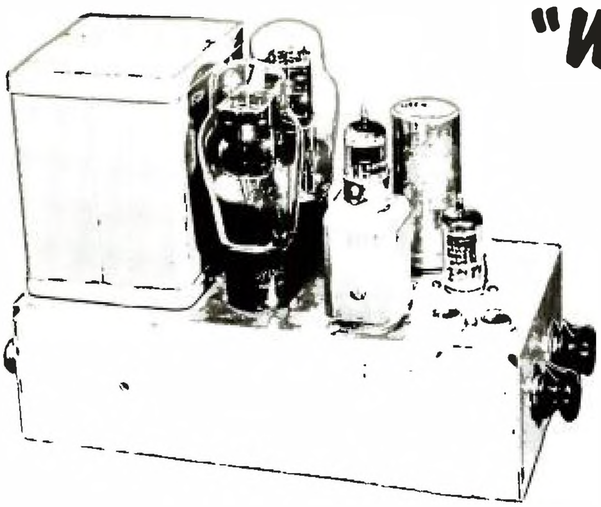

Figure 1

"*Williamson*" Type Amplifier Using 6A5's

J. H. BEAUMONT

A simple and effective amplifier based on the now-familiar circuit originally appearing in "Wireless World."

THE CONTINUALLY INCREASING POPULARITY of the Williamson amplifier among music lovers and technicians alike prompts another version of this circuit, the third to appear in this country. Designed for 6A5's, it will not deliver as much power to the speaker as either of the others; but use shows its nominal rating of six watts to be ample for home use. The arguments for and against large reserve power have never been resolved among engineers, and no attempt will be made to do so here. The low-power amplifier is regaining its popularity after having been nearly lost in the welter of claims that grew up around amplifiers using the 6L6 and the attendant fanfare about 25- and 30-watt outputs. There is no particular need for arguing that there should *not* be as large a power reserve as is reasonably possible since most circuits exhibit greatly improved distortion and linearity characteristics when they operate well below their ratings, but it is worth considering that the average power delivered to the speaker for "normal" room volume in the usual living room is of the order of 6 milliwatts, as has been established by tests. On this basis, the thousand-to-one reserve ratio of this amplifier seems adequate. If an efficient speaker is used, the amplifier will produce more volume than most listeners can tolerate, with sufficient reserve to maintain clean reproduction of any music.

The original plan was to provide a fixed gain package which would operate from a preamplifier containing all the necessary controls. However, the idea of a self-contained preamplifier seemed so attractive that it was added to the design, with consequent modifications in the circuit. To avoid an additional stage of gain, high-mu triodes were used for inverter and driver stages. The direct-coupled inverter was changed slightly to conform to the configuration of the direct-coupled preamplifier in order to preserve uniformity and to ensure the excellent characteristics which have been observed with this arrangement in several circuits. Direct-coupled pairs, which are a characteristic of the Williamson, are seldom seen in amplifier service, though their use for this purpose was established in this country as long ago as 1940.[1] The configuration shown here has been used for some five types of stages with considerable satisfaction. The cathode circuit of the 6A5's had to be modified because the cathodes in these tubes are tied to the filaments. There are no other major changes from the original circuit. The output transformer chosen was a Freed F-1951, which gives excellent results. Miniature tubes were used in place of octals because of the higher mu available in this series. *Figure* 1 shows the external appearance of the complete amplifier.

Preamplifier Description

Starting at the input plug, let us consider those parts of the circuit that merit discussion. The preamplifier, which is constructed in a Vector plugin can, is a familiar circuit which has been modified slightly for direct coupling. Its operating characteristics remain essentially the same as the capacitance-coupled version. Referring to the schematic, *Fig.* 2, the input grid resistor, R_{11}, was set at 0.1 meg because this value works well with the General Electric cartridges which were used with this amplifier. When other cartridges are to be used, it is preferable to use the values specified by the manufacturer for flat response.

[1] C. G. McProud and R. T. Wildermuth, "Direct-coupled input stage for phase inversion in audio amplifiers," *Electronics*, October 1940.

R_7 and C_5 form a compensating network in the feedback loop to eliminate the tendency of this preamplifier circuit to droop at frequencies above the crossover point, a condition which is inherent to the circuit since the crossover point is located on the knee of the compensation curve produced by the feedback-loop components. When this droop is added to that often found in cartridges and present even in amplifiers which are rated flat, the result can be as much as a 5-db drop at frequencies between crossover and 5,000 cps. This is sufficient to be noticeable, and has an effect of reducing the brilliance of music. The compensating network tends to decrease the feedback as frequency increases, thus offsetting the droop. Values for these components may have to be varied to suit an individual amplifier, but normally the capacitor should have a reactance of about ten times R_8 at the crossover frequency. If the response rises, the value of the capacitor should be decreased; if response drops off, C_5 should be increased. R_7 may vary between the value of R_8 and one-half that value, increasing if there is a rise at 10,000 cps, and decreasing if there is a droop at this point.

Adjustment of the network was made with a Cook Series 10 frequency record so that the cartridge would be included. The pickup used with this amplifier exhibits excellent response characteristics with the Cook record, showing no more than plus or minus 1-db variation through 10,000 cps.

The preamplifier may be built on a regular Vector socket if the plug-in feature is not desired. However, the preamplifier plug-in socket may be used as a source of power for an external preamplifier if at any time it is desired to use one, and plug-in preamplifiers allow changes to be made without disturbing the internal wiring. The circuit shown here is the third used with this amplifier since its construction was started. It is worth noting that if the octal socket is used as a source of external power there can be no heater grounds in the external equipment because the heater string is connected to the 6A5 cathodes and is "off ground" by the amount of their bias. If a separate heater pair is supplied on the power supply used with the amplifier, it may be wired to the preamplifier socket, though in general, the d-c bias on the heater string is considered desirable.

Parts mounting on the post of the Vector unit will be much simplified if the screw joining the parts is taken out and the octal plug removed entirely. This allows the post to be rotated so that its lugs are conveniently located with respect to the novel socket lugs. Components which pass into the octal base, such as C_4, should be fastened at one end and plenty of lead length left on the other. Leads from the lugs to the socket are fastened to their lugs and left projecting below the end of the post far enough to pass through the octal pins. Fiber-glass sleeving should be used on leads only where one crosses another, or comes near a lug; the rest of the wiring may be done with bare wire. *Figure* 3 shows the appearance of the preamplifier, both cased and uncased.

When all wiring and soldering is complete, the octal plug is re-assembled and all leads passed through their respective pins. When the screw has been tightened, the lead ends are cut off flush with the pins and soldered. If a layout is made before assembly is undertaken, it is possible to arrange the parts so that all the leads will pass almost straight from the post into the plug pins. The ground lug on the base of the can should be connected to the common ground point of the preamplifier.

The remainder of the stages were wired on Vector sockets because they offered an interesting approach to parts mounting which could be completed stage by stage and inserted in the chassis with all leads attached. This simplifies assembly greatly, and the resulting job will be both compact and neat, as shown in *Fig.* 4. This type of mounting avoids the troubles often found in getting strip mountings to operate satisfactorily due to the necessarily greater length of critical leads. The only critical leads leaving the Vectors are the grid leads of the following stage, and the capacitors may be hung from one socket to the next if these give trouble.

Further ease in assembly can be obtained by using a 6 x 10 Bud Minibox in place of the chassis indicated here. These boxes come in two sections, one of which forms the top and ends of a chassis, and the other the sides and bottom. Work on the top section can be done, unhampered by sides, and the completed unit will be housed in a neatly finished box.

Moving into the amplifier proper, R_{15} and R_{16} provide isolation for the two inputs and R_{36} is the gain control. The amplifier-inverter stage has the same basic configuration as the preamplifier and requires no comment, except that R_{18} and R_{19} should be a matched pair to obtain as nearly a balanced output as possible. C_6 and C_7 were intentionally made small in value in order to preserve a smooth bass response down to the low-

PARTS LIST

R_1, R_2	2200 ohms, ½ watt
R_3, R_4	3900 ohms, ½ watt
R_5, R_6	10,000 ohms, 1 watt
R_7, R_8	47,000 ohms, 1 watt
R_9, R_{10}	68,000 ohms, 1 watt
R_{11}, R_{15}, R_{16}	0.1 meg, ½ watt
R_{12}, R_{13}, R_{14}, R_{17}, R_{20}, R_{21}, R_{22}, R_{23}	0.1 meg, 1 watt
R_{18}, R_{19}	0.1 meg, 1 watt, 5%
R_{24}, R_{25}	0.27 meg, ½ watt
R_{26}, R_{27}	0.47 meg, ½ watt
R_{28}, R_{29}	47 ohms, 2 watt, 5%
R_{30}, R_{31}	100 ohms, 2 watt
R_{32}	350 ohms, 10 watt wire-wound
R_{33}	1.0 meg, audio taper
R_{34}	50,000 ohms, linear
R_{35}	100 ohms, wire wound
R_{36}	0.25 meg pot, Ohmite
$C_{1a, b, c, d}$	20-20-20-20/450 v, elect.
C_2, C_3	0.1 µf, 400 v, Aerolite
C_4, C_5	.01 µf, 400 v, Aerolite
C_6, C_7	.004 µf, 400 v, Aerolite
C_8, C_9	.002 µf, 400 v, Aerolite
T_1	Output transformer, Freed F-1951
V_1, V_2, V_3	12AX7
V_4, V_5	6A5
P_1, P_2	Amphenol 80-C
P_3	Jones P-202
P_4	Jones P-306-AB
P_5	Octal socket, Amphenol
	Vector B8-N socket ass'y
	Vector 10-O-9T
	Vector 8-N-9T

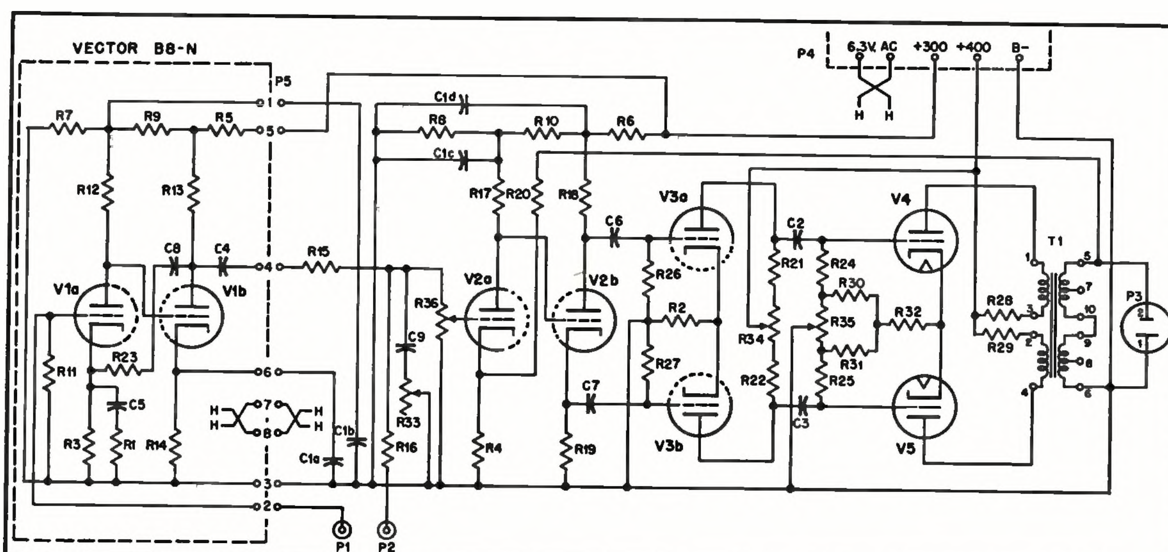

Fig. 2 Complete schematic of the 6-watt amplifier described.

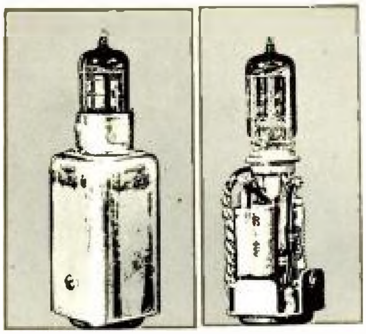

Fig. 3. The plug-in preamplifier, cased (left) and with the case removed (right).

est frequency because feedback loops around two or more stages usually require that some adjustment be made within the loop to avoid response peaks at the frequency extremes, with consequent oscillation. A simple means of achieving this is to make the response of one stage poor with respect to the others.[2] There seemed to be no need of special components to reduce the high-frequency response, and the amplifier exhibits excellent stability throughout its range.

C_9 and R_{35} provide a controllable high-frequency roll-off. These values provide approximately 20-db loss at 10,000 cps. This is ample to provide proper equalization for long-playing records. No high boost was desired, or considered advisable. When the response of a system can be made truly flat to at least 20,000 cps there should be no need of high boost. All long playing records require de-emphasis; most shellac records of recent vintage have pre-emphasis added, and will require a certain amount of de-emphasis. In other cases, surface noise becomes excessive when boost is used to capture highs on a record where they are deficient.

No bass control is provided in this design at all. If one is desired it may be added either internally or as part of an external preamplifier. It can be shown that a satisfactory bass compensation can be worked out for virtually all records so far as their recording characteristic is concerned,[3] and that the crossover frequency may be adjusted by listening preference. Beyond this there is a legitimate doubt that control is needed, except to compensate for low listening levels which may best be done in any case with a loudness control. While it is true that records vary in bass response, so do live concerts, and this variation should be considered as a normal part of listening. An amplifier should have a clean and flat response down to its lowest frequency to assure the *clarity* of bass reproduction, which is more important than any amount of volume.

R_{34} in the plate circuit of the driver serves to balance the signals to the grids of the 6A5's. Should any serious unbalance occur when the control is at its mid-point, preceding circuits and tubes should be checked. R_{33} equalizes the plate currents of the 6A5's by adjusting a portion of the bias voltage to which the grid returns (R_{24}, R_{25}) are connected. The balance is read by connecting a milliammeter at the points marked *2* and *3* on the output transformer. Balance within a few microamperes can be obtained when the circuit is warm. R_{28} and R_{29} must be matched within 1 per cent to ensure an accurate reading, and 10 per cent resistors may be matched on a bridge to find a pair. This method was used because cathode metering cannot be used with 6A5's—their cathodes being effectively tied together by the filament wiring.

No power supply is shown inasmuch as none was built specifically for the amplifier. The supply voltages shown on the schematic may be obtained from any well designed supply. With these voltages the amplifier is in a somewhat overbiased Class A condition. If the 6A5 supply voltage is reduced to 300 volts and R_{32} adjusted to give 45 volts bias from cathodes to ground, the tubes will then be operating at their rated Class A point.

The strapping of the output transformer shown in *Fig. 2* is for a speaker load of 16 ohms. Other strappings may be determined from the instructions accompanying the transformer. The feedback, using the component values indicated, will be approximately 5 db. The amplifier is stable under all conditions observed, and the driving conditions are such that more feedback would have required more gain elsewhere in the circuit for full output, which did not seem desirable. The over-all response of the equipment is essentially flat from 35 to 20,000 cps, using the Cook record, and the listening quality of the amplifier fully validates the superiority of the Williamson circuit.

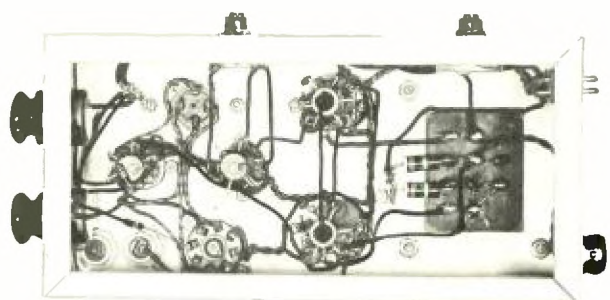

Fig. 4. Under-chassis view of the amplifier. Note the neatness resulting from the use of Vector sockets.

[2] F. E. Terman, "Radio Engineer's Handbook," p. 397 ff, 1st Edition. New York: McGraw-Hill Book Co., 1943.

[3] Howard T. Sterling, "Simplified Preamplifier Design," AUDIO ENGINEERING, November 1949.