July 11, 1933. J. J. GILBERT 1,917,882

SIGNALING SYSTEM

Filed Jan. 27, 1932

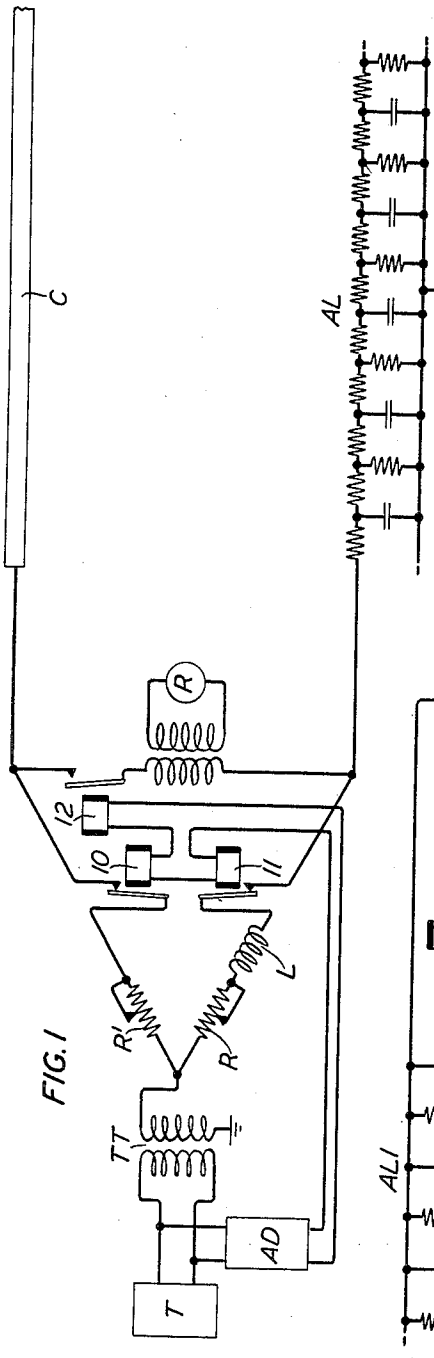

FIG. 1

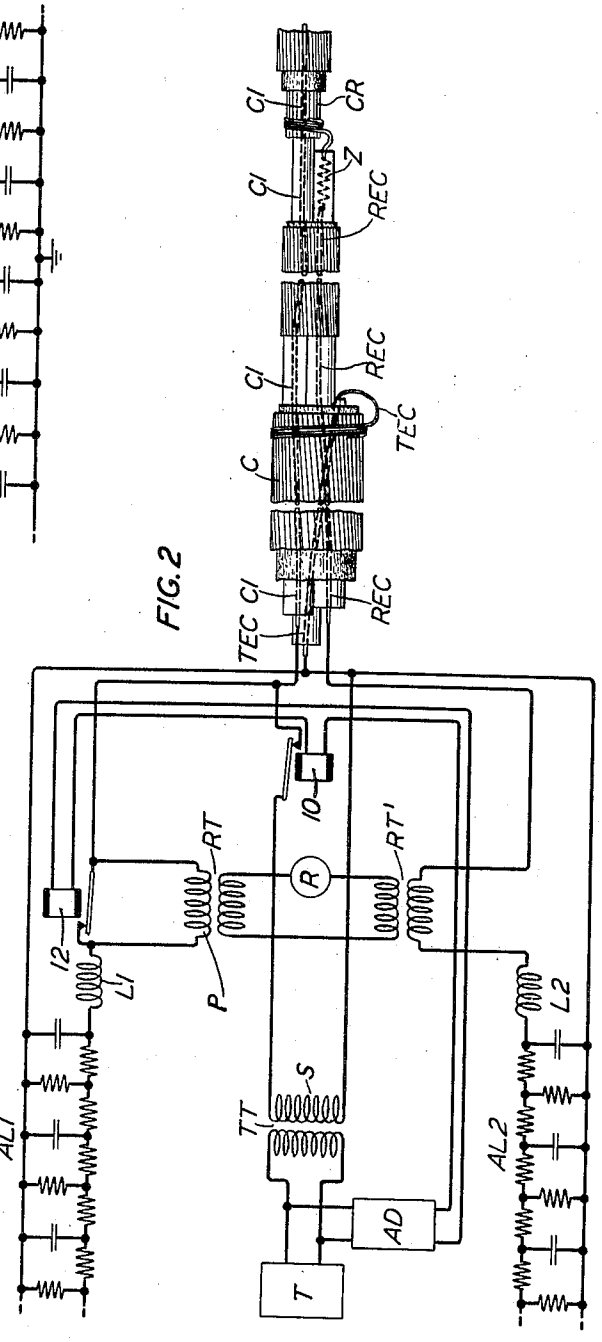

FIG. 2

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SIGNALING SYSTEM

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This invention relates to the transmission of electric currents, and provides improvements in the two-way transmission of such currents, for instance, in the two-way repeating of telephone or carrier telegraph currents.

It has been discovered that where use is made of high speed switching means, or other quick-operating means responsive to transmission, for controlling a repeating circuit, in order that when the repeating circuit is in use it may operate effectively in only one direction at a time, the operation of the control means may be deleteriously affected by transient energy which may discharge from the line connected to the output of the repeater after the input to that line has ceased. In general, when the input transmission to the line ceases, some energy will return from it and will enter the output of the repeater. There are various factors which may cause energy sent out by a repeater to reenter it. For example, the energy may be reflected from terminal apparatus; or it may be stored in the line and sent back to the repeater, or stored in terminal apparatus and fed back to the line and repeater upon cessation of input from the repeater to the line.

In addition to the kick-back energy which manifests itself in the form of an alternating current, a residual charge remains upon the line after the transmitter has been disconnected from the line. This residual charge produces a slowly decaying current in any direct current path which is present at the terminal. In the case of a long submarine cable the initial value of this current is about 30 to 40 decibels down from the level of the previously impressed signals; it may take several times the transmission time of the cable for this current to decay to a value 100 db. further down. This decaying or relaxation current is due chiefly to the low frequency components of the transmitted signals which are much slower in dying out than the higher frequency components after the electromotive forces causing them have been removed. A deleterious effect of this relaxation current upon the operation of the circuit is that when the receiving amplifier is connected to the line when such a current is flowing, there is a sudden change in terminal impedance which generates high frequency voltages; currents produced by these voltages are transmitted through the receiving amplifier as a disturbing click.

A general object of this invention is to avoid the effect upon receiving apparatus connected to a line conductor of the residual charge which remains stored in the conductor after the transmitter has been disconnected.

In order to attain the above and other objects of this invention, the receiving or output circuit of the cable or transmission line is bridged between conjugate points of the transmission line and an artificial line, and the transmitter is connected to the apex of the bridge circuit. The side branch of the bridge circuit which is connected to the artificial line includes means such as a filter or choke coil whereby the amplitudes of high frequency currents transmitted into the artificial line are small compared with those currents transmitted into the cable, so that the low frequency components of the transmitted currents are transmitted in equal proportions into the cable and the artificial line. After the transmitter has been disconnected, there are residual charges (relaxation currents, chiefly of low frequency components) in both the transmission line and the artificial line. These charges from the two lines balance each other and consequently produce no resultant effect upon the receiving circuit.

In general, high frequency components of telephone signals die out rapidly, and in the normal operation of a system such as is contemplated by this invention, these high frequency currents are practically completely dissipated before the receiving circuit is connected to the line. It is usually important that high frequencies be impressed upon the transmission line in full volume. Therefore, a feature of this invention is a filter or choke coil arrangement for preventing the artificial line from exerting a drain on the high frequency components from the transmitter. By virtue of this feature, although the low frequency components sent to the transmission line and the artificial line are

approximately equal, the high frequency components which enter the artificial line are very small.

The invention may be better understood from the following detailed description of its features and of its principles of operation, in connection with the accompanying drawing in which identical reference characters designate similar parts, and in which:

Fig. 1 shows a diagrammatic representation of a submarine telephone system constituting one embodiment of the invention; and

Fig. 2 shows a diagrammatic representation of a submarine telephone system constituting another embodiment of the invention.

In Fig. 1 the outputs of a transmitter T and of a transmitting transformer TT work into a bridge circuit, the arms of which comprise adjustable resistances R and R′, a filter L, a cable C and an artificial line AL. The artificial line AL is such as to simulate the cable C in the lower ranges of frequencies and to have a low impedance to the higher ranges of frequencies, this being desirable for the receiving condition. A preferred type for such an artificial line is a resistance-capacity type as shown. The bridge circuit also contains the armature contacts of two voice operated relays 10 and 11, one in each branch. These relays are controlled by the transmitter T and the amplifying detector AD to automatically close their contacts on transmission of signals and to open them on reception of signals. The receiving or output circuit R of the system is bridged, as shown, between conjugate points of the cable C and the artificial line AL. The receiving circuit includes the armature contact of a voice operated relay 12. Relay 12 works in a manner opposite to that of voice operated relays 10 and 11, that is, it is open on transmission and closed on reception of signals. The relays 10, 11 and 12 are of the fast-operating and slow-releasing type. The resistances R and R′ are adjusted so that the low frequencies transmitted into the cable and the artificial line are equal in amplitude. The filter L is chosen so as to have negligible impedance compared with that of resistance R at low frequencies, but high impedance compared with that of R at high frequencies, so that the amplitudes of the high frequency currents transmitted into the artificial line AL will be small compared with those of the current transmitted into the cable. This arrangement possesses the further advantage that the load on the transmitter is reduced.

The operation of the system shown in Fig. 1 is as follows: We assume the armatures of relays 10, 11 and 12 in the position shown which is that corresponding to the transmission of speech from the transmitter T. As stated above, these relays release their respective armatures with a delayed action. When the near end subscriber stops talking, the contacts of relays 10 and 11 remain closed for a short time interval to allow the weak endings of the signal currents to pass, even though they fail to maintain the output of the amplifying-detector AD operative. After that time has elapsed the contacts of relays 10 and 11 are released (opened) whereby the transmitter is disconnected from the line. At this moment there are residual charges of equal potentials, composed chiefly of low frequency currents, i. e., the relaxation currents, in the transmission line C and the artificial line AL. The armature contact of relay 12 is now closed and thus the charges in the two lines being of equal potentials, balance each other, and consequently produce no appreciable effect (disturbance) in the receiving circuit.

In the modification of the invention which is shown in Fig. 2, the submarine telephone system illustrated comprises a main cable C1 and transmitting and receiving earth cables TEC and REC, respectively. The receiving earth cable REC is connected to the primary winding of the receiving transformer RT′ and the main cable C1 is connected to the primary P of receiving transformer RT. The contact of voice operated relay 10 is closed on transmission and open on reception of signals. The secondary winding S of the transmitting transformer TT is connected as shown over the armature of relay 10 to the main cable C1 and to the transmitting earth cable TEC. A filter L1 is connected in series with the artificial line AL1 simulating the cable. In a manner similar to filter L of Fig. 1, the filter L1 is constructed so as to offer a low impedance to low frequencies and a high impedance to high frequencies, in order to prevent unnecessary drain on the transmitting amplifier. In order to prevent unbalancing the network on reception of signals, and to cause statics or interfering voltages in the receiving earth cable REC to balance statics or interfering voltages in the main cable C1, a similar filter L2 and artificial AL2 line are connected as shown in the circuit of the receiving earth cable REC. The terminal sections of the sending and receiving earth connections TEC and REC respectively and of the main cable C1 may be enclosed in the same armor (as shown) to form a composite cable C. At a short distance (e. g. about 5 miles) from shore, the conductor of the sending earth cable TEC is connected to the armor of cable C, and at a distance of the order of about 200 miles from shore the conductor of the receiving earth cable REC is connected as shown through an impedance element Z to the grounded concentric return conductor CR of the main cable C1 which extends to the distant end. The provision of the im-

pedance element Z is for the purpose of terminating the receiving earth REC in such a manner that its impedance, as seen from the near terminal, closely approximates that of the main cable C1.

The operation of the embodiment of the invention shown in Fig. 2 is as follows: We assume the armatures of relays 10 and 12 in the position shown which is that corresponding to the transmission of speech by the transmitter T. Relays 10 and 12 release their armatures slowly. During speech transmission the primary winding P of the receiving transformer RT is short-circuited so as to prevent any of the transmitted energy from affecting the receiver R and to permit the transmitted energy to divide between the transmission line (conductor C1) and the artificial line AL1 in the proper manner. When the near end subscriber stops speaking, the armature of relay 12 is released first, and the release of the armature of relay 12 removes the short-circuit across primary winding P. Relay 10, in releasing its armature, disconnects the transmitter T from the line. The residual charges stored in the cable and in the artificial line, which are of approximately equal values, balance each other and have no serious disturbing effect upon the receiver R.

What is claimed is:

1. A submarine signaling system comprising a cable, a receiving circuit, means for connecting and disconnecting said cable to and from the circuit at frequent intervals, and means including an artificial line for overcoming the effects of residual cable voltages in said circuit at the instant when said cable is connected thereto.

2. In a signaling system, a transmission line, a sending mechanism and a receiving mechanism, means for alternately connecting and disconnecting said mechanism to and from said line, and means for preventing excessive currents at the time of connecting the receiving mechanism to the transmission line, said means comprising a device connectable to the receiving mechanism and adapted to counteract the residual line voltage.

3. In a signaling system, a transmission line, an artificial line, a receiving circuit connectable to both lines, means for transmitting low frequency currents in equal, and high frequency currents in unequal proportions, into said transmission line and artificial line respectively, whereby residual charges in the transmission line due to previously transmitted low frequency currents do not injuriously affect the receiving circuit when the latter is connected to said line.

4. System as defined in claim 3 in which said frequency transmitting means includes a filter and a resistance element, said filter having a low impedance at low frequencies and a high impedance at high frequency, as compared with the impedance of said resistance element.

5. A signaling system comprising a transmitting circuit and a receiving circuit, a line conductor and a balancing conductor therefor, means for alternately connecting and disconnecting said line conductor to and from said receiving circuit, the receiving circuit being bridged to conjugate points of said conductors, whereby, the effect upon the receiving circuit of any residual charge which remains stored in said conductors after disconnection therefrom of the transmitting circuit is reduced.

6. A deep sea telephone system comprising a main cable, a sending earth cable and a receiving earth cable, a transmitting circuit adapted to be connected to points across said main cable and said sending earth cable, a receiving circuit adapted to be coupled to points between said main cable and said receiving earth cable, means for switching said main cable to and from the receiving circuit, and an artificial or balancing cable for said main cable, whereby low frequency currents in said main cable are prevented from detrimentally affecting said receiving circuit.

7. System as defined in claim 6, further characterized by a balancing cable across points of the sending earth cable and the receiving earth cable respectively whereby the effects of interfering currents in the receiving sea earth cable are caused to balance the effects of interfering currents in the main cable.

In witness whereof, I hereunto subscribe my name this 21st day of January, 1932.

JOHN J. GILBERT.