Gilding The Lily

DAVID SARSER and MELVIN C. SPRINKLE

Details of a few simple changes in the Musician's Amplifier to improve performance and listening quality.

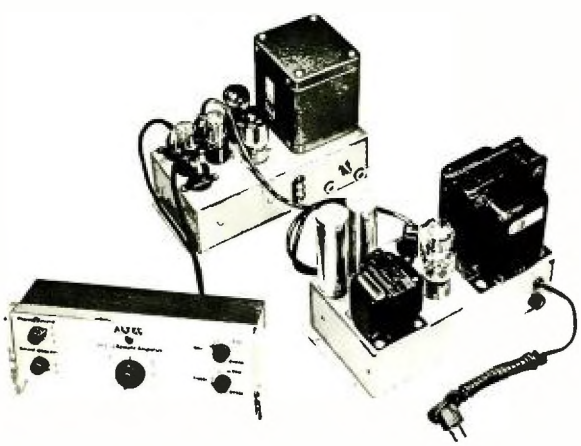

Fig. 1. The converted Musician's amplifier, using the Ultra-Linear connection of the output stage, which employs 5881's instead of the 807's previously specified. The Altec Lansing A-433-A "front end" is shown with the main amplifier and power supply.

THE WISE MAN who said that "imitation is the sincerest form of flattery" certainly must have had the Musician's Amplifier in mind. Since its introduction to the American Audio scene, the opinions of the authors have been confirmed by literally thousands of audio enthusiasts and engineers who have built them. Further confirmation has been indicated by the many other versions of "The Williamson" amplifier that have appeared both in kit and in wired form. It is conservative to say that no other audio amplifier has ever had such a wide publicity, so many unanimously enthusiastic users, and so many imitators.

As it does to all things, time has brought some changes to the Musician's Amplifier, and it is felt that the authors should bring to the attention of others certain improvements which can be made in the Musician's Amplifier. All of these changes have been field-tested and are recommended to those who have built the amplifier as per the original article. They cannot be made if the original circuit and components were not followed.

Increasing Power Output

The preceding articles by Hafler and Keroes describe a unique new power amplifier circuit which is between a tetrode and triode in characteristics and performance. This circuit requires an output transformer which is understood to have a tap at 43 per cent of the turns from center to each plate. Although not shown on the circuit diagram, the output transformer specified in the original Musician's Amplifier article has a center tap in each half of the primary winding, which is at 50 per cent of the winding, not too far from 43 per cent. As the circuit has certain features of interest, we investigated the possibility of using the taps to adapt the Musician's Amplifier and improve its performance. An amplifier was built with an A-B switch, arranged so that in one position the circuit was the conventional Musician's while in the other position the screens were connected to the center taps of each half primary. The results were checked on an intermodulation analyzer and proved to be encouraging. At low powers, say up to 7 watts, there is no difference in distortion, both being under 1 per cent IM and most of the way both are way under 0.5 per cent. Above 7 watts, the Musician's Amplifier begins to have increasing amounts of IM reaching 8 per cent at 12 watts. At this power the tapped connection amplifier is still under

1 per cent, and its IM distortion does not begin to climb until the power output is 16 watts reaching 8 per cent at 19 watts. These results are summarized in *Figs.* 2 and 3. It must be emphasized that the above power figures are those as read on the IM meter and are not equivalent sine-wave power. If the figures are converted to equivalent sine-wave power by multiplying by the factor 1.47, then the power output at 8 per cent is 27.9 watts, while the equivalent sine wave power at 1.5 per cent IM is 22 watts. Effectively, the power output has been increased to 158 per cent of its previous value. This is certainly a worthwhile improvement—particularly when it costs no more than two pieces of wire and eliminates the two 100-ohm resistors which tie the screens to the plates.

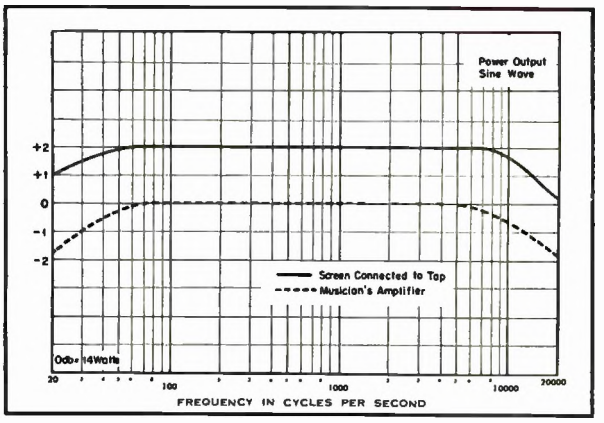

Fig. 3. Power output vs. frequency curves for original and converted amplifiers.

Operation

Checks were made on the effect of the change on the plate and screen currents and on dissipation at both full-signal and quiescent conditions. It was found that the tubes were operating within ratings so that satisfactory tube life may be expected. Checks also were made on the response, square-wave performance, and source impedance; these were found to be affected very little. One item of importance was found: as originally described, the circuit is very nearly Class A and the power amplifier is operated toward the upper regions of plate dissipation ratings, but well within ratings. The bias on the final stage was increased so as to go toward Class AB. operation. It was found that any move toward higher bias caused the IM distortion to climb, even at relatively low power levels. The original bias resistor of 250 ohms gives optimum results with the new connection.

By going to the tapped connection for the screens, the gain of the amplifier without feedback is increased by about 4 db. With a 4700-ohm resistor supplying feedback voltage from the 16-ohm output connection, the gain increase by using the taps is around 0.5 db or less.

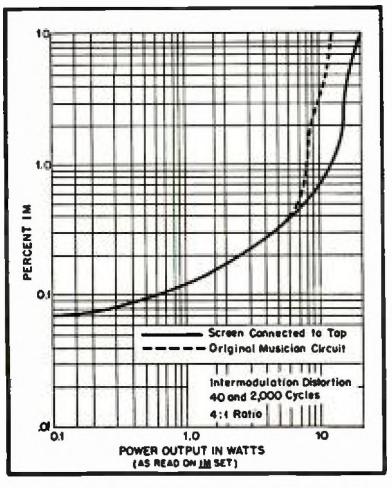

Fig. 2. Intermodulation distortion curves for the original Musician's amplifier (dotted line) and for the converted model (solid line).

Thus the amount of feedback is increased to around 24 db. With most of the amplifiers converted by the authors, there is no tendency toward instability either at sub-audible or supersonic frequencies. Depending on the capacitance and condition of decoupling capacitors, it is possible that a tendency of the loudspeaker to "breathe" or oscillate slowly at 1 cps or less may be encountered. It is recommended that when the change to tapped operation is made, the feedback resistor be increased to 6800 ohms. This value will provide 20 db of feedback, and tests have shown that no appreciable increase in distortion results. For other secondary connections, the feedback resistor may be figured as 1700 times the square root of the nominal secondary impedance.

One of the most interesting and important features of the Musician's Amplifier is the way in which it overloads. Sine-wave power output tests can be made conveniently, quickly, and more accurately than might be supposed, by feeding in a sine-wave signal and increasing the input level until the waveform of the output as seen on a cathode ray oscilloscope begins to clip at the tops and bottoms, or begins to get "bumps" on the sides at low frequencies. The original amplifier overloads so smoothly that it is often difficult to tell just when the beginning of overload is reached. Furthermore, when the tops and bottoms of the waves are being clipped, after overload really is evident there is no ringing or fuzz, but only a clean clip. With the change to the screen tap connection, it was found that the overload was just as smooth as with the conventional triode connection.

Some inquiries have been made as to whether or not a large capacitor should be connected across the self-bias resistor of the output stage. It is well known that a large bypass capacitor should be connected across the bias resistor in Class AB stages, as this improves operation at the higher power levels. During the original work, the bypass capacitor was tried and was abandoned because it produced no significant effect. This is because the power amplifier is practically pure Class A. With the tapped arrangement the capacitor was found to have an improving effect at higher power outputs. For maximum power output connect a 50-μf 50-volt capacitor across the bias resistor. However, it can be omitted with the assurance that no noticeable difference will be heard at lower levels.

Listening Tests

Of course the final test of the merits of an audio circuit is now and probably ever shall be the listening test. In music, listening quality is everything. Having an amplifier with an AB switch is an advantage in listening tests, and after considerable listening it is our opinion that the change *does* improve the sound, particularly on fortissimo musical passages when played at concert hall level. At the usual apartment house living room loudness, operation of the switch produces very little noticeable change. Several users tell us that after living with modified Musician's Amplifiers for several weeks, they are convinced that they sound better at all loudness levels.

For those who have built the Musician's Amplifier as originally written up, with the specified output transformer, here are the details for making the conversion:

1. Remove both 100-ohm resistors (R_{g1} and R_{g2} on the schematic) that tie screens to plates of the output tubes.
2. Connect a wire from the screen of the tube whose plate connects to terminal 1 of the transformer to the adjacent terminal 2.
3. Connect a wire from the screen of the other output tube (its plate connects to terminal 6 of the transformer) to terminal 5.
4. Change the feedback resistor from 4700 ohms to 6800 ohms (or to a value equal to $1700\sqrt{Z_{vc}}$ if an output impedance other than 16 ohms is being used).

Output Tubes

In the original paper, the authors used the 807 as an output tube in place of the KT-66 valve used in Williamson's design. At that time the KT-66 was not available in America, although it is now.

Recently Tung-Sol Electric, Inc. introduced the 5881 tube which is, in effect, a single-ended 807. The total plate and screen dissipation in the triode connection is 26 watts with a plate-to-cathode voltage of 400. It has the further advantage of single-end construction and the now almost standard octal base. The

5881 has been used in the Musician's Amplifier, both in the original model and in those converted to Ultra-Linear operation, and has been found to be very satisfactory from all angles—performance, tube life, cost, and appearance. These tubes are manufactured to a high degree of uniformity, so it is no longer necessary to purchase them in matched pairs. The ruggedized construction minimizes changes in element spacing—and the consequent changes in characteristics—with heating or mechanical vibration. Because of these advantages, the 5881 is now our standard tube.

Power Supply

There have been several changes in the power supply which warrant a discussion. In the original paper, the editor inserted the words "oil-filled capacitors" in the text material.[1] The accompanying photograph showed round cans in the power supply, and the authors had much correspondence as to where round can oil-filled 8-μf capacitors could be obtained. The answer is simple: the photograph was made with 8-μf electrolytic capacitors. In a number of cases when they could be obtained at reasonable prices, oil-filled capacitors have been used; however, the cans have not always been round. Oil capacitors of 6 or 8-μf. will give a hum-free amplifier. The voltage rating should be at least 600 volts.

The original power supply showed two filter chokes and three filter capacitors. We have found that there is no hum in an amplifier powered from a supply containing only one choke and having two filter capacitors of 6 or 8-μf. The reason for the use of only one choke is to cut down on the d.c. voltage drop in the power supply filter.

Another change in the power supply is in the rectifier tube. The original paper recommended a type 5U4G rectifier. The 5V4G or the older 83V were considered, and their advantage in having a lower internal tube voltage drop was fully recognized, but they were not used because of some past experience with internal tube leakage or shorts. The 5VAG tubes have become readily available because of their wide use in TV receivers as dampers, and it appears that modern construction has made them quite reliable. Thus, we now recommend that the 5V4G be used as a rectifier for improved results. The voltage surge during warmup is practically eliminated with this tube.

With these changes, the output voltage under full load is around 440 volts measured from B plus to ground. With a cathode bias on the output stage of 40 volts, the d.c. plate voltage as measured from plate to cathode on the 5881 tubes is just about 400 volts. With these voltages on the tubes, the cathode current is around 63 ma, and no trouble should be encountered in obtaining the power levels or the low distortion of the Musician's Amplifier. Hum and noise in the power amplifier are inaudible.

[1] We *still* prefer oil-filled capacitors. Most electrolytics rated at 600 volts or more are built-up units using two lower-voltage electrolytics in series. Ed.