

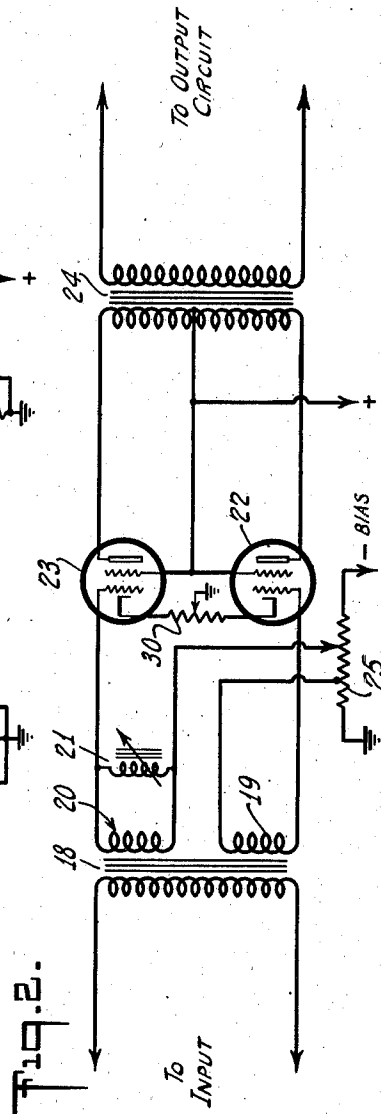
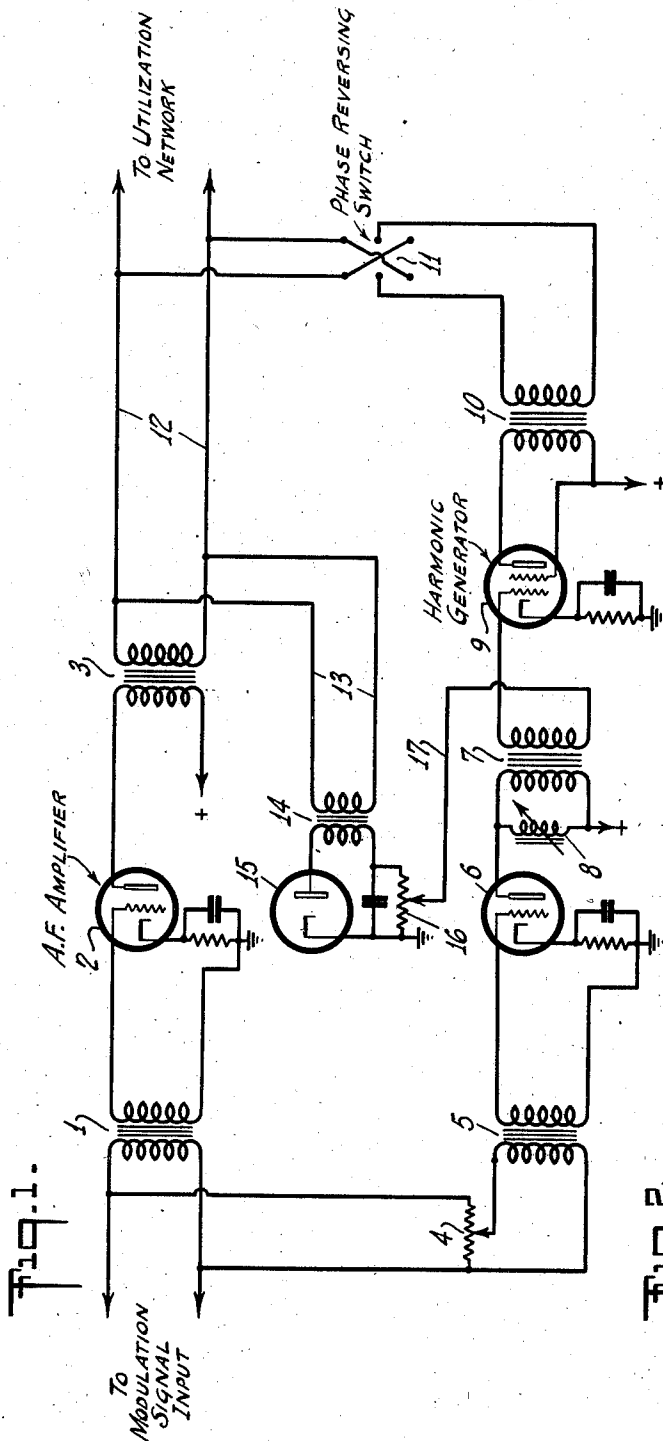
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AUDIO TRANSMISSION NETWORK

2,379,714

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2 Sheets-Sheet 1



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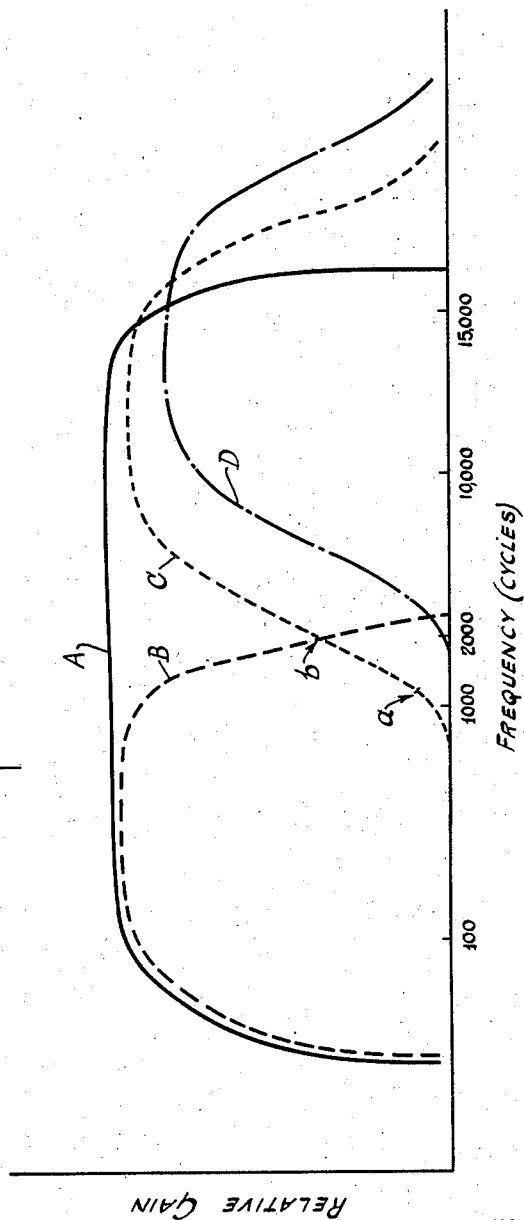
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Fig. 3.



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AUDIO TRANSMISSION NETWORK

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10 Claims. (Cl. 179—1)

My present invention relates to audio transmission networks, and more particularly to a method of, and means for, re-inserting generated harmonics to improve narrow band reception.

In the transmission of intelligence over wires or radio, it would be advantageous oftentimes to reduce the band width of transmission, or of reception, thereby to avoid interference and higher audio frequency noises, as for example, tube hiss. The band of transmission, or of reception, can be reduced only to a certain degree without impairing the intelligibility of the modulation signal, should the latter be voice or music.

It may, therefore, be stated that it is one of the main objects of my present invention to provide a method of modulation signal transmission wherein the intelligibility of the modulation signals is reduced to a point where the intelligence sought to be transmitted is impaired; a predetermined higher portion of the transmitted modulation signal being subjected to a distortion process thereby to produce harmonics, and the harmonics being utilized in the transmitted modulation signal energy to improve the aforesaid intelligibility.

It has been experimentally demonstrated that definite improvement of intelligibility can be had by receiving a long-distance, short-wave telephone signal on a 4 kilocycle (kc.) band in the intermediate frequency (I. F.) amplifier; the higher portion of the received band of audio frequencies being distorted to produce harmonics and the resulting harmonics being re-inserted in the audio frequency energy to give considerably improved intelligence and at the same time avoid strong local interfering signals. Standard broadcast station signals, such as are used in the 550-1700 kc. range, are not full range, and they too can be improved by the present method of harmonic distortion and re-insertion thereby to extend the apparent audio frequency range. The method is, also, applicable to phonograph reproduction where the space on the recording disc is limited and does not permit full range recording. Similarly, the method may be applied to sound-on-film recording, where the speed of the film will not permit full range recording, as for example, on 16 and 8 millimeter film.

Another important object of this invention is to provide a method of automatically controlling the level of the reinserted harmonics to prevent them from becoming too prominent.

Yet another important object of this invention is to provide an audio transmission system which

utilizes an audio amplifier, a connection being made to the amplifier input to excite an auxiliary amplifier, and the output of the latter being passed through a high-pass filter to excite a generator of distortion harmonics with voltage produced by the higher audio frequencies; there being utilized a path between the harmonic generator and the audio transmission network whereby to restore to a desired degree portions of the harmonic content of the original audio frequency signals lost either in transmission or reception.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings,

Fig. 1 shows an embodiment of the invention;

Fig. 2 illustrates a modification;

Fig. 3 illustrates various characteristics of the present system.

Referring now to the accompanying drawings, there is shown in Fig. 1 an audio transmission system which embodies an audio transformer whose primary winding may be connected to any desired source of modulation signals. It is to be clearly understood that this invention is not limited in any way to the nature of the modulation signal source. While the invention is described specifically in connection with audio frequency signals, that is, intelligence covering a range up to 15,000 cycles, it is to be clearly understood that the invention may be applied to frequency bands lying above the audio range. Furthermore, the modulation signal source itself may be the detector output resistor of a radio broadcast receiver operating in the 550 to 1600 kc. band. Or, if desired, the receiver may be a frequency modulation receiver operating in the assigned 42-50 megacycle band. Furthermore, the modulation may be the detector output of a facsimile or television receiver. Again, the signal source can be a microphone used in recording. The source of modulation signal energy can be a microphone used in sound-on-film recording, where the speed of the film will not permit full range recording. For the purpose of specific illustration, let it be assumed that the signal source provides a band of audio frequencies, such as voice or music.

The secondary winding of the transformer is connected to the input electrodes of an audio frequency amplifier tube 2. The audio amplifier tube is of conventional construction and connections, as those skilled in the art will readily recognize. The plate circuit of amplifier tube 2 includes the primary winding of the audio transformer 3. The secondary winding of the transformer 3 is connected to any desired modulation utilization network. The nature of the utilization network will depend on the system in which the amplifier is used. It may be a reproducer of the loudspeaker type in the case of radio reception; or it may be a recording device; or it can be a television reproducer. The numeral 12 designates the output leads to the utilization network.

It is to be understood that the network 1-2-3 as shown has the various elements thereof constructed and designed to provide a high fidelity audio transmission line. That is, the transformers are chosen so that audio frequencies of the entire audio frequency range can be transmitted faithfully. Those skilled in the art are fully acquainted with the manner in which such high fidelity audio transmission is secured. To provide the harmonics to be re-inserted into the transmission line, a potentiometer 4 has its resistor connected across the primary winding of transformer 1. The amplifier tube 6 has its input electrodes coupled to the secondary winding of an audio transformer 5, and the primary winding of the latter is connected across an adjustable portion of the potentiometer resistor.

In other words, the adjustable slider of the potentiometer 4 is connected to one end of the primary winding of transformer 5. The plate circuit of amplifier 6 includes the primary winding of transformer 7. The plate output transformer 7 is peaked by the retardation coil 8 whereby the transformer 7 can assume the characteristics of a high-pass filter. In other words the coil 8, which is a choke coil whose inductance can be varied as indicated by the arrow, functions to adjust the pass band characteristic of transformer 7 so that a selected portion of the higher audio frequencies can be transmitted to the input electrodes of the tube 9.

Tube 9 is shown as of the screen grid type. The signal grid bias is so chosen, and the magnitude of the positive voltage applied to the screen grid and plate is such, that tube 9 functions to distort the audio wave forms applied thereto. The tube can be operated class B or C, or in any other manner which yields rich harmonics. The output voltage developed by tube 9 is rich in harmonics. It is not believed necessary to describe the construction of the harmonic generator in further detail. Those skilled in the art are fully acquainted with the manner of constructing a tube circuit so as to distort audio waves supplied thereto thereby to provide abundant harmonics in the output circuit.

The harmonic energy is fed through the transformer 10 along with the fundamental frequencies which were supplied through transformer 7. The combined harmonic energy and fundamental frequencies are fed into the output leads 12. A phase reversing switch 11 is provided so that the harmonic energy can be fed into the output circuit in proper phase relation. The reversing switch need not be used, if so desired. It will be realized that the fundamental frequencies developed across the output of transformer 10 can be filtered out by using an additional high-pass filter between transformer 10 and switch 11. Such

a filter would permit only the harmonic frequencies to be fed to the output connections 12.

In order to prevent the harmonics from becoming too strong during high transmission levels, as would ordinarily be the case in the latter condition of audio amplitude, there is employed a control circuit whose input leads 13 are connected to the opposite ends of the secondary winding of transformer 3. The audio energy, amplified by tube 2, is fed through leads 13 to the transformer 14. The latter has its secondary winding arranged in series with the space current path of a diode rectifier 15 and load resistor 16. The load resistor 16 is properly by-passed for audio frequency components. There will be developed across resistor 16 a direct current voltage whose amplitude is dependent upon the percentage modulation, or input signal energy level. In other words, during high amplitude levels of audio transmission, the voltage developed across resistor 16 will have a greater magnitude.

It is only necessary to provide the direct current voltage connection 17 to a point on resistor 16 which becomes increasingly negative with respect to the grounded cathode end of the resistor as the transmission amplitude level increases. The end of lead 17 connected to resistor 16 may be made adjustable, and the other end of the lead 17 is connected to the lower end of the secondary winding of transformer 7. It will now be seen that the signal grid of tube 9, the harmonic generator, is variably biased in dependence on the value of the voltage developed across resistor 16. If the transmission level at the input terminals of amplifier 2 reaches, or exceeds, a predetermined amplitude level, the output of the harmonic generator 9 will be decreased.

In Fig. 2 there is shown a modification of the invention wherein the modulation signal input energy is applied to the primary winding of an audio transformer 18. The transformer 18 is provided with a pair of secondary windings 19 and 20. A tube 23 has its signal grid connected to the high side of winding 20. The low side of winding 20 is connected by an adjustable tap to a desired point on the bias potentiometer resistor 25. The potentiometer 25 has one end thereof grounded, while the opposite end may be connected to a direct current source which will provide the negative bias for the grids of tubes 22 and 23. In shunt with winding section 20 there is arranged a choke coil 21 whose inductance value may be adjusted, as shown by the arrow therethrough.

The secondary winding 19 has one end thereof connected to the signal grid of tube 22. The opposite end of the winding is connected to a point on resistor 25 which is at a less negative potential relative to the point on the resistor to which winding 20 is connected. Hence, the grid of tube 23 is given a more negative bias than the signal grid of tube 22. The cathodes of tubes 22 and 23 are connected in common through a resistor 30. The midpoint thereof is connected to ground to provide additional bias for the tubes, and to provide a commonly used hum balance. The screen grids and plates of tubes 22 and 23 are connected to the positive terminal of a common energizing source. The plates of the two tubes are arranged in push-pull relation. The audio transformer 24 couples the output circuit to the push-pull connected plates of the tubes 22 and 23.

The winding 20 is tuned by the retardation coil 21 so as to function as a high-pass filter. This is similar to the function of transformer 7 with the shunt retardation coil 8. Tube 22 is

biased normally, and it amplifies the signal energy in a distortionless manner. The tube 23, which is more negatively biased, functions to produce distortion and thereby provides a rich harmonic output. By virtue of the push-pull connection of the plates of tubes 22 and 23, a portion of the 2nd harmonics of the fundamental frequencies that are passed by tube 23 are balanced out of the energy transmitted through transformer 24 by the balancing energy available from tube 22.

In Fig. 3 there is shown a graphical analysis of the functioning of the invention. "Frequency" in cycles is plotted against "Relative gain." The curve A represents the approximate characteristics of a high fidelity audio amplifier. In other words, this is the characteristic of the audio transmission system 1—2—3 in Fig. 1, and 18—22—24 in Fig. 2. Curve B represents the pass band characteristic of a good I. F. amplifier with a pass band width not sufficiently broad to convey all of speech intelligibility. In other words, let it be assumed that the audio networks used in either of Figs. 1 or 2 are employed in a radio receiver of the superheterodyne type, wherein the I. F. amplifiers have pass band widths represented by curve B in Fig. 3. Such an I. F. amplifier is shown to have a pass band width of 4 kc., since some 2000 cycles is passed on either side of the carrier. Obviously, in such case the reproducer would produce slightly unintelligible speech or music.

The curve C represents the approximate characteristic of transformer 7 in Fig. 1 as the result of the action of the retardation coil 8. It will be seen from this characteristic that there is passed to the harmonic generator 9 of Fig. 1 frequencies over 1000 cycles. The frequencies between 1200 cycles at point a and 2000 cycles at point b represent 800 cycles that is fed into the harmonic generating tube 9 to be later re-inserted to improve the intelligence impaired due to the narrow band I. F. amplifier characteristic. The range between curves C and D represents approximately 800 to 1000 cycles amplified, distorted and the harmonics re-inserted to extend the apparent band pass to about 5000. In the broadcast band about 2200 cycles would be passed to the harmonic generator to extend the range from 15,000 to 17,000 cycles.

For partially restoring the higher harmonic content of standard broadcast band intelligence, the high-pass filter feeding the harmonic generator tube 9 would have a characteristic similar to curve D of Fig. 3. Approximately the same characteristics would be used to build up the higher harmonic content in reproduction that is normally lost in phonograph recording, and in sound-on-film recording. It has been demonstrated that the present invention is of particular value in rebroadcasting of foreign station transmissions, when reduction of the received band width is desired to a void interference, and when the transmitted signal does not carry sufficient intelligence. This is the case when a foreign station being received has a poor remote pick-up due to a poor line.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. A method of transmitting a narrow band of modulation signal frequencies through a transmission network having a relatively wider frequency pass band which includes, deriving from the narrow band of signal energy those frequencies located in the upper portion of the narrow band, producing harmonic frequencies from said upper portion frequencies, and combining the harmonic frequencies with the aforesaid narrow band signal energy thereby to improve the intelligibility of said narrow band signal energy.

2. In combination with a high fidelity audio amplifier network, a high-pass filter having input terminals connected to the input terminals of said amplifier, means for producing harmonic frequencies in the output of said high-pass filter, and means for injecting said harmonic frequencies into the output of said amplifier.

3. A method of improving the intelligibility of a narrow band of audio frequencies which includes deriving from the narrow band energy those frequencies located in the upper portion of the narrow band, converting the upper portion frequencies into harmonic frequencies, combining the harmonic frequencies with the original narrow band frequencies, and controlling the magnitude of the harmonic frequencies in response to the amplitude level of the narrow band energy.

4. A method of improving the intelligibility of a narrow band of audio frequencies which includes deriving from the narrow band energy those frequencies located in the upper portion of the narrow band, converting the upper portion frequencies into harmonic frequencies, separating the produced harmonic frequencies from the selected fundamental frequencies producing same, combining the harmonic frequencies with the original narrow band of frequencies, and controlling the amplitude of the harmonic frequencies in response to the amplitude level of the narrow band energy.

5. A method of transmitting a narrow band of audio signal frequencies through a transmission network having a relatively wider audio frequency pass band which includes the steps of deriving from the narrow band of audio signal energy those audio frequencies located in the upper portion of the narrow band, producing harmonic frequencies from said upper portion frequencies, separating the harmonic frequencies, and combining the harmonic frequencies with the aforesaid narrow band signal energy thereby to improve the intelligibility of said narrow band signal energy.

6. In combination with a high fidelity audio amplifier network, a high-pass filter having input terminals connected to the input terminals of said amplifier, a tube circuit for producing harmonic frequencies in the output of said high-pass filter, means for injecting said harmonic frequencies into the output of said amplifier, and additional means responsive to the audio signal level for controlling the harmonic amplitude.

7. A modulation signal transmission system comprising a main modulation signal amplifier channel, an harmonic channel having input and output terminals, means for applying to said harmonic channel input terminals energy from said main channel, a high-pass filter in said harmonic channel to produce energy of frequencies in the upper portion of the main channel fre-

quency band, a distortion generator adapted to be fed with the output of said filter, said generator producing harmonics means for connecting said output terminals of the harmonic channel to said main channel to inject into the latter said harmonic frequencies, and means responsive to signal amplitude to control the harmonic amplitude.

8. A method of improving the intelligibility of a narrow band of audio frequencies, which includes deriving from the narrow band energy such frequencies as are located in the upper portion of the narrow band, converting the upper portion frequencies into harmonic frequencies, combining the harmonic frequencies with the original narrow band frequencies, and controlling the amplitude of the harmonic frequencies, in response to the amplitude level of the narrow band energy, by rectifying said narrow band frequency energy and using the rectified energy to control the harmonic conversion.

9. A method of transmitting a predetermined band of frequencies through a transmission network having a relatively wider frequency pass band which includes, deriving from the band those frequencies which are located in the upper portion thereof, producing harmonic frequencies from said upper portion frequencies, and combining the harmonic frequencies with the total predetermined band.

10. A method of improving the intelligibility of a band of audio frequencies which includes deriving from the band energy those frequencies located in the upper portion of the narrow band, converting the upper portion frequencies into harmonic frequencies, separating the produced harmonic frequencies from the selected fundamental frequencies producing the same, and combining the harmonic frequencies with the original narrow band of frequencies.

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