

High-Quality Treble Amplifier

Cdr. CHARLES W. HARRISON, JR., USN*

The author describes a four-watt amplifier which employs a single-ended output stage, and which is intended for use as a driver for the tweeter of a two-way speaker system for home use. This unit will considerably decrease the cost of a two-amplifier system.

1. Introduction

IN A RECENT PAPER¹ the writer described a dual-channel playback system consisting of a dividing network and two identical amplifiers for driving the bass and treble sections of a dual loudspeaker. This arrangement is economical when speaker elements of approximately the same efficiency are employed, as for example, horn-type speakers for the reproduction of both the low and high frequencies. When the bass section is much less efficient than the treble system, as will be the case when direct-radiator dynamic loudspeakers are used for bass and a horn-type speaker for treble, it becomes entirely feasible to use amplifiers of considerably different power output ratings in a divided amplifier system. For example, if a direct-radiator bass speaker, in the appropriate baffle, has a conversion efficiency of 5 per cent, and the high frequency driver with horn has an efficiency of 50 per cent, 40 watts input to the woofer and 4 watts input to the tweeter will result in the radiation of 2 watts of acoustic power in each channel. One will be able to achieve low-frequency/high-frequency balance² under most circumstances, and simultaneously utilize the power capabilities of the bass and treble amplifiers. As a practical matter the proper setting of the volume controls on the amplifiers to obtain the most pleasing response must be determined experimentally by conducting listening tests in the room in which the dual loudspeaker is located.

The purpose of this note is to describe a simple 4-watt single-ended amplifier intended for use as a driver for treble speakers, such as the Western Electric 594A, Jim Lansing D-375, or Altec 288B, when used in a home music reproducing system, or small auditorium. The fact that the power output of the amplifier

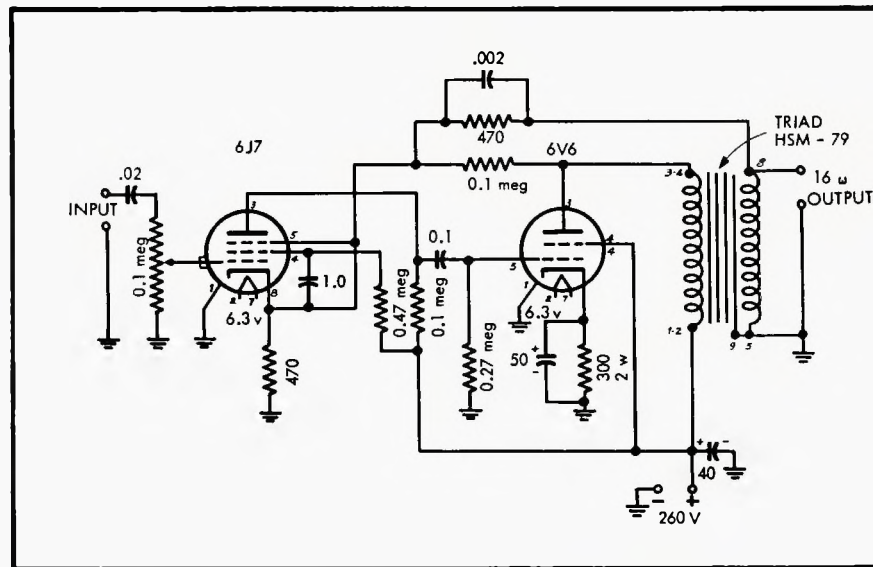


Fig. 1. Schematic wiring diagram of 4-watt treble amplifier.

cannot exceed 5 watts, regardless of the frequency and amplitude of the excitation voltage, insures that the tweeter diaphragm will not be fractured by the inadvertent application of low-frequency signals, or by the development of faults in the treble amplifier.

The Amplifier

The amplifier is built around the Triad HSM-79 hermetically sealed, high-fidelity output transformer. This transformer has a 5000-ohm primary designed to carry an unbalanced current of 40 ma, and secondary impedances of 16, 8 and 4 ohms are available. The guaranteed frequency response is within 1 db from 50 cps to 25 kes.³ The response is greatly improved particularly at the high end of the frequency spectrum, by the application of negative feedback around the

transformer. Two tubes are used in the amplifier—a 6J7 followed by a 6V6. The schematic is shown in Fig. 1. Two feedback paths are employed—one from the plate of the 6V6 to the cathode of the 6J7; the other path is from the secondary of the output transformer to the cathode of the 6J7. These paths are not independent, i.e., changing the circuit parameters in one path changes the effective value of feedback into the other path.

Performance Data

The performance data presented here was obtained from measurements made on an amplifier having circuit values shown in Fig. 1, with the following exceptions: (a) The .02- μ f input capacitor was shorted. (b) A 270-ohm resistor was used in the cathode circuit of the 6V6 output tube in lieu of the 300-ohm 2w resistor shown in the drawing. The measured grid bias was 12 volts. (c) The interstage coupling capacitor was 0.06 μ f instead of 0.1 μ f as shown.

A 16-ohm resistor was used to load the amplifier for all tests.

The component values employed in the feedback paths result in approximately 20 db loss in gain compared to the gain of the amplifier without feedback.

Figure 2 is the power curve of the amplifier. It was obtained by adjusting the input signal voltage at each fre-

* 1401 N. Pocomoke St., Arlington 5, Virginia

¹ Charles W. Harrison, Jr., "High-quality dual-channel amplifier," *AUDIO*, January, 1956.

² Balance between the low and high frequencies depends on such factors as the directive properties of the speakers, crossover frequency, speaker locations, room acoustics, and the spectral distribution of the energy in the program material. Consideration of these factors may dictate different power ratio requirements for a given system.

³ Some readers may feel that the low-frequency response of the Triad HSM-79 transformer is inadequate. The fact that the primary winding carries unbalanced d.c. makes it difficult to achieve high primary inductance. Thus one might anticipate degraded low-frequency response compared to the response of high-fidelity output transformer types designed for push-pull applications. If the amplifier is to be used in the treble channel of a dual-channel playback system, it is perfectly satisfactory—and even desirable—for the frequency response to begin falling off at approximately an octave below the crossover frequency. The "fusing" of the treble driver is enhanced by a rolloff in the bass response of the amplifier.

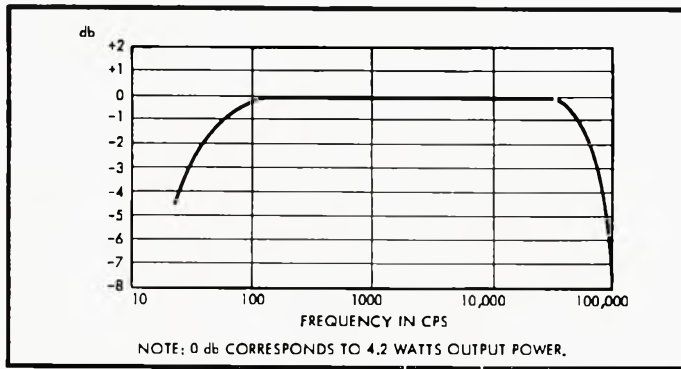


Fig. 2. Amplifier power curve.

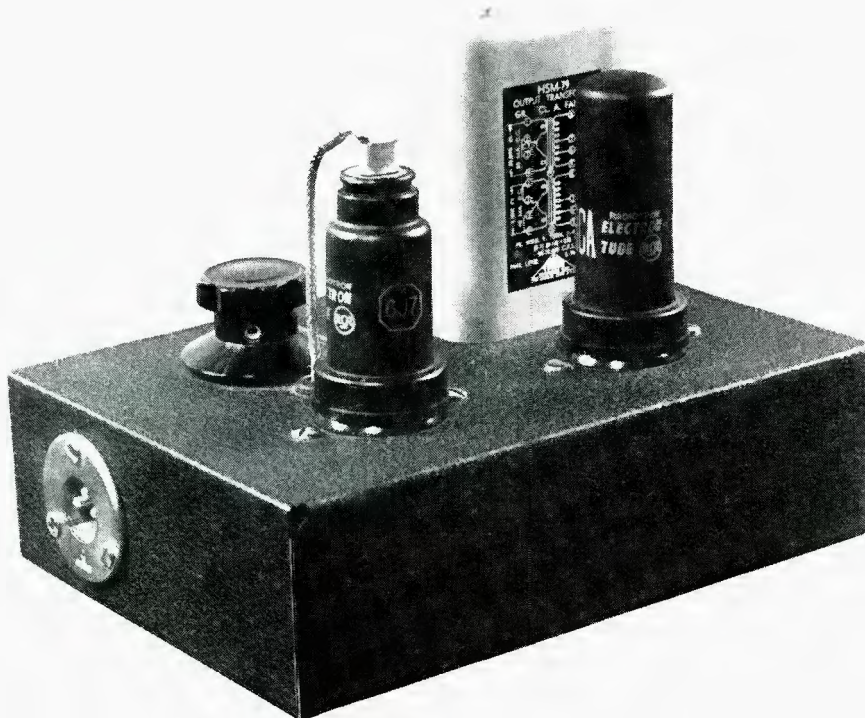


Fig. 3. Photograph of completed amplifier.

quency of measurement until barely visible waveform distortion occurred. The power output was then computed at that frequency. Thus Fig. 2 is in reality a curve showing power output as a function of frequency for constant distortion. 0 db corresponds to the power output of 4.2 watts. It is believed that approximately 3 per cent harmonic distortion in the amplifier can be detected by eye, when a good oscilloscope is used for viewing the output wave shape.

When the input signal voltage is adjusted so that the amplifier delivers 2 watts at 1000 cps, the amplifier is flat from 30 cps to 80 kes. It is down 2.5 db at 20 cps and again at 100 kes, tapering off to -8 db at 150 kes and -12.5 db at 200 kes.

The response of the amplifier to a 20,000-cps square wave is highly satisfactory; to a 10,000-cps square wave the response is perfect.

Constructional Details

The amplifier is easily built on a 5" x 7" x 2" chassis. All resistors are 1

watt except the cathode resistor in the 6V6 circuit. The output transformer must be connected in the circuit as shown to insure that the feedback is degenerative. Figure 3 shows the completed amplifier, and Fig. 4 shows the component arrangement.

The Power Supply

Many audio hobbyists possess a power pack that may be used to power the treble amplifier. The power supply described in a previous article¹ provides plate and filament voltages for both the bass and treble amplifiers in the writer's dual-channel playback system. A 10-watt resistor of 750 to 1000 ohms is required to drop the plate voltage to the correct value of 260 v. This resistor is shown in Fig. 4. The plate current of the 6V6 does not vary more than 1 or 2 ma from zero signal to maximum signal, so the voltage regulation of the power supply is not too important.

The power requirements of the treble amplifier are 6.3 v.a.c. at 0.75 a, and 260 v.d.c. at 45 to 50 ma. The schematic for a suitable, yet inexpensive power supply is given in Fig. 5. The transformer should have minimum ratings of 300 v.d.c. at 60 ma; 6.3 v.a.c. at 1 a, and 5.0 v.a.c. at 2 a. A 5Z4 is employed as a full-wave rectifier, and filtering is accomplished by use of a resistance-capacitance network. Such filters are recommended when the current drain does not exceed 50 ma. When choosing a plate transformer for use with RC filters it is important to remember that the power consumed in heating the filtering resistors must be provided by the transformer. If the power supply design is not carefully executed a transformer of

(Continued on page 44)

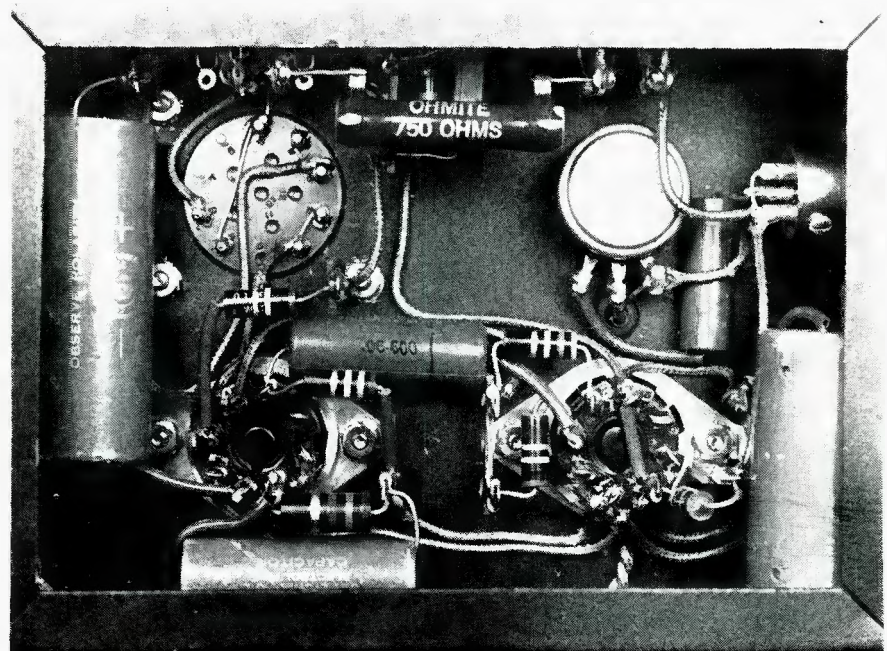


Fig. 4. Arrangement of components in the amplifier.

marginal rating for a given job will be overloaded when RC filtering is employed.

The resistor labeled R in *Fig. 5* must be chosen so that 260 v.d.c. is delivered to the amplifier. One may not be re-

quired. Positive heater bias of one-tenth the plate voltage is provided by the bleeder network. The bypass capacitor grounds the center-tap of the 6.3 v.a.c. winding to audio frequencies and must not be omitted if hum is to be minimized.

Conclusion

The writer is of the opinion that a high-quality playback system requires the employment of a dual-channel amplifier. A high-level dividing network cannot operate satisfactorily unless each filter section is terminated in a pure resistance of appropriate value. The driving-point impedance of a speaker is complex and functionally related to frequency. It may be predominately reactive at some frequency in the pass band. This accounts in part for the fact that dual loudspeakers employing high-level dividing networks do not always sound right. Constructional details covering an excellent dual channel amplifier were presented in reference 1. The use of the treble amplifier described in the present article will reduce the cost of the system with no sacrifice in performance. When used to drive the writer's speaker,⁴ which is located in a room of modest size, the obtainable sound intensity level approaches the threshold of pain over the entire frequency range of the speaker.

The availability of a high-quality sim-

⁴ Charles W. Harrison, Jr., "Coupled loudspeakers," 3rd Audio Anthology, Radio Magazines, Inc. (1955) pp. 101-105.

gle-ended transformer makes it desirable to re-examine the utility of single-ended amplifiers for high-fidelity applications when high power output is not a requirement. The advent of tubes with high transconductance, such as the Mullard EL-34 and Tung-sol 6550, which result in high power sensitivity and low drive requirements, makes it highly desirable for transformer manufacturers to produce a line of transformers capable of carrying the plate current in the primary winding and that are comparable in performance to those manufactured for push-pull application. It should be possible to obtain easily 10 watts of power output from a single-ended amplifier employing only two stages. The circuit is not complicated and there is no requirement for a phase splitter. Large values of negative feedback may be applied and the amplifier will remain unconditionally stable if the output transformer is properly designed. Admittedly, it is somewhat more difficult to design a good transformer for single-ended output stages than for push-pull application. But the Triad Transformer Corporation has made a good start in producing the model HSM-79 transformer, and this should serve as a challenge to other manufacturers in this field. ●

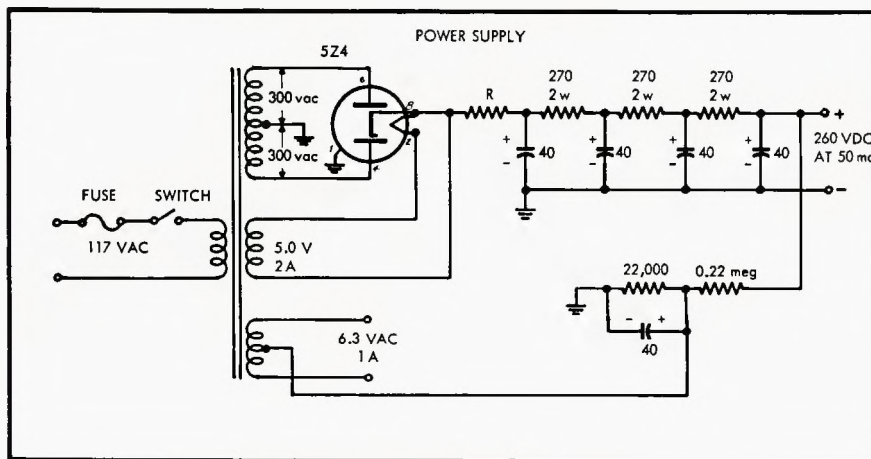


Fig. 5. Power supply featuring RC filtering.