New Medium-Cost Amplifier of Unusual Performance

G. LEONARD WERNER* and HENRY BERLIN**

Fulfillment of the design requirements for a high-quality music-system amplifier demands a careful analysis of these needs, which are presented here by the authors along with their solution in a practical unit.

A LARGE NUMBER of "high-fidelity" amplifiers have been introduced in recent months. A thorough survey of this situation convinced us that although each manufacturer provides somewhat different facilities and characteristics in his particular hi-fi amplifier, a common standard could be deduced from the units available, and that there was a need for a medium-cost amplifier providing all the features a completely flexible high-fidelity amplifier-preamplifier system requires, plus extremely wide frequency response and low distortion.

Such a unit is the Masco "Concertmaster" 20-watt amplifier-preamplifier combination, the result of an extensive development program undertaken for the purpose of fulfilling the need for a unit having the required characteristics—and, if possible, more—at a price within the budget of the average hi-fi enthusiast as well as that of the small radio broadcast station and recording studio.

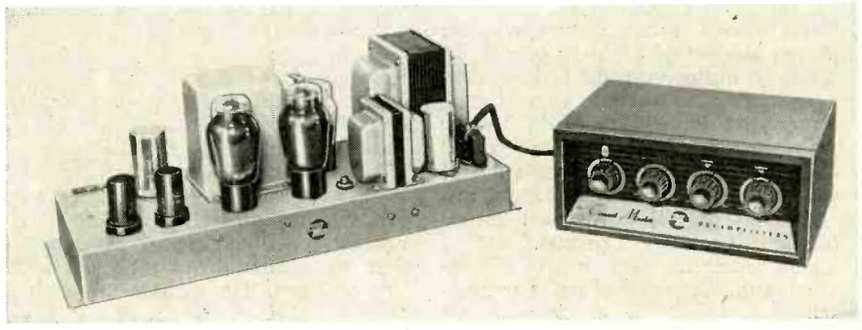
An amplifier and preamplifier were developed that lend themselves to custom-built-radio-phonograph installation (particularly for reproduction of live FM programs with an excellent degree of the illusion of realism), to high quality monitoring of live program material, to tape recording—in short, to whatever application in which the finest possible performance is essential.

What is a "High-Fidelity" Amplifier?

It seems to be generally agreed that a good amplifier-preamplifier combination which is to be used as part of a modern music reproducing system, should preferably have the following characteristics:

1. Extremely wide frequency range well beyond the low- and high-frequency limits of audibility.
2. There must be perfect stability—no tendency to distortion-producing low- or high-frequency oscillation.
3. There must be a high damping factor to minimize speaker excursions and consequent distortion.
4. As a factor of the above characteristics, a considerable amount of negative feedback must be applied.
5. Hum level should be below the threshold of audibility.

* *Chief Engineer, and* ** *Sales Engineer, Mark Simpson Mfg. Co., Inc., 32-28 49th Street, L.I.C. 3, N.Y.*



6. A preamplifier must be provided with inputs for radio tuner, phonograph, and other reproducing devices, all of which may be left connected at the same time.
7. The preamplifier must provide selective equalization for all popular types of recordings, both old and new.
8. A loudness control[1,2] must be provided to give a variation of amplifier output which will be in accordance with the sensitivity of the human ear rather than in the manner of the conventional volume control. The various program inputs which are otherwise uncompensated should have a calibrating control so that the loudness control will vary the response from each in the same manner. This is essentially a calibrating system for the loudness control.
9. A low-impedance output must be available on the preamplifier so that the basic power amplifier may be placed at any reasonable distance away from the preamp without loss of high frequencies.
10. Bass and treble controls are still required to provide response variations in accordance with individual tastes. The treble control also provides a means of varying the degree of roll-off from that already incorporated in the equalizing networks.
11. The power supply must have an extremely low internal impedance.

[1] David Bomberger, "Loudness control for reproducing systems." AUDIO ENGINEERING, May 1948.

[2] John Winslow, "Full-range loudness control." AUDIO ENGINEERING, Feb. 1949.

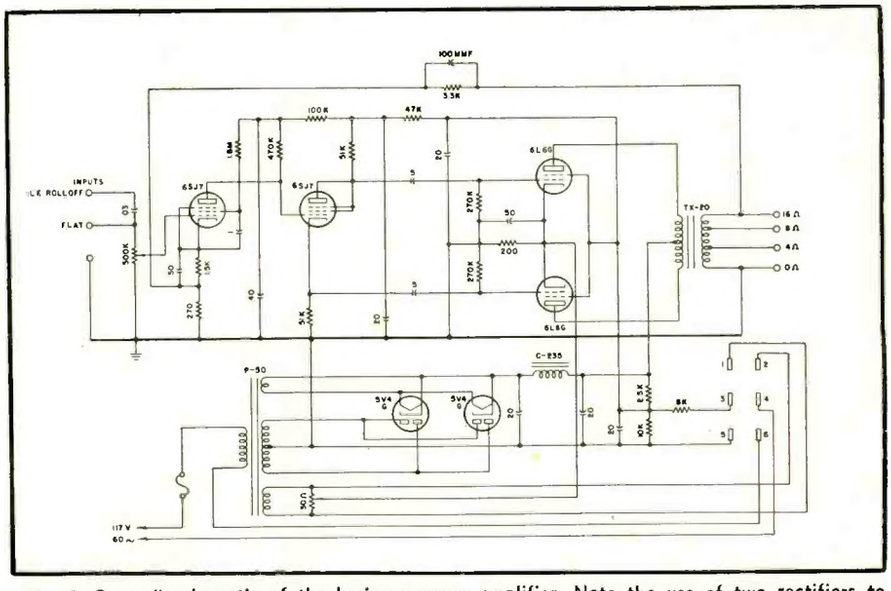


Fig. 1. Over-all schematic of the basic or power amplifier. Note the use of two rectifiers to provide adequate current handling capacity.

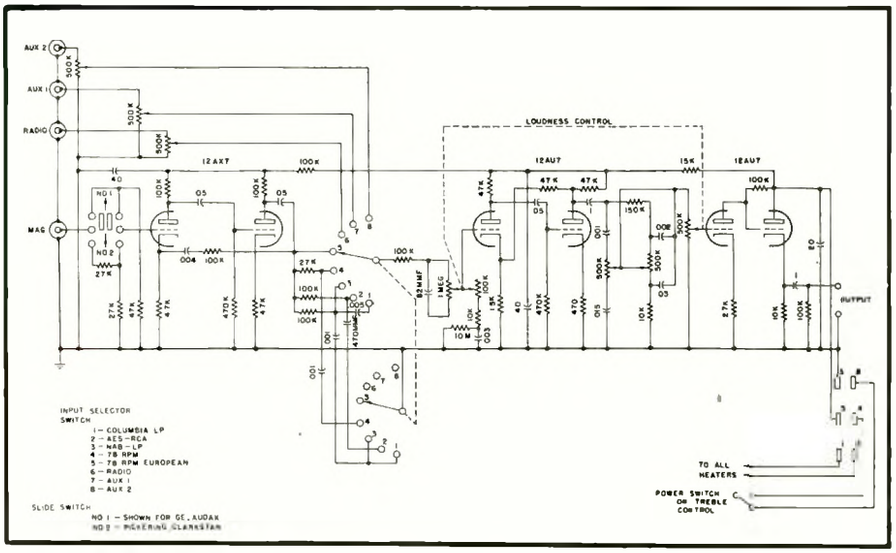


Fig. 2. Schematic of the control unit used with the basic amplifier of Fig. 1.

The Basic Amplifier

A schematic diagram of the amplifier is shown in *Fig.* 1. Note that the circuits shown are, in today's advanced design practices, essentially conventional. A noteworthy exception is the use of direct coupling to reduce the phase shift or phase distortion usual in purely resistance-coupled amplifiers. In fact, the basic power amplifier employs only *one* R-C coupled stage. Excellent power supply regulation is achieved by means of paralleled 5V4G rectifiers, resulting in a low source impedance and sufficient power capacity to supply the extra-heavy power requirements for clean, undistorted bass reproduction.

Figures 3 through 6 indicate the power output, distortion, and response characteristics of the basic amplifier. *Figure* 3 shows power output of the amplifier versus percentage of harmonics. It will be noted that there is less than 0.2 per cent harmonic distortion up to 20 watts and no more than 2 per cent distortion at 25 watts.

Figure 4 indicates the frequency response at the 20-watt level—within ½ db from 10 to 50,000 cps. Usable output extends to well above 100,000 cps, being no more than 3 db down at 8 cps and at 100,000 cps.

Figure 5 indicates the response at the 1 watt level, 10 to 75,000 cps ± 0.1 db, and down only 3 db at 5 and 140,000 cps. This figure assumes practical significance when it is remembered that average room output level is 100 *milli*-watts. The amplifier is required to be able to deliver clean reproduction of the peaks—at least ten times the average power, or 1 watt. When it is noted that intermodulation distortion (*Fig.* 6) is so small as to be actually not measurable at 1 watt (intermodulation is no more than 0.2 per cent at 20 watts), and harmonic distortion as shown in *Fig.* 3 is similarly low, then it will be recognized that for practical purposes this amplifier is distortionless.

Stability has been achieved in this amplifier as a result of the wide frequency response and minimum phase

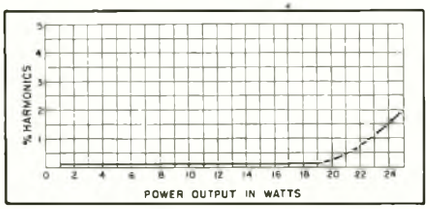


Fig. 3. Harmonic distortion vs. power output at 20 cps.

shift. Twenty-six db of feedback is applied around all three amplifier stages and the output transformer to achieve almost complete freedom from distortion, excellent stability, and a damping factor of 30. The effective output impedance at the 16-ohm tap is approximately 0.5 ohm.

Low hum and noise level (100 db below 20 watts on basic amplifier, 75 db below 20 watts with the preamplifier connected) are achieved by careful component layout and by use of an adjustable hum balancing network which biases the filaments positively to eliminate filament-to-cathode emission, a frequent cause of hum.

The basic amplifier has a sensitivity of 2.0 volts r.m.s. for 20 watts output and is provided with its own volume control to compensate for higher input levels. One of the two amplifier inputs goes directly into the volume control for flat response, while the second input feeds the signal through a .03-μf capacitor which reduces the response by 3 db at 50 cps for minimizing turntable rumble and other low-frequency disturbances, and also proivdes an input for blocking d.c.

For universal convenience, the amplifier chassis was designed so that it could be either rack-mounted or placed in either a bottom- or side-mounted position in a console.

The Pre-Amplifier

The preamplifier (*Fig.* 2) was designed to be an ideal companion piece to the basic amplifier. Appearance was considered to be just as important as the technical aspects and a handsome, hand-rubbed mahogany cabinet was chosen to provide a unit that would quietly grace any living room. The preamp was so designed that the chassis could be easily removed to allow mounting it behind the panel of a console, with the black and gold control panel in the front.

Four standard input jacks were provided on the rear panel: Three marked respectively AUX 1, AUX 2, and RADIO, to allow connection of radio tuner, TV tuner, tape recorder, crystal pickup, etc. These are high-impedance, flat-response inputs and are each provided with individual controls available at the rear of the chassis for adjusting the input level of each program source so that the loudness control will work in the

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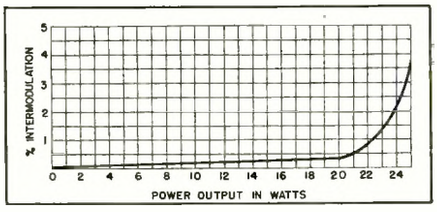

Fig. 6. Intermodulation distortion vs. power output, using 60 and 7000 cps mixed 4:1.

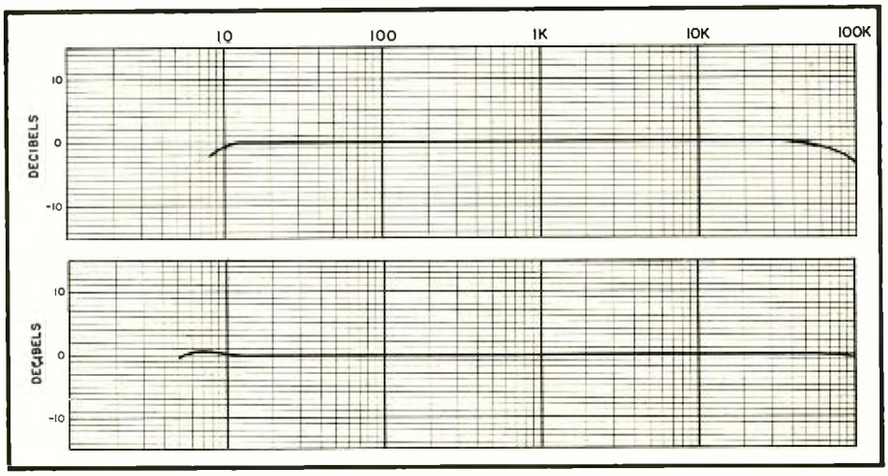

Fig. 4 (above). Frequency response of the entire amplifier at the 20-watt level, and Fig. 5 (below), at the 1-watt level.

same way for each. Once these controls are set they need not be readjusted.

The fourth input, designed for various magnetic pickups, is independently equalized and compensated. This input is provided with a switch placed adjacent to it which adds or removes attenuation as required for use of either the low-output type of cartridge such as the GE or Audak, or high-output cartridges like Clarkstan or Pickering.

An eight-position selector switch with a dial of novel design works with the MAG input to provide almost every type of equalization possible in a single switch. Nearly every type of characteristic recorded on a disc may be equalized with this switch. Equalizations provided are as follows:

Position 1—Columbia LP (500-cps turnover, 16 db rolloff at 10 kc., playback equalization for constant velocity below 100 cps).

Position 2—AES-RCA (400-cps turnover, 12 db rolloff at 10 kc).

Position 3—NAB-LP (500-cps turnover, 16 db rolloff at 10 kc).

Position 4—78's (400-cps turnover, 6 db rolloff at 10 kc).

Position 5—European 78's (350-cps turnover, flat at high end).

Positions 6, 7 and 8 select the high-impedance, flat-response inputs.

The loudness control, as is well known, provides an essentially flat response at its maximum setting, and boosts the response at the low and high frequency ends as the loudness is reduced, in accordance with the curves of Fletcher and Munson[1] describing the variation of sensitivity of the human ear with both loudness and frequency. This control was incorporated purely as a means of providing added pleasure to music listening through realism of reproduction. Bass and treble controls are provided to allow variation of the response in accordance with individual tastes. *Figure 7* shows the extent of variation incorporated in these controls: 17.5 db boost and 13.5 db cut at 20 cps, 21.5 db boost and 22.5 db cut at 20,000 cps. Center positions of these controls provide flat response, and there is no interaction between the controls. Crossover frequency is 800 cps.

In summary, we have described an amplifier and preamplifier system offering the flexibility and performance required for most high-fidelity applications, intended for the low- and medium-priced market and using standard, easily available tubes, yet surpassed by few if any similar commercially available units. The superiority of these units has been established not only by laboratory measurements as described, but also by comparative listening tests (the familiar A-B tests) with live material under similar conditions. In the present state of the art, it would be difficult to surpass the performance of this equipment.

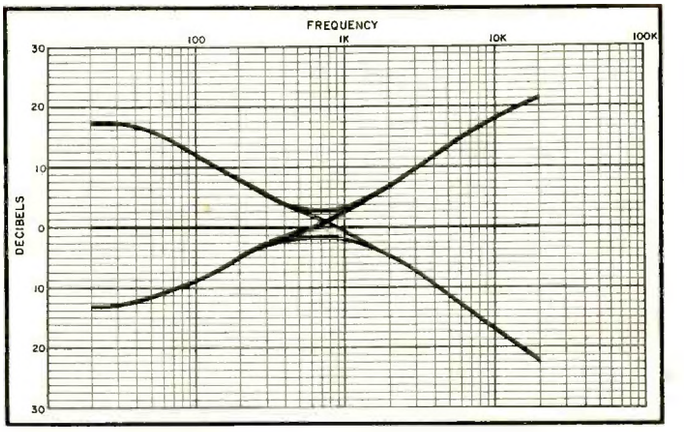

Fig. 7. Frequency characteristics of the tone controls, showing response at maximum settings, as well as at the flat position.