Improvements on the Universal Amplifier

Description of the second model of the unit described in the previous article—with certain minor refinements and slightly improved performance.

One of the difficulties in building only one of a piece of equipment is that there is no opportunity to improve on layout, circuit, or mechanical design in the same fashion that a manufacturer would before introducing the instrument or equipment to the market. The Universal Amplifier described in the preceding article was no exception to this difficulty, as was mentioned. Certain changes and improvements were indicated as desirable if a second unit were to be built. Not that the unit was unsatisfactory as it was—but although it performed well and turned out good recorded tapes, there were a few slight deficiencies.

In the first place, the transformers used for inputs were relatively old, and while their frequency response was adequate for most applications, there was a 4-db peak at 10,500 cps which caused a higher hiss level than was considered desirable on playback. Also, there was some loss in the circuit for direct monitoring of the incoming signal, as compared to the NOR position of *Sw₁*, necessitating an increase in the gain setting of the amplifier which followed. Furthermore, it was felt that the difficulty of changing the volume controls—in case they became noisy—was too great.

Accordingly, the entire amplifier was rebuilt. The same outside case was used, as well as the same panel, VU meter, and switching arrangements. The input transformers were changed to Triad HS-5 and the output transformer was changed to Triad HS-52. The Triad

HS-5 transformers were designed to work from a 30/50-ohm microphone into a grid; frequency response is extended, and the amplifier is now free of the hiss level which accompanied the first model. This was not considered too troublesome at the time of the first articles on this amplifier, because it was felt that very few who might wish to duplicate the unit would go to the expense or trouble of obtaining the Western Electric transformers specified for the input circuits.

All three of the Triad transformers are mounted in the same size of case, and the total chassis space required was somewhat less than with the three previously employed. This permitted the use of a 4-section electrolytic capacitor for plate-supply decoupling and for bypass across the cathode resistor of the output stage, since space enough for this capacitor (a Cornell-Dubilier UP-22245C) was available along the rear of the chassis. The feedback capacitor C_{11} is mounted between the output transformer and the filter capacitor.

With all of the transformers and these two capacitors mounted along the rear of the chassis, space was available for the mounting of the tubes in a row, thus making it possible to locate all six of them on a single rubber-mounted aluminum channel, basically similar to that used for the first four tubes in the original construction. The resistors and capacitors related to the tubes are mounted on a resistor board which is spaced about ¼ in. below the socket terminals. This resistor board was made up from a punched phenolic strip and a number of terminals supplied by Naald. With these terminals and the punched strips, and using the small staking tool designed for applying them, it is possible to make up any kind of terminal strip desired. For this particular application, a total of 31 resistors and capacitors are mounted on a single strip just below the tube sockets, thus making for short leads from the socket terminals to the associated components.

The volume controls are mounted on two brackets—one holding R_{11}, and the other holding R_7 and the inclusive control, R_{11}. Short flexible shafts are used between the knobs and the controls—with panel bearings and shaft extensions used at the panel to provide a good bearing for the knob shafts. The flexible shafts can be seen in *Fig*. 3.

The principal change in circuitry is in the cathode-follower section, V_6 in the original circuit, and V_{6a} and V_{6b} in the revised arrangement. This provides some additional gain so that when the unit is used with a home radio system, the output at terminal 3 of J_6 is at the same level as the signal fed into terminal 2—the loop circuit between the FM tuner and the remainder of the system. One section of the 12AU7 is employed as an amplifier, with about 10 db of gain; the other section is a cathode follower, and feeds the signal out at a low impedance. J_{10} has been added, with the voltage divider R_{49} and R_{50}, so that an ordinary patch cord may be inserted between J_{10} and J_6 to permit the use of the amplifier as an

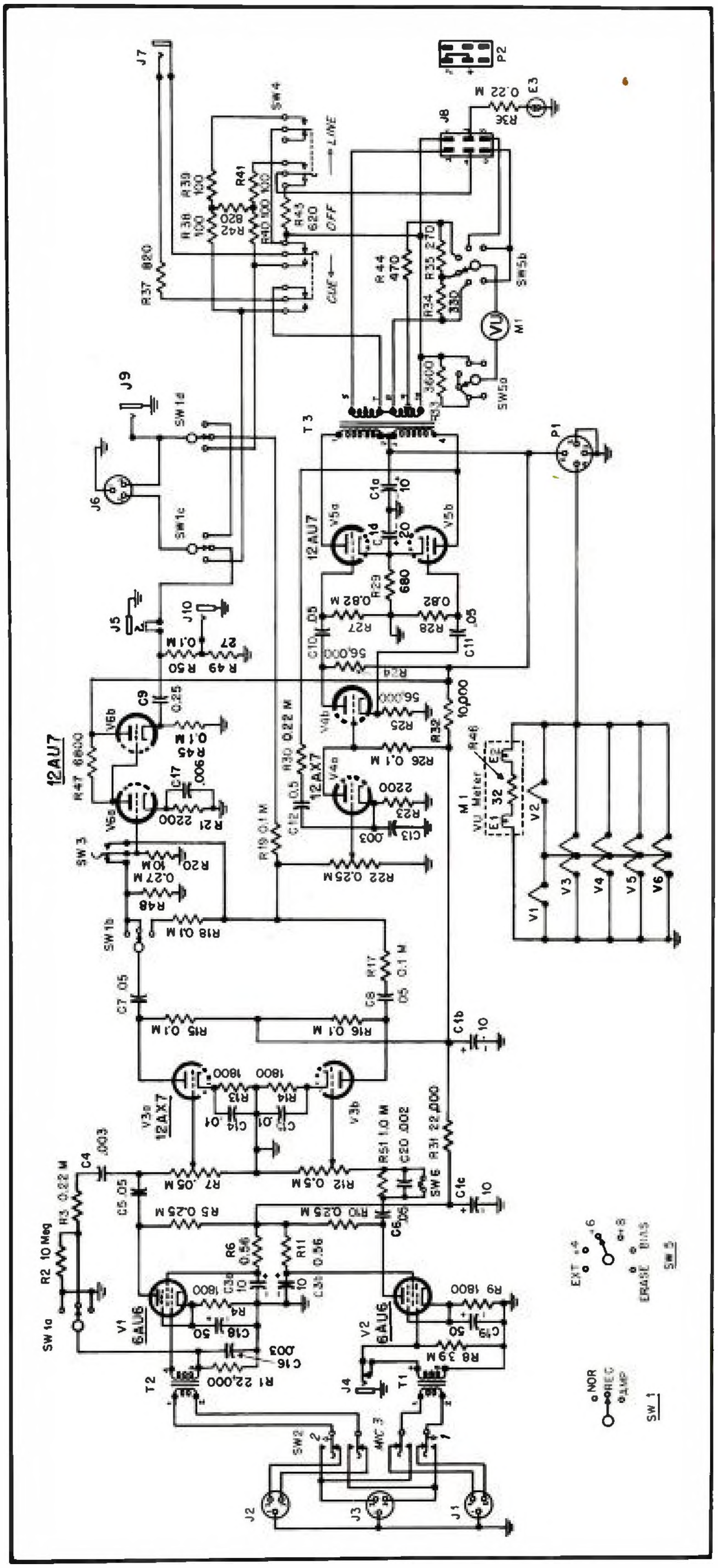


Fig. 1. Revised schematic for the second model of the Universal Amplifier. Principal changes are in equalizing circuits and in monitor output circuit for playback channel.

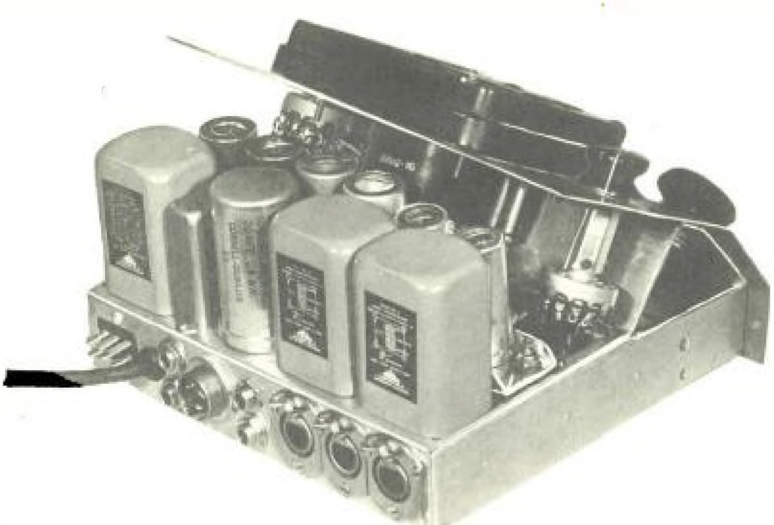


Fig. 2. View of chassis removed from case to show new transformers, 4-section filter capacitor, and mounting of selector switch. Chassis design is essentially the same as in the first model, but all six tubes are now located on rubber-mounted channel strip.

artificial reverberation generator. Performance is somewhat improved, and the level available at J_{10} is just sufficient for convenient operation of the gain control, R_{11}. Note that the voltage divider consists of a 0.1-meg resistor and a *27-ohm* resistor, which provides only a very small portion of the total output signal at the cathode of V_{6b} for feeding back into the circuit on the grid of V_1.

One other refinement in the circuit is the addition of a dialogue equalizer between the plate of V_1 and the gain control of the microphone channel. This equalizer consists of R_{41} and C_{20}, and serves to reduce the gain approximately 10 db at 100 cps, with a gradual slope up to normal gain at 500 cps.

The use of a 12AU7 instead of the 5879 in the monitor circuit changes the requirements of the heater circuit somewhat, and the new wiring is shown in *Fig.* 1. The VU meter lights were changed to No. 47's, and the resistor between them in the meter case was increased to 32 ohms to reduce the illumination to a suitable intensity.

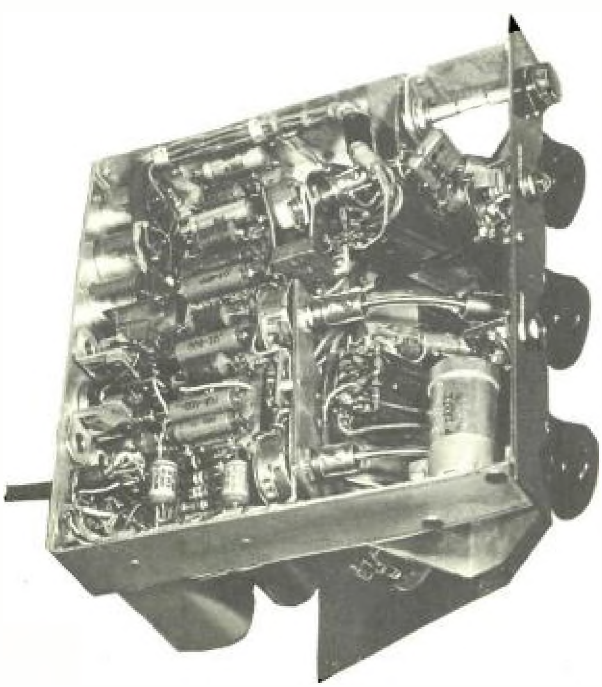
The basic construction plan is the same as in the original model—minor changes being made to accommodate the components used in the improved version. The 4-section filter capacitor is mounted directly on the chassis in holes punched. drilled. and filed by hand —rather than on a standard phenolic mounting wafer—in order to save space.

The 2-section capacitor C_{3a} and C_{3b} is mounted on the right side apron of the chassis just behind the front panel as shown in *Fig*. 3. The two cathode bypass capacitors C_{18} and C_{19} are mounted on the resistor board. and are C-D BBR 50-6 capacitors, 50 µf at 6 volts, and quite small.

The components of the dialogue equalizer, R_{41} and C_{20}, are mounted directly on Sw_6, and the components of the tape playback equalizer are mounted on a small resistor board just above the dialogue equalizer switch. By using two Mallory extension bushings, Sw_1 has been lowered to a position where the terminals are about flush with the chassis deck. A small resistor board. located between R_7 and R_{21} and mounted on the bracket which holds the two pots. provides for R_{17}, R_{18}, and R_{19}, the mixer network, as well as for R_{16}. R_{16} connects directly from one of the terminals of the capacitor C_9 to the ungrounded end of R_{16}. R_{26} is connected directly from terminal 4 of the output transformer to a terminal of C_{11}.

A small shield made of tin was required to eliminate all traces of oscillation due to the proximity of J_1 and J_6. Before this shield was installed. the amplifier would go into oscillation when R_{11} was turned up past 50 per cent rotation. The shield eliminated the trouble completely.

The new model has all of the operating conveniences of the original. together with improved frequency response and the added advantage of the dialogue equalizer on the microphone channel. If necessary. a similar equalizer could be wired into the second channel. but the writer's requirements have not made it necessary yet. Perhaps that will come in the third version—although to date there have been no indications that this second model will be rebuilt.



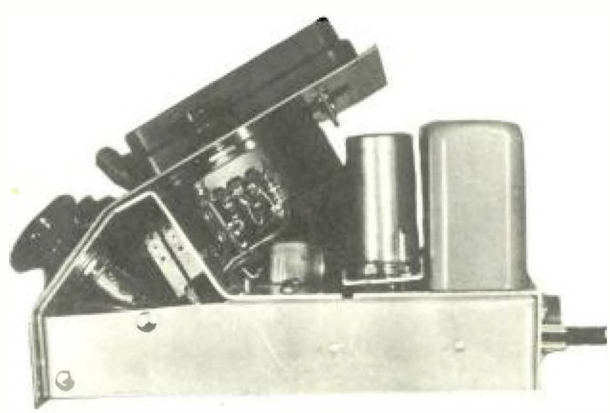
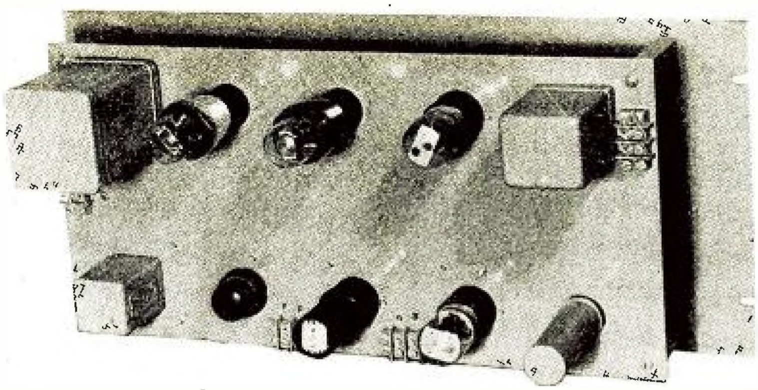


Fig. 3 (left). Bottom view of second model of the amplifier to show placement of volume controls and short flexible shafts from knobs on panel to the controls. This permits considerably shorter leads from the tube-mounting channel and the associated circuits to the controls, with appreciably less need for equalization to maintain high-frequency response. Fig. 4 (above). View of right end of the chassis to show placement of tube channel on which all six tubes are mounted.



Rear view of high-fidelity volume expander.

mum frequency response of the amplifier used to supply power to the diode. If a wide-band—30-10,000 cps—frequency range is used, it is apparent that the control voltage will be influenced by the strongest signal currents within that frequency range. Furthermore, low-frequency rumble and thumps, and high-frequency surface noise and clicks, will produce false control and consequent gain increase. It is best, therefore, when using a single band of frequencies from which to derive the control signal, to limit the response to from 500 to 3000 cycles. The effective loudness is determined by this band of frequencies, anyhow, so it is logical to use the same region for the controlling voltage.

An interesting effect was achieved by splitting the control amplifier into two channels, each supplying a separate diode. The outputs of the diodes were connected in series, and the individual amplifiers were arranged so that they would overload when supplying half the necessary control voltage. One amplifier passed the frequency range from 100 to 500 cycles; the other from 600 to 3000 cycles. Either amplifier alone could only produce half the total expansion, regardless of the energy in the pass band. It required energy in both bands to produce full expansion. This condition prevails in full orchestra, organ, or band music, at which time full expansion is required. This system prevented "blasting" when a single instrument or voice momentarily overbalanced the full ensemble. The results were very good, but on most records the improvement over the single-channel system of restricted frequency range did not justify the circuit complexity.

Expansion Indicator

A 6AF6 electron-ray tube is used as an indicator of the amount of expansion. It has a considerable advantage over a pointer-type meter, because of its freedom from dynamic error. It is adjusted so that the eye is just closed when the 6P5 control tubes are cut off.

The last important problem is the linearity of expansion versus input signal. It is very important not to have any "steps" in the expansion control. The plate-current variations with input signal, with the control voltage derived from the previously described rectifier system, are shown in *Fig. 3*. The change in plate resistance is not exactly the type of curve needed to produce a linear expansion. This condition was greatly improved by making the total range of expansion about 6 db more than desired, and reducing the over-all gain by means of inverse feedback. Since the gain reduction is a function of the amplifier gain, it is apparent that the amount of feedback will vary as the amplifier gain is varied. The gain will be reduced more at full amplification than at low levels. This has the effect of straightening out the expansion curve and reducing its slope, thereby accomplishing the desired end. This is shown in *Fig. 4*. The feedback also contributes somewhat to the over-all low distortion obtained with this device. The curves of intermodulation distortion versus input signal level are shown in *Fig. 5*. The harmonic distortion is barely measurable.

Fig. 6 shows the main amplifier circuit arranged to be inserted in a high-impedance amplifier. The action is identical with that of the low-impedance unit.

It will be noticed that this circuit can be used as a remotely operated gain control. It is merely necessary to substitute for the control signal a 22½-volt battery and potentiometer.

A little care must be exercised in using the volume expander. It should never be used on program material where the source of sound is inherently incapable of a volume range of more than 20 to 30 db. This applies to solo instruments (other than piano and organ), solo voices, string quartets, and so on. On orchestral, choral, and organ music it can be used on almost any record with excellent effect. The actual manner in which the original recording was controlled determines whether 8 db or 12 db of expansion can be used. Paradoxically enough, the wider the volume range on the original recording, the more expansion can be tolerated.

In *Fig. 4*, it will be noticed that in the 12 db position the input signal necessary to cover the entire range of expansion is about 29 db. This is about the volume range of a good modern recording. When playing such a recording it is best to set the expansion control so that the eye of the indicator tube fully closes on average peak levels. The expansion will then be completely off on very low-level signals. On records of more restricted range, it is best to set the expansion control so that surface noise just does *not* operate the indicator. This will then give the maximum increase of volume range.

It is good practice to install the expander with a gain control following the unit. The expansion control can then be left in the full-on position, and the input gain control used to adjust for input signal peaks. The output gain control then controls loudspeaker volume, and all of the output peaks will be at the same level, regardless of the actual level on the recording.

Fig. 6. Modifications needed for high-impedance input circuit. Input signal should be about 2 volts rms, maximum.