Building the "WILLIAMSON" AMPLIFIER

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Fig. 1. Two views of the audio amplifier. The power supply is built on the same chassis as the amplifier.

High quality performance is obtained from this American version of a British design.

THE Williamson amplifier circuit* originated in England by D. T. N. Williamson has attracted worldwide attention from high fidelity enthusiasts because of the almost perfect quality of the reproduced output. There are many features in the amplifier that make it an attractive construction project for the builder. The circuit is simple, free from critical adjustments, and may be built economically of top quality parts at a cost of less than $50. Within its power rating of 10 watts at less than 1% intermodulation, the amplifier proves to be ideal for home and small auditorium installations.

The performance of the amplifier, based on listening tests, can best be described as containing the elusive "presence effect," a quality inherent in low distortion equipment with the flat frequency response and low phase shift that enables speech and musical transients to be correctly reproduced. The bass response is solid and free from harmonic distortion. Highs are clean and crisp with none of the shrillness so often experienced with other amplifiers.

Since a number of the components specified in the original amplifier are of English manufacture, considerable effort was made to choose substitute parts that would permit the same high degree of performance attributed to its prototype.

The circuit diagram of the amplifier is shown in Fig. 2. The circuit contains four resistance-coupled stages and is operated with 20 decibels of voltage feedback taken from the secondary of the output transformer and carried around the complete amplifier. Medium mu triode tubes are used throughout and are biased to operate with minimum distortion. A noteworthy feature of the amplifier lies in the selection of the type of output tube. This is a power tetrode which is connected in the circuit to function as a medium mu power triode. The driving voltage required is much smaller than that taken by the more conventional 2A3 or 6B4 type of output tube, and the driver operates with considerably lower distortion.

The first two stages of the amplifier are somewhat unusual. The first stage, which is a voltage amplifier, is directly coupled to the second, a cathodyne inverter. This method of coupling is made possible by the high operating potential on the inverter cathode. The two stages are self balancing and bias themselves to a low distortion operating point.

The heart of the amplifier is the output transformer. This device must provide response that extends well beyond the limits of the audio band in order to limit phase shift to the requisite degree in the feedback circuit. It is the degree of success with which this is achieved that makes for fidelity in musical transient reproduction. The original specifications of the output transformer call for response which is down not more than 3 db. at 3 c.p.s. and at 60 kc. An American counterpart, the Acrosound TO-290, faithfully copies the performance of the original and is used in the circuit here described.

The type 7N7 tube has been selected for use in the voltage amplifier stages because of its shielded construction, low internal capacity, and symmetrical base layout that permits direct point-to-point wiring. The output tubes are the type 807, the characteristics of which are similar to the KT-66 British type used in the original. The plate resistance, however, is about 20% greater for the 807, and this requires a corresponding increase in the plate-to-plate match of the output transformer in order to obtain the same low figures of distortion in the output. The plate-to-plate impedance of the transformer is, therefore, 12,000 ohms instead of the 10,000 ohms specified for the original. Another excel-

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lent output tube which may be used is the *Western Electric* type 350A. This tube has greater power capabilities than the 807 and will provide up to 25% more output.

One deviation has been permitted in the circuit and is based on the operating characteristics of the 807. An electrolytic condenser has been added across the cathode biasing resistor arrangement of the output stage and has been found to be of material advantage in further reducing distortion at high output levels.

Construction

The amplifier is constructed on a single 10 x 14 x 3 inch chassis. Considerable care has been taken in the layout to permit direct point-to-point wiring in all signal circuits and to avoid extraneous couplings which may introduce instability into the feedback loop. In the construction of the amplifier a ground bus is not used since no improvement will be effected through its use provided several precautions are observed. Ground returns should be made closely adjacent to the stage affected. This may be easily done by using sockets with ground lugs projecting from the mounting ring. It is also desirable, but not essential, to solder one mounting tab of each electrolytic condenser to the mounting plate and one point on the plate to the chassis. The filaments are wired by running a separate two-conductor pair to each stage. When wired in this manner only one pair of leads carrying the stage current enters into proximity with the stage, and the hum field is reduced. The filament lines do not necessarily have to be twisted. It is desirable that they be cabled or taped compactly together. The filament wiring is grounded at one point only; at the first stage, as indicated.

After the amplifier is wired and checked, it may be turned on and connected to a speaker load. If any motorboating is experienced the two plate leads connected to the output transformer should be interchanged. The plate currents may then be balanced, after which no further adjustments will be required. The amplifier will be driven to full output by about two volts r.m.s. Although a volume control has been included on the amplifier chassis to permit setting the level when the unit is used with a variety of inputs, for most installations it will not be required, and may be replaced by a resistor of equivalent value. A power take-off plug has been provided to facilitate external control from a separate preamplifier chassis.

A suggested preamplifier circuit is shown in Fig. 3. It incorporates tone controls and compensating controls for the various recording characteristics and is designed for use with reluctance cartridge input. Crystal cartridges can, however, be operated into the tuner input channel. Constructional details are not given and are

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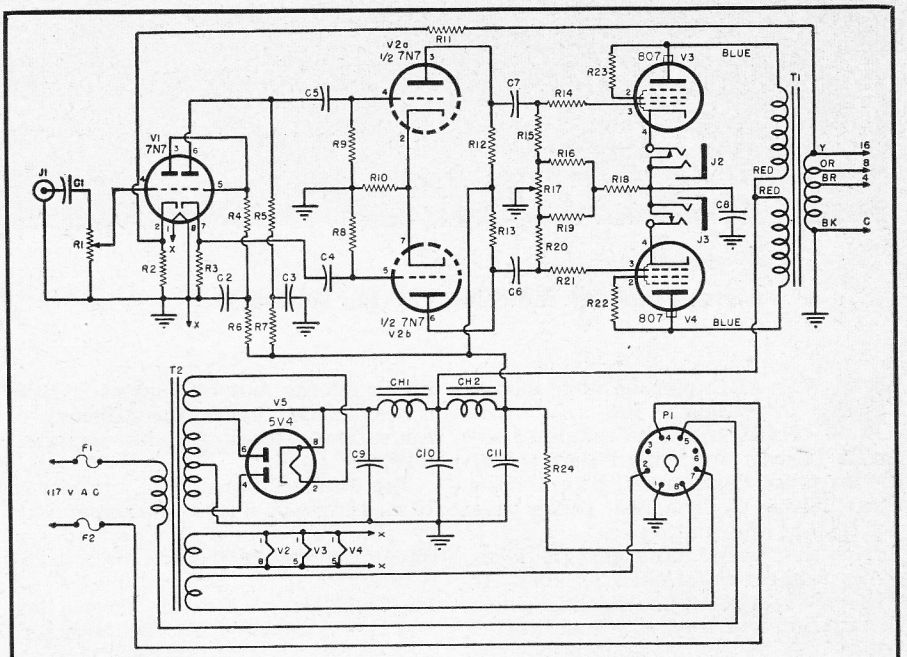
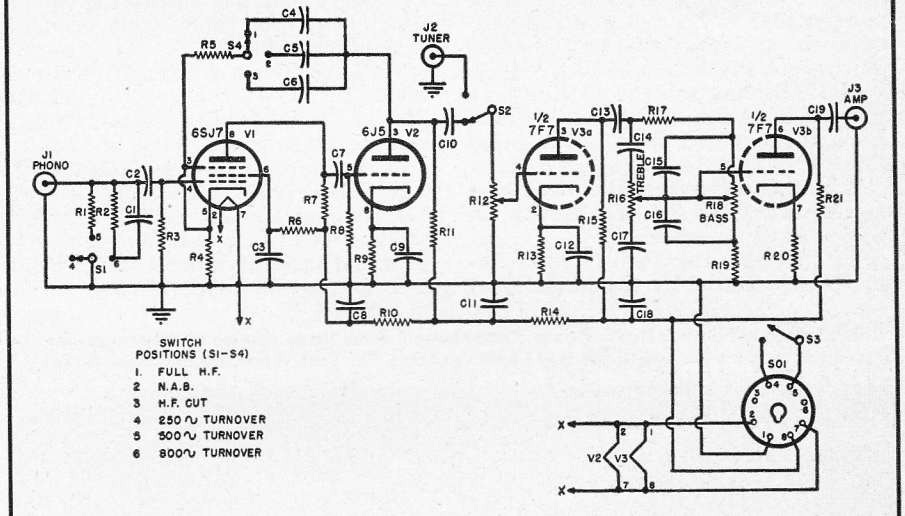


R_1—*1 megohm vol. control*
R_2—*470 ohm, ½ w. res.*
R_3, R_5—*22,000 ohm, ½ w. res. (matched pair ± 1%)*
R_4—*47,000 ohm, 1 w. res.*
R_6—*33,000 ohm, ½ w. res.*
R_7—*22,000 ohm, ½ w. res.*
R_8, R_9—*470,000 ohm, ½ w. res.*
R_{10}—*560 ohm, ½ w. res.*
R_{11}, R_{24}—*4700 ohm, ½ w. res.*
R_{12}, R_{13}—*47,000 ohm, 2 w. res. (matched pair ± 1%)*
R_{14}, R_{21}—*1000 ohm, ½ w. res.*
R_{15}, R_{20}—*100,000 ohm, ½ w. res.*
R_{16}, R_{19}, R_{22}, R_{23}—*100 ohm, ½ w. res.*
R_{17}—*100 ohm, 2 w. wirewound pot.*
R_{18}—*300 ohm, 10 w. res.*
C_1, C_4, C_5—*.05 µfd., 600 v. cond.*
C_2, C_8—*10/10 µfd., 450 v. elec. cond.*
C_6, C_7—*.25 µfd., 600 v. cond.*
C_8—*500 µfd., 50 v. elec. cond.*
C_9—*4 µfd., 600 v. cond.*
C_{10}, C_{11}—*20 µfd., 450 v. elec. cond.*
T_1—*Output trans. 12,000 ohm plate-to-plate, to 4, 8, 16 ohms (Acrosound TO-290)*
T_2—*Power trans. 425-0-425 v. @ 130 ma.; 6.3 v. @ 3.5 amp.; 6.3 v. @ 3.5 amp.; 5 v. @ 3 amp. (Acrosound TP-310, Stancor P-4004, or equiv.)*
CH_1—*4 hy., 150 ma. filter choke*
CH_2—*4 hy., 50 ma. filter choke*
J_1—*Input jack*
F_1, F_2—*Fused line plug*
P_1—*Octal plug*
V_1, V_2—*7N7 tube*
V_3, V_4—*807 tube*
V_5—*5V4 tube*

Fig. 2. Complete circuit diagram of the American version of the "Williamson" amplifier.

Fig. 3. Suggested preamplifier incorporating tone controls and equalizing networks.



R_1—*15,000 ohm, ½ w. res.*
R_2, R_{10}, R_{14}—*10,000 ohm, ½ w. res.*
R_3—*10 megohm, ½ w. res.*
R_4—*560 ohm, ½ w. res.*
R_5—*27,000 ohm, ½ w. res.*
R_6—*1.2 megohm, ½ w. res.*
R_7—*270,000 ohm, ½ w. res.*
R_8—*470,000 ohm, ½ w. res.*
R_9, R_{13}, R_{20}—*1100 ohm, ½ w. res.*
R_{11}—*47,000 ohm, ½ w. res.*
R_{12}—*1 megohm pot.*
R_{15}, R_{21}—*22,000 ohm, ½ w. res.*
R_{16}, R_{18}—*3 megohm pot.*
R_{17}—*300,000 ohm, ½ w. res.*
R_{19}—*30,000 ohm, ½ w. res.*
C_1, C_{17}—*.002 µfd., 400 v. cond.*
C_2, C_5, C_{16}—*.01 µfd., 400 v. cond.*
C_3—*.5 µfd., 400 v. cond.*
C_4—*.02 µfd., 400 v. cond.*
C_6—*.007 µfd., 400 v. cond.*
C_7, C_{10}, C_{19}—*.05 µfd., 400 v. cond.*
C_8, C_{11}, C_{18}—*20 µfd., 450 v. elec. cond.*
C_9, C_{12}—*20 µfd., 25 v. elec. cond.*
C_{13}—*.03 µfd., 400 v. cond.*
C_{14}—*500 µµfd. mica cond.*
C_{15}—*.001 µfd., 400 v. cond.*
J_1, J_2, J_3—*Open circuit jack*
S_1, S_4—*S.p. 3-pos. rotary sw.*
S_2, S_3—*S.p.s.t. sw.*
SO_1—*8-prong socket*

often forced upon a reader's attention. Therefore, you must portray in your copy an understanding of the reader's needs and desires. Suggest that the person buy the radio or television set, not because your store is selling them, but because they will benefit the user.

Many ads use illustrations of various types to expand and amplify the copy or reading material. Since there are several effective ways of displaying your merchandise in your advertisements we will discuss these different techniques in some detail in next month's article.

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"Williamson" Amplifier

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left to the discretion of the builder. Care should be taken in the wiring to ground the filament line adjacent to pin No. 7 on the 6SJ7 stage. This tube is biased by a combination of cathode and grid leak bias; an arrangement that minimizes tube noise.

Performance

The distortion-free characteristics of the amplifier are immediately apparent upon the first playing. The lack of false bass response and bass transient hangover is also striking, and can be attributed to the exceptionally low output impedance of the amplifier which is in the neighborhood of three-tenths of an ohm on the sixteen ohm tap. The damping factor seen by the speaker is, therefore, about 48, and results in a real improvement in the transient characteristics of the speaker.

The curves taken of intermodulation, shown in Fig. 4, reveal the low distortion content of the output. It is clearly seen that the 10 watt rating of the amplifier is a conservative one, since for any condition of measurement the intermodulation is less than 1%. It might also be mentioned that these curves were taken at a lower-than-normal plate supply voltage of 400 volts on the 807 output tubes. For

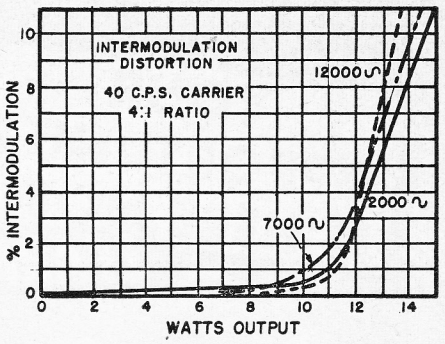

Fig. 4. Intermodulation distortion.

the normal plate supply voltage of 425 volts, about 15% more output or 11.5 watts can be expected for the same amount of intermodulation distortion.

The excellent transient characteristics of the amplifier can be deduced from the frequency response curve shown in Fig. 5. The response is shown for a 100 milliwatt output level and under the conditions both with and without feedback. The influence of the output transformer can easily be judged from these curves. Without feedback the response is down 3 db. at 55 kc. and at 12 c.p.s. It should be noted that this response is that of the complete amplifier and includes the normal roll-off in gain of the individual stages as caused by the tube input capacities and the effect of the stage coupling condensers. With feedback the curve is flat to 75 kc. and lacks the usual resonant rise associated with feedback amplifiers at the high frequency end of the band; a condition that causes ringing and a dissipation of power at unwanted frequencies. The response at maximum output power taken with distortion limited to 2% is also noteworthy and indicates the undistorted response to be down only 3 db. at 8 c.p.s. and at 50 kc.

It is the excellence of these results and the uniformity with which they may be achieved that is largely responsible for the growing popularity of the Williamson amplifier.

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Fig. 5. Frequency response characteristics of the audio amplifier.