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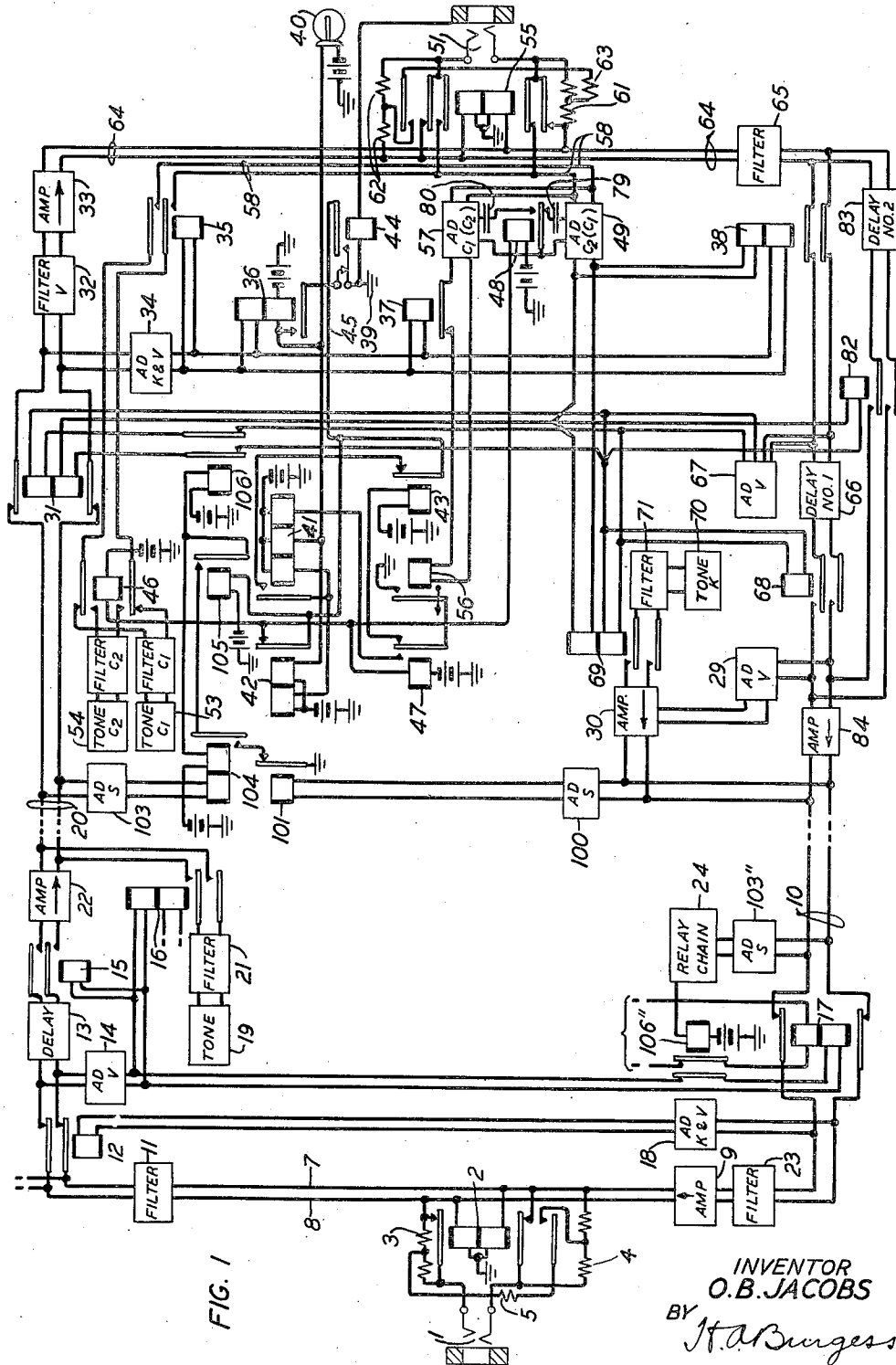
O. B. JACOBS

2,050,610

TELEPHONE TOLL SWITCHING

Filed Dec. 23, 1932

4 Sheets-Sheet 1



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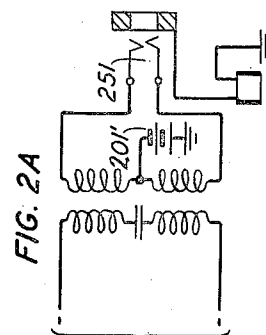
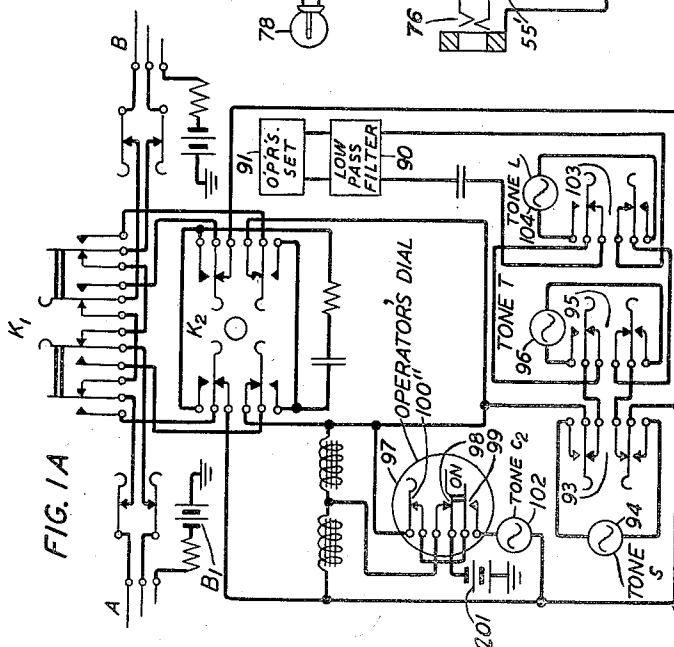
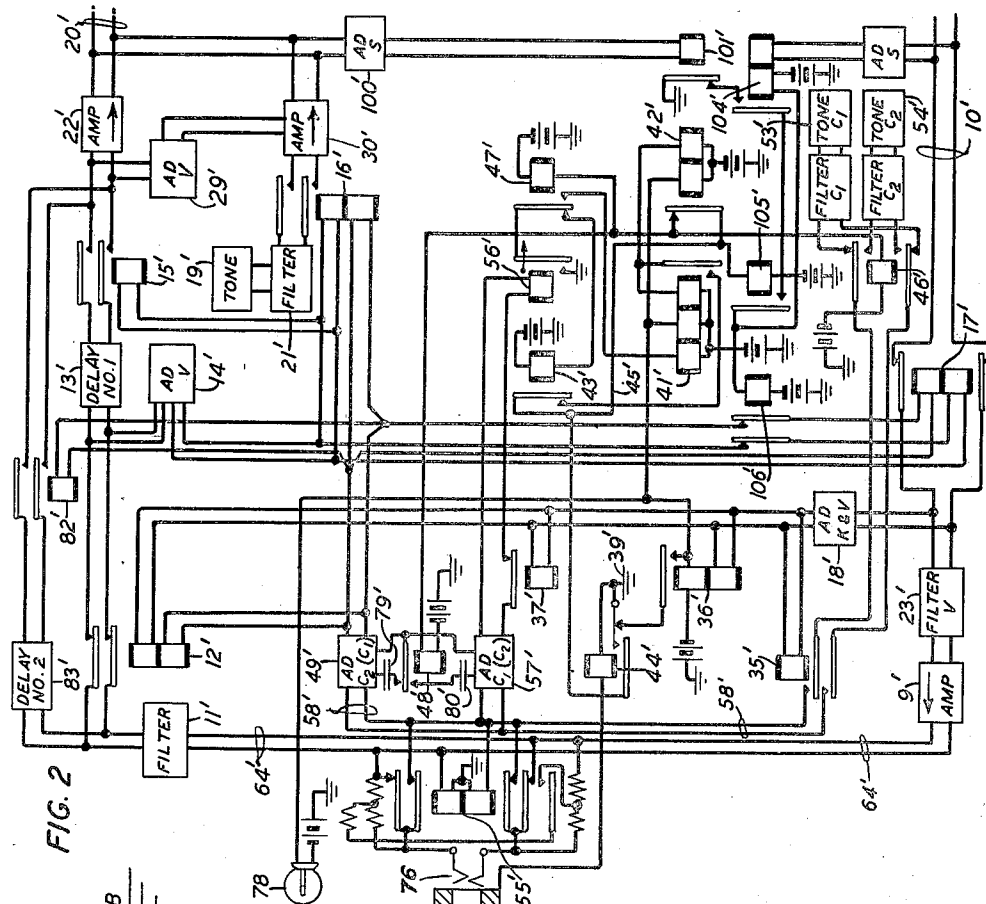
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TELEPHONE TOLL SWITCHING

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4 Sheets-Sheet 2



TO LOCAL EXCHANGE

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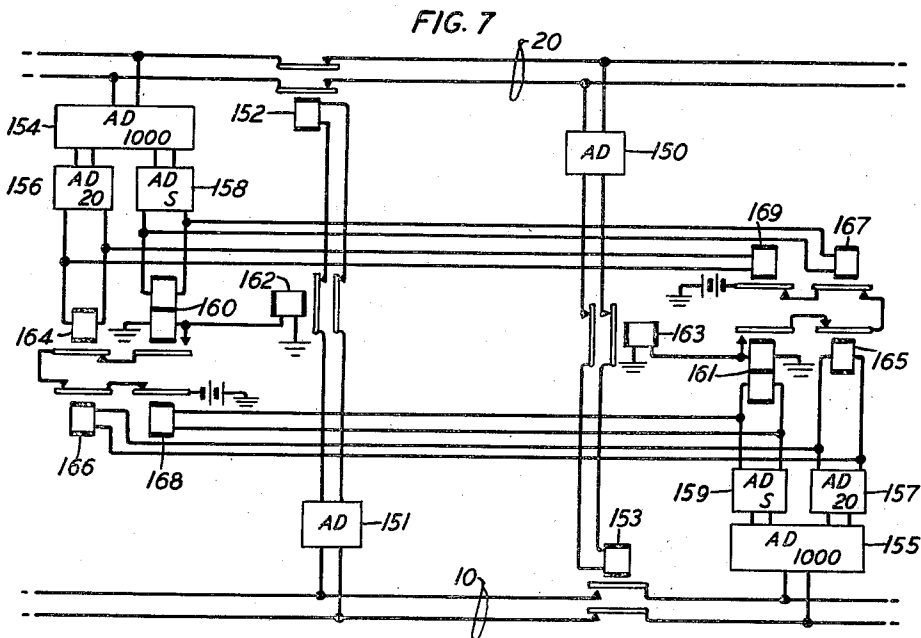
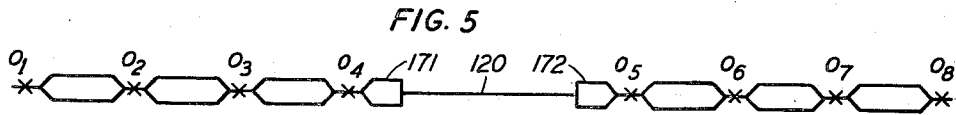
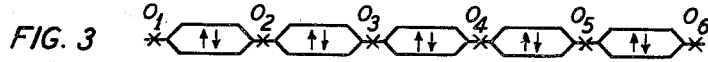
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TELEPHONE TOLL SWITCHING

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4 Sheets-Sheet 3



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TELEPHONE TOLL SWITCHING

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4 Sheets-Sheet 4

FIG. 4

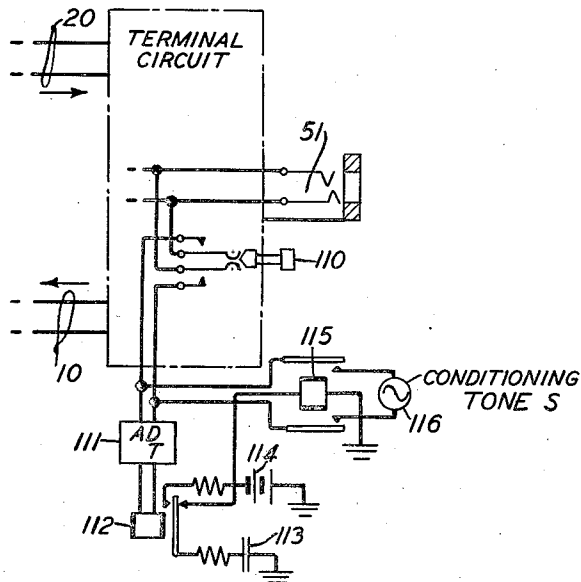
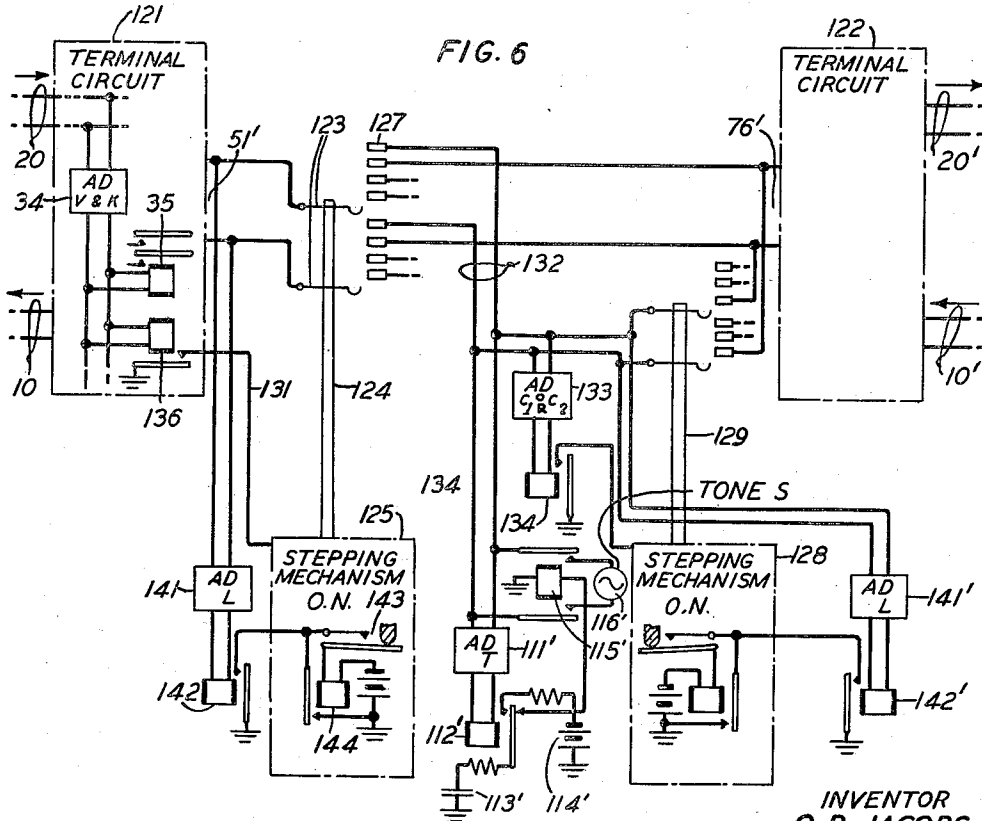


FIG. 6



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TELEPHONE TOLL SWITCHING

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No. 648,559½

23 Claims. (Cl. 179—170)

The present invention relates to transmission control and particularly to the control of speech transmission in systems comprised wholly or in part of four-wire lines.

5 A particular object of the invention is to facilitate the interconnection of four-wire circuits and the invention comprises various features cooperating to that end. Some of these features are of more general application than to four-wire circuits and as to all such features the invention is not to be construed as limited in its objects or applications to four-wire transmission.

10 A specific object is to enable four-wire circuits to be interconnected by standard two-wire toll cord circuits and with substantially the same operating technique as is employed in connecting two-wire toll lines.

Among the objects sought to be realized by the invention are:

- 20 (1) Elimination of echo paths at junctions.
- (2) Positive operation of voice-controlled devices at all intermediate points.
- (3) Reduction of lock-out effects.
- (4) Avoidance of special switchboard equipment and operating methods.

25 (5) Such features of primary or basic importance as economy, simplicity, the avoidance of increased overall attenuation or time of transmission, and the avoidance of any feature that might interfere with future developments such as the application of dial control to toll line switching. As to this latter, the invention includes as a feature, a dial controlled switching system for toll lines.

30 In accordance with the specific embodiment of the invention herein described and illustrated, the elimination of echo paths at the junction points of a built-up circuit is accomplished by arranging the junction circuit to transmit only one way at a time. Hybrid coils are dispensed with and voice-operated or tone-operated control circuits are used to keep the oppositely transmitting circuits isolated from each other and to connect them one at a time to the junction circuit.

45 Positive operation of the voice-control devices is secured by use of a tone transmitted slightly in advance of the speech, and preferably during the speech transmission as well, to perform the switching operations between each one way line and the junction circuit or the circuit to which the four-wire system may lead, such as transoceanic cable, radio link, etc.

50 Elimination of lock-out effects is attained by arranging the tone control so that precedence

is given (as between two oppositely directed transmissions) to that speech which first reaches a previously conditioned switching point located preferably near the electrical center of the connection.

5 The avoidance of special switchboard equipment is realized by employing as special equipment, apparatus which can be situated elsewhere than immediately at the switchboard, thus conserving the advantageous space relations that have become standard in switchboard practice.

The various other features and objects will be apparent as the description of the specific embodiment proceeds.

15 In the system to be described more in detail hereinafter, a number of four-wire toll links are arranged to be interconnected by two-wire junction lines. Considering a terminal of a four-wire link, there are present three circuits, viz. a receiving terminal of a two-wire line (one side of the four-wire circuit), a transmitting terminal of a two-wire line (the opposite side of said four-wire circuit) and the end of the junction circuit. Only two of these circuits are normally connected, say the receiving terminal and the junction line. When transmission is to take place from the junction line into the transmitting terminal, a tone (or speech) impressed on the junction circuit severs the normally existing connection and makes the alternative connection, that from the junction circuit to the transmitting terminal. At the same time (or slightly in advance) a tone is sent out over the transmitting line. At the next junction the same arrangement exists, so that the tone received there impresses a (preferably different) tone on the junction circuit which makes the corresponding switchover at that junction point, sends out a tone over the next line and so on. The original tone was sent out by a speech wave that is to be transmitted and that closely follows the tone which, as described, makes the necessary circuit switchovers in advance to prepare a transmission path for the speech.

45 There is no necessary frequency relation between the tones used in different portions of a system. Thus, designating the tone sent over a toll line as tone K, and the tone used locally on a junction circuit as tone C, different lines may use tones K₁, K₂, etc. respectively different in frequency, the only requirement being that the tone be capable of operating the tone-controlled devices associated with that particular line, and that it have different frequency characteristics from speech so that the two do not interfere with each

other. Two tones C_1 and C_2 are preferably used for opposite directions in the junction circuit for reasons that will be made apparent later. These tones, likewise, have frequencies outside the speech range.

Since the opposite sides of a four-wire link are at no time connected, but have their terminals always effectively isolated, there can be no reflection back over a receiving line from a junction point, of energy sent over the transmitting side.

The junction circuit, being a two-wire circuit, may be switched in any suitable manner as by ordinary two-wire toll cord circuit methods or by automatic switches such as are employed for switching ordinary telephone connections.

A better understanding of the various features and objects of the invention will be had from the following description of the preferred embodiments illustrated in the accompanying drawings.

Figs. 1, 1A and 2 of the drawings when placed side by side with Fig. 1 at the left of Fig. 1A show a schematic circuit layout of a complete station for interconnecting two four-wire links by a two-wire cord circuit, and at the left portion of Fig. 1 there is shown enough of the next adjacent junction point to aid in tracing through a call.

Fig. 2A shows a local line jack.

Figs. 3 and 5 are diagrams illustrating the function of a control point intermediate the terminals of a built-up connection.

Fig. 4 is a schematic showing of a method of setting an operator's position so that it becomes a control station.

Fig. 6 illustrates the use of machine switching under dial control for interconnecting two four-wire links; and

Fig. 7 shows an echo suppressor modified in accordance with this invention to enable the use of a control point intermediate the ends of a circuit and avoid lock-out effects.

It is thought that the system can best be understood by describing the functions performed by the various elements of the system in putting through a call and carrying on a conversation over the system. For the most part the elements of the system are individually known in the telephone art. Where a less well-known element is encountered it will be described.

Referring now to the through connection represented by Figs. 1, 1A and 2 with Fig. 1 placed to the left of Fig. 1A, the operation will now be described. It will be assumed that the call is to be put through from Fig. 1 to Fig. 2 beginning at the left of Fig. 1. As stated above, not all of the apparatus is shown in the left-hand portion of Fig. 1, but only that which is necessary in considering the tracing of a call, the remainder of the equipment corresponding to that shown at the right hand of Fig. 1 being omitted for simplicity.

It will be assumed that the operator has plugged into jack 1. Relay 2, as in standard practice, will be unoperated if the connection is from a long toll line but will be operated to cut in the pad 3, 4, 5 if the connection is from a local line. In any case, the relay is operated to insert the pad when the operator presses her talking key.

The operator having plugged in and pressed her talking key begins to talk as, for example, by saying "hello operator" or some equivalent, and these speech waves are impressed across conductors 7 and 8. The receiving amplifier 9 prevents these speech waves from getting into the westward circuit 10, but they are passed through the

voice filter 11 and normal contacts of relay 12 to the delay circuit 13. A portion of the speech waves also passes into the amplifier-detector 14 which may possess suitable amplification together with a rectifier and filter for producing direct currents from the speech waves suitable for operating relays. As a result, relays 15, 16 and 17 are operated. Relay 17 in operating cuts off the receiving circuit 10 so that any incoming speech waves that may subsequently arrive in this circuit are prevented from reaching the amplifier-detector 14 or the springs of jack 1. Relay 16, in operating, applies tone "K" of characteristic frequency from the source 19 through the filter 21 to the eastward or outgoing circuit 20. Relay 15 in operating closes the normally open circuit on the output side of delay network 13 so that the speech, which has temporarily been delayed, is allowed to pass out over the circuit through amplifier 22 and into the line 20.

Delay network 13, which may be of the acoustical, mechanical or electrical type, is given a sufficient time delay constant to insure that the tone from source 19 has been applied to circuit 20 a short interval before any of the speech gets into line 20. Also, the time constant of the delay is so related to the operate time of relay 15 that this relay has time to close its contacts before the initial portion of the speech wave reaches these contacts, thus preventing initial clipping of the speech. After cessation of the speech, amplifier-detector 14 is without current and the relays restore to the condition shown in the drawing after sufficient hangover to prevent final clipping.

When the tone K from source 19 reaches the opposite end of the circuit 20 it passes through the normal contacts of relay 31, and into the amplifier-detector 34, which is responsive both to speech and to the tone K. The tone K is rectified and made suitable for operating relays, the relays 35, 36, 37 and 38 now operating.

Relay 36 in operating applies ground from 39 to a part of its own winding and also to lamp 40 and winding of relays 41 and 42. Lamp 40 is thus caused to light notifying the operator at this position that a call is incoming. Relay 36 locks itself up to maintain ground 39 on lamp 40 and hold the lamp lighted even though the initial impulse of tone K coming in over circuit 20 may have been of momentary occurrence as a result of the initiating operator having spoken. Relay 41 prepares a locking circuit for itself and for relay 42 through its front contact and through the back contact and armature of relay 43 to armature of sleeve relay 44 but this circuit is not completed at this time. Relay 42 in operating disconnects lead 45 from its armature contact, and therefore, from the winding of transfer relay 46 and relays 47 and 48.

When the operator at Fig. 1A observes the lighting of lamp 40 she inserts plug A into the jack 51 thus causing operation of sleeve relay 44 from the sleeve battery B_1 in the cord circuit. The operation of relay 44 transfers the ground 39 from the armature of relay 36 to conductor 45 thus allowing relay 36 to release and extinguishing lamp 40. Relays 41 and 42 are not released, however, since the locking circuit previously traced for these two relays is now completed at the armature of relay 44 and ground 39. None of the relays 46, 47 or 48 is therefore operated.

The relay 46 being unoperated, tone of frequency C_1 from source 53 passes through its

corresponding filter, normal contacts of relay 46 to the armatures of relay 35.

As stated above, relays 37 and 38 also are operated at the same time as relay 36. In fact, each time that speech or tone K is received over line 20 after a pause, each of the relays controlled by the amplifier-detector 34 will operate and at the cessation of speech will release. Thus relay 37 is always operated when relay 35 is operated and removes relay 56 from control of amplifier-detector 57 which responds to the tone C₁. Any of this tone, therefore, which finds its way into the circuit 58 does not operate relay 56.

Relay 38 in operating opens the westward circuit 10 at the back contacts of its armatures and prevents transmission toward the left in this circuit.

The operator in Fig. 1A after pressing her talking key K₁ may now talk to the operator in Fig. 1. Battery 101 is applied over her talking key to the jack springs and causes operation of pad relay 55 which cuts the path comprising series resistances 61, 62 and shunt resistance 63 into the talking circuit. Her speech passes into circuit 64, and through speech filter 65, normal contacts of relay 38 to delay network 66. A portion of her speech also passes into amplifier-detector 67 and causes the operation of relays 31, 68 and 69. Relay 69 applies tone K from source 70 through filter 71 and vario-amplifier 30 to the outgoing line circuit 10. Relay 68 completes the circuit at the output of delay 66 to allow the speech to pass out also over circuit 10 a short interval after the beginning of the tone. Relay 31 opens the connection of circuit 26 thus preventing the reception of any incoming speech that may arrive subsequently over that path.

The purpose of the vario-amplifier and its controlling circuit, amplifier-detector 29, is to make the outgoing tone K initially strong and to modulate its strength when it is accompanied by speech so that its amplitude is low when the speech amplitude is high and vice versa. Initially, when there is not yet any speech impressed on the amplifier-detector 29, the tone is sent out at full amplitude and thus exerts positive control over the various relays which it is to operate. This variable amplification can be attained by methods known in the art in volume control circuits, as by applying the rectified speech from circuit 29 to the grid biasing circuit of the amplifier 30 so that its amplification varies depending upon the output of the amplifier detector 29.

The speech in circuit 10 proceeding towards the left to the calling operator's station passes through the normal contacts of relay 17, speech filter 23, and amplifier 9 and through the pad to jack 1 and the cord circuit of the initiating operator. The tone K which preceded the speech in circuit 10 passes into amplifier-detector 13 and operates relay 12 thus opening eastward line 20 at its input end before speech arrives at the armature of the relay. Amplifier-detector 18 is kept operated while tone or speech or both are being received over line 10. When the operator at Fig. 1A ceases talking, relays 31, 68 and 69 release after sufficient hangover to permit the last of the speech in delay network 66 to pass on out into the line 10. At the opposite end of circuit 10 relay 12 releases thus rendering the circuit 20 operative. Also, when the operator in Fig. 1A releases her talking key relay 55 releases removing the pad 61, 62, 63 from the circuit.

The operator in Fig. 1A may now receive instructions from the operator of Fig. 1 over the talking circuit previously traced over line 20. When the tone K sent out from source 19 by this speech arrives at the right of the figure, and causes the operation of relays 35, 36 and 37, these relays are for the moment without effect but relay 38 as usual opens the circuit 10 thus preventing received speech from finding its way back into circuit 10. The speech incoming over line 20 passes through filter 32, amplifier 33, and pad 61, 62, 63 to jack 51 and thence to the cord circuit, but tone K is eliminated from this circuit by filter 32.

The operator at position 1A now completes the connection by inserting the opposite plug, B, of her cord circuit into the jack 76, Fig. 2 after which she speaks into the circuit at the right to call the attention of the next operator.

The course which this speech traverses is entirely analogous to that already described in connection with Fig. 1 and the pieces of apparatus that are involved have been given the same reference characters with the prime mark added for ease of comparison. Information is exchanged between the second and third operators in the same way as between the first and second operators to enable the connection to be extended as desired.

Let it now be assumed that the connection is complete and in readiness for the parties to begin talking. For the purpose of the present description, it will be assumed that the connection is not sufficiently long to require the transmission of a conditioning signal, the purpose of which will be described later on. Let it also be assumed that the operator at position 1A restores key K₁ to normal, thus removing battery from the cord circuit, which releases relays 55 and 55' and allows the two pads to drop out of the circuit. At the same time, the release of these relays results in the connection of leads 58 and 58' from relays 35 and 35' to the springs of the jacks of the respective terminal circuits, so that tones under the control of relays 35 and 35' may reach the amplifier-detectors on circuits 53' and 58 respectively. When the party at the left begins to talk the speech traverses the circuit 20 in the manner that has already been described, accompanied by tone K which is impressed on the circuit slightly ahead of the speech and throughout the duration of the speech as already described. When this tone arrives at amplifier-detector 34, the operation of relay 35 as described applies some of the tone C₁ from source 53 to the springs of jack 51. (Some of this tone passes into circuit 58 and amplifier-detector 57 but this has no effect since relay 37 is operated by tone K at this time.) The tone C₁ passes through the cord circuit over the talking conductors into the jack 76 and is impressed on the conductor 58' leading to the amplifier-detectors 49' and 57'.

It will be observed that when the operator plugs into jack 76 thus causing relay 44' to pull up, relay 36' and consequently relays 41' and 42' had not at this time been operated since there was no incoming call on this jack and lamp 73 was not lighted. Thus when relay 44' operates it finds the back contact of relay 42' closed and causes the energization of relays 46', 47' and 48' from ground 39' over conductor 45'. Relay 46' interchanges the connections of tone sources 53', 54', so that the latter, rather than the former, is connected to the armatures of relay 35'. 75

Relay 47', by shifting its armature, prevents the operation of relay 43' by relay 56' for a purpose to be described later on. Relay 48' in shifting its armature changes the tuning of the input circuits of amplifier-detectors 49' and 57' so that they are respectively selective to their alternate rather than to their normal tone frequencies. That is, amplifier-detector 49' now becomes selective of tone frequency C₁ while amplifier-detector 57' is now receptive to tone C₂. This may be done, for example, by removing condenser 79' from the input tuned circuit of amplifier-detector 49' and connecting condenser 80' into the tuned circuit of amplifier-detector 57'.

It will be seen, therefore, that the tone C₁ which was traced from source 53 through the cord circuit to jack springs 76 and circuit 58', is now permitted to pass through amplifier-detector 49' where it is suitably rectified and amplified and rendered capable of operating relays 12', 16', 17' and 82'. Relay 17' in operating opens the circuit 10' to prevent the reception of speech over that line. Relay 16' projects tone K (or K' if desired) from source 19' through vario-amplifier 30' out over the line section 20'. Relay 12' disconnects the delay network 13' from the circuit and relay 82' substitutes the delay network 83' which has a smaller delay time than delay network 13'. This use of a smaller delay is permissible because of the fact that the tone K at the originating station started out slightly ahead of the speech and, in turn, caused the cord circuit tone C₁ to precede the speech by a slight interval. This, in turn, means that the tone K from the source 19' is applied to the line 29' slightly ahead of the speech so that in fact no delay at all may be necessary at 83'. However, a delay network 83' has been provided and may be necessary in some cases because of the time required for the operation of the various relays used to repeat the tone K from the first section 20 into the second section 20'.

The operation at the distant end of the line section 20' upon the arrival there of the tone K and speech as described is entirely similar to that already described for the line section 20, and so on from section to section.

It will be understood that the speech arriving over line section 20, Fig. 1, as described passes through filter 32 and amplifier 33, the upper part of circuit 64, normal contacts of relay 55, jack springs 51, talking conductors of the cord circuit, jack springs 76, normal contacts of relay 55', circuit 64', filter 11', delay network 83' (if any) front contacts of relay 82', amplifier 22' and out over the line section 20'.

It will be understood that speech coming from the subscriber at the right is transmitted in an entirely analogous manner and arrives eventually over circuit 10' at the apparatus shown in Fig. 2 where it passes over the normal contacts of relay 17' into filter 23', amplifier 9' and the lower part of circuit 64', normal contacts of relay 55' to jack springs 76. The tone which precedes and accompanies this speech, as well as a portion of this speech, passes into amplifier-detector 18' and causes operation of relays 35', 36', 37' and 12'. Relay 12' opens the circuit leading to line circuit 20' to prevent the speech from amplifier 9' from finding its way into that circuit. Relay 36' is without effect since the ground connection at 39' is broken by the energization of relay 44'. Relay 35' closes and projects tone C₂ from tone source 54' over the normal contacts of relay 55', jack springs 76, the connected cord

circuit, jack springs 51, normal contacts of relay 55, the lower part of circuit 58 to amplifier-detector 49, where it is made capable of operating relays 31, 38, 69 and 82. Relay 31 cuts off line 20. Relay 69 projects tone K from source 70 through filter 71 and the vario-amplifier 30 to the line section 10. Relay 38 removes the delay network 66 from the circuit and relay 82 substitutes delay network 83. The speech which was traced from circuit 10' to the springs of jack 76 above passes over the cord circuit to jack 51, normal contacts of relay 55, the lower part of circuit 64, filter 65, delay network 83, amplifier 84 and into line section 10.

When tone K on line section 10', as above described, reaches the amplifier-detector 18' to operate relay 35', it operates relay 37' as already noted. Thus, the tone C₂, which passes into circuit 58' under control of relay 35' and reaches the input of amplifier-detector 57', over circuit 58', is made incapable of operating relay 56' because the back contact of relay 37' is opened whenever relay 35' is energized.

It will be observed from the foregoing description that when a plug is inserted into a jack in response to the lighting of a lamp (as was done in the case of lamp 40) the cord circuit tone which is later projected into the cord circuit from that jack is tone C₁ and, conversely, that where a plug is inserted into a jack in order to extend a call rather than to answer a call (as described above in the case where lamp 78 was not lighted) the cord circuit tone that is later projected into the cord circuit over that jack is tone C₂. This comes about from the fact that in the first mentioned case, relay 42 is energized and remains energized throughout the connection, whereas in the second case relay 42' does not become energized.

There may be instances in actual practice where it is necessary or inevitable that both jacks into which the plugs of a given cord circuit are inserted have their corresponding lamps lighted. Such situation may occur where a lamp is lighted just at the instant when the operator plugs in or where there is a waiting call, or possibly in other situations. Cases also may occur where neither lamp is lighted when the plugs are inserted in the jacks.

In order to insure that the two cord circuit tones projected in different directions over the cord circuit are different, an extra amplifier-detector 57 or 57', together with associated relay circuits is provided. It is described above that when the operator plugged into jack 51 in response to the lighting of lamp 40, relay 42 became energized and prevented the energization of relays 46, 47 and 48. Let it now be assumed that the plug which is inserted into jack 76 is inserted at the time lamp 78 is lighted. Relay 36' being therefore operated, the operation of the sleeve relay 44' extends locking ground over conductor 45' as described in connection with Fig. 1 to hold relays 41' and 42' operated, they having previously been operated from relay 36'. With relay 42' operated, relays 46', 47' and 48' remain unoperated so that the circuit is in condition to project tone C₁ from source 53' into the cord circuit under control of relay 35'. Let it now be supposed that the first party to talk is at the left so that the speech comes in over toll line section 20. When relay 35 operates to send tone C₁ from source 53 into the cord circuit, this tone comes in over circuit 58' and into amplifier-detector 57', amplifier-detector 49' having its nor-

mal tuning to tone C₂. The received tone C₁ operates relay 56' thus causing operation of relay 43' which breaks the holding circuit for relay 41' allowing this relay and relay 42' to release. The holding ground from conductor 45' now causes the operation of relays 49', 47' and 48', interchanging the tone sources 53', 54' and interchanging the tuning of the amplifier-detectors 49' and 57'. The tone C₁ present in circuit 58' is now able to pass through amplifier-detector 49' and cause the operation of relays 12', 16', 22' and 17' in the manner previously described. Relay 47' in operating disconnects relay 43' from the control of relay 56' for a purpose to be described presently. When relay 47' operates, it not only disconnects relay 43' from the control of relay 56' but it places relay 41' in the circuit controlled by relay 56'. If both lamps are out when the plugs are inserted in the jacks, relays 47 and 47' are operated so that relays 41 and 41' are under the control of relays 56 and 56' respectively. 46, 46' and 48, 48' also are operated conditioning both terminals to send out tone C₂. Then, if the first party to talk is at the left, tone C₂ from source 54 will operate amplifier-detector 57' which is tuned to C₂. This will operate relay 56' which will cause relay 41' to operate and lock, thus operating relay 42' which causes the release of relays 46', 47', and 48'. This reconditions the right-hand terminal to receive C₁ and send out C₂, as well as arranging the circuit associated with amplifier-detector 57' in the condition such that it will respond only to C₁ coming through the cord circuit. This eventuality might occur if the left-hand plug is moved to another terminal when the lamp of the latter is lighted. Thus each terminal is equipped to automatically coordinate with a terminal to which it may be connected. If the first party to talk had been at the right instead of at the left, the left-hand terminal would have interchanged its C₁ and C₂ tuning. From this point on the operation is the same as has already been described. If the first party to talk had been the party at the right instead of at the left the interchange would have been made between tone sources 53 and 54 instead of between tone sources 53' and 54' and the amplifier-detectors 57 and 49 would have had their tuning interchanged instead of the amplifier-detectors 49' and 57' as described.

The tones C₁ and C₂ are preferably outside the speech range, for example 6,000 and 7,000 cycles respectively, and the filters 11, 23, and 65 have pass ranges which permit speech currents to pass but prevent these cord circuit tones from entering outgoing toll line section 20', 10 etc. A low pass filter 99 is shown associated with the operator's set for preventing these tones from reaching her set. Strictly this filter would not be required with only so much cord circuit apparatus as is illustrated since the talking key cuts off (by relays 55 and 55') these tones from the cord circuit when the key is operated. The filter is shown, however, since the operator's set might otherwise be subjected to these tones in case of monitoring by a key not shown in the drawings. These tones, while outside the speech frequency range, may still be of audible frequency.

Referring to Fig. 3, a number of operators' positions O₁ to O₆ are shown with sections of four-wire toll line between, and it is assumed that these toll line sections have been interconnected by the means disclosed in Figs. 1 and 2 so as to extend a long talking circuit. With only so much of the apparatus as has been thus far described

in Figs. 1 and 2, mutual lockout between the opposite talkers might in the case of very long circuits prove troublesome. For example, the subscriber adjacent O₁ starts to speak and his speech progresses to a point, say between O₄ and O₅ when the other talker begins to speak. All of the apparatus at positions O₁ to O₄ has been operated as previously described to disable the path in the O₄ to O₁ direction so that the speech from O₆ cannot pass beyond position O₄. For a similar reason the speech in the O₁ to O₆ direction is not received because the opposite speech disables the receiving apparatus at O₅ and O₆. A maximum lockout interval equal to the time of transmission from O₁ to O₆ is thus possible.

This lockout time can be practically eliminated, however, if the system is so controlled that whichever speech first reaches the middle of the connection is insured a free path all the way to the far terminal. With such arrangement the circuit cannot remain in a condition in which neither party can hear the other party talking, which is what is understood by the term "lockout". The lockout prevention is accomplished as will now be described by sending a conditioning signal to make any prearranged position the control point. Obviously it is desirable to have some position near the middle of the connection act as the control point.

Referring again to Figs. 1 and 2, let it be assumed that the position shown in detail in Fig. 1A has been designated (in some manner to be described at a later point) as the control station, and that the operator at this position by pressing key 93 and key K₁ controls the application of conditioning tone "S" from source 94 to the springs of both jacks 51 and 76. This tone S is different from any tone K, K' etc. used on any toll line section and is also different from the cord circuit tones C₁ and C₂, and any other tones that may be used, so that the sending out of this conditioning tone in no way conflicts with the sending and receiving of those tones. It will also be clear that the tone S is not sent out until the connection has been fully extended and until just before the parties are to begin to talk.

The conditioning tone S lies in the speech range, and hence is capable of operating the voice controlled circuits. It may, for example, be a 1000 cycle wave interrupted at 30 cycles per second so as to afford the possibility, as by successive detection and tuning, of enabling this tone to be differentiated from speech for purposes of selectivity while being able to operate the voice controlled circuits. When the tone S is applied to springs of jack 51, it passes into circuit 64 via normal contacts of relay 55, through filter 65 and normal contacts of relay 33 to delay circuit 66. A portion of the tone operates amplifier detector 67 and relays 31, 63 and 69 as in the case of speech. Relay 68 extends the connection by closing its contacts, after relay 69 has applied tone K from source 70 to line 10. The tone K is transmitted to toll stations to the left and is accompanied after a slight interval by tone S. Besides going out on the line, tone S reaches amplifier detector 100 associated with the terminal ending in jack 51. In this amplifier detector, it is selectively detected and caused to operate relay 101, and this same action takes place at the homologous portion (i. e. the outgoing portion) of each of the other toll stations on line 10 to the left, since tone S is transmitted to all of these stations in the same manner as has been described above for speech. Similarly as the tone is pro-

jected simultaneously toward the right, over jack 76, relays 15', 16', and 17' first operate, tone K is sent out accompanied an instant later by tone S, the latter operating the amplifier detector 103' and relay 101' (with similar action at the other stations toward the right). The function of relay 101 (101') is to nullify the effect of any conditioning tone that may have been transmitted previously through the terminal in the opposite direction. This relay removes ground from relay 104 (104'), the action of which is described below.

The effect of tone on the incoming side of each of the stations to the right and left of the station of Fig. 1A can be understood from considering that tone S is coming into the right-hand portion of Fig. 1 from the left over circuit 20 (since the circuits of all of the toll stations may be assumed to have like equipment). Such tone is selectively received by amplifier detector 103 and operates relay 104. At this time relay 105 is already operated from ground 39 supplied by the sleeve relay 44. Since at this instant it may be assumed that tone S is being sent over any given section of toll line in only one direction, relay 101 in the receiving side of each of the stations to the left and the right at which tone S has been received is not operated, and a circuit is closed by relay 104 from ground at back contact of relay 101 and front contact of relay 105 to winding of relay 106 and battery, causing relay 106 to operate. Relays 104 and 106 lock up over contacts of relays 101 and 105. Relay 106 opens at its two armatures the control leads to both windings of relay 31 thus preventing this relay from being operated by oppositely directed speech, either directly or through the agency of the cord circuit tones.

Reverting, therefore, to the previous assumption that the station of Fig. 1A is the control station from which tone S is sent, that relays 101 and 101' at this station are operated by this tone solely for the purpose of nullifying any previous conditioning, and that the disabling that has been described in connection with the control circuits of relay 31 does not take place actually at this station but only at the incoming circuit of each of the other toll stations at which tone S is received, it is clear that the right of way is always given to speech leaving the control station (Fig. 1A in the assumed case) over speech incoming toward that station. Thus, in the case of speech which is about to arrive from the left over line 20 at the control station, if speech is at this instant going out toward the left over circuit 10, relay 31 is energized, opening circuit 20. When tone K preceding this speech in circuit 10 reaches the next station to the left it passes through the contacts of relay 17 which has been disabled by the previous action of tone S on amplifier detector 103' acting through relay chain 24 (corresponding to relays 104 and 105) to operate relay 106''. Thus, speech (or tone K) in circuit 20, traveling toward the control station, Fig. 1A in this case, is unable to effect energization of relay 17 to interrupt oppositely transmitted speech. The speech (or tone K) in circuit 10, however, traveling as it is, away from the control point, is able to operate relay 12 and prevent transmission over line 20 toward the control point, Fig. 1A.

The manner in which the conditioning tone may be sent under control of the originating operator is shown in Fig. 4 in conjunction with the

cord circuit, Fig. 1A. When the connection is first being extended, the station which in any given connection is to be the control station is designated as by a chart or some suitable routine. As the connection is made from toll position to toll position under instructions from the originating operator and the station which is to serve as control station for that connection is reached, the operator at that station is asked to press her conditioning key 110 (Fig. 4) which is preferably positioned close to and just beneath the jack 51 used for that connection. This key locks in closed position and the process of setting up the connection continues as before, the control station being, as previously stated, preferably near the middle of the connection.

After the connection has been set up and the called subscriber reached and just before the parties start to talk the originating operator presses her key 95 (Fig. 1A) thus sending a short impulse of tone T from source 96 over the circuit. This tone is in the speech range and is capable of operating all of the relays which are adapted to be operated by speech on the several links. It may be a 1000-cycle wave interrupted at 50 cycles and thus differentiated from toll ringing current of 1000 cycles interrupted at 20 cycles and from tone S of 1000 cycles interrupted at 30 cycles.

When tone T comes into the station of Fig. 4 over line 20 and reaches the springs of jack 51, in the manner already described for the transmission of speech over the circuit, it finds key 110 depressed, passes into amplifier detector 111 and after selection and detection operates relay 112 which transfers its armature to include condenser 113 in a charging circuit with battery 114 and suitable resistances. At the cessation of the tone T, relay 112 releases and connects the now charged condenser 113 into the circuit of relay 115 which is operated momentarily by the condenser discharge. In operating, relay 115 sends a short impulse of conditioning tone S from source 116. This tone passes out from the control station in both directions in the manner already described in the alternative case when it was assumed that the control tone was sent from the operator's cord circuit by pressing key 93, and conditions the circuit for operation with the circuit at which button 110 was pressed as the control station. When the subscribers have finished talking and the connection is taken down, key 110 is restored by the operator or it may be released under control of a sleeve relay (not shown). Amplifier detector 111 is so tuned as not to pass tone S so that relay 112 is not operated by this tone.

The terminals of a circuit containing a link unavoidably subject to lock-out, such as a transoceanic telephone cable circuit operated on a two-wire basis, may be arranged in accordance with this invention so that the operator at either terminal of the circuit, or both operators, may send the conditioning signal, but the control will be arranged to be effective at the two ends of the link that are subject to lockout. Consider, for example, that in Fig. 5 a transatlantic cable 120 terminates in suitable four-wire circuits indicated at 171 and 172 which lead in turn to operators' positions O₄ and O₅ respectively. The apparatus at all of the operators' positions O₁ to O₆ excepting the terminals of lines 171 and 172, may be like that shown in Figs. 1, 1A and 2. The four-wire terminal circuits 171 and 172 may be local or extended to suit conditions. Their terminals

at O₄ and O₅ may be similar to the other terminals with the exception that they are permanently conditioned to give the right of way to speech incoming from the submarine cable section. One way in which this may be accomplished is by permanently disconnecting the contacts of relay 103 (103') and leaving the circuits concerned open at that point. Obviously, certain apparatus is not required in such a terminal, such, for instance, as relay 17 (17'), and the unnecessary items need not be provided. If desired, a circuit similar to Fig. 1 (Fig. 2) may be used at the permanent junction between the submarine cable proper and the four-wire extension circuit, thus obtaining the same benefits from the use of tone K over the four-wire extension as in the case of other four-wire links. In such a case, assuming that the submarine cable link will not transmit tones outside of the speech range, relay 55 (55') will be omitted and circuit 64 connected directly to the submarine cable while circuit 58 and its associated features will not be used. Also the contacts of relay 106 (106') will be permanently strapped so that speech coming over the four-wire extension circuit to the submarine cable junction will not be able to interrupt speech passing in the opposite direction at that location.

If now a through connection is set up as shown in Fig. 5 from operator's position O₁, to operator's position O₈ either operator O₄ or O₅ or both may send the conditioning signal as by operating a key similar to key 53 or one arranged to connect a generator 116 (Fig. 4) to the jack springs as is done by key 116 and relay 115 of Fig. 4. Suppose that operator O₄ sends out such tone S. It traverses the land line to the left and conditions the apparatus at stations O₁, O₂, O₃ and O₄ for giving preference to speech passing toward O₁ from O₄. It also traverses the transoceanic cable 120 to station O₆, and thence to stations O₆, O₇ and O₈ conditioning them to give preference to speech passing from O₅ toward O₈. It will be seen that exactly the same result would follow if the operator at O₅ had sent the tone S and likewise the same result would follow if both operators at O₄ and O₅ had sent the conditioning tone. This is an advantage since no set international precedence need be observed or procedure agreed upon in case of international toll connections.

The tone control features that have been described are adapted to dial control of toll connections as will now be described in connection with Figs. 2 and 6. The various tone sending, tone receiving and tone relaying apparatus that has been described is fast-operating so that it is adapted to serve to transmit dial impulses for the purpose of setting up a connection and thereafter the same tone-operated devices serve to exert the various controls described above in connection with the two-way transmission of speech.

Referring first to Fig. 6, the terminal circuits 121 and 122 are similar in essential features to those shown in Figs. 1 and 2 where they were assumed to be interconnected by a cord circuit (Fig. 1A). In Fig. 6 instead of jack springs 51 and 76, the circuits are terminated on pairs of leads 51' and 76', respectively. The leads 51' extend to brushes 123 of a selector switch 124 provided with suitable stepping mechanism 125 not shown in detail. The switch has a bank of stationary contacts 127, one set of which is connected to leads 76' so that a connection may be extended from terminals 51' to 76' upon movement of selector

switch 124 to select and connect with the proper terminals. It will be understood that other stationary contacts 127 are connected to other trunk conductors like 76' leading to other four-wire toll lines and terminal circuits similar to 122, any of which may be reached by brushes 123 upon dialing the appropriate number.

To adapt terminal circuit 121 for controlling switch 124, the lamp circuit 40 (Fig. 1) is in effect converted into an impulse repeating circuit, relay 136 corresponding to relay 36 of Fig. 1 except that relay 136 is not provided with a locking circuit. The actual switch mechanism 124 and stepping mechanism 125 may vary widely in practice and any suitable prior art type may be used, such for example, as that disclosed in U. S. Patent to C. L. Goodrum 1,251,503, January 1, 1918 and the disclosures therein referred to. The usual release mechanism of the prior art is modified, however, to the extent that in the present system a special release tone is sent over the system to cause the release of all of the selector switches, this being necessary since there is no normal battery current flow or other current over the line conductors to hold the switches operated.

An auxiliary switch mechanism 129 with stepping mechanism 128 is used for the special function of selecting a particular station as the control station from which the conditioning tone is to be sent, as will be more fully described later on.

The operation of the automatic or dial control circuits will now be described. It will be noted that the cord circuit (Fig. 1A) includes an operator's dial 97. This dial is provided with a pair of off-normal contact springs 98, 99 and an interrupter contact 100''. When the operator starts to move the dial in its forward direction and continues to move it until the finger stop is reached, contacts 98 open and contacts 99 close. This results in cutting off battery 201 and applying instead across the line the source 102 of tone C₂. The talking key K₁ is at this time in operated position and splitting key K₂ is thrown to close its right-hand outer contacts so that tone C₂ passes out into the circuit, such as springs of jack corresponding to jack 76 of Fig. 2 and through the back contacts of relay 55' which was released by the removal of the battery to circuit 58' at the particular operator's position at which the dialing is being done. Let it be assumed that this position is at the left terminal of Fig. 1 so that the tone C₂ is applied to jack 1. The effect of the application of this tone is to operate relay 16 in a manner already described in detail in connection with Fig. 2 (by operation of an amplifier detector corresponding to 49' of Fig. 2). Relay 16 applies tone K to outgoing line section 20.

Tone K after traversing line 20 reaches the terminal circuit 121 of Fig. 6 which is the same as that at the right-hand end of Fig. 1 except as modified to respond to dial control. Tone K passes into amplifier detector 34 and operates relays 35 and 136. Relay 35 applies tone C₁ from source 53 (see Fig. 1) to the terminals 51' of the talking circuit and hence the brushes 123 but this is without effect since the brushes are out of contact with any terminals and are so arranged as not to have their electrical circuit completed until after they have reached the selected terminals as is common in the art of automatic telephone switching. Relay 136 in operating makes connection at its front contact to ground from conductor 131 leading to stepping mechanism 125. As regards the control of the stepping and circuit

elements 125, the energization of relay 136 may correspond to removal of the receiver from the switchhook in the Goodrum patent supra. That is, a circuit is established in the switch control system 125 which upon subsequent interruption under dial control will guide the movements of switch 124 to select certain contact terminals 127 (as in the case of the making and breaking of the energizing circuit of relay 26 of Goodrum).

Upon release of the dial by the operator after she has moved it to the finger stop as described, the dial rotates back to its normal position and in so moving operates springs 100'' to interrupt the supply of tone C₂ a definite number of times corresponding to the digit that is dialed. This causes a corresponding number of interruptions of the circuit of relay 16 and of tone K and consequently of the circuit of relay 136, thus driving switch 124 to select and connect to the terminals 127 to which circuit 76' is connected. (As is common practice in selector operation, the switch may also have a hunting or non-directive movement to select an idle trunk from a group of trunks terminating in the level or row to which the switch was directly moved as provided for, for example, in the Goodrum patent.)

As the operator dials the next digit, the forward movement of the dial operates the off-normal contacts to send out tone C₂ as before, which in turn sends out tone K over circuit 20, causing operation of relays 35 and 136 at terminal 121. Relay 136 is without effect since the movement of the usual side switch or equivalent in stepping mechanism 125 has rendered lead 131 of no effect. Relay 35, however, applies tone C₁ from source 53 (see Fig. 1) to circuit 51', brushes 123, terminals 127 and circuit 76', and this in turn operates relay 16' in terminal circuit 122 (as in Fig. 2) causing tone K to be sent out over toll line 29'. The effect of this at the next switching point is the same as that described for tone K coming into terminal circuit 121 over line 20 in the first instance. The dial impulses of the second (and later) digits interrupt these tones on the various parts of the built-up circuit to control selector switch mechanism at the next (and subsequent) switching point (s) in the manner that has been described with reference to Fig. 6. Of course the selectors at any one switching station may require two or more digits, depending on the number of outgoing lines from that point.

It will now be assumed that the station of Fig. 6 is to serve as the control station on a particular connection. In this case it will usually happen that this station is two or several stations removed from the dialing point. But, at any rate, after a certain number of digits the station of Fig. 6 will be reached. Then, in order to set this station up as the control station for the subsequent two-way conversational control, a special digit (such as "0") is dialed. This operates switch 124 as before except that brushes 123 are now carried to the topmost terminals shown in the figure, and thus make contact with leads 132. The next digit is of the proper number of impulses to select circuit 76' (assuming this is the desired outgoing circuit). This digit operates relay 35 to apply tone C₁ to circuit 51', brushes 123, stationary terminals 127 and leads 132 and amplifier detector 133, operating relay 134. This operates exactly as relay 136 operated, to control switch mechanism 128 to move switch 129 to connect to line 76'. The subsequent talking circuit, therefore, at this station passes through both

switches 124 and 129. Subsequent digits are sent as before to complete the extension of the connection.

After the called party is reached and just before the parties begin to talk, the originating operator depresses key 95 (Fig. 1A) for an instant, causing tone T to be sent over the system over the regular voice transmission path. When tone T comes into the station of Fig. 6, it passes in part into amplifier detector 111' and causes operation of relay 112'. This operates in conjunction with elements 113', 114', 115' and 116' (as in the case of Fig. 4, elements similarly designated except for the prime) to send a momentary impulse of conditioning tone S over the build-up connection in both directions from the Fig. 6 station. The effect of the conditioning tone is the same as previously described.

At the conclusion of the conversation, the originating operator (or the called operator if there is one, or either or both) depresses key 103 in her cord circuit, thus sending an impulse of tone L over the entire talking connection. This may comprise some speech frequency wave such as 1000 cycles interrupted at a characteristic rate such as 60 cycles to distinguish it from tones S and T and any other tones such as ringing current that may be used on the system. Tone L in coming into each of the stations at which a selector switch is to be released, is selected and rectified at amplifier detector 141 and operates relay 142. Off-normal contact 143 is now found closed, since the switch is out of its normal position, so that operation of relay 142 actuates release magnet 144 for switch 124 and this locks up over its own armature in series with off-normal contact 143. Release magnet 144 remains operated until the switch 124 is fully restored to normal whereupon contact 143 opens and magnet 144 restores. Switch 129 is similarly released, as are also all of the other switches used in the connection. (Release magnet 144 operates to release the selector as described in the Goodrum patent, e. g. magnet 57 of the latter.)

It was pointed out above that that station is the control station which last sends out the tone S. This fact makes it unnecessary to provide a special tone T for the functions that have been described for it. For if tone S is first sent out from the originating station to trip apparatus at an intermediate station and thus determine the latter as the control point it makes no difference that the tone S on its way to the control point conditions momentarily some of the stations for the wrong direction. For as soon as the tone S is again sent out from the station that is to be the control point, it reconditions these particular stations as well as conditions all of the other stations.

In the foregoing description of the function of the conditioning tone S and the manner of sending it out, no mention was made of the effect which it might have on echo suppressors. It is common to equip long toll lines with suppressors either near the middle of a repeater section or near one end. Speech traversing one side of the four-wire circuit disables the opposite side so as to prevent echo currents from coming back to the talker through the opposite line. Where a centrally located switching point is to serve as the control station for the voice or tone operated switching used in two-way conversations as above described, an ordinary echo suppressor would tend to defeat such operation since voice in either

direction, whether toward or from the control point, disables the opposite line so that no preference is given to the speech that has got past the control point.

5 Fig. 7 shows an echo suppressor modified according to the invention to overcome this difficulty. The echo suppressor itself comprises amplifier detectors 150 and 151 connected to lines 20 and 10, respectively, and each operating under
10 voice control to open the opposite line by operating relay 153 or 152, respectively. Each line is, according to this invention, equipped with other amplifier detectors, 154 in the case of line 20, and 155 in the case of line 10, each tuned to
15 respond to and detect 1000 cycle current. Ordinary ringing current is assumed to comprise 1000 cycle current interrupted at 20 cycles, while tone S, it will be recalled, is a 1000 cycle current interrupted at 30 cycles. Amplifier detector 154
20 connects to two amplifier detectors 156 and 158 tuned to respond to and detect respectively the 20 cycle and the 30 cycle component of the detected 1000 cycle current from 154. Amplifier detector 155 has corresponding second stage amplifier detectors 157 and 159. The purpose of
25 these will now be made clear.

Let it be supposed that, for a given connection, the control point is to the left of Fig. 7 so that the conditioning tone is sent over line 20 from
30 the left. It is detected at 154 and 158 and causes operation of relay 160, which locks itself up in parallel with relay 162, assuming the relays 164, 166 and 168 to be unoperated at this time. Relay 162 opens the control circuit of relay 152 so that
35 any speech traversing line 10 toward the control station (at the left) is not able to operate relay 152 and cut off or disable line 20. When tone S was received over line 20 to operate relay 160, it also operated relay 167 but this relay releases
40 again at the cessation of the impulse of tone.

If the conditioning tone had been sent from the right over line 10, relays 161 and 163 would have operated instead of relays 160 and 162, with the corresponding effect, namely, to prevent
45 speech in line 20 from disabling line 10 through operation of relay 153.

It will be apparent that the entire system described herein, is so arranged as to be conditioned by the conditioning tone that is last sent. Fig. 7
50 conforms to this arrangement. If tone S is first sent (either intentionally or by mistake) from the left over line 20 and operates relays 160 and 162, and subsequently tone S is sent from the right over line 10, the latter in operating relay
55 168 opens the holding circuit for relays 160 and 162 so that they restore and in operating relays 161 and 163 condition the circuit for the control point at the right. Ringing tone sent in either direction over the system will restore the echo
60 suppressors to normal operating conditions by releasing either the pair of relays 160 and 162 by operation of relay 164 or 166 or the pair of relays 161 and 163 by operation of relay 165 or relay 169.

65 It was described above that when the operator depressed her talking key K₁, Fig. 1A, battery from 101 is applied to the talking conductors and operates pad relay 55 to insert loss in the talking circuit and to prevent tone C₁ or C₂, as the
70 case may be, from passing out of circuit 58 into jack 51 and thence into the operator's telephone set.

The same result follows from plugging into a
75 local line, on which the speech volume is natu-

rally higher than at an intermediate station on a toll connection. Fig. 2A illustrates the jack circuit, battery 201' being permanently connected to the jack springs 251. With this arrangement
5 no tone can pass from the terminal into the local line, so that it will not reach a subscriber's station.

In the case of some two-wire toll circuits on which no control tones are used but which are not equipped with jack terminals like that of
10 Fig. 2A, the relay 55 will remain unoperated when connection is made to a terminal like that of Fig. 2. To provide against tones C₁ and C₂ being sent out over such line and reaching a subscriber or the distant operator such lines may
15 be equipped with a filter like 90 of Fig. 1A in case the line itself does not have sufficiently high attenuation at the frequencies concerned as to reduce these tones to unobjectionably low amplitude.

In the case of a two-wire submarine cable link similar to 120 in Fig. 5, but capable of transmitting tones C₁ and C₂ in such a way that the receipt of one of them from a distant terminal
20 can be positively detected at the other terminal when speech and a different tone are being transmitted into the cable at the near terminal, the submarine cable link may be considered as similar
25 to an elongated two-wire cord circuit. In such a case both circuits 64 and 58 (64' and 58') 30 will be permanently connected to the submarine cable. Any two-wire land line forming a permanent link between two four-wire circuits and meeting the transmission conditions given for the submarine cable case may be used in the same
35 way as just described for the submarine cable link.

From the general disclosure that has been given, it will be apparent to those skilled in the art to make various modifications and alterations
40 without departing from the invention, the scope of which is given in the appended claims.

What is claimed is:

1. In a telephone system, two long four-wire circuits terminated at the same geographical location, a short junction circuit including a two-wire switching portion, for operatively interconnecting said four-wire circuits, voice-controlled switching devices for connecting one end of said
45 junction circuit alternatively to one or the other side of one four-wire circuit, other voice controlled switching devices for alternatively connecting the opposite end of said junction circuit to one or the other side of the opposite four-wire circuit, and means including a source of tone
50 waves associated with said system for coordinating said switching devices to insure that speed received over the incoming side of one four-wire circuit is transmitted through said junction circuit into the outgoing side of the other four-wire
55 circuit.

2. In a telephone system, two long four-wire circuits terminated at the same geographical point, switching means for connecting the incoming end of the first circuit to the outgoing end
60 of the second circuit, switching means for alternatively connecting the outgoing end of the first circuit to the incoming end of the second circuit, tone-operated means controlled by the speech that is to be transmitted over said circuits for
65 operating said switching means to effect the aforementioned connections, said switching means maintaining at all times the two ends of the same four-wire circuit isolated from each other, sources of tone waves associated with the outgoing ends
70 of the two circuits, and means for transmitting the tone waves over the outgoing ends of the two circuits.

of the said four-wire circuits, and means transmitting tone waves from said sources under control of speech applied to the system, said switches being operated by the tone waves so transmitted.

3. In a telephone exchange, a telephone switchboard, a pair of telephone lines terminating on said board, a junction circuit connectible to said lines, switching means in said exchange controlling transmission between said junction circuit and said lines, and means controlled by voice energy on one line for operating said switching means to permit voice received over one line to be transmitted over the other line.

4. In a telephone exchange, a telephone switchboard, a pair of telephone circuits terminating on said board, a junction circuit connectible to said lines, switching means in said exchange controlling transmission between said junction circuit and said lines in a through talking circuit from one line to the other, a source of tone waves having a frequency outside the speech range for controlling operation of said switching means, and means operated by voice applied to a line, for determining the control of said switching means by said tone waves.

5. In a telephone system, a pair of long four-wire circuits to be interconnected to extend a talking circuit, a short junction circuit including a two-wire portion, switching means for connecting one end of said junction circuit to one four-wire circuit and the other end to the other four-wire circuit, said switching means normally making actual connection between said junction circuit and one side of each respective four-wire circuit but only potential connection to the opposite side of each four-wire circuit, a switching device actuated in response to tone waves transmitted in one direction over the system for shifting the connection of one end of said junction circuit to the side of the four-wire circuit to which it is not normally actually connected, and a switching device actuated in response to tone waves transmitted in the opposite direction over the system for shifting the connection of the other end of said junction circuit to the side of the four-wire circuit to which it is not normally actually connected, whereby said four-wire circuits are operatively connected to transmit speech in either direction when speech is traversing the system in that direction.

6. A system as defined in claim 5 in which each of said switching devices is operated in response to a tone wave, of a frequency outside the speech range, applied to its control circuit, and means actuated by voice energy in the system for controlling application of tone wave energy to the control circuits of said respective switching devices.

7. In a telephone system, two four-wire links connected in tandem, a source of tone, outside the voice frequency range, associated with the transmitting end of each link, a junction circuit including a two-wire portion local to an interconnecting point and connecting adjacent terminals of said links for tandem operation, a source of junction circuit tone waves associable with said junction circuit, said junction circuit being normally conditioned against speech transmission from one link to the other, means controlled by speech impressed on the first link for transmitting tone waves from the associated tone source over the transmitting side of said link followed by said speech and tone simultaneously, means at the interconnecting point actuated by said initial tone energy to impress junction circuit

tone upon said junction circuit, means controlled by said latter tone energy to condition said junction circuit for transmitting speech from the first to the second link, and means also responsive to said latter tone for sending out tone from the associated tone source over the second link.

8. In a telephone system comprising four-wire links terminating one adjacent another, local two-wire junction circuits respectively enabling one link to repeat into and receive from the next succeeding link, means controlled by speech impressed on the system for transmitting tone energy on the first link, means including a source of junction circuit tone associable with each junction circuit and a source of tone waves for each side of each link for repeating said impressed tone waves from link to link through the system, said junction circuit tone conditioning said junction circuit for transmission of speech waves from one link to the next in only one direction at a time.

9. The combination with a two-wire telephone cord circuit adapted to interconnect four-wire circuits terminating on the same switchboard, of a source of tone waves, local to said board, said four-wire circuits each having one side normally operatively connected to said cord circuit and the opposite side normally disconnected therefrom, means controlled by waves received over one four-wire circuit for transmitting tone waves from said source over said junction circuit and means controlled by said tone wave energy for shifting the connection of the distant end of said cord circuit from that side of the four-wire circuit to which it is normally connected, to the opposite side of said four-wire circuit.

10. In combination, two four-wire line terminals to be interconnected, a junction line including a two-wire portion having its opposite ends normally connected to one side of each of the respective four-wire lines and disconnected from the opposite side, a source of tone waves associable with said junction line, means operated under control of speech waves applied to either of said four-wire lines for applying said tone waves to said junction circuit and switching means operated by the tone waves sent through the junction circuit for switching its distant end out of its normal connection into its alternate connection with that four-wire line with which that end of the junction circuit is associated.

11. In combination, two four-wire lines to be interconnected, a junction circuit including a two-wire portion for connecting said lines, a source of first tone waves, a source of second tone waves, of different frequencies, associated with said junction circuit, means controlled by speech waves on one four-wire line to send the first tone waves over the junction circuit, means controlled by speech waves on the other four-wire line to send the second tone waves in the opposite direction over the junction circuit, and switching means at each end of the junction circuit controlled by said respective tone waves to connect its distant end to the outgoing side of the respective four-wire line.

12. A combination according to claim 11 in which the sources of tone are normally conditioned to send the first tone waves in both directions through the junction circuit, and means for automatically changing over to the second tone wave for one of the two directions of transmission.

13. In combination with two four-wire circuits to be interconnected, a junction circuit including

a two-wire portion for interconnecting them, sources of first tone waves and second tone waves associated with each end of said junction circuit, voice operated means to send one of said tones in one direction through the junction circuit to condition the connection for voice transmission in that direction, voice operated means to send the other tone in the other direction through the junction circuit to condition the connection for voice transmission in that direction, means dependent upon which four-wire line is the calling line for automatically coordinating the sources of tone waves so that different tones are sent in opposite directions through the junction circuit, and voice operated means operable upon the initial voice transmission through the circuit to effect such coordination between the tone sources in case of failure of the first coordinating means.

14. In a telephone system, a line, an operator's position, a calling signal thereat, means to transmit speech over said line to said position, and means actuated by the initial speech waves on said line for operating said calling signal, means at said position for extending a talking connection from said first line to another line or circuit and means operated from said last-mentioned means for making said signal unresponsive to currents on said line during the time that said talking connection is maintained.

15. In a four-wire toll transmission system, four-wire links connected in tandem, voice-operated switching devices at each point of interconnection for permitting speech to pass between succeeding links in but one direction at a time, said devices normally functioning to permit that speech to pass which first reaches any given interconnecting point regardless of its direction of transmission, means capable of conditioning said devices to permit speech to pass in one direction at any and all times, and to pass in the opposite direction only in the absence of speech in the first direction and means for transmitting a conditioning tone over the system to the various interconnecting points to operate said conditioning means.

16. A system as defined in claim 15 having a control station intermediate the ends of the toll transmission system, and means to send said tone in both directions from said control station over the system, said tone conditioning all of said devices to insure transmission from the control station while permitting transmission toward the control station only in case there is no speech being transmitted through the same point in the direction away from the control station.

17. A system as defined in claim 15 having a control station intermediate the ends of the toll transmission system, the control station being determined as that station from which the conditioning tone is sent, means at the control station for sending such tone, and means controlled over the line from a distant point for operating the tone sending means at the control station.

18. In a four-wire circuit, an echo suppressor having one side for disabling one line of the four-wire circuit under voice control from the opposite line and another side for exerting similar control over the opposite line from the first line, means for disabling one side of said echo suppressor to make it unresponsive to such voice control from one of said lines while leaving said

one of said lines in condition for through transmission, and means to transmit a characteristic tone over one side of said four-wire circuit to operate said disabling means.

19. A combination according to claim 18 including means to restore said echo suppressor to normal bi-lateral functioning, and means to send a characteristic tone over said four-wire circuit to operate said restoring means.

20. A long toll connection comprising four-wire links interconnected by junction circuits each including a two-wire portion, voice-operated means at an originating end of the connection for sending out a tone over the first link simultaneously with speech, means to delay the speech transmission so that the initial part of the tone precedes the initial speech, means at each junction circuit to relay tone waves from each link to the next, switching means at each junction circuit operated by said tone waves to condition the junction circuits and links for speech transmission in the direction of transmission of the tone waves, delay circuit means for delaying the speech behind the tone waves at the input end of each link and means at each junction point controlled by the tone waves for reducing the amount of delay that is effective for the speech in the input end of the link outgoing from that point.

21. In a telephone system, a four-wire terminal, a junction circuit for connecting said terminal to other lines, a voice operated device for sending tone waves out over the outgoing side of said four-wire terminal along with speech received from another line through said junction circuit, delay means for delaying transmission of the initial speech wave behind the initial tone wave, said junction circuit adapted to have tone impressed on it when it is used to connect to a preceding line equipped with a voice-operated device at its input end similar to that associated with the aforesaid outgoing line, and means operated by tone so impressed on said junction circuit for reducing the time delay introduced for the speech in said outgoing line.

22. A four-wire line terminating at an exchange in a jack on a switchboard, a second similar four-wire line similarly terminated on said switchboard, a two-wire cord for interconnecting said jacks, each line being equipped at said exchange with switching means adapted to operatively connect its two sides (incoming and outgoing) to its aforementioned jack, one side at a time, means for transmitting tone waves over each side of each line under control of voice waves, and means operated in response to tone received at said exchange over one line for operating said switching means to cause only the incoming side of that line to be operatively connected to its line jack and only the outgoing side of the opposite four-wire line to be operatively connected to its jack.

23. In a telephone exchange, a telephone switchboard, a cord circuit for interconnecting lines terminated on said board, means in said exchange associated with said lines for controlling transmission over said lines, a source of control current waves in said exchange and means for sending waves from said source through said cord circuit for operating said transmission controlling means.

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