Popular Electronics
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GET 400 WATTS OF CLEAN STEREO POWER WITH AMPZILLA

SPECIFICATIONS

	4 OHMS	8 OHMS	16 OHMS
CONTINUOUS POWER (both channels driven)	Over 300 W per channel	200 W per channel	100 W per channel
THD OR IM (any level to full power)	Less than 0.2%	Less than 0.05%	Less than 0.05%
FULL-POWER FREQUENCY RESPONSE	±1 dB from 1 Hz to 100 kHz		
1-WATT FREQUENCY RESPONSE	±3 dB from 0.02 Hz to 500 kHz		

PE TESTED

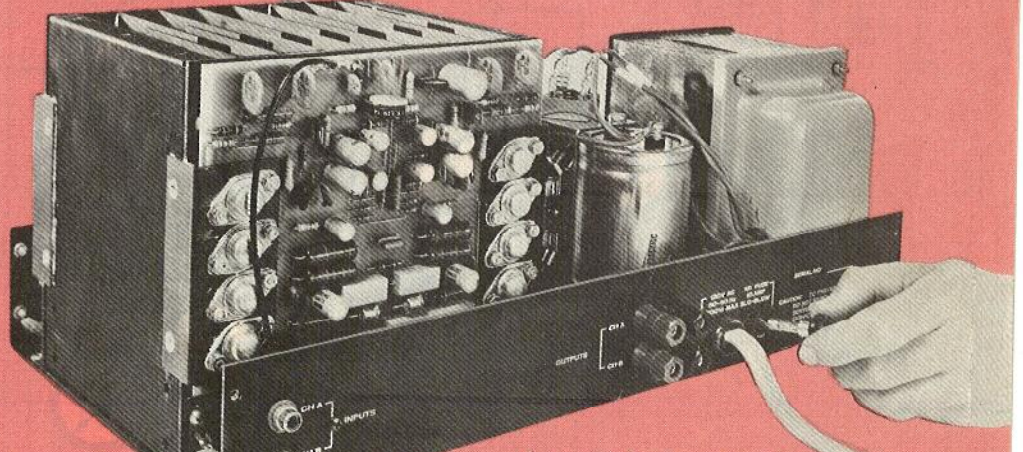
CONSTRUCTION

BY JAMES BONGIORNO

NOW YOU can build a superpower, high-fidelity stereo amplifier (200 watts per channel at 8 ohms with both channels driven) that boasts extremely low distortion, extra-wide bandwidth, ultra stability, very low noise and high inherent reliability! Called "Ampzilla," it is an audio power amplifier for kit builders who want truly high output power (see Hirsch-Houck Labs evaluation) that promises to retain its state-of-the-art design for many years.

The most distinctive visible feature of Ampzilla is its cooling chimney. This is a six-inch square opening extending from top to bottom of the amplifier. The output transistor heat-sink fins are interleaved within the chimney. A fan draws cooling air in at the bottom (which is raised from the supporting surface by plastic feet) and blows it over the fins and out the top.

In examining performance specifications, observe that the full-power frequency response is within 1 dB from under 1 Hz to over 100 kHz. As a result, it will pass a full-power 20-kHz square wave. Adherents of low-efficiency speaker systems and rock groups should also note that there's full power at the low end, 20 Hz. Addi-



Ampzilla has a rise time at full power of less than 3 μs with no overshoot or ringing. Sensitivity is 1.63 V rms for 200 W at 8 ohms; input impedance: 70,000 ohms; damping factor; over 100.

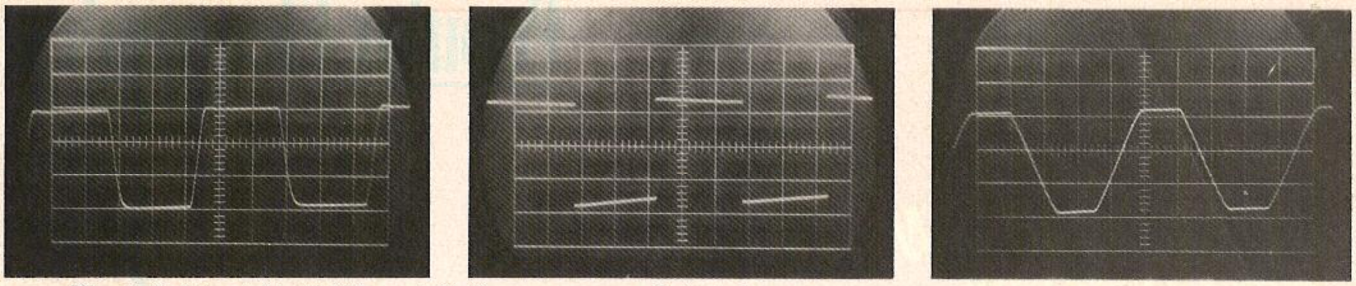


Fig. 1. Left to right: 20-kHz and 20-Hz square waves into 8 ohms at 200 W rms; and clipped 20-kHz sine wave also into 8 ohms.

tionally, if the amplifier should ever be driven into overload, clipping is as clean as can be. All this can be verified by examining the scope photos in Fig. 1.

Total harmonic and intermodulation distortion figures are unusually low at any power level up to clipping, as indicated in the specifications. Of special interest here is the absence of crossover notch in the milliwatt region. The highly stable amplifier will not oscillate, blow fuses or otherwise misbehave even when working into a pure reactive load. And since the

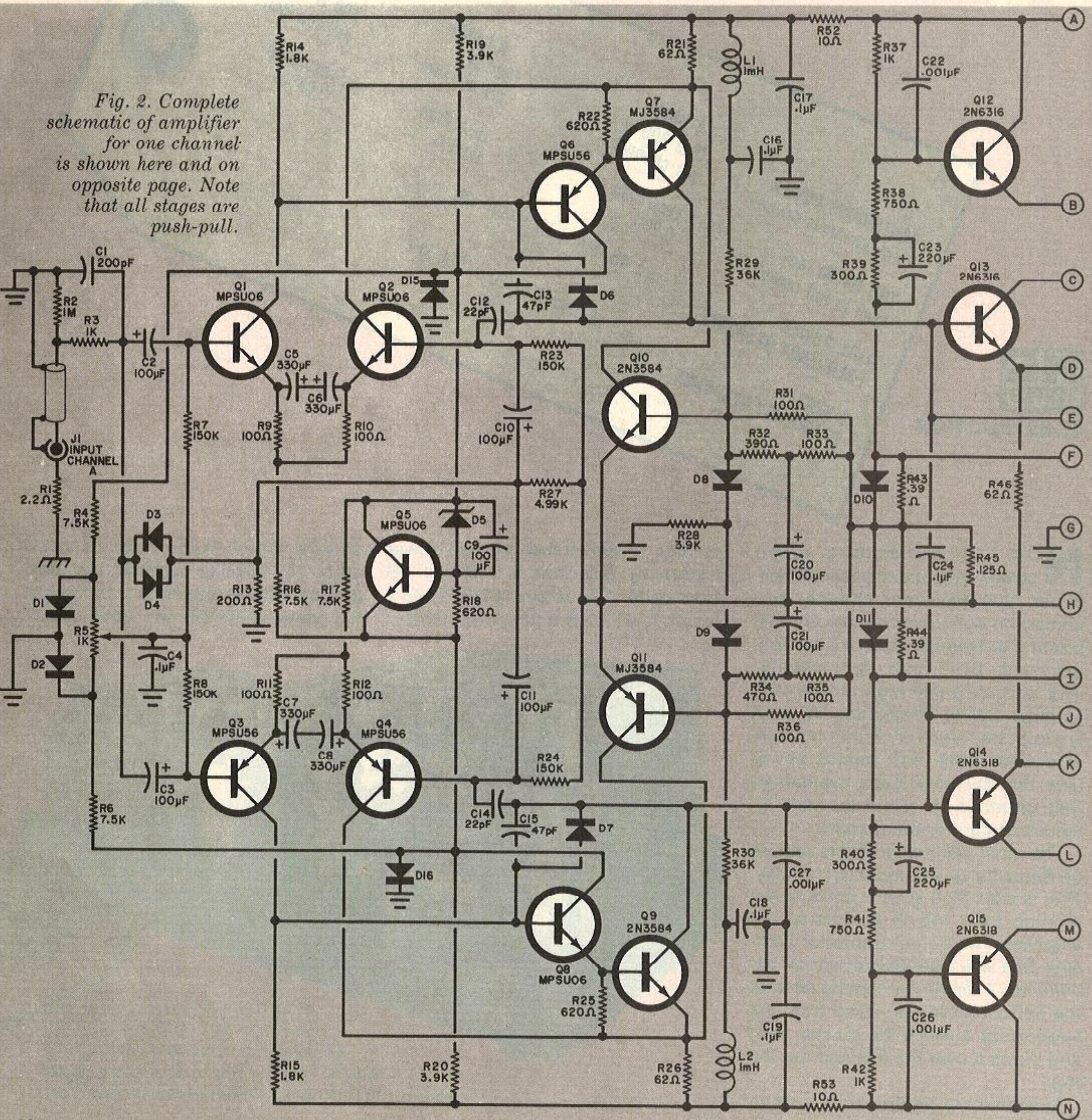


Fig. 2. Complete schematic of amplifier for one channel is shown here and on opposite page. Note that all stages are push-pull.

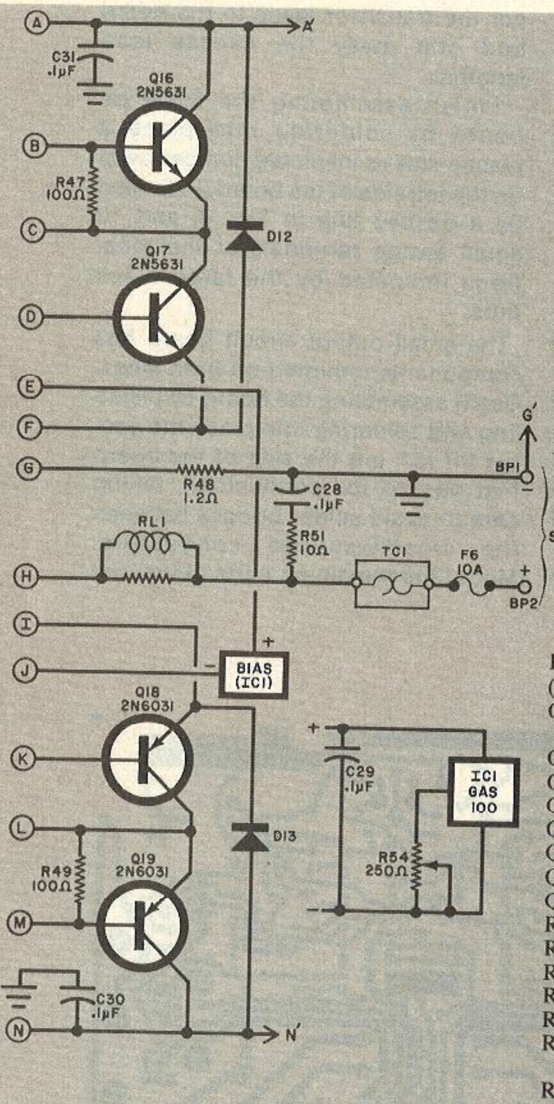
unit's design is fully pushpull from input to output, modulation noise is totally absent at low frequencies. Overall noise, too, is diminished since there is no ground loop. Measurements made with an r-f filter to eliminate r-f contamination yield a noise figure of −112 dB.

About the Circuit. Since most amplifiers employ a single differential input circuit, they are essentially single-ended designs. Virtually all power amplifiers can accurately reproduce sine waves fed into their inputs. However, it is not necessarily true that all amplifiers will accurately reproduce music and voice signals that are generally nonsinusoidal and rarely have positive and negative peaks that are equal in amplitude. The obvious solution to accurately amplifying music and voice signals, of course, is to use separate amplifiers for the positive and the negative half cycles. If the amplifiers are identical, it is then possible to obtain a virtually "perfect" amplifier.

Due to its unique mirror-image design, Ampzilla is an almost perfect amplifier. The positive and negative half-cycle amplifiers in Ampzilla share a common feedback loop, an advantage for any source that must drive the amplifier.

The biasing system in Ampzilla employs a unique integrated circuit (*IC1* in Fig. 2) that contains five operational amplifiers. The op amps in this IC track the quiescent output current in such a way as to make thermal runaway impossible.

The output stage of Ampzilla operates in a quasi-class-A mode, while the driver and slave output stages are driven class A for the full cycle. Only the driven output transistors, *Q17* and *Q18*, are operated class B. However, *Q17* and *Q18* do not switch from positive to negative. Rather, they traverse back through the class-A region at



PARTS LIST

(For power supply and **one channel)**

BP1, BP2—Five-way binding post (one red, one black)
C1—200-pF, 100-volt ceramic capacitor
C2, C3, C10, C11, C20, C21—100µF, 10-volt electrolytic capacitor
C4, C24, C29—0.1-µF, 16-volt ceramic capacitor
C5-C8—330-µF, 10-volt electrolytic capacitor
C9—100-µF, 50-volt electrolytic capacitor
C12, C14—22-pF, 500-volt, 10% ceramic capacitor
C13, C15—47-pF, 500-volt, 10% ceramic capacitor
C16-C19, C28, C30, C31—0.1-µF, 100-volt ceramic capacitor
C22, C26, C27—0.001-µF, 500-volt, 10% ceramic capacitor
C23, C25—220-µF, 16-volt electrolytic capacitor
C32, C33—16,800-µF, 75-volt com- puter-grade electrolytic capacitor
D1-D4, D15, D16—1N4148 diode
D5—1N5878C 51-volt, 5% zener diode
D6-D9—1N4938 diode
D10, D11—1N5823 diode (do not substitute)
D12, D13—1N4004 diode
D14—MV5022 (Monsanto) diode
F1-F4—AGC 6-ampere fuse
F5—MDL 10-ampere slow-blow fuse
F6—AGC 10-ampere fuse
IC1—GAS100 op amp integrated circuit
J1—Phono jack
L1, L2—1-mH r.f.c. (12-ohm dc resistance)
(*Do not substitute for following transistors.*)
Q1, Q2, Q5, Q8—MPSU06 transistor (Motorola)
Q3, Q4, Q6—MPSU56 transistor (Motorola)
Q7, Q11—MJ3584 transistor (Motorola)
Q9, Q10—2N3584 transistor
Q12, Q13—2N6316 transistor
Q14, Q15—2N6318 transistor
Q16, Q17—2N5631 transistor
Q18, Q19—2N6031 transistor
R1—2.2-ohm
R2—1-megohm
R3—1000-ohm
R4, R6, R16, R17—7500-ohm
R7, R8, R23, R24—150,000-ohm
R9-R12, R31, R33, R35, R36, R47, R49—100-ohm
R14, R15—1800-ohm
R18, R22, R25—620-ohm
R21, R26, R46—62-ohm
R29, R30—36,000-ohm
R32—390-ohm
R34—470-ohm
R48—1.2-ohm
R52, R53—10-ohm
All resistors ½ watt, 5%
R5—1000-ohm, linear-taper trimmer potentiometer
R13—200-ohm, ½-watt, 1% resistor
R19, R20, R28—3900-ohm, 1-watt, 10% resistor
R27—4990-ohm, ½-watt, 1% resistor
R43, R44—0.39-ohm, 5-watt, 10% resistor
R55—2000-ohm, 5-watt, 10% resistor
R50—2.2-ohm, 2-watt, 5% resistor
R51—10-ohm, 2-watt, 5% resistor
R45—0.125-ohm, 10-watt, 3% resistor
R39, R40—300-ohm, 1-watt, 2% resistor
R37, R42—1000-ohm, 2-watt, 2% resistor
R38, R41—750-ohm, 2-watt, 2% resistor
R54—250-ohm, linear-taper trimmer potentiometer
RECT1—200-PIV, 25-ampere bridge rectifier
RL1—32 turns u16 enameled wire wound on R50
S1—Dpdt 15-ampere switch (Cutler-Hammer No. 7241K2 or similar)
T1—106-volt center-tapped, 12-ampere transformer (1500 volt/amperes)
TC1 — 70° C thermal cutout (Elmwood Sensors)
Misc. — Suitable heavy-duty alum. chassis; mounting bracket for RECT1 and fuse block; 1000-sq-in. finned heat sink; fuse block for four fuses; fuse holder for F5; fuse holder for F6; "Boxer" fan (IMC Magnetics Corp.); 3½-in. long L bracket with 1½-in. and 1-in. legs for small heat sink; silicone paste; insulators for transistors; insulating fish paper (goes between large pc board and chimney); shielded cable; No. 16 or No. 14 stranded and solid hook-up wire; heavy-duty ½-in. (minimum) tall hard plastic feet; No. 6 solder lugs (3); No. 6 crimp ring-type solderless lugs; small rubber grommet; heavy-duty three-conductor line cord; shoulder fiber washers (2) for J1; machine hardware; rubber washers (4) for mounting power transformer; solder; etc.

Note: The following items are available from the Great American Sound Co., Inc., 8780 Shoreham Dr., West Hollywood, CA 90069: Complete stereo amplifier kit, including assembly manual for $340, plus shipping for 65 lbs. (specify fan speed: slow, medium or fast.); factory-wired for $475; with wattmeters for $525 (plus shipping); Set of four etched, drilled, screened, and staked pc boards for $20; Special power transformer for $100, plus shipping for 45 pounds; Chimney and L brackets, $50; Special GAS100 operational amplifier IC for $1.50. A power-reading wattmeter system with 2 meters and with a range selector switch is also available for $35 in kit form or $50 factory wired and tested.

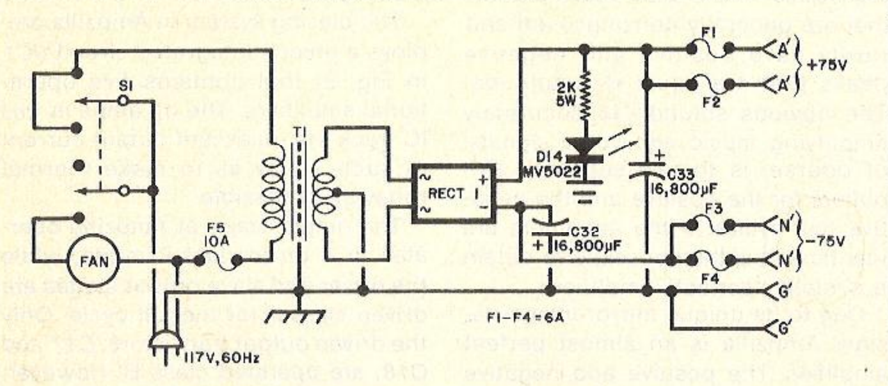


Fig. 3. Power supply schematic. Special transformer is used to handle load and get good balance.

the zero-crossing point. This eliminates the cross-over notch found in most other power amplifiers.

The complementary differential input pairs consisting of *Q1/Q2* and *Q3/Q4* are supplied current by the *Q5* floating regulator circuit. This regulator also provides a turn-on/turn-off delay that eliminates thumps.

The output stage of the amplifier is a full-complementary series system that employs the latest in epitaxial-base power transistors. (These are special transistors. No attempt should be made to replace them with other types.) The predrivers and protection devices are designed to operate at frequencies up to 30 MHz; do not try to substitute other devices for them.

The power supply circuit for Ampzilla is shown in Fig. 3. Power transformer *T1* has a special bifilar winding that exactly locates the center tap. The wire used in winding the transformer is heavy-gauge copper with a square cross section designed to eliminate ground loops. There are no commercial substitutes for the transformer that will work as well as that available from the kit supplier (see Parts List).

The open-loop gain of the amplifier is about 70 dB. So, filter capacitors *C32* and *C33* have unusually high capacity values because only the minimum amount of feedback has been designed into the amplifier to optimize the stability factor.

Construction. Assembling Ampzilla is a relatively simple, straightforward job. Almost all of the components mount on two (for each channel) printed circuit boards. The half-size etching and drilling guides and components placement diagram are shown in Fig. 4.

A convenient place to start assembly is by wiring the large pc board, referring to Fig. 4 for parts locations and Fig. 5 for details on how to mount *Q7* and *Q9* through *Q15* and the metal heat sink bracket to the board. Note in Fig. 5 that the transistor mounting screw heads must be soldered to the board, necessitating the use of *nickel*-plated screws. Before soldering the screws down, place over each a nylon shoulder bushing, followed by the bracket (make sure the bushings engage the bracket holes). Temporarily screw down the nuts to hold the assembly together.

After soldering the heads of the screws to the board, remove the nuts and mount the transistors, sandwiching between each transistor and the bracket an insulator liberally coated on both sides with silicone paste. Make absolutely certain that you install the transistors in their proper locations on the board. Then fasten each transistor down via its pair of machine screws with No. 6 lockwashers and 6-32 machine nuts. Solder the transistor leads to the board and clip away the excess lead lengths.

Finish assembling the large pc board by soldering into place a plastic-sleeve-insulated jumper wire on the foil side of the board (indicated by a dashed line in Fig. 4) and 16 small swage terminals at the locations indicated by the large black dots.

The small output circuit board has components mounted on both sides. Begin assembling the board by installing and soldering into place the socket for *IC1* (on the side of the board that has no foil conductors), taking care to avoid solder bridges between the closely-spaced conductors. Mount the remaining parts of the out-

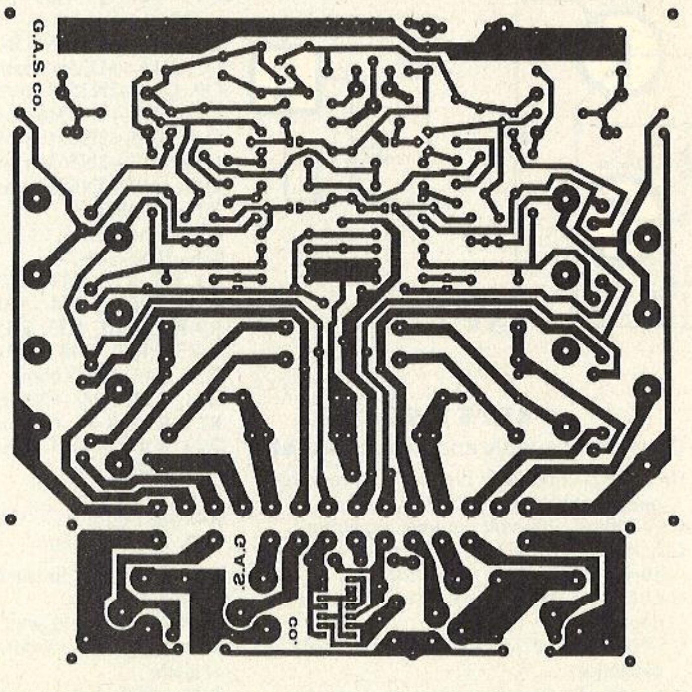
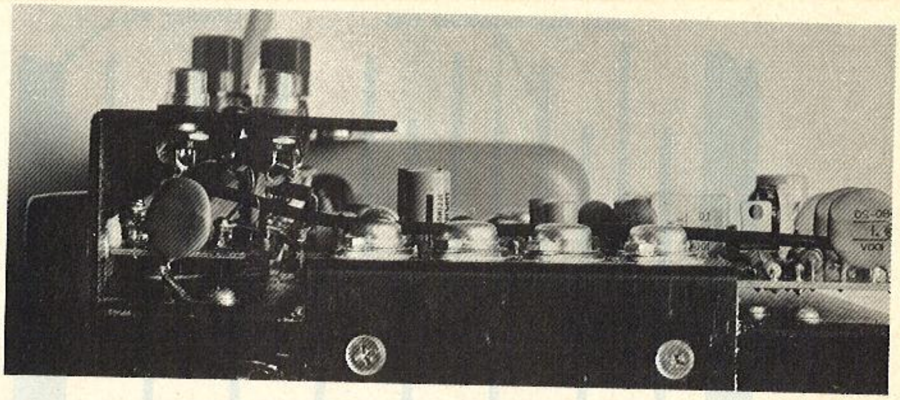


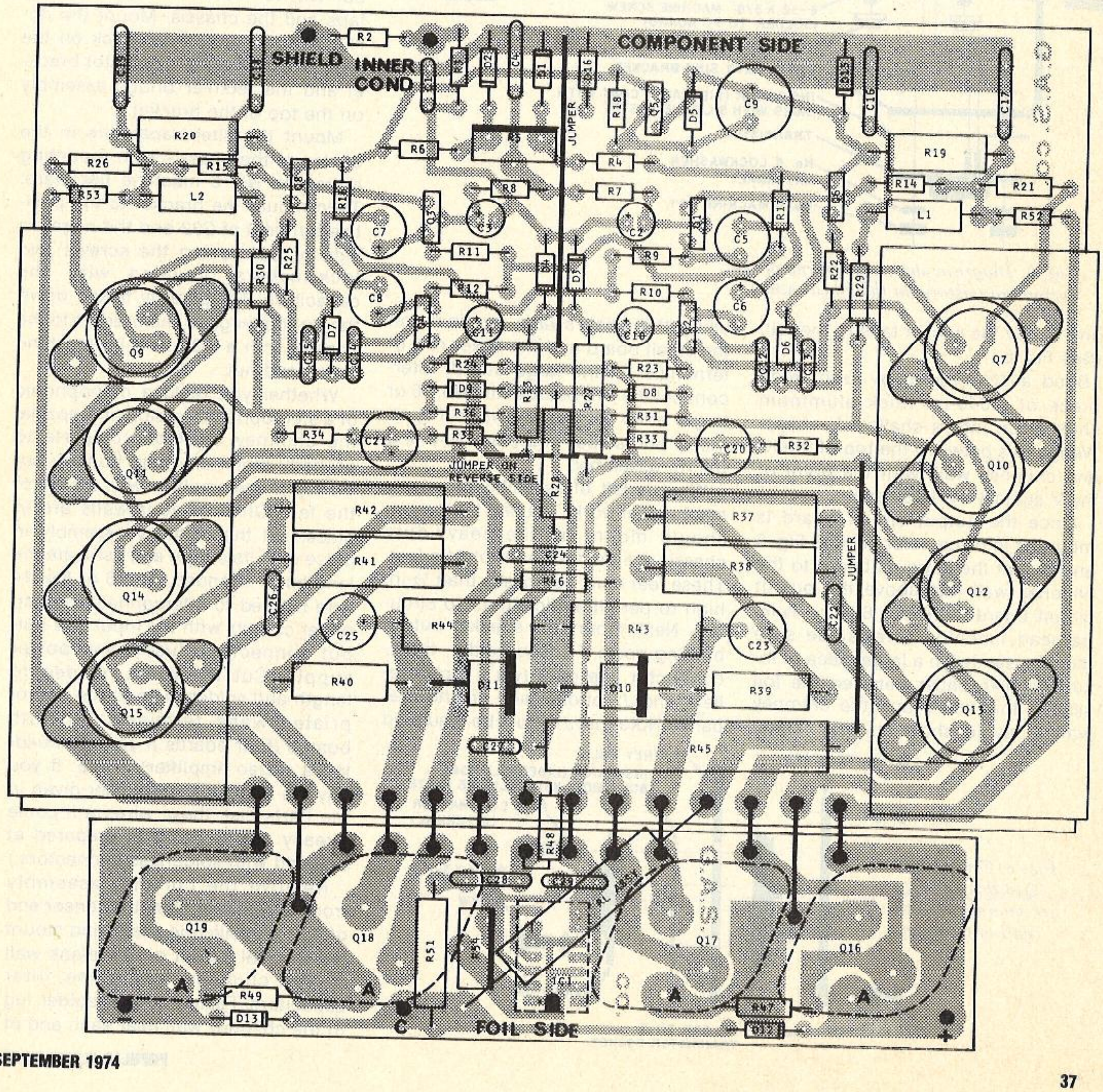
Fig. 4. Foil patterns for pc boards for one channel are shown half-size at the right. Component placement on opposite page.

put circuit (except *R48* and the *RL* assembly), including the 14 small swage terminals along the board's upper edge and 3 large swage terminals along the lower edge.

Install *IC1* in its socket. The power transistors *must* be installed in the following manner. First, place an insulator, liberally coated on both sides, on each transistor. Next, install the transistors in their respective locations on the chimney wall, and push into place the four molded transistor sockets. Make sure the shoulders on the sockets engage the holes in the chimney wall. Then, anchor the transistors in place with machine hardware. Finally, install the pc board assembly over the sockets



Detail photo of J1-input end of chassis and C31/C32 installation. Mounting of metal heat sink bracket is shown in Fig. 5.



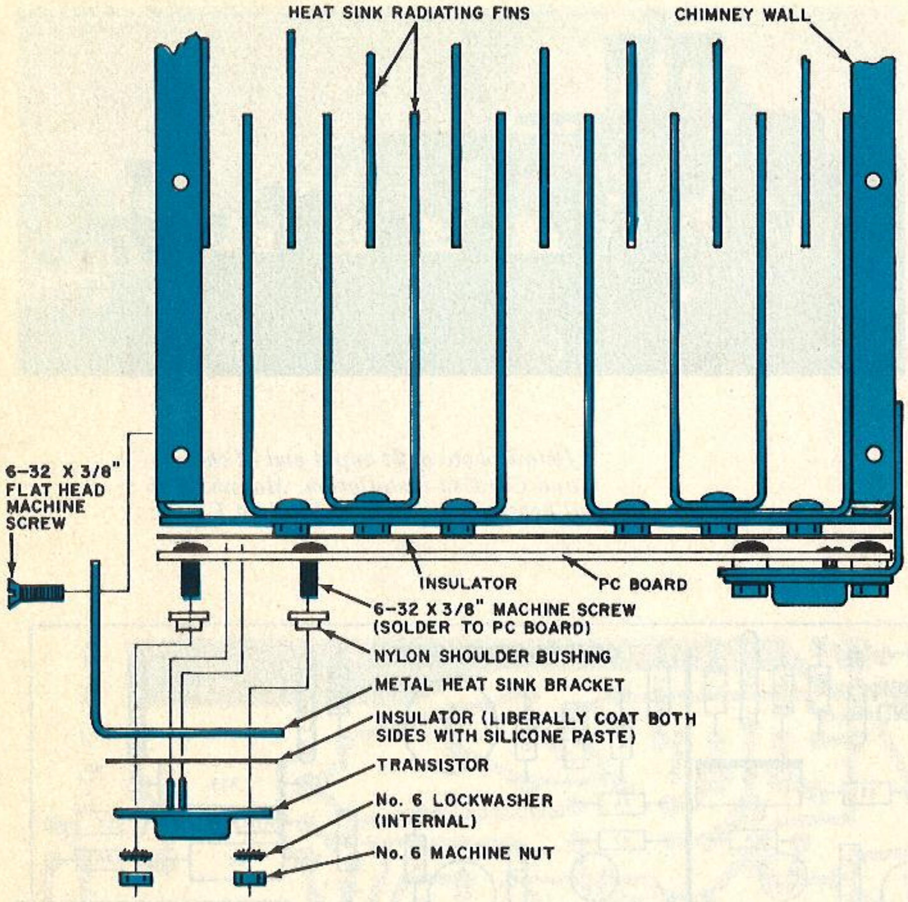


Fig. 5. Diagram shows mounting of the output transistors on their heat sinks.

and solder the socket tabs to the foil. (See Fig. 6.)

Bend a 1½-in. long by ½-in. wide piece of 0.040-in. thick aluminum shim stock into a shallow V shape. Wedge this between the top of the IC and chimney wall, with the point of the V against the IC's case.

Once the output circuit board is mounted in place, refer back to Fig. 5 and mount the large pc board to the chimney wall just above the output circuit board with four 6-32 × ⅜-in. flathead machine screws. Be sure that you sandwich a large piece of insulating fish paper between the foil side of this board and the chimney wall to avoid short circuits. Then, using the small swage terminals on the small board and the lower row of terminals on the large board, interconnect the two boards with No. 16 or larger solid wire as shown in Fig. 4. Install and solder into place *R48* and the *RL* assembly.

What is left of assembly is largely mechanical work. The first things you should mount on the heavy-duty chassis are the four hard-plastic feet. These feet must be no less than ½-in. high to permit sufficient air to circulate. Next, mount the speaker output binding posts, *F5* fuse holder, three-conductor line cord (via a strain relief), and *J1* phono jack on the rear panel. Note that *J1* must be insulated from chassis ground with a shoulder fiber washer setup.

The front panel contains power switch *S1* and speaker fuse holder. Note that *S1* has two power-on positions — one for fan only, and the other for fan and amplifier. If you elect to install a power-on indicator (the optional LED and current limiting resistor shown connected to the 75-volt line in Fig. 2), this should also go on the front panel, at the opposite end from the power switch.

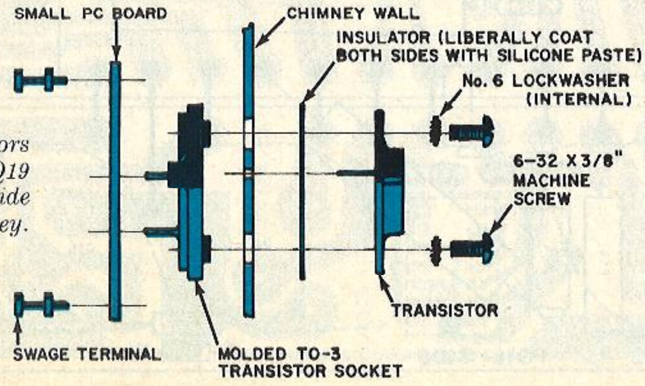
Now, mount the heavy power transformer at one end of the chassis with No. 8 or No. 10 machine hardware (⅝-in. long screws, nuts, ½-in. flat washers, and lockwashers) as shown in Fig. 7. Shock mount the transformer by placing a deformable rubber washer between the mounting tabs and the chassis. Mount the dc-line power supply fuse block on the long side of the filter capacitor bracket and the rectifier bridge assembly on the top of the bracket.

Mount the filter capacitors in the center of the chassis with mounting rings and No. 6 machine hardware. Then mount the bracket to the positive terminal of *C32* and the negative side of *C33*, using the screws and lockwashers provided with the capacitors. Temporarily fasten down the bottom edge of the bracket to the chassis with a 6-32 × ¾-in. machine screw and nut.

Whether you build a monophonic or a stereophonic version of Ampzilla, the chimney must be complete to properly direct any heat buildup out the top of the amplifier with the aid of the fan. Once all four walls are in place, set the chimney assembly in place over its cutout and estimate the lengths of stranded No. 16 or No. 14 wire needed to interconnect the amplifier circuits with the input and output connectors, fuses, and power supply. Cut the wires needed to length and solder them to the appropriate swage terminals on both boards (four boards if you are building a stereo amplifier). (Note: If you buy the kit from the supplier given in the Parts List, these wires will come already cut to size and prepared at one end with solderless connectors.)

Remove the chimney assembly from the chassis. Coat the sensor end of *TC1* with silicone paste, and mount the thermal cutout on the blank wall of the chimney facing the filter capacitors. Fasten a No. 6 solder lug to the chimney wall near each end of

Fig. 6. Transistors Q16 through Q19 are mounted inside wall of chimney.



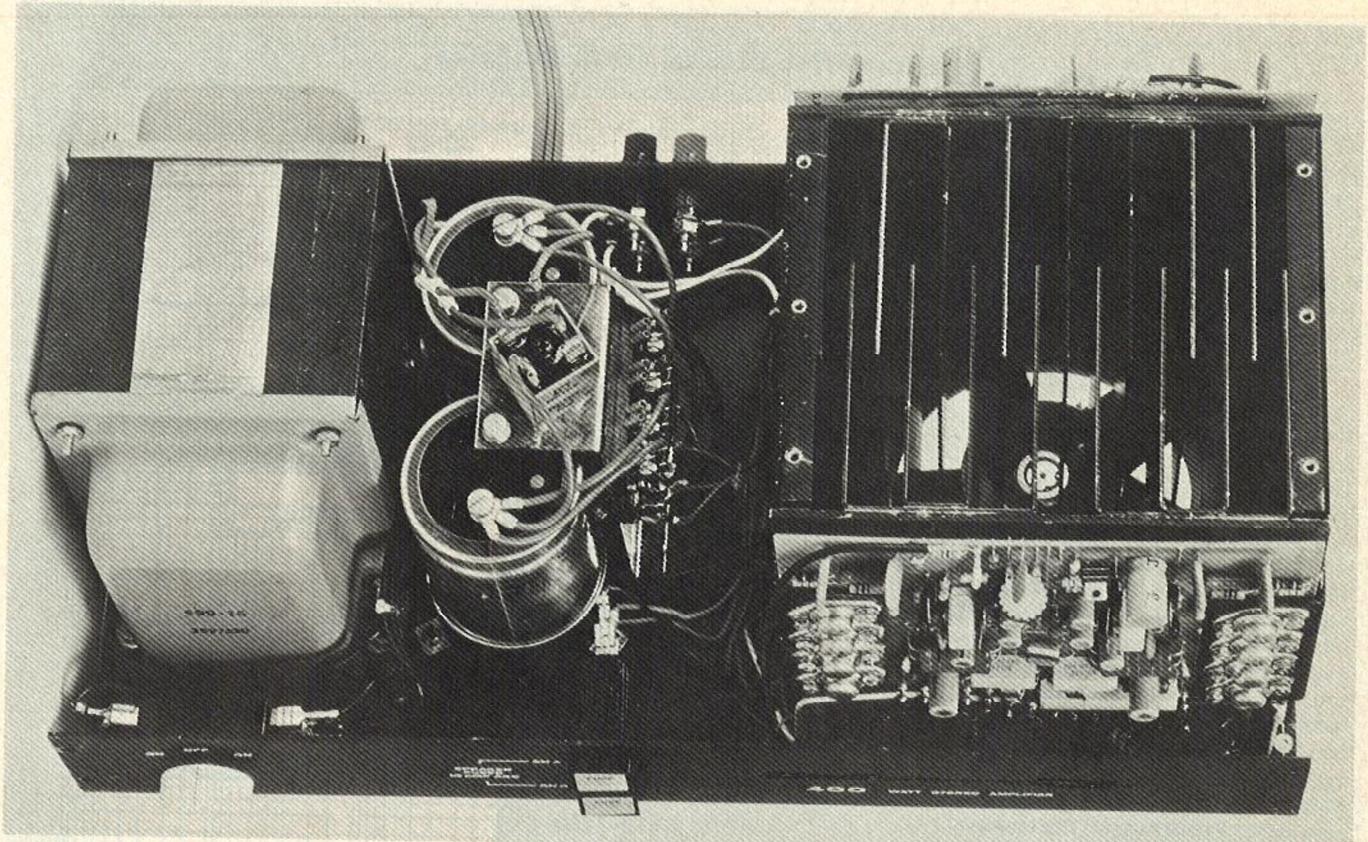


Fig. 7. Overall view of amplifier shows transformer mounting and fan at bottom of heat sink chimney.

the output circuit board and install and solder $C30$ between the (–) swage terminal on the output board and one lug and $C31$ between the (+) terminal and the other solder lug.

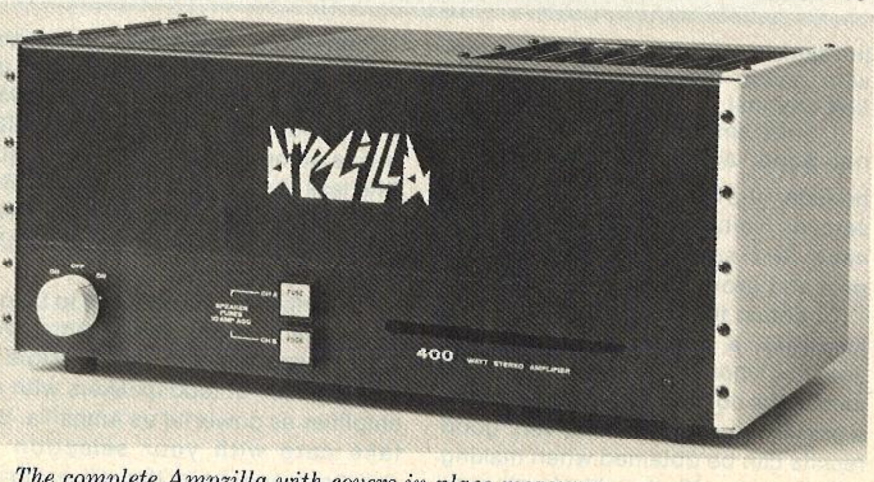
Mount the fan on the chassis over its cutout. Then pass its power cord through a rubber-grommet-lined hole in the chimney wall. Before mounting the chimney assembly in place, connect the shielded cable coming from across $R2$ on the large pc board to $J1$ and $R1$ from the common lug on $J1$ to a No. 6 solder lug mounted on the rear of the chassis.

With the chimney assembly in place, interconnect the rest of the circuit. The three heavy-gauge ground wires, two from the speaker ground terminals (in a stereo system) and the other from $T1$'s center tap, should be terminated in No. 6 crimp-type ring lugs and fastened to the chassis via the bottom mounting screw on the filter capacitor bracket. Finally, $D12$ and $D13$ install in the circuit directly from the appropriate lugs on the fuse block and proper terminal of $TC1$. To keep everything neat, bundle the cables with several cable ties.

Checkout & Adjustment. Install the Ampzilla's fuses. Then set bias potentiometer $R54$ for minimum resistance and offset potentiometer $R5$ to center of rotation. Using an ohmmeter, connect one lead to speaker output binding post $BP2$ ("hot" output connector) and touch the other test lead to each of the output transistors' cases (points marked with an A in Fig. 4), one at a time, and note the resistances. The meter pointer must indicate more than 500 ohms dc resistance for each transistor. Remove the test lead from $BP2$ and connect it directly to chassis ground. Repeat the measurements on the output transistor cases. Allowing time for the filter capacitors to charge up, which might take several seconds, there should be no short-circuit indications from the transistor cases to ground.

Touch one ohmmeter test probe to the case of $Q7$ and the other to the case of $Q9$ (both on the large pc board). These are the two bias points, and the ohmmeter should indicate a resistance of 2000 ohms or less — if the bias potentiometer is still set for lowest resistance.

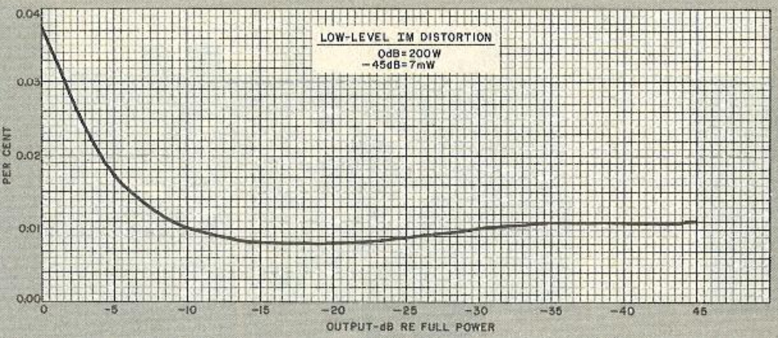
If the resistance measurements check out, connect a dc voltmeter between one channel's "hot" output speaker binding post ($BP2$) and chassis ground. Disconnect the power lines from the channel not under test. Wrap a couple of turns of electrician's tape around the free ends of the dis-



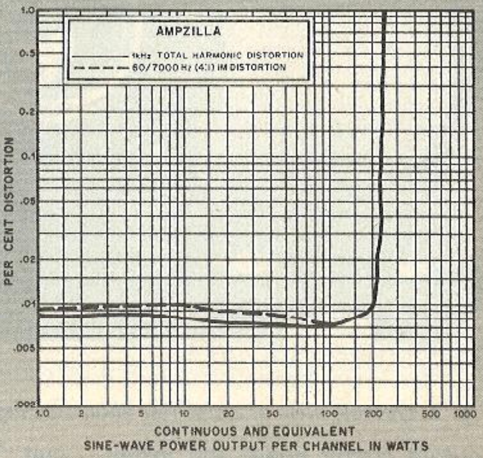
The complete Ampzilla with covers in place measures 17½ inches wide by 7 inches high by 9 inches deep.

Hirsch-Houck Labs Tests Ampzilla

Ampzilla is aptly named. Its 45-pound (20.5-kg) weight and more than 400 watts of output power place it solidly in the audio "monster" amplifier class. The heavy-duty, three-conductor power cord emphasizes the fact that this brute is definitely not to be plugged into an ordinary switched outlet on a preamplifier.



Low-Level IM distortion is exceptionally small, indicating there is no crossover notch.



Curves of distortion vs power output show under 0.01% THD to 200 watts output.

Laboratory Measurements. With both channels driven simultaneously at 1000 Hz into 8-ohm loads, the output waveform clipped at 225 watts/channel. Into 4-ohm loads, the maximum power was 350 watts/channel, while into 16-ohm loads it was 132 watts/channel.

Using 8-ohm loads, the 1000-Hz THD was less than 0.01 percent for all power outputs up to 200 watts/channel. It rose to 0.03 percent at 220 watts/channel just before clipping occurred. The IM distortion followed a similar pattern, measuring just less than 0.01 percent up to 200 watts/channel and reaching 0.43 percent at 220 watts/channel. The low-level IM distortion was exceptionally low, indicating a complete lack of crossover "notch" distortion. It measured about 0.01 percent from 7 milliwatts to 25 watts output, with a smooth rise to 0.037 percent at the rated 200-watt output.

We drove the amplifier at frequencies from 20 Hz to 20,000 Hz to 200, 100, and 20 watts/channel output into 8-ohm loads. The harmonic distortion measured between 0.003 percent and 0.01 percent at all power levels for frequencies higher than 200 Hz. It rose slightly at the lower frequencies to a maximum of 0.05 percent at 20 Hz (at the 200-watts/channel level).

The gain of the amplifier is fixed. An input of 0.35 volt (350 mV) was needed to drive it to a reference 10-watt output, while 1.7 volts drove it to the clipping level. The output noise was 83 dB below 10 watts (96 dB below rated power). As would be expected from a top-quality amplifier, the frequency response of Ampzilla was flat over the entire audio range and well beyond. Our measurements revealed a variation of less than ±0.1 dB from 5 Hz to 40,000 Hz. The response was down 1 dB at 200,000 Hz and 3 dB at 330,000 Hz. The square-wave rise time was 1.3 µs.

User Comment. Ampzilla is a state-of-the-art amplifier in its electrical characteristics. Unlike other amplifiers of comparable ratings, this one runs literally cool to the touch even after extended full-power operation. (The middle-speed cooling fan was incorporated in the test unit.) In fact, at the conclusion of our tests, which frequently overheat amplifiers and trip their thermal protective devices, the heat sinks on Ampzilla were still cool to the touch. The only signs of heat were in the vicinity of our test load resistors.

All in all, we cannot imagine a less expensive way of obtaining several hundred watts of cool audio power with truly insignificant distortion than is available with Ampzilla.

connected wires to prevent them from shorting together or to the chassis while you perform the following test. Plug the line cord into a three-wire grounded 117-volt, 50-Hz ac receptacle and set power switch *S1* to the amplifier-on position. With the power on, if the voltage indication is greater than +0.5 or −0.5 volt, immediately turn off the power and look for the trouble. However, if you obtain the proper voltage indication, turn off the power and unplug the line cord. Wait a minute or so until the charge on the filter capacitors bleeds off; then, reconnect the wires to the unchecked channel's pc board. Perform the same test on the untested channel with power disconnected from the first channel.

If both amplifier channels check out good, adjust the offset potentiometer (*R5*) in each channel for a zero dc voltage indication between each *BP2* speaker output binding post and ground.

To obtain the best results from this amplifier, a commercial distortion analyzer should be used. But since most of us do not have access to such a piece of test equipment, very good results can be obtained when making adjustments with the aid of only a dc voltmeter.

Connect the voltmeter's test leads to the cases of *Q7* and *Q9*, one on each. Adjust bias potentiometer *R54* until you obtain a reading of 2.0 volts. This is an approximate setting, just a little less than is actually needed. But it is in a "safe" area because too much bias can thermally destruct the output transistors.

The amplifier is now ready to be put into service in your hi-fi system. One word of caution: It is very possible to destroy a set of loudspeakers with an amplifier as powerful as Ampzilla. So, take care with your selection of speakers and hold the drive signal down to a reasonable level. ◈