

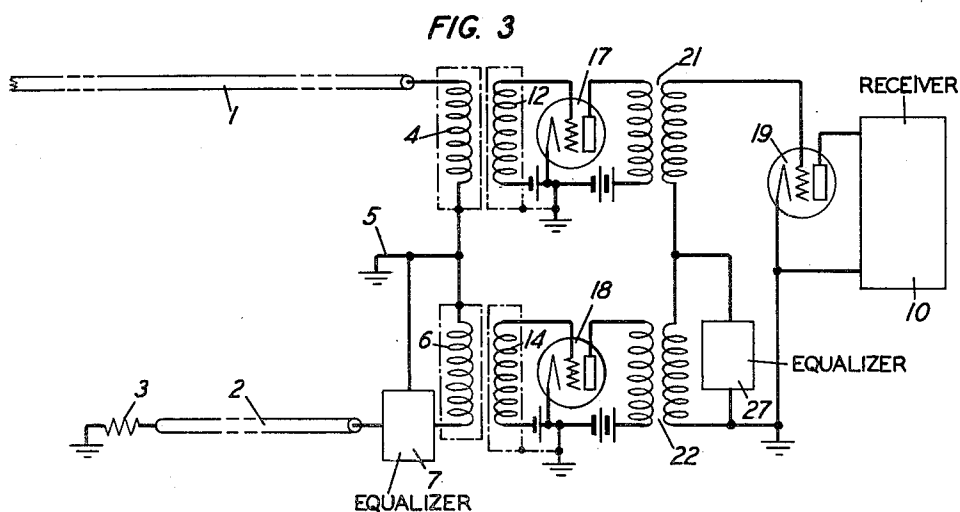
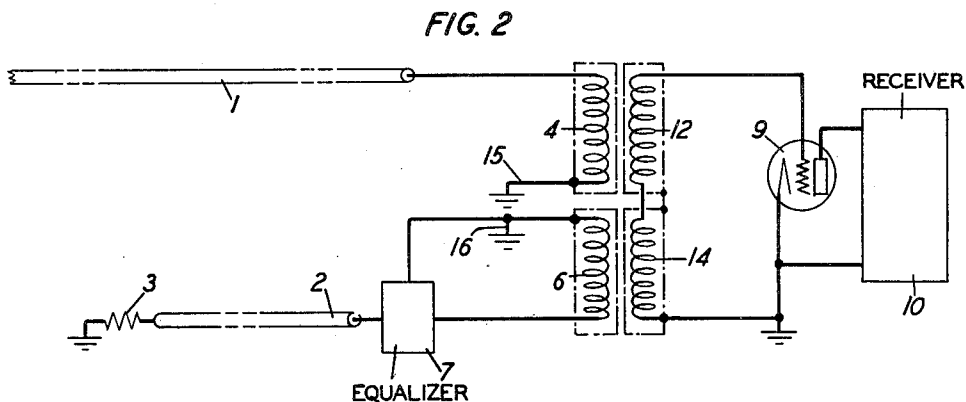
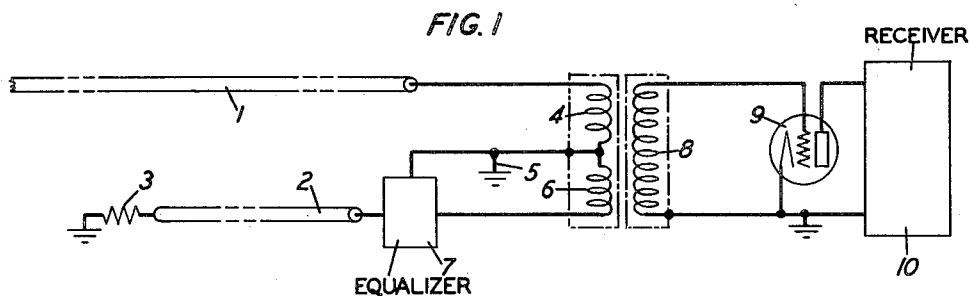
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CIRCUIT FOR REDUCING INTERFERENCE

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CIRCUIT FOR REDUCING INTERFERENCE

Application filed February 10, 1932. Serial No. 591,962.

The present invention relates to the suppression of interference in electrical transmission systems and has particular reference to submarine cable telegraph or telephone systems.

An object of the invention is to reduce interference in a signaling system, such as a submarine cable system, while keeping the transmission efficiency high for the signals.

It has been shown in J. J. Gilbert Patent 1,678,184, July 24, 1928, that interference from extraneous sources can be reduced by employing as receiving-earth a section of cable similar to and paired with the main conductor and terminated in deep sea water with a network simulating the main conductor in impedance. As pointed out in that patent, this type of termination, while greatly reducing the interference, also reduces to a lesser degree the transmission efficiency because of the increased receiving impedance as compared with single core type of cable.

It is an object of the present invention to retain the interference-reducing advantages of the receiving sea earth conductor of that patent without substantially increasing the receiving impedance of the system for signals.

It is proposed to attain this object according to this invention by employment of a local earth connection (or connections) to which the main cable and the balancing conductor are separately and independently connected through couplings that are opposed with respect to the receiver. Similar interference present in both couplings will be balanced out in the receiver but the signal passes into the receiver mainly through only one of the couplings so that the impedance of the balancing conductor is not presented to the received signal.

In the drawing, Figs. 1, 2 and 3, respectively, show three different modifications of terminating circuits, according to the invention, employing separate opposed couplings between the terminal conductors and the signal receiver.

In Fig. 1 the main cable is shown at 1 with the balancing cable at 2 terminated at sea by the resistance 3 as disclosed in the Gilbert

patent above referred to except that in the present case the balancing cable 2 is laid near but is not necessarily paired with the main cable. The main cable conductor is connected through a primary winding 4 with the local earth connection 5 and the balancing cable 2 is connected through a similar primary winding 6 to the same earth conductor 5, the windings 4 and 6 being opposed with respect to the common secondary winding 8. Any suitable amplifier, diagrammatically indicated at 9, may be connected to the secondary winding 8 and this amplifier may lead to any suitable type of receiver 10.

Assuming that the main cable 1 and the balancing cable 2 are exposed to the same interference and that the balancing cable 2 is properly terminated at 3 the interference voltages applied to the windings 4 and 6, respectively, are substantially equal and are balanced out in the secondary winding 8.

The signals received over the cable 1 are not similarly balanced out, however, because the signal currents in the balancing cable 2 are zero or very small depending upon the extent to which the inductive effects between conductors 1 and 2 are reduced.

It may be necessary or desirable in practice to include a shaping network at one or more points in the circuit for use in refining phase and amplitude adjustments in order to obtain a more complete balance of the interfering current in windings 4 and 6. One such network, equalizer 7, has been illustrated in Fig. 1, as included in circuit with the balancing cable 2. Other networks may be included in either side of the circuit as desired.

The balancing arrangement of Fig. 1 includes a single secondary winding 8 common to both primary windings 4 and 6. This may have the disadvantage of providing enough coupling between the primary windings 4 and 6 to give the effect of paralleling the main cable and balancing cable, resulting in loss of signal energy.

Fig. 2 avoids this difficulty by using two separate transformers 4-12 and 6-14 in place of the three-winding arrangement of Fig. 1. These two transformers may be separated in space and suitably shielded from each other

to prevent inductive effects between them. To facilitate this, separate grounds with individual grounding conductors 15 and 16 are shown. The coupling between the transformers may be kept negligibly small so long as the tube input impedance remains high with respect to the transformer impedances.

Any residual coupling between the opposed circuits is still further reduced by the arrangement of Fig. 3, in which the balancing is done in the second stage amplifier 19, which is connected to the transformers 4-12 and 6-14 through individual unilateral amplifiers 17 and 18. In this arrangement amplifier 17 amplifies signal current and interference current while amplifier 18 amplifies substantially only interference current. The outputs of these two amplifiers are combined in reverse phase in the grid circuit of the amplifier 19. A second network 27 is disclosed in the grid circuit of amplifier 19 for aiding in securing an exact balance between the interfering currents arriving over the two paths. This type of connection avoids the use of an ungrounded input transformer secondary winding 12 (as in Fig. 2) included above the grounded input secondary 14. The ungrounded secondary 12 belongs to the signal input transformer 4-12 which is usually of high secondary impedance. The arrangement of Fig. 3 is more flexible in providing the first stage amplifiers 17 and 18 and interstage transformers 21 and 22 and may result in improved overall amplifier characteristics.

The circuits that have been described may be used for balancing out interference of any frequencies that may be present, including either telegraph range or telephone range.

While the balancing conductor 2 has been referred to as a cable terminated in deep water, the invention contemplates also the use of balancing conductors of other types, such for example as a short cable, for balancing out receiving end interference of a local character.

Other types of balancing connections than those illustrated and described may be used to effect suppression of interference. In general, the balancing may be accomplished at any essentially voltage-operated point in the amplifier. The common return path need not necessarily be ground but may be a conductor.

It is, of course, impossible in practice to secure a perfect match in transmission characteristics between the two conductors 1 and 2 over a wide frequency band. One advantage of a network like 7 or 27 is to reduce the level of some especially troublesome interfering frequency that may be present. Applicant has used equalizer 7 across either winding 4 or 6 in cases where imperfect balance existed between conductors 1 and 2, thus making of conductors 1 and 2 and windings 4

and 6 (with the aid of equalizer or equalizers 7) a bridge in which the balance at a chosen frequency was completed by adjustment of network 7.

What is claimed is:

1. The combination of a main loaded submarine cable exposed to extraneous interference whereby signals as received over said cable are accompanied by interference currents also received over said cable; and a second cable conductor exposed to like interference and having transmission properties similar to those of said main cable, local earth connections for both cables at a receiving point, a coupling element included in each local earth connection, and a receiver differentially coupled to said coupling elements, said receiver having impressed on it signal currents principally through one of said coupling elements and the interference currents in opposed relation from both coupling elements, whereby the signals are received while the interference currents are reduced in said receiver.

2. A main loaded submarine cable, with receiving end termination, a balancing cable laid adjacent the main cable from its receiving end to a point at sea beyond a zone of interference, which is to be neutralized and exposed to interference similar to that picked up by the main cable, said balancing cable having suitable impedance termination at sea and transmission properties similar to those of the main cable, a receiver, and electrically separate couplings between said main cable and said balancing cable, respectively, and said receiver.

3. The combination recited in claim 2 in which said receiver comprises a space discharge amplifier and said separate couplings are made to the input of said amplifier.

4. The combination recited in claim 2 in which said separate couplings comprise a pair of space discharge tube circuits, having input and output circuits, their input circuits being coupled, respectively, to said main cable and said balancing cable, while their output circuits are coupled in opposed sense to said receiver.

5. In combination a long deep-sea loaded cable exposed to extraneous interference, a receiving ground therefor, a balancing cable having similar electrical transmission properties to the main cable and extending to a distance at sea adjacent the main cable, whereby said balancing cable is exposed to similar extraneous interference, a receiving ground connection for said balancing cable, a receiver, and mutually opposed couplings between said receiver and said main and balancing cables, whereby extraneous interference is balanced out in said receiver.

6. A submarine cable, subject to atmospheric, static, or induced interference from extraneous sources near its shore end, a bal-

ancing conductor having similar transmitting properties to said submarine cable and subjected to like interference, receiving ground connections for said cable and balancing conductor, a receiver coupled to said submarine cable for receiving signals over said cable, and a coupling between said receiver and said balancing conductor opposing the interference in said balancing conductor to that in said submarine cable.

7. A combination according to claim 5 in which said couplings include an equalizer for correcting for imperfect balance between said cable and said balancing cable for at least a portion of the received frequency range.

In witness whereof I hereunto subscribe my name this 5th day of February, 1932.

EVERETT T. BURTON.