Fig. 5. Heathkit EA-2 amplifier "sounds as good as it measures" and looks as good as it sounds.

THE HEATHKIT EA-2 AMPLIFIER

At $27.95, the Heathkit EA-2 composite amplifier—phono preamp, tone controls, and 12-watt power amplifier, on one chassis, as shown in *Fig.* 5—is a surprise package. Its low price might lead the casual observer to dismiss it as something of a toy, perhaps worthy only of a junior audio system for the children or the den or the workshop, or the like. Actually, it is a grown-up performer, within its 12-watt rating. And it must be remembered that the difference between a 12-watt amplifier and a 30-watter, which few sneeze at, is only 4 db, a relatively slight volume difference to the ear.

The circuit of the EA-2 is essentially orthodox and at the same time up to date. The magnetic phono preamp consists of a single stage, followed by losser type equalization. Subsequently there is a stage of gain for all the inputs, a volume control, another stage of gain, and the tone controls, which are the conventional Sterling type. The power amplifier section follows the trend toward use of a pentode input stage direct-coupled to a triode employed both as a phase inverter and driver for the output tubes. Pentode and triode are in a single envelope, the now widely used 6AN8. The phase inverter is the familiar split-load type, which some experts hold to be as good as any. The output stage is ultra-linear, using the highly-regarded EL84's.

The EA-2 is easy to assemble and took this reviewer the equivalent of four evenings. (The reviewer probably takes a good deal more time than the average, because he checks all resistors for value, checks capacitors for value and leakage, checks continuity of connections by means of an ohmmeter, doubles back after every dozen steps or so to check his work, and so on. On the other hand, the careful approach has paid off in that every one of the dozen or more kits he has built in this manner has worked correctly right from the start.) Although the chassis is only 8-3/16" deep by 12½" wide, the layout is uncramped and at no time requires a surgeon's dexterity.

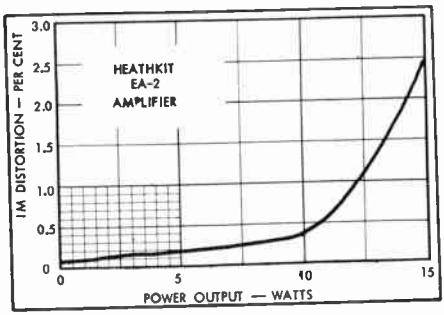

Fig. 6. IM distortion curves for the Heathkit EA-2.

Parts of high quality, as for example the use of molded paper capacitors, an ECC83 as the input tube, EL84's as the output tubes, an EZ81 as the rectifier, and power and output transformers about as husky as can be accommodated within the amplifier's dimensions.

Size of the output transformer is reflected in the ability of the EA-2 to turn

out at least 12 solid, clean watts at 20 cps, as viewed on an oscilloscope. At the rated power of 12 watts, the frequency response measured was ± 0.5 db between 30 and 10,000 cps, and 1.5 db down at 20 and 15,000 cps, and 3 db down at 20,000 cps. Below 12 watts, frequency response remained essentially the same within this range.

High-frequency response was also checked with the gain control set at 6 db below maximum; the resistance of the gain pot acts as a low-pass filter in conjunction with the input capacitance of the 6C4 (largely due to Miller effect), and the low-pass action is greatest when the pot is at mid-resistance. At this setting, response was down only 0.5 db more at 10,000 cps, 1.2 db more at 15,000 cps, and 2 db more at 20,000. This slight a deterioration in treble response is hardly apt to be noticed. Moreover, it is quite unlikely that one will be operating the amplifier with gain as far advanced as 6 db below maximum. With gain 10 db below maximum, there was no additional loss at 10,000 cps, about 0.5 db at 15,000, and 1 db at 20,000. At 20 db down, no additional losses were observed.

To obtain maximum flatness of response, with bass and treble control knobs pointing straight up (12 o'clock), it was necessary to rotate the treble control pot about 15° counter-clockwise (center lug pointing to about 11:30). Parts tolerances would account for this. It was not necessary to adjust the mounting of the bass control pot.

Probably the most fascinating thing about the EA-2 is its low distortion. As shown in *Fig.* 6, it does not exceed 1 per cent IM until equivalent sine wave power (the wattmeter reading of two signals mixed in 4:1 ratio is multiplied by 1.47 to obtain the power of a sine wave having the same peak) is above 12 watts. At 10 watts equivalent sine wave power, IM was only 0.33 per cent. From 3 watts down, it measured 0.1 per cent or less. The IM meter employed for these measurements uses frequencies of 60 and 5000 cps and has a residual reading of about .06 per cent. At 10 watts and below, the performance of the EA-2 leaves little if anything to be desired with respect to distortion. And it bears repeating that most audiofans will not be using more than five watts.

An amplifier that measures well with respect to distortion may not sound clean. Often it will be found that such an amplifier displays excessive ringing when square waves upward of 1000 cps are passed through it. The EA-2 exhibited *no ringing whatsoever* on square waves of 1000, 5000, 10,000 and 20,000 cps, and even with treble boost applied.

Still on the subject of distortion, it was found that at 1000 cps the EA-2 clipped at just about 15 watts. So one can think of the EA-2 as a 15-watt amplifier since IM is just a little over 2 per cent at this point.

Sensitivity of this Heathkit is quite sufficient. It was measured at approximately 0.3 volts on high-level inputs and 8.6 mv on the magnetic phono input for 12 watts output. Since one can count on approximately 15 to 20 mv on peaks from even the weakest magnetic cartridges, no problem of inadequate gain is anticipated on magnetic phono input. High-level sources generally turn out from 0.5 to 3 volts on peaks, so there is no problem in this respect either. In fact, the problem may be too much signal input. For example, some piezoelectric cartridges deliver a volt or two on peaks, and some magnetic cartridges put out much as 100 mv or more. In the case of high-level sources, the input signal could easily be cut by reducing the lower leg of the voltage divider at the input. The signal of a high output magnetic cartridge can be reduced by replacing the 47,000-ohm load resistor with an appropriate voltage divider consisting of two resistors having a total value recommended by the cartridge manufacturer.

Only RIAA phono equalization is provided; however, this suits virtually all records presently made and, with slight adjustment of the tone controls, is adequate for records made prior to 1954. Between 30 and 15,000 cps, equalization did not deviate more than 1.5 db from the RIAA curve.

The tone controls of the EA-2 provide a substantial range of boost and cut. Ample bass boost is particularly welcome since no loudness compensation is provided for the Fletcher-Munson effect. At 30 cps, a maximum of 16.5 db boost and 17.5 db cut were measured. Maximum treble boost measured 16 db at 15,000 cps, and cut 21.5 db.

Since the EA-2 aims so high, it is not unfair to talk about its drawbacks, even though its price is so low. One drawback is the provision of only three inputs—tuner, crystal-phono (suitable for ceramic cartridges as well), and magnetic phono. However, a tuner, TV, tape machine, or other high level source can also be fed into the crystal-phono input. The audiofan desiring more inputs probably would not find it difficult to replace the existing selector switch and to mount an additional input jack or two.

A salient omission is an output for feeding a tape recorder. But this could be rectified quite easily, if desired. In fact, in constructing his EA-2, the reviewer paved the way for such an addition in the future. Instead of mounting a seven-pin wafer socket for V2, a 6C4, he mounted a nine-pin ceramic socket in the same hole and employed half of a 12AU7, which is the same as a 6C4. The other half of the 12AU7 can eventually be employed as a cathode

follower, requiring only a coupling capacitor and three resistors to be added to the circuit. The cathode follower would be inserted between V2 and V3, and a jack intended for feeding a tape recorder would be connected to the output of the new stage.

In terms of performance, the only criticism that can be directed at the EA-2 is its modest signal-to-noise ratio. On high level inputs the reviewer measured 60 db noise and hum below 12 watts output at 1000 cps. On magnetic phono input he measured a 47 db signal to noise ratio. Ratios at least 10 db higher would be more in line with professional performance.

With gain control full down, slight hum can be heard within a few feet of a speaker of average efficiency. This originates in the power amplifier section (V3, V4, V5) and is likely due to inadequate filtering of the B + supply for the output tubes. In a quiet listening room and when the program source contains little noise, the hum might be bothersome to a listener sitting close to the speaker. We tried adding a 30-ohm resistor between the rectifier cathode and the B + lead of the output transformer, bypassing this point to ground with a 40 μf electrolytic capacitor for the additional filtering and increased the signal-to-noise ratio by about 11 db.

But overall, as it stands, the EA-2 provides exceptional performance at its price, and in a number of respects excellent performance at any price. To the handy audiophile, it furthermore offers attractive opportunities for increasing flexibility of performance; and possibly he may find a way to reduce hum, if it does turn out to be a problem in his case.

HEATHKIT W-6M AMPLIFIER

There was a time when the "home-built" amplifier was the only type available to the hi-fi enthusiast, because there were no factory-built models for this market. These amplifiers were also, in most instances, home-designed, and they did not *always* perform as their designers hoped. Now, of course, there are all sizes, types, and colors of amplifiers available as finished products, and all may be presumed to work satisfactorily from the first moment they are plugged in. There are still plenty of people —this observer is one—who enjoy building something, particularly when in doing so we can save quite a bit of money—basically that representing factory labor and its associated overhead and profit. Heath equipment has long been noted for its reliability, and in the new W-6M 70-watt amplifier the results are all that could be desired, and at a price that betokens a considerable saving.

This amplifier, shown in *Fig.* 3, measures 14¼ inches wide, 12½ inches deep, and 9½ inches in height, and has a shipping weight of 59 pounds. Most of this weight is, as would be expected, in the two transformers, so it is obvious that there is no skimping on quality. The circuit, which is shown in *Fig.* 4, offers some innovations which result in a high degree of performance. The first two stages consist of the two halves of a 12AU7, direct coupled. The second half is the usual split-load (cathodyne) phase splitter, and it feeds a 12AX7 voltage amplifier, which in turn feeds a 12BH7 which is a cathode-follower driver for the two 6550 output tubes in an ultra-linear circuit.

The power supply uses a voltage doubler circuit with four silicon rectifiers and more than adequate filtering. An extra winding on the power transformer provides 130 volts to a selenium rectifier for bias supply. Plate currents in the output stage tubes are metered, and provision is made for balancing the two tubes by varying the bias on the driver tubes. Conventional output impedances of 4, 8, and 16 ohms are available for loudspeaker loads, and an additional 70-volt output tap is provided for feeding large speaker distribution systems. When driving loudspeaker loads, the damping is adjustable over a range from 0.5 to 10 by means of a continuously variable control.

Performance

Frequency response is within ±0.5 db from 6 to 70,000 cps, with smooth rolloff beyond these limits to ensure transient stability. Power output is down 3 db at about 13 cps, while harmonic distortion remains below 0.25 per cent over the important ranges, and only reaches 1 per cent at 70 watts at frequencies of 20 and 10,000 cps. Intermodulation distortion reaches 1 per cent at about 73 watts, and at our rating point—2 per cent IM—the output was measured at 81 watts. Full output is reached with an input of 1.1 volts, and hum and noise measures lower than 70 db below 1 watt.

One of the problems encountered with the Williamson-type circuit—comprising the direct-coupled input pair of stages—was its poor performance as regards overload recovery. This was shown by oscillograph traces of signal output when the level was changed quickly from a high value to a very low value—a condition that is common in musical program material. No such instability was observed with the W-6M, however, and only the slightest amount of ringing was noticed on 10,000-cps square waves when driving a loudspeaker load, and none at all on frequencies below 2000 cps.

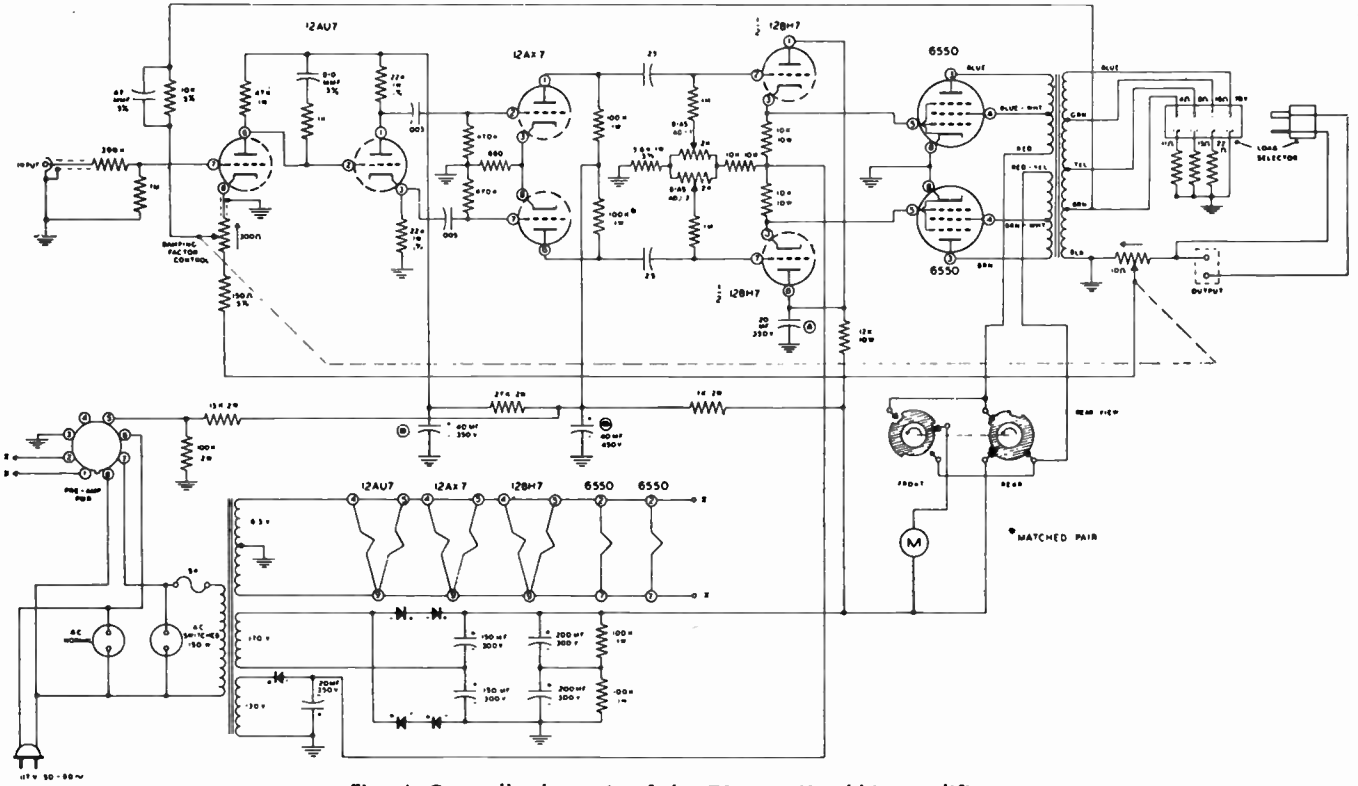

Fig. 4. Over-all schematic of the 70-watt Heathkit amplifier.

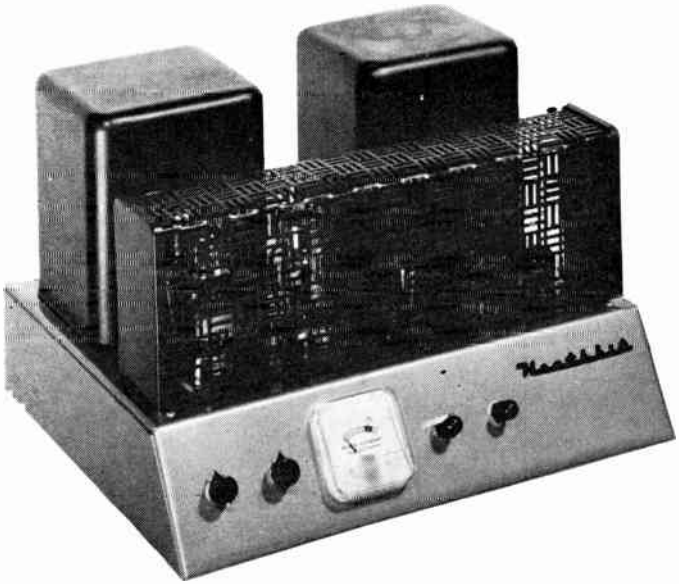

Fig. 3. External appearance of Heathkit W-6M-70-watt amplifier.

Variable Damping

The schematic of *Fig.* 4 shows an unusual arrangement of the output wiring. Note that the variable-damping-factor control is a dual potentiometer, with the 10-ohm section in the return side of the output winding. In order to maintain constant gain as the damping factor control is rotated, three different resistors are used for the three low-impedance output taps. Thus the control—which changes the ratio of voltage feedback to current feedback—can be calibrated directly in damping factor, and gain and distortion remain constant for any setting of the control.

With a high-quality speaker system there is little difference in performance as the damping-factor control is turned, but as the quality of the speaker and enclosure is lowered, the effect becomes more and more noticeable. The higher values of damping factor minimize cabinet resonance and thus reduce any boominess that might result from poor enclosure balance. When used to drive a number of speakers at the same time, the damping factor should best be operated at its maximum position.

Construction

As with other Heathkits that we have had personal experience with, the W-6M "builds" nicely. The instructions are well written, and give the impression that once being completed, they were possibly given to a completely inexperienced constructor to find out if they were sufficiently clear and complete. After completing and testing the amplifier, we "unbuilt" it far enough to add a 25-volt transformer, a full-wave selenium rectifier, and filter capacitors so as to have a 24-volt d.c. supply for a new preamplifier. The space between the power and output transformers is wide enough to accommodate the rectifier and the capacitors, and the extra transformer will just go into the space under the output transformer.

And then—after the manner of silent picture subtitles—came stereo. The problem now is to find space enough (and strength enough) in a cabinet to hold two of these units—118 pounds—completely aside from the need for physical strength enough to lift them. We shall remain quite content with a smaller amplifier for the second speaker, using this model for the principal speaker and the five others that are distributed around our home at strategic locations. By which we mean to imply that we consider this one of the better amplifiers available and will continue to use it.

That is, we suppose until somebody introduces a practical 100-watt amplifier for home use.