Audio-Facts

Testing a High Quality Audio Amplifier

by Robert B. Dunham

What would you do if someone placed an amplifier on your service bench and said he'd like to have it checked? Would you say you don't take jobs like this, or would you attempt to do what the customer wants? To help you in making up your mind, we will discuss the methods and procedures that should be employed in checking an amplifier used by an owner who is critical of the quality of his home music system.

Although most modern amplifiers are simple when compared with some of the other pieces of equipment used in a high quality audio system, tests and adjustments on an amplifier are necessary if optimum reproduction is to be obtained. High quality amplifiers are rugged and ordinarily will operate over long periods of time with no special attention; however, the need for service can be expected eventually because tubes and component parts age and change in value or characteristics. If something happens to disturb the normal operation of an amplifier, tests will be required to aid the technician in locating and repairing the trouble. As a rule, a newly-constructed amplifier should be checked to determine whether or not the unit is operating as it should.

The technician has an advantage if he is capable of listening to a sound system and of judging just how well an amplifier is operating. This method is limited, however, because such things as power output, percentage of distortion, frequency range, and stability of operation can be tested accurately only with the use of instruments.

The task of servicing an amplifier will be approached by outlining and explaining the test procedure that we have been using for a number of years. To make this a practical discussion, let us assume that the amplifier in question is a modified Williamson, schematically shown in Fig. 1. The modified Williamson has been chosen because amplifiers of this type are frequently used and because the circuit is typical of modern amplifier design. The basic tests to be made on any high-quality audio amplifier, regardless of type, size, and power-output rating, will be similar to those made on the modified Williamson.

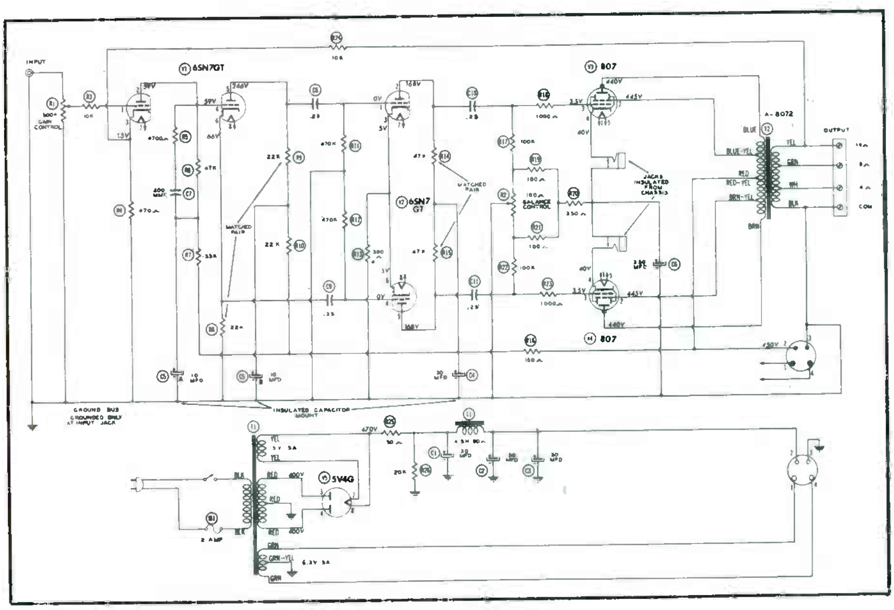

Fig. 1. Schematic of Modified Williamson Amplifier.

Preliminary Measures

One of the first things we do is to question the owner and learn something about the history and present condition of the amplifier. Does it operate at all? Is the sound distorted? In other words, we try to find out why the amplifier was brought in to be checked. Maybe the unit has been constructed by the owner and has never been turned on. We know from experience that if nothing is known concerning the operating condition of an amplifier, we had better be prepared for anything when it is turned on for the first time.

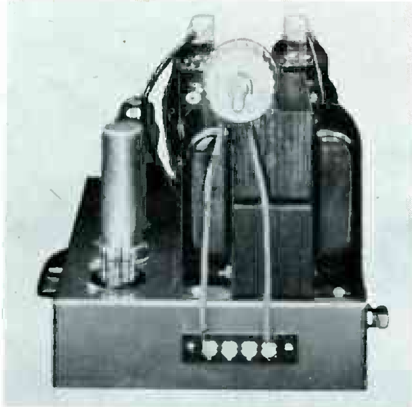

Fig. 2. Pot Used for Amplifier Load.

We have made a practice of first testing the tubes. Most amplifiers are capable of developing large amounts of power, and damage can be caused by the excessive currents which may exist under abnormal operating conditions. Making certain that all tubes are good and correcting any undesirable conditions that can be detected by visual inspection are worthwhile preliminary measures, particularly if blown fuses and damaged equipment are to be prevented when subsequent operating tests are made.

Amplifier Load

A loudspeaker is seldom connected to the amplifier when making tests with instruments. In the first place, a lot of noise is eliminated; also, damage to the loudspeaker by excessively high signal levels is prevented. In addition, the varying load presented to an amplifier by the loudspeaker creates inaccuracies when certain tests are being made.

Instead of a loudspeaker, a 16-ohm, 25 or 50 watt resistor should be connected across the 16-ohm output terminals of the amplifier. Fig. 2 shows a 25-ohm, 25-watt potentiometer being used in this application. The power rating of the resistor depends on the power-output rating of the amplifier, because the resistor must be capable of handling the full power output without overheating.

Fig. 3. Leads and Phone Plug for Measuring Cathode Currents With DC Milliammeter.

We have used a power-resistor decade box as a load when making most tests because resistors of the proper value and wattage are not readily available. Although a non-inductive resistor should be used, we have found that the decade box is satisfactory for most tests since frequency response is not affected until the frequencies of the signals being measured approach 100,000 cps.

Oscilloscope

The vertical input of an oscilloscope is connected across the resistor load. It is important that the "hot" lead of the oscilloscope be connected to the high side of the resistor and that the ground lead be connected to the ground side. This precaution should be taken when connecting any piece of test equipment.

We have found that an oscilloscope is practically indispensable when making tests on an amplifier. Symptoms that are not even suspected are often discovered when the signal output of the amplifier is viewed on the oscilloscope screen. If the oscilloscope is equipped with an internal calibrator or a separate calibrator is used, the peak-to-peak value of the signal voltage developed across the load can be measured and the power output can be calculated.

DC Milliammeter

A DC milliammeter is alternately plugged into the two jacks provided on the amplifier to check the cathode current of each of the output tubes. A meter having a range of at least 150 ma should be used since the normal cathode current of each output tube is usually close to 60 ma. A pair of leads terminated in a phone plug are used in this particular application. As indicated in Fig. 3, the positive lead is connected to the prong, and the common lead is connected to the shell or base of the plug. The other ends of the leads have been equipped with plugs that match the meter input jacks.

Fig. 4. Measurements Corp. Model 31 Intermodulation Meter.

DC Voltmeter

When uncertain about the condition of an amplifier, we usually check the supply voltages with a DC voltmeter. This would be accomplished by connecting a voltmeter between pin 2 of the power supply socket and ground in Fig. 1. Of course, this same meter set to the correct range and function may also be used to check the various voltages at points throughout the amplifier.

With the test equipment previously mentioned, an amplifier can be checked for such things as hum, oscillations, and other symptoms of abnormal operation. We usually connect a signal source to the input of the amplifier before we turn it on.

Intermodulation Analyzer

An intermodulation analyzer can be used to definite advantage when testing an amplifier. The value of such a unit lies in its ability to quickly and easily provide indications of how well an amplifier is operating. It gives direct readings of the percentage of intermodulation distortion produced at various power levels within the range of the amplifier.

We use a Measurements Corp. Model 31 intermodulation meter, illustrated in Fig. 4, to generate signals at 60 cps and 3000 cps simultaneously. These signals are combined in a ratio of 4 to 1 (the amplitude of the 60 cps signal is 4 times that of the 3000 cps signal). The output of the generator section in the intermodulation analyzer is connected to the input of the amplifier, and the input of the analyzing section is connected in parallel with the oscilloscope at the output of the amplifier.

After power has been applied for a length of time sufficient for all units to become stabilized, we are ready to test the amplifier. We will not go into details concerning the manipulation of the test equipment controls since the technician should be acquainted with this phase of the operation. The tubes and the meters are watched carefully when the amplifier is turned on because we do not know what to expect in the way of abnormal operation. The first moments can be critical; therefore, the meters are watched for any abnormal voltage or current that may indicate trouble. The amplifier is watched for smoke or other signs of overheating. The tubes are also watched since the rectifier tube in the power supply and the output tubes can be damaged by excessive currents.

Balance in the Output Tubes

Balance in the output tubes should be checked before any further tests are made. The plug, attached to the DC milliammeter, is alternately inserted into the two jacks and the balance control R2 is adjusted until identical current readings for each tube are obtained. Sometimes it is necessary to replace one or both of the output tubes with ones that have matching characteristics before the output circuits can be balanced.

Since balance in the output stage is so important, it is vital that the stage that drives the output section also be balanced. A tube with balanced sections should be used as the driver tube V2 so that identical but opposite signal polarities will be fed to V3 and V4. A reliable tube checker can be used in the selection of V2.

With the output stage balanced and the operation of the amplifier at least partially stabilized, we can check for excessive hum and undesirable oscillations. The output from the intermodulation analyzer is reduced until no signal is fed to the input of the amplifier. If a signal is visible on the screen of the oscilloscope, it is being generated within the amplifier. This is where the convenience of an oscilloscope can be appreciated because hum or oscillations will be very apparent. The waveform and frequency of an unwanted signal

Table 1—Results of Typical Intermodulation-Distortion Test

Output			% Intermodulation Distortion
(watts)	(volts rms)	(volts as read on meter of IM unit)	
¼	2.0	1.6	0.1
½	2.8	2.26	0.1
1	4.0	3.2	0.12
2	5.6	4.53	0.13
3	6.9	5.54	0.16
4	8.0	6.4	0.2
5	8.9	7.15	0.21
7	10.6	8.47	0.23
10	12.6	10.12	0.3
15	15.5	12.4	0.4
18	17.0	13.62	0.5
20	17.9	14.31	0.55
25	20.0	16.0	2.0
30	21.9	17.53	7.0

are made visible and can be used as valuable clues in the location and elimination of the trouble.

Additional tests can be made if no obvious troubles have been found. The output control of the intermodulation analyzer is advanced to produce a signal at the input of the amplifier and the gain control (R1) of the amplifier is set to maximum. Quite a few things can be learned about the operation of the amplifier by observing the output signal on the screen of the oscilloscope. There will be an increase in the amplitude of the signal if the amplifier is working. Distortion will be noted as changes in the shape of the symmetrical waveform of the output signal. Clipping of signal peaks will indicate overloading within the amplifier. Maximum usable power output will have been reached when overloading is first noticed.

Intermodulation tests can be made very quickly and easily with the Model 31. The percentage of intermodulation is usually very low at low output levels, and the percentage of distortion will increase at a slow rate as the output of the amplifier is increased. The increase in intermodulation distortion is usually very gradual until the overload point is reached and then the increase is very rapid. Intermodulation distortion tests should be made at various signal levels between minimum and maximum output.

Table 1 contains many of the values that were obtained when intermodulation checks were made during the development of the modified Williamson amplifier of Fig. 1. Note that a much greater difference in distortion percentage was produced when the output was increased from 20 to 25 watts than that obtained between 10 and 15 or 15 and 20 watts.

Further explanation of Table I is required since we list the rms voltages developed across the load resistor as well as the voltage readings from the meter of the intermodulation analyzer. We listed both because an AC meter could be used if a 60 cps sine-wave signal were used instead of the mixed-frequency signal from the intermodulation meter. The amplifier is actually developing more power than that indicated by the meter of the intermodulation unit because the meter is not very sensitive to 3000 cps. When the intermodulation meter alone is used to check power output, we have to compensate by the factor of .8 as indicated by the difference in the values listed in columns 2 and 3 of Table I. It should be mentioned that this factor will be different if the analyzer provided signals having different frequencies than those used in this case.

The intermodulation analyzer is valuable because of the amount of data that can be found in one series of tests. In addition to the distortion figures indicating how linear the operation of an amplifier is, we also learn the power capabilities of the amplifier. ▲