A Quality Amplifier For The Home

ALBERT PREISMAN*

Mothers and wives can operate this unit, which has a built-in preamplifier and an absolute minimum of confusing knobs and dials. Even the selector switch is cleverly eliminated; manufacturers take note!

THE HI-FI ENTHUSIAST has been the butt of innumerable jokes for many years. The most fanatic have been accused of listening, not to music, but only to white noise, and the somewhat more reasonable members of this irascible fraternity make a fetish of "systems" with a bewildering multiplicity of knobs and switches, so as to be able to control every conceivable characteristic of the reproduced sound (except, apparently, its loudness).

The writer was accused by his good frau of never having a radio or phonograph that was simple in operation, presentable in appearance, and satisfying in performance, and the thing that rankled most in his mind was, of course, the truth of the accusation. So he sat down to figure out a circuit that could accommodate a phonograph pickup, an FM tuner, and a magnetic tape recorder, to be housed in a presentable cabinet, and arranged to be operated with a minimum of switches and controls.

The pickup chosen was an ordinary GE variable-reluctance dual type having a 1-mil diamond stylus and a 3-mil sapphire stylus. The necessary preamplifier was built into the main amplifier rather than on a separate chassis. The power supply, however, was built on a separate chassis to minimize hum pickup.

The FM tuner happened to be a Meissner; of course any other make can be used. The important thing is that the output level is much higher than that of the phonograph pickup, hence the tuner can be connected into the system at a point immediately following the preamplifier.

The tape recorder happened to be a Magnacordette. This has its own preamplifier, which functions both for recording and reproducing, and in the latter case has an output level comparable to that of the FM tuner. Hence it would be only natural to connect the recorder into the system at about the same point as the tuner.

This, then, suggested the layout that is actually employed. Following the preamplifier is an amplifier stage consisting of two sections of a 12AX7 whose plates are connected in parallel to a common plate load resistor. The grid of one section connects to the preamplifier, but the grid of the other section is fed, through a pair of separate series 75,000-ohm resistors, from the FM and tape-recorder outputs. The two series resistors merely serve to isolate the tuner and recorder from one another to a satisfactory degree.

In other words, the stage following the phono preamplifier is an electronic mixer stage, and the grid of one section is in itself arranged to mix two inputs. Hence a total of three inputs can be accommodated, and any one, two, or all three sources can be used to feed the loudspeaker. It requires no particular technical savvy to operate: if you want to play the phonograph, you turn on the amplifier, start the turnable, place the pickup on the record, and there you are. If you want to play the FM tuner, turn on the tuner as well as the main amplifier; if your wish is the tape recorder, turn it on as well as the main amplifier. Should you—perish forbid—wish to play two at once, or all three, merely turn on those you want. This is all admittedly very obvious, hence it is a desirable characteristic for the family instrument.

Now, as to tone controls: Women are not interested in engineering; that's why engineers have to work overtime designing engineering gadgets that do the technical work for them. Witness automatic transmissions, power steering, automatic washing machines, pre-cooked oatmeal, etc. Hence no equalizer was employed in this system; it has a fixed amount of bass boost, and a flat high-frequency response. The only control is a tone control of the "chopper-offer" type; it provides a rather sharp cutoff at 10 kc, 8 kc, or 5 kc, as desired, and is used (only by me, of course) to cut down the excessive surface noise on some old 78-r.p.m records that I have.

Perhaps the rest of the family will be enticed in time to use it, but since they play only LP's and 45's, they appear to have little need for it. It is desirable to have this control act on all three inputs, hence it is arranged to follow the mixer stage, and so requires a separate tube section for this purpose.

The present horsepower race among manufacturers of the horseless carriage had its origin in the power output race that began in the 20's, when the UX 112-A supplanted WD-11 or UV 201-A tubes in push pull. There is a group of diehard moderates who claim one or two watts output is sufficient. However, audio power is relatively cheap, and so this amplifier employs two 1622 tubes in push-pull, with a power output of 16 watts. Such power output may not be necessary for the home, but then one is under no compulsion to turn the gain up to a maximum. And if it should be desired to employ this amplifier for a larger room, the power is there to use.

However, the amplifier described here is readily modified to suit the specific needs of the builder. The tone control can be eliminated if not desired; the bass boost can be made variable, and smaller power tubes can be employed. Other possible variations may occur to the reader as he persues the description that follows.

The Phono Preamplifier

The complete amplifier diagram is shown in *Fig.* 1. The preamplifier consists of a 12AX7, with its two sections connected in cascade and employing feedback. But first we note the R-C input networks to the first grid; the use of these tends to cut down turntable rumble, although the best way to minimize this is to use a turntable as free of this characteristic as possible, and then to install it in a rock vault 10 feet underground.

Incidentally, the ordinary three-speed changer that I am using had excessive rumble until I slipped some rubber snubbers between the metal chassis and the wooden frame on which it is supported by three conical springs. It seems that the springs are too free and permit the whole assembly to quiver like a dowager's third chin at a gabfest; the rubber snubbers hold it in check like a whalebone corset.

The input resistor of 10,000 ohms seems to give the most satisfactory high-frequency response. An initial value of 20,000 ohms permitted the GE pickup to develop a double-humped peak at 6,000 and 10,000 cps, with a minimum at 8,000; the present value produces a reasonably smooth response.

Low-frequency boost is obtained by feeding back from the plate of the second tube to the cathode of the first via a .04-μf capacitor in series with a 47,000-ohm resistor. By varying the values of these two components, the low-frequency peak may be varied to a certain extent, both in magnitude and frequency. However, an additional boost is obtained by the .011-μf capacitor and 270,000-ohm resistor shunting the 50,000-ohm volume

* *Capitol Radio Engineering Institute, 16th & Park Road, N. W., Washington 10, D. C.*

control, together with the 75,000-ohm resistor above this combination.

This latter network produces a reduction in gain, but the gain is more than sufficient anyway, and the additional bass boost of 4.2 db raises the total to 19 db. Of course more can be had, but the response from a test record using the RCA New Orthophonic curve seems quite satisfactory for the values given.

One advantage of employing two separate circuits for bass boost is that their peaks may be staggered and thus used to shape the curve to a certain degree. The curve as obtained for the values shown is exhibited in *Fig. 2*; the curve marked "Phono Input" shows a peak centered at about 45 cps. This is to be compared with the response marked "FM Input," which is that of the amplifier stages following the preamplifier. The slight dip below 50 cps in the latter curve is mainly due to the output transformer.

The 75,000-ohm resistor in the bass-boost network can be made variable in order to vary the amount of bass boost. The 540-ohm cathode resistor of the first stage may be changed to a potentiometer, with the 47,000 ohm resistor connected to the arm. In this way the amount of bass boost can be varied in this network without varying the position of the peak in the frequency spectrum.

A switch in series with the feedback network can be used to disconnect it when a flat response is desired, such as when it is desired to connect a microphone. The concomitant increase in gain is usually desirable in such a case because of the normally lower output of the microphone. However, I prefer to use the preamplifier in the Magnecordette for this purpose, hence I have omitted the switch.

One further point to note is the .015-μf cathode bypass capacitor employed in the second stage. It does not take effect until about 4,000 cps, at which point it begins to decrease the inverse feedback in this stage and thus raise the high-frequency response. This appears necessary in the case of triodes because of the appreciable input capacitance of a triode stage owing to the Miller effect. The resulting attenuation of the higher frequencies by several such stages is counteracted to an appreciable degree by this small bypass capacitor. By varying its value, the point at which compensation begins to take effect can be varied; a smaller value causes the compensation to set in at a higher frequency.

When the amplifier was completed, it was found that the hum was appreciable, owing in part to the bass-boost. The solution was to feed the heater of the first 12AX7 (whose two sections constitute the preamplifier) with the plate current of the two 1622 tubes operating in push-pull. Since these operate essentially class A, the even-harmonic components that are present in the combined cathode current are relatively small, and produce no noticeable effects in the preamplifier. The reduction in hum is very marked; most of the residual hum now present is very small, and is mainly due to stray magnetic fields acting on the phono pickup, FM tuner, or Magnecordette. The latter is particularly sensitive to stray 60-cps magnetic fields.

The 12AX7 heater is placed in series with a 22-ohm resistor and 25-ohm potentiometer. This increases the voltage drop to a value adequate to serve as self bias for the push-pull output stage. The 25-ohm potentiometer serves further to vary the bias of one 1622 tube relative to the other; in this way two 1622 tubes can be equalized as to d.c. plate current flow in the output stage. The 10,000-ohm resistor is required to draw additional bleeder current because the 12AX7 heater requires more d.c. than do the plates of the 6L6 tubes at an operating potential of 250 volts. The 10,000-ohm resistor also serves as a bleeder for the power supply.

Mixer and Equalizer Stages

The 50,000-ohm volume control following the preamplifier stages is for the phono pickup only, since it is assumed that the tuner and tape recorder have their own volume controls. In this way each volume control can be preset to its average position, so that there is no sudden blare of sound as the system is switched from one source to another.

The third stage employs the two sections of a 12AX7 tube in the form of an electronic mixer, as mentioned previously. The common plate resistor of 39,000 ohms was found to be the desirable value to use in conjunction with the bridged-T network following it. The latter employs a 2-henry Hycor toroidal inductor, which can be switched by two sections of a 3-gang switch to bridge various combinations of series capacitors.

The bridged-T configuration gives a sharp attenuation dip at the frequency at which the two capacitors and the in-

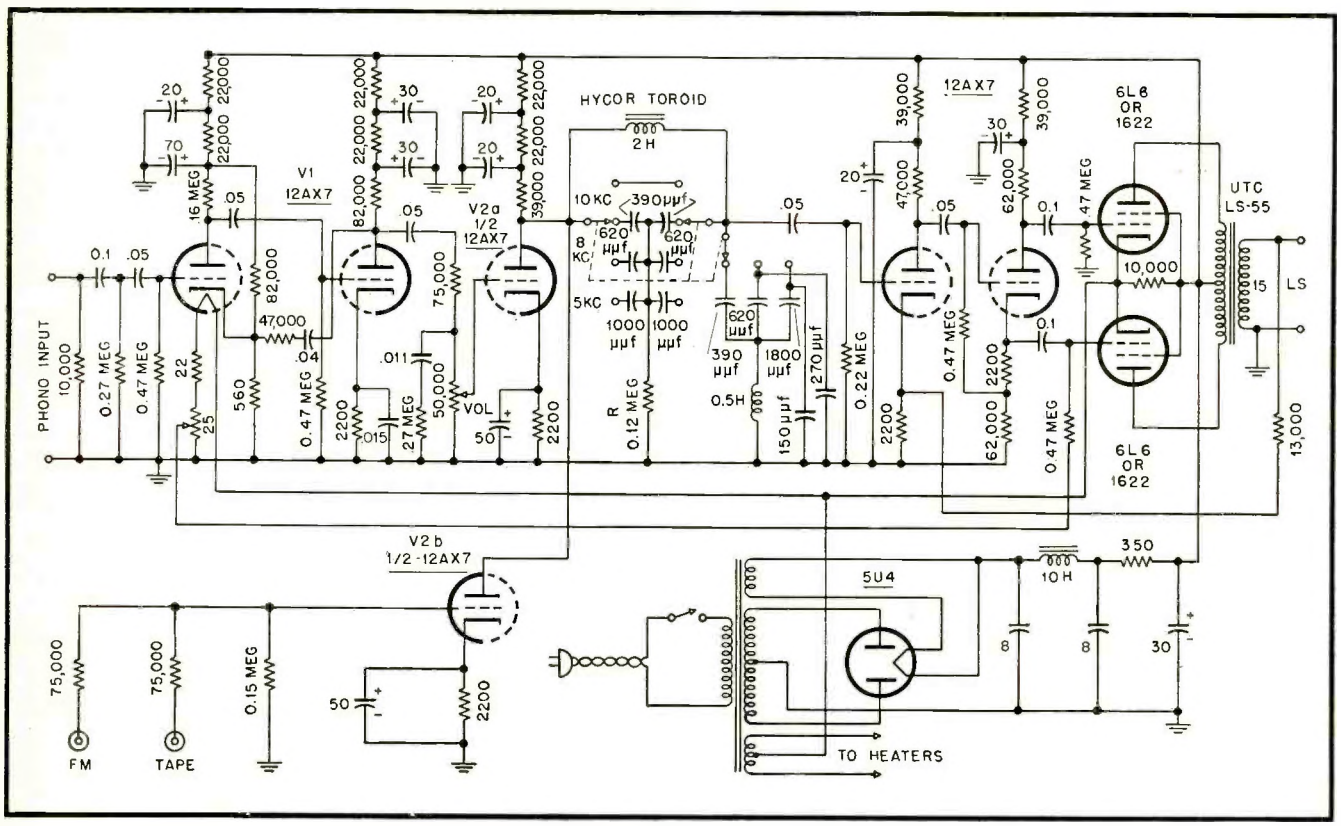

Fig. 1. Complete schematic of the amplifier. The input switch is eliminated by mixing all three sources so that it is only necessary to turn on tuner, phono, or tape machine as desired.

ductance are in series resonance. The value of R must be adjusted to the proper value to produce this sharp selective attenuation effect, but its value is not particularly critical. The magnitude indicated is 120,000 ohms, but this value would differ with different inductors.

Approximate values of the capacitors used are indicated, but exact values are best determined experimentally by running a frequency response curve on the amplifier and adjusting the capacitor values until the proper response is obtained. Actually, odd values may be required to hit the desired frequency, and in this case a practical dodge is to use slightly unequal values of capacitors. A little patience and a number of capacitors will result in the response dropping off fairly sharply at the desired cutoff frequency.

However, the bridged-T network attenuates only in the vicinity of one frequency; above that frequency its transmission approaches the normal value once more. To hold down the response beyond the attenuation frequency, the series-resonant network following the bridged-T is employed. This involves a 0.5-henry choke and suitable series capacitors, mounted on the third section of the 3-gang switch, to operate in conjunction with the bridged-T.

Approximate values are shown for these capacitors also, but here again the capacitors should be chosen experimentally to resonate at a suitable higher frequency than the corresponding frequency of maximum attenuation of the bridged-T, and thus hold down the response to a suitably low value at the higher frequencies.

However, for the 8000- and 5000-cps attenuation frequencies, the simple series resonant circuits permit the response to rise again beyond its resonant frequency, because the amplifier still has adequate gain in this region. Hence, two additional shunting capacitors are employed from the corresponding two switch contacts to ground, and these hold the response down to an acceptably low value.

The response curves of the filters are shown in *Fig.* 3. The peaks shown are due to a tendency for the bridged-T choke to resonate with the following

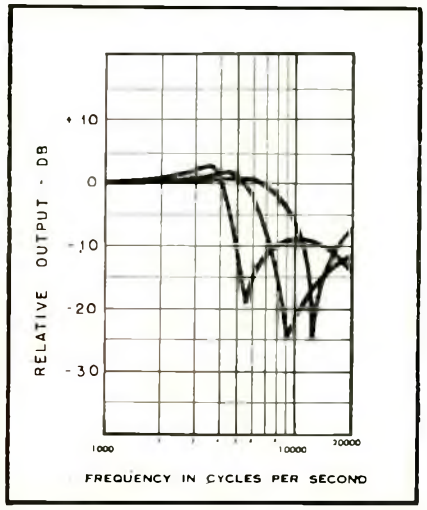

Fig. 3. This graph shows the characteristic with each of the three filters switched in.

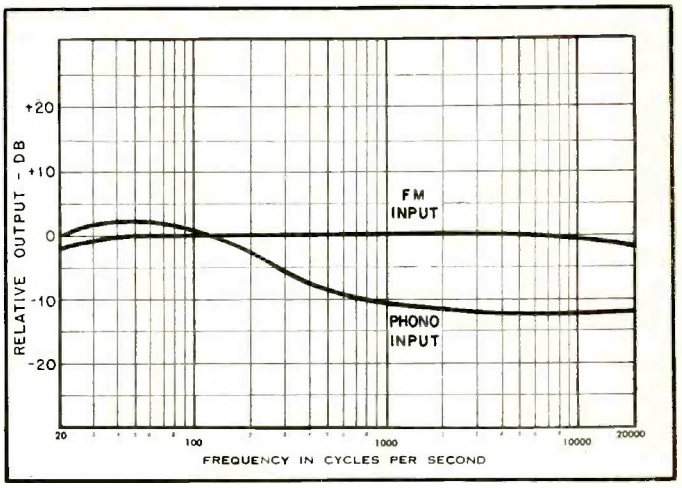

Fig. 2. Amplifier response from the pickup and tuner inputs to output.

series-resonant circuit; the rise in gain after the frequency of maximum attenuation is due to the inability of the series-resonant circuit to keep the response down. The results are quite satisfactory despite these peaks, and in spite of the grave admonitions to avoid peaks, the "ringing" of the system is not noticeable to the listener.

The main reason for employing such a rather involved network is to obtain as wide a frequency response as possible consistent with the surface noise of the record or other source. For LP's and even good 78's I use the amplifier wide open; I can take a certain amount of hiss. Incidentally, I seemed to get a sharper attenuation curve using the bridged-T insead of a parallel twin-T, which otherwise would have been more attractive because it requires only resistors and capacitors.

Power Output Section

The next two stages are sections of a 12AX7 tube, as indicated. The reason two sections are employed is to obtain feedback from the secondary of the output transformer to the cathode of the first section, and then to use the second section as the phase-splitter stage.

The amount of feedback that can be employed is limited; for the UTC LS-55 output transformer the values of 13,000 ohms for the feedback resistor, and 2200 ohms for the cathode resistor seem to permit the greatest allowable amount of feedback. Tests made by measuring the regulation of the output voltage as the load resistance is varied indicate that the internal output impedance, looking into the 15-ohm secondary terminals, is reduced to 4 ohms.

The split cathode resistor employed in the phase-splitter stage affords the correct grid bias for the stage and at the same time the correct drive voltage for the connected 1622 grid.

The output stage in itself is conventional. The 1622 tubes are operated at values recommended by RCA, 250 volts on the plates and screen grids, and – 18 volts self bias. The output, as measured at the secondary of the output transformer, is 16 watts, and was determined by observing the output wave shape on a scope, and noting where it just began to flatten. The exact percentage is not important, as this is more power output than is required in the home.

The maximum gain was found to be about 102 db at 1000 cps. This is not only very high, considering that no input step-up transformer is employed, but it is also in excess of that required by any phonograph pickup; indeed, it reaches down into the thermal and microphonic noise levels of the first stage. This is particularly the case since the gain at low frequencies is an additional 18 db. A 12AU7 can be successfully substituted for the first 12AX7, with about 7 db reduction in gain. Hence, one might just as well use the 12AX7 and run the volume control a little lower.

The power supply is of conventional

(*continued on page 47*)

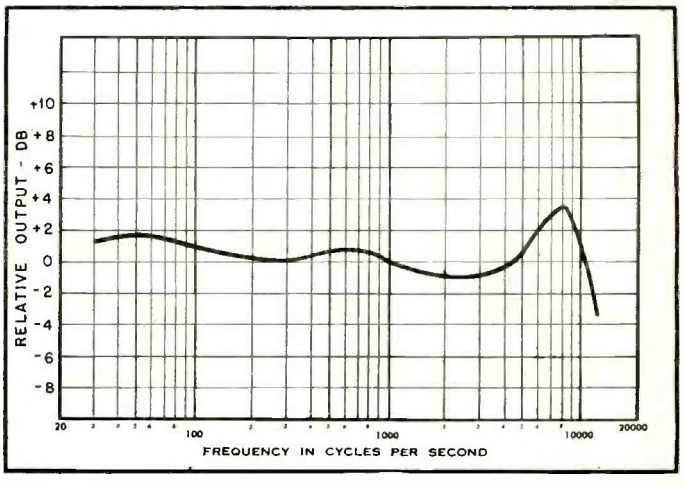

Fig. 4. Over-all response from the grooves of a test disc to a dummy load resistor following the output transformer is satisfactorily flat.

design and needs little comment. The reason for the dropping resistor as a second filter is that a spare television power transformer was used, which developed an unexpectedly high voltage. This was reduced to meet the rated plate and screen voltages of the 1622 tubes; perhaps the transformer you may have available will not require the same treatment.

Oil-filled filter capacitors of relatively low values were employed rather than electrolytics; however, the writer is not particularly prejudiced against them. There is, however, a satisfaction in knowing that these components will stand up indefinitely, although, admittedly, large electrolytic capacitors were used for decoupling purposes in the various stages, and hence in time trouble may occur at these points. Although smaller decoupling capacitors could be used, the values indicated do stabilize the amplifier to a large extent against line surges and similar "bumps."

This amplifier is operated into an LC1A speaker installed in an infinite baffle of about 15 cubic feet volume. The results are generally approved by people who have listened to the system, and it appears to be very suitable for the home.

As a matter of final interest, *Fig.* 4 shows the response of the system from the G-E pickup to a 15-ohm load resistor, employing a Dubbings D-101A record for the RCA New Orthophonic curve. The results, it will be noted, are fairly flat, particularly at the low-frequency end of the spectrum, and confirm the satisfactory conclusions drawn from listening tests.