A Practical Commercial Output-Transformerless Amplifier*

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SINCE THE appearance of the author's first paper on the subject of output-transformerless amplifiers, he has had numerous inquiries for further details regarding the amplifier which he described.[1] A program of further work was instituted with a view to producing a practical, commercial version of this basic amplifier design. The present paper will describe the results.

BASIC DESIGN OF THE AMPLIFIER

To review the basic design of the amplifier, reference should be made to Fig. 1. A pentode tube, V_1, is operated as a high-gain voltage amplifier and is directly coupled to the phase-splitter tube, V_2. The cathode-load resistor of V_2 is returned to ground through the load, which may be the 16-ohm voice coil of a conventional loudspeaker. Signal voltage developed across the plate-load resistor of V_2 is applied between grid and plate of the output tube V_3. Likewise, signal voltage 180° out of phase, developed across the cathode-load resistor of V_2, is applied between grid and plate of output tube V_4.

The Output Stage

The output tubes are connected in series and biased for class B_1 operation. The output load is connected with its "high" side to the cathode of V_3 and the plate of V_4 and its "low" side to ground. Each of the output tubes has its own power supply, consisting simply of a metallic rectifier, X, and a capacitor, C. Due to the balanced nature of the output circuit, no dc flows through the load.

Feedback Arrangements

The potentiometer in shunt with the load has its arm in the cathode circuit of the voltage-amplifier tube, V_1. When the arm of the potentiometer is at ground, there is no overall negative feedback and the full gain of the amplifier is obtained. With the arm at the high side of the load, there is 100% negative feedback, and the gain of the amplifier is essentially unity. Because of the minimum number of phase-shifting components in this amplifier, large amounts of negative feedback may be utilized. The writer has constructed amplifiers of this type with as much as 60 db of feedback without any evidence of instability.

Driving Voltage

In this circuit, the output tubes are working as cathode followers and thus require large driving voltages from the phase-splitter tube. With this type of phase-splitter, the signal voltage across the plate and cathode resistors is essentially of the same magnitude as the input voltage to the tube. Normally, this would require a large voltage output from the voltage-amplifier tube. Fortunately, because the speaker load is also in the input circuit of the phase-splitter tube and in the correct sense to provide positive feedback, a much lower voltage suffices. In fact, the signal voltage to the input of the phase-splitter tube need not be much greater than the fixed bias of the power tubes, for maximum output.

Positive and Negative Feedback

A feature of this amplifier, as can be seen in Fig. 1, is that the output load is connected to the input circuits of all the tubes used in the amplifier for the purpose of obtaining both positive and negative feedback. This has been accomplished without the use of any reactive components (which might produce undesirable phase shifts) other than the load itself.

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[1] Julius Futterman, "An Output-Transformerless Power Amplifier," JOURNAL OF THE AUDIO ENGINEERING SOCIETY, 2, 252–6 (October 1954).