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SUBMARINE CABLE TELEGRAPHY

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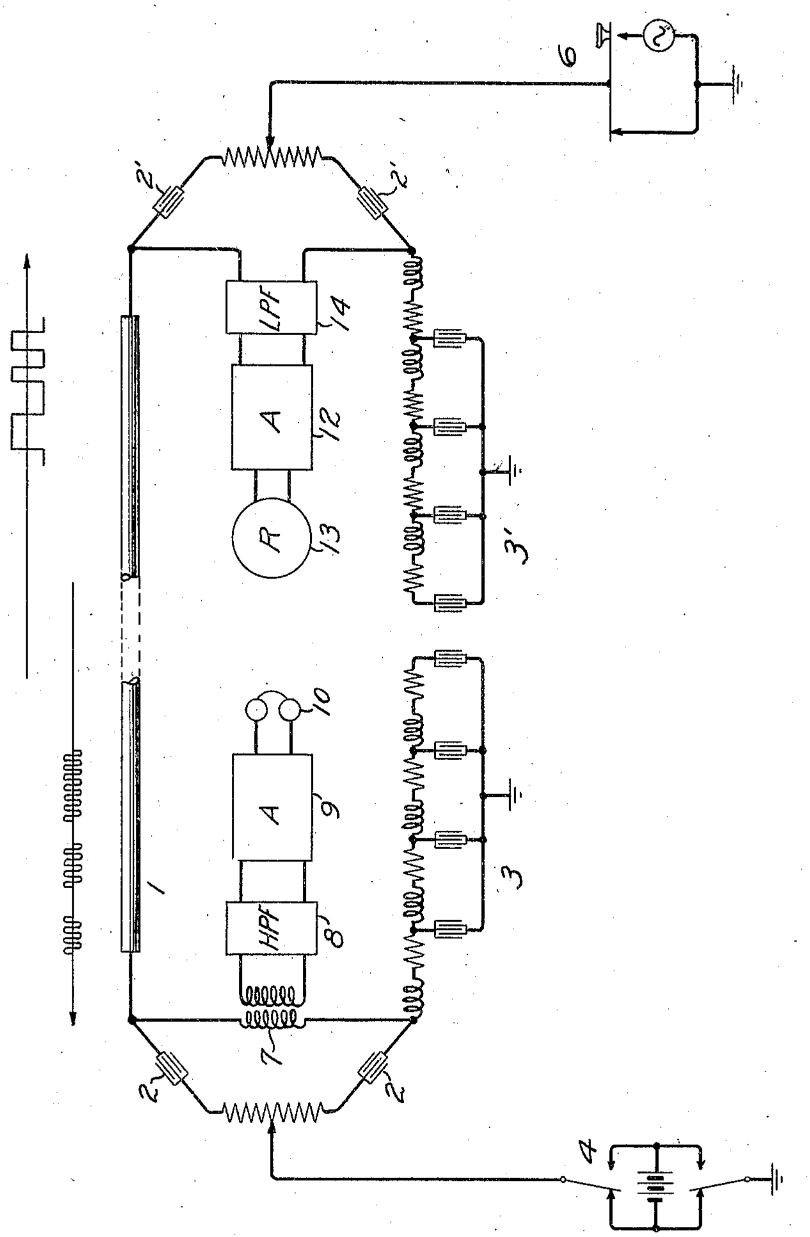

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SUBMARINE-CABLE TELEGRAPHY.

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This invention relates to electrical transmission and particularly to submarine telegraphy. An object of the invention is to provide a novel method and means for signaling over a transmission line simultaneously in both directions. A further object is to provide a method and means for operating a long loaded telegraph cable simultaneously in both directions at high signal speeds.

Submarine telegraph cables of the ordinary non-loaded type are commonly operated simultaneously in two directions to a great advantage, the outgoing and the incoming signals at each end being separated by means of a duplex bridge comprising two approximately equal ratio arms and an artificial line closely simulating the cable as regards its electrical characteristics. Difficulty is encountered, however, when an attempt is made to apply this method of operation to long loaded telegraph cables. This difficulty arises from the variability of the inductance and resistance of the loaded cable which makes it difficult to secure an artificial line that will give as good a balance with a loaded cable as is commonly obtained in practice with non-loaded cable.

A method which has sometimes been employed on short loaded telegraph cables where the degree of balance obtainable does not permit simultaneous two-way operation with currents of a given frequency, is to employ one range of frequency for signaling in one direction and another range of frequency for signaling in the opposite direction, the outgoing and incoming signals at each end of the cable being separated by the combined use of a balancing network and a filter. In this case neither the duplex bridge with its artificial line nor the filter would be sufficient by itself to prevent interference between outgoing and incoming signals. However, by the combination of the two, simultaneous two-way operation is successfully secured.

It is well known that the traffic capacity of long telegraph cables, when operated in one direction only is limited by the extraneous disturbances to which the cable is subject. These disturbances may be caused by electrical apparatus or machinery in the neighborhood of the cable terminals, and in this case, of course, can be reduced or removed, but are more often of natural origin and similar in character to the well-known "static" of wireless telegraphy in which case they are unavoidable except by special construction of the cable. In common operating practice with non-loaded cables the transmitting voltage is limited by considerations of safety, and the highest speed obtainable for one-way operation is that at which the signal, transmitted at the maximum permissible voltage, is received with sufficient intensity to be legible on the sensitive recording apparatus which, of course, records both the interference and the signal. The requirement of legibility demands that the received signal be of substantially greater amplitude than the extraneous interference lying in the same frequency band as the signal. Otherwise, the interfering disturbances will mask the signal and cause errors in reading the transmitted messages. Interference of higher frequency than the frequency band of the signal can, of course, be eliminated by means of suitable filters, so it is only interference of the frequencies lying within the frequency band of the signal which is of serious consequence. The same considerations apply to one-way operation of a long loaded cable if operated by automatic or recording means, except that by virtue of the inductive loading the limiting speed set by interference is much higher than for the non-loaded cable.

In the method of operation according to this invention it is proposed to operate the loaded cable in one direction by means of automatic or recording means and at a speed such that the received signal is of greater amplitude than the interference, and to operate it simultaneously in the other direction by a modulated wave train of frequency higher than any involved in the signal sent in the first direction. Thus a low frequency channel is provided in one direction and a relatively high frequency channel in the other direction. Since the low frequency channel is operated up to the limit set by interference, and since the high frequency signals are attenuated more than the low frequency signals, it follows that the amplitude of the high frequency signals will not be large, and may even be small, in comparison with that of the interference. Hence, if automatic or recording means were used to receive the high frequency signal, the received signal would be rendered illegible by the interference. In order to make it possible to read the high frequency signal through the interference, it is proposed to make use of reception by ear. To accomplish this the received signal will be amplified to such a strength that it is audible in a telephone receiver. Now it is a fact that a skilled individual can by this means read signals which would be quite undecipherable if recorded by such means as an oscillograph. The individual is able to concentrate his attention on the tone of the signal, and although the interfering disturbance may be many times the amplitude of the signal, he will, if sufficiently skilled in the art, be able to read messages without error through the interference. Experiments have shown that with interference of the character encountered in submarine cables, an operator can distinguish and read a telegraphic signal by ear through interference of average amplitude more than ten times the amplitude of the signal and having peak values more than a hundred times the amplitude of the signal. It has further been found by experiment that an operator can read audible signals consisting of wave trains in which the highest frequency involved is only of the order of 100 cycles per second.

In order to make the invention more clear an installation will be described and some definite figures of frequencies and speeds given. The accompanying drawing shows schematically a preferred embodiment of the invention.

A submarine cable 1, which may be of the continuously loaded type terminates in duplex bridges containing the usual blocking condensers 2, 2′, and artificial lines 3, 3′ to balance the cable at the respective ends. The artificial line 3 should be balanced with particular care for the high frequency signals, and the artificial line 3′, for the low frequency signals. At one terminal is an automatic transmitter 4, which may conveniently be of the type commonly employed in submarine cable telegraphy, or of the type employed in multiplex printing telegraphy. Transmitter 4 sends messages composed of impulses of variable length, spacing and polarity through the cable to the receiving apparatus at the distant end. At the other terminal of the cable is transmitting arrangement 6 comprising a key which serves to transmit wave trains generated by an alternator, the key serving to regulate the length of the wave trains in the manner commonly employed for alternating current telegraphy. Signals transmitted by the key of the transmitter 6 are received through the transformer 7, a "high pass" filter 8, amplifier 9 and telephone receivers 10. The function of the high pass filter, which is an electrical network which permits frequencies above a certain value tc be transmitted and represses frequencies below that value, is to assist in eliminating from the high frequency signal, which it is desired to receive, the low frequency disturbance which would be otherwise caused by the simultaneous low frequency transmission in the reverse direction. The function of the amplifier, which may be conveniently of the well-known audion type, is to increase the intensity of the signals sufficiently to make them conveniently audible. The signals from the transmitter 4 are received through a network at the distant end consisting of a "low pass" filter 14, a combined amplifier and shaping network 12 and a recording receiving device 13. The function of the "low pass" filter 14 is to eliminate from the low frequency signal, which it is desired to receive, disturbances created by the transmission of the high frequency signal. The function of the amplifier and shaping network is to increase the amplitude of the low frequency signal so that it may be successfully recorded and to restore the shape of the signal so that it may be legible in the recording apparatus. The structures of high pass and low pass filters, amplifiers and shaping networks are well known and they are hence shown only diagrammatically. The nature of the received signals is indicated by the curves shown above the respective terminal apparatus.

For the sake of giving definite figures let the cable be of the continuously loaded type in which a layer of permalloy, an alloy of nickel and iron of high permeability, is used to secure high inductance. Let us assume a cable of 2300 miles in length loaded with permalloy tape having such dimensions and permeability as to give an inductance of 60 milhenries per nautical mile. On such a cable it is anticipated that the average amplitude of unavoidable interference at the signaling frequency will be approximately one microampere. With a transmitting voltage of 50 volts the low frequency signals may then be transmitted at such a speed that the received signal has an amplitude of, let us say, 5 microamperes in order not to be made illegible by the interference. This will permit a speed corresponding roughly to 60 cycles, and the low frequency signal will thus consume the frequency band from 0 to 60 cycles. Signals may be sent in the reverse direction by a wave train of fundamental frequency of 130 cycles and at a voltage of 50, this being the limit set my considerations of safety, giving a received current at this frequency of .2 microampere, which will be of smaller amplitude than the interference, but which will nevertheless be legible through it by ear. Let us suppose that the signaling speed in the high frequency channel corresponds to 20 cycles per second, then the frequency band occupied by the high frequency signal will be from 130—20 or 110 cycles to 130+20 or 150 cycles, leaving the frequency band from 60 cycles to 110 cycles to provide for the frequency overlap of the filters. It is to be understood that the above figures are only given as illustrative, and the particular values of frequency and current amplitude will have to be chosen by trial for each installation.

Although I have described my invention with reference to two-way operation, it is pointed out that both the high frequency and low frequency channel may be operated in one direction and the same principles of reception may be taken advantage of. For some installations it is expected that more than one high frequency channel may be used, separation between channels being made by appropriate filters. It may be desirable to equip the terminal from which direct current signals are ordinarily sent with an auxiliary set of apparatus like that at the other terminal, and to equip the terminal from which alternating current is ordinarily sent with an auxiliary set of apparatus like that at the direct current transmitting terminal, so that direct current signals may be transmitted in the direction in which traffic is greatest at any given time.

What is claimed is:

1. The method of signaling over a submarine telegraph cable which comprises simultaneously transmitting two trains of signals, one train of signals being transmitted as a series of impulses of variable length and spacing and received with amplitude substantially greater than ordinary extraneous disturbances, and the other being transmitted as a modulated sine wave and received with amplitudes substantially less than such extraneous disturbances.

2. The method of signaling over a submarine telegraph cable which comprises simultaneously transmitting trains of signals in opposite directions, the transmission frequencies being different for each train, one train of signals being transmitted as a series of impulses of variable length and spacing received with amplitudes substantially greater than the extraneous disturbances, and the other being transmitted as a modulated wave train and received with amplitudes substantially less than that of the oppositely directed signals.

3. The method of operating a loaded submarine telegraph cable which consists in transmitting signals in one direction at a speed such as to give received signals large in comparison with ordinary extraneous disturbances, and transmitting signals of substantially lower received current strength in the opposite direction.

4. The method of signaling over a submarine cable of such character that signals are highly attenuated which comprises simultaneously transmitting two trains only of signals, the transmission consisting of transmitting in one direction with direct current signals only and in the other direction with alternating current signals only, the latter signals being transmitted as a modulated sine wave.

5. The combination with a submarine cable of such character that duplex balanced circuits cannot be relied upon to separate outgoing from incoming signals involving the same frequency range, of terminal apparatus including such duplex balance circuits, means for transmitting direct current signals in one direction only, and means for transmitting alternating current signals in the opposite direction only.

6. The combination with a long submarine telegraph cable, of balanced-bridge terminal circuits including artificial balancing lines, means for transmitting signal currents in one direction, means for transmitting signal currents involving a different frequency range in the opposite direction, transmission being limited to said two one-way channels, and terminal frequency filters for aiding in the separation of outgoing from incoming signals.

7. The combination with a long heavily-loaded submarine cable, of means for transmitting direct current signals from one terminal, means for transmitting modulated carrier current signals from one terminal in the range of from 75 to 300 cycles per second, transmitting voltages being limited to the range of forty to seventy five volts, and automatic means for receiving and recording said direct current signals, said cable having such characteristics as to attenuate the modulated current signals to the order of ordinary extraneous disturbances or less and the direct current signals to an amplitude not less than several times that of said disturbances.

In witness whereof, I hereunto subscribe my name this 26th day of May A. D., 1922.

OLIVER E. BUCKLEY.