



A 15-Watt Direct-Coupled Amplifier

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Describing a stable, well designed amplifier suitable for high quality music reproduction or for small commercial program distribution systems.

SOME TIME ago the author commenced the design and construction of a high quality audio amplifier for his personal use at home. Complexity of circuit design or difficulty of adjustment were considered unimportant, for it was not intended to publish the circuit. The amplifier was finally completed and gave satisfactory results. Only then did it occur to the author that perhaps others would be interested in the design finally adopted.

The circuit is not complex, though it may appear so because of unconventional circuit arrangements. The unorthodox features include a duplex thermostatically controlled power supply, a unique form of loudness control, direct coupling throughout (except preamplifier), push-pull throughout (except preamplifier), and an input circuit permitting the use of either an unbalanced or push-pull signal. At the least, the design is an interesting study in wire. At most, in the author's opinion, it is an excellent amplifier.

Design specifications are used to define certain objectives. In this case, we wanted an amplifier that sounded as we thought it ought to sound, had no hum or tube noise, and had output power sufficient for home use. How are these requirements expressed in figures? It is difficult to say. Experts argue the problem interminably.

But there must be something more specific to aim at than the generalities just mentioned, so the following specifications were set up:

Power output: 15 watts maximum
10 watts below 1% distortion from 30 to 10,000 cps
Frequency range: 20-20,000 \pm 0.5 db
Hum and noise: inaudible at all volume levels

Gain: full output with 0.5 volts or less rms input. A preamplifier permitting the use of magnetic phonograph pickups is to be incorporated.

Circuit Details

The design program commenced with a study of the better known commercial circuits and a number of published diagrams. Most of these designs were more or less conventional. By great refinement, a high degree of excellence had been attained in many of them. Nevertheless, there appeared to be two general ways in which conventional design might be improved somewhat. First, almost all of these circuits employed either transformers or capacitor-resistor networks for interstage coupling, and it appeared that a part of the overall distortion of the amplifier originated in these coupling devices. Obviously, then, the elimination of coupling circuits would result in an improvement of the quality of amplification, provided the system used in lieu of conventional coupling was itself distortion free. Secondly, most of the circuits employed single-ended stages for part of the circuit rather than push-pull arrangements. It was thought that a fully push-pull circuit, if feasible, would assist in reducing the second harmonic distortion produced in most equipment.

With these preliminaries in mind, design was commenced. Low- μ triodes were tentatively decided upon for the output stage. 6A5G's were attractive, for they produced the desired power output at small distortion values: they did not require nearly as much driving voltage as the 6AS7G; they had reasonably low plate current and voltage requirements; and they were almost completely hum free.

After design and construction had been completed, it was found that the drivers were capable of providing a peak-to-peak potential of about 210 volts.

This is sufficient to drive almost any output tube. Consequently, with appropriate changes, an experimenter may substitute his favorite tube for the 6A5G's shown in the schematic. The author tried 6L6's (tetrode connected), 807's (triode connected), and 6B4G's. 6A5G's seemed to give better results than any of the others, though this is difficult to prove.

Glass enclosed triodes are used for voltage amplifiers. Both 6SN7's and 6SL7's are rugged and non-microphonic. The glass envelopes facilitate trouble shooting. In addition, glass tubes are somewhat less gassy than their metal counterparts. The use of dual triodes cuts down on the total number of tubes required and is also desirable because the two triode sections are more likely to have similar characteristics than separate tubes.

To eliminate conventional coupling devices, direct coupling is used throughout. Direct coupling is inherently free of all forms of distortion. Its principal disadvantages are the high plate supply voltage required, critical balancing, and the possibility of operating tubes at incorrect potentials. Of these problems, maintenance of balance of the circuit was found to be the most difficult to overcome. Balance was finally secured by the use of direct-coupled inverse feedback from the cathodes of the drivers. This arrangement not only corrects for tendencies of the tubes to shift their operating potentials and currents, but also maintains signal balance between the two halves of the push-pull voltage amplifier circuit.

It can be shown that plate supply resistors common to both tubes of a push-pull arrangement assist in stabilizing the d.c. potentials of a direct coupled circuit. Resistors R_{s1} , R_{s2} , R_{s3} , and R_{s4} have such an effect.

This feedback does not, of course, correct distortions which may arise in the output tubes and output transformer.