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DEEP SEA CABLE TERMINAL

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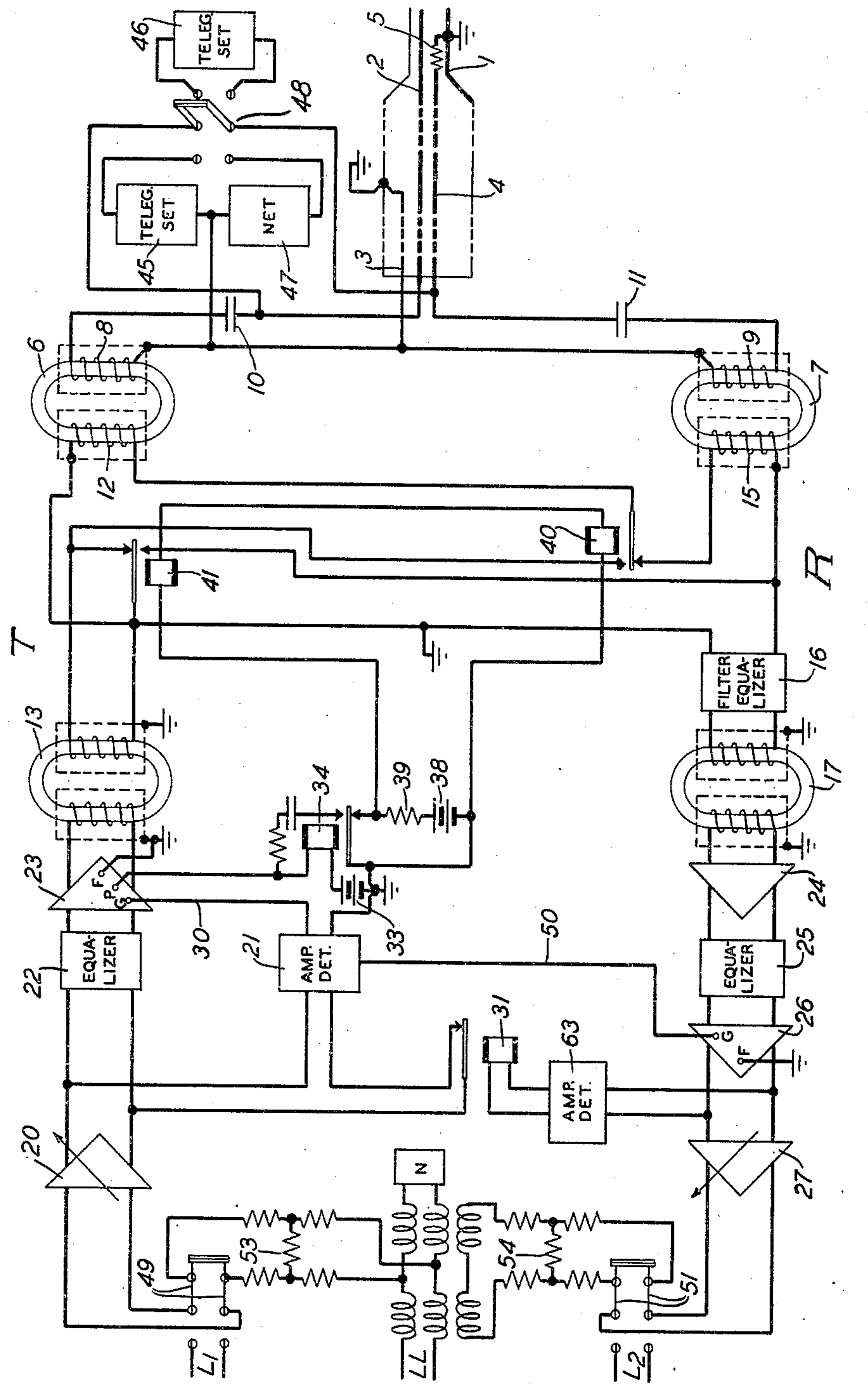

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DEEP SEA CABLE TERMINAL

Application filed June 1, 1931. Serial No. 541,143.

The present invention relates to a terminating circuit for a two-way signaling system using a ground return such, for example, as in the case of a transoceanic telephone cable.

Two-way transmission over a cable is obtained by switching the cable into and out of connection with a transmitting branch and a receiving branch alternatively to enable the system either to transmit or to receive. The switch mechanisms for accomplishing this are controlled by the speech waves or other current traversing the system. In the usual case of a long cable having high attenuation the transmitting energy is enormous in comparison with the received energy. This fact makes it important to insure that no connection is ever made between the transmitting branch and the receiving branch such as would result in impressing on the receiving branch a large amount of energy, which might destroy the relatively sensitive receiving apparatus or produce other troublesome or disturbing effects in the receiving circuit. In providing the necessary switching mechanism, it is important that no switch contacts be used in the cable or ground conductors themselves since otherwise clicks of large magnitude may be produced in the receiving circuit due to the very considerable differences of potential that exist between different portions of the circuit. It is also important to insulate the cable proper from the station equipment so as to provide against accidental application of the high voltages used in transmitting directly to the cable.

The present invention meets these various requirements and also provides an efficient and properly proportioned terminal circuit for accomplishing two-way speech transmission between land line circuits and a transoceanic telephone cable. The invention has several important advantages and features which will appear more fully from the detailed specification and description to follow.

In the drawing, the single figure shows a schematic circuit diagram of a terminating circuit for a transoceanic cable.

Application for Letters Patent, Serial No. 459,663 filed June 7, 1930 by C. N. Nebel, discloses a two-way terminal circuit for a transoceanic cable of the so-called twin-core type in which the cable is connected to the terminal circuit through a single two-winding transformer. In the present application the type of transoceanic cable that is disclosed is of the single core type comprising a core, a sending sea earth and a separate receiving sea earth, and the invention has particular reference to a terminating circuit for this type of cable. Except for this main difference the general transmitting and receiving circuit elements and the type of voice operated switching control may be similar to those disclosed in the application referred to, the detail differences being indicated hereinafter. Since these particular features form no part of the present invention, they will not be described specifically but the nature of their function and operation will be clear from the above-noted application to which reference may be made. The drawing has been simplified to omit the details of these various elements, but the elements are generally indicated in the drawing by similar reference characters to those employed in that application.

Referring now to Fig. 1 of the drawing, the land line LL at the left is arranged for two-way repeating with the deep sea cable CL shown at the right in the figure, through the medium of a four-wire circuit comprising a transmitting branch T and a receiving branch R. By throwing the switches 49 and 51 to their alternate positions, a four-wire land line L_1, L_2 may be substituted for the line LL, L_1 being for transmitting and L_2 for receiving. Resistance pads 53 and 54 prevent singing due to unbalance when the two-way line LL is used.

The cable itself comprises the usual sheath 1, the cable core, indicated at 2, and two other conductors 3 and 4, leading respectively to a sending sea earth which may be a fraction of a mile from shore to a receiving sea earth which may be several miles out for the purpose of reducing interference such as static noise. The earth connections for the conductors 3 and 4 are made by attaching these conductors electrically to the cable sheath. The receiving sea earth conductor 4 includes an impedance 5 equal to the characteristic impedance of the cable itself.

Two transformers 6 and 7, which are so far as possible identically alike, are provided for connecting the cable respectively to the transmitting and receiving branches of the four-wire circuit. The transformer 6 has one winding 8 connected on one side to a terminal of the large capacity 10, the opposite terminal of which is directly connected to the cable core 2. The other terminal of winding 8 is connected to earth conductor 3 and to winding 9 of transformer 7. The other end of winding 9 is connected to receiving sea earth 4 in series with the large capacity 11. The other winding 12 of transformer 6 is connected through switching points to the secondary winding of the output transformer 13 in the transmitting branch T. The other winding 15 of transformer 7 is connected through switching points and through equalizer 16 to the primary winding of the receiving or input transformer 17 in the receiving branch R.

The transmitting branch T also contains, in addition to the elements already named, a variable amplifier serving as a volume control 20, an equalizer 22 and a power amplifier 23 which may contain any desired number of stages. Branched off from the transmitting circuit T between the volume control 20 and equalizer 22 is a circuit leading to the amplifier detector 21 for controlling the switching operation, this amplifier detector being identical with that disclosed in the prior application of Nebel referred to.

The receiving branch R contains, in addition to the elements already mentioned and beginning at the secondary of transformer 17, a receiving amplifier 24, equalizer 25, and further amplifiers 26 and 27, the latter of which is shown to be variable for volume control purposes. Between amplifiers 26 and 27 a circuit is branched off from the receiving circuit R leading to amplifier detector 63 which may be identical with the corresponding amplifier detector of the Nebel application referred to. For simplicity of showing, this amplifier detector 63 instead of acting precisely as disclosed in that application, controls actuation of a relay 31 which when its armature is attracted opens the input circuit of the amplifier detector 21 to protect the latter against false operation during receiving periods.

As described more fully in the Nebel application referred to, the transmitting circuit T is normally in a disabled condition and the receiving circuit R is normally in condition to receive signals from the cable. The speech waves received from the cable are transferred by transformer 7 through the normally closed back contact of relay 40, and through winding 12 of transformer 6 and equalizer 16 to the primary of the step-up transformer 17, the secondary of which is connected directly to the receiving amplifier 24. Further equalization takes place in equalizer 25 and the waves are further amplified by amplifiers 26 and 27 and impressed upon the land line LL. The speech waves in the output of amplifier 26 act through amplifier detector 63 to operate relay 31 thus disabling amplifier 21 during the time when speech is being received. Equalizers 16 and 25 may be designed in accordance with the disclosure of the U. S. patent of Mathes and Horton, No. 1,844,-422, issued February 9, 1932. In general, they have a loss characteristic which is very much greater for the lower speech frequencies than for the high in order to compensate for distortion in the cable and to provide for any so-called reshaping of the waves that may be necessary.

During the transmitting period and in the absence of speech waves in the receiving circuit R, the waves which are received over the line LL, pass into the volume control 20 and from there into equalizer 22 and amplifier 23. At this time, however, amplifier 23 is inoperative to transmit as disclosed in Nebel's application referred to, due to the fact that an abnormally large negative grid bias is applied over wire 30 from the output of amplifier detector 21. The transmitting circuit T is also disabled at a further point by the armature of relay 40 which normally holds open the series circuit between transformers 13 and 6 and by relay 41 which normally holds closed at its back contact a shunt across this path. The speech waves being transmitted pass in part into amplifier detector 21 and set up such a voltage therein, as described in Nebel's application, that the grid potential of amplifier 23 is shifted to its proper value for transmitting purposes, this voltage being applied between conductor 30 and the ground potential leading to the filament of the amplifiers.

As a result of this shift in the grid potential of amplifier 23 space current flows through the amplifier tube and through the winding of relay 34 from the plate battery 33. Relay 34 attracts its armature thus removing the normal shunt which has up to this time existed across the terminals of battery 38 and resistance 39. Relays 40 and 41, therefore, attract their armatures. Relay 40 in attracting its armature opens at the back contact of the armature the receiving circuit, upper conductor leading from the secondary 15 of the transformer 7. When the armature completes its stroke it closes at its front contact the transmitting circuit, upper conductor, from transformer 13 to winding 12 of transformer 7. Relay 41 in attracting its armature first opens the normal shunt across the transmitting circuit between transformers 6 and 13, and at the completion of the armature stroke, closes a shunt across the receiving branch at the input of equalizer 16.

At the same time that amplifier detector 21 placed a potential on the grid of the amplifier stage 23 through conductor 30, it also applied over conductor 50 a large negative grid bias potential to the grid terminal of amplifier 26 in the manner disclosed more fully in Nebel's application referred to, so that during the transmitting period amplifier 26 is rendered incapable of transmitting by virtue of the excessive negative bias potential on the grid. As in the case of that application referred to, this amplifier 26 may comprise a number of stages.

At the cessation of speech currents coming over the land line LL, amplifier detector 21 is without current and the circuits restore to their normal condition after sufficient hangover time to insure that the last portions of the speech are transmitted. The potential applied over conductor 30 from amplifier detector 21 to grid of amplifier 23 shifts to high negative value reducing the space current to zero. Relay 34 then, after sufficient hangover, releases and causes relays 40 and 41 to be deenergized. Relay 41 in releasing its armature opens the shunt across the receiving branch and at its back contact closes the normal short circuit across the transmitting path. Relay 40 in releasing its armature first opens the transmitting path between transformers 6 and 13 and at its back contact establishes a normal connection for the receiving circuit including the secondary winding 15 of transformer 7, winding 12 of transformer 6 and the input leads to the equalizer 16.

At the time the speech waves ceased in the amplifier detector 21 the high negative potential that had been applied over conductor 50 to the grids of the amplifier tube 26 was removed from conductor 50 so that amplifier 26 was restored to receiving condition.

It will be noted that in the circuit of Fig. 1 no switching contacts are inserted in the cable conductors themselves either in the core or in the sending and receiving ground conductors. As stated above, there may be a considerable difference of potential between these three conductors and if switching contacts are inserted directly in these conductors, clicks of large magnitude may be produced. These are avoided, however, by placing the switching contacts at the positions shown on the drawing separated from the cable conductors by the coupling transformers 6 and 7.

The use of these coupling transformers 6 and 7 also makes it possible to insulate the cable proper from the station equipment so as to provide maximum protection from accidental application of the station batteries directly to the cable. These transformers are suitably shielded for purposes of protection and also for the purpose of draining off any unbalance currents which may exist. It will also be noted that the receiving circuit has one side always connected to ground, the switching point being connected so as not to open or close this circuit connection. The equalizer 16 may be of the balanced or unbalanced type.

Condensers have been shown in series with the main core and the receiving earth to minimize the effect of earth currents and these condensers will also serve to reduce the interference from telegraph in case the cable is composited.

It will be observed that both transformers 6 and 7 are used in receiving while only transformer 6 is used in sending. In the receiving condition the signal coming in over the cable flows from the cable core through winding 8 to ground over the local ground conductor 3. So long as the impedance of this ground connection is sufficiently low, there will be no appreciable signal through winding 9 to earth, since the impedance of the receiving sea earth connection is relatively very high. Static and other interference picked up by the cable by induction or otherwise will be for the most part alike in the cable core 2 and receiving sea earth conductor 4. If the circuit is symmetrical, equal currents due to interference will flow between each of conductors 4 and 2 and conductor 3 (ground) through windings 8 and 9 respectively, and these currents will be neutralized in the receiving circuit including windings 12 and 15 in series, as stated. It is desirable from the standpoint of symmetry that the shields shown around windings 8 and 9 be disposed symmetrically and that the potentials of both be suitably fixed. During the interval of armature travel, a transmission path exists from the transmitting to receiving branches through the capacities of the relays 40 and 41 and the coils 6 and 7, and unless the loss in this path is kept high the circuit may momentarily be in the singing condition. To avoid this the shields of windings 12 and 15 may be connected as shown. It will be observed that the shield of winding 15 is not connected to a point at ground potential.

The circuit may be composited for telegraph by adding any suitable telegraph apparatus 45 for transmitting and suitable apparatus 46 for receiving. In order to maintain the symmetry of the circuit as regards neutralizing received interference in the telephone receiving circuit, a network 47 simulating apparatus 45 is connected as shown. That is, apparatus 45 is connected between the cable core 2 and ground conductor 3 (when switch 48 is closed to the left) and the equivalent network 47 is connected between the ground conductor 3 and receiving sea earth conductor 4. When switch 48 is thrown to the right to receive telegraph, the apparatus 46 is connected between the cable core 2 and receiving conductor 4. The receiving telegraph apparatus 46 is thus protected from interference currents in conductors 2 and 4 since these are applied to apparatus 46 in such phase as to neutralize one another.

By connecting the transmitting telegraph in the position shown at 45, only one-half as much energy is required as though apparatus 46 were used to send, assuming the same strength of received signal at the distant end.

Since transformers 6 and 7 are made alike, so as to balance out in the telephone receiving circuit the interference currents, as described, they should be so constructed as to give very low modulation. This may be accomplished by using magnetically stable cores of constant permeability under conditions of use.

What is claimed is:

1. A terminating circuit for a cable having a core, a sending earth and a receiving earth connection, comprising a transformer connected between the core and the sending earth, and a second transformer connected between the receiving earth connection and the sending earth.

2. A terminating circuit for a cable having a core, a sending earth and a receiving earth connection, comprising a two-way telephone system, and connections between said system and said cable maintaining said core and receiving earth connection electrically symmetrical with respect to said sending earth.

3. A terminating circuit for a cable having a core, a sending ground and a receiving ground, comprising two electrically similar transformers, one having one winding connected between the core and the sending ground and the other having one winding connected between the receiving ground and the sending ground, each transformer having a second winding, and switching means for including only one of said second windings in circuit to transmit into the cable but for including both of said second windings in circuit in series with each other for receiving the cable.

4. A four-wire terminating circuit for a transmission line comprising two electrically similar transformers each having a winding adapted for connection to said line, means actuated by signals traversing the system for connecting a transmitting branch of said four-wire circuit to the other winding of one of said transformers to transmit into said line, and means controlled by signals traversing the system but conditioned when the system is not transmitting to connect the receiving branch of said four-wire circuit to the said other winding of said one transformer and the corresponding winding of the other transformer in series with each other for receiving from said line.

5. In a four-wire telephone circuit comprising two one-way paths, a transmitting connection adapted to be associated with one path and a receiving connection adapted to be associated with the other path, voice-operated switching mechanism comprising a pair of relays having armatures, one relay in its normal condition having an armature included in a normal shunt closed across one path said armature holding open a shunt across the other path, and the other relay in its normal condition having an armature holding the transmitting connection for the first path open and its said armature included in the receiving connection of the other path whereby said last path is held closed, said relays, upon energization in response to transmitted speech, opening their normal and closing their alternate connections.

6. A circuit according to claim 2 in which said connections include telegraph terminal appartus and a balancing circuit therefor.

7. A terminating circuit for a cable having a core, a sending earth and a receiving earth connection, comprising a speed transformer connected between the core and the sending earth, a second speech transformer connected between the receiving earth connection and the sending earth, a telegraph set and a balancing network therefor, said telegraph set being connected in shunt to one of said two transformers and said balancing network being connected in shunt to the other of said transformers whereby a terminal circuit is provided which is symmetrical for both telephone and telegraph with respect to said sending earth.

In testimony whereof, I hereunto subscribe my name, this 22nd day of May, 1931.

ARTHUR W. HORTON, Jr.