Nov. 3, 1931. H. W. DUDLEY 1,830,226

TRANSOCEANIC CABLE CIRCUIT

Filed Aug. 8, 1930 3 Sheets-Sheet 1

FIG. 1

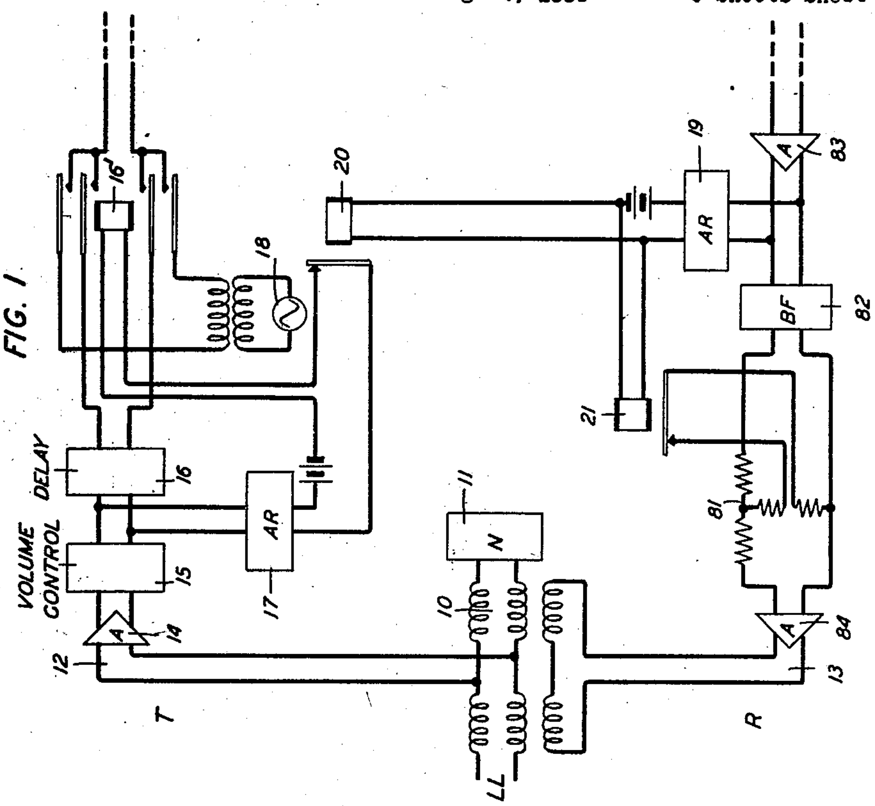
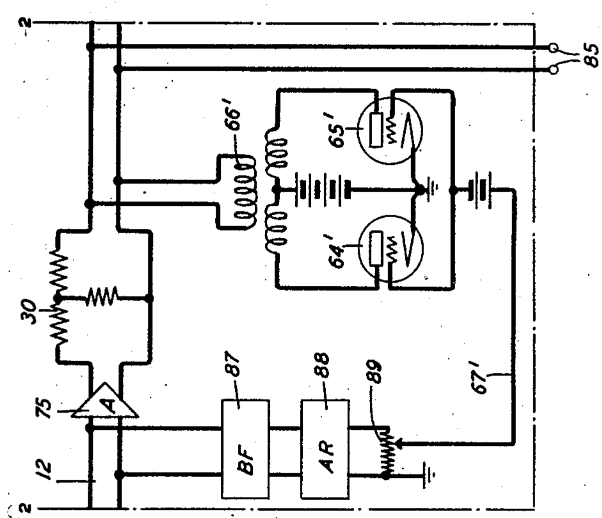


FIG. 3



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TRANSOCEANIC CABLE CIRCUIT

Filed Aug. 8, 1930 3 Sheets-Sheet 2

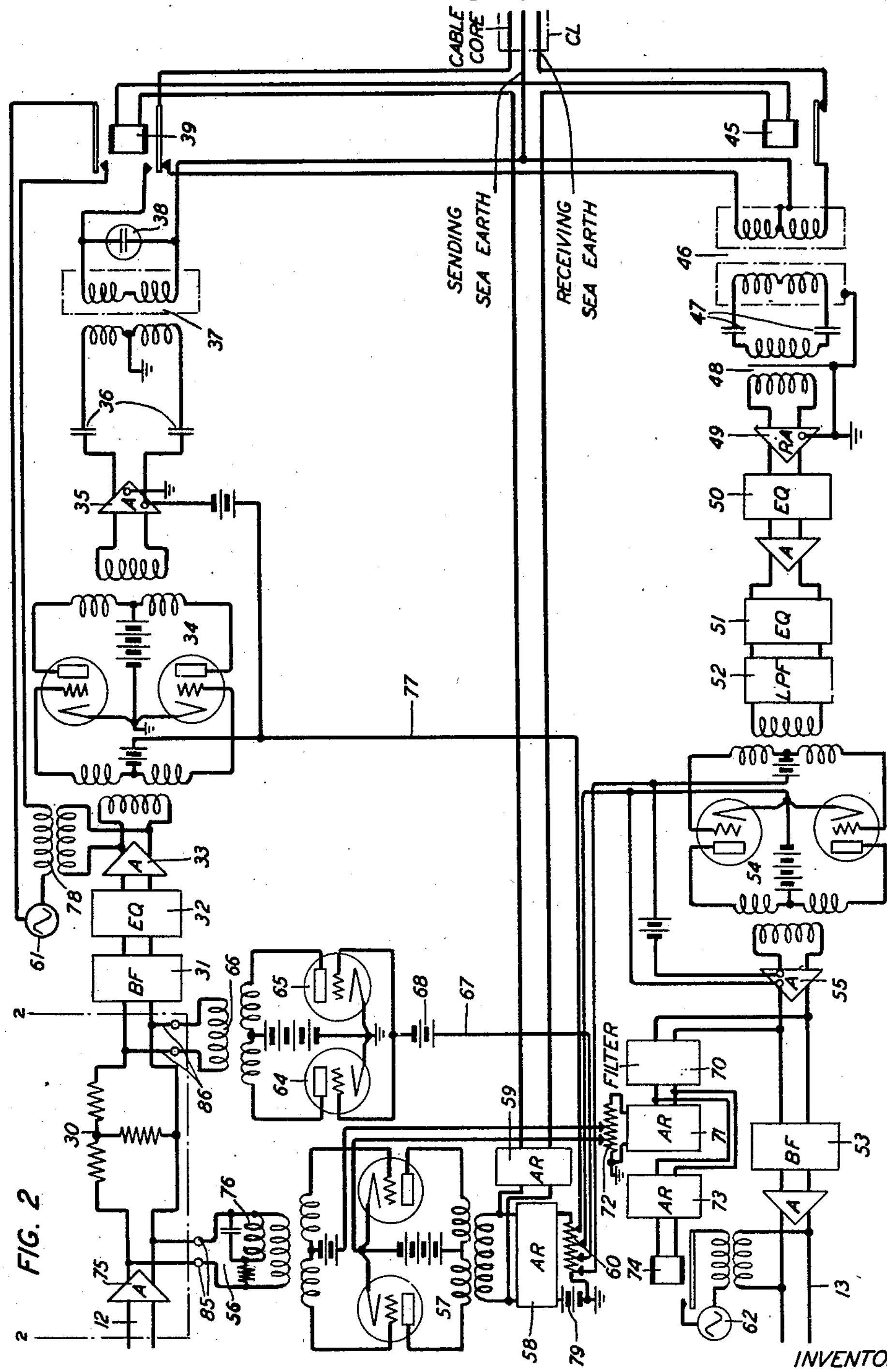

FIG. 2

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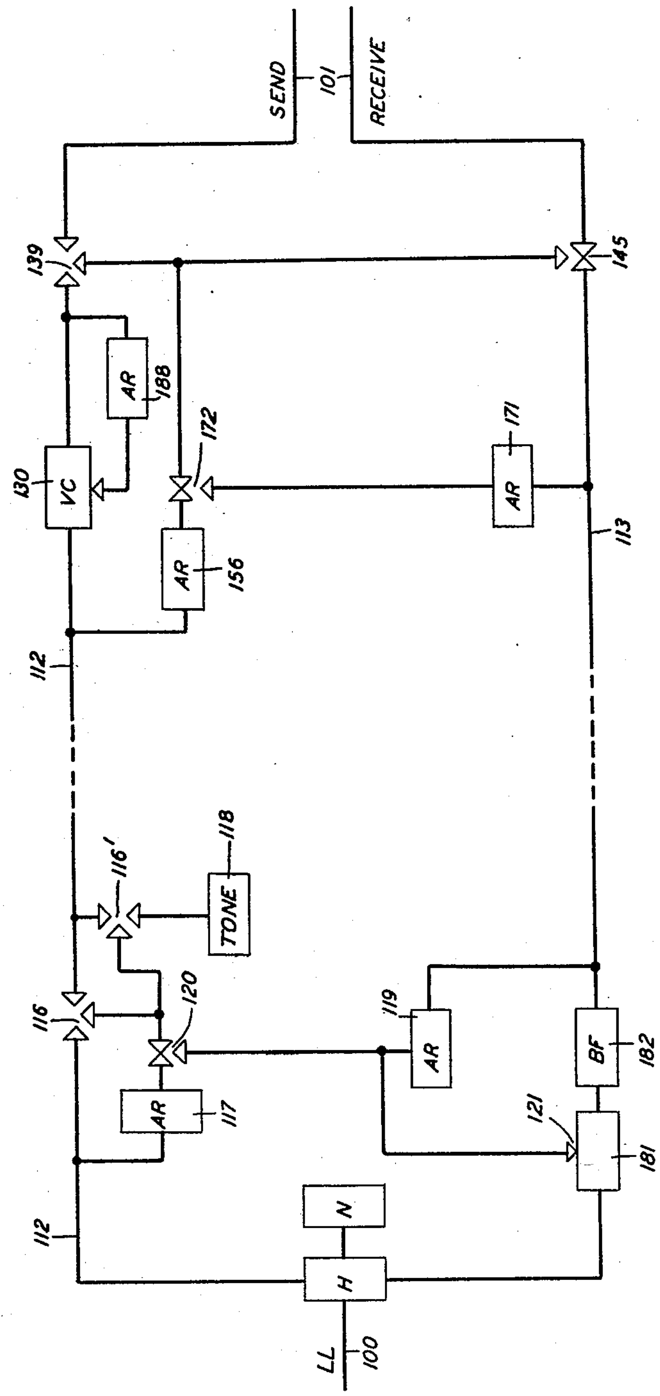

FIG. 4

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UNITED STATES PATENT OFFICE

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TRANSOCEANIC CABLE CIRCUIT

Application filed August 8, 1930. Serial No. 473,853.

This invention relates to transmission control in a telephone or other signaling system, particularly in an electrically long, two-way signaling circuit of high attenuation and large transmission time such as a transoceanic cable.

A system of the general type to which the present invention is particularly applicable is disclosed in an application of G. Crisson and S. B. Wright Serial No. 391,598, filed Sept. 10, 1929. In that system a cable station is connected by land lines to a distantly located terminal station where provision is made for extending the circuit so as to enable commercial telephone connections to be made to the terminal station and thence to the cable from any desired point, either directly from a subscriber's station or over a toll line. The principal supervision of the circuit, including setting up of connections, observation of the service and control of the transmission, is exercised at the land line terminal station, the supervision and attention that is necessary at the cable station being of a secondary order, such as testing and circuit maintenance. Voice-operated switching devices are used at the cable station for enabling the cable to be connected alternatively to a transmitting circuit and to a receiving circuit, one at a time. Since the cable has high attenuation, high power amplifiers are necessary in the transmitting circuit and high-gain low-level amplifiers are necessary in the receiving circuit. The main function of the cable station switching circuits is to effect this alternative connection of the cable to the transmitting or to the receiving circuit as required and to prevent circulation of energy (or singing) in this cable terminal circuit involving as it does extremely high amplification. At the land line terminal station, on the other hand, commercial speech levels are dealt with, so that the apparatus at this station is of less special design, the principal functions here being to adapt the circuit to the different transmission requirements of the various connections and to exercise control over the switching and other apparatus at the distant cable station. There must, of course, be close coordination at all times between the terminal station and the cable station.

One object of the present invention is to improve the coordination between the terminal and cable stations, by giving the terminal station more positive control of the cable station and by improving transmission control at and between said stations.

A feature of the invention comprises the use of a continuous wave to control the various switching operations, in whole or in part, this wave serving also according to a further feature, as a gain control wave.

A further feature comprises a switching circuit which gives the receiving echo suppressor a more favorable sensitivity margin for a given echo suppressor circuit.

A further feature comprises an improved receiver input connection from the cable.

Further objects and features will appear more fully from the following detailed description of preferred embodiments disclosed in the attached drawings.

The present invention will be described in connection with a single-core cable with sending and receiving sea earths, as disclosed and claimed in an application of A. M. Curtis, Serial No. 382,011, filed July 29, 1929. On the assumption of equal lengths and equal propagation constants, and the same values of input current, it can be demonstrated that while 3 db. more power is required for a twin-core than for a single-core cable, the receiving signal voltage is 6 db. greater. The resistance noise is of the same magnitude in a twin-core as in a single-core cable with a receiving sea earth in which the artificial line resistance balances the cable. The resistance noise is 3 db. less if the receiving sea earth is omitted. As regards signal-to-noise ratio, therefore, the twin core cable is 3 db. better than the single-core cable without receiving sea earth and is 6 db. better than a single-core cable with receiving sea earth. This leads to the result that a single-core cable without receiving sea earth should be designed for 3 db. less attenuation than the corresponding twin-core cable, and that a single-core cable with receiving sea earth should be designed for 6 db. less attenuation than the corresponding twin-core cable, on the assumption stated above. The assumption of the same input current in both cases is made in view of the fact that the loading material (or other factors) places an upper limit on the permissible transmitting current level.

The invention will be more fully understood from the following detailed description taken in conjunction with the drawings in which Fig. 1 and Fig. 2 when placed side by side with Fig. 1 at the left show the two ends of a complete terminal system including the cable station (Fig. 2) and the terminating or control station (Fig. 1); Fig. 3 shows an alternative type of gain control circuit to that shown in Fig. 2; and Fig. 4 is a key schematic showing an alternative scheme of transmission control to that of Figs. 1 and 2.

Referring first to Figs. 1 and 2, the land line LL with the usual hybrid coil 10 and balancing network 11 is shown leading into the land line terminal station (or control station) of Fig. 1. This line is provided with a transmitting branch 12 and a receiving branch 13. Transmitting branch 12, which includes apparatus to be described in due course, leads eventually as one side of a four-wire circuit to the distant cable station of Fig. 2. Here it includes transmitting amplifiers and other apparatus to be described later, and terminates in a suitable connecting circuit for the cable itself which is indicated at CL.

Similarly the receiving branch 13 of Fig. 1 is extended as the opposite side of the four-wire circuit leading from the cable station in Fig. 2, where it includes suitable amplifiers and other cable terminal apparatus and connects to the receiving circuit of the cable CL.

As stated above, voice operated switching is employed at both the land line terminal and the cable station, the latter being auxiliary to the former. The provision of directional switching at the land line terminal does not make it possible to eliminate switching at the cable station. The cable station must put in sufficient loss to prevent singing at all times. The land line terminal does not need to put in excessive loss since singing cannot occur due to its failure. The land line terminal must discriminate between speech and noise and keep clipping down to a minimum. The cable station must function in phase with the land line terminal unless blocked by received speech and should be designed to give no additional clipping. Since the land line terminal does not have the function of preventing singing it is preferable that its operation should not block the receiving path. The land line terminal switching is on the transmitting side since this station is to exercise the main control.

The principal apparatus in the transmitting branch of the land line terminal comprises input amplifier 14, volume control circuit 15, delay device 16, switching apparatus (relay) 16′, and amplifier rectifier 17. The purpose of the source of tone waves 18 will be described later.

It is necessary to have at the land line terminal a device to disable the transmitting speech path during receiving to prevent an unbalance or echo current, on receiving, from setting up the transmitting circuit. This disabler is shown as comprising amplifier-rectifier 19 and associated relay 20. A second relay 21 is also operated from the amplifier-rectifier to remove loss from the receiver for a purpose to be described later.

The amplifier-rectifiers 17, 19 may be of any appropriate type for converting speech waves into direct current suitable for controlling relays. The volume control 16 is preferably of the type shown in application Serial No. 375,629 filed July 3, 1929 by J. L. Hogg, although any suitable type either manually or automatically operated may be used. The delay device 16 may be a low pass filter type of sectional network or other electrical type, or acoustical or mechanical, of which all three types are known in the prior art.

The transmitting branch 12 as it appears in the cable station, Fig. 2, leads first through a gain control circuit 30 to be described later, and then through filter 31, equalizer 32, amplifiers 33, 34 and 35, series capacities 36 (which cut down the low frequencies and prevent their being sent into the cable), transformer 37, across which is connected a protection valve 38, such as a gas filled tube with suitable breakdown voltage, and finally the normally open contact of switching relay 39 to the cable itself. The connection of the transmitter leads to the cable is made between the cable core and the sending sea earth, as shown.

The receiving branch 13 of Fig. 2 beginning with the cable (between core and receiving sea earth), includes normally closed contact of switching relays 39 and 45, shielded transformer 46, series capacities 47, step-up transformer 48, receiving amplifier 49, equalizers 50, 51, filters 52, 53 and amplifiers as shown, including in particular the switching amplifiers 54 and 55.

The equalizers 32, 50 and 51 are for the purpose of equalizing for the unequal attenuation by the cable over the transmitted frequency range, and effecting any further speech distortion that may be necessary or desirable in order to obtain as high quality over-all transmission and reception as possible. It is preferable to have the equalizers at opposite ends of the cable effect together a complementary distortion to that of the cable and any other circuits or apparatus connected between equalizer 32 at one station and equalizer 51 at the other cable station so that the speech as it appears at the output side of the latter is as nearly as may be the same as that entering the former.

The cable station of Fig. 2 includes a dual type of directional switching similar in general to that disclosed in an application of C. N. Nebel Serial No. 459,663 filed June 7, 1930. That is, it includes relays 39, 45 and also circuits for removing gain from the amplifiers 34, 35 or 54, 55, as the case may be, and converting these amplifiers into loss elements. For this purpose there is branched off from transmitting circuit 12 a circuit 56 leading to amplifier 57, and amplifier-rectifiers 58 and 59. The circuit of amplifier-rectifier 58 includes a battery 79 and a resistance 60 in its direct current path, and from this resistance suitable connections are made to the transmitting amplifiers 34, 35 and receiving amplifiers 54, 55 to render them effective or ineffective. Amplifier-rectifier 59 is also provided for controlling relays 39 and 45.

While it is possible to actuate the directional switching circuits by speech waves at the several points in the system, it is preferable, according to the present invention, to employ a source of continuous waves which is in turn controlled by speech to effect switch control. For this purpose, tone source 18 of Fig. 1 is arranged to be connected to circuit 12 whenever relay 16′ is operated by the speech waves entering circuit 12 from line LL. Also a source of tone frequency waves 61 is provided at the cable station, to be connected to the transmitting circuit whenever relay 39 is operated. A third source of tone frequency waves is shown at 62 (Fig. 2) for transmission over circuit 13 to control the disabler in the receiving side of Fig. 1.

Assuming that the frequency range of speech current, to be impressed on the cable is from about 275 cycles to 3000 cycles, tone frequencies outside of this range either below or above may be used for transmission over the cable. It will be assumed that tone frequency source 61 generates a current of 200 cycles frequency and that the similar tone source at the opposite end of the cable produces a wave of the same frequency. It might in some cases be preferable to use a samewhat different frequency for the opposite direction of transmission. Also it will be assumed that the tone frequency sources 18 (Fig. 1) and 62 (Fig. 2) produced waves of 3100 cycle frequency.

The tone frequency sent from the land terminal circuit of Fig. 1 over branch 12 to the cable terminal serves not only to actuate the switching circuits at the latter station, but also as a gain control. For this purpose the vacuum tubes 64 and 65 have their anodes coupled to winding 66 which is shunted across branch 12 on the output side of resistance network 30. The grids of tubes 64 and 65 are connected by lead 67 to a point on resistance 60 so that these grids are polarized by the current in the output of the amplifier-rectifier 58. An additional fixed bias in the form of a battery 68 may also be used. A disabler circuit is provided at the cable station in shunt of receiving circuit 13 comprising filter 70 and amplifier-rectifier 71, the output of which contains resistance 72 for controlling the input amplifier 57 in the transmitting switching control circuit. The second amplifier-rectifier 73 controls relay 74 which in turn controls application of the tone waves from source 62 to circuit 13.

The operation of the circuit as a whole will now be described. Waves incoming on the land line LL arrive at the hybrid coil 10 and pass in part into branch 12 where they are amplified at 14 and are transmitted through the volume control 15. A portion of the speech waves in the output of the volume control are applied to the amplifier-rectifier 17 and cause actuation of relay 16′. This relay at its inner contacts closes the normally open transmitting branch 12 and at its outer contacts connects source 18 of tone waves across circuit 12. The delay network 16 has delayed the initial speech sufficiently to enable relay 16′ to operate fully. The tone waves from source 18 and the speech traverse branch 12 simultaneously. Dependent upon the amount of delay provided by network 16, the tone waves may be sent out at the same time as or in advance of the speech.

Arriving at the cable station (Fig. 2) the speech and tone waves pass through an initial amplifier 75 and through resistance pad 30 to the input of the band filter 31.

As stated above, the tone waves in this part of the system are of a higher frequency than the speech. Both waves pass in part into circuit 56, but the tone waves are favored by the presence of a resonant circuit 76 which provides enough tuning to cause the input circuit to amplifier 57 to discriminate to the desired degree in favor of the tone frequency waves. These waves, therefore, are amplified at 57 and produce a steady current through resistance 60 in the output of amplifier-rectifier 58. They also operate through amplifier-rectifier 59 to cause relays 39 and 45 to attract their armatures.

Prior to the arrival of the waves at the station of Fig. 2, amplifiers 34 and 35 had their grids biased so far negative with respect to the filaments that these amplifiers were in a high loss or non-transmitting condition. This large negative bias was supplied over conductor 77 from resistance 60 through which direct current normally flows from battery 79. Upon the arrival of the tone and speech waves as described, however, the current flow in resistance 60 was so modified as to remove or reduce the negative bias applied to the grids of amplifier stages 34 and 35 and to bring the grid bias to the proper operating point.

Band filter 31 is a band pass filter which permits the speech waves of from 275 to 3000 cycles to pass, but suppresses the tone frequency waves of 3100 cycles per second as well as noise and speech waves outside the 275–3000 cycle range. The speech therefore passes on through the filter 31, equalizer 32 and amplifiers 33, 34 and 35 and through series capacities 36 which discriminate against low frequency noise and other undesired low frequency energy, thence through transformer 37 and through the now closed upper contact and lower armature of relay 39 so that the speech currents are applied between the cable core and the sending sea earth.

It will be understood that during the foregoing operations the receiving branch 13 is disconnected from the cable and is rendered incapable of transmission. This effect is produced by the operation of relays 39 and 45 which sever the connection from the cable to the receiving sea earth before relay 39 completes the sending circuit for the cable. The lower armature of relay 39, it will be noted, serves two purposes. In its lower position it connects one side of the receiving circuit to the cable core and in its upper position it connects the transmitter to the cable core. This insures that the cable core is disconnected from the receiver before it is connected to the transmitter. The armature of relay 45 likewise disconnects the other terminal of the receiver as soon as the armature leaves its back contact.

The receiving amplifiers 54 and 55 are rendered nontransmitting by impressing on them, through resistance 60 during the transmitting period, an excessive negative grid bias. It will be noted that the filaments and grids of amplifiers 54 and 55 are connected to resistance 60 in an opposite direction with respect to amplifiers 34 and 35. The drop of voltage in resistance 60 which reduces the negative bias of the transmitting amplifiers therefore serves to increase the bias of the receiving amplifiers 54 and 55.

Returning again to the transmitting branch for a further description of the operations taking place there, the operation of relay 39 closes at its upper armature the circuit of tone source 61 so that some of the tone frequency waves are impressed through transformer 78 upon the input of amplifier 34. This results in sending tone waves of 200 cycle frequencies out over the cable at the same time as the speech.

As the attenuation of the transmitting branch 12 changes from time to time the amplitude of the tone wave as received at the station of Fig. 2 also varies and results in a slight variation in the voltage developed in resistance 60. This in turn results in a variation in the bias applied to the grids of the two tubes 64 and 65 which controls their output impedance, effectively in shunt across the branch 12 by virtue of coupling to the winding 66. By thus varying the shunt impedance the amplitude of the speech waves passing into the filter 31 may be kept substantially independent of changes in line attenuation.

When the speech waves on the line LL cease relay 16′ releases its armatures and removes tone source 18 from across circuit 12. This results in cessation of current in the circuit 56 (Fig. 2) and in the amplifier-rectifier 59. Also the current in resistance 60 assumes its normal value. As a result amplifiers 34 and 35 are changed to their non-transmitting condition while amplifiers 54 and 55 are made operative by change of their respective grid bias voltages. Also relays 39 and 45 release their armatures. Relay 39 at its upper contact removes tone source 61 from the circuit and as its lower armature leaves its front contact the transmitter is disconnected from the cable. Relays 39 and 45 then connect the cable by their lower armatures to the receiving circuit.

Speech and tone waves received over the cable from the distant terminal pass directly into the normally operative receiving branch and through transformer 46, series capacities 47, input transformer 48 and the various amplifiers and equalizers that have already been referred to. The filter 70 does not transmit speech, but readily transmits the tone waves to the amplifier-rectifiers 71 and 73. Amplifier-rectifier 71 causes current to flow through resistance 72 in response to the tone waves and this current develops a voltage which is applied as a large negative bias to the grids of amplifier 57 so that this amplifier is prevented from transmitting any waves which may be present in circuit 12. The second amplifier-rectifier 73 causes the operation of relay 74 which applies tone waves from generator 62 to circuit 13. Band filter 53 transmits the speech, but does not transmit the tone frequency waves.

Both of the speech and tone frequency waves traverse circuit 13 to the terminal station, (Fig. 1). The tone waves pass into amplifier-rectifier 19 (which may be and preferably is made selective to these waves) and causes the operation of relays 20 and 21. Relay 20 opens the normally closed contact in the circuit of relay 16′ and prevents operation of that relay by any voltage present in circuit 12. Relay 21 by opening its normally closed contact removes the shunt loss from the impedance network 81, the purpose of which will be described later.

The speech waves pass through band filter 82 (which excludes the tone frequency waves) and through the network 81, now in the low loss condition and are impressed upon line

LL (suitable amplifiers are indicated at 83 and 84).

The purpose of the impedance network 81 is to provide, in effect, a margin of sensitivity for the receiving disabler circuit. It will be noted that volume control 15 is provided in the input of circuit 12 and ahead of the amplifier-rectifier 17. This is desirable for several reasons, one of which is that it is desired to have amplifier-rectifier 17 operate at constant volume. As different subscribers talk over the circuits and different length connections are used, it is apparent that the speech volume received over the line LL will vary considerably. The volume control 15, in effect, equalizes these variations which means that at times amplifier-rectifier 17 will respond to currents on line LL that are very much weaker than at other times. In effect therefore, the sensitivity of the amplifier-rectifier 17 is increased with respect to the received speech on line LL as the volume is raised at 15.

It is necessary that amplifier-rectifier 19 be made sufficiently sensitive to insure its operation by the weakest received speech in circuit 13 that would be capable of operating amplifier-rectifier 17 upon finding its way across from circuit 13 into circuit 12 due to unbalance of the hybrid coil, or any other reason. Since it is desired to make amplifier-rectifier 17 of high sensitivity to avoid excessive delay and to prevent clipping, this places very high requirements on the disabler circuit 19 unless means are provided to give a sensitivity margin to the latter.

This sensitivity margin is provided by network 81 and relay 21. Whenever amplifier-rectifier 19 is in its normal or unoperated condition, network 81 is in its maximum loss condition since its shunt is closed. Therefore any received waves which fail to cause operation of the echo suppressor will be highly attenuated (for example, 10 db.) at 81 before reaching the hybrid coil 10. As regards their effect on amplifier-rectifier 17 therefore, it is seen that a sensitivity margin exists in favor of echo suppressor 19.

The network 81 does not introduce additional loss to the speech since it is cut out of circuit by relay 21 whenever speech is being received. The order of operation of the relays is preferably such that relay 20 opens its back contact before, or at least as soon as relay 21 operates. The increased sensitivity obtained by use of network 81 and relay 21 permits the use of smaller transmitting time delay in delay network 16 and smaller hang-over time for preventing initial and final clipping.

There are several advantages in using a tone frequency wave between the land line terminal and the cable sta ion. The tone frequency enables faster operation of the apparatus controlled by it at the cable station and permits doing away with delay networks and hang-over times in the transmitting circuit at the cable station. It is also possible to secure a better margin over noise by using a tone frequency wave than if speech waves were employed directly to control the transmitting amplifier-detector. This is possible without unduly increasing the power transmitted over the connecting line. For example, the control frequency may represent only 10% of the speech power transmitted. The control frequency also gives the effect of a higher sensitivity for the transmitting amplifier-detector at the cable station without actually having a sensitivity as high, thus making for both quicker operation and less liability to false operation by noise. One reason for the effect of greater sensitivity is that the control wave is sent out at a constant amplitude and the make and break at the beginning and end of the wave trains represents a sudden transition, whereas in the case of speech, the initial sounds often-times represent slowly growing energy and the final sounds trail off into gradually decreasing energy. These effects are not favorable to positive actuation of the switching circuits.

In addition to the foregoing advantages of the tone frequency, there is the further advanatge of convenient regulation for variations in the transmission equivalent of the inter-connecting circuit as has already been described.

An alternative circuit for regulating the transmission is shown diagrammatically in Fig. 3. The circuits included within the broken outline of Fig. 3 are intended to replace those in the outline labeled 2—2 of Fig. 2, the terminals labeled 85 in Fig. 3 corresponding to terminals 85 of Fig. 2. When using the alternative circuit of Fig. 3 the conductors 86 of Fig. 2 are broken at the junction indicated by the small circles in Fig. 2 and vacuum tubes 64 and 65 are therefore rendered without effect.

Referring in detail to the circuit of Fig. 3 the amplifier 75 and resistance pad 30 correspond to those of Fig. 2. The tone frequency coming from the land line terminal over circuit 12 is selected by band filter 87 which partly or wholly excludes speech and is rectified in the amplifier-rectifier 88 to produce current flow through resistance 89. Vacuum tubes 64′ and 65′ and transformer 66′ perform similar functions to elements 64, 65 and 66 of Fig. 2. That is, these tubes acting through winding 66 supply a shunt impedance across circuit 12 which is varied under control of conductor 67′ leading to resistance 89. As the amplitude of the received control wave varies, the shunt impedance produced by tubes 64′ and 65′ varies at the same time and in the proper direction and amount to maintain constant level in the circuit 12 to the right of network 30 in Fig. 3. One advantage of this arrangement over that of Fig. 2 is that constant level is maintained for the control circuit 85 leading to the transmitting amplifier-detector.

Some further detailed description will now be given of the receiving circuit at the cable station. It will be noted that the receiving transformer 46 has its primary permanently connected to the main circuit ground which is the sending sea earth. This effectively prevents high voltages from being developed along the receiving circuit which might result in a click. The secondary winding shield is grounded at the receiving amplifier ground.

The series capacities 47 together with the inductances in the circuit provide the effect of a high pass filter which greatly attenuates the very low frequencies (under about 100 cycles per second) without the employment of additional resistances which might increase the resistance noise. This network is capable of producing a loss at 50 cycles of about 50 db. This high loss at the very low frequencies is important both from the standpoint of increasing the decay of relaxation current as well as discriminating against low frequency interference from neighboring cables or other sources. The series capacity represented by condensers 47 may be of the order of 1 to 2 mf. and the step-up ratio of input coil 48 may be 35 or greater.

Passing along to the receiving amplifier-detector this should have a hang-over time sufficient to insure that the last of the speech and tone wave energy has had time to reach the land line terminal and release relay 20 thereat and to allow for the dissipation of any energy in the interconnecting line (13) between the two stations of Fig. 1 and Fig. 2 after relay 20 has been released. In other words, the hang-over time should be about twice the time of transmission between the stations of Fig. 1 and Fig. 2.

Instead of using separate tone frequency sources for the cable and the interconnecting line circuits, a single source of tone frequency may be used for each direction of transmission through the entire system. The manner in which this is accomplished is illustrated in Fig. 4.

This figure is a single line schematic in which the circuit details may be the same as those of the previously described figures. The arrows represent switching points. When two of the points are shown in contact in the figure this means that the circuit is normally established at that point. The single arrowhead indicates that some sort of control is effected at that point. When the arrows are separated, this means that the circuit is normally open. The opening and closing control is indicated by a third arrow directed toward the pointed contacts of the two arrows. The actual form which the switching contacts may take is illustrated and described in connection with the previous figures and may comprise a relay or circuits for disabling an amplifier or the like. The land line 100 is indicated at the left of the figure and the cable circuits for sending and receiving are respectively indicated by 101 at the right.

Speech waves incoming over land line 100 arrive at the hybrid coil H and balancing coil N and are transmitted over circuit 112 and through the medium of amplifier-rectifier 117 to effect the closing of the speech path and of the tone source 118 at 116′. All of this apparatus is, of course, at the land line terminal. At the cable terminal the control current passes into the amplifier-rectifier 156 and causes the closing of the speech circuit at 139 and the opening of the receiving circuit from the cable at 145. Both the speech and the tone frequency waves are therefore transmitted into the cable over the sending lead at 101. The tone frequency also operates through the amplifier-rectifier 188 to control the regulator circuit 130 to maintain the level going into the cable constant as regards variation in the attenuation of circuit 112.

The effect of the waves at the distant terminal may be seen from considering the effect of the received waves in the station of Fig. 4. The received speech and tone frequency waves arrive over the cable 101 and pass through the normally closed contact 145 into the receiving circuit 113. The tone frequency waves actuate amplifier-rectifier 171 which disables the circuit of transmitting amplifier-rectifier 156 at point 172. The speech and control waves continue over circuit 113 to the distant land line terminal where the tone frequency operates amplifier-rectifier 119 which disables the transmitting amplifier-rectifier at 120 and controls the loss network 181 at point 121. Band filter 182 corresponds to filter 82 of Fig. 1.

The control frequency may be the same or different in the opposite directions of transmission. Assuming the speech range to be from 275 cycles upward to some suitable upper limit, a control frequency of 200 cycles may be used for both directions. The control frequency may be used over only a part of the circuit, for instance between the land terminal and the cable terminal.

In a transatlantic telephone cable, the equipment at the left of the broken lines in Fig. 4 (or that in Fig. 1) may be located at New York with similar equipment at London while the equipment at the right of the broken lines (or that in Fig. 2) would be located at Newfoundland with similar equipment at Ireland. That is, interconnecting lines 12, 13, or 112 and 113 extend on the one side, from New York to Newfoundland, and on the other side, from London to Ireland, the cable extending from Newfoundland to Ireland.

What is claimed is:

1. In a signaling system including a line, a transmitting station for said line, a distantly located control station, a transmitting amplifier at said transmitting station normally disassociated from said line, a source of continuous waves at said control station, means controlled by signals to be transmitted from said control station for causing continuous waves from said source to be transmitted to said transmitting station along with said signal, and means at said transmitting station responsive to the received continuous waves for operatively associating said transmitting amplifier with said line to repeat said signals into said line.

2. In a signaling system including a line, a transmitting station for said line, a distantly located control station, a transmitting amplifier at said transmitting station normally disassociated from said line, a source of continuous waves at said control station, means operated by signals to be transmitted from said control station for sending waves from said source to said transmitting station simultaneously with said signals, and means at the latter station operated by said continuous waves for operatively associating said transmitting amplifier with said line for enabling the signals to be sent into said line.

3. In a signaling system a line, a transmitting station for said line, a distantly located control station, a circuit interconnecting said stations, a transmitting amplifier at said transmitting station, an amplifier and a source of continuous waves at said control station, both of said amplifiers and said source of continuous waves being normally inoperative to transmit, means controlled by signals to be transmitted for effectively connecting both the amplifier at the control station and said source of waves to said circuit, and means at the transmitting station controlled by waves from said source for effectively connecting the amplifier thereat to said line.

4. An input system for an ocean cable comprising a cable station and a control station at a distance therefrom, a line interconnecting said station and subject to variable transmission equivalent, a transmitting amplifier for the cable located at the cable station, means at the control station for sending continuous waves of constant volume into said line under control of signals to be transmitted, and means at the cable station operated by said waves for effectively connecting said amplifier to the cable and compensating for variations in the transmission equivalent of said line.

5. In a four-wire telephone circuit comprising a transmitting circuit and a receiving circuit, a voice-operated circuit associated with the transmitting circuit, an echo suppressor associated with the receiving circuit and controlling said voice-operated circuit, a loss element normally in said receiving circuit following said echo-suppressor, and means controlled by speech energy in the receiving circuit for removing said loss element from the circuit.

6. In a telephone circuit having an echo-suppressor therein, means for effectively increasing the margin of sensitivity of said echo-suppressor with respect to other apparatus associated with the system, comprising a loss element normally connected in the circuit following the echo-suppressor, and means controlled by received speech for removing said loss element.

7. The combination with a signal-operated transmission control circuit, a transmitter made operative or inoperative by said circuit, and a gain adjustment circuit also operated from said transmission control circuit, and controlling the gain of said transmitter.

8. In a signaling system including a line, a transmitting station for said line, a distantly located control station, a transmitting amplifier at said transmitting station normally disassociated from said line, a source of continuous waves at said control station, means controlled by signals to be transmitted from said control station for sending to said transmitting station, and in advance of said signals, continuous waves from said source, and means at said transmitting station responsive to the received continuous waves, for operatively associating said transmitting amplifier with said line to repeat said signals into said line.

9. In a long distance telephone system, a transmitting station, an amplifier thereat adapted for connection to and disconnection from the transmission path outgoing from said station, a distant control station, having means for sending to said transmitting station speech and energy other than speech coincidentally with and for the duration of said speech, and means at the transmitting station actuated and released under control of said energy for controlling connection of said amplifier to and disconnection of it from said path.

10. A system as defined in claim 9, in which means are also provided at said transmitting station for adjusting the level of the outgoing speech under control of said energy received from the distant control station.

11. In a four-wire telephone system, comprising oppositely directed one-way transmission paths, a voice-operated circuit controlling one path, a disabler circuit therefor controlled by speech energy incident upon the other path, and means for providing a margin of sensitivity for said disabler comprising a loss element normally inserted in said other path following said disabler, and

means for removing said loss element under control of speech energy incident upon said path.

12. In a two-way signaling circuit, a cable having conductor terminals, a transmitting branch and a receiving branch, one conductor of each of said branches being normally connected to one of said cable conductor terminals, and means actuated under control of signals traversing the system for alternately connecting the remaining conductor of each of said branches to another one of said cable conductor terminals.

13. In a two-way cable system, a cable having a core, a sending conductor and a receiving conductor, a transmitting branch and a receiving branch, one conductor of the transmitting branch being permanently connected to said sending conductor, one conductor of said receiving branch being normally connected to said receiving conductor, a relay having an armature movable between alternate contacts, said armature being connected to the cable core, and said alternate contacts being connected respectively to the remaining conductors of said transmitting and receiving branches.

14. In an ocean cable system for telephony, a receiving amplifier having a high ratio step-up input transformer, a cable receiving circuit comprising a shielded transformer, and a low-resistance circuit of large series capacity connecting said transformers.

15. In a telephone system having a land line terminal station, a distantly located cable terminal, an ocean cable leading to a remote cable terminal station, and a land line terminal station distantly located beyond said remote cable terminal station, voice-operated switching mechanism at a plurality of said stations for enabling the cable to be used alternatively for the opposite sides of a two-way telephone conversation, and means comprising a source of tone waves transmitted through the system for controlling actuation of said switching mechanism at each of said plurality of stations.

16. A two-way telephone system comprising a terminal station having a transmitting and a receiving branch, said transmitting branch being normally disabled, said receiving branch being on its input side normally in condition to receive waves representing speech but having means normally reducing its transmission efficiency on its output side, and means acting under control of received waves representing speech for increasing the transmission efficiency of said receiving branch on its output side.

17. A system according to claim 16 in which said first means comprises a finite impedance in the output circuit of the receiving branch and said second means comprises a circuit operated by speech representing waves for effectively removing said impedance from the circuit.

In witness whereof, I hereunto subscribe my name, this 6th day of August, 1930.

HOMER W. DUDLEY.