KIT REPORT

A CONSTRUCTION REPORT
THE TAMING OF AMPZILLA

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with the cooperation of
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I WAS ONE of the very first to purchase the Great American Sound Company's much-heralded first product, the super power amplifier kit modestly known as "Ampzilla."[1] Designed by Jim Bongiorno and incorporating many design innovations, Ampzilla appears to be a real value in terms of clean watts per dollar invested, particularly in kit form. However, the successful and painless completion of a kit of this sophistication and complexity is not something which is automatically ensured, nor something which can be covered by the spec sheet. Thus there is a real need for an evaluation report which does more than extol the virtues of a finished kit product.

The sample I tested may well be the greatest ever in many regards; but, more important to the kit builder, can it be duplicated, starting from a box of parts? As a matter of fact, the realization of the performance quoted for any kit is highly dependent upon the person constructing it; and a great deal of the measure of the overall quality of a given kit is contained in how well the manufacturer recognizes potential problem areas for the home constructor, and how effectively he deals with them to guarantee your successful completion of his design.

Kits differ in degrees of complexity, ranging from the simplest up to color TV's, ham radio rigs and super power amplifiers. None of the three latter kits is for the novice; but on the other hand, any potential constructor of a kit on this level should understand his or her responsibility towards success. Thus it is the purpose of this review to illustrate the following:

1. what it takes to complete a kit (such as Ampzilla in this case);
2. the performance of the finished kit.

The emphasis will be on the construction phase, with a blow-by-blow description of difficulties encountered and solutions to problems--the kind of thing you want to know before you decide to put your cash on the line.

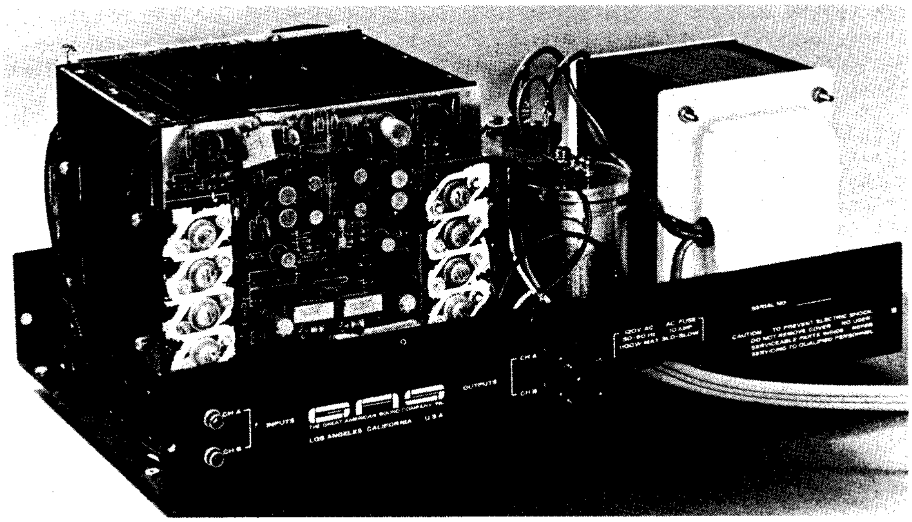


Fig. 1: Ampzilla with the cover removed, rear view.

Ampzilla: A Brief Description

Ampzilla is a super power amplifier, harnessing the capability to deliver 200 watts into 8 Ohms, or over 300 watts into 4 Ohms. This is a per channel rating and it applies on a continuous basis, with both channels driven. THD and IM at any power level (up to full output) is quoted as below 0.05% for 8 or 16 Ohm loads, below 0.25% for 4 Ohm loads. Full power response is rated at ±1dB, 1Hz to 100kHz, while low level (1 watt) response is ±3dB, 0.02Hz to 500kHz. How all of this comes out in the final kit is covered in the "Performance" section below.

Both the mechanical and the electrical design of Ampzilla are innovative; some of the former may be seen in Fig.1, a view of the completed amplifier with the exterior cover removed. Half the interior of the chassis is taken up by the 1.5kw power transformer and power supply components, which supply ±65V* (unregulated) at over 12 amps. You've probably heard of brute force power supplies, but practically everything in Ampzilla is brute force: power switch, line cord, 16,800µF filters, 25A bridge, and a heat sink assembly the like of which you've never seen before.

In fact the heat sink chimney is probably the most distinguishing mechanical (and one of the electrical) features of Ampzilla. This assembly occupies the remainder of the chassis space, and the amplifier circuits are literally built around it. Each channel uses four 16A, 140V-rated TO-3 power transistors which rest at the bottom of the heat sink on either side, facing inward. On the outside, electrical connections are made to these transistors via a small PC board which also sockets an IC bias regulator. This IC is ceramic packaged for thermal conductivity, and rests directly on the main heat sink between the pairs of output transistors. The thermal feedback this provides is used to adjust the bias to the output stage automatically so as to maintain optimum performance in the crossover region. A fan mounted underneath forces cooling air through this 1000 sq. in. heat sink; the warmed air exits through an opening in the outside cover.

*See notes under "Performance," below.

The two large drive boards (one per channel) mount vertically on either side of the heat sink assembly; these mount the largest number of the circuit parts. Eight TO-66 power transistors mount on L brackets which attach the drive board to the main heat sink, as well as heat sink the transistors.

The "integral" design of the drive/output stage/heat sink assembly holds interconnecting wiring within Ampzilla to a minimum; precut lengths and pre-attached, heavy, quick-disconnect connections simplify the assembly of what wiring does exist. Mechanical interconnections (there are loads of screws) are simplified by captive nuts pressed into the chassis--there are no nuts and bolts.

Electrically speaking, Ampzilla is noteworthy beyond the impressive size of its components. Each channel uses a complement of 19 transistors, and is completely symmetrical--push pull from input to output. One feature of this concept of design is Jim Bongiorno's dual differential input stage, which aims at reducing asymmetrically produced distortion (I'll comment later on the performance of this circuit).

The IC regulator I mentioned above programs the bias voltage applied to the output stage. This IC tracks the current in the output stage, preventing thermal runaway, or crossover notches due to insufficient bias. Working in conjunction with the bias regulator is a scheme which maintains a small class A idle current at all portions of the cycle in the output transistors. At low levels the output transistors operate class A, but they switch to class B for high levels, the switching being accomplished via Schottky power diodes. It is this biasing feature which gives Ampzilla its very low low-level distortion.

All internal bias currents within the amplifier are derived from a "floating" regulator, which has a built-in turn-on and turn-off delay. This gives controlled on-off characteristic, which eliminates the ugly thump of switching transients.

Protection is an important factor in an amplifier of this power capability, both for the amplifier and for the speakers it is to drive. In addition to the line fuse, Ampzilla has individual fuses in the ±65V supply lines and fuses in the speaker lines. Also in the speaker lines are thermal cutouts, attached to the heat sink assembly. Within the circuit itself, safe area limiting protects the output transistors.

Building the Kit

Since the kit I received was an early model and probably doesn't represent current production in all details, constructors today would most likely not encounter some of my initial problems. A few parts turned up missing, but were replaced subsequently. The manual provided for the kit consisted of a series of typed instructions which in some cases did not exactly match the parts provided. I received only one wiring diagram, no schematic at all, and no pictorial diagrams. Construction of the kit was therefore laborious, as I had to go back and forth between the typed instructions and the magazine article which supposedly tells you how to put it together.[1]

Neither set of instructions is adequate by itself; but between the two of them I was able to manage. I trust that the final manual eliminates these difficulties, but I have never received one to verify this. However, since the major source of difficulty in taming Ampzilla is not really related to the quality of instruction, the manual is not an overriding factor in this case.

Construction begins with the separation and counting of parts. Although this is the most wearisome phase of any kit to me, it is important. Spot possible missing or damaged parts so you can obtain replacements as soon as is possible.

GAS warn you of the importance of careful and explicit adherence to their instructions. This is certainly an essential point, especially in this case, as you are building a high performance amplifier using many expensive transistors. A set of output transistors for *one* channel will set you back $32, so read and heed!

Most of the small components are contained on two large drive boards, one of which is visible in Fig.1. I encountered relatively few problems in assembling these boards. A few polarities were missing from electrolytics, and two diode symbols (D10, D11) were ambiguous, but these could be straightened out by reference to the schematic. D5, a zener, is not marked for polarity and had to be checked against an Ohmmeter and data sheet. The real problem with the drive boards turned up later in checkout (see box on p.16). If you build an Ampzilla, you will want to read the material on this problem over carefully.

Take care as you install the many power transistors which make up Ampzilla. Use liberal amounts of silicon grease, and check each and every transistor and its heat sink mounting surface for possible burrs.

Most important, check each insulating washer for cracks or tears and overall quality. They should be either mica or aluminum oxide, not the thin plastic film variety. The plastic types cannot take the torque required in mounting, and tend to shear. In the kit reviewed here, this happened in three cases involving the TO-66 units on the drive board, not only blowing fuses but also laying two output transistors to rest. The washers literally caught fire; thus they are entirely inadequate for the job here. So, to avoid difficulty, use plenty of silicon grease and be very careful in mounting these transistors.

When the drive boards are finished, check them over carefully for correct component installation and soldering, and give them preliminary Ohmmeter checks. After a power supply checkout, you are ready to apply power to the drive boards to verify their operation alone prior to connection in the circuit as a whole. The boards are jumpered in a special manner for this test, and you need a 'scope, signal source, and DC meter. What you are checking for is correct output DC bias, and that the unit functions as an amplifier. I strongly suggest you also perform the more detailed tests described in the box on p. 16.

Assuming all is well, you next construct the heat sink. This is an extremely messy and tedious job, and you end up with heat sink grease all over everything.

Next you assemble the drive boards to the heat sinks, and connect them to the output stage drive board and transistors. After some wiring of outputs, inputs, and power connections, you are almost ready for turn-on.

Double-check everything, run a final Ohmmeter test, and the moment of truth is before you. Rotate the bias trimmer full off to prevent full output stage conduction.

When you first apply power to the full amplifier, it is best to use a Variac or other means of bringing the voltage up slowly. If you haven't a Variac, you can place two 1K 2W resistors in the fuse holder (in series with the ±65V lines). This will reduce the voltage to the circuit; it will still work if it's o.k., but won't blow if it's not.

Setting It Up

GAS recommend you set up Ampzilla in one of two ways. Using a sine wave source, and a 'scope connected to the "distortion out" jack of an analyzer set to null, you bring the output stage bias up to just remove the spikes caused by crossover notches. This works o.k., and you get a positive indication. Alternately, you can set bias on the output transistors to 2.1V with a DC meter.

I found the reading to *be* 2.1V when the distortion was nulled, so this method also works well if your meter is accurate. A caution here: be sure your meter *is* accurate--if it reads low you'll cook the output stage with too much bias current. For this reason I wouldn't recommend this bias setup method be used at all. A sure-fire simple method is detailed below under "Performance."

At this point, with both channels trimmed, the amplifier is ready for use after the heat sink is bolted into place and the remaining mechanical parts are buttoned up.

Performance

Testing Ampzilla proved to be quite a challenge, in more than a few ways. The first go at it brought about the spectacular demise of that set of power transistors. However, even after I had cleared up the problems which caused this, there remained the not inconsiderable task of characterizing its performance with reasonable accuracy. In view of its very impressive specifications and extremely high power, this presents problems in measuring equipment resolution, the AC power source used, and the load resistors used to dissipate its healthy output. All of these factors came to bear in performance testing, but I managed to cope with them successfully. In the narrative which follows, I will mention where I made certain allowances for the sake of finishing this report in a reasonable length of time.

The tests I performed on Ampzilla were the traditional THD and IM tests, frequency response, gain, power output, and a number of waveform photos which illustrate several aspects of performance. Most of the data obtained in these tests is implicit in the figures which follow, but they will also be described so that you can gain an overall perspective for yourself.

The first test run was for total harmonic distortion across the band at various power levels, with both channels driven simultaneously. This data is shown in Figs.2A, 2B and 2C for 8 Ohm loads. The tests were run after preconditioning for one hour at a 65 watt output. Ampzilla survived this test o.k., but did manage to warm its heat sink chimney quite noticeably.

In general this data is quite good, as it is well below the spec of 0.05% at all but the extreme high frequencies of 15kHz or more. In fact, at mid-frequency, the THD for levels below 100 watts approaches the equipment residual, which is down around 0.002%. This may be noted from 2C, which is the same data, but plotted in terms of 1kHz THD versus power.

I had a problem with obtaining stable readings below 200Hz due to beat frequencies developed between the test signal and the power line harmonics. For this reason I omit this data, although it never appeared to be in excess of the specification. (This is one of the areas where further work is indicated, and as further results become available I will report them.)

My major reservation regarding the THD tests is in the relatively high 15-20kHz distortion. I feel this is not a totally valid picture of Ampzilla's performance in this area, and may be partly set-up related, because a subsequent test on other units of the same make did not achieve results even as good as the above. So at least some, if not all, of the key to good measurements as a well de-bugged test lashup. At any rate, this data clearly represents exceptional performance over the major portion of the frequency range, since in most cases we are talking about THD at or below 0.01%, even up to 200 W.

I spent a major portion of the testing time in taking IM measurements, and the results obtained here also reflect in a conclusive way the quality of Ampzilla's performance. During these tests I evolved a very positive method of bias setup, which requires only a DC meter capable of reading 50mV or less with reasonable accuracy.

Fig.3 details my 8 Ohm IM measurements, both channels driven, with the 0dB reference equal to 200 watts of output (per channel). Note that the worst of the two is 0.045% at rated output, and at lower levels it drops sharply to below 0.01%. In fact, at any level below 20 watts of output the IM is less than 0.01%, and the A channel is actually at the equipment's residual of 0.003% over part of the range. The apparent rise of IM at low levels is not truly distortion, but noise limitations of the amplifier. Thus you can see that low level IM rise in this amplifier is virtually non-existent, in view of the fact that 45dB below 200 watts is 6.3mW!

I also took data for 4 Ohm and 16 Ohm operation, with similar quality results.

Experimentation with the bias adjustment revealed a marked effect on low level IM, as I expected. Observing the % IM at the -30dB output level with max full scale sensitivity (0.1% on the Crown IMA), you can bring bias up from zero until the IM drops to a minimum and ceases to decrease. Past this "knee" point, further bias increases had no discernible effects on IM. By monitoring the drop across either of the 0.39 Ohm emitter resistors in the output stage (R43 or R44), the DC bias current in the output may be measured.

In this amplifier, 20mV across these resistors was the magic number (for both channels) beyond which distortion decreased no further. To allow for aging and to provide a safety factor, I recom-

FIG. 2A: AMPZILLA, THD, CHANNEL A TOTAL HARMONIC DISTORTION

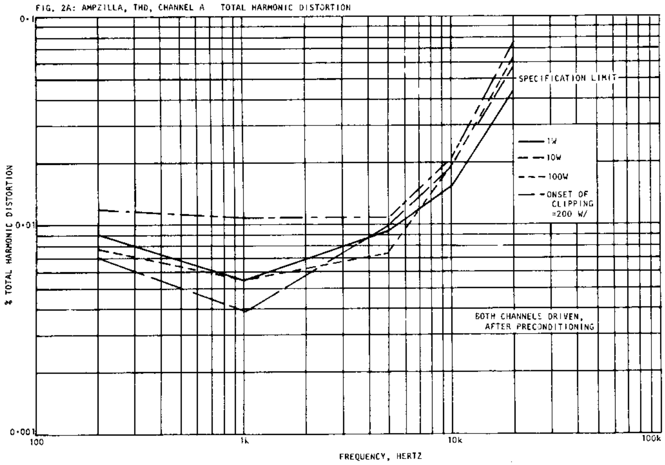


FIG. 2B: AMPZILLA, THD, CHANNEL B % TOTAL HARMONIC DISTORTION

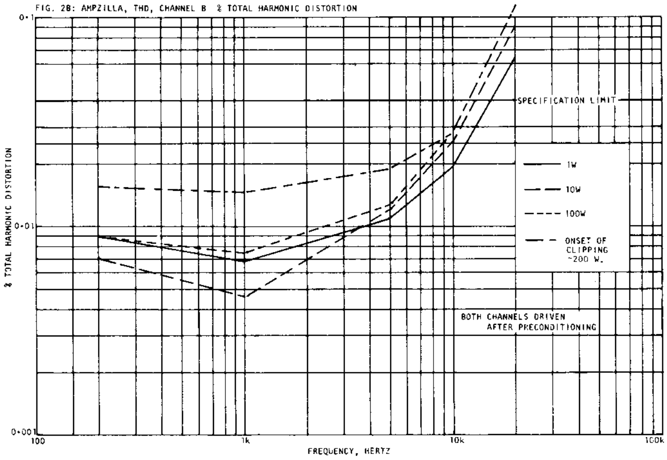
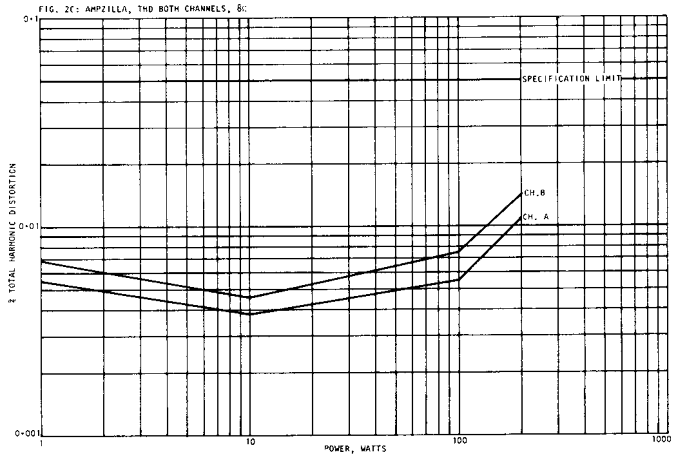


FIG. 2C: AMPZILLA, THD BOTH CHANNELS, 8Ω



mend setting this voltage at 30mV, which yields 75mA of idle current in the output. This condition yielded the IM results above. You will not go wrong with this quite simple, yet positive method of adjustment if you have a meter with resolution adequate to make the measurement. You should do it after zeroing output (within a few millivolts) for best accuracy.

Frequency response checks on Ampzilla are also quite a challenge to measure, because of the extremely wide bandwidth. With some difficulty, however, the specs were verified. You will gain an even greater appreciation of the implications of the tremendous power bandwidth of Ampzilla by examining the waveform photos in Fig.4a-d.

I measured Ampzilla's gain and found it to be 27.3dB. This indicates a 1.73 volt RMS input sensitivity for rated output.

1kHz power output at the clipping level was checked and found to be 210 watts into 8 Ohms, both channels. Since this is only 0.2dB above the specified power, I measured the power supply voltages under this driving condition, with an AC line voltage of 120V. I found them to be only ±64.1V, a far cry from the stipulated ±75V. At no signal, with 120V AC input they rose to ±68.7V. In fact, under *no* normal AC line conditions were these voltages ever found to be ±75V, a factor which suggests that perhaps my power transformer was an early model which was later updated.

This would explain reports that other Ampzillas cranked out more power (230-250 watts on two other samples whose data was available for comparison). It would also explain some of the sharp rise in distortion just at the 200 watt level in IM tests, just below, but not actually into clipping. At high output currents and output voltage swings which approach clipping, the output stage begins to develop significant IM. This shows up mostly at 4 Ohms, but is also evident in 8 Ohm operation near clipping. At 16 Ohms the effect has almost disappeared, as IM is still only 0.007% at 100 watts of output.

If the higher voltage (75V) supplies are typical of later Ampzilla production, this would mean that high level IM distortion should be even better than the results shown here.

I checked single channel 4 Ohm output power and found it to be over 400 watts at clipping. 16 Ohm operation check out as 120 watts per channel.

At this point a word to the wise is appropriate on realizing the maximum power of which this amplifier is capable. Since the power capability is directly related to the AC line voltage, you must ensure that this (or any other super power amplifier) is fed adequate amounts of AC input voltage. This means *you* must guarantee a full 120V AC at Ampzilla's line cord when it is fully loaded and driven to rated output. Under these conditions, it may well be drawing *over 1kW* from the AC line.

Never use extension cords with a super power amp, and don't connect into circuits which have other loads. Never switch on-off remotely through a preamp power switch, unless it uses relays or other means of handling 10A or more of AC. If possible, run a separate feeder back to your AC power distribution panel, using #10 conductors if you can. This is really a subject in itself, and I hope a future article can deal with the formidable power and signal handling problems in a large modern audio system.

Finally, we get to waveform pictures which say as much about the performance of Ampzilla in themselves as piles of data. These are shown as Fig.4a through 4f.

4a shows the output in response to a 10kHz square wave, at a 1 watt output level. Note that the waveform is well damped, with just the slightest suggestion of an overshoot. For the same conditions, 4b and 4c show the rise and fall times respectively, under 2µS for both.

As level increases, the overshoot rises perceptibly, but still remains very well behaved, as in 4d. This 10kHz square wave is nearly at full output, and represents a peak power of over 300 watts into 8 Ohms. Here the rise and fall is slew-rate limited to about 20V/µS, yielding a rise/fall time of 5µS. This perhaps best indicates Ampzilla's transient response, which is indeed excellent. It is however longer than the updated specification claims, namely 2µS or 40V/µS.[3]

At the other frequency extreme, 4e shows a 20Hz square wave response at the same level. Note the barest suggestion of tilt, indica-

FIG. 3A: AMPZILLA INTERMODULATION DISTORTION 8Ω (0dB = 200 Watts)

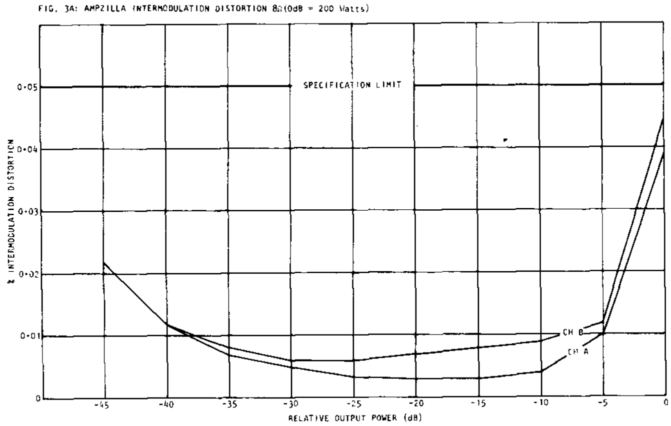


FIG. 3C: AMPZILLA INTERMODULATION DISTORTION 16Ω (0dB = 100 Watts)

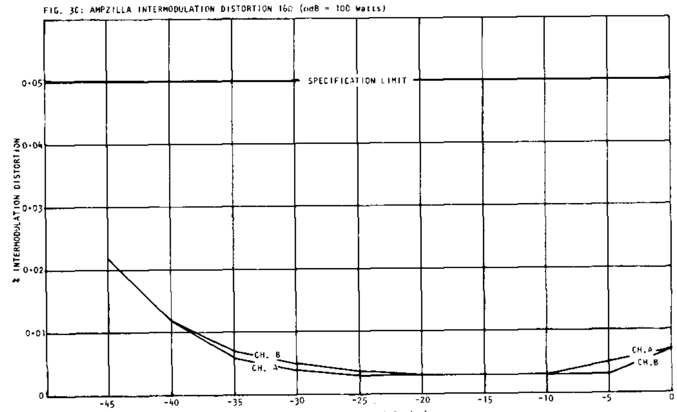
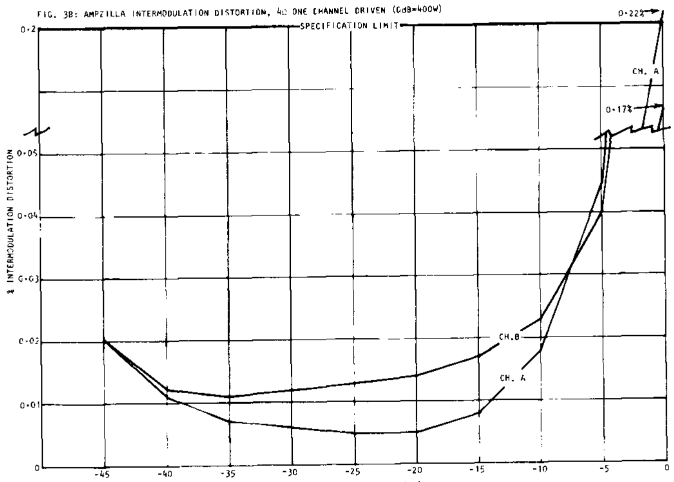


FIG. 3B: AMPZILLA INTERMODULATION DISTORTION, 4Ω ONE CHANNEL DRIVEN (0dB=400W)



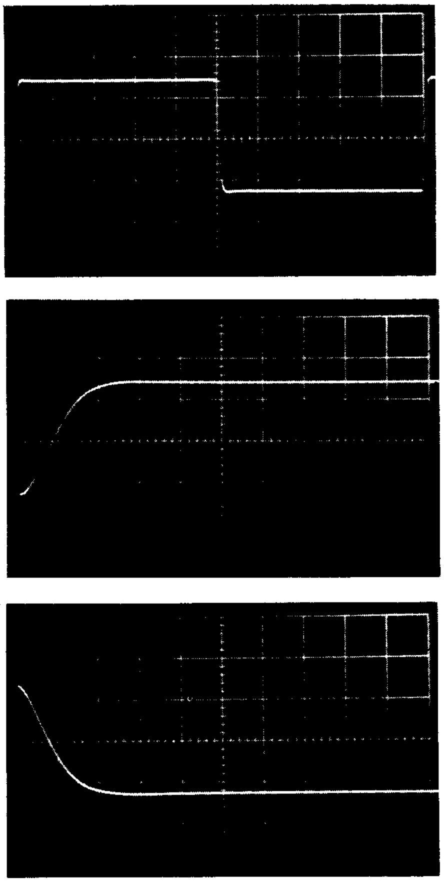


Fig.4A (top) 10kHz, 1W square wave, 2V/div V, 10μs/div H. Fig. 4B (center), 10kHz 1W square wave (risetime) 2V/div V, 1μs/div H. Fig. 4C, bottom, 10kHz, 1W square wave (falltime) 2V/div V, 1μs/div H.

tive of the extremely low LF 3dB point. Again, the power level is over 300 watts.

4f shows another aspect of performance, high frequency overload recovery time. The lower level waveform is a ¼ power 20kHz triangle wave, the higher amplitude shows clipping and subsequent recovery time, which is only a few microseconds.

Listening Tests

After all is said and done with measurements, the ultimate test is with the ear. We all are familiar with the "tests good, sounds bad" story. Fortunately, with Ampzilla the good measurements correlate with good listening.

Although I have lived with the sound of Ampzilla for no more than a few months as yet, it does have a sound of its own. This is not to imply sound coloration, rather the opposite. It has a smooth, warm sort of sound which seems pleasant, even when the source material is less than optimum. With first rate sources, the sound reminds you again what high fidelity is all

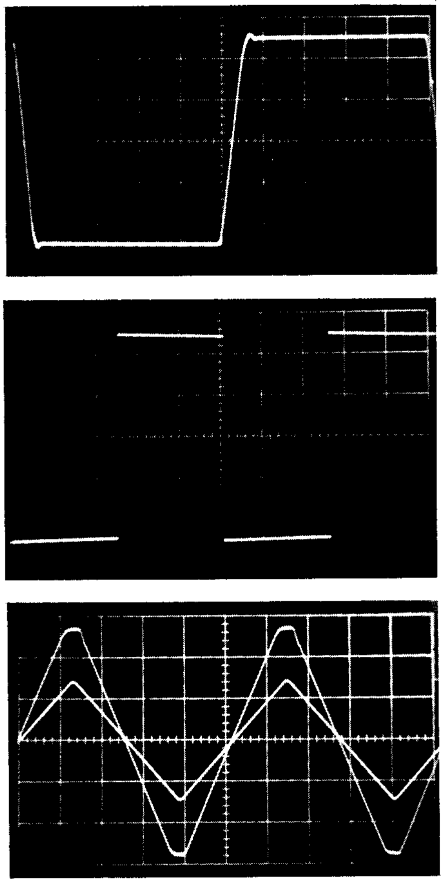


Fig. 4D (top) 10kHz, 312W square wave, 20V/div V, 10μs/div H. Fig. 4E (middle) 20Hz 312W square wave, 20V/div V, 10ms/div. Fig. 4F (bottom) 20kHz triwave: clipped, and ¼ full output, 20V/div V, 10μs/div H.

about--it is astounding. The sonic impact it delivers can be awesome.

One feature of the super power amps rarely touted is the extra dynamic range capability allowed for equalization. With less than super power, you can easily drive an amplifier into clipping with large (≥20dB) boosts and high listening levels. Not so with Ampzilla: it seems to thrive on this combination, effortlessly cranking out gobs of power.

Test Equipment Performance Check

Oscilloscopes: Tektronix 453 with C-30A camera, Tektronix 531 with D plug-in
Distortion Analyzers: THD-Sound Technology 1700A, IM-Crown IMA
Meters: HP 3575A Gain/phase, Data Precision 1450*, Heath IM-48
Generators: Wavetek 111, Heath IG-18

*Necessary for construction and checkout (or its equivalent).

Beyond the sheer power, its definition and clarity are impressive. Of course this type of evaluation is subjective, and a factor which we can't at present reduce to a number or spec which will predict how it sounds. Until we do, our ears must still be the final judge (as they always should be). In this particular case, I would have to say that Ampzilla is one of the finest, if not the finest, power amplifiers I have ever heard.

In addition to this aural accuracy, Ampzilla has an exceptional (and welcome) absence of on-off thumps, being well behaved in turn-on and turn-off characteristics.

Comments

This report has described the building, de-bugging and performance of the stereo power amplifier, "Ampzilla," from a kit. The construction of this kit I would not recommend to anyone but the advanced audio amateur with appropriate equipment. Even then, you must take the utmost care and really know what you're doing to prevent possible disaster, or performance short of maximum.

For optimum performance of the input stage, I recommend to any kit builder (even if you have already completed the unit) the matching of the input stage components, unless you have already measured performance and are satisfied. I am led to understand that matching of at least these transistors is part of the production process as a matter of routine on factory Ampzillas. *[All kits are now shipped with matched input transistor pairs.--Ed.]* This measure, and appropriate setup of the bias adjustment, should allow you to achieve results comparable to those reported, which are exceptional.

In final summation, building, testing, and using Ampzilla ranks as one of the outstanding experiences in my audio lifetime. Because of the problems mentioned, it was the most trying kit I have ever completed, and at times was frustrating almost to the point of bitterness. On the plus side, though, having "tamed" Ampzilla is a reward which truly can be savored, not just because of the sense of accomplishment of a victory in battle, but by the continuing experience of its sonic delights. The over-all impression I'd like to leave with you is a positive one. Although in this review I have criticized several aspects of Ampzilla as a kit, the comments have a positive objective: because when you successfully complete this amplifier and achieve its characteristic performance, you will possess a state-of-the-art

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OPTIMIZING AMPZILLA'S INPUT

WHEN I BENCH CHECKED the drive boards for Ampzilla, I found one had inadequate range in its bias trimmer, which is supposed to set the output to 0V DC. Taking a closer look at both, on the board which would zero, I checked the range of trim and found it to be asymmetrical, rather than ±0.6V. Fig.B1 is a simplified DC circuit of Ampzilla's input stage, which will be used to explain how this was happening.

Here R5 is the bias trimmer, which has a range of ±0.6V DC, intended to zero any DC offset generated by the Q1-Q4 dual differential input stage. Of course if Q1 through Q4 and the associated components were perfect, there would be no DC offset, and the R23-R24 junction would be the same potential as R5's arm. Then R5 could be set for 0V DC, and the output would sit at 0V DC, which would make R5 superfluous. But the presence of R5 tells us something about the circuit. Further, the fact that R5 cannot adjust out all of the offset tells us more.

It took many hours of tedious transistor testing, measurement and general grief before I was able to evolve a real solution to this difficulty. Actually the problem involves not a single component, but a combination of them. To sum it up, the cumulative tolerances of the relatively loosely controlled components (the 5% R's) and the mismatching of the four transistors can add up to a poorly DC balanced input stage. From the voltages shown (actual measurements), you can see that the collector currents do not match at all, and that this particular circuit has a 1.1V offset.

This circuit also directly affects the bias current which flows in the IC bias regulator, which is the collector current of Q7. This may be monitored via the DC drop across R21, the 62 Ohm resistor. Jim Bongiorno had previously warned me to check this voltage. He said it should be 1.8V or less, which keeps the IC current below 30mA. Since R21 voltage drops on both boards was greater than 1.8V, this definitely indicated something amiss.

Digging into the circuit and measuring the critical voltage drops gave me the values indicated in Fig.B1. Actually four resistor tolerances can cause unbalance *per pair* of transistors, as well as the transistors themselves. These are R7-R23, R9-R10 for Q1-Q2, and R8-R24, R11-R12 for Q3-A4. Further, the magnitude of voltage drop across R7-R23 and R8-R24, about a volt, is not at all conducive to base voltage balance at Q1-Q2 (or Q3-Q4) should these resistor pairs be mismatched, or the base currents mismatched.

We are talking about *a few tens of millivolts* of difference voltage to these pairs to upset current balance. If the base resistors drop 1 volt apiece, a 10% unbalance (permissible with 5% R's) yields 100mV of difference. When you double this possibility with the 2nd differential pair, then add the effects of transistor mismatching (the kit transistors are unmatched discrete units, MPS U56 and MPS U06's), you can begin to appreciate the likelihood of unbalance.

I made a great number of tests on these boards to evaluate the best

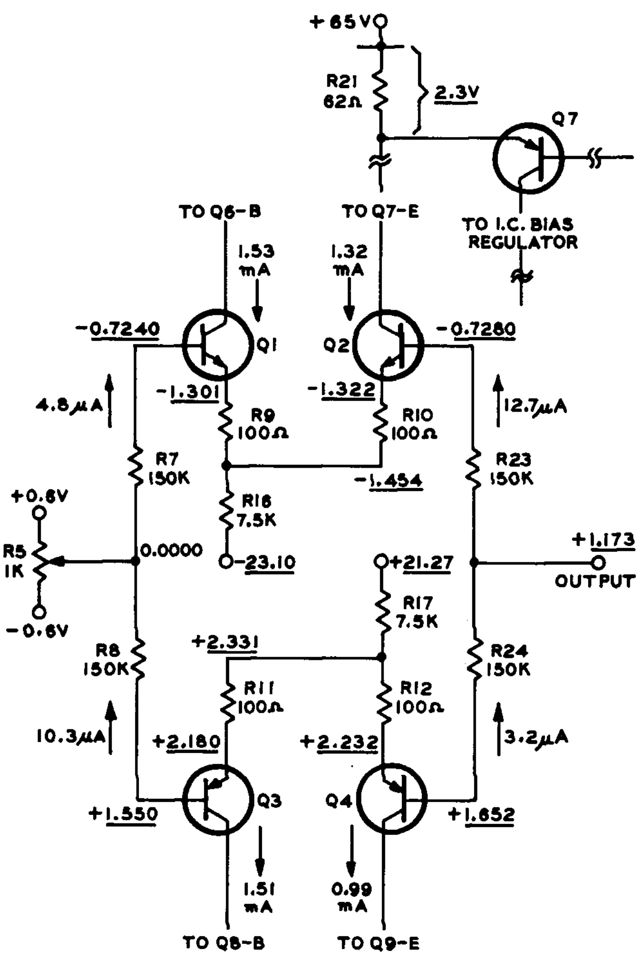


Fig. B1: Measured DC conditions on a sample Ampzilla input stage.

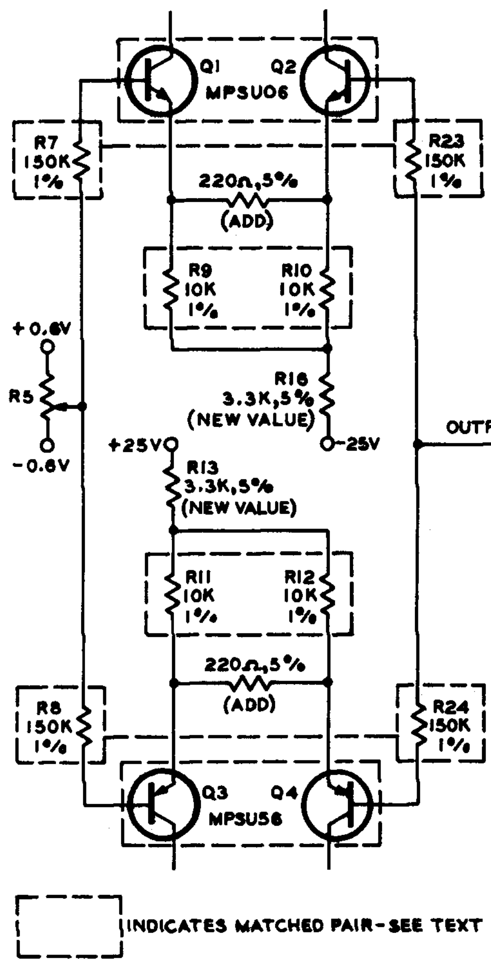


Fig. B2: Modified Ampzilla Input Stage.

and simplest change which would effect improvement. Of these, matching the resistors mentioned and both pairs of transistors made the greatest improvement. I modified the DC feed paths to the emitters slightly, namely value changes to R9, R10, R11, R12, R16 and R.17. These changes are indicated in Fig. B2.

I changed R9-R10 (and R11-R12) to 10K 1% types which tend to force the emitter currents of both pairs to match, in spite of other parameters. This also necessitated a value change to R16 and R17 to retain the same DC currents. Then, to retain the same value of DC emitter coupling, I added a pair of 220 Ohm resistors between the emitters (on the component side, between R9-R10 and R11-R12). Both the 3.3K and 220 Ohm units can be 5% types. For details, see photo, Fig.B4.

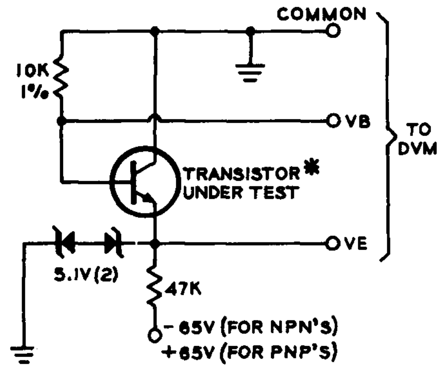
To match the transistors into like pairs, you must test all the units supplied to log their V_{BE}'s. This can be done with a relatively simple circuit such as B3, using the Ampzilla power supply voltages. Plug the units in one by one *[turning on power* after *insertion.--Ed.]* and allow each to stabilize within a millivolt. This takes a little while as the transistor warms up. Fig.B3 details a set of readings on six MPS U06's.

From the gathered data, try to pick a pair which match up in the V_E column to within 5mV of one another. Don't worry about the absolute voltage, just the match. For example, units ##1 and 2 are a good choice from these (I actually used them), and ##3 and 6 would be next best. H_{FE} should also match, but from what I've seen this follows if the V_E's match.

Do this for both the MPS U06's and MPS U56's, and place the matched units in the Q1-Q2 and Q3-Q4 sockets of each board. The remaining transistors can be used elsewhere.

The best way to match the 10K and 150K resistors is to select pairs from a number of 1% units. If you can obtain a quantity of resistors from the same manufacturing batch, you will probably be able to match them to much better than 1%. 10K 1% units for example will be within 100 Ohms of 10K, but with careful selection you can find pairs which will be 5 to 10 times closer to one another. A 20 Ohm differential would be 0.2%, 10 Ohms, 0.1%, etc. Again, don't worry about the absolute value, just the match.

For the 150K units, the matching is most important because of the high DC voltage they drop in the circuit. In experimenting with the biasing of the circuit I temporarily changed these 150K units to 10K matched pairs. With the change I



**NPN shown; can be either type with appropriate supply polarity.*

Test Sample	V_B	V_E	HFE (Calculated)
#1	.0612	.6588	229
2	.0586	.6540	239
3	.0711	.6711	197
4	.0715	.6740	196
5	.0741	.6791	189
6	.0673	.6700	208

Fig. B3: Test Circuit for Matching Input Transistors.

noticed that a significant improvement in balance and DC stability came about, for the reasons mentioned above. This change could present serious problems, however, as it lowers the input impedance to 6K, a figure not compatible with many preamps, and it also lowers the gain. Further it raises the LF 3dB point from 0.02Hz to 0.159Hz, which is less disastrous, but it would deteriorate the 20Hz LF square wave response.

In light of this, the only alternative is to match the 150K resistors as close as practical. I was able to find pairs matched to within 0.05% or less (75 Ohms). Once you have your matched pairs selected, place them in the positions indicated in Fig.B2.

After these changes, the DC offset in both channels was less than 15mV, which is quite good. Currents were matched as well as could be measured, and the R21 voltages were 1.5V, indicating happiness here also.

If you're wondering about the real necessity for this, remember that a DC offset biases your speakers, and also causes unnecessary dissipation in the output stage. It also detracts from the advantages of the symmetrical input stage, as it is obviously no bnger completely symmetrical when offset. Without the change Ampzilla takes quite a while to stabilize after turn-on, which may be the reason one reviewer has already commented on this point.[2]

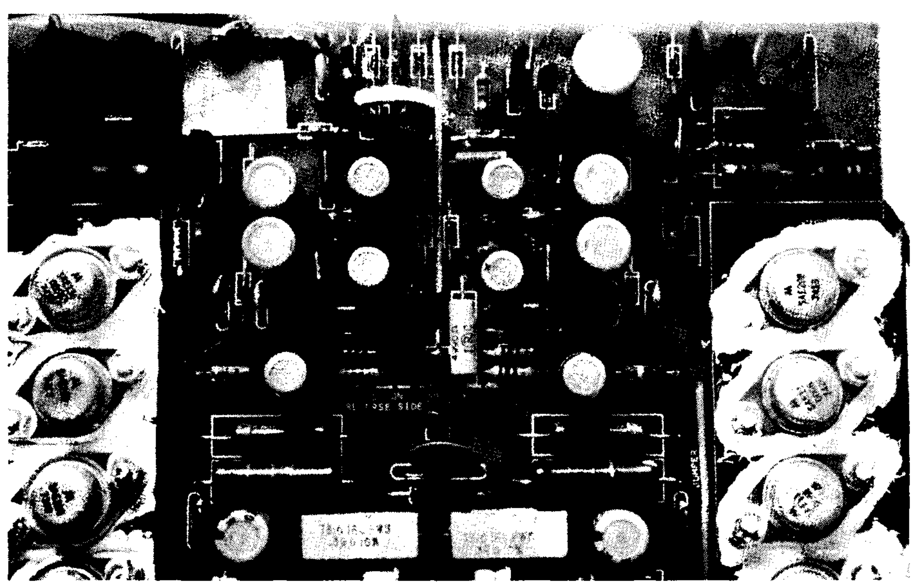
Unfortunately, however, you need precision test equipment to make these measurements. I used a 4½ digit DVM, and it takes precision resistors. Should there be sufficient interest in these, Old Colony Sound Lab will consider a kit for the matched components.

Fig. B4 below shows the author's added 220 Ohm resistors and the new 1% types he added.

ALAS, ALACK

While checking proof on this issue we learned that G.A.S. will no longer offer the kit Ampzilla.

Price on the factory assembled unit is $809. from your local dealer. G.A.S. tell us they will sell you a manual for $2 postpaid. Great American Sound Co., Inc. 10929 Vanouwen St., N. Hollywood,CA 91605. Oh well, Walt is preparing reports on Heath and Dynaco units.



CONSTRUCTION REPORT--*from page 15*

power amplifier--your graphs and your ears will both testify to that fact. It will also most probably remain so for years to come, in view of its lineage.

References

1. Bongiorno, James, "Get 400 Watts of Clean Stereo Power with Ampzilla," *Popular Electronics*, September 1974.
2. Ampzilla Review, *The Absolute Sound*, Vol.2, #5, Fall 1974.
3. Ampzilla Specification, *The Gasette*, Vol.1, #2, 1975.

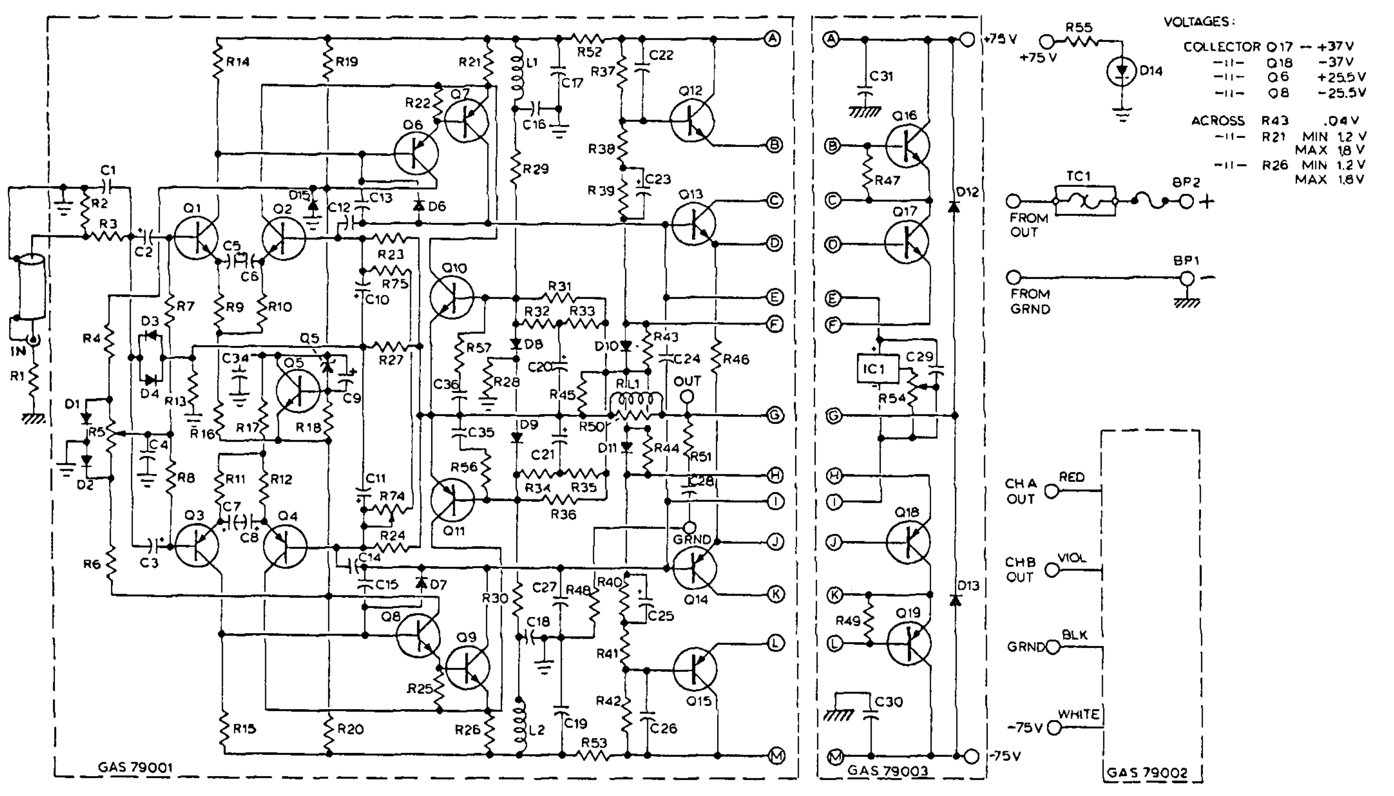
MANUFACTURER'S COMMENT

THANK YOU FOR SENDING ME a draft of your review of Ampzilla. I must say that I was quite surprised after reading Walter's manuscript. To be very frank with you, I honestly expected to be burned at the stake. Quite the contrary, I think the review is exceptionally kind considering the circumstances. Indeed, Walter did receive the very first Ampzilla kit, and I can flatly state that his being a guinea-pig was slightly unfortunate, since the kits being sent out today are a world apart from the one Walter received.

The enclosed manual, which I hope you will pass on to Walter for further comments, will make all of the ambiguities very clear. The first manual was obviously an experiment in terror, and for the first hundred kit builders, I am glad I was at least miles away from them in order not to bear the brunt of maniacal cries of violence.

You have my full permission to publish this letter as a full apology to those people who received our first product. We just did not have the combined fifty years of experience of Dynaco and Heathkit. Anyway, I am not going to make many waves but rather just a few comments concerning the status of Ampzilla today, in order to show that we are indeed truly concerned that our product shall be righteously received. I will take these points in as much order as I can:

1. All Ampzilla kits sent out as of June 1, 1975, have a 100% revised kit builders' manual. As you will note, it has full illustrations and captions and check-out procedures and schematics, &c. &c. Furthermore, Ampzilla is now available only in metered form.
2. The transformer supplied in Walter's kit is indeed an early one and does not have the correct supply voltages. The supply voltage of Ampzilla right from the start, except for the first fifteen prototypes, all supply the correct voltage of ±75 Volts DC.
3. Power transistors used in Ampzilla are 30 Ampere devices and not 16 as quoted by reviewer Jung. These are obtained on a selection basis and therefore are quite expensive.
4. The main construction chassis layout diagram supplied is in full color, as you can see by the enclosed manual; the original Walter received was a black and white velox.
5. We are on our third layout change (for mechanical parts only) on the PC boards, and all marking and screening has been vastly improved over that on the original.
6. Contrary to what Walter states, D5, a 51 Volt Zener, *does indeed* have a polarity dot denoting the cathode.
7. The kits supplied today have a totally re-worked L bracket for supporting the sixteen TO66 transistors. We found the holes on the first brackets far too large which caused the transistor case itself to deform, thus biting through the thero-film wafers causing short circuits. This has been rectified and for the last four months the hole sizes on the L bracket have been reduced from .250 inches to .187 inches. Furthermore, a special tooled plastic insert is used between the PC board and the L bracket. This plastic wafer has flanges which project through the holes being flush with the seating underneath the transistor. This of course makes the effective hole size around the transistor even less, thoroughly eliminating any possibility of short circuits. Since adopting this new procedure, we have had absolutely zero failures in this area.
8. I disagree with Walter in his preference for mica or aluminum



wafers. The therofilm wafers we use are far superior and, in plain language, they do not crack, warp, chip, deform, rip or tear. This is not to say that they cannot be damaged in shipment because this does indeed happen once in a while, and of course we will replace defective ones immediately.

9. We do agree that building the heat sink is quite a messy job. However, the most important thing you should understand is that the white thermal compound ought not to be allowed to get into your clothing. It is extremely difficult to remove.

10. I do agree that the use of a variac is absolutely the best insurance when first turning on the amplifier with a very small signal of 100mV input running through the amplifier. One can observe a very distorted sine wave as the variac is turned up slowly. As the variac is increased the sine wave will of course begin to look better and better, indicating that the amplifier is operational. *We do not advise* using the 1K 2 watt resistor as Walter suggests. They do not offer enough protection in case of a malfunction. The present kits are supplied with ¼ Amp fuses for this procedure and are obviously infinitely faster than waiting for a 1K resistor to burn up.

11. I firmly agree with Walter that it is inadvisable to try to adjust the amplifier's bias to 2.1 volts as stated in the original manual. If you haven't distortion measuring equipment available, then the correct procedure would be to adjust the bias for between 20 and 30mV of drop across either of the .39 Ohms resistors.

12. Ampzilla easily passes the new FTC pre-conditioning requirements, and even though the temperature may feel noticeably warm, it is quite safe, as our thermal cutouts are set at a low 70° Centigrade.

13. I suspect that Walter's unit has some layout or other contributing inaccuracy, because his measured 20kHz distortion is too high. We adjust factory-wired Ampzillas for .04% THD at full power at 20kHz when the amplifier is cold, and after warm-up it automatically reduces. I do believe that there may also be some possible set-up errors in testing since the Sound Technology instrument, while a superb piece of gear, has some unique set-up related problems.

14. Regarding the square wave tests, I believe there are some errors possible due to the test set-up. This is indicated by the statement and photo showing some overshoot. When Ampzilla is built correctly, the layout is neat and the test set-up to measure is done correctly, there will be no overshoot, even with full power square waves. The reason I believe the test set-up is contributing some error is that the measured rise and fall time is 5 microseconds, which is too slow. Furthermore it seems to me this test was measured beyond the stated specificactions of 200 watts. If Ampzilla is driven to the clipping point with square waves, the output power delivered is over 400 watts, and under these circumstances many other circuit parameters begin to have effects on performance. Furthermore, it is vitally important to make absolutely certain that the rise and fall times of the signal itself actually get into the amplifier and are not lost within the cable path. The only proper way to measure the true speed of the amplifier is to use 50 Ohms terminations at all points leading to the input. This will, of course, ensure that the speed of the input signal itself is far greater than the response of the amplifier.

15. I have saved this resistor matching situation for last, and I hope anyone intending to build Ampzilla will fully understand that the modifications prescribed by Mr. Jung are totally unnecessary. The kit he received probably did not have matched devices with it. All Ampzillas are now supplied with matched transistors for the critical input stage. Therefore, any additional selection is totally unnecessary. We can attest to this because we have had virtually no problems relating to these components. These components are all selected and matched for both factory-wired units and kits.

Again I want to thank you very much for your interest in our product. If I can be of any further help or service to you, please do not hesitate to contact me.

JAMES BONGIORNO, President
The Great American Sound Co., Inc.

WHEN YOU MOVE

You will help us reduce headaches here a lot if you will tell us at least six weeks before you load the U-haul. Send us your old address and the new one. One further thing that assures you of getting your magazines is a guarantee on your change of address form that tells your old post office you agree to pay forwarding postage on your magazines. The postoffice will destroy your magazine if they do not have such a guarantee from you. Forwarding postage for issues of The Audio Amateur *is 20¢. Thanks for your help.*

WALT JUNG REPLIES:

3. 2N6031 and 2N5631 transistors are on the Ampzilla's parts list, and the Motorola catalog lists them as 16A devices, thus the comment. Obviously I had no way of knowing the GAS part numbers are selected units--but this should also make it clear that the 2N numbers are *not* completely equivalent and should not be listed as substitutes!

7 & 8. I still like mica washers and aluminum. I've never seen one cut the way the film units do, and have never lost a transistor because of them.

10. I did not devise this method to burn up 2 watt resistors, but to allow a voltage drop which could be measured to indicate trouble and yet be safe.

14. I believe these comments to be a misinterpretation of the data. Small signal rise and fall times are clearly just about 2μs, as shown by 4b and 4c. 4d shows slewing ability, or large signal risetime of 5μs. This is from the same 50Ω generator (at a higher level), so the difference is not in the setup.

The peak voltage was carefully set to 50V which is below the 200 watt, 8 Ohm sine wave level which is, of course, 56V peak (40V RMS). So I'm quite sure it was not clipping, and the measurement is within reason as far as actual performance goes. As I said, however, I don't fault the amplifier for this performance, it is good. I just wonder why it does not agree with the specification cited, unless the 40V/μS rating applies to small signals only.

15. A flat brand of "unnecessary" regarding my modification of the input stage is really not an answer to the issue, but sounds to me like a dodge. No question that my transistors were unmatched--the data fairly screams this out. Beyond that, the resistor tolerance tightening and matching is an unquestionable improvement, and enhances balance to a degree impossible with unmatched pairs. As to whether it is desirable or worthwhile to effect improvement in "the critical input stage" (Mr. Bongiorno's own words), I think so. I also think my measurements, for both DC and AC performance, particularly the IM measurements, speak for themselves.

I don't particularly like the dismissal of a fair amount of work to correct a design oversight as "unnecessary." Most people reading the write-up on the input stage will conclude something was wrong, and when all was done, things were in a better state due to my changes. If Mr. Bongiorno feels this is unnecessary, so be it.