Sept. 9, 1941. J. M. RIDDLE, JR 2,255,679

AUDIO FREQUENCY AMPLIFIER

Filed May 31, 1939

Fig. 1.

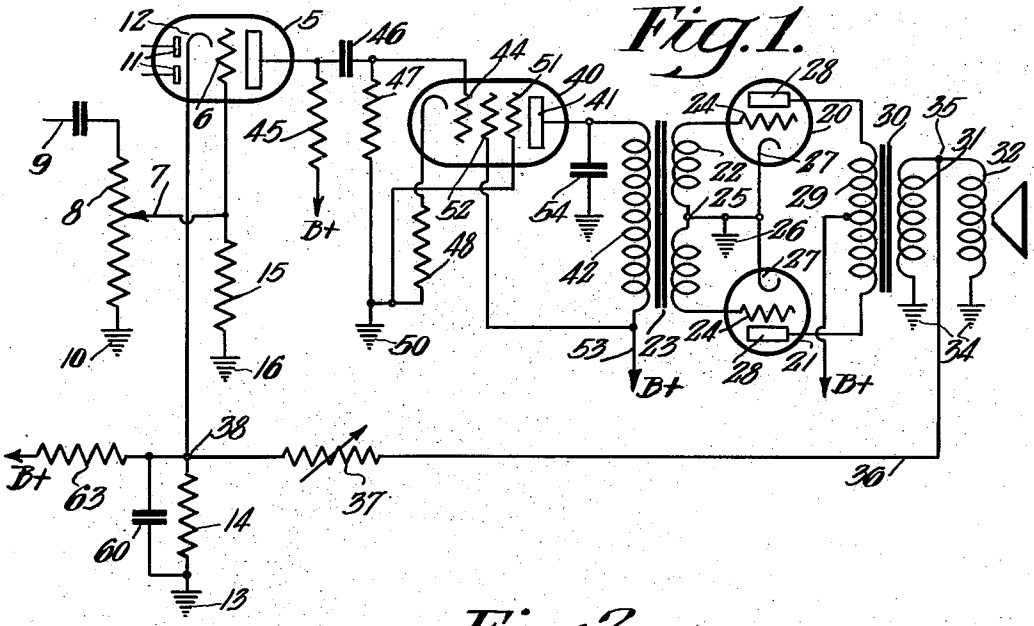
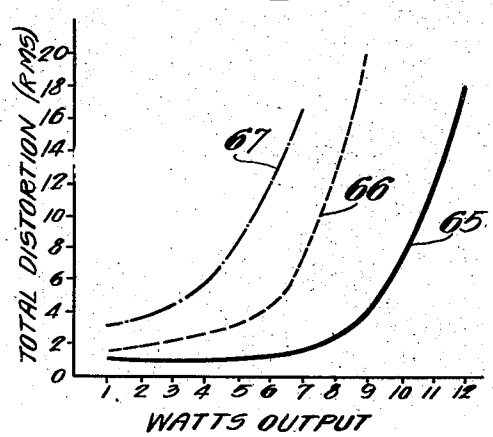


Fig. 2.



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AUDIO FREQUENCY AMPLIFIER

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2 Claims. (Cl. 179—171)

The present invention relates to audio frequency amplifiers, and has for its object to provide an improved audio frequency amplifier for producing large power output without distortion, with a minimum number of amplifier tubes and with a relatively low power audio frequency input voltage.

The invention is particularly adapted for use in battery operated radio receivers wherein the power supply is limited, while, at the same time, a relatively high undistorted power output is desired.

In providing a high power output, it is desirable to utilize a class B or class AB audio frequency output amplifier, requiring power over all or part of each cycle, and it is therefore a further object of the present invention to provide an audio frequency amplifier having adequate driving power and sufficient gain to operate with an output stage requiring driving power from a high impedance source, such as a high impedance triode amplifier, and with a small tube complement.

It is also a further object of the present invention to provide an improved audio frequency amplifier for low power radio apparatus providing a relatively high gain, and high power output with low distortion through the effective use of inverse or degenerative feedback.

It is also an object of the present invention to provide an improved audio frequency amplifier having a class B output power stage of the zero bias type requiring driving power over substantially the full frequency cycle, with a relatively high gain driver stage therefor of the pentode type permitting a high order of inverse feedback to overcome distortion in the feedback loop, including the driver stage.

In battery operated receivers and amplifiers, the class B or class AB output stage is advantageous in that in the absence of received signals the anode current is relatively low. A disadvantage of the class B or class AB amplifier stage lies in the fact that it requires a relatively high powered driver. While inverse feedback tends to decrease distortion in an amplifier, it also tends to reduce the over-all gain of the amplifier.

Accordingly, it is also an object of the present invention to provide an improved audio frequency amplifier which permits a class B or class AB amplifier stage to be utilized in connection with a high gain driver stage which permits a high order of inverse feedback without appreciably reducing the overall gain below a desired value such as is normally provided without inverse feedback.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing.

In the drawing,

Figure 1 is a schematic circuit diagram of an audio frequency amplifier embodying the invention, and

Figure 2 is a graph showing curves illustrating an operating characteristic of the amplifier shown in Fig. 1.

Referring to Fig. 1, the audio frequency amplifier shown by way of example comprises a high impedance triode, voltage amplifier provided by a tube 5 as a first stage having a control grid 6 connected to the volume control contact 7 of a volume control potentiometer 8, to which incoming audio frequency signals are applied through an input lead 9 and a ground or chassis connection 10.

The high impedance first stage amplifier tube may be included in the same envelope with diode detector anodes indicated at 11 having a common cathode 12 connected to ground or chassis 13 through a low resistance bias resistor 14. The bias potential from the resistor 14 is applied to the control grid 6 through a grid resistor 15 connected to chassis as indicated at 16.

The amplifier output stage comprises a pair of class B amplifier triodes 20 and 21 having a balanced input circuit comprising the secondary 22 of a step-down transformer 23 providing a low resistance input circuit connected at its terminals to the control grids 24 and having a center tap 25 connected to ground 26 and to the cathodes 27, as indicated, for zero bias class B operation. The output anodes 28 are connected in balanced relation to the primary 29 of the class B output transformer 30, the secondary 31 of which is connected with the loudspeaker load represented by the voice coil 32.

One side of the secondary circuit is grounded to chassis as indicated at 34. The opposite high potential side of the secondary is provided with a terminal connection 35 for an inverse feedback lead 36 having a series controlling resistor 37 therein and an output connection to the cathode terminal 38 of the cathode resistor 14 in the first stage, thereby to provide inverse feedback to the first audio frequency stage under control of the resistor 37.

The amplifier utilizes a pentode tube 40 as the second stage amplifier or driver stage for the

output stage. The use of a pentode tube for a driver stage ordinarily results in severe distortion and an unsatisfactory fidelity characteristic. However, the pentode driver has the advantage that a higher power output is obtainable therefrom because of the better plate efficiency of the tube for a given plate voltage. This provides an adequate power source for driving an output stage of the class B or class AB type and, at the same time, takes less output voltage from the first audio frequency amplifier stage 25.

The advantage of the high signal gain and power of the pentode is retained by providing a relatively high degree of inverse feedback which is sufficient to correct the high distortion characteristic of the pentode driver stage, while a portion of the relatively high gain is maintained through the amplifier substantially higher than available with a usual triode driver.

In the preferred arrangement shown, the pentode driver stage is connected between the first stage tube 5 and the class B stage 20—21 by connecting the output anode 41 of the pentode to a high impedance primary 4 of an interstage coupling transformer 23, and the input or signal grid 44 is coupled to the high impedance output circuit 45 of the first stage amplifier through the usual capacity coupling means 46 provided with a high resistance grid leak 47.

The pentode is provided with an unbypassed cathode resistor 48 from which bias for the control grid 44 is derived and a predetermined degree of degeneration which further aids in preventing distortion. Furthermore, the unbypassed resistor does not introduce any phase shift. The cathode circuit is grounded as indicated at 50. The suppressor grid 51 is connected to ground and the screen grid 52 is connected to the positive supply lead indicated at 53, which also supplies the anode 41. The primary 42 is shunted by a capacitor 54 which cuts off the amplifier response above the audio frequency range to prevent oscillation at a higher frequency such as 35 kc., where the low leakage reactance tends to resonate.

With an RCA 6Q7 tube for the first stage amplifier, an RCA 6J7 pentode as the tube 40 and the tubes 20 and 21 provided by a single RCA 6N7 class B twin output tube, highly stable amplifier operation has been obtained in a low power battery amplifier with a resistor of substantially .5 megohm at 45 and 47, a coupling capacitor of .5 mmf. at 46, and a grid leak of 1 megohm at 15. The self-bias resistor 48 without by-pass is approximately 600 ohms.

The resistor 14 in the cathode circuit of the first stage amplifier 5 is preferably of a low value and may be of the order of 680 ohms to prevent degeneration in the first stage 5. For this reason, bleeder current is provided therethrough from a suitable source controlled by a series resistor indicated at 53. The by-pass capacitor 60 is of a value sufficiently small to prevent introducing any frequency characteristic into the feedback circuit.

It has been found that, with a resistance of 1500 ohms at 37 a feedback of the order of 32 db. is permissible, and that when this resistance is increased to 3200 ohms and the feedback is increased to substantially 36 db., stable operation is possible, for the reason that the pentode driver stage is included in the feedback loop between the amplifier input circuit and the output stage. Heretofore, as is well known, an inverse feedback of the order of 15 db. has been considered normal.

This amplifier is highly effective and economical for battery operated receivers and the like for the reason that a high gain tube such as a pentode may be used as a driver stage for a class B amplifier. The high power sensitivity makes it possible to drive the class B or class AB output stage effectively without appreciably loading a high mu or high impedance first stage amplifier. The distortion of the pentode may entirely be eliminated by the high order of feedback through the loop including the pentode tube while the remaining gain of the pentode is effective to provide a desired over-all gain for the amplifier.

For a given wattage output, the three-stage amplifier shown has an over-all characteristic as indicated by the curve 65 in Fig. 2, whereas, with an equivalent rating triode driver in place of the pentode 40, the distortion is indicated by the curve 66. The distortion of a standard class B amplifier with triode driver and no feedback is indicated by the curve 67.

It has been found that the undistorted power output of an amplifier, as shown in Fig. 1, may be of the order of 40 percent higher than that obtained with a conventional class B feedback amplifier provided with a triode driver stage and first stage amplifier.

Summarizing the foregoing, the inverse feedback loop is provided through the three amplifier stages, thereby correcting distortion and other undesirable frequency characteristics of the pentode driver stage, permitting the full power output therefrom to be made available for driving the class B stage and permitting a relatively high gain through the amplifier by reason of the high gain of the pentode stage over the reduction in gain introduced by the high degree of inverse feedback.

I claim as my invention:

1. An audio frequency amplifier comprising, in combination, an output stage having a low impedance input circuit requiring power over at least a portion of each signal cycle, said amplifier stage having a low gain and a relatively high power output, means for compensating for said low gain and for providing power for said input circuit comprising an amplifier stage having a high power sensitivity and a high impedance output circuit, a step-down transformer having a high impedance primary winding connected in said high impedance output circuit and having a low impedance secondary connected in said first-named input circuit thereby to provide a step-down coupling connection between said high impedance output circuit and said low impedance input circuit, an output circuit for said output stage, an output transformer having a primary connected in said last-named output circuit and having a low impedance secondary, means providing a load circuit connection for said secondary, means providing an inverse feedback loop through said amplifier stage and said low impedance secondary to compensate distortion generated in said amplifier stage, and means for controlling the inverse feedback current through said loop.

2. In an audio frequency amplifier having a zero bias, class B, balanced output stage requiring power input over at least a portion of each signal cycle, of means for compensating the low gain of said amplifier stage with a minimum number of preamplifier stages comprising an amplifier stage having a high power sensitivity and a high impedance output circuit, a step-down

transformer having a relatively high impedance primary connected with said last-named output circuit and having a relatively low impedance secondary connected in the input circuit of said output stage, a step-down output transformer for said output stage having a low impedance secondary, means providing an inverse feedback connection from said last-named secondary through said amplifier stage, and means in said feedback connection and in said amplifier stage for controlling the tendency of said amplifier to oscillate above the audio frequency range of the amplifier when the feedback is intensified above a predetermined normal value.

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