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ELECTRIC WAVE TRANSMISSION

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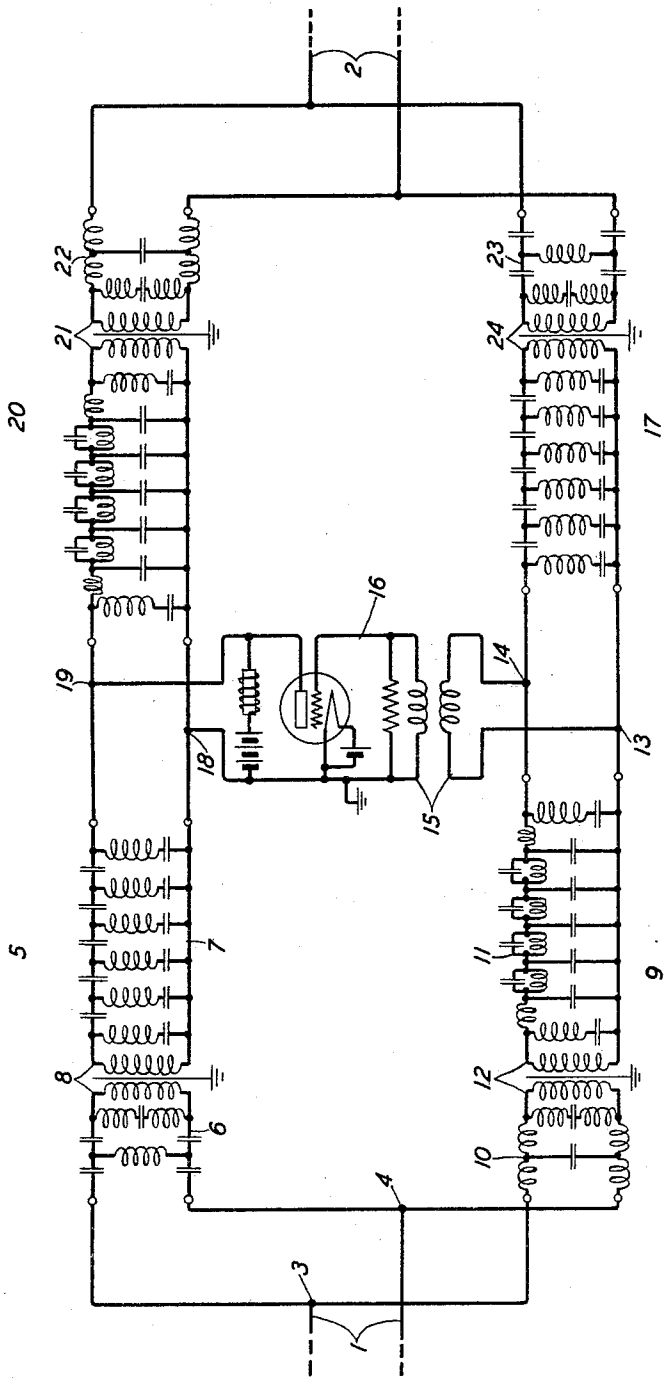

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ELECTRIC WAVE TRANSMISSION

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This invention relates to wave transmission and more particularly to two-way carrier repeating systems. It has for its object to obtain economy of impedance elements in carrier frequency repeaters.

It is common practice in the art of carrier frequency transmission to provide a repeater, or amplifier, between two transmission lines, for the purpose of raising the level of the signal currents. To enable transmission to proceed in both directions through unilateral amplifiers, two parallel paths are provided in the repeater, one for transmission in each direction. For the purpose of confining the signals propagated in each direction to their respective paths in the repeater, the signals of the two directions of transmission are assigned different frequency bands by means of properly appointed carrier waves, and directional filters are employed in the repeater to select for each path the corresponding band of signal frequencies. In the one path, the directional filters are of the high pass type which select the upper of the signal frequency bands, while in the other path the filters are of the low pass type which select the lower of the signal bands.

There are present in a transmission line due to line unbalances and external interference, extraneous currents which flow in parallel along both line conductors and return by way of ground. These currents, which have been called longitudinal currents, produce no noise in signal transmission provided they are not permitted to set up voltages in the metallic circuits. To prevent the introduction of noise into the line in disturbing amounts, all lines in which longitudinal currents are present must be accurately balanced with respect to ground. This requires that the directional filters of the repeater be of the balanced construction if the repeater circuits are metallically connected to the transmission lines.

It would be desirable, from the standpoint of economy to employ filters which are unbalanced in form, inasmuch as the unbalanced construction requires fewer impedance elements than the balanced construction. But the use of unbalanced filters requires that the repeater be metallically isolated from the transmission lines by means of repeating coils. The objection to the use of repeating coils at the repeater terminals is the difficulty of building coils capable of transmitting the signal bands and yet which do not generate modulation products in disturbing quantities. The modulation products, of which the third order is the most deleterious, are generated in the magnetic core material of the repeating coils. Repeater stations are commonly calculated to raise the transmission level by about 60 decibels; which means that the level difference at the repeater terminals between the signals of the two directions of transmission is about 60 decibels. The proper suppression of cross-talk ordinarily requires that the modulation voltages be about 60 decibels below the level of the fundamental voltages. These considerations place upon the transformer a modulation requirement of about 120 decibels; that is, the voltages of modulation must be 120 decibels below the voltages which cause them. Up to the present time this modulation requirement has been unattainable in repeating coils designed to transmit frequency bands at ordinary carrier frequencies.

It is contemplated in accordance with this invention to locate repeating coils within the filters instead of at the repeater terminals, thereby obtaining the benefit of the attenuation in the portion of the filters lying between the repeating coils and the repeater terminals to reduce the modulation requirement to a value more readily obtainable. In this arrangement the filter portions lying between the repeater terminals and the repeating coils need be balanced, but the remaining filter portions are unbalanced. Another factor tending to reduce the modulation requirement in this arrangement is the effect of the transmission lines in shunting about half the modulation currents from the repeater. There are also other factors contributing to a reduction of modulation in this arrangement, and these will be mentioned subsequently.

The invention will be better understood by reference to the following detailed description taken in connection with the accompanying drawing, the single figure of which shows

the invention embodied in a carrier frequency repeater.

The repeater shown in the figure is connected between transmission lines 1 and 2 and is arranged to amplify low frequency waves traveling from line 1 to line 2 and high frequency waves traveling in the opposite direction. The directional discrimination is effected as follows:

At terminals 3 and 4 of line 1 the transmission circuit branches into two paths, the upper of which contains a high pass filter 5 comprising a balanced portion 6 and an unbalanced portion 7 inductively coupled by shielded transformer 8, and the lower of which contains a low pass filter 9 comprising a balanced portion 10 and an unbalanced portion 11, coupled by transformer 12. The lower path is continued to line 2 through a high pass filter 17 and the upper path is likewise continued through a low pass filter 20. The filter 17 and 20 are similar to filters 5 and 9 respectively. Between the junction points 13 and 14 of the two filters in the lower path and the junction points 18 and 19 in the upper path is connected a unilateral amplifier 16, the input circuit of which includes a suitable transformer 15. By virtue of the selective characteristics of the filters the path of low frequency currents entering the repeater from line 1 is through low pass filter 9, in the lower path, to amplifier 16 and from the output of the amplifier through low pass filter 20 to line 2. High frequency currents entering from line 2 follow the path constituted by filter 17, amplifier 16 and filter 5 to line 1. All currents traverse the amplifier in the same direction.

For purposes of economy it is desirable that the amplifier 16 and its associated filters should be of the unbalanced type with one side grounded in each case. Since the transmission lines 1 and 2 are generally of the balanced type the use of an unbalanced repeater makes it necessary to have shielded transformers for coupling to the lines. If these transformers are of the usual iron cored type, this being necessary for high efficiency, and if they are placed at the ends of the repeater they are found to be productive of undesired currents which give rise to cross-talk due to the modulating action of the magnetic cores. For example, the amplified low frequency currents in passing into line 2 would generate in the transformer high frequency harmonics which could enter the high-pass filters and travel with the normal high frequency waves. The filters preferably use inductance coils with non-magnetic cores in order that they may not themselves become sources of modulation currents. As the inductance values are usually small this is practicable and economical.

To prevent the generation of cross-talk currents in the transformers, the filters are made, in accordance with the invention, in two parts, one of which is balanced and the other unbalanced, and the shielded transformers are inserted between these parts. The unbalanced parts are located next to the amplifier and the balanced parts are connected to the balanced lines. Thus, filter 5 comprises an unbalanced portion 7 and a balanced portion 6 which are coupled by shielded transformer 8, and filter 9 comprises unbalanced portion 11 and balanced portion 10 coupled by shielded transformer 12. Filters 17 and 20 comprise similar portions coupled by shielded transformers 21 and 24 respectively.

When the transformers are located within the filters as described above the modulation products generated therein are subject to the selective transmission of the end portions of the filters, the effect of which is to attenuate those components that might enter the complementary path so that their disturbing effect is negligible. Thus, the amplified low frequency currents may generate undesired high frequency harmonics in transformer 21 but such of these as might enter filter 17 are attenuated by the balanced portion 22 of filter 20 so that their intensity is negligible. Similarly, low frequency modulation currents produced in transformer 8 by the modulation of two amplified high frequency currents of different frequencies are attenuated by end section 6 of filter 5 so that they have negligible effect in the low frequency channel. It should be noticed also that since the transformers 12 and 24 in the input or low level paths are located within the filters the high intensity output currents from the other paths are so attenuated by the respective end portions 10 and 23 that they cannot enter these transformers to produce modulation currents.

Since the modulation currents are of small intensity relatively to the currents producing them, the degree of attenuation in the end portions of the filters need not be very great. Ordinarily, the end portion of the filter need not provide more than one-fourth or one-fifth of the total attenuation of the filter.

It is to be understood that the invention herein described is capable of general application and it is not to be limited to the specific embodiments disclosed but only as indicated by the scope of the appended claims.

What is claimed is:

1. In a carrier frequency repeater comprising two transmission paths connecting two sections of a balanced line, a low pass filter in one path, a high pass filter in the other path and a repeating coil having electrically separated windings connected between two portions of the filter in one of said paths, said filter portions being adapted to transmit the same frequency band, one of said portions being balanced, the other unbalanced, whereby undesirable currents reaching said coil are reduced by said filters.

2. In a carrier frequency repeater comprising two transmission paths connecting two transmission lines, a low pass filter at each end of one of said paths, a high pass filter at each end of the other of said paths and four repeating coils having electrically separated windings, each of said filters being partially balanced and partially unbalanced, the balanced portions being those nearest the terminals of the transmission lines, and one of said repeating coils being connected between the balanced and unbalanced portions of each of said filters, whereby longitudinal currents from said lines are prevented from passing said repeating coils into the unbalanced filter portion and fundamental frequency currents from each of said paths are attenuated in the balanced filter portions of the other of said paths and modulation currents generated in said coils are attenuated in the filters within which they are connected.

3. In combination, a balanced line, a frequency selective circuit for transmitting waves of a given frequency range to said line, a second frequency selective circuit for transmitting waves of another frequency range from said line, and a one-way path connecting said circuits, at least one of said circuits comprising a broad band filter consisting of two portions, one of said portions being balanced and the other unbalanced, said balanced portion being nearest said line, said two portions being adapted to pass the same frequency band and said two portions being connected by a repeating coil having electrically separated windings, whereby undesirable currents reaching said coil are attenuated by said balanced filter portion.

4. A wave transmission system comprising two balanced lines, an amplifier for said lines, a path for transmitting waves from the first said line through the amplifier in a given direction to the other line, another path for transmitting waves from said other line through said amplifier in said given direction to said first line, four filters, one of said filters being located at each end of each of said paths, each of said filters comprising two portions, said two portions being adapted to transmit the same frequency band, one of said portions being balanced and the other of said portions being unbalanced, said unbalanced portion being nearest said amplifier, and four repeating coils with electrically separated windings, one of said repeating coils being connected between said two portions of each of said filters, whereby longitudinal currents from said lines are prevented from passing said repeating coils into said unbalanced filter portions, fundamental frequency currents from each of said paths are attenuated in said balanced filter portions of the other of said paths and modulation currents generated in said coils are attenuated in the filters within which said coils are connected.

5. A wave transmission system comprising two balanced lines, a one-way amplifier for repeating from one of said lines to the other and from said other line to said one line, one input path connecting said one line to the input side of said amplifier, another input path connecting said other line to the input side of said amplifier, one output path connecting the output side of said amplifier to said other line, another output path connecting the output side of said amplifier to said one line, one output frequency grouping directional filter in said one output path for passing one range of frequencies and suppressing a lower range, another output frequency grouping directional filter in said other output path for passing said lower range and suppressing said one range, one input filter in said one input path for passing said one range and suppressing said lower range, another input filter in said other input path for passing said lower range and suppressing said one range, each of said four filters comprising two portions, said two portions being adapted to pass the same frequency band, one of said portions being balanced and the other of said portions being unbalanced, said unbalanced portion being nearest said amplifier, and four repeating coils with electrically separated windings, one of said repeating coils being connected between said two portions of each of said filters, whereby longitudinal currents from said lines are prevented from passing said repeating coils into said unbalanced filter portions, fundamental frequency currents from each of said output paths are attenuated in said balanced filter portions of said filters in said input paths and modulation currents generated in said repeating coils are attenuated in the filters within which said coils are connected.

In witness whereof, I hereunto subscribe my name this 16th day of October, 1930.

ALBERT G. GANZ.