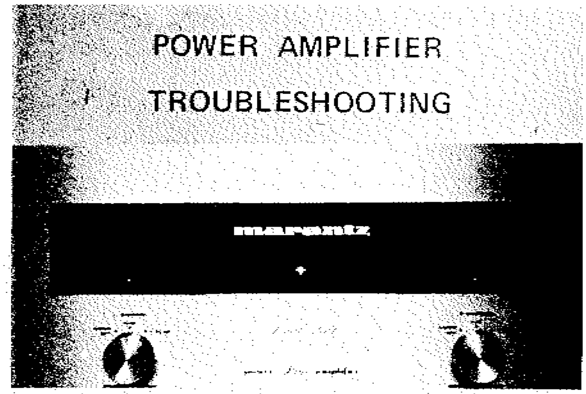
Superscope Technical Services

Lesson PA-1

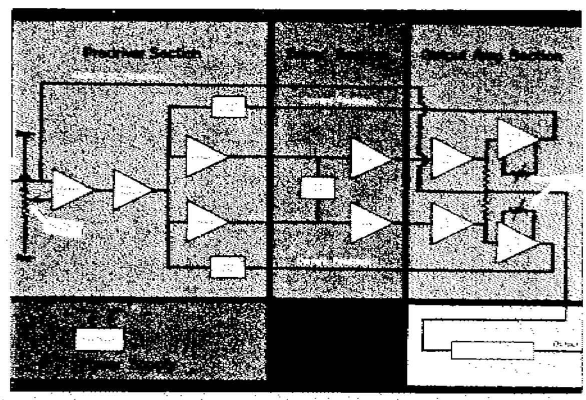
Power Amplifier Troubleshooting

SUPERSCOPE ®

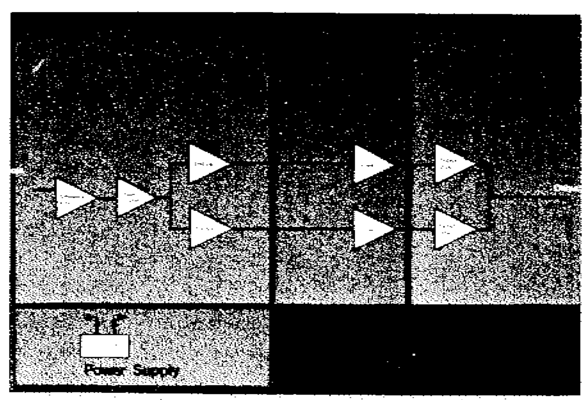
The power amplifier is the backbone in any audio system. It amplifies audio voltage and current to a level which can power the loudspeakers. In a moment we'll troubleshoot a high quality Marantz power amplifier, but first, let's briefly describe its sections and protection circuits.



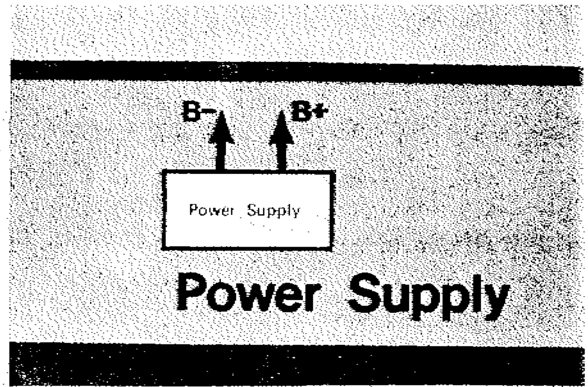
Modern, solid state Superscope and Marantz power amplifiers are designed in the push-pull, complimentary symmetry configuration. No output transformers are employed, because none are necessary. The output impedance of these power amplifiers will match the impedance of 4, 8, and 16 ohm loudspeakers without resorting to three different taps off an output transformer secondary.



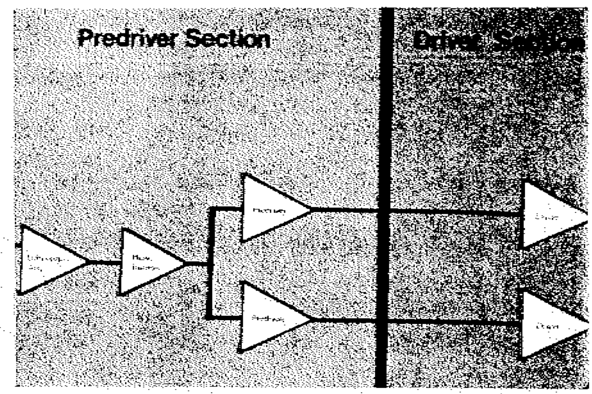
All power amplifiers contain these four basic sections: The predriver section, driver section, the power output amplifier section, and the power supply.



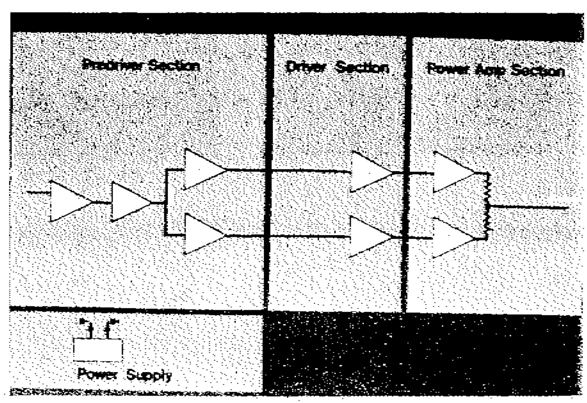
The power supply provides DC operating voltage for the predriver, driver, and power output amplifier sections.



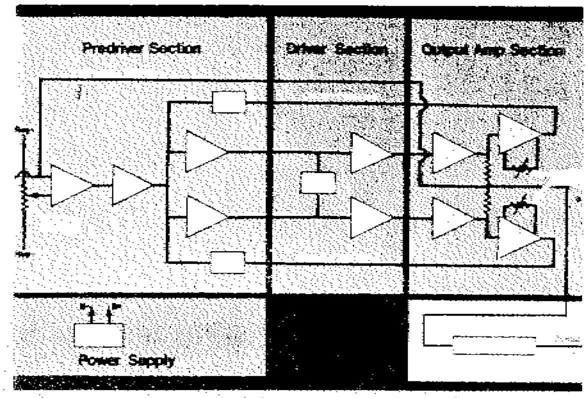
The predriver and driver sections amplify audio voltage ...



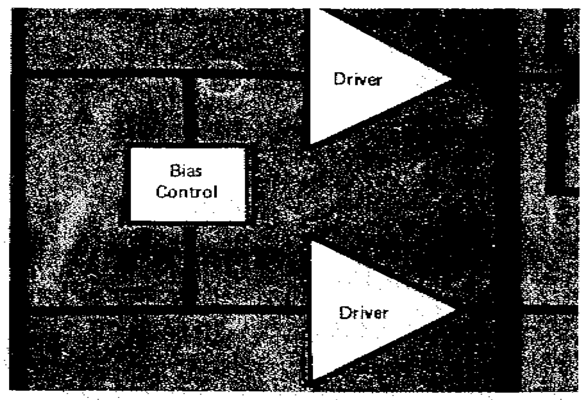
while the last section, the power output amplifiers, amplify audio current to a level which can drive the loudspeakers.



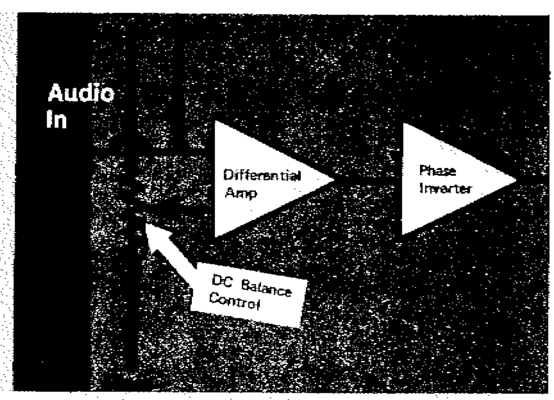
Elaborate protection and feedback circuits are found in most of our power amplifiers. These limit current or voltage at various stages to prevent excessively high current from reaching the power output transistors. Too much current overheats output transistors and causes them to fail. Let's go through these protection circuits one at a time.



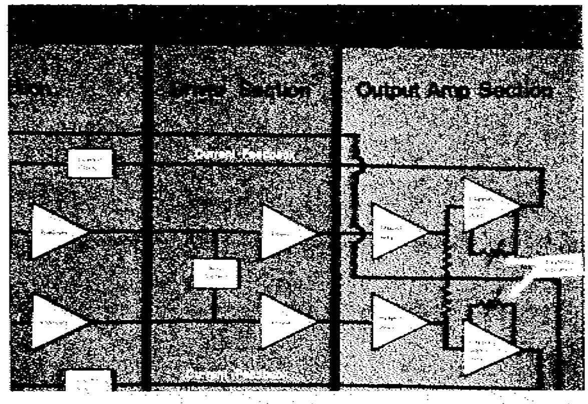
In most Marantz and Superscope power amplifiers, the bias voltage at the driver transistors is controlled by an adjustable bias control, which we'll check and adjust shortly. In most units a heat-sensitive bias protection circuit is incorporated with the bias control. It equalizes bias voltage on both driver transistors over the normal thermal operating range of the power amplifier.



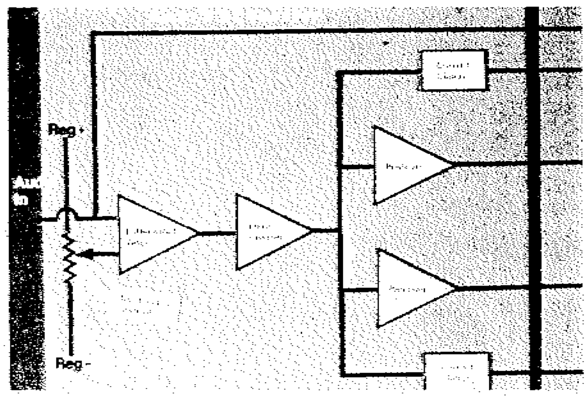
Still another adjustable component - the DC balance control - assures that the DC component at the audio output will be zero volts. DC balance is adjusted in one manner when the power amplifier is directly coupled to the output, and in another manner when the power amplifier is connected to the output through capacitors. We'll explain both adjustment procedures shortly.



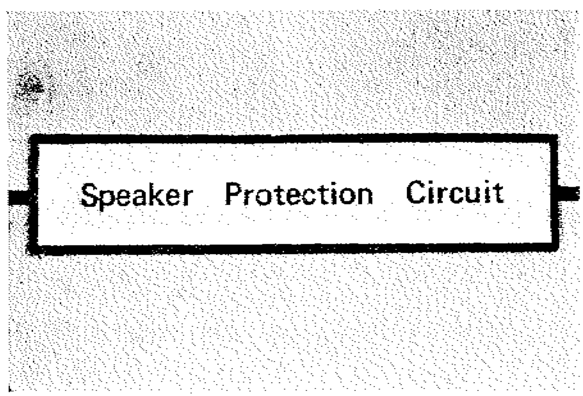
Some Marantz power amplifiers, including the Model 250 we'll be troubleshooting, employ current feedback. Through two current clamping transistors, this current overload protection circuit controls the bias voltage level at the predrivers. It limits predriver gain whenever current exceeds the level determined by a pair of clipping control pots. Whenever power transistors are replaced, the clipping points of this current overload protection circuit, as well as DC bias and DC balance, must be checked and adjusted as required.



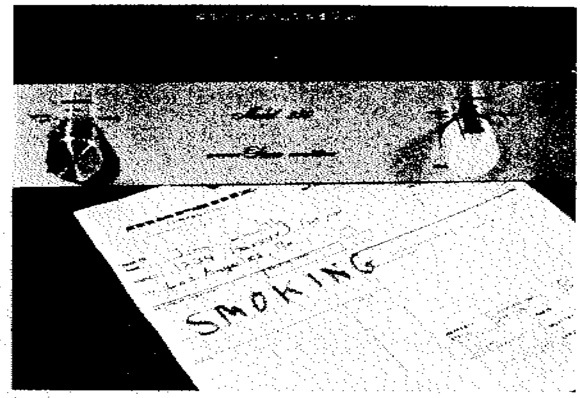
Another circuit, the audio and DC feedback circuit, limits the voltage output of the first predriver stage by applying negative feedback to it. Besides preventing overamplification of voltage in the predriver, negative feedback actually reduces the total harmonic distortion level of the audio output.



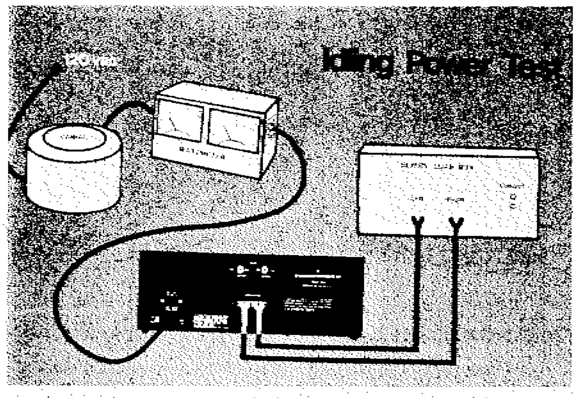
Finally, most Superscope and Marantz power amplifiers contain a speaker protection circuit, which protects the loudspeakers against cone-blowing DC voltage. In this lesson, we'll show you how to test it.



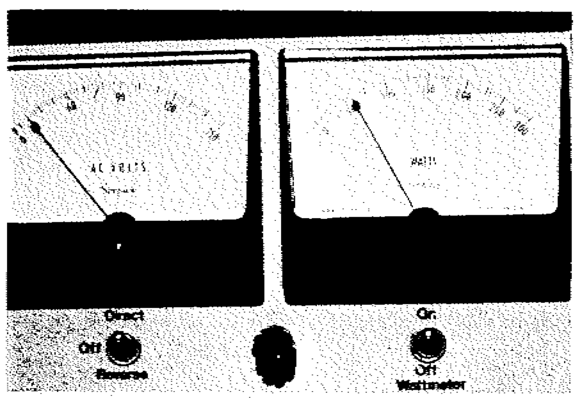
Right now, let's troubleshoot a Marantz Model 250 power amplifier. It contains all the protection circuits we've just mentioned. The complaint is "smoking," but the complaint could just as well have been "dead" or "no output."



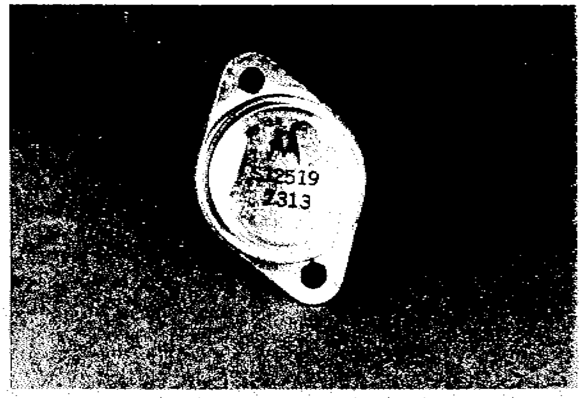
First, check idling power. This test measures power consumption with no audio applied. If excessive current consumption is the problem, this test will detect it quickly. Connect the amplifier's power cord to 120 volts AC through a Variac and a wattmeter. Then connect the speaker output terminals to an 8 ohm resistive load.



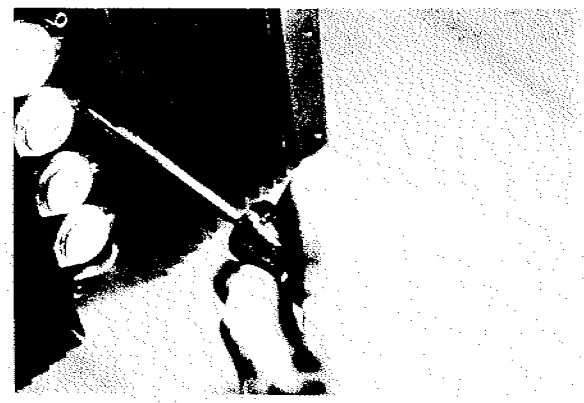
Slowly increase voltage while observing the wattmeter. When line voltage reaches 120 volts AC, the wattmeter should read between 35 and 55 watts for the Model 250. In this case, wattage begins to exceed 55 watts long before 120 volts is reached, so we immediately shut off power to avoid damaging even more components.



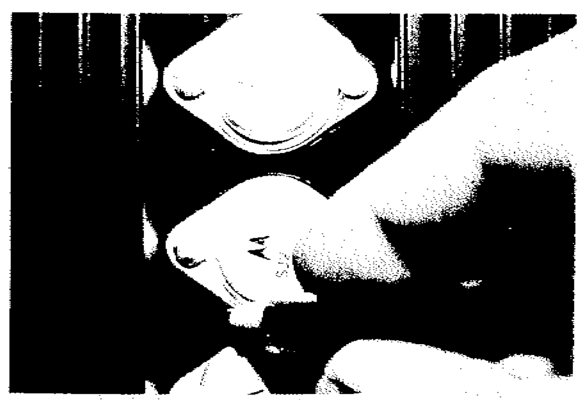
We've established the unit is drawing too much current. The power output transistors are the first components to check, since they are the most vulnerable to current overload. Checking transistors properly requires sophisticated test equipment. However, here is a practical transistor field test which only requires a VTVM set for reading resistance.



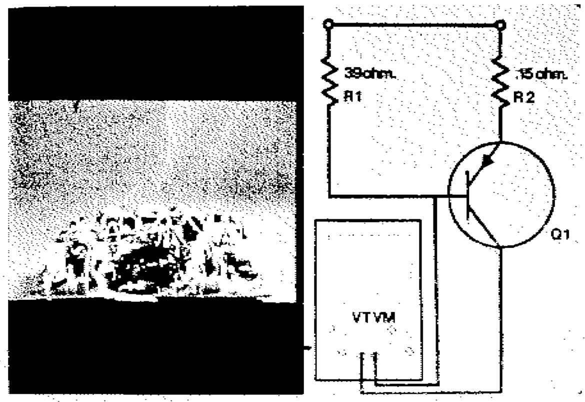
To test them, the transistors must be removed from the heat sink.



Before removing them, however, mark the last two transistor identification digits on the heat sink. This prevents confusing an NPN for a PNP transistor during replacement.



We're checking these transistors out of circuit for two reasons: First, operating the amplifier at full rated power might damage even more components. Second, components connected to the output transistors might affect the resistance measurements.

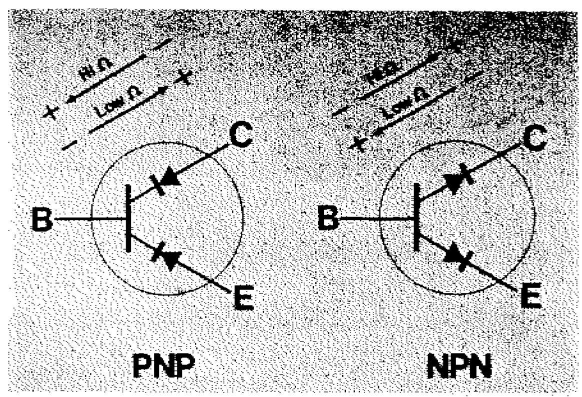


The output transistors are tested for forward conduction, leakage, and emitter to collector shorts.

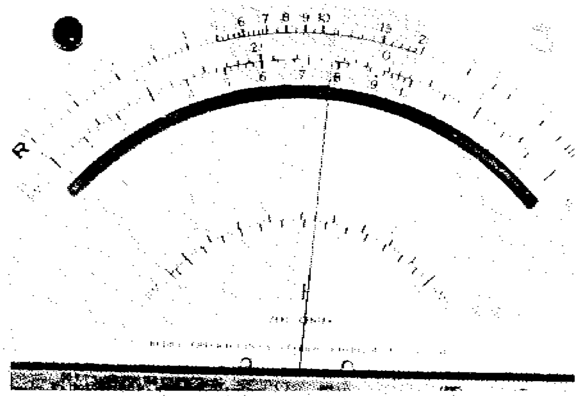
Check Output Transistors for:

1. Forward Conduction
2. Leakage
3. Emitter to Collector Shorts

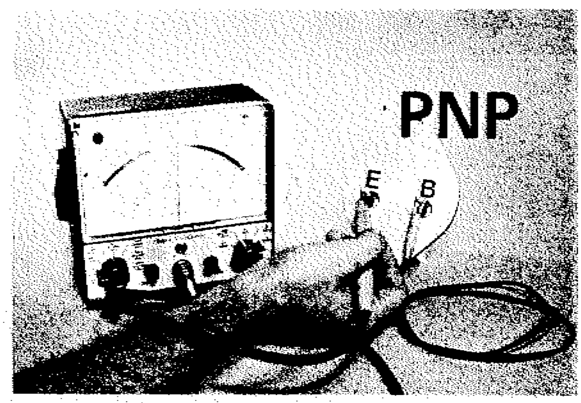
Let's test forward conduction first. A power output transistor can be considered as two diodes joined at the base. So resistance will be high when voltage is applied to these junctions in one direction, and low when voltage is applied in the opposite direction. Forward conduction is measured from base to emitter and base to collector with a VTVM set for reading resistance.



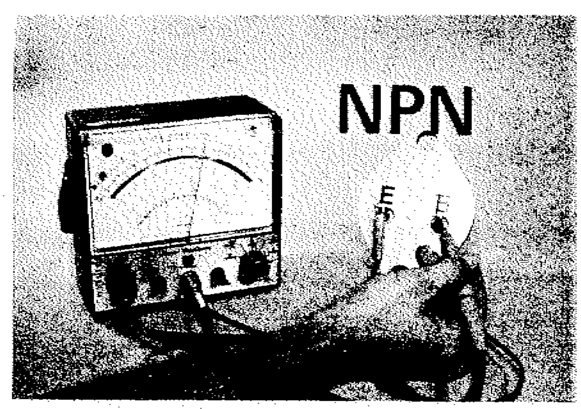
For silicon PNP transistors, the resistance reading should be between 5 and 20 ohms ...



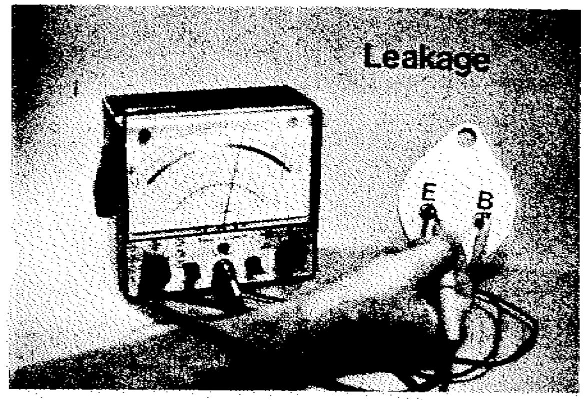
when the positive test lead is at the emitter or collector and the negative test lead is attached to the base. Reverse the test leads and resistance should increase to several megohms. This is because reverse polarity voltage is being applied.



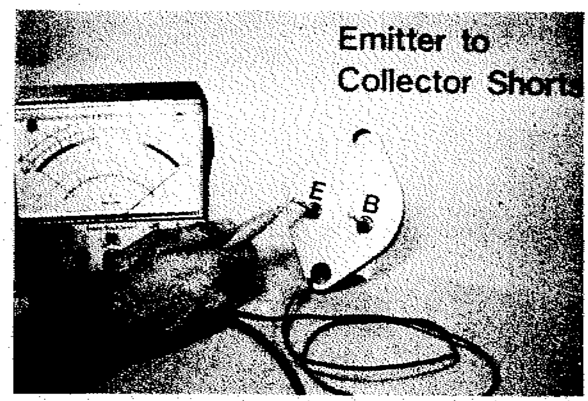
For NPN transistors, forward conduction checks are made with the meter leads reversed from those shown for PNP's.



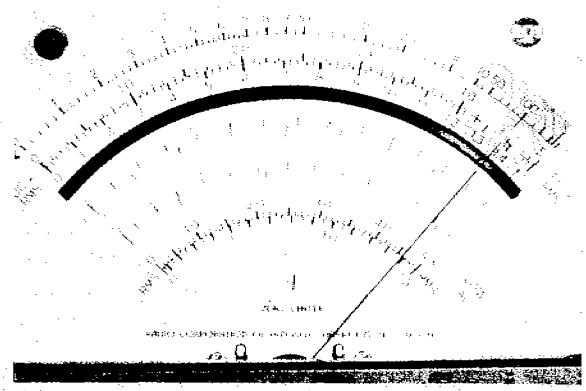
To measure transistor leakage, switch the VTVM to a higher resistance scale. With reverse polarity voltage applied, resistance will drop below the megohm range if the transistor is leaky, as is shown here. Check NPN's with the positive lead at the emitter or collector; the negative test lead at the base. Reverse the leads to test PNP's.



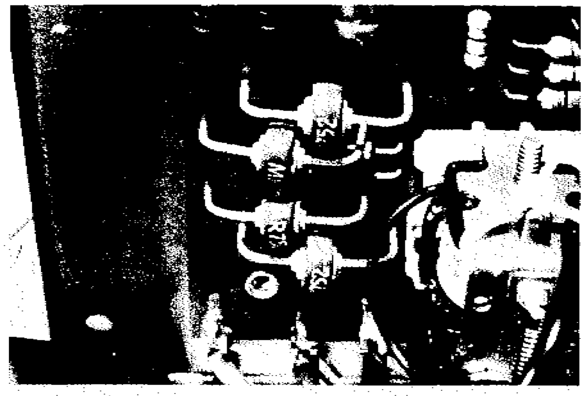
Finally, check the transistor for an emitter to collector short. Connect the test leads to the emitter and collector.



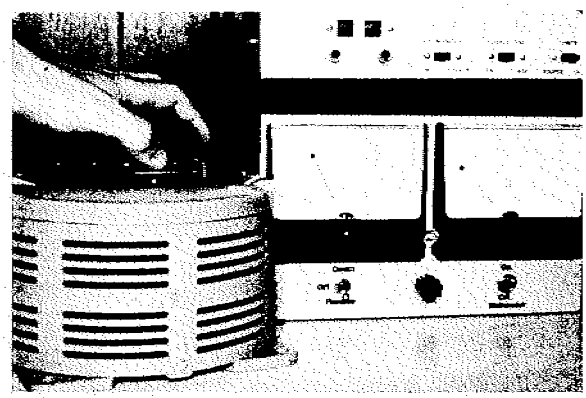
Resistance should be in the megohms when test voltage is applied in either direction.



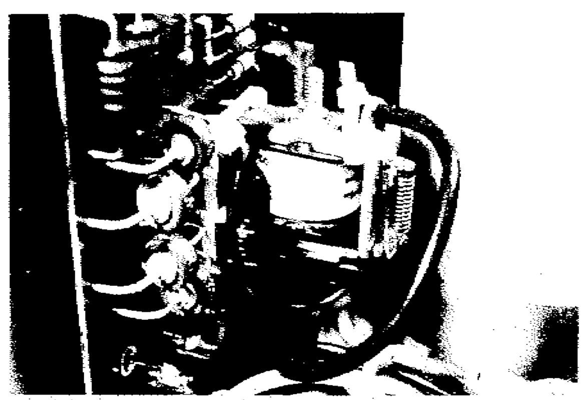
The power supply's full wave bridge is also a common victim of current overload. The output transistor shorts, drawing excessive current through the bridge diodes causing them to open. Obviously, simply replacing the shorted output transistor or transistors won't solve this situation!



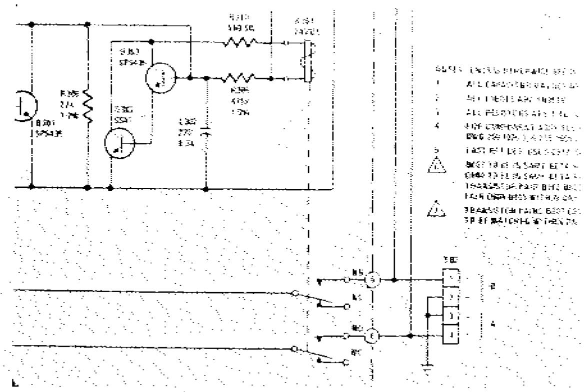
Next, we'll recheck idling power to see if current consumption is now back to normal.



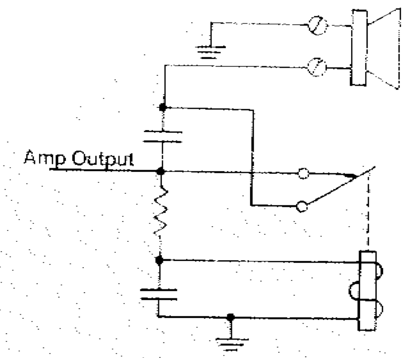
When we measure idling power, we're also checking the speaker protection circuit. The speaker protection relay should energize at a line voltage of about 98 volts AC. This closes the circuit to the speaker output terminals.



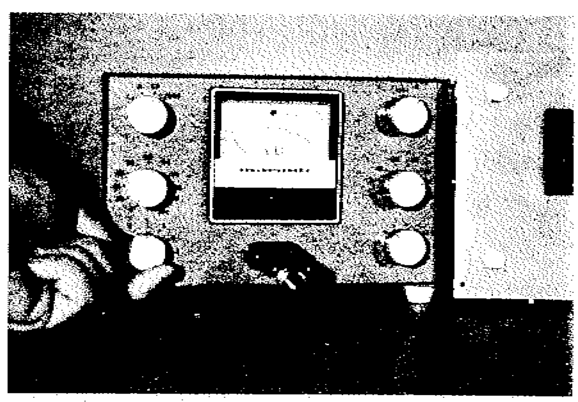
In the Model 250, as in most Marantz power amplifiers, receivers, and stereo combination amplifiers, the DC protection relay is de-energized when the unit is turned off or if DC is present at the amplifier output terminals.



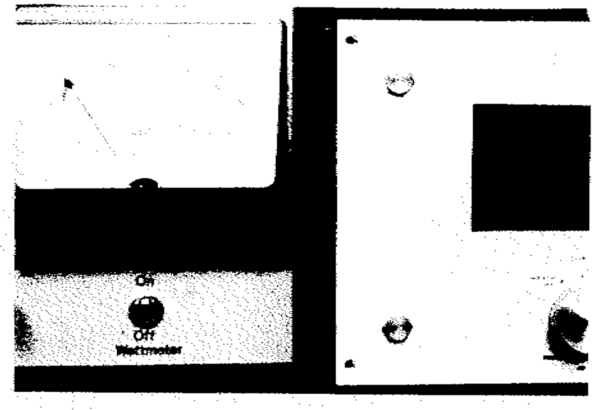
In Models 18 and 19, however, the relay is energized when DC is present. Therefore, the relay in these receivers shouldn't click in when the unit is turned on. However, there will be a 2 to 10 second delay before audio is heard.



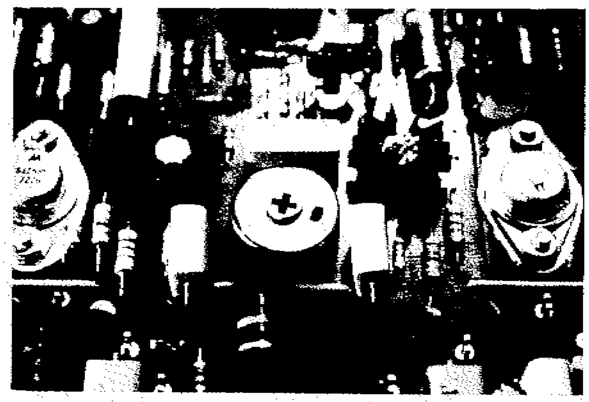
Here's another quick way to check the speaker protection circuit. Simply connect an audio oscillator to the power amplifier and feed in a 5 Hz audio signal. Increase audio output. The relay should click 5 times per second, if it's good and if the speaker protection circuit is operating correctly.



An idling power check discloses the power amplifier is within specs for current consumption, drawing less than 55 watts at 120 volts AC. But the job isn't completed yet!



After transistors or biasing devices have been replaced, you should always recheck DC bias, and if it's necessary, readjust the bias control pot, such as the one shown in the middle of this picture.

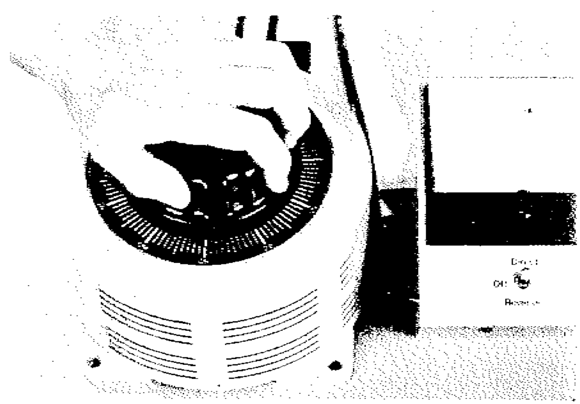


By far the most accurate method for checking output transistor bias is to measure the no signal operating voltage across one of the common emitter resistors in the power output transistor stage.

Most Marantz and Superscope service manuals provide detailed information for making a correct quiescent current voltage measurement. However, some of our manuals describe alternate methods which will give satisfactory results.

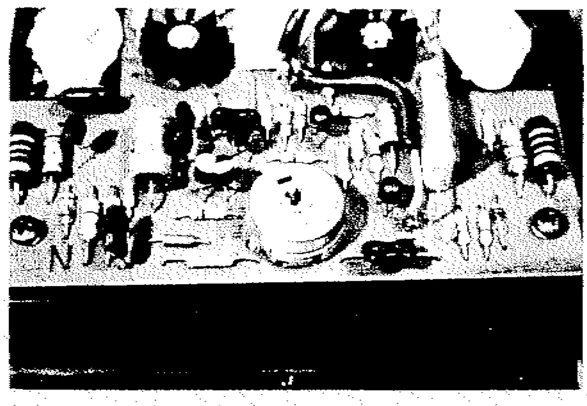
To measure the emitter resistor voltage drop and adjust the DC bias, connect an instrument capable of measuring millivolts across the emitter resistor. The power amplifier is connected to a Variac and terminated in an 8 ohm load.

Gradually increase line voltage at the Variac while observing the wattmeter. If it indicates a higher reading than specified at any point before the 120 volt line voltage is achieved, immediately shut off power and recheck the power amplifier components. Something is still causing the amplifier to draw too much current.

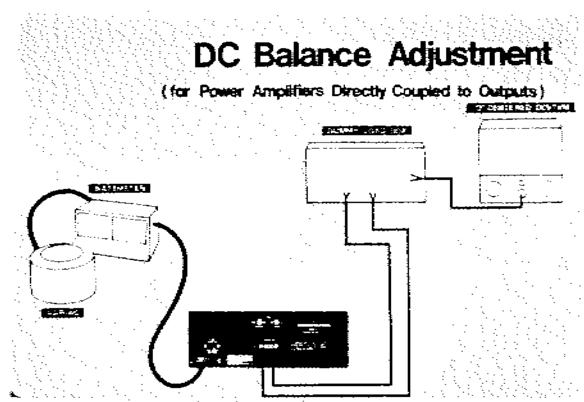


When 120 volts AC can be achieved safely, adjust the bias control for the specified emitter resistor millivoltage drop.

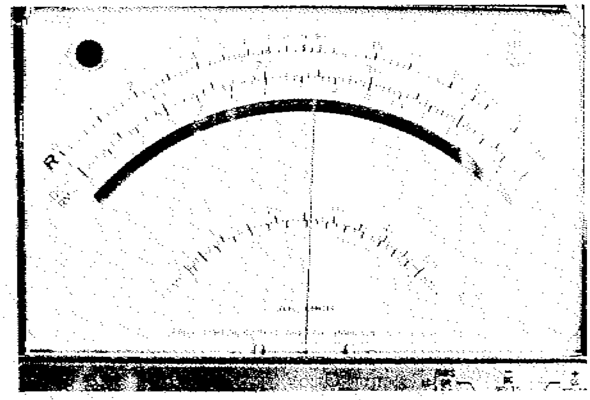
With bias properly adjusted, check DC balance and adjust the DC balance pot, if necessary. This must be done after bias has been adjusted, because resetting the bias could result in a positive or negative DC voltage at the speaker output terminals. Excessive DC voltage there blows speaker cones!



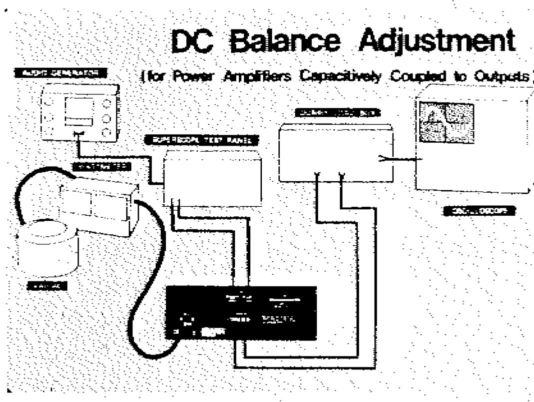
To adjust the DC balance of an amplifier directly coupled to the output, the unit should be connected to an 8 ohm resistive load and warmed up thoroughly on a soak rack. A zero centered DC VTVM is connected to the amplifier output. Note that no audio signal is applied during this check.



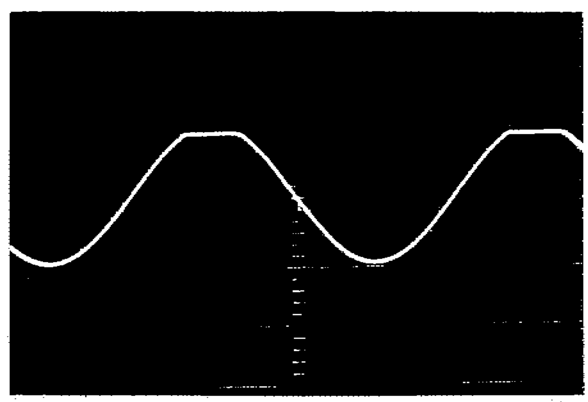
Then adjust the DC balance control for zero volts DC. Continue to adjust the DC balance control, switching the meter to progressively more sensitive voltage ranges. The final adjustment is made with the DC VTVM set to its most sensitive voltage range, which must be capable of accurately measuring 50 millivolts or less.



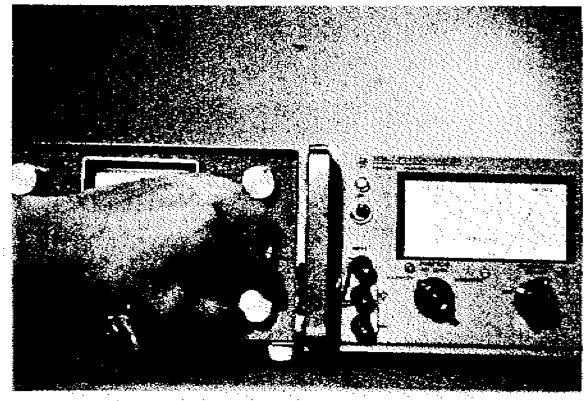
To adjust the DC balance of an amplifier coupled to the output through capacitors, connect an audio oscillator to the power amplifier inputs and apply a 1 kHz audio signal at minimum output. Connect an 8 ohm resistive load and an oscilloscope to the amplifier output terminals. The scope will be used to monitor the output waveform.



Adjust the audio oscillator output until the power amplifier waveform just begins to clip. Then set the DC balance control for symmetrical clipping of the positive and negative peaks of the waveform.

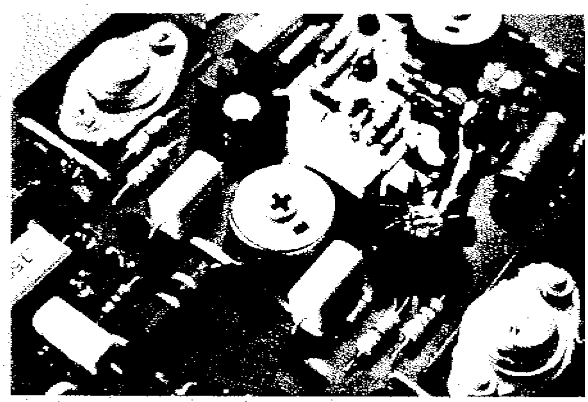


Now adjust the audio signal level to 40 percent of rated power amplifier output. Operate the amplifier until it is warmed up to normal operating temperature.

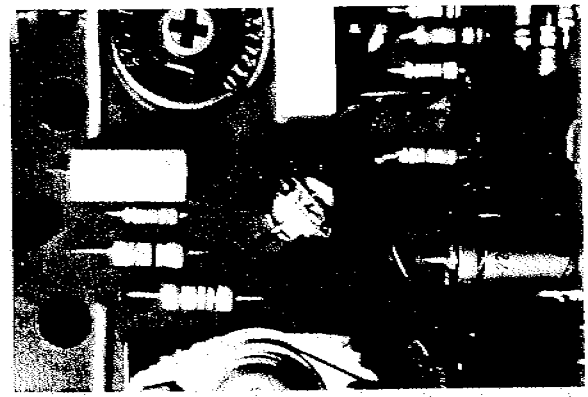


Remove the audio signal and remeasure the voltage drop at the emitter resistor. Readjust the bias control and DC balance if necessary. Continue to adjust the bias and DC balance until a stable condition is obtained.

Sometimes the bias control can't be adjusted for the desired emitter resistor voltage drop. This usually means the bias control circuit is defective.



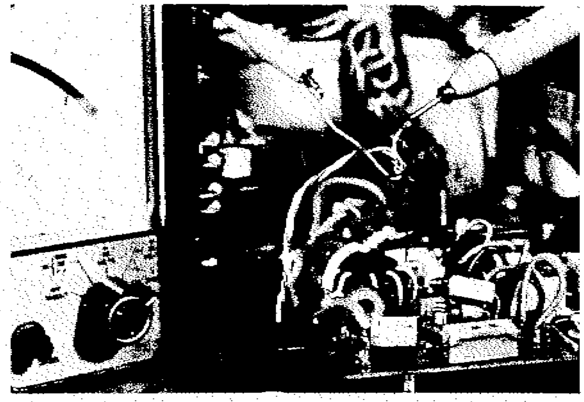
In the Model 250, the bias circuit consists of a diode, which is thermally coupled to the predriver to compensate for increases in temperature ...



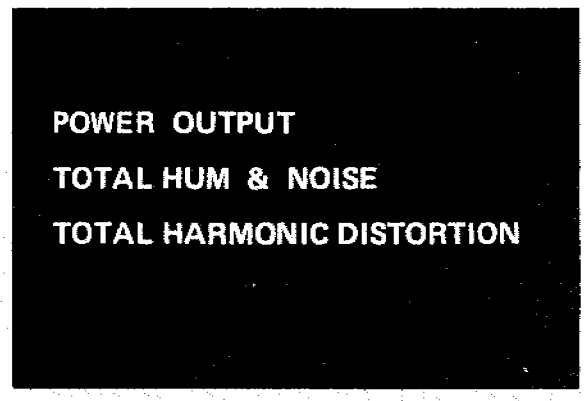
and a bias transistor which is thermally coupled to the heat sink.

If problems are encountered in adjusting bias, the diode should be detached at one end and tested in both directions with a VTVM set for reading resistance.

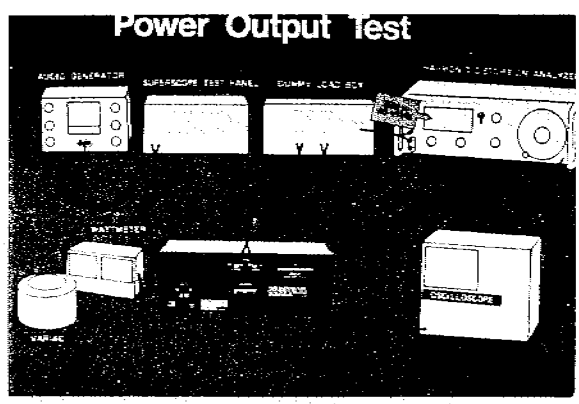
To test the bias transistor, detach two of its leads to remove it from the circuit. Then check it for forward conduction, shorts, and leakage with a VTVM.



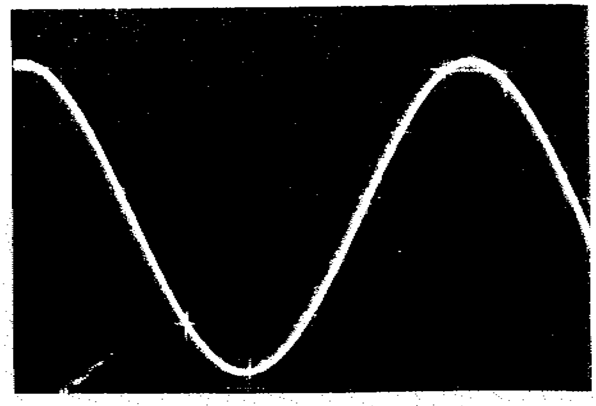
We've adjusted bias and DC balance, there's no DC in the output, and line consumption at idle is normal. Now we're ready for power output, hum and noise, and distortion tests.



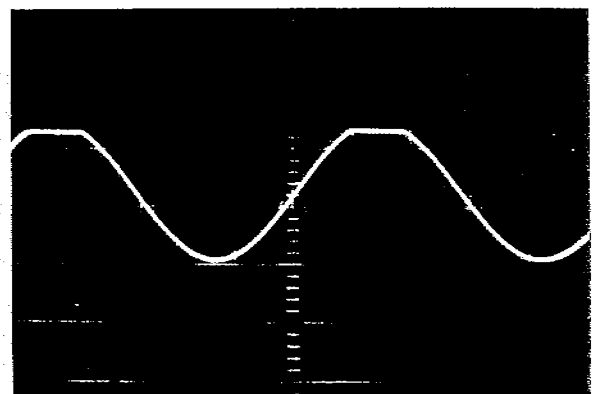
To measure power output, feed a 1 kHz audio signal from the audio generator through the test panel to the power amplifier. The speaker outputs are terminated in a resistive 8 ohm load. Monitor the output with an oscilloscope and an AC VTVM.



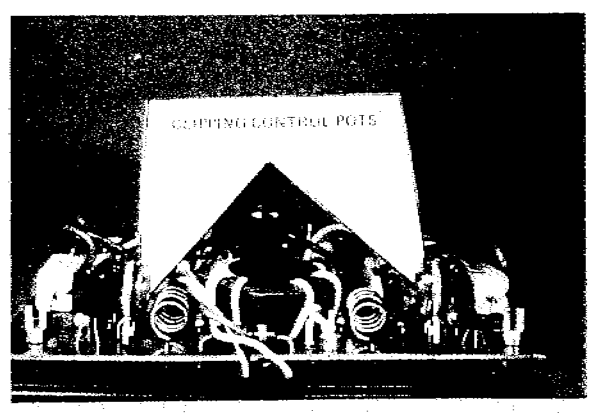
Adjust the audio oscillator output until the waveform on the scope is just below clipping. Read the output voltage on the AC VTVM. It should equal or better the power output voltage specified in the service manual.



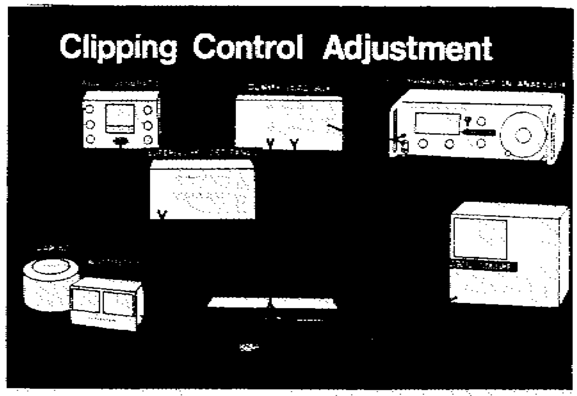
If either the positive or negative waveform clips at rated output in the Model 250 or other Marantz units employing clipping control pots ...



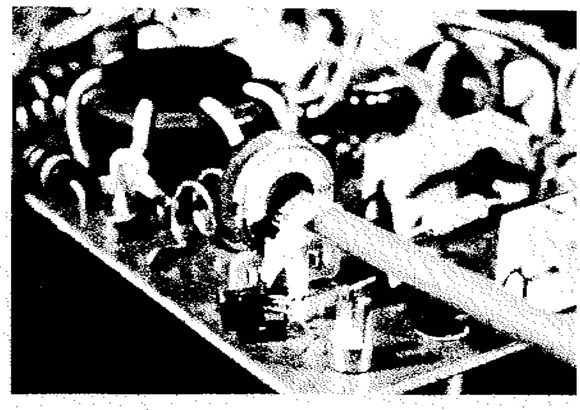
these pots should be readjusted. They control the limiter transistors in the overload protection circuit.



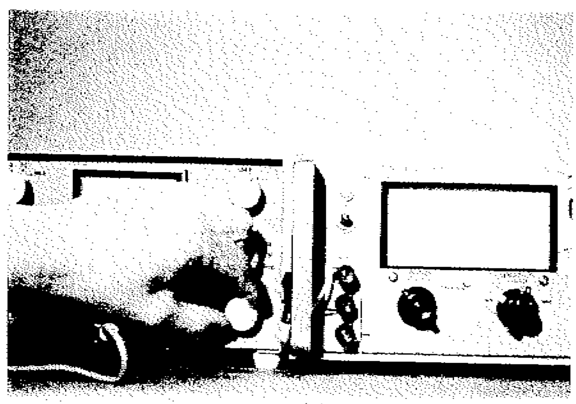
To adjust these pots, start with an audio oscillator set to a 1 kHz frequency at minimum output. The oscillator is connected through the test panel to the power amplifier's left and right channel inputs. The power amplifier's outputs are terminated in a 4 ohm load and monitored with an AC VTVM and an oscilloscope. A 4 ohm rather than an 8 ohm load is employed so the power amplifier will operate at its maximum current level.



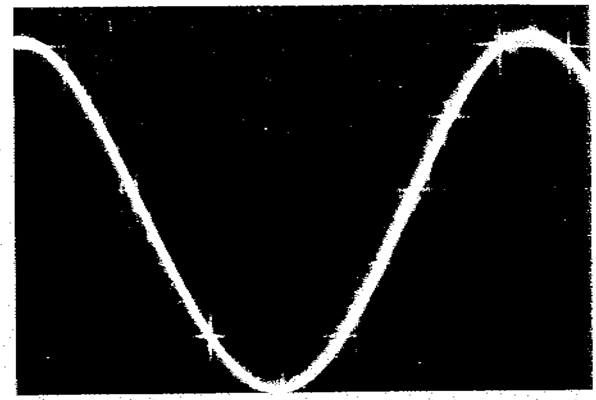
First, turn the clipping control pots fully counter-clockwise. Use a plastic screwdriver to avoid shorting out any components. Remember: One clipping control pot adjusts the positive clipping point; the other pot controls the negative clipping point.



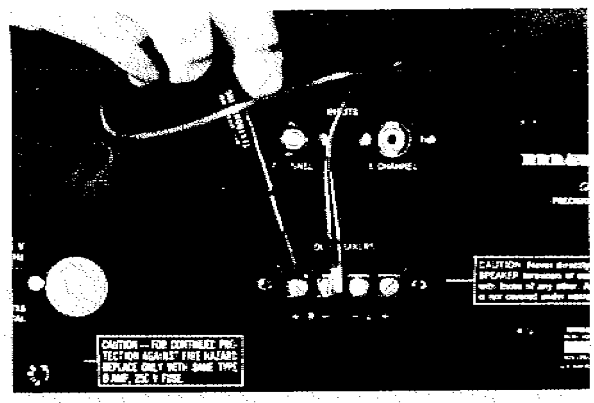
Increase the oscillator output until the power amplifier output reaches 25.5 volts.



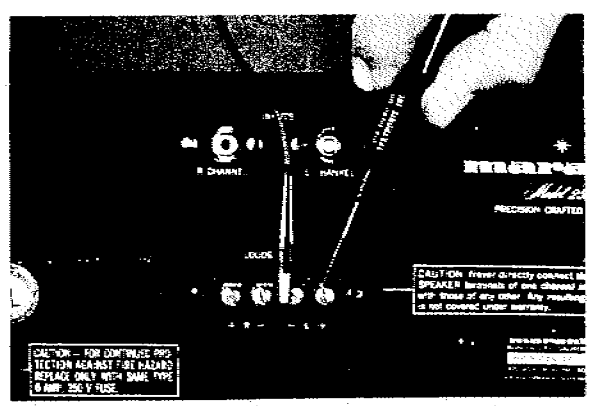
Checking the scope pattern, adjust the appropriate clipping control until the waveform is just below clipping. Repeat this adjustment for the other channel if its necessary.



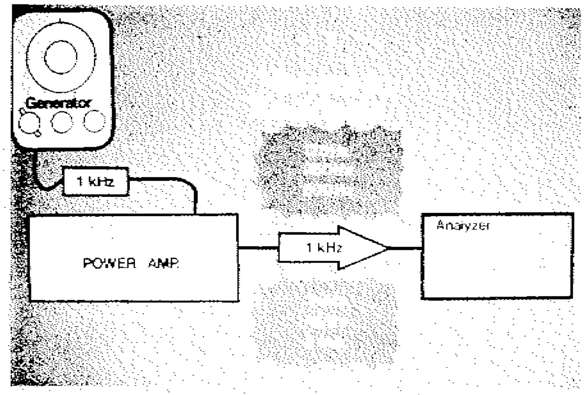
Next, check total hum and noise. Connect a VTVM across the right channel output terminals. Short out this channel's input with a shorting plug and operate the amplifier at 120 volts AC with no audio signal being applied. Now read the output voltage for the Model 250. It should measure 25 millivolts or less.



Repeat this test on the left channel. In this case, both amplifier channels are within specifications.

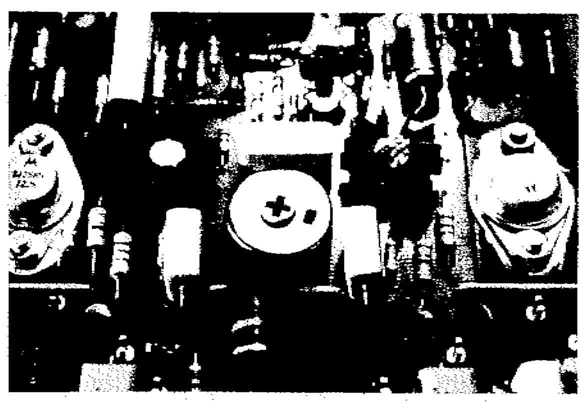


Finally, let's check Total Harmonic Distortion or THD. This test measures the residual harmonics and noise present when a single audio frequency passes through the amplifier.

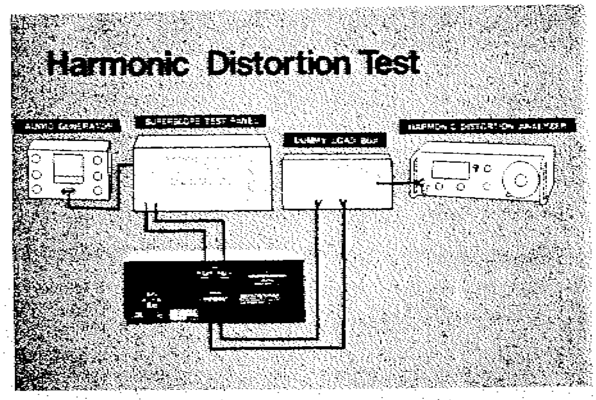


Excessive distortion in the power amplifier is usually caused by mismatched betas of the output transistors, or severe nonlinearity in any of the audio amplifier components.

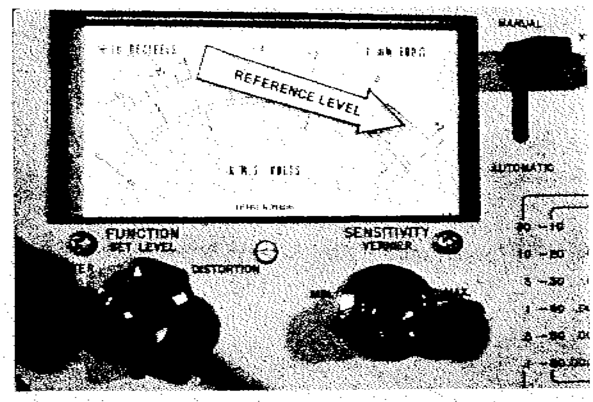
Sometimes, as we stated earlier, distortion results from a misadjusted bias control.



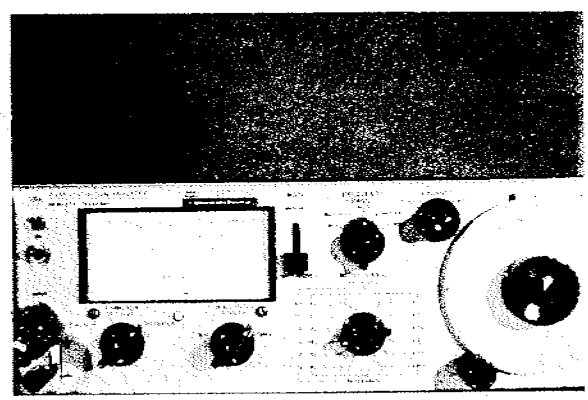
Here is the distortion test set-up. The audio generator is connected to both power amplifier inputs through the stereo test panel; the power amplifier's outputs are terminated in an 8 ohm load. The distortion analyzer is connected to the power amplifier at the dummy load box.



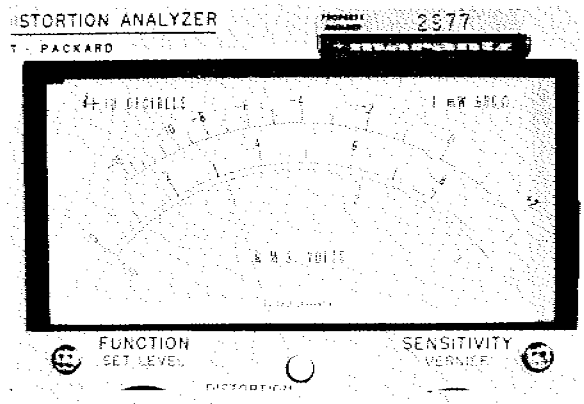
Start with 1 kHz audio and set a full scale reference level on the distortion analyzer.



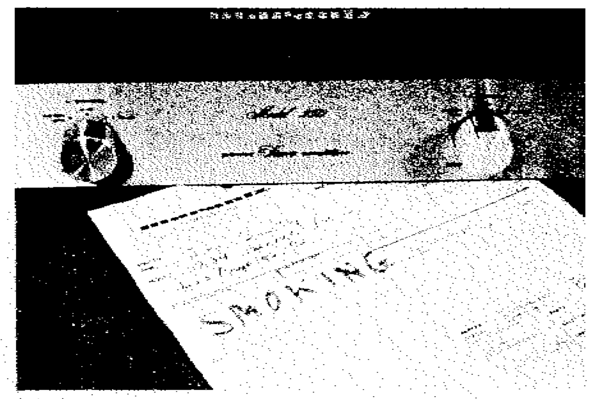
Then, null out the audio and measure the distortion. THD shouldn't exceed 0.1 percent fot the Model 250.



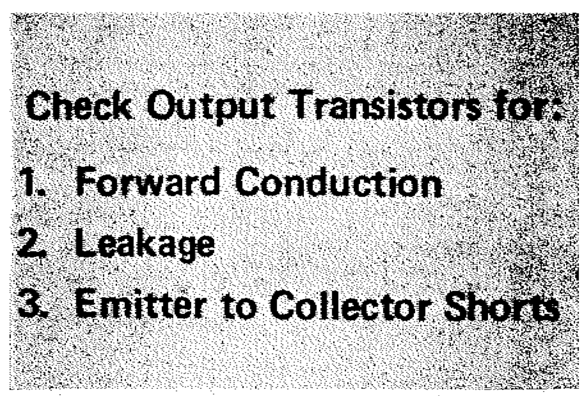
Now repeat the THD test using a 20 Hz and 20 kHz audio frequency. For the Model 250, THD should still be 0.1 percent or less at both of these frequencies.



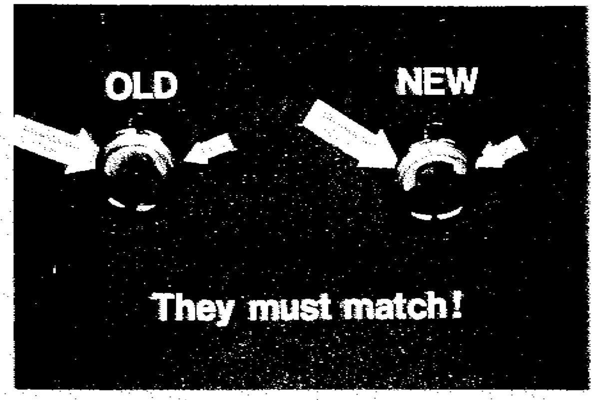
Let's review. The power amplifier was smoking, suggesting excessive current consumption. An idling power test confirmed this.



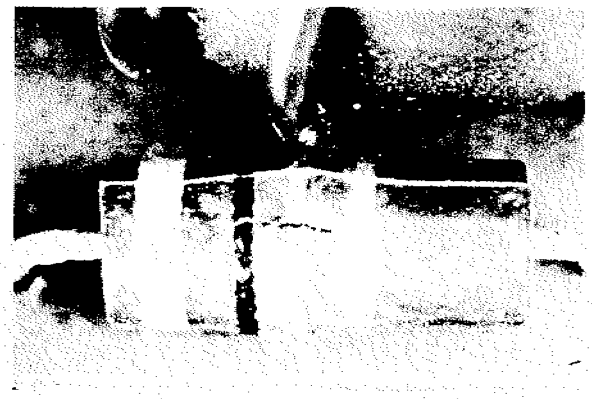
Then, we checked the output transistors out of circuit for forward conduction, leakage, and emitter to collector shorts with a VTVM. Because of the possibility that some partially damaged output and driver transistors wouldn't appear damaged during this check, all output and driver transistors were replaced.



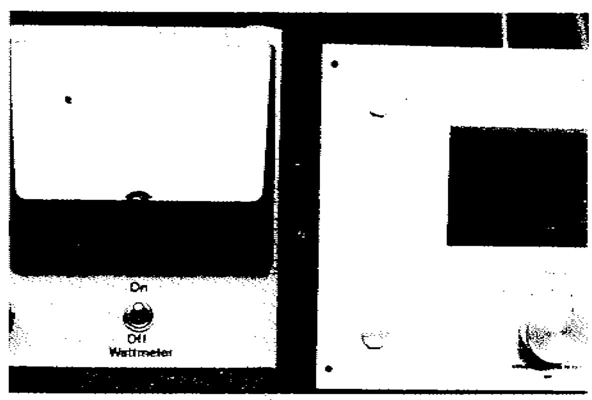
We made certain the beta and breakdown voltages of the replacement and defective transistors matched.



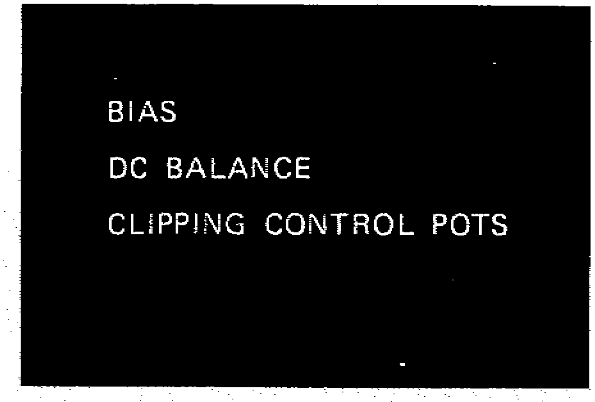
Then, we made a visual inspection to locate and replace any burned or broken components.



We rechecked idling power. Current consumption was now normal.



When power amplifier transistors are replaced, always check and adjust the bias, DC balance, and clipping control pots if there are any.



Successful hum and noise, power output, and THD tests indicated the power amplifier was properly repaired. Now it is ready to be returned to the customer. The job was done right, and that's your assurance of customer satisfaction.