A New Triode Amplifier

Reliable performance, ruggedness, and low distortion characterize this latest version of the triode amplifier—a good construction project for those interested in performance rather than labels.

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THE ENTHUSIASTIC RECEPTION given our two earlier triode amplifiers (using, respectively, 6BX7's and KT88's as output tubes), has prompted us to be on the lookout for new tubes which would allow still further refinements in the art of triode amplifier design.

This latest effort uses as output tubes Genalex KT77's, tubes which are fairly unsung in the United States, and have not yet, to the best of our knowledge, been used in any domestic commercial circuits. This tube is very much smaller than its big brother, the KT88, has the same 7AC basing, and is capable of similar feats.

We have rated this amplifier at a conservative 20 watts, but it is built on a chassis little bigger than the original 10-watt 6BX7 amplifier. The KT88, operated at maximum ratings in push-pull triode, requires an input of 80 watts to the output stage in order to deliver 27 watts of audio. The KT77's, in this circuit, deliver over 20 watts for an input of 55 watts. Of more importance than the difference in efficiency is the fact that whereas the KT88's function at plate voltages on the order of 500 volts, requiring either special high-voltage or series-connected electrolytics in the power supply, KT77's are designed to operate at plate voltages some 50 volts less, thereby allowing the use of conventional filtering elements. The two types of tubes share the desirable characteristic of drawing almost constant plate current, regardless of output level, but the KT77's require considerably less grid driving voltage than the KT88's.

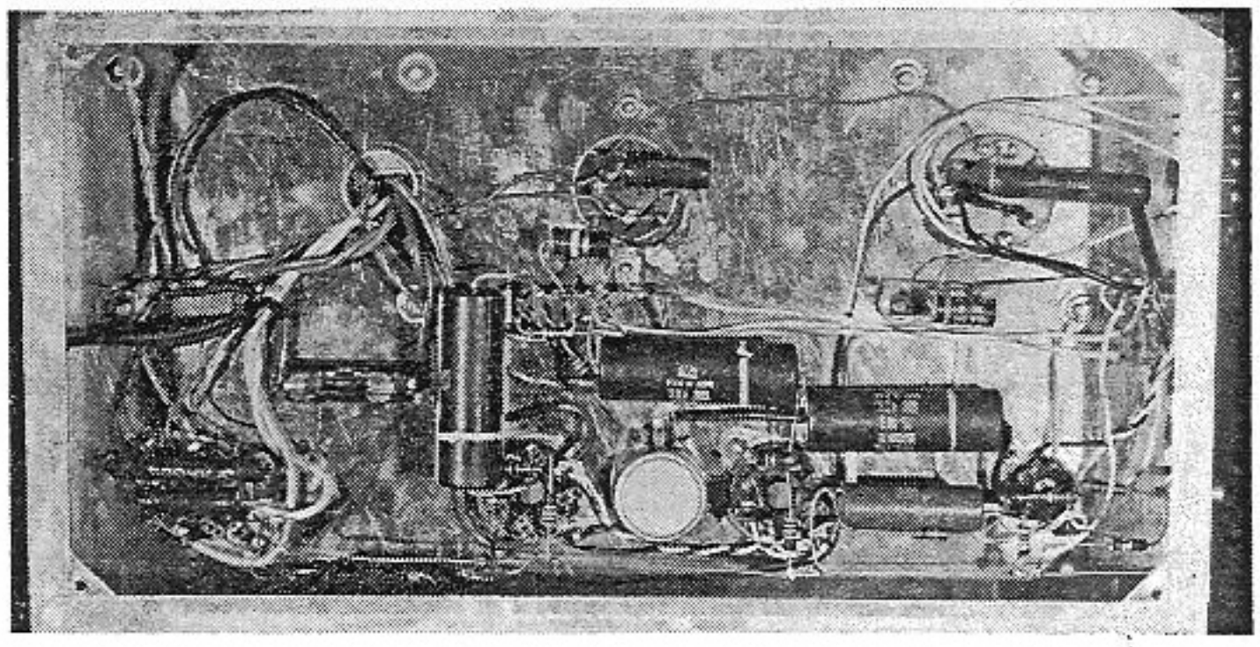


Fig. 2. Under-chassis view of the amplifier.

Because of all these characteristics, we have been able to simplify both the power supply and the amplifier circuit (see *Fig.* 1). The choke in the power supply has been eliminated, although plenty of RC filtering remains. For the power transformer we have chosen the inexpensive Triad "100" series, with excellent results. The output transformer, however, is not the place to economize, and, once again, we have chosen a husky, well rated component, this time the hermetically sealed Triad HSM-84.

The KT77 requires a comparatively small grid signal; because of this we have abandoned our previously-used pseudo-520 circuit, and have employed instead a simple floating paraphase inverter feeding the output stage directly. This means a saving of one tube and a handful of resistors and capacitors. More important, operating parameters are less dependent upon individual component values, and 10 per cent resistors have been used almost exclusively with no ill effect. The one disadvantage to this circuit is its comparatively low gain, even with the KT77's, but more about that later.

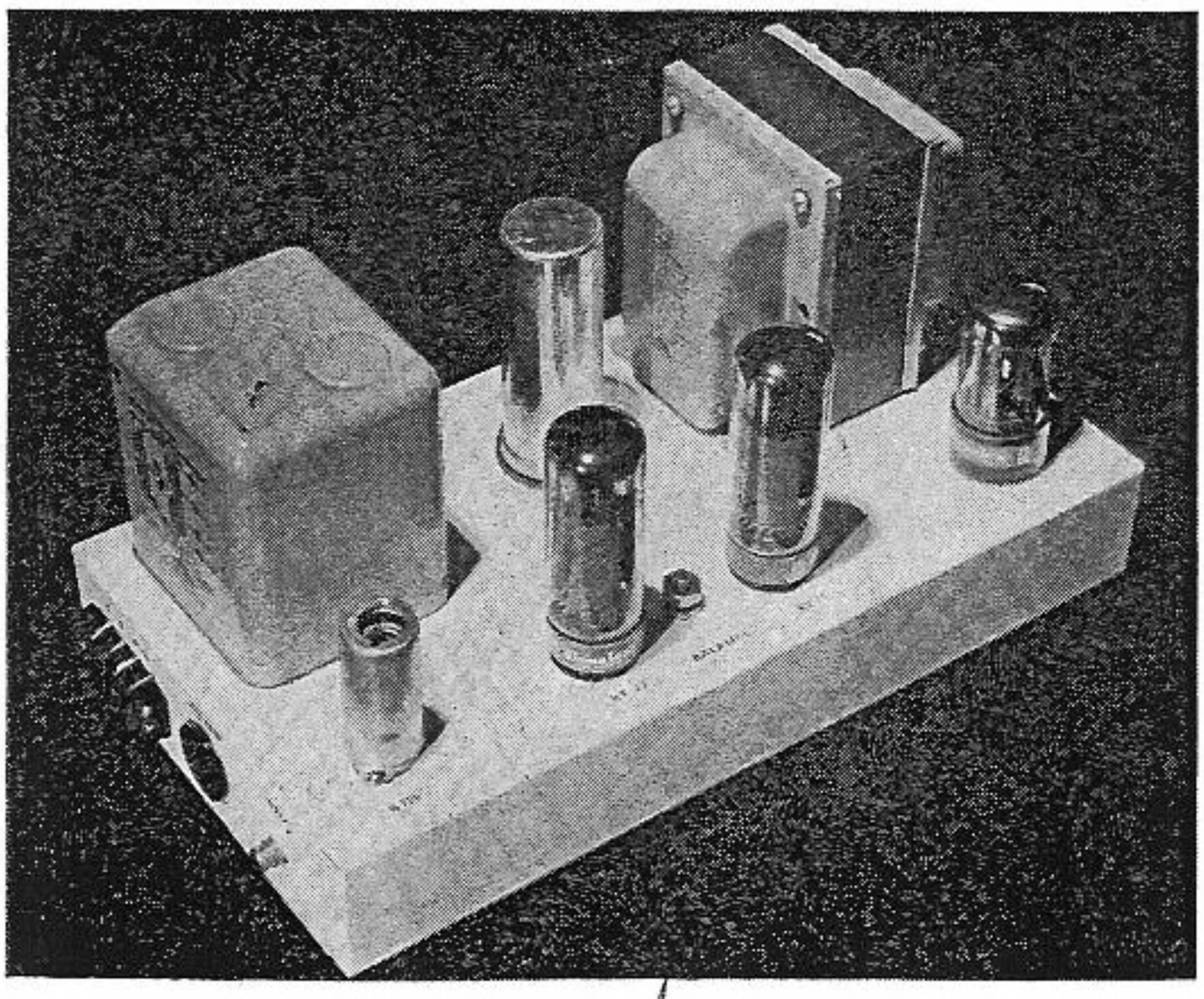
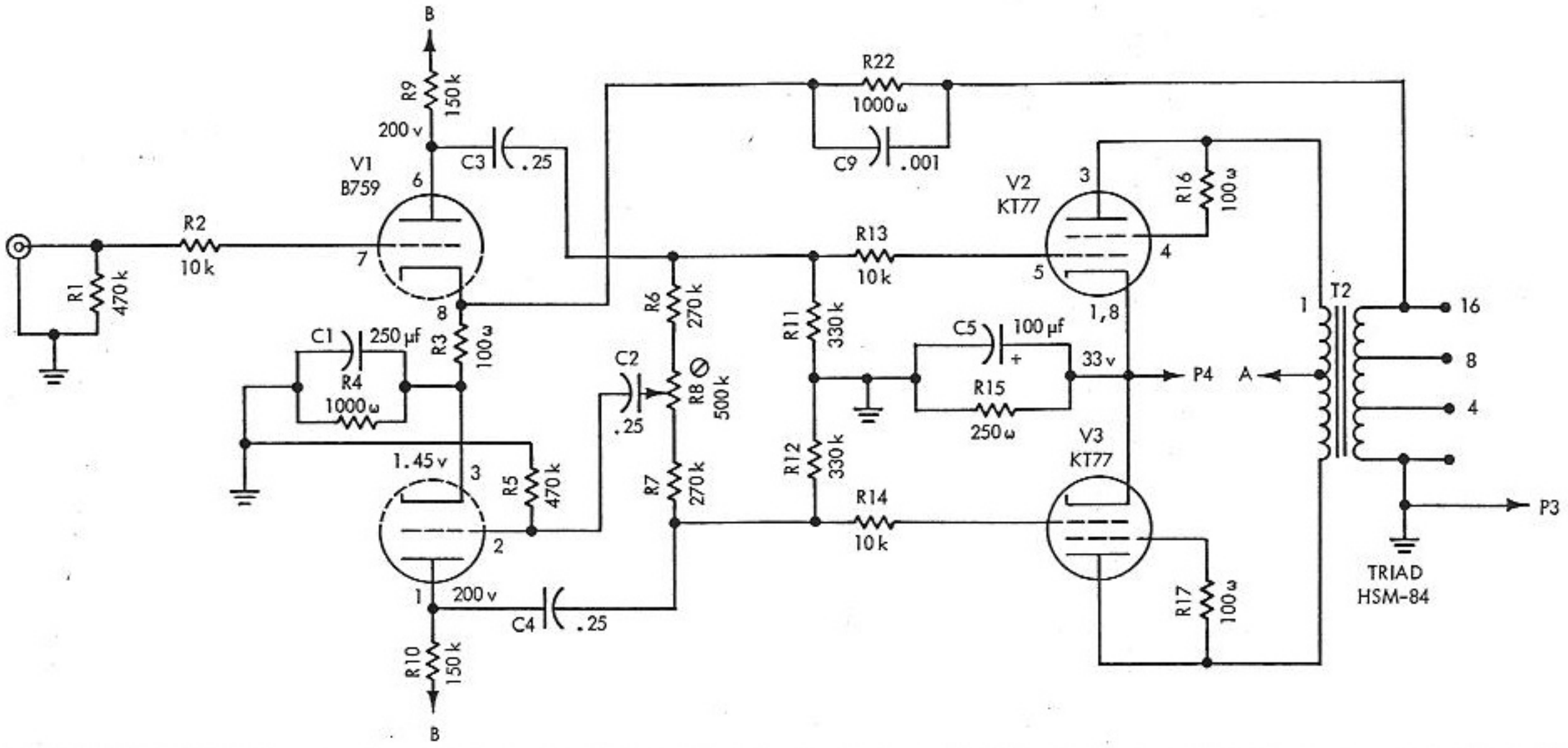


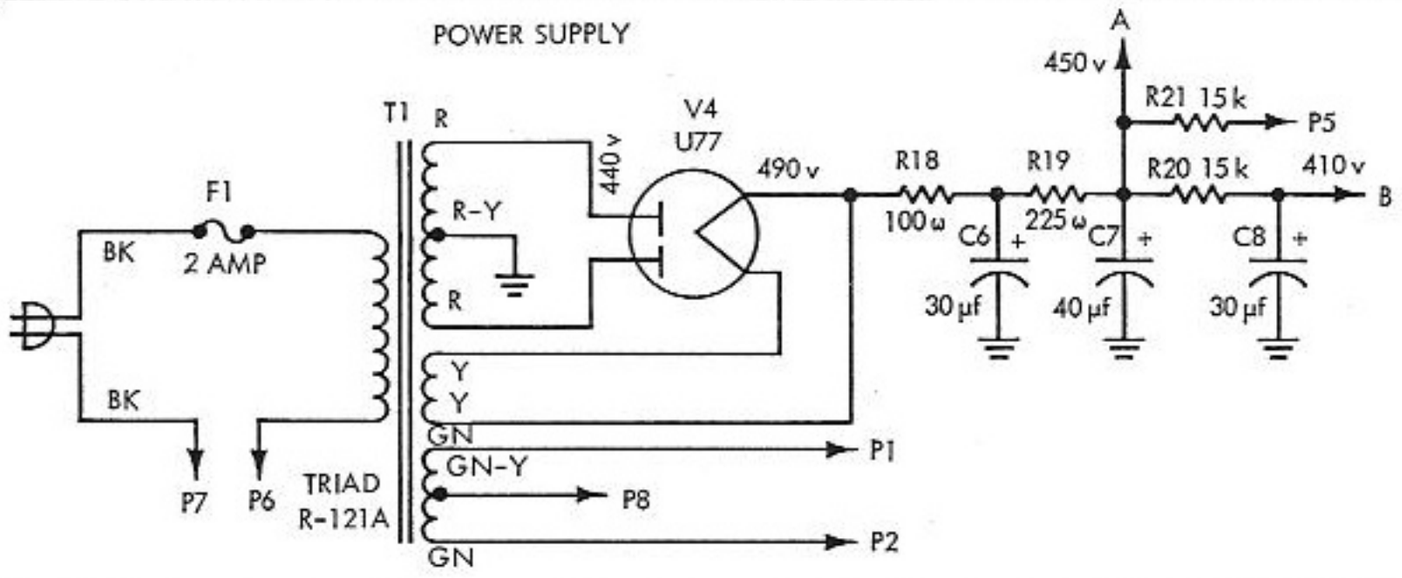
Fig. 1. Top view of new triode amplifier.

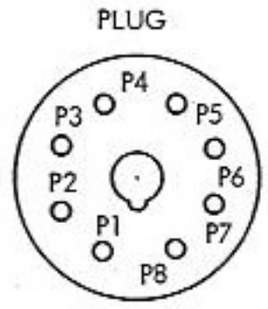
The Circuit

The input signal enters the upper half of the phase inverter, the lower half being fed from the tap on R_s. Traditionally, this circuit uses two resistors, the upper being slightly smaller than the lower. Rather than search for something as exotic as, say, a 273k resistor, we have used a balance control which, being variable, can be adjusted both for equal output voltages and to compensate for unbalanced output tubes (undesirable, see below). Capacitor C_2 looks larger than it need be; preliminary testing with 0.05 μf here produced severe distortion in the low-frequency region, which was caused by the inverter going out of balance because of the rising reactance of the smaller capacitor. We have concluded that, with this circuit, C_2 must be large enough to keep things under control to well below the bandpass of the amplifier.

The output and screen-suppressor resistors are values recommended by Genalex. The cathode bias resistor is somewhat smaller than recommended by Genalex for 450 volts on the plate, but plate dissipation is, at 27.5 watts per tube, within the design maximum value of 28 watts, and well below the absolute maximum of 35 watts. (Values are total plate and screen.)







PARTS LIST

C1 250 µf, 6WV ELEC.
C2, C3, C4 0.25 µf, 600 V
C5 100 µf, 50WV ELEC.
C6, C7, C8 30-40-30 µf, 525 WV ELEC.
C9 0.001 µf, 100 V (SEE TEXT)
F1 2 AMP, 3AG
R1, R5 470k
R2, R13, R14 10k
R3 100 ω
R4, R22 1000 ω
R6, R7 270k
R8 500k POT. (SCREWDRIVER SHAFT)
R9, R10 150k
R11, R12 330k
R15 250 ω, 10W, 5%
R16, R17 100 ω
R18 100 ω, 5W
R19 225 ω, 5W
R20, R21 15k, 5W
T1 TRIAD R-121A
T2 TRIAD HSM-84
V1 B759 (GENELEX)
V2, V3 KT77 (GENELEX, MATCHED PAIR PREFERRED)
V4 U77 (GENELEX)

(ALL RESISTORS 1/2W, 10% UNLESS OTHERWISE STATED)

Fig. 3. Schematic of amplifier, including a socket for powering an unpowered preamplifier.

The power supply uses simple RC filtering all the way through, with no increase in hum, instability or distortion. The electrolytic we used (Cornell-Dubilier UPI 1D1992) is actually meant as a replacement for a Dyna amplifier; the 40 µf section is made up of two paralleled 20's. A power takeoff for a preamp is included; it will provide about 300 volts at 10 ma as well as filament. If no preamp is used (as is most likely the case; we realize that a power takeoff is an anachronism, but we have an un-powered preamp of which we are very fond) make up a jumper plug, shorting pins 6 to 7 and 4 to 8. Or, perhaps, leave out the socket and make the connections inside, using a switch for the a.c. if you like. The connection from 4 to 8 puts a positive bias on the heater center-tap, which is somewhat more effective in reducing hum than grounding. Actually though, hum is completely inaudible under any conditions, even floating filaments.

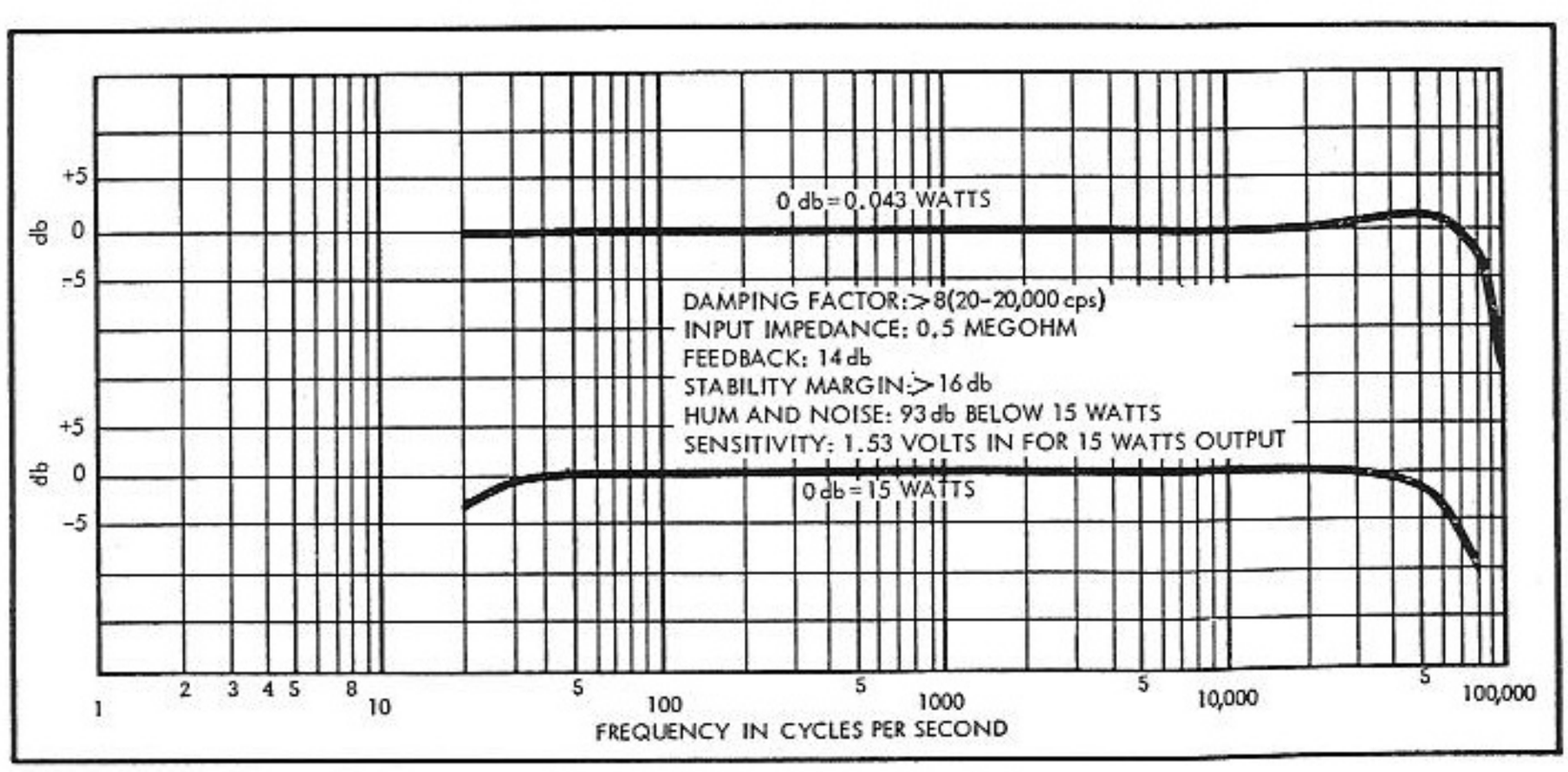


Fig. 4. Frequency response.

Performance

The frequency response is shown in *Fig.* 2. It is dead flat throughout the audible range at all levels. The slight hump around 50 kc may be eliminated completely by a careful trimming of C_9; the optimum value lies around 0.0013 µf.

Figure 3 is the power-versus-frequency curve. The amplifier puts out over 20 watts continuous over most of the range before clipping; music power rating would be on the order of 25 watts. Of great importance is the nature of the clipping—this amplifier, when properly balanced, will clip perfectly symmetrically, and, even at the bottom end, will

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AMPLIFIER

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make almost perfect square waves out of sine waves before any notching appears. It shows no sign of instability, even when driving an open circuit, or a purely capacitive load. Harmonic distortion at 10 watts is below 0.5 per cent, 20 to 15,000 cps. Transient response, indicated by square wave passage, is excellent.

The damping factor is greater than 8 throughout the entire audible range. This is just about right for most speakers; acoustic suspension systems may require a bit of bass boost. About 14 db of feedback is used. More will not improve the listening quality to any degree; however if you have gain to spare (this is a limiting consideration here; the amplifier, as is, requires close to 2 volts for 20 watts output) try increasing the size of R_3. In our tests we went to the limit here (R_3 open) and detected no oscillation, although we measured more than 30 db of negative feedback. Do not try to increase the amount of feedback by decreasing the size of R_{22}; this controls the operating point of the phase inverter, and changing it will create all sorts of new problems.

A note about the output tubes: The British, in general, seem to use separate bias resistors in the output stage, a practice which American audio design does not usually follow. We think that if one uses matched tubes, separate resistors accomplish nothing, and, in addition to requiring separate, large bypass electrolytics, are actually disadvantageous if they are less than perfectly matched. However, since we do use a common resistor, it is most necessary that matched tubes be used, preferably factory matched, since factory matching includes transconductance as well as emission.

Although we prefer the luxury of separate amplifiers for each channel, it is very likely that some will desire a stereo version of this circuit. For them we would recommend an R-25A power transformer and two U77's in a push-pull arrangement in the common power supply. This would run somewhat cooler, at least as far as the power transformer is concerned, than the monophonic version.

How does it sound? As far as we can tell, the amplifier described here has as complete an absence of any sound of its own as any we have heard. Of course it is rated at only 20 watts, which limits its use to other than, say, filling an auditorium. For normal use, however, we think it is the best balance of sound, size, and price we have yet encountered.

We feel a good measure of our success can be attributed to the willing assistance of the Triad Transformer Corp. and British Industries Corp. Æ

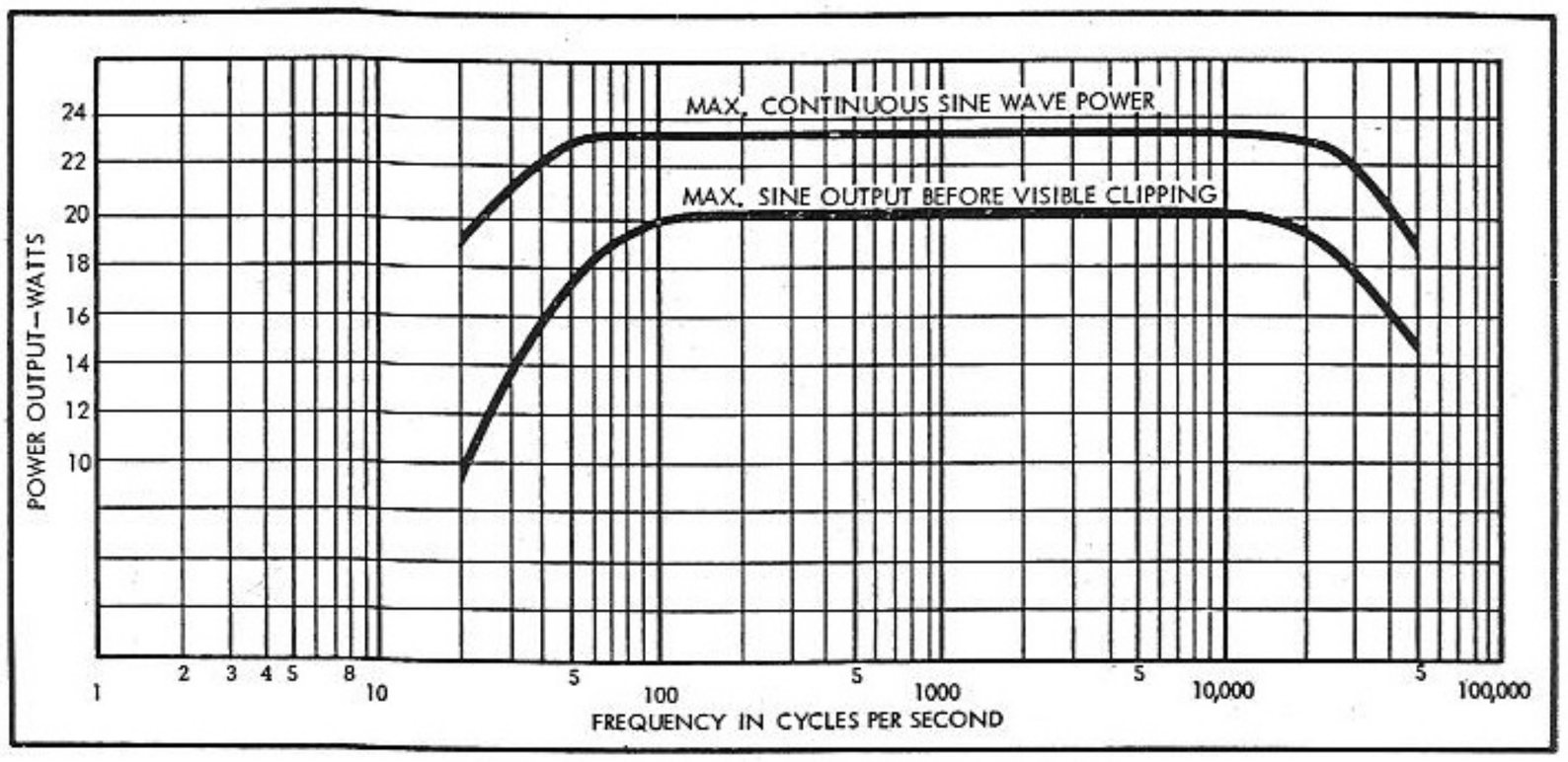

Fig. 5. Power-versus-frequency curve.