March 24, 1925. 1,530,537

H. A. AFFEL

ELECTRICAL TRANSPOSITION SYSTEM

Filed Aug. 31, 1922

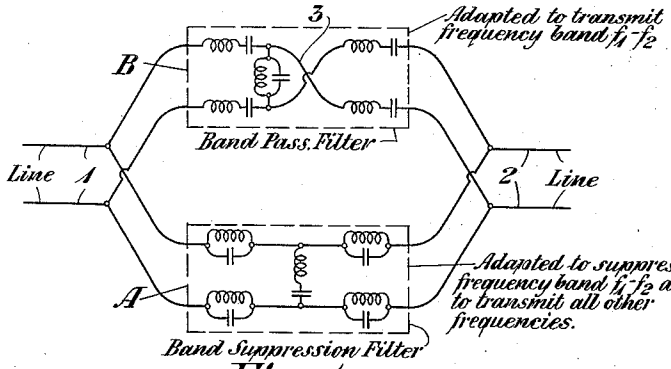


Fig. 1

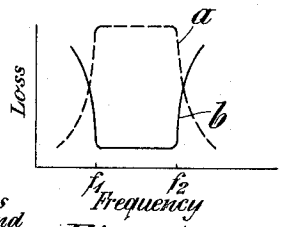


Fig. 1a

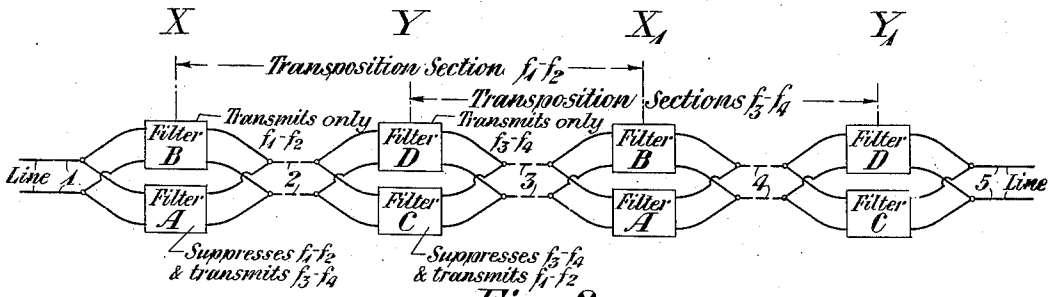


Fig. 2

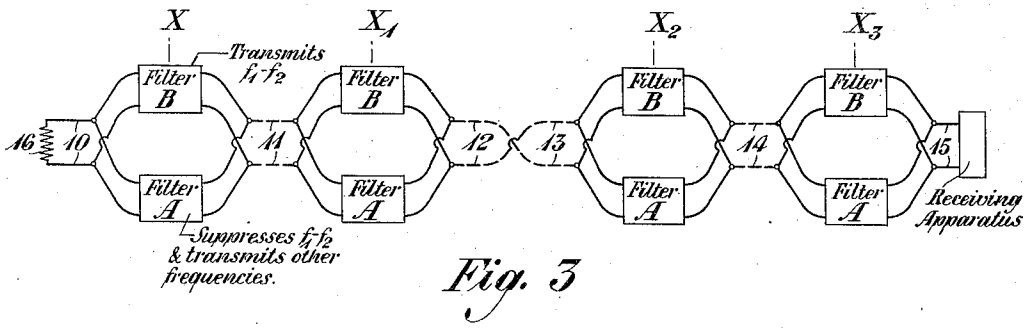


Fig. 3

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UNITED STATES PATENT OFFICE.

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ELECTRICAL TRANSPOSITION SYSTEM.

Application filed August 31, 1922. Serial No. 585,436.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Electrical Transposition Systems, of which the following is a specification.

This invention relates to electrical transposition systems and particularly to an arrangement for transposing a line circuit adapted for the simultaneous transmission of a plurality of frequencies or bands of frequencies.

Heretofore in the operation of systems in which signaling was carried on by means of a relatively low frequency current or range of low frequency currents such as required for voice transmission, where it has been necessary to transpose pairs of wires to prevent mutual interactions, due to inductive or capacity effects between them, it has been customary to introduce the transpositions at intervals which were short relative to the wave lengths of the electric currents concerned. This has usually entailed no particular hardship, since, as noted above, the frequencies were relatively low and the wave lengths correspondingly long.

When transposing wires to prevent mutual interactions, or in other words crosstalk, between paralleling pairs at the higher frequencies for the operation of high frequency telephone or telegraph systems, i. e., carrier current systems, the problem becomes increasingly difficult. The wave lengths involved in this case are relatively short and in order to carry out the general principle of providing transportation intervals which are a small fraction of the wave length, requires, in many cases, the insertion of transpositions at points extraordinarily near together. In fact the number of transpositions required and the physical difficulty involved in obtaining the accurate frequency spacing, often renders it impracticable to employ such an arrangement, effective throughout a wide range of frequencies. A lesser number of transpositions may, however, be provided where it is desired to have the action effective only at a single frequency over a relatively narrow range of frequencies because in this case the rapid phase changes act in a sense to transpose the currents automatically at frequent intervals.

It is the object of this invention to provide means whereby line circuits may be effectively transposed to prevent interactions between circuits throughout a wide range of frequencies, covering low frequencies as well as high frequencies, with a minimum number of transposition points. The particular feature by which this objective is achieved is the use of what may be termed selective transpositions, namely, means whereby a line circuit may be effectively transposed at a given point for a particular frequency, or band of frequencies, and at the same time rendered untransposed at the same point for other bands of frequencies than those for which it is desired to transpose the said line at that point. By this means a complete transposition system, effective throughout the desired wide range of frequencies, may be provided by superposing the designs of a plurality of transposition systems, each of itself relatively simple, involving a minimum of transpositions and effective for a portion of the total frequency range involved. The points at which transpositions are required for one part of the range and not for another part of the range are effectively provided for by a selective transposition as above noted, the points at which both circuits are required to be transposed being served by a simple transposing of the wires in the ordinary manner.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing, in which Figure 1 shows a simple form of embodiment of the invention, Fig. 2 shows the application to a line circuit of a plurality of units such as are shown in Fig. 1, and Fig. 3 shows the application of the invention to a directive radio antenna.

In Fig. 1, 1 and 2 represent two sections of a line which is adapted to have transmitted thereover a plurality of frequencies, or bands of frequencies. Inserted between the sections 1 and 2 of the said line circuit, and in series therewith, is an electrical network which may be termed, for the purpose of description, a transposition group.

It is the purpose of this circuit to divide the frequencies being transmitted over the line into different bands, thereby permitting the circuit carrying one or more of the bands to be crossed, or transposed, while maintain-

ing in the circuit carrying the remainder of the frequencies, the normal disposition of the wires. This arrangement thus provides the selective transposition previously referred to.

This network consists in a plurality of filters connected in parallel electrically with each other, thereby affording a plurality of paths between the sections 1 and 2 of the said line circuit, through which the plurality of frequencies, or bands of frequencies traversing the said line must pass. While only two filters have been shown in the group shown in Fig. 1, it is to be understood that the invention is not limited to this particular number, but may be varied without changing the scope of the invention. The filter designated A is of the type known in the art as a band-suppression filter and is disclosed in the patent to G. A. Campbell, No. 1,493,600, dated May 13, 1924. This filter, the transmission frequency characteristic of which is represented by the dotted curve *a* in Fig. 1[a], is adapted to suppress a particular band of frequencies such, for example, as that represented by f_1—f_2 and to transmit readily, or substantially so, all frequencies lying without that band. This is clear from a consideration of Fig. 1[a], which shows the variation of loss of the network A for various frequencies impressed upon the said network. Thus, it will be seen that for frequencies below f_1 and above f_2, the transmission loss is fairly low, whereas it is very high for the band lying between f_1 and f_2. The filter B, whose characteristic curve is designated *b* in Fig. 1[a], is of the type known as band-pass filters. This filter, with the exception of the transposition of the conductors designated 3, is disclosed in the patent to G. A. Campbell, 1,227,113, dated May 22, 1917. A consideration of the characteristic curve, shown in Fig. 1[a] shows that the transmission loss to currents below f_1 and above f_2 is very great, whereas the transmission loss lying between these limiting frequencies is relatively small. This means, of course, that the band f_1—f_2 will be readily transmitted through a filter of the type represented by B, but that frequencies or bands of frequencies lying without those limits will be substantially suppressed. Since filter A suppresses the same band of frequencies which is readily transmitted by filter B, these filters are termed complementary and are hereinafter referred to by that term. By reversing the conductors of the filter B at the point 3, the line is electrically transposed with respect to the currents that are transmitted through the filter B, but the line is not transposed with respect to currents of the frequencies transmitted through the filter A. It will be clear, therefore, that if, for example, a band of frequencies f_1—f_2 and another band of frequencies lying without the range of the said first band, arrive over the section 1 of the line circuit, the band f_1—f_2 will be transmitted through the filter B and, due to the transposition 3, will be impressed in an opposite sense across the section 2 of the said line circuit. The other frequencies will not pass through the filter B, but will be transmitted through the filter A, and since the conductors thereof are not reversed, the said other band of frequencies will be impressed across the section 2 of the line in the same sense in which they were impressed across the line 1.

The application of a plurality of transposition groups, such as shown in Fig. 1, is illustrated in Fig. 2. In this figure, 1, 2, 3, 4 and 5 represent five sections of a line circuit which are connected together by means of a plurality of transposition groups, the object of which is to transpose the said line for a particular frequency, or band of frequencies in order to prevent cross talk into some adjacent pair of wires. Let it be assumed that the points X and X_1 represent points at which it is desired to transpose to prevent cross talk for frequencies lying within the band f_1—f_2 and Y and Y_1 represent desired transposition points for preventing cross talk for frequencies lying within the band f_3—f_4. There should accordingly be inserted at X and X_1 a transposition group comprising a filter B adapted to transmit the band of frequencies f_1—f_2 and to suppress all other frequencies, and a filter A which will transmit all of the said other frequencies and will suppress the band f_1—f_2. The transposition group shown at Y and Y_1 comprises a filter D, which is adapted to transmit the band of frequencies f_3—f_4 (viz, the said other frequencies transmittted by the filter A at points X and X_1) but to suppress the band f_1—f_2, and a filter C, which is adapted to transmit the band f_1—f_2, but to suppress the band f_3—f_4. Each of the filters B and D has its conductors reversed as represented by 3 in Fig. 1. Accordingly, it will be seen that if two bands of frequencies, for example, f_1—f_2 and f_3—f_4 arrive over the section 1 of the said line, the band f_1—f_2 will be transmitted through the filter B and will be impressed across the line 2 in an opposite sense. The band f_3—f_4 will be transmitted through the filter A and impressed across the section 2 in the same sense in which it was impressed across the section 1. These two bands will then be impressed across the tranposition group at Y. The band f_3—f_4 will be transmitted through the filter D and, due to the transposition therein, the band will be impressed across the section 3 in an opposite sense to that in which it was impressed across section 2. The band f_1—f_2 will be transmitted through the filter C and impressed across section 3 in the same sense in which it was impressed across

section 2. Accordingly, it will be seen that the line, which is made up of a plurality of sections designated, for example, 1 to 5 inclusive, is transposed at the points X and X_1 for currents of the band f_1—f_2, but is not transposed for all other frequencies. At points Y and Y_1 the said line is transposed for currents of the frequencies f_3—f_4 but is not transposed for currents of other frequencies.

It will be apparent that any number of transposition groups may be used in a line such as shown in Fig. 2, depending upon the number of bands of frequencies for which it is desired to transpose the said line.

The arrangement shown in Fig. 3 represents the application of this invention to a directive loop antenna, the object of which is to make the antenna better responsive to waves received from a particular direction. In my copending application, Serial No. 607,193, filed Dec. 15, 1922, I showed the use of a transposed loop antenna, which, by the proper locating of the transposition points, was better adapted to receive waves of a particular frequency, or band of frequencies, and to exclude or suppress currents of other frequencies. Such an arrangement, as was therein disclosed, tended to minimize the effects of static and also of interference from stations other than that from which it was desired to receive signals. The arrangement shown in Fig. 3 is an application of the present invention to the antenna broadly shown and claimed in the said copending application. In Fig. 3 the antenna per se is represented by a plurality of sections designated 10 to 15 inclusive. Across the one end of section 10 is a terminating resistance 16, which simulates the characteristic impedance of the antenna. The other end of section 10 is connected with the filters A and B, the filter B being designed to transmit, for example, the band f_1—f_2 and filter A being designed to suppress that frequency but to transmit all other frequencies. By the proper location of the transposition groups at the points X_1, X_2 and X_3 the antenna is made highly selective for frequencies lying within the desired band and is made non-selective for other frequencies.

While I have shown two uses to which my invention may be applied, its scope is not limited, since many other and varied uses will occur to those familiar with the art. Furthermore, while I have shown the use of band filters of various types in the drawing in which the invention is embodied, and have described these particular types of filters in the specification, it must be understood that the invention is not limited to these particular types of filters. Nor is it limited to the transmission of bands of frequencies since the invention is applicable to the transposition of a transmission circuit for a plurality of single frequencies as well as for bands of frequencies.

Although this invention has been disclosed in a particular form it is capable of embodiment in other and different forms within the spirit and scope of the appended claims.

What is claimed is:

1. In an electrical transmission system, the combination with a transmission circuit adapted to transmit a plurality of frequencies, of a group of filters inserted between sections of the said circuit, the said filters being connected in parallel and complementary in frequency selection whereby frequencies transmitted by one filter will be suppressed by the other, and one of said filters having a transposition therein whereby the transmission circuit will be transposed at that point for the frequencies transmitted by that filter.

2. In an electrical transmission system, the combination with a line adapted to transmit a plurality of bands of frequencies, of a group of filters inserted between sections of the said line, the said filters being connected in parallel and of the complementary band-pass and band-suppression types, the band-pass filter having its conductors transposed whereby the said line will be transposed for the band of frequencies transmitted through the said band-pass filter.

3. In an electrical transmission system, the combination with a line adapted to transmit a plurality of bands of frequencies, of a group of filters inserted between sections of the said line, the said filters being connected in parallel and of the complementary band-pass and band-suppression types, so designed that the band of frequencies transmittable through one will be suppressed by the others, the band-pass filter having its conductors transposed whereby the said line will be transposed for the band of frequencies transmitted through the said band-pass filter.

4. In an electrical transmission system, the combination with a line circuit adapted to transmit a plurality of frequencies, of a plurality of filters, one of said filters being adapted to transmit readily one of the said frequencies and to suppress the other frequencies, and the other of said filters being adapted to transmit readily the said other frequencies and to suppress the frequency transmitted by the first mentioned filter, the said first mentioned filter having its circuit transposed so as to effect a transposition of the line circuit for the frequency transmitted therethrough.

5. In an electrical transmission system, the combination with a line adapted to transmit a plurality of frequencies, of a group of filters arranged in parallel with each other, the said group being inserted between

sections of the said line, one of said filters being adapted to transmit readily one of the said frequencies and to suppress the other frequencies, and the other of said filters being adapted to transmit said other frequencies and to suppress the said first mentioned frequencies, the said line being transposed through the said first mentioned filter.

6. In an electrical transmission system, the combination with a line adapted to transmit a plurality of bands of frequencies, of a plurality of groups of parallel filters connected in series with the said line, the filters of each group being of the complementary band-pass and band-suppression types, the band-pass filter having its conductors transposed whereby the line will be transposed for the band of frequencies transmitted therethrough, and similar groups being spaced along said line at intervals representing a transposition section for the particular band of frequencies transmitted by the band-pass filter of the group.

7. In an electrical transmission system, the combination with a line adapted to transmit thereover a plurality of bands of frequencies, of a plurality of groups of filters connected therewith, each group comprising a band-pass and a band-suppression filter of the complementary types, the said band-pass filter of each group having its conductors transposed, thereby effecting a transposition of the said line at that point for the band of frequencies passed by the said filter, similar groups being spaced along the said line at intervals representing a transposition section for the band of frequencies passed by the band-pass filter of the said group.

8. In an electrical transmission system, the combination with a line adapted for the transmission of a plurality of bands of frequencies, of a group of parallel filters in series with the said line, the said filters being of the complementary band-pass and band-suppression types, and a second group of parallel filters also in series with the said line, the said filters being of the complementary type designed so that the band transmitted by the band-pass filter of the second group will be different from the band transmitted by the similar filter of the said first group, the said band-pass filter of each group having its conductors transposed, thereby effecting a transposition of the line at the said points for the particular bands of frequencies transmitted through the respective band-pass filters.

9. In an electrical transmission system, the combination with a line adapted for the transmission of a plurality of bands of frequencies, of a plurality of groups of parallel filters in series with the said line, the said filters of each group being of the complementary band-pass and band-suppression types, and corresponding filters of all the groups having similar transmitting and suppression characteristics, and a plurality of other groups of parallel filters also in series with the said line, the said filters of each group being of the complementary type, and corresponding filters of the various groups having the same transmitting and suppression characteristics, but so designed that the band transmitted by the band-pass filter of one of the latter groups will be different from the band transmitted by the corresponding filter of one of the former groups, the said band-pass filters of all groups having their conductors transposed to effect a transposition of the line for the particular band of frequencies transmitted thereby, the groups of each of said plurality of groups being spaced along said line at distances apart representing a transposition section for the particular band of frequencies passed by the band-pass filters of each group.

In testimony whereof, I have signed my name to this specification this 29th day of August, 1922.

HERMAN A. AFFEL.