1* and *b2* relay S⁵ in series with the loop. A circuit is also closed for relays RA⁵, and RD⁵ in parallel: ground, *b3*, relay RA⁵, battery, and *b3*, *ra1*, relay RD⁵ battery. Both relays operate in the same way as described for Fig. 4 and a short A. C. pulse is sent over the junction JL1 to the distant exchange by relay P⁵ which is energized from ground at *rd1*.

It will be assumed here that the junction terminates in an exchange such as exchange B. The said short pulse originates therein a call. Relay RD⁵ on releasing closes a circuit for relay BB⁵: ground, *rd2*, *bb1*, *ra2*, relay BB⁵, battery. Relay BB⁵ operates. When the register at the distant exchange is ready to receive a digit over JL1, the subscriber hears the dial tone and proceeds to send the digits of the required number. For each opening of the dial, relay S⁵ releases and closes the circuit for relay P⁵: ground, *a1*, *s1*, *m1*, *bb2*, *ra3*, relay P⁵, battery. Relay P⁵ operates and connects the A. C. source ACS to the junction. The impulses are then transmitted to the distant register.

When the called party answers a short A. C. pulse is sent back from the distant exchange and is received by relay D⁵, which closes the circuit for relay A⁵: ground, *d1*, *b5*, relay A⁵, battery. Relay A⁵ closes the circuit of relay M⁵: ground, *a2*, *n1*, M⁵, battery. At the end of the pulse relays D⁵ and A⁵ restore and a circuit is closed for relay N⁵: ground, wire W, *m1*, relay N⁵ and M⁵ in series, battery. When relay M⁵ operated it opened at *m2* the *b*-wire,

which is reclosed at *n2* upon relay N⁵ operating. The reply of the called party is then signaled back to the local circuit.

At the end of the conversation, if the calling party is the first to replace the receiver relay S⁵ releases but nothing happens until ground is removed from relay B⁵. Relay B⁵ then releases and operates relays RB⁵, RC⁵ and RD⁵ in turn and relay RD⁵ operates relay P⁵. A long A. C. pulse is sent forward to the distant exchange to cause the release of the circuit therein.

Relay BB⁵ was locked in parallel with relay P⁵ and was released at the same moment as relay P⁵. Relay RB⁵ is slow-releasing to guarantee a definite interval between the long releasing impulse and a new starting impulse, if the circuit has been seized again during the long releasing impulse after relay RA⁵ has been released.

The relays which are acting for incoming calls are D⁵, DD⁵, G⁵, GG⁵, GA⁵, H⁵, X⁵, P⁵, and GB⁵. The operation in this case is the same as described for the circuits of Figs. 2 and 3 and will therefore not be described again.

It will be now assumed that the circuit of Fig. 5—A has access over a junction line JL2 to a toll operator's position TB at a center exchange. In this case the operations are very similar to those described in connection with Fig. 5. The operations are as follows:

When the circuit is seized by a local group selector relays B^{5a}, RA^{5a} and RD^{5a} are operated and a short A. C. pulse is sent out as before. Relay RA^{5a} closes a circuit for relay G^{5a}: Ground *ra4*, *q1*, *b2*, *gg1*, *gg2*, relay G^{5a}, battery, and in parallel thereto for relay Q^{5a}: ground, *ra4*, relay Q^{5a}, battery. Relay Q^{5a} is slow-operating and thus relay G^{5a} has time to operate and to lock at *g1*. Relay Q^{5a} closes a circuit for relay GG^{5a}: ground, *dd1*, *g2*, *q2*, *gg3*, relay GG^{5a}, battery. Relay GG^{5a} locks at *gg4* to *g1* and at *gg5* prepares a locking circuit to *dd2*. It provides also a locking circuit for relay Q^{5a}: ground, *g1*, *gg4*, *gg3*, *q3*, relay Q^{5a}, battery.

If the number dialed by the subscriber is not local, ground is temporarily provided over wires W¹ and W² and relay K^{5a} and therefore also relay P^{5a} operate. A short A. C. pulse is therefore transmitted to the center to light the calling lamp therein.

The position of this circuit remains now unchanged until the end of the conversation as in Fig. 5. If the calling party hangs up, the circuit for relay B^{5a} is opened. Relay B^{5a} operates relays RB^{5a}, RC^{5a}, RD^{5a} and P^{5a} in turn. Relay P^{5a} connects the A. C. source ACS to the line. As soon as relay RD^{5a} leaves its back contact, relays RA^{5a} and BB^{5a} release. Relays RB^{5a}, RC^{5a}, RD^{5a} release slowly in turn. Relay RD^{5a} releases relay P^{5a} and a long A. C. pulse has thus been sent forward to the distant exchange to

signal the end of the call. The circuit waits now for a short backward A. C. pulse which is originated from the distant exchange as soon as the toll operator has withdrawn the plug. This backward A. C. pulse operates relays D^{5a} and DD^{5a} . Relay DD^{5a} releases relay G^{5a} but relay GG^{5a} remains on front contact during the pulse. At the end of the pulse relay D^{5a} , DD^{5a} , GG^{5a} and Q^{5a} release in turn and the circuit is again normal.

Referring now to Fig. 6, the circuit is seized from the distant exchange by a short A. C. pulse which will be sent from the circuit in Fig. 5—A. This operates relays D^6 and DD^6 and the latter operates at $dd1$ relay G^6 , which locks and disconnects at $g1$ relay J^6 from the banks of the group selectors, such as GS^6 , in order to busy the junction $JL2$ thereat. Relay C^6 operates in parallel with relay G^6 and at $c3$ relay H^6 is short-circuited to provide a supervisory loop through relay S^6 . At the end of the A. C. pulse relays D^6 and DD^6 release. Relay DD^6 operates at $dd2$ relay L^6 which in turn operates relay GG^6 over ll and $gg1$ and this relay locks under the control of relay G^6 and transfers at $gg1$ the control of relay G^6 to relay L^6 . Relay GG^6 closes at $gg3$ also a holding circuit for relay C^6 . When relay C^6 operated it closed a circuit from the dial tone interrupter DT over $c4$, $bs1$, primary of dial tone coil DC , battery and dial tone is transmitted to the calling subscriber. It should be noted that the calling lamp CL has not yet been displayed.

If the number dialed is such that the services of the operator are required, a further short A. C. pulse is received. Relay DD^6 operates which operates relay RD^6 . At the end of the pulse relay DD^6 opens the short circuit across relay BS^6 and this relay operates in series with relay Q^6 . Relay BS^6 cuts off the dial tone and lights the calling lamp CL . When a plug is inserted in the jack AJ , the dial tone coil is disconnected from the line, the lamp CL is extinguished and a locking circuit for relays BS^6 and Q^6 is closed.

At the end of the conversation a long releasing pulse is received. Relay DD^6 operates for a sufficiently long time to release relay L^6 which in turn release relay G^6 . At the end of the pulse relay GG^6 restores and the circuit is again normal with the exception of relays BS^6 , Q^6 and RD^6 which are held from the jack. When the plug is withdrawn, relay BS^6 and Q^6 restore. Relay Q^6 opens the circuit of relay RD^6 , but during the slow circuit release of this relay, relay P^6 operates and sends back a short pulse to release the outgoing end of the junction.

In the case where it is not necessary to call the attention of the operator, i. e., of a local call, a long releasing pulse is received instead of a short one, and while relay BS^6 will operate momentarily during the releasing time of

relay GG^6 the circuit of the lamp has already been opened by relay G^6 so that the lamp does not light at all.

What is claimed is:

1. In a telephone system, a line, means at one end of said line responsive to direct current signals for conversion into and transmission of alternating current signals over said line and means at the other end of said line responsive to said alternating current signals for conversion into and transmission of direct current signals beyond, said last mentioned means being responsive to a preliminary short alternating current signal to prepare it for the reception of succeeding alternating current signals for conversion into direct current signals.

2. In a telephone system, a line, means at one end of the line for transmitting short alternating current impulses and long alternating current impulses over said line, an alternating current converting circuit at the other end of the line seized in response to a short alternating current impulse received over the line and released in response to a long alternating current impulse received over the line.

3. In a telephone system, a line, a current converting impulse circuit at one end of the line including a plurality of relays operative to seize said converting circuit in response to a short alternating current impulse received over said line and effective to release said converting circuit in response to a long alternating current impulse received over said line.

4. In a telephone system, a current converting circuit means responsive to the reception of direct current signals for transmitting alternating current dialing signals or responsive to the reception of the alternating current signals for transmitting alternating current ringing signals, means for seizing said circuit means and transmitting to it direct current signals for conversion into said dialing signals, and means for seizing said circuit means and transmitting to it alternating current signals for conversion into ringing signals.

5. In a telephone system, a calling subscriber's line, an alternating current converting outgoing circuit, an alternating current converting incoming circuit, a line between said converting circuits, an operator's position, means for establishing a connection between said calling subscriber's line and said operator's position over said converting circuits and connecting line, means responsive to the calling subscriber replacing his receiver on the hook for transmitting a long alternating current impulse from said outgoing converting circuit over said connecting line to said incoming converting circuit, and means responsive to said long alternating current impulse and to the operator releas-

ing said established connection for releasing said incoming converting circuit and for transmitting a short alternating current impulse over said connecting line to said outgoing converting circuit, and means responsive to said short alternating current impulse for releasing said outgoing converting circuit.

6. In a telephone system, a calling subscriber's line, an outgoing alternating current converting circuit, an incoming alternating current converting circuit, a line connecting said converting circuits, an operator's position, means for establishing a connection between said calling subscriber's line and said operator's position over said outgoing converting circuit said connecting line and said incoming connecting circuit, means responsive to the calling subscriber hanging up his receiver for transmitting a long alternating current impulse over said connecting line from said outgoing converting circuit to said incoming converting circuit, means responsive to the operator releasing the established connection prior to the calling subscriber hanging up his receiver and to the reception of the long alternating current impulse by said incoming converting circuits for thereafter transmitting a short alternating current impulse from said incoming converting circuit over said connecting line to said outgoing converting circuit for releasing said incoming converting circuit, and means responsive to the reception of said short alternating current impulse by said outgoing converting circuit for releasing said outgoing converting circuit.

7. In a telephone system, a calling subscriber's line, an outgoing alternating current converting circuit, an incoming alternating current converting circuit, a line connecting said converting circuits, an operator's position, a signal at said operator's position, means for establishing a connection between said calling subscriber's line and said operator's position over said outgoing converting circuit said connecting line and said incoming converting circuit comprising means for sending alternating current impulses and means responsive to a first alternating current impulse transmitted over the connecting line for seizing the incoming alternating current converting circuit, and means responsive to a second alternating current impulse transmitted over said connecting line for operating said signal at the operator's position, means responsive to the calling subscriber hanging up his receiver for transmitting a longer alternating current impulse over said connecting line from said outgoing converting circuit to said incoming converting circuit, means responsive to the operator releasing the established connection prior to the calling subscriber hanging up his receiver and to the reception of the long alternating

current impulse by said incoming converting circuit for thereafter transmitting a short alternating current impulse from said incoming converting circuit over said connecting line to said outgoing converting circuit for releasing said incoming converting circuit and means responsive to the reception of said last-mentioned short alternating current impulse by said outgoing converting circuit for releasing said outgoing converting circuit.

8. In a telephone system, a calling subscriber's line, an outgoing alternating current converting circuit, an incoming alternating current converting circuit, a line connecting said converting circuit, an operator's position, a signal at said operator's position, means for establishing a connection between said calling subscriber's line and said operator's position over said outgoing converting circuit, said connecting line and said incoming connecting circuit comprising means for transmitting an alternating current signal over said connecting line for seizing the incoming alternating converting circuit, means for transmitting a second alternating current impulse over said connecting line, means responsive to said second alternating current impulse for actuating said signal at said operator's position, means responsive to the seizing of the incoming alternating converting circuit by the operator for releasing said signal, means responsive when the calling subscriber hangs up his receiver for transmitting a long alternating current impulse over said connecting line from said outgoing converting circuit to said incoming converting circuit, means responsive to the operator releasing the established connection prior to the calling subscriber hanging up his receiver and to the reception of the long alternating current impulse by said incoming converting circuit for thereafter transmitting a short alternating current impulse from said incoming converting circuit over said connecting line to said outgoing converting circuit for releasing said incoming converting circuit, and means responsive to the reception of said short alternating current impulse by said outgoing converting circuit for releasing said outgoing converting circuit.

In witness whereof, we hereunto subscribe our names, this 28th day of January, 1932.

LESLIE B. HAIGH.
HENRI E. A. BORZER.