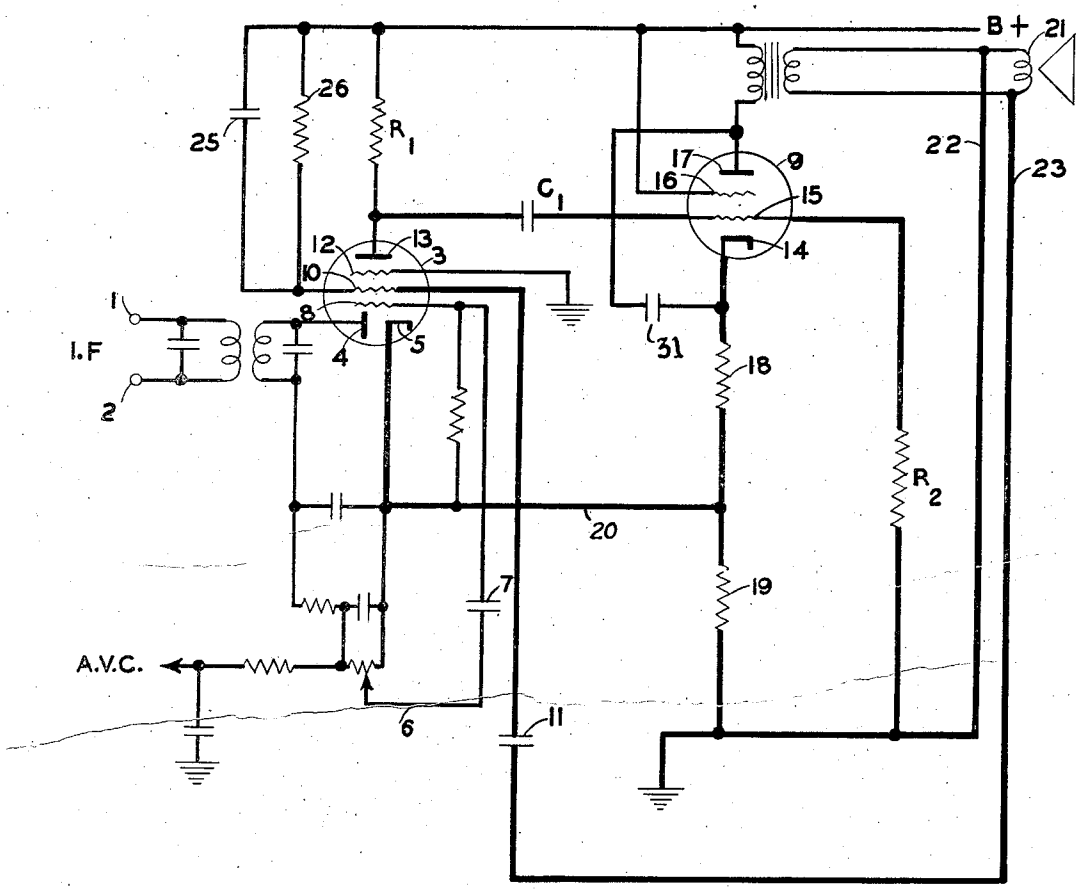
Sept. 24, 1946. H. TOOMIM 2,408,242

REGENERATIVE BASS COMPENSATION CIRCUIT

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FIG. 1.



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FIG. 2.

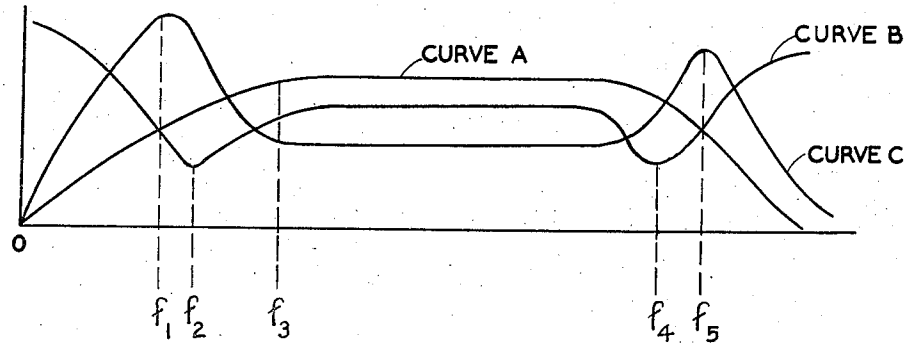
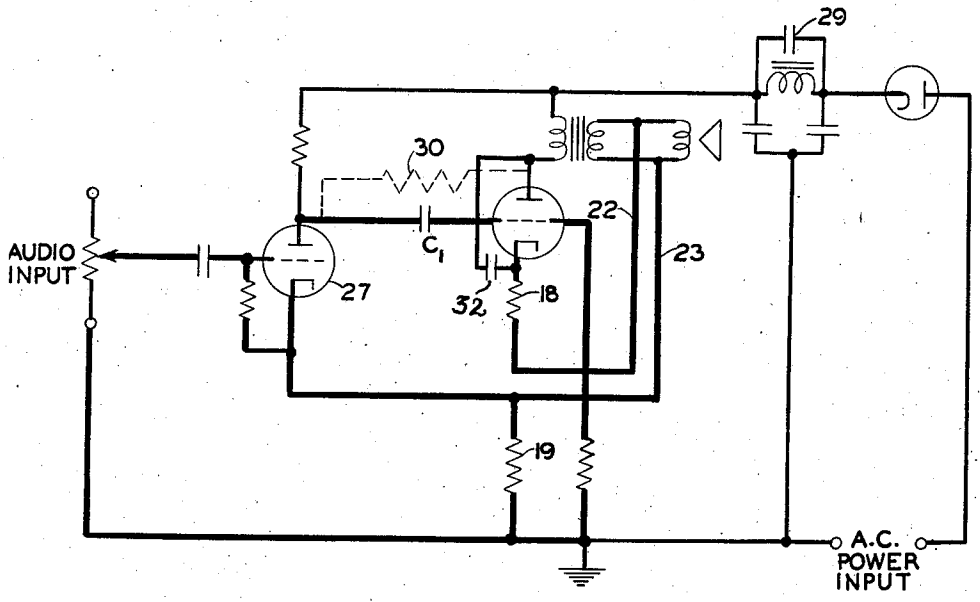


FIG. 3.



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REGENERATIVE BASS COMPENSATION CIRCUIT

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12 Claims. (Cl. 179—1)

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Regenerative bass compensation circuits such as shown, for example in Shepard Patent No. 2,313,098, have been found to be practical and efficient circuits for use in order to drive a small loudspeaker to reproduce lower audio frequencies. Such a regenerative compensation circuit has the advantage that a volume compression action as well as almost any desired degree of compensation may be readily secured by regeneration over two stages of amplification.

It has heretofore been suggested that such regenerative circuit be used in combination with degeneration derived from the voltage across the load impedance. This type of regeneration effectively reduces the impedance from which the load works and therefore has a beneficial damping effect.

Small radio receivers, of which the largest volume is sold, generally use two audio frequency tubes, the first of which is a combination diode detector and triode amplifier, and the other a power output tube. The combination of the regenerative and degenerative feed backs referred to above has heretofore been proposed in circuits adapted for use in such sets. In such use, a pentode has been proposed for use as the first audio tube, following the detector. In such a circuit, as shown in Figure 5, of the Shepard patent mentioned above, it is necessary to use a separate stage of detection prior to the audio pentode stage in order to be able to use the grids of the pentode for the various feed back voltages.

It has also been suggested to use a duplex diode pentode tube as the first audio tube, as shown in Figure 6, for example, of said Shepard patent. This has, however, in circuits heretofore proposed, involved the sacrifice of a considerable amount of power, actually in Figure 6 of said Shepard patent, a sacrifice of 50% of the power.

An object of this invention is to provide a regenerative bass compensation circuit which combines the advantages of a degenerative feed back as mentioned above, but eliminates the disadvantages of such combination. By the use of my invention I am able to employ a combination diode pentode tube as the first audio tube of a radio set having a power output tube, and avoid the disadvantages referred to above. I am also able to do this while providing excellent filtering, or some other means of hum reduction, which is necessary, or at least highly desirable, in all bass boost amplifiers as the regenerative bass boost makes the amplifier highly susceptible to power supply ripple.

A feature of my invention is the combination

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of a regenerative and degenerative feed back between the screen grid and cathode of an audio amplifier, to produce a desirable bass boost characteristic, by the use of only a minimum of additional elements.

Another feature of my invention is the combination of a suitable humbucking or filtering means in such a circuit.

In the drawings,

Figure 1 is a circuit diagram illustrating a preferred embodiment of my invention;

Figure 2 is a series of curves illustrating the operation of the circuits of my invention; and

Figure 3 is a circuit diagram illustrating possible modifications of my invention.

In Figure 1 an incoming radio frequency signal, which may be the intermediate frequency output of a heterodyne stage of a radio receiver, is indicated as being applied to the terminals 1, 2 at the left of the figure. It will be understood that this will be the output of the last intermediate frequency stage of a superheterodyne radio receiver which embodies my invention. The incoming intermediate frequency signal is rectified in tube 3 in the diode rectifier which comprises the anode 4 and cathode 5. This is a usual rectifier circuit in accordance with standard practice. An A. V. C. voltage may be produced for use in any desired manner in accordance with usual practice. Also in accordance with usual practice, the audio frequency signal is applied through lead 6 and condenser 7 to the first grid 8 of the tube 3. This signal will be amplified in the tube 3 and supplied to the power output tube 9 where it will be further amplified and translated in the loudspeaker.

In my circuit I employ a condenser C_1 between the anode 13 of the tube 3 and the grid 15 of the tube 9 which, as shown, may have a preferred value of .004 microfarads in order to discriminate in favor of the higher frequencies. The voltage applied to the grid 15 will therefore have a characteristic of amplitude with respect to frequency which is illustrated in curve A of Figure 2. This voltage will, of course, vary the plate current and, due to the resistances 18 and 19 in the cathode lead of tube 9, the potential of the cathode will vary accordingly. A portion of the voltage across the resistances 18 and 19 will be fed back through the lead 20 to the cathode of tube 3 in regenerative phase. Accordingly, these voltages will be further amplified in the tube 3, as will be understood.

A dynamic loudspeaker of approximately 6 inches diameter will have a resonance peak at

low audio frequencies and a second but lower resonance peak at high audio frequencies. I connect the voice coil 21 of such a loudspeaker through leads 22 and 23 and condenser 11 in the circuit between screen grid 10 and ground to produce an effective voltage between the grid 10 and cathode 5 in degenerative phase. The effective voltage fed back from the loudspeaker is indicated in Figure 2 by curve B, which will be recognized as the resonance curve of such a speaker turned upside down.

The curves have been shown in this form for convenience of explanation. It will be understood that the feedback represented by the curve B is actually a negative feedback and, therefore, might be shown below the zero line. If it were so shown then the total effective feedback at any frequency could be determined by simply adding curves A and B. Such an addition would show that a maximum positive feedback occurs at frequency F_1 and again at frequency F_5. It will be understood that in thus transposing curve B to be below the zero line, the left end of curve B as it appears in the figure will coincide with zero and the right end of curve B as it appears in the figure will also coincide with zero.

Curve C of Figure 2 indicates the voltage at the control grid 15 of the output tube 9 due to the combination of curves A and B. It will be noted from Figure 2 that curves A and B cross at frequency f_1 which will be a frequency of approximately 100 cycles. At or near this frequency the effective voltage, due to the combination of regeneration and degeneration, will have its maximum as indicated by curve C. Therefore, the loudspeaker output will be given an effective bass boost at approximately this frequency.

It may also be seen from Figure 2 that curves B and C again cross at frequency f_5, which will be approximately 4000 cycles. There will accordingly also be an accentuation of this frequency, which is desirable as it gives the loudspeaker characteristic the effect of crispness in reproducing speech.

It will be understood that the regenerative voltage will be smaller than the degenerative voltage at all frequencies between the two speaker resonance points. The overall effect will therefore be regenerative except for frequencies within the pass band of the loudspeaker at which the overall effect will be degenerative.

In order to compensate for anode supply potentials I provide condensers 11 and 25 and resistance 26. Any hum potentials present will divide between the condensers 24 and 25. These will be supplied to the grid 10 in phase to neutralize any potentials from the same source which may be applied to the anode 13. By a suitable choice of values for the condensers 24 and 25 the hum may be minimized to the extent necessary.

It will be noted that in my circuit I am using the inverse speaker characteristic to define or select a desired regeneration frequency, thereby eliminating the necessity for using special frequency selective networks for such a purpose, and therefore eliminating the necessity for circuit elements that have previously been used in such circuits, while improving the characteristics of the circuits themselves. By applying all feedback voltages to the screen of the pentode I also make it possible to combine in such a tube a diode detector operating in the usual fashion. This is highly desirable as it permits the use of standard tubes now available, and avoids the necessity of designing an intermediate frequency amplifier, around combination diode-pentode low gain tubes. It effects an increase in gain on the order of 2 to 1 with tubes now available, as well as being more economical.

The use of the inverse speaker characteristic to select a regeneration frequency may be accomplished in other circuits, in which a triode or other type tube is used in either or both circuits. One such circuit is shown in Figure 3 in which both the regenerative and degenerative feedbacks are applied between the grid and cathode of the tube 27. The operation of Figure 3 is otherwise substantially the same as that of Figure 1, and will be understood therefrom.

When triodes are used, as shown in Figure 3, the sensitivity to power supply ripple is great enough to require excellent filtering or some other type of hum reduction. Since neutralization is difficult when the triode is used, I have shown, in Figure 3, the use of a filter circuit which, by employing a condenser 29, may be made resonant to the principal ripple frequency, and therefore, filters this frequency out to the necessary extent at only a slight increase in cost.

In Figures 1 and 3 I have illustrated a portion of the circuit in heavy black lines, which portion includes leads 22 and 23 from the voice coils of the loudspeaker. It will be understood that in feeding back a voltage from the voice coil in degenerative phase, this voltage may be fed back by applying it at any point in the circuits defined by these heavy black lines. Wherever it is applied in this circuit its effect will be the same qualitatively. Its quantitative effect will be different, depending upon the impedance of the particular speaker used. As a practical matter therefore the point at which this voltage will be inserted will be chosen in accordance with the impedance of a particular speaker it is desired to use with my circuit.

In Figure 3 I have indicated, in broken lines, a resistance 30 connected between the anodes of the two tubes. Such a resistance so connected may be used to supply the degenerative feed back voltage reflected from the voice coil, in which event the leads 22 and 23 will be removed and the resistances 18 and 19 connected. The impedance of the loudspeaker will be reflected back into the primary coil connected to the anode of the output tube and thus modify the voltage appearing at this anode. This voltage will be fed back through the resistance 30 to the anode of tube 27 and thereby be introduced into the regenerative loop indicated by the heavy lines. The voltage thus introduced will be introduced in degenerative phase so that the operation of the circuit will be the same as before.

It will be understood that while I have illustrated specific circuits and particular values, my invention is capable of various modifications which will be understood by those skilled in the art. I do not desire, therefore, to be restricted to the particular details shown and described, but only within the scope of the appended claims.

It will, of course, be understood that conventional systems of tone compensation, such as tapped volume controls, etc., may be used in combination with the circuits disclosed herein with the usual benefits.

What is claimed is:

1. An audio amplifier circuit comprising an input circuit, an audio amplifier tube, and an output circuit, a transducer connected in said output circuit, means for regeneratively feeding

back to said amplifier a voltage having a characteristic which discriminates against frequencies lower than the low frequency resonance point of said transducer and in favor of frequencies higher than the low frequency resonance point of said transducer, means for degeneratively feeding back to said amplifier a voltage having a characteristic which discriminates in favor of frequencies higher than the low frequency resonance point of said transducer, and means for deriving said second voltage from said transducer.

2. An audio amplifier circuit comprising a pair of audio amplifier tubes, a circuit which discriminates in favor of high frequencies connecting the output of the first tube to the input of the second tube, an output circuit for said second tube, a transducer connected in said output circuit, means for regeneratively applying a portion of the current from the output of said second tube to the input of said first tube, and means for degeneratively applying a voltage derived from said transducer to the input of said first tube, whereby the overall frequency response characteristic of said amplifier circuit is affected by said transducer to produce a boost of low frequency response.

3. An audio amplifier circuit as defined in claim 2, in which the first tube is a combination diode pentode tube, and a detector circuit connected between the diode anode and the cathode of said tube.

4. An audio amplifier circuit as defined in claim 2, in which the first tube has a plurality of grids including a screen grid and a cathode, and in which the feed back voltages are applied between said screen grid and cathode.

5. An audio amplifier circuit as defined in claim 2, in which the first tube has a plurality of grids including a screen grid and a control grid, and in which the feed back voltages are applied between the screen grid and cathode and no feed back is applied between the control grid and cathode.

6. An audio amplifier circuit as defined in claim 2, in which the transducer voltage is introduced into the circuit of the regenerated voltage.

7. An audio amplifier circuit comprising a combination diode-pentode first amplifier tube and a power output tube, means for applying a radio frequency voltage to the diode of said first tube, a

rectifier circuit connected to the diode elements of said first tube whereby said radio frequency voltage is rectified, means for applying said rectified audio frequency voltage to the control grid of said first tube whereby it is amplified therein, a condenser connected between the anode of said first tube and the control grid of said second tube, a pair of resistances connected in the cathode lead of said second tube, a connection from the midpoint of said resistances to the cathode of said first tube, an output circuit connected to said second tube, a loudspeaker connected in said output circuit, said loudspeaker having a voice coil, a condenser connected to the screen grid of said first tube, and a circuit connecting said voice coil between said condenser and said resistances.

8. An audio amplifier circuit as defined in claim 7, in combination with means for compensating anode supply potential variations.

9. An audio amplifier circuit comprising a pair of amplifier tubes, the first of said tubes being a triode, a circuit which discriminates against low frequencies connecting the output of said first tube to the input of said second tube, means for regeneratively supplying current from the output of said second tube to the input of said first tube, an output circuit connected to said second tube, a transducer connected in said output circuit, and means for deriving a voltage from said transducer and applying said voltage degeneratively to the input circuit of said first tube, whereby the overall frequency response characteristic of said audio amplifier is affected by the impedance characteristic of said transducer.

10. An audio amplifier circuit as defined in claim 2, in which the degenerative feed back voltage is derived from said transducer and supplied to said first tube by means of a resistance connected between the anodes of said tubes.

11. An audio amplifier circuit as defined in claim 7, in which said degenerative voltage is derived from said transducer and supplied to said first tube by means of a resistance connected between the anodes of said tubes.

12. An audio amplifier circuit as defined in claim 7, in combination with a rectifier and a power rectifier circuit having a filter section resonant to the principal ripple frequency in the output of said rectifier.

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