BATTLES IN PRINT about amplifier power requirements may be amusing, but they have left a good many people confused. There are so many factors that enter into an answer for any specific case that generalizations are not only foolish but misleading (see "Editorial," Nov. 1957 issue, p. 15); the only thing that can be said safely is that there are as many applications for super-quality amplifiers of moderate maximum power as for high-power units of equivalent quality, and perhaps more. Since the former are less expensive to build, why not use one if it is adequate for your needs?

The amplifier described in this article is virtually distortionless up to 10 watts output. It has excellent transient response and stability, wide frequency range, and a simple circuit. Total cost for parts is less than $45. This sum buys you performance differing from that of the best amplifiers you can buy only in the matter of maximum power limits.

The Circuit

A 12AX7 triode section is used as the input voltage amplifier, direct-coupled to the second triode section in a split-load phase inverter. The advantages of direct-coupling to the phase inverter (elimination of one low-frequency rolloff network, and consequent simplification of feedback problems) are very well known, and need not be enlarged on here.

The phase inverter drives a pair of EL84 output tubes directly; connected as pentodes, the EL84's have very good linearity and high enough power sensitivity to make additional drive amplification unnecessary. A Dynaco

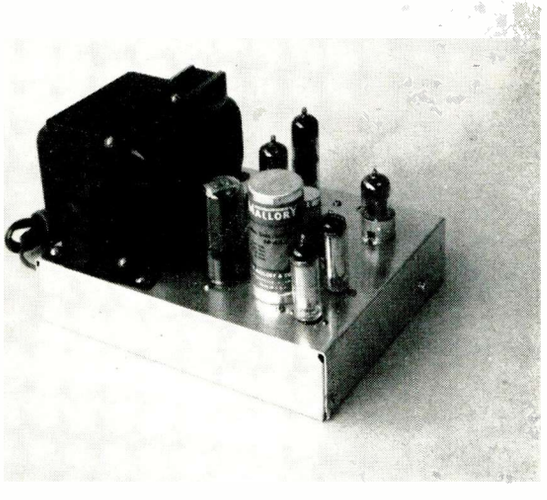


Fig. 1. The 10-watt super-fi amplifier is built on a 7 by 9 by 2-inch chassis base. Both transformers are at far end.

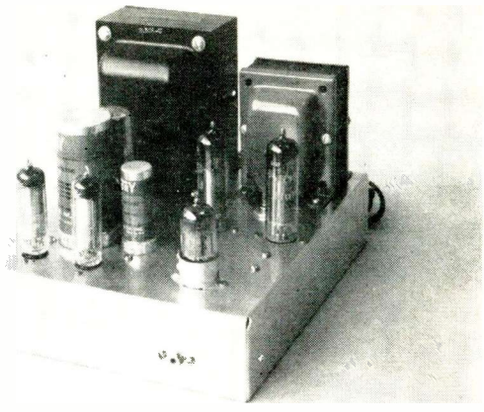


Fig. 2. Power supply components as viewed here are on the left side. The voltage-regulator tubes are closest to front.

A-410 output transformer is used. Others that would be suitable (with, possibly, a different value of feedback capacitor) include the Acrosound TO-310, the Partridge P-5202, the Peerless S-510-F, and the UTC LS-54. DC balance for the output stage is adjustable by means of a 50-ohm potentiometer in the cathode circuit. Cathode bias — simplest, most reliable, and perfectly satisfactory in this instance — is employed, with bypass capacitors.

A most unusual feature of this amplifier is the superb high-voltage regulation, obtained by using two OA2 regulator tubes in series across the output of the power supply. This provides a regulated 150 v for the plate of the input amplifier stage, and a constant 300 v for the output-stage screen circuit. The amplifier's stability is improved considerably by the voltage regulation, and so is its linearity at power-output levels near maximum. The 5Y3GT rectifier works comfortably under its maximum rating in this amplifier; the power transformer, rated at 150 ma, is called on to supply only a little over 90 ma. There is plenty of reserve to furnish power to a preamplifier, if the builder wants to add an output power receptacle.

Construction Notes

Wiring of the amplifier is not critical. The following suggestions, however, may be of benefit.

Use of a bus bar, grounded only at the input jack, is recommended although not essential. To prepare the bus, straighten an 18-inch piece of No. 12 bare copper wire and tin it. One end of a 9-inch piece should be soldered to a lug slipped under one of the input-jack mounting screws. It should be bent to pass over the center of the 12AX7 and the EL84 socket nearest the center of the chassis. The other end should be soldered to the speaker-terminal-board lug in line with the EL84 (the ground

If you're 'going stereo' and need a topnotch second amplifier, or if your demand is simply for high quality at low power, you'll be interested in building

A Super-Fi

lug). It should be spaced about ½ in. above the tube pins. A support for the center of the bus is made by soldering a 1-inch piece in the center terminal of each EL84 socket, after bending the top ½ in. of each at right angles to provide a place for a soldered connection. The remaining 7 in. of bus wire is soldered to the first bus midway between the 12AX7 and first EL84, and passes over and is soldered to the center terminal support of the other EL84 socket.

The unused leads from the output transformer are placed out of the way, after the bare ends are clipped off. Tape should cover the ends of the leads, to prevent a possible short, or they may be soldered to unused terminal tie points.

There is no hum-balancing potentiometer for the filament voltage, so wiring of the heaters should be done carefully. Twist the leads tightly together, and keep them close to the chassis and away from the tube grid pins.

The four-section electrolytic capacitor should be mounted on an insulating wafer and the can grounded to the bus bar.

The 2,500-ohm, 4-watt resistor is a current-limiting resistor for the voltage-regulator tubes. It's value was calculated for a 117-volt AC line voltage; if the voltage available is much lower than 117, it may be necessary to reduce the resistor value in order to keep the regulator tubes burning a pleasant purple. The reverse is true if the input voltage is much higher than 117. A milliameter connected between pin 2 of the 5Y3 and the end of the resistor (disconnected of course, from pin 2) should read between 25 and 32 ma when the resistance value is correct.

A 500-K audio-taper potentiometer may be used if an input level control is desired. It should be installed where the input jack is now positioned, and the jack moved about 1½ in. toward the center of the chassis.

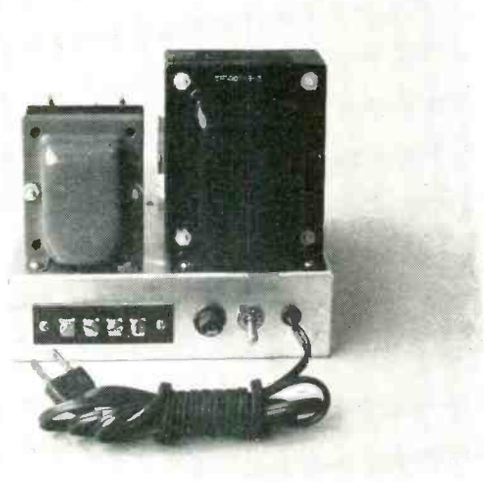


Fig. 3. Rear view, showing layout of the output terminals, fuse, switch, and line cord. Compare with pictorial, p. 23.

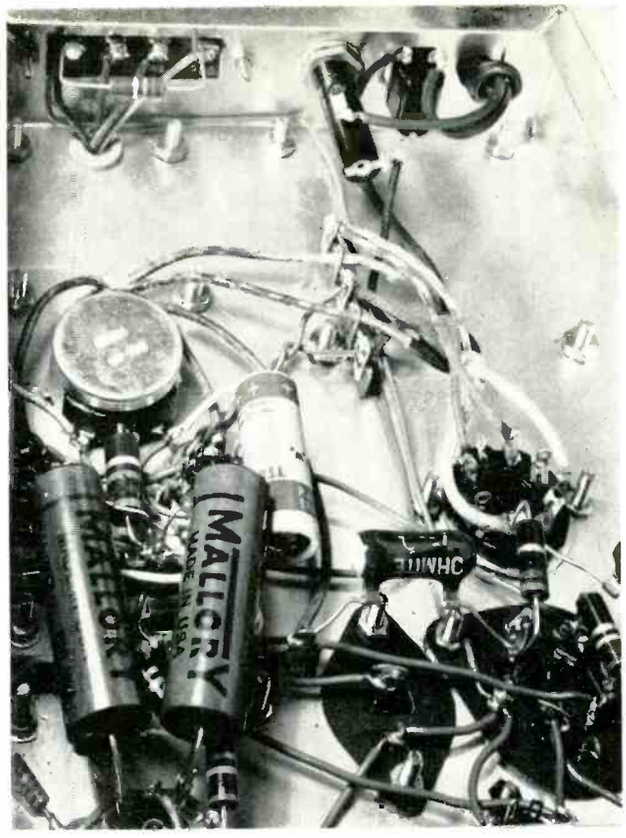


Fig. 4. Bottom view. Parts are identified on the next page.

The 50-ohm potentiometer should be adjusted for lowest intermodulation or, if a distortion meter is not available, for equal DC current through the two EL84's.

Following is a table of voltages (DC with respect to the chassis) measured when the amplifier is operating properly. Those on the 12AX7 may be expected to vary widely; ±20% difference would not be abnormal. NC means no connection; AC means filament voltage.

Voltage Chart

	1	2	3	4	5	6	7	8	9
12AX7	70	0	1	AC	AC	200	70	71	AC
EL84's	NC	NC	11	AC	AC	NC	350	NC	300

Parts List

Resistors

1 18-K, ½-w, 10%.
3 470-K, ½-w, 10%.
1 3.9-K, ½-w, 10%.
1 270-K, 1-w, 10%.
2 150-K, 1-w, 10%.
1 15-K, 1-w, 10%.
1 50-ohm, 4-watt linear pot.
1 68-K, 1-w, 10%.
1 1-K, 1-w, 10%.
1 120-ohm, 1-w, 10%.
1 150-ohm, 2-w, 10%.
1 2.5-K, 4-w, 10%.
1 750-ohm, 4-w, 10%.

by Arthur I. Zabriskie

10 WATTER

Miscellaneous

1 SPST toggle switch.
1 fuse holder and 2-ampere fuse.
1 phono input jack.
2 7-pin miniature tube sockets.
1 octal tube socket.
2 9-pin miniature tube sockets.
1 9-pin miniature tube socket, with shield.
1 7×9×2-inch aluminum chassis base.
1 power cord with plug.
1 4-terminal output-terminal board.
Screws and nuts, tie-point terminal strips, wire, solder, etc.

Capacitors

1 180-$\mu\mu$fd ceramic disc.
2 0.1-μfd, 600-v paper.
1 10-μfd, 450-v electrolytic.
2 50-μfd, 25-v electrolytic.
1 20/20/20/20-μfd, 450-v electrolytic.

Transformers, Tubes

Output transformer, Dyna A-410 or equiv.
Power transformer, Thordarson 24RO6U or equiv.
1 12AX7 or ECC83.
2 EL84's.
1 5Y3GT.
2 OA2's.

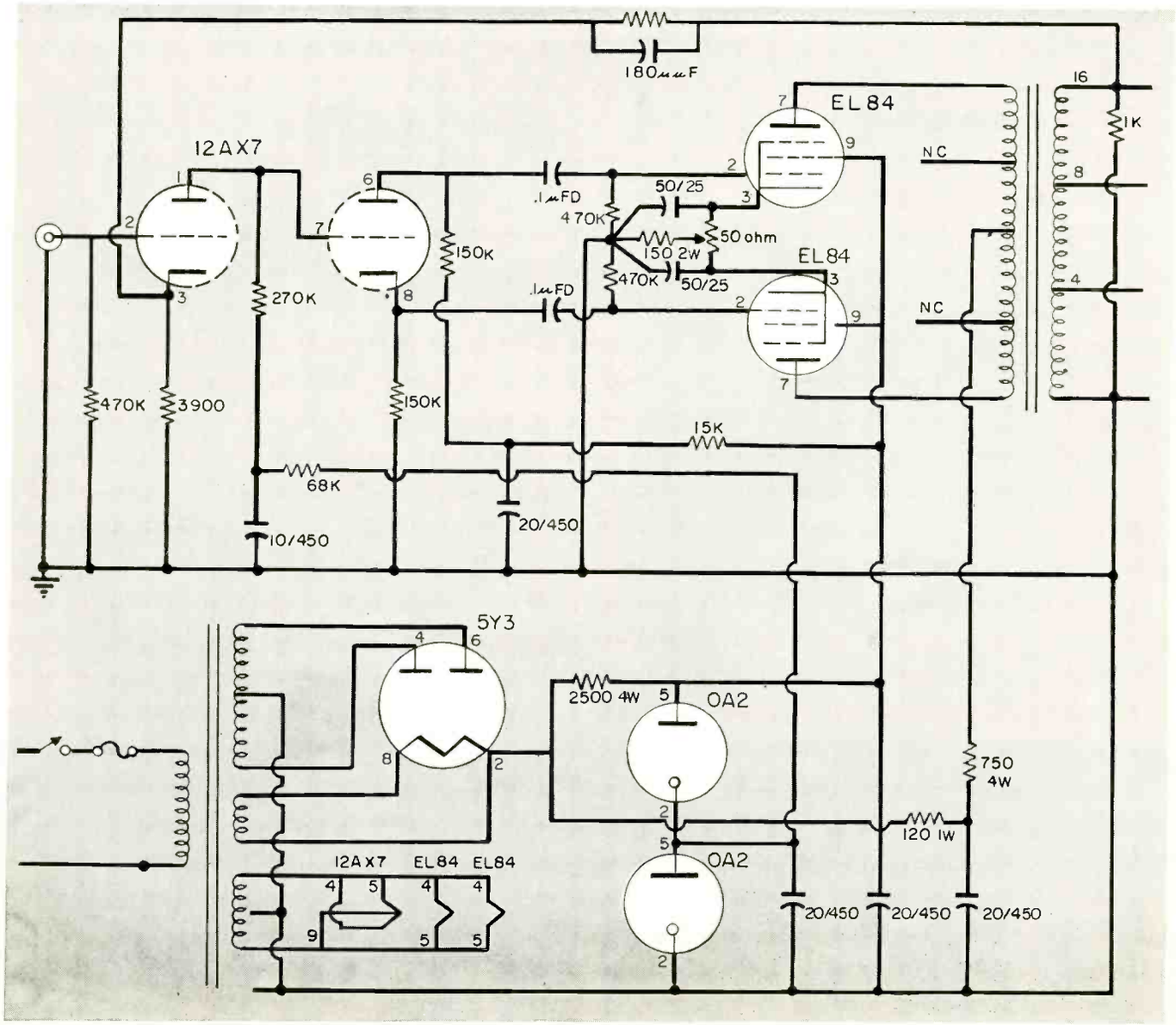
AUDIOCRAFT Test Results

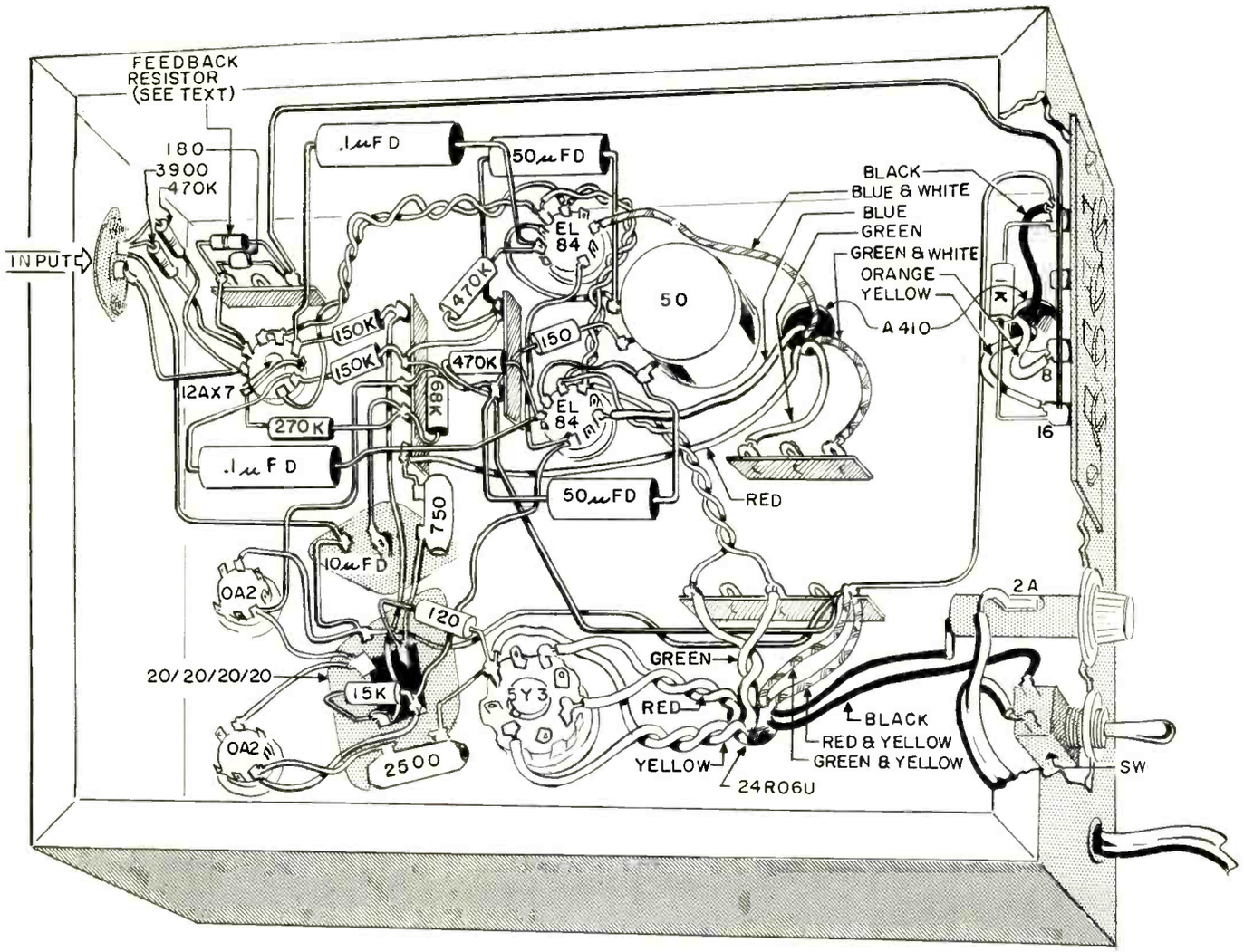
Our version of Mr. Zabriskie's amplifier is pictured in the illustrations for this article, and in the pictorial wiring diagram. We departed slightly from the original in a few places wherein it was determined by experiment that the changes would be for the better. The schematic diagram shown herewith incorporates our modifications. Our ground bus, for example, consisted simply of a wired circuit between selected terminal tie points, and connected to the chassis at only one place; see the pictorial diagram. Some resistor values were optimized also.

The most significant change, however, was in the feedback-resistor value. Originally 33 K was specified. This gave a sensitivity of 1.5 v input for 10 w output, but supplied only 16 db of over-all feedback. We found that the feedback could be increased to 30 db (on a resistive load) before oscillation began. Decreasing the value of the feedback resistor to 18 K provided what seemed to be an optimal compromise: feedback of 20 db, sensitivity of 2.5 v (which most preamps can deliver without strain), and an increase in damping factor. Further, it leaves a stability safety margin of 10 db, which is more than adequate.

If you need greater sensitivity you can increase the feedback resistor to 27 K. That produces feedback of 18 db, and 1.9 v input will drive the amplifier to 10 w output. Or, if you prefer, you can get 25 db of feedback with an 8.2-K resistor; then you'll need to put in 4.2 v to get 10 w out. The amplifier will remain stable.

Schematic diagram of the super-fi 10-watter. The feedback resistor, nearest top of drawing, is discussed in the text.





Small-parts layout and wiring. Not shown is a four-ohm output connection, simply because the Dynaco A-410 does not have one.

The more feedback you use, obviously, the lower will be the distortion in the operating range, and the less sensitive the amplifier will be. But don't try to go over 25 db or you may run into stability problems. To help you make your own choice, we have plotted IM-distortion curves for feedback which results in 2-volt and 4-volt sensitivity; these values correspond closely to feedback resistors of 27 K (18 db) and 8.2 K (25 db), respectively. In Fig. 5, for either value the distortion is below 0.1% up to 2 w, and below 0.7% at 10 w. Distortion reaches 2% at 12 w in the first case and at 14.5 w in the second. For feedback of 20 db (an 18-K resistor, specified in the parts list), the distortion curve would be intermediate between the two shown. Other tests were conducted with the 18-K value.

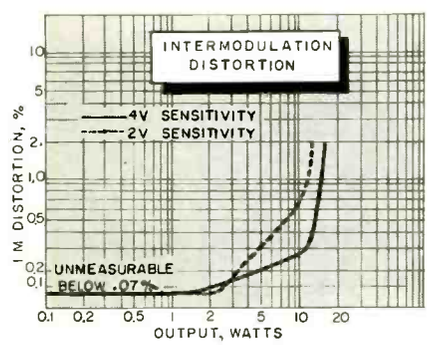
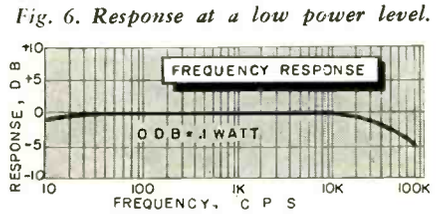


Fig. 5. IM for two feedback values.

Frequency response is shown in Fig. 6. Response is down less than 1 db at 10 cps and 30 Kc; it is down 2.5 db at 50 Kc, and 5 db at 80 Kc. This curve was taken at a low power level, of course. Note that the rolloff is smooth and peak-free, which confirms the excellent stability of this amplifier. At low frequencies stability is, as far as pulse tests can determine, perfect. High-frequency square waves show virtually no ringing, yet have sharp corners and flat tops.

Maximum continuous sine-wave power output before clipping, at various frequencies, is diagramed in Fig. 7. Over most of the range this occurs at 11 w; at 20 cps and 20 Kc, maximum output is slightly over 10 w.

Fig. 6. Response at a low power level.



With reasonably efficient speaker systems this amplifier sounds as good as its very low distortion and excellent stability would imply, at any tolerable sound level. It is just as satisfactory for speaker systems of moderate efficiency in listening rooms not excessively large. If you have a setup like one of these, and are construction-minded with an eye toward maximum value, we don't see how you can go wrong on this one. Another thought: one or two of these amplifiers could fit very well into a stereo system.

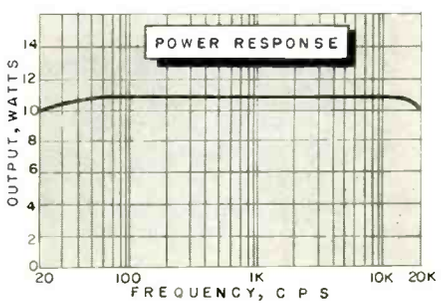


Fig. 7. The power curve is excellent.