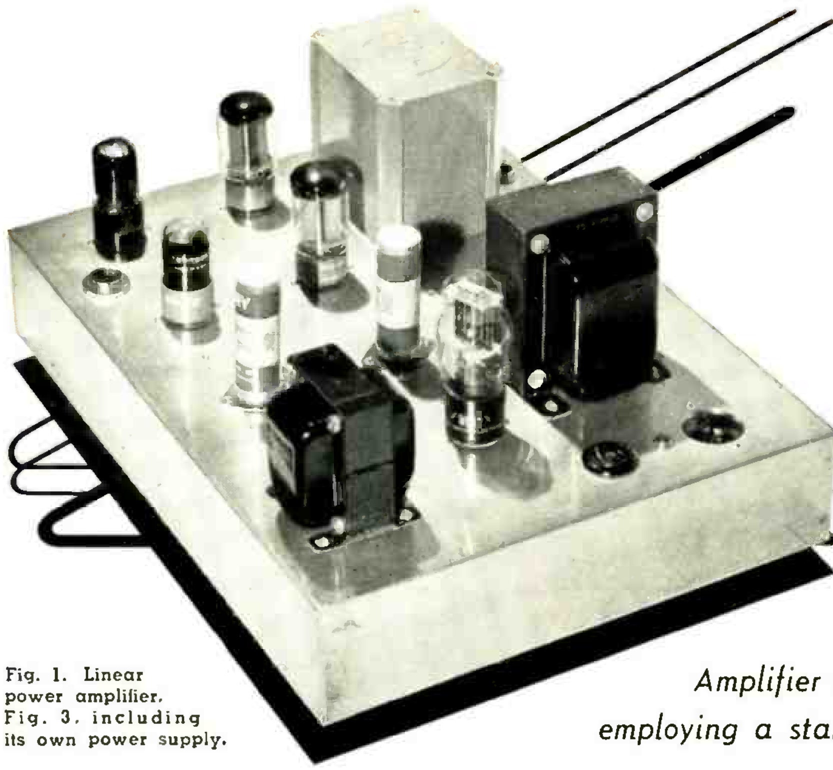

A LINEAR POWER AMPLIFIER

By
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Fig. 1. Linear power amplifier, Fig. 3, including its own power supply.

Amplifier conversion to "Ultra-Linear" operation employing a standard audio output transformer unit.

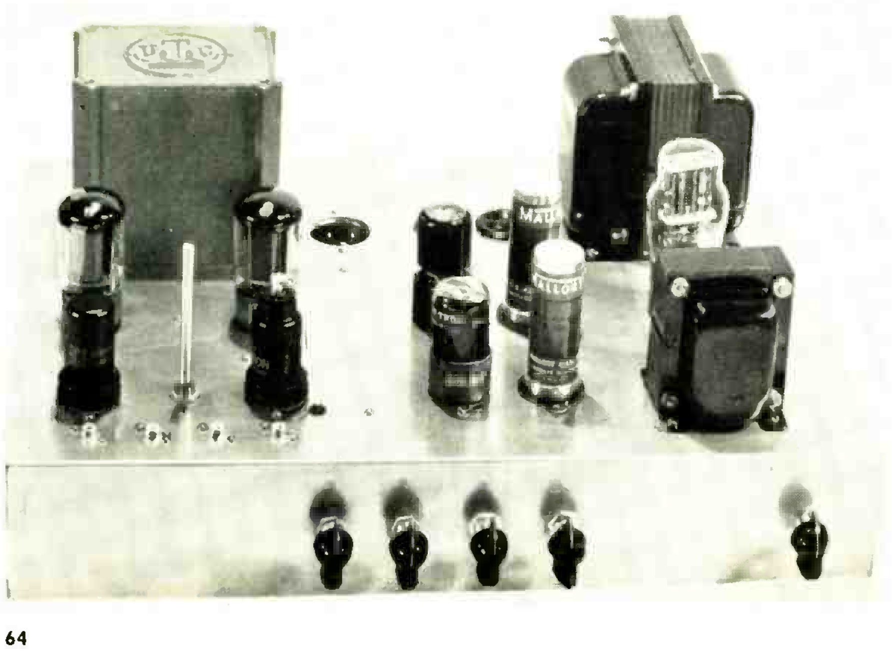
EDITOR'S NOTE: *The author, in presenting this article, does not in any way wish to detract from the work done by Hafler and Keroes in their article "Improving the Williamson Amplifier" which appeared in the February issue of RADIO & TELEVISION NEWS. The circuit used by the author is very similar to that presented by Messrs. Hafler and Keroes except for a few variations which help to reduce the cost. Of particular importance is the fact that a standard output transformer (UTC LS-57) has been used instead of a specially-designed unit. The high voltage requirements are lower and there is a variation in the feedback circuits. All-in-all, the author has achieved a good design at a lower over-all parts expenditure.*

RECENT literature[1] has focused attention on a new mode of operation for power output tubes. The screen grids of the output tubes are connected to the "B+" supply through taps on the primary of the output transformer. The internal impedance, maximum power output, and distortion are functions of the ratio of screen load impedance to plate load impedance. Proper selection of this ratio gives higher power output than that obtainable from normally connected triodes while exhibiting the low internal impedance of the triode. Distortion values are better than either straight triode or tetrode operation. These facts have led many to "ultra-linearize" the very popular Williamson circuit. The results have been very successful [2, 3]. In effecting "ultra-linear" operation a new output transformer was required in many cases. This article will describe a "linear amplifier" using an output transformer found in many conventional amplifiers constructed during the last few years.

Fig. 1 shows the complete linear power amplifier. The complete circuit of this amplifier is shown in Fig. 3. As can be seen from the schematic the circuit configuration resembles the "Williamson": a voltage amplifier direct-coupled to a split-load phase inverter, followed by push-pull triodes driving the output tubes.

The output transformer is a *UTC* LS-57. The primary of this transformer has two windings. Each winding has a tap 60% from "B+" terminal to plate terminal. Normally the transformer will match 5000 or 3000 ohms depending on whether the total winding or the tap is used. By connecting the plate leads to the "B+" terminals of the transformer the taps are at 40% of the "B+" to plate impedance. If the taps are now connected to the screen grids of the output tubes, a ratio of screen load impedance to plate load impedance of 40% is obtained. Although this is not the optimum ratio recommended by Mr. Hafler and Mr. Keroes in their

Fig. 2. Another version of the linear power amplifier with its own power supply and including a preamplifier. The preamp diagram is not included in this article. The photo has been presented merely to show relative placement of parts.



[1] *Hafler and Keroes: "Improving the Williamson Amplifier," RADIO & TELEVISION NEWS, February 1953.*
[2] *Hafler and Keroes: "Ultra-Linear Operation of the Williamson Amplifier," Audio Engineering, June 1952.*
[3] *Sarser and Sprinkle: "Gilding The Lily," Audio Engineering, July 1952.*

article, the results are not too far from optimum.

A pair of 5881's are the output tubes. This tube is being widely used for high quality audio work. It is more rugged than the 6L6 and may be used as a direct replacement.

Feedback is taken from the secondary of the output transformer to the cathode of the first stage. Apparently 20 db reduction in output, measured with a resistive load, is obtained with this loop.

A "high frequency" feedback loop is connected from the plate of each output tube to the plate of the tube driving it. The purpose of these loops is to provide a smooth control of the high frequency region. High frequency oscillation often encountered in feedback amplifiers is prevented by the proper selection of *R* and *C* in these loops. Transient distortion also seems to be greatly reduced.

It was discovered that by placing a 0.02 μfd. condenser across the common cathode resistor of the 6SN7 the slight bit of high frequency fuzz observable on a cathode-ray oscilloscope at high power output was eliminated.

All stages were designed for wide bandwidth at low distortion. The dual triode 6SL7 in the first stages gives more gain and less distortion than the usual 6SN7.

Less than 0.5 volt will drive the amplifier to over 20 watts output. The intermodulation distortion rises to about 2% at an equivalent sine wave power of 22 watts. Frequencies of 60 and 3000 mixed 4 to 1 gave results similar to those obtained with 60 and 7000 cps mixed 4 to 1. The power response was 30 to 20,000 cps flat at over 20 watts.

Construction of the amplifier is straightforward. Fig. 2 shows the amplifier together with a preamplifier[4] on the same chassis. An amplifier which had been in service three years was converted to linear operation. It is shown in Fig. 4. Note the precautions that were taken to obtain the desired results a few years ago. Balancing potentiometers were found unnecessary and are not found in the later models. In fact the amplifier described was constructed of standard components with tolerances no better than ± 20%.

EDITOR'S NOTE: *We disagree, in part, with the author's suggestion regarding the precautions that were taken years ago. Many of the present-day audio amplifiers include these so-called "obsolete" precautions. For ultimate performance to please the most critical ear, it is necessary to use a balancing pot or to choose with care the values of the resistors in the output stage to produce a balanced condition. It is also advisable that the resistances of R_5-R_6 and R_8-R_9 be matched to within ± 1%.*

Excellent results, over a period of time, have been obtained from this amplifier. It is a good construction project and offers those who have amplifiers food for thought.

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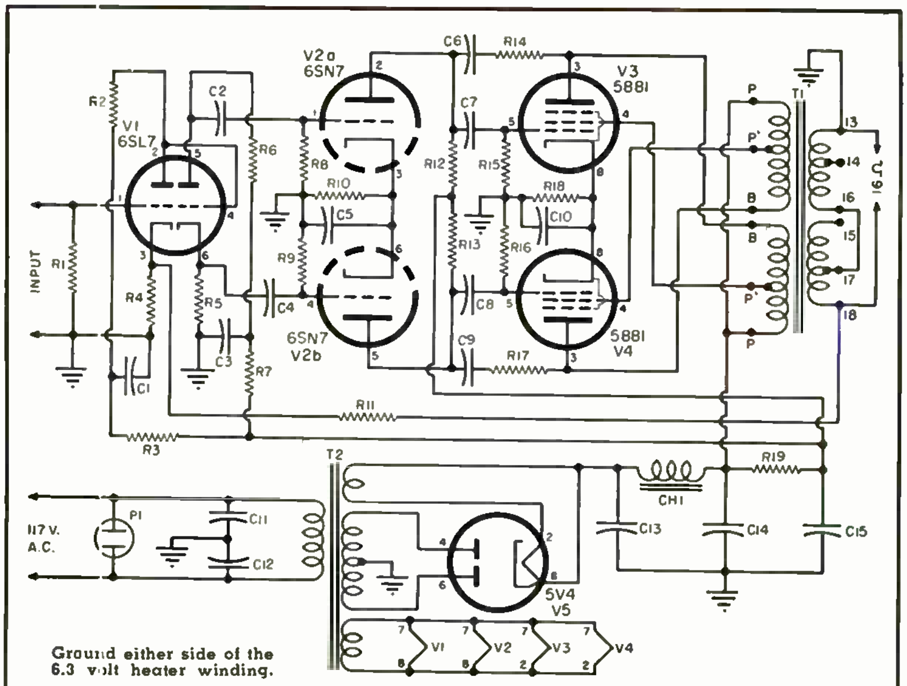
[4] *St. George and Drisko; "Versatile Phonograph Preamplifier," Audio Engineering, March 1949.*



Ground either side of the 6.3 volt heater winding.

R_1, R_8, R_9—470,000 ohm, 1 w. res.
R_2—270,000 ohm, 1 w. res.
R_3, R_{11}—33,000 ohm, 1 w. res.
R_4—470 ohm, ½ w. res.
R_5, R_6, R_{12}, R_{13}—47,000 ohm, 2 w. res.
R_7—22,000 ohm, 1 w. res.
R_{10}—560 ohm, ½ w. res.
R_{14}, R_{17}—10,000 ohm, 1 w. res.
R_{15}, R_{16}—100,000 ohm, 1 w. res.
R_{18}—350 ohm, 10 w. res.
R_{19}—2500 ohm, 5 w. res.
C_1, C_3, C_{13}, C_{14}, C_{15}—20 μfd., 450 v. elec. cond.
C_2, C_4, C_7, C_8—.25 μfd., 600 v. cond.
C_5—.02 μfd., 200 v. cond.
C_6, C_9—75 μμfd., 500 v. cond.
C_{10}—100 μfd., 50 v. elec. cond.
C_{11}, C_{12}—.1 μfd., 600 v. cond.
T_1—Output trans. (UTC LS-57, see text)
T_2—Power trans. 375-0-375 v. @ 150 ma.; 5 v. @ 3 amps.; 6.3 v. @ 4.7 amps. (Thordarson TS-24R06-U)
CH_1—8 hy. @ 150 ma. choke, 145 ohms d.c. (Thordarson T-20C54)
P_1—117 v. a.c. plug receptacle
V_1—6SL7 tube
V_2—6SN7 tube
V_3, V_4—5881 tube
V_5—5V4 tube

Fig. 3. Circuit diagram of the "linear" Williamson amplifier. The output transformer is shown driving a 16-ohm load. To drive an 8-ohm load, the secondary of the output transformer should be wired as follows: Join terminal 16 to terminal 18, also join terminal 13 to terminal 15. The 8-ohm load is then connected to terminals 13 and 18. If desired, the feedback resistor from the secondary of the output transformer can be changed from 33,000 ohms to 27,000 ohms. However, the over-all performance of the amplifier will not be appreciably altered if this resistor is not changed.

Fig. 4. Another amplifier that was converted to "linear" operation. In this particular case, the power supply was built on a separate chassis. The original Williamson amplifier was designed to be built on two separate chassis, that is, the amplifier and power supply are built as separate units. When converting the Williamson amplifier to "linear" operation, as described in this article, there need be no change in the power supply which may be used as is without affecting performance.