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J. M. EGLIN

2,088,292

ELECTRICAL COMMUNICATION SYSTEM

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FIG. 1

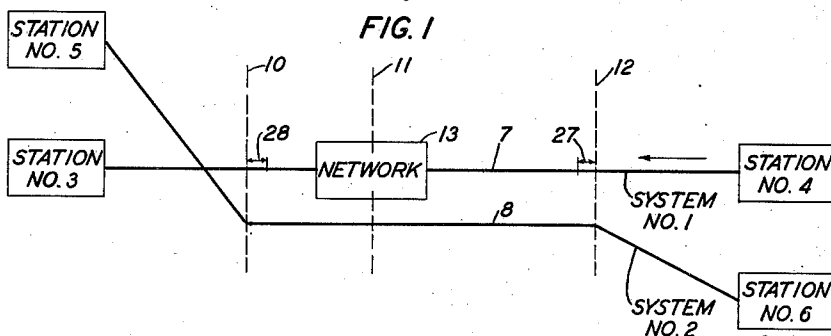


FIG. 2

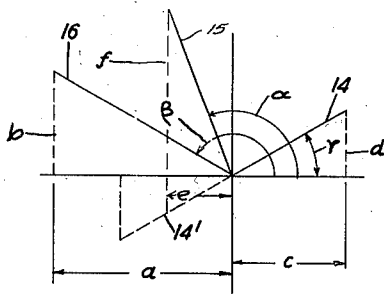


FIG. 3

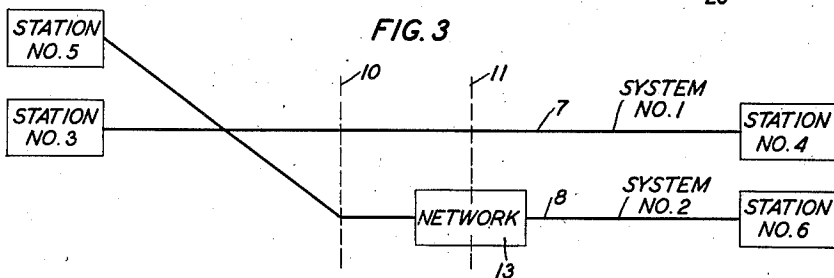
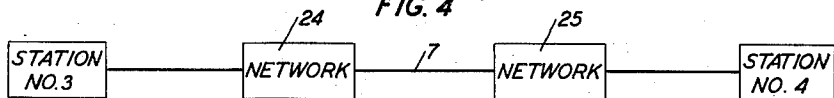


FIG. 4



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ELECTRICAL COMMUNICATION SYSTEM

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8 Claims. (Cl. 179-78)

This invention relates to electrical transmission systems and more particularly to the reducing or neutralizing interference in communication lines.

Transmission systems or lines are frequently subjected to interference or noise over at least a portion of their length.

This interference or noise may be reduced or eliminated by transposing the conductors of the line at regular and relatively short intervals. This transposition may be accomplished either mechanically by changing the relative positions of the wire or by twisting them together or electrically with transformers. In other arrangements filters have been inserted in the system to eliminate the interference or noise by suppressing the frequency or frequencies of the interference or noise but also suppress the corresponding frequencies of the transmitted band. The effects of the interference may be also reduced by applying a neutralizing voltage which is similar to the disturbing potentials but opposite in phase thereto.

These methods, however, are unsuited to single conductor ground return transmission systems in which the ground or sea water transmits part of or all of the return currents such as employed for submarine cables and, in addition, will not reduce the interference or noise produced within any transmission line due to modulation of the signal current by the transmission line or magnetic loading materials associated therewith.

It is the object of this invention to provide means for neutralizing interference or noise including modulation products in communication transmission lines and in particular in long submarine cables.

In accordance with this invention a network is inserted at any convenient point in the portion of the line subjected to the interference which alters the phase and amplitude of the interference received from the line from the far side of the network so that it will substantially neutralize the interference received from the line from the near side of the network. This network may also be inserted in an adjacent disturbing circuit instead of the disturbed circuit; or a network may be inserted in both the disturbed and disturbing circuits which will similarly neutralize the interference received in the disturbed circuit.

This invention may be more readily understood from the following description of several specific embodiments when read with reference to the attached drawing in which:

Fig. 1 illustrates in diagrammatic form a preferred embodiment of this invention;

Fig. 2 shows a vector diagram of the interference currents received at station 3 of Fig. 1;

Fig. 3 shows a modification of Fig. 1 in which the network is connected in the disturbing circuit;

Fig. 4 shows a submarine cable system employing two networks;

Fig. 5 shows a filter arrangement which may be used in connection with the network; and

Fig. 6 shows a more complicated filter and network arrangement which may be employed to substantially neutralize disturbing currents having a plurality of frequencies.

Referring now to Fig. 1, two transmission systems 1 and 2 are shown. System 1 includes communication stations 3 and 4 which are connected together by transmission line 7. These stations 3 and 4 may be either or both telephone and telegraph stations and may transmit either ordinary signal current impulses or carrier current impulses or both. The transmission line 7 is suitable for transmitting the various kinds of impulses and may be of a single conductor ground return type or a full metallic circuit. System 2 comprises stations 5 and 6 connected by transmission line 8. System 2 may be another communication system or a power system or any other system transmitting electrical currents. System 2 is also intended to represent all sources of interference such as radio transmission systems, earth currents, etc. A portion of the transmission line 8 of system 2 is shown adjacent the transmission line 7 of the communication system 1 so that it would normally induce into the transmission line 7, noise currents due to current flowing in the transmission line 8 of system 2. In general most of the noise potentials induced in system 1 by currents flowing in system 2 would be induced between the dotted lines 10 and 12 as shown in Fig. 1.

The noise currents received at station 3 from line 7 due to the potential induced in a small elemental length 27 of line 7 will be attenuated and changed in phase by the propagation constant of line 7. In a similar manner current due to potentials induced into the elemental length 28 of line 7 will be altered both in phase and amplitude when received at station 3. However, since the currents from the elemental length 28 have to travel over a much shorter line than those received from elemental length 27, they will be attenuated less and have their phase changed

less than the current from the elemental length 27.

The interference received at station 3 will thus be the sum of the currents due to potentials induced in each of the elemental lengths of the line exposed to the interfering field of line 8 or any other interfering field and may have an amplitude such as represented by the length of vector 15 and a phase such as represented angle α as shown in Fig. 2 which is composed of a real part e and an imaginary part f and may be represented as $e+jf$. Likewise the interference received at station 3 from a portion of the line between any point 11 on the line and 12 may be represented by some vector such as 16 of Fig. 2 which may be represented as $a+jb$. While the interference received between points 11 and 10 may have some value such as represented by vector 14, $c+jd$ of Fig. 2. If now a network 13 is inserted in line 7 at point 11 which will alter the amplitude and phase of the current passing through it so that vector 16 of Fig. 2 which represents the interference received at station 3 from the section of line 7 between points 12 and 11 is exactly opposite to and equal in magnitude to the vector 14 of Fig. 2 as shown by vector 14' which represents the interference received at station 3 from line 7 between points 11 and 10, these two interfering currents will substantially neutralize each other and thus neutralize the interference received at station 3.

The inserted network 13 performs two functions; the first being to adjust the amplitude of the current received at station 3 from line 7 on the far side of network 13 between points 12 and 11 so that it is equal to the amplitude of the interference current received at station 3 from line 7 from the near side of said network 13 between points 11 and 10; and the second being to alter the phase of these currents so that they are substantially opposite. The first function may be performed by an attenuation network or an amplifier depending upon which of the two currents is larger. Both of these kinds of apparatus are well known and need not be described herein. The second function of network 13 may be performed by any suitable phase shifting network, examples of which are disclosed in United States patents to Hunter 1,543,772, June 30, 1925, Nyquist 1,770,422, July 15, 1930 and Bode 1,828,454, October 20, 1931. In the case of transmission systems with ground or sea water return circuits it is desirable to make the influence of the ground connections of the shunt elements of these networks of small importance. This may be done by (1) making the impedance of the shunt elements as high as possible; (2) separating the delay apparatus from the system by a transformer or transformers; and (3) by connecting the delay apparatus to only the ungrounded side of the system.

It is also possible to insert network 13 in disturbing line 8 of such systems as shown in Fig. 3. The operation in this case is quite similar to that described for Fig. 1. The network serves to alter the phase and amplitude of the current in line 8 so that the current as received at station 3 from line 17, due to current flowing in line 8 which is beyond the network, will substantially neutralize the current received at station 3 from line 7 due to the current flowing in line 8 on the near side of filter 13.

Fig. 4 shows the manner in which this invention may be applied to a submarine cable 7 such as disclosed in United States Patent 1,486,863 granted to O. E. Buckley on March 18, 1924 connecting stations 3 and 4. Here two networks 24

and 25 are shown inserted in the cable 7. As shown in Fig. 4, network 24 is provided to alter the amplitude and phase of modulation products received at station 3 due to signal currents flowing in the cable 7 to the right of network 24 so as to substantially neutralize currents due to modulation products induced in the cable 7 due to signal currents flowing therein to the left of network 24. Similarly, network 25 is inserted to alter the phase and amplitude of the modulation or interference currents received at station 4 due to signal current flowing in conductor 7 to the left of network 25 so as to neutralize the modulation currents received at station 4 due to signal current flowing in cable 7 to the right of network 25.

Thus, as illustrated in Fig. 4, when it is desired to reduce, or substantially eliminate interference noise currents at both terminals of the line or cable, it will usually be desirable to employ a network at each of two points of the line. One of these networks serves to substantially eliminate the interference noise currents received at one station, while the other network serves to substantially eliminate the interference currents received at the other station.

In case the greater proportion of the modulation products due to magnetic material employed in loading the cable occurs at or near the transmitting end of the cable where the high level transmitting currents are flowing in the conductor, it may be desirable or necessary to interchange the relative positions of the two networks; that is, the network employed to substantially eliminate the interference at station 3 would be located in the position shown by network 25 of Fig. 4 and the network employed to substantially eliminate the interference received at station 4 would be substantially in the position shown by network 24.

In inserting two networks in the cable to compensate or substantially eliminate the interference received at both terminals of the cable, the effects of one network upon the other must be carefully considered and compensated for when designing these networks.

However, in case the transmission in the different directions is at different frequencies, only the interference or modulation products which lie within the respective frequency bands needs be considered. In this case it is possible to readily separate the respective currents and to insert a network which will operate upon the desired frequency band which is used to transmit the currents in the respective directions. In this case the networks will have substantially no effect upon each other so the interaction between them need not be considered.

Such arrangement is shown in Fig. 5. Here network 17 allows currents and a band of frequencies to pass through to which no phase or amplitude adjustment is applied, but prevents currents of other bands of frequencies from passing through it. Currents of these other frequencies pass through filter 18 and network 19 and have their phase and amplitude adjusted in the desired manner. Filter 18, however, prevents current having frequency which is transmitted by filter 17 from passing through filter 18 and network 19. A network arrangement such as shown in Fig. 5 may be employed at each end of the line in which case the transmitted, or possibly the received currents will pass through network 17 while the other currents, that is the received currents or possibly the transmitted currents will

have to pass through filter 18 and network 19 to have their phase and amplitude altered so as to substantially neutralize the interference or modulation currents received at the respective terminals of the line.

The frequency band of the interfering or noise currents is usually small or narrow so that a simple network is all that is necessary to change the phase of currents of the noise frequency the desired amount. In certain cases the frequency band of the interfering currents may be wider in which case more complicated networks such as disclosed in the Bode supra patent may be employed. In cases where it is necessary to substantially eliminate noise currents having very wide frequency bands it may be necessary to provide numerous delay networks in combination with filters to secure the correct amplitude and phase adjustments for the currents of the various frequencies. In certain cases it may be desirable or necessary to pass a portion of current of different frequency through the same or parts of the same delay network. An arrangement for accomplishing some of these results is shown in Fig. 6. Here filters 20, 22 and 26 separate currents having different bands of frequencies and permit currents of the various bands to pass through the respective filters. As shown in Fig. 6, the phase and amplitude of the current passing through filter 26 are not adjusted. The currents passing through filters 20 and 22, however, do have their amplitude and phase adjusted. The amplitude and the phase of the currents which passes through filter 20 are adjusted by network 21 in the desired manner. Similarly, the currents passing through filter 22 have their phase and amplitude adjusted by network 23 as well as by a portion of network 21.

The foregoing description of the several embodiments of this invention is for the purpose of illustrating the various features thereof. The scope of the invention will now be set forth in the following claims.

What is claimed is:

1. An electrical transmission system comprising a portion exposed to interfering fields, an electrical network connected in said exposed portion for adjusting the amplitude and phase of the interfering currents received from the far side of said network so it will substantially neutralize the interfering currents received from the near side of said network.

2. In a portion of an electrical communication line subjected to interference potentials, an electrical network connected in said portion of said line for altering the interference currents received from the far side of said network so that it will neutralize the interference currents received from the near side of said network.

3. In an electrical transmission system for transmitting communication currents, a portion of which is subjected to interference or noise potentials, a method of reducing these interference or noise potentials, characterized in this, that an electrical network is connected in said portion of said system subjected to interfering potentials for changing the interference currents received from the far side of said network so that it will substantially neutralize the interference currents received from the near side of said network.

4. An electrical transmission system comprising

ing a transmission line inductively loaded with magnetic material in combination with electrical networks connected in series therewith for altering the amplitude and phase of currents of modulation products received at terminals of said cable due to signal currents flowing in said cable on the far side of said network so as to substantially neutralize currents of modulation products received at the terminals of said cable due to signal currents flowing in said cable on the near side of said network.

5. An electrical communication system comprising a transmission line, a second transmission line adjacent a portion of said first transmission line whereby interference currents are induced in said first transmission line by currents flowing in said second transmission line, characterized in this that a network is connected in said first transmission line so as to alter the phase and amplitude of the noise potentials received at the terminals of said first transmission line due to the noise potentials induced into said first transmission line on the far side of said network so that said interference currents will substantially neutralize the interference currents received at the terminals of said line due to potentials induced into said first transmission line on the near side of said network.

6. In combination, an electrical communication system, a transmission line therein, a second transmission line adjacent thereto which induces noise currents into said first transmission line due to currents flowing in said second transmission line, and a network connected in said second transmission line to alter the phase and amplitude of the currents flowing therein so that the noise currents received at the terminals of said first transmission line from the currents flowing in said second transmission line on the far side of said network substantially neutralize the noise currents received at the terminals of said first transmission line due to currents flowing in said second transmission line on the near side of said network.

7. A method of operating a transmission system for substantially eliminating interference currents received at a point of a transmission system which consists in transmitting to said point a portion of the interference currents induced in said system with an amplitude and phase change effected only by the transmitting signaling currents and line and transmitting the remaining portion of the interference currents induced in said system to said point with an amplitude and phase change in addition to the amplitude and phase change effected by the transmitting line.

8. An electrical transmission system comprising a transmission line subjected to stray currents in combination with filters and networks connected in said line which alter the phase and amplitude of currents of only the frequencies of said stray currents, said filters and networks being so located in the line that the phase and amplitude of a portion of said stray currents received at the terminals of said line will be altered so as to substantially neutralize the remaining portion of said stray currents received at said line.

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