

Low-power amplifiers (20-watters) cost about three dollars a watt to build. The 75-watt Leasebreaker can be constructed at a cost of one dollar a watt.

little job with enough wallop to enable anyone to break his lease by popular request within three minutes! Whether or not that is your projected use for it, this amplifier will deliver—subject to rising costs and picking up a few good buys—one watt of power per dollar of construction cost.

It is an engineering maxim that when cost is an object, no element of a system should be unduly stronger, or unduly weaker, than any other. There is no sense in paying for performance that cannot be utilized. At the outset, we gained considerable simplification in design by deciding that the amplifier would be used only to handle program material and not sinusoidal signals. This is a compromise that has been used for years in the design of modulators for high power AM transmitters.

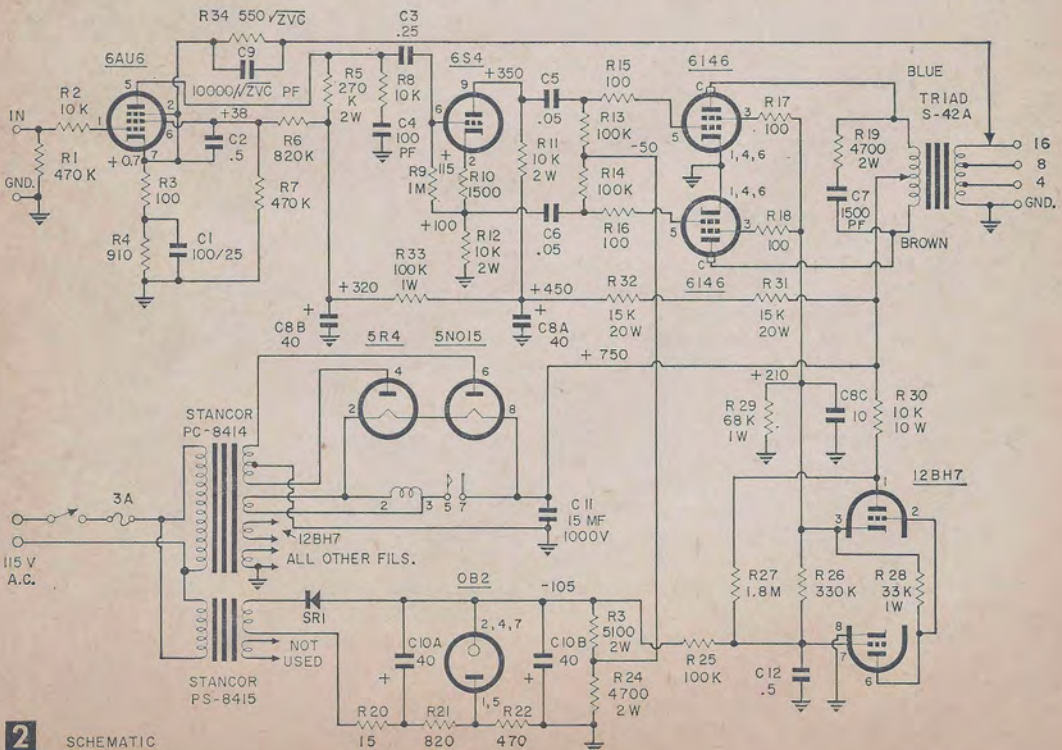
The Leasebreaker

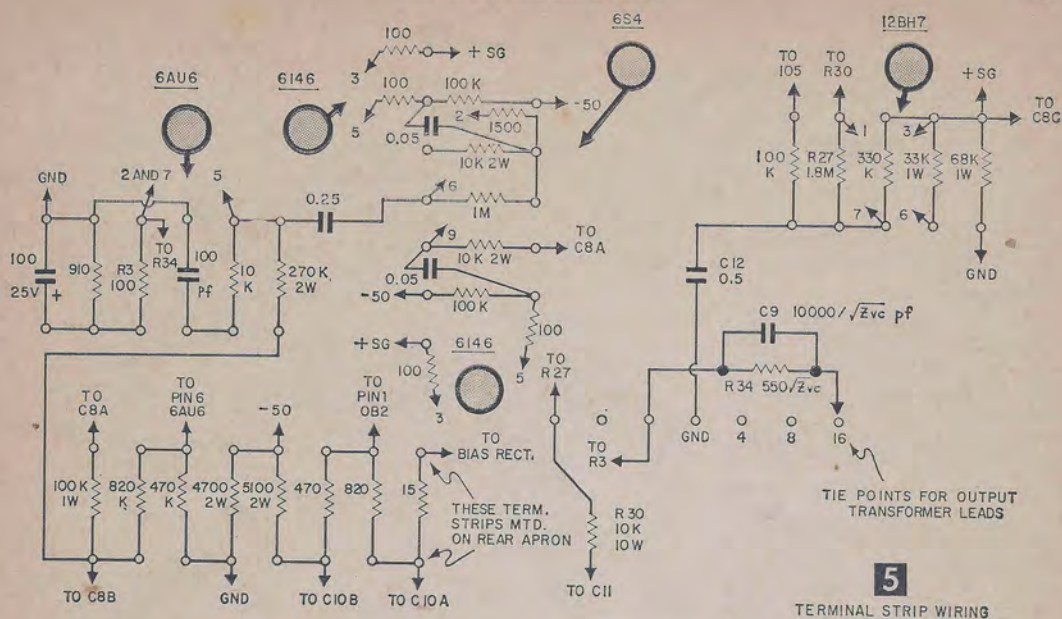
Not the perfect amplifier—that hasn't been built—but an outstanding bargain in high-power amplifiers. Net price, including tubes, is \$75—or a dollar per watt

By LEE/SHERIDAN

WHEN we decided we needed a new amplifier we knew we wanted the greatest possible power output per dollar of cost. What we achieved was a dandy

ters. Since a sine wave contains much more average energy than does program material of the same peak amplitude, it is permissible to use much lighter components than would





between heater and contacts. We preferred the octal-based relay to the miniature for this job because the octal socket provides a longer flashover path to ground than does the miniature.

A simple bias supply is provided with a configuration which permits use of a dual 40 mfd can. An OB2 glow tube holds the bias voltage constant. With the values shown, it draws about 10 mils. Some selection of the 5100 and 4700 ohm resistors may be needed to get just exactly minus-50 volts at the tap, and these should be 2-watt units for best temperature stability.

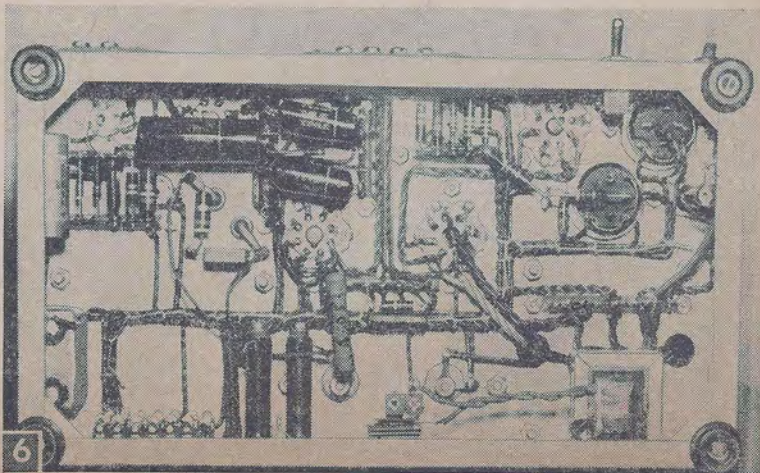
Screen regulation is an absolute necessity if maximum power is to be developed. We blithely started with VR tubes and encountered trouble! By the time the screens are stabilized the tubes are beyond their ratings when there's no signal. And there is also considerable additional heat dissipation.

So we cast about for a simple solution and came up with that shown in Fig. 2. Note that the conditions which increase the screen drain also pull down the supply voltage considerably, due to the poor high-voltage regulation.

The 12BH7 is a husky

twin triode, designed for use as a TV vertical deflection amplifier, with a 500-v plate voltage rating and a permissible dissipation of 3.5 watts per section. The two sections are connected in series, with the upper as pass tube and the lower as dc amplifier. The control voltage divider is returned to the minus-105-v bias supply, to keep the dc amplifier grid near ground, yet allow large swings.

In operation, this has proved an excellent little regulator, its output voltage being the same at full output as at zero signal, with a rise of about 10 v in the middle range. Initially, the output voltage had a tendency to drift with changes in line voltage, but the addition of R26 reduced this drift to an acceptable range. Correction is not complete, of course, because the dc amplifier does not have sufficient gain.



Construction. We constructed The Leasebreaker compactly on a 2 x 7 x 13-in. chassis, and the large transformers and filter capacitor must butt against each other in order to fit (see Figs. 1, 3 and 4). Tubes and electrolytic capacitors are placed along the front, the 6146's being staggered, rather than side by side, to reduce the heat problem.

A neat terminal board effect is achieved through the use of Cinch-Jones 2000 series terminal strips mounted in parallel pairs (See Fig. 5). For the input stage, we used 2006's; a 2005 and 2007 for the phase inverter, 2005's for the screen regulator, and 2008's for mounting miscellaneous power supply resistors. This scheme is a real space saver, since tube sockets may easily be straddled.

The two 15K 20-watt dropping resistors are mounted with long screws through the back apron of the chassis. Be sure to use an insulated shoulder washer here and several insulated flat washers on each end!

Cinch type 2C7 sockets were used for the two electrolytic cans. Note that the outer contacts are tied together to make maximum use of contact area. The bias supply capacitor should be provided with an insulated sleeve, since its can is negative with respect to the chassis.

A double ground system is used to avoid hum troubles, for the charging current through the 15 mfd capacitor is quite high and can easily give trouble if it gets into a common ground bus. For this reason, a power supply ground is made right at the negative terminal of the 15-mfd capacitor to which transformers, electrolytic capacitors and 6146 cathodes are returned. A separate signal ground is made at the input terminals, to which all other grounds are returned through separate ground wires.

Good quality steatite sockets should be used, at least for the rectifier and delay relay, since these parts carry the full 750 volts.

Use an aluminum chassis, be-

MATERIALS LIST—LEASEBREAKER

Design.	Description
T1	45000 ohms plate-to-plate to 4, 8, 16 ohms (Triad S-42A)
T2	600-0-600v, 220ma; 5v, 3a; 2 x 6.3v, 3a (Stancor PC-8414)
T3	115v, 15ma; 6.3a, 0.6a (Stancor PS-8415, Triad R-54X)
V1	6AU6
V2	6S4
V3, V4	6146
V5	5R4
V6	0B2
V7	12BH7
V8	Amperite 5N015
SR1	50 ma, 115-v selenium rectifier
C1	100 mfd, 25-v electrolytic
C2	0.5 mfd, 600-v bathtub or 0.5 mfd, 400-v molded paper tubular
C3	0.25 mfd, 600-v molded paper tubular
C4	100 mmfd mica
C5, C6	0.05 mfd, 600-v molded paper tubular (matched, if possible)
C7	1500 mmfd, mica
C8	40-40-10 mfd, 450-v electrolytic (Mallory FP 376.8)
C9	10000 μ Zvc mmfd
C10	40-40 mfd, 450-v electrolytic (Mallory FP-238)
C11	15 mfd, 1000-v oil
C12	0.5 mfd, 200-v molded paper tubular
(All resistors $\frac{1}{2}$ watt 10% unless otherwise indicated)	
R1	470 k
R2	10 K
R3	100
R4	910, 5%
R5	270 K, 2 w
R6	820K
R7	470 K
R8	10 K
R9	1 meg
R10	1500 w
R11, R12	10 K, 2w matched
R13, R14	100 K matched
R15, R16	100
R17, R18	4700 2w
R19	15
R20	820
R21	470
R22	5100, 2w, 5% } see text
R23	4700, 2w }
R24	100 K
R25	330 K
R26	1.8 meg
R27	33 K 1w
R28	68 K 1w
R29	10 K 10w
R30	15 K 20 w
R31, R32	100 K 1w
R33	550 μ Zvc

Miscellaneous

2	Millen #36002 ceramic plate caps
1	SPST toggle switch
1	extractor fuse holder
1	3AG, 3-amp fuse
2	Cinch #2008 terminal strips
2	Cinch #2007 terminal strips
2	Cinch #2006 terminal strips
3	Cinch #2005 terminal strips
3	Cambridge Thermionics #X2006 (or equivalent) insulated terminals
1	2 x 7 x 13" aluminum chassis
2	7-pin miniature tube sockets
2	9-pin miniature tube sockets
4	octal tube sockets
2	Cinch #207 FP capacitor sockets
1	Eby #56-2 (or equivalent) screw terminal strip
1	Eby #56-4 (or equivalent) screw terminal strip
	hook-up wire, rosin solder, misc. hardware

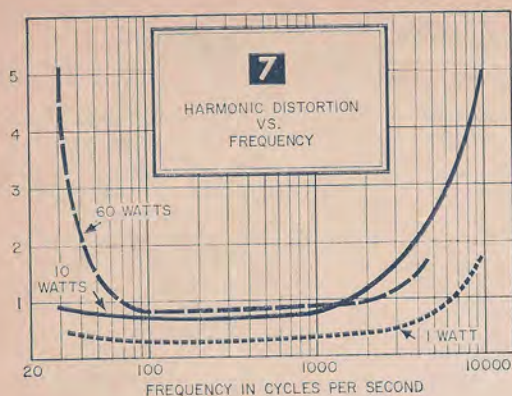
cause the high heat conductivity of the metal makes the whole chassis surface available as a radiator. While heat dissipation of this amplifier is considerably below that of most others in its power class, its compact design does keep the dissipation per unit volume fairly high. For this reason, The Leasebreaker should never be enclosed in a small space.

Testing. With the 5R4 removed, a dummy load connected and the feedback loop open, the first job is to adjust the bias. Select 4700 and 5100 ohm resistors so that the bias is minus-50 volts. If necessary, other resistors can be shunted across one or the other for vernier adjustment.

Next, if a milliammeter is available, check the current drawn by the 0B2, which should be around 10 mls. Variation of R21, an 820-ohm resistor, can raise or lower this as desired.

To set the screen voltage, replace the 5R4 and turn on the power. The high voltage at the 15-mfd capacitor should be around 750 v. Now check screen voltage. If it is not in the range of 200-215 v, shunt one of the resistors in the control voltage divider. Shunting R27 reduces the screen voltage; shunting R25 increases it. Use high values for the first try; the circuit is quite sensitive.

When screen voltage is set, the various other voltages can be checked. A VTVM should be used to measure the 6AU6 plate and screen. If results are



satisfactory, feed a 400-cycle test signal into the input and turn up its level. The amplifier should deliver 75 watts (33 v rms into a 15-ohm load) just at the clipping level as seen on a scope.

As regards the feedback loop, if the output transformer primary leads have been connected as indicated, and if the manufacturer is uniform in attaching leads to the windings, the feedback should be negative. With the oscillator providing the 400-cycle test signal set for low output, watch the output signal on a scope while touching a 22K resistor across the feedback terminals. If the output decreases, the feedback is indeed negative and the proper feedback resistor may be installed. If the output increases, reverse the output transformer primary leads and try again. It is wise to use the 22K resistor for the initial test so that if the feedback happens to be positive, the amplifier will be spared the burden of violent oscillation. Resistor R34 and capacitor C9 are chosen according to voice coil impedance (see Materials List); but explicitly:

Voice Coil Impedance	R34	C9
16 ohms	150 ohms	2500 mmf
8 ohms	200 ohms	3600 mmf
4 ohms	270 ohms	5000 mmf

With the feedback loop closed, a frequency response run at a level of about 1-v output may be made. The amplifier should be down about 0.5 db at 20 and 20,000 cycles, and should fall continuously outside of those points as discussed previously.

Note particularly—this amplifier is intended only to be flat to 20 kc, not to 100 kc! People accustomed to 100-kc bandwidth and a fancy square wave response will be disappointed by this—but our aim was a stable amplifier. This type of response is the price of using a cheap output transformer. Similarly at the low end—but it should be noted that smoothly falling response below 20 cycles is beneficial in attenuating rumble from turntables.

In checking the power output, the amplifier

should deliver 65 watts at 30 cycles and 75 watts at 40 cycles and above, at the clipping level and just before noticeable flattening appears on the scope. Full power should not be run continuously above 5000 cycles since the network across the output transformer primary begins to absorb power and the 4700 ohm resistor R19 will "head west" in a big hurry.

Instead, make quick checks at 10 and 15 kc by turning up the oscillator for no more than a second or two, reading the meter and immediately turning down the oscillator. Power should be 65 watts at 10 kc and 40 watts at 15 kilocycles.

This drooping power response does no harm to program material where the vast bulk of power lies below 1000 cycles, and the amplifier will break up at low frequencies long before the point where high-frequency power will endanger the 4700-ohm resistor.

The Leasebreaker may be used with any standard pre-amplifier, although we don't recommend that the preamp power be drawn from the amplifier, as it is very difficult to provide sufficient plate supply decoupling to make the system really stable at sub-audible frequencies. Either the preamp should be self-powered, or a separate power supply should be built for it. Voltage gain from input to 16-ohm output is 20, hence 1 v in will produce 25 watts—a sensitivity of the same order as any usual home music amplifier.

Internal impedance as measured at the 16-ohm output tap is 1.3 ohms, resulting in a damping factor of 12, which is adequate for restricting speaker hangover. Total hum and noise output with the input shorted is less than 5 millivolts at the 16-ohm tap, or better than 75 db below 60 watts output. This is predominantly power-supply ripple due to imbalance in the output tubes, but 5 millivolts of hum is so low as to be barely audible a foot from a good speaker.

Harmonic distortion was measured as a function of frequency for several power levels and the results were about what might be expected.

The low-level distortion is higher than that in units of the Williamson type, but not seriously, since any reasonable amplifier distortion pales into insignificance compared to that contributed by even the best of speakers. The curves (Fig. 7) show the usual rise at the ends of the range, the low end curve at 60 watts being due to the onset of core saturation. The high end rise, however, is only of academic interest since the 10- and 60-watt power levels will never be reached by program material at frequencies above 1000 cycles.

If you haven't seen curves like Fig. 7 before, be advised that the usual practice of using only mid-band frequencies in distortion ratings tends to make an amplifier look better than it really is.