My invention relates to amplifier networks. More specifically my invention is a method of and means for reducing hum or distortion arising within amplifier networks.

I am aware of arrangements for reducing hum in amplifiers. One well known method is a feedback system in which the residual hum in the output of an amplifier may be amplified. The residual or amplified hum is fed back to an earlier stage of the amplifier and there induced to oppose the original hum. The residual hum is then inversely proportional to the feedback amplification. If the residual hum is to be made very small, the feedback amplification must be made correspondingly great. This leads to serious difficulties; namely, excessive regeneration, and instability. Attempts to overcome these difficulties by phase shifting and band pass filters, instead of correcting the difficulty, operate to merely shift the oscillation or excessive regenerative point to a different frequency, generally within the useful band.

The present invention contemplates a method of reducing hum by means employing the total hum produced in the network rather than the residual hum after cancellation. This method requires a minimum of hum amplification and therefore a negligible problem of excessive regeneration and self oscillation. Furthermore in the present invention ordinary band pass networks may be used without deleterious effects on the amplifier network.

One of the objects of my invention is to reduce the hum in the output of an amplifier network by utilizing the total hum within the network, and feeding back this hum to cancel the output.

Another object is to eliminate output hum by amplifying the hum to overcome losses and feeding back the amplified hum to thereby cancel the original output hum without deleterious oscillation of the amplifier.

A further object is to correct regenerative tendencies outside the useful range of the amplifier by the use of appropriate filters in the feedback network.

In the accompanying figures, Figure 1 is a schematic diagram of one embodiment of my invention.

Figure 2 is a schematic diagram of a modification of the invention, and

Figure 3 is a circuit diagram illustrating an embodiment of the invention.

In Figure 1, a pair of input terminals are represented by reference numerals 1, 2. The input terminals are connected through the secondaries 5, 1 of transformers 9, 11 to the input of an amplifier 13. The output of this amplifier 13 is connected to the input 15 of a second amplifier 17. The output of the second amplifier is represented by numerals 18, 21. A potential source of hum is represented by the block 22. It will be seen that this hum is established within the second amplifier. Hum potentials of this type may be generated by alternating currents used for heating the cathodes, by incomplete filtering in the plate current source, or similar disturbances.

The input 15 to the second amplifier 17 is connected to the primary 25 of transformer 11. The output 19, 21 of the second amplifier is connected to the primary 27 of transformer 9. The transformers 9—11 are disposed so that no coupling exists between them, and their secondary potentials of the desired signals are opposed to each other and are adjusted to equality. Furthermore, the secondaries are connected in a high impedance input circuit. Because of the negligible coupling between input and output of the second amplifier no difficulties are experienced by the self-oscillation of this amplifier 17.

Hum potentials produced within the second amplifier appear as a difference in the form of the input and output potentials of the amplifier 17. This potential, representing hum, is fed back through the transformers 9—11 to the input circuit 1—2. The amount of feedback and the phase thereof may be adjusted to exactly oppose the hum created within the second amplifier 17. Normal signal potentials are not fed back due to the phase opposition of the secondaries.

The compensating hum potential now appearing across the input terminals 15 is impressed through transformer 11, on the input of the first amplifier in proper phase to maintain this compensating hum. The compensating hum fed through the amplifier 13 opposes the hum produced in 17 and may be made to substantially cancel such hum effects. Thus an anomalous condition exists in which hum or distortion created within the second amplifier may persist within the amplifier but it is eliminated from the output terminals of the amplifier.

The stability of the second amplifier 17 has already been explained. It has been found that a small gain in the first amplifier is sufficient to overcome the losses in the feedback circuit, and because of the small gain and the phasic connections of the entire network, the first amplifier is not inclined toward self-oscillation. Since the operation of the device is dependent on the entire hum potential, rather than the residual hum,
substantially perfect hum elimination may be secured. If phase shifts occur, the phase of the hum bucking potential should be corrected to produce elimination. Without such phase correction, the hum may be reduced but not eliminated.

In Figure 2, a modification of the circuit of Figure 1 has been illustrated. The input terminals 31, 33 are connected to the input of an amplifier network through a band pass circuit 37. The output of the amplifier network is represented by terminals 39, 41. One of the input terminals and one of the output terminals may be grounded as shown. The other input 31 and output 39 terminals are connected by a resistor 43 of high value. The resistor 43 is arranged to establish opposing signal potentials at a tap 44 intermediate its terminals. The high impedance of this resistor offers negligible coupling between the input and output circuits of the amplifier. A resistor 45 of low value is connected between the tap 44 intermediate the ends of the high impedance resistor 43 and ground. The low impedance resistor 45 is connected to the input of an amplifier 47 by means of a slider 48. The output of the amplifier 47 is connected to a band pass circuit 37. This circuit 37, as previously explained, is serially included in the input to the amplifier network 45. The band pass circuit may be used to eliminate currents of frequencies which tend to establish excessive regeneration. This circuit 37 may likewise be used as a phase correcting network.

In the operation of the circuit of Figure 2, it is presumed that a source of undesired hum potential exists within the amplifier network 36. Although signal potentials impressed on the input 31, 33 are substantially eliminated in the resistor 43, the hum currents within the amplifier network 36 will flow through the high impedance resistor 43 and ground. The potentials developed by these currents are impressed on the amplifier 47, and are therein amplified just sufficiently to overcome the losses in the resistors 43, 45 and band pass 37. The amplified potentials are impressed on the input to the amplifier network 36 in proper magnitude and phase to substantially cancel the hum within the amplifier network 36. The amount of hum potential fed back may be determined by adjustment of the slider 48 or gain of the amplifier 47. The band pass circuit 37 may be used to eliminate currents of a frequency which cause excessive regeneration. This circuit 37 may also include means for correcting undesirable phase shifts.

In Figure 3, the input circuit is represented by the transformers 51, 53 whose windings have been serially connected as shown. The secondary 55 of input transformer 51 is connected to the input circuit of a thermal amplifier 57. The output of this amplifier may be coupled by a transformer 59, or other suitable coupling means, to the input of a second thermal amplifier 61. The output of the second thermal amplifier is represented by a transformer 65. The cathodes 65, 67 may be self biased as shown. The cathodes are energized by heaters 69, 71 which are energized by alternating current from a source represented as 72. It is presumed that the undesired hum originates in this source 73 which is within the amplifier network just described.

The high potential points of the first amplifier input and the second amplifier output are connected by a resistor 75. The coupling and the impedance of this resistor are in accordance with the preceding description of resistor 43. A resistor 77, whose impedance is relatively low, is connected between a point intermediate the terminals of the resistor 75 and ground. A slider 79 is connected to the resistor 77, and serially through the biasing battery 81 to the grid 83 of an amplifier 85. The cathode 87 is connected to a battery 89 and ground. The output of this amplifier 85 is connected to a band pass circuit 91 which may include a phase correcting network. The output of the band pass circuit 91 is connected to the primary 93 of transformer 53. Inasmuch as the theory of operation is essentially the same as the foregoing circuits, it is not necessary to repeat the description.

It should be understood that my invention is not limited to any particular type of amplifier, but may be applied to any amplifier network in which an undesired hum is established. For example, the foregoing circuits may be applied to audio amplifiers, power amplifiers, modulators, and radio frequency amplifiers. I have also discovered that these circuits may be entirely suitable for the elimination of distortional effect other than or including hum, created within an amplifier network. The phase correcting networks may be applied to any portion of the amplifying system. In a similar manner, band pass filters may be used in various positions other than the one illustrated.

I claim as my invention:
1. An amplifier having input and output circuits, each of said circuits including a transformer, and included between said circuits a source of undesired disturbance, means for eliminating said undesired disturbance from the output of said amplifier comprising a high impedance circuit connecting the secondary of the transformer in said input circuit and the secondary of the transformer in said output circuit, a second amplifier having an input and an output circuit, a connection from said high impedance circuit to the input circuit of said second amplifier, and a connection from said second amplifier output circuit to the first mentioned input circuit including means for correcting undesired phase shift of currents flowing in either of said amplifiers so that currents may be applied to said first mentioned amplifier which are of such a phase and amplitude that said disturbances are substantially reduced.
2. An amplifier having input and output circuits and included between said circuits a source of undesired disturbance, means for eliminating said undesired disturbance from the output of said amplifier comprising a high impedance circuit connecting said input and output circuits, a second amplifier having an input and an output circuit, a connection from said high impedance circuit to the input circuit of said second amplifier, and a connection from said second amplifier output circuit to the first mentioned input circuit, said last named connection including serially connected means for correcting undesired phase shift of currents flowing in the last mentioned connection.
3. An amplifier having input and output circuits and included between said circuits a source of undesired disturbance of certain frequencies, means for eliminating said undesired disturbance from the output of said amplifier comprising a high impedance circuit connecting said input and output circuits, a second amplifier having an input and an output circuit, a connection from
said high impedance circuit to the input circuit of said second amplifier, and a connection from said second amplifier output circuit to the first mentioned input circuit, said second amplifier output circuit including a band pass filter circuit for attenuating currents of frequencies other than said certain frequencies which flow through either of said amplifiers.

4. An amplifier having input and output circuits and included between said circuits a source of undesired disturbance of certain frequencies, means for eliminating said undesired disturbance from the output of said amplifier comprising a high impedance circuit connecting said input and output circuits and arranged to oppose signal potentials existing between said circuits, a second amplifier having an input and an output circuit, a connection from said high impedance circuit to the input circuit of said second amplifier, and a connection from said second amplifier output circuit to the first mentioned input circuit, said last named connection including means for correcting undesirable phase shift of currents flowing in the last mentioned connection, and further including a band pass filter circuit for attenuating currents of frequencies other than said certain frequencies which flow through the last mentioned connection.

5. The method of controlling undesirable disturbing currents of certain frequencies within a band distinct from the desired frequency band, said disturbing currents originating within an amplifier having input and output circuits, which comprises coupling said input and output circuits, causing said disturbing currents to flow through said coupling, amplifying said disturbing currents, correcting any undesired phase shift of said amplified currents, attenuating currents of other than said certain frequencies and impressing the resulting currents on the input of said amplifier so that currents are established which substantially oppose the disturbing currents in said amplifier.

6. The method of controlling undesirable disturbing currents of certain frequencies within a band distinct from the desired frequency band, said disturbing currents originating within an amplifier having input and output circuits, which comprises coupling said input and output circuits, causing said disturbing currents to flow through said coupling, amplifying said disturbing currents, adjusting the phase of said disturbing currents, attenuating currents of frequencies other than said certain frequencies, and impressing resulting currents on the input of said amplifier so that currents are established which substantially oppose the disturbing currents from said output circuit without substantial change in the amplitude of currents of frequencies other than said certain frequencies.

7. The method of controlling undesirable disturbing currents of certain frequencies within a band distinct from the desired frequency band, said disturbing currents originating within an amplifier having input and output circuits, which comprises coupling said input and output circuits, causing said disturbing currents to flow through said coupling, amplifying said disturbing currents, correcting any undesired phase shift of said amplified currents, attenuating currents of other than said certain frequencies and impressing the resulting currents on the input of said amplifier so that currents are established which substantially oppose the disturbing currents in said amplifier.

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