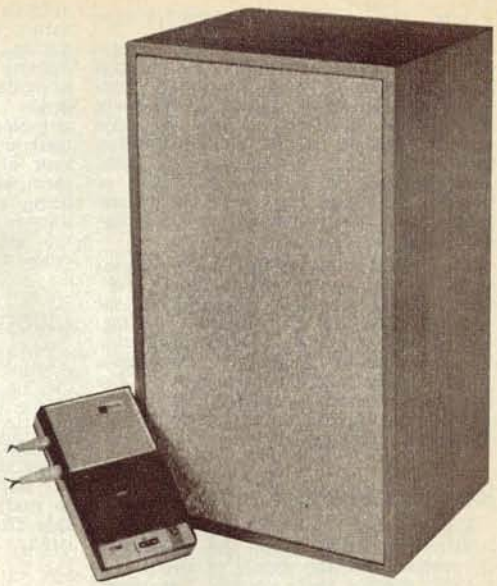
Powered Loudspeaker For Portable Recorders

By LEO SIMPSON



This article discusses several ideas for those who wish to improve the sound quality from cassette recorders or portable radios. It describes the use of a larger speaker enclosure in place of the internal speaker, the construction of a power amplifier to provide still more boost, and a mains power supply to save battery costs.

Practically everyone who owns a portable radio or miniature tape recorder has wished, at some time or other, to connect an external loudspeaker to improve the quality of the reproduction. After all, one cannot expect wide range sound from a small loudspeaker with little or no baffling. An external speaker of even average quality will improve the sound from just about any small set, provided the amplifier is not so badly designed that the internal loudspeaker is actually masking a lot of inherent distortion. The external loudspeaker, by virtue of its greater cone area, larger magnet, and improved baffling, will usually be far more efficient than the set's internal speaker and will allow the amplifier to operate at a lower, more distortion-free level.

Besides using the set with an external loudspeaker it is usually desirable to have a mains supply to conserve the batteries. The quality of reproduction from any amplifier depends to a large extent on the regulation of the power supply. While new batteries provide a portable power supply with good voltage regulation, this tends to deteriorate long before they have reached the end of their service life. This deterioration is caused by the gradual depletion of the chemical components of the battery. Poor regulation and reduced voltage causes an increase in the level of distortion, a decrease in the sensitivity of portable radios, and a general fall-off in power capability of the amplifier.

Since this kind of deterioration would largely offset the advantage of a more efficient speaker system, with or without its own amplifier, a power supply becomes almost essential if lengthy periods of operation are envisaged. There is also the straight-out economic aspect to be considered, as it is surprising just how expensive battery power becomes when batteries have to be replaced every few weeks.

The need for a separate power amplifier to drive the speaker is dictated by the limitations of most portable units. Their power output is usually limited to a few hundred milliwatts and, while even this will sound a whole lot better when applied to a large efficient speaker system, it is not really sufficient in many applications.

What is desired then, is a loudspeaker-cum-amplifier with a power of, say, 3 watts, with the mains supply for the amplifier arranged to do double duty by supplying the power requirements of the cassette player or portable radio. As further icing on the cake, the amplifier would be suitable for direct connection to a ceramic cartridge: an arrangement which could perform sterling service at parties and so on.

The speaker system used should be one of the more efficient types—a bass reflex type would be ideal—to obtain the best performance with the proposed amplifier. The small bookshelf enclosures are seldom efficient enough to be driven to an adequate level with a 3-watt amplifier.

For our prototype unit we used the Playmaster One-Point-Three loudspeaker as described in July, 1969. The amplifier is based on the 3-plus-3 Stereo Amplifier described in August, 1968. The sensitivity has been increased to 150mV for full output, partly as a result of dispensing with the balance and tone controls, and partly at the expense of lower input impedance, which is now of the order of 500K. A ceramic cartridge such as the BSR C1 will drive the amplifier into clipping, even on lightly recorded discs. The volume control at the input enables the amplifier to handle a wide range of signals without being overloaded.

A value of 500K is somewhat less than ideal as a load for a ceramic cartridge, and will result in some loss of bass response. However, it is not as serious in practice as might be imagined, particularly in the kind of casual listening application for which this equipment is intended. If it should transpire that the particular cartridge has output to spare, then it would be advantageous to add as much resistance as possible in series with it; i.e., at the "top" of the volume control. This will reduce its output but improve the bass response.

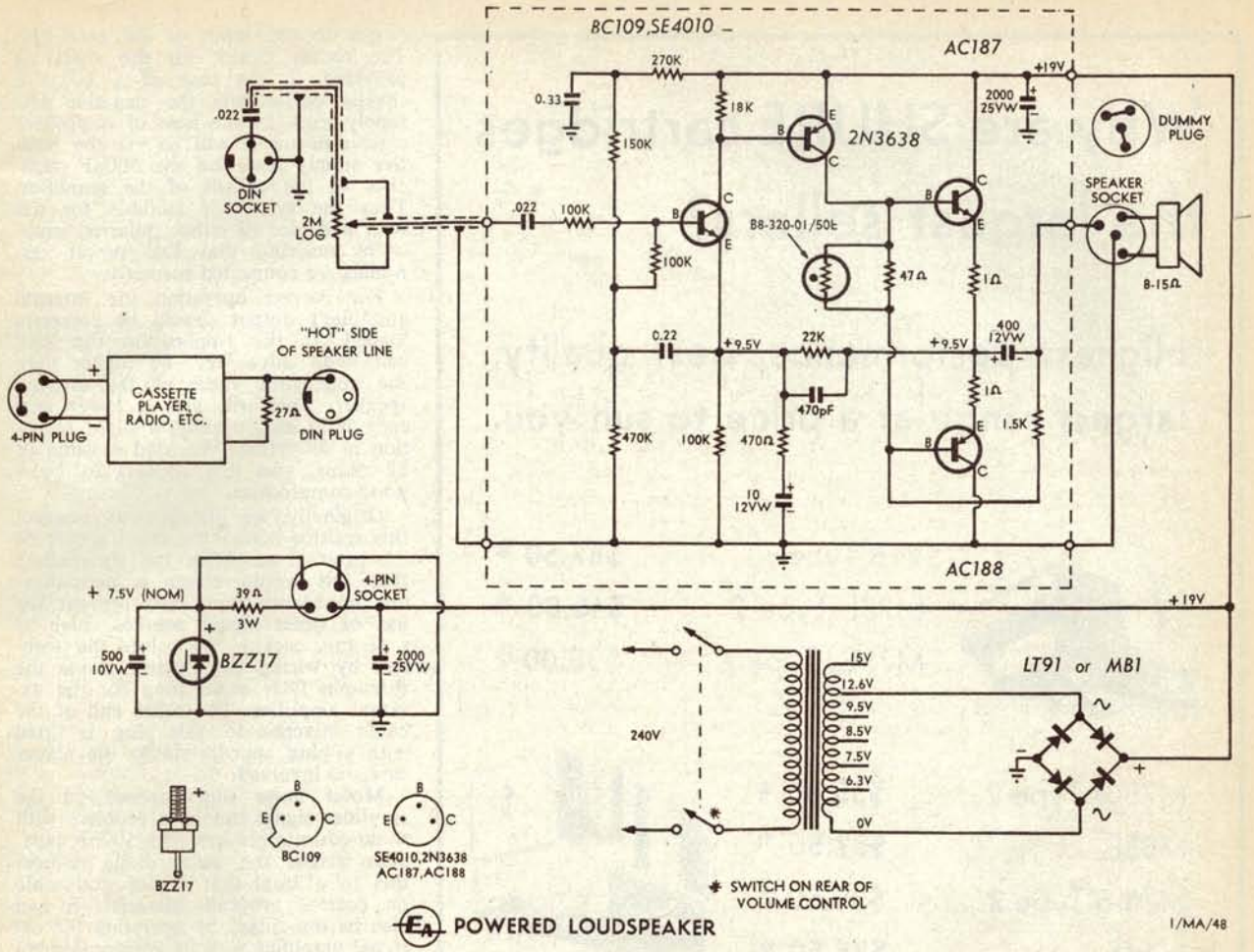
The power supply for the amplifier consists of a small power transformer with a multi-tapped secondary winding, the 12.5V tap feeding a bridge rectifier. The D.C. output from the rectifier is filtered by 4,000uF of capacitance. Part of the DC output is fed to a zener diode network which supplies the DC requirements of the signal source; tape recorder, radio, etc. A 6, 7.5, or 9-volt zener diode may be used, depending on the voltage required. For simplicity we have only shown a 7.5 volt zener on the circuit diagram. If a 6-volt zener diode is used the series resistor may be increased from 39-ohms to 47 ohms to avoid unnecessary current drain.

With the 7.5 volt zener in circuit the standing current is around 250mA which is the main reason for the large amount of filter capacitance. Some signal sources, such as a record changer, will not require low voltage DC and to avoid unnecessary power wastage when the DC is not required we have arranged for the zener diode network to be disconnected from the circuit when not in use. We have used a four-pin plug and socket for the DC output. The plug is wired with a link, as shown on the circuit diagram, and this serves the purpose of a switch. When the plug is removed no power is supplied to the zener diode network.

The maximum power available from the amplifier will depend on whether the zener diode network is in circuit or not. With it out the power output into an 8-ohm load will be 3 watts continous, dropping to 2 watts continuous with the zener network in circuit. A similar order of power output can be obtained with a 15-ohm loudspeaker if the 15-volt secondary winding of the transformer is used. The 15-volt winding must not be used if the amplifier is intended for use with an 8-ohm speaker, to avoid running the output transistors in excess of their ratings.

Connection from the four-pin DC output socket to the cassette, portable radio etc., is by means of a "patch cord" terminated with a connector appropriate to the particular device. Usually, the act of inserting this connector will automatically disconnect the internal batteries. If no such provision exists it may be possible to provide a change-over jack and socket, and modify the player or radio for use with an external supply.

Most cassette players and portable radios have a socket allowing an ex-



The complete circuit diagram of the Powered loudspeaker. Note that the 27 ohm load resistor for the cassette player is wired inside the 3-pin DIN plug which connects to the amplifier. Alternative zener diodes for voltages other than 7.5V are specified in the parts list.

tension speaker to be fitted and we elected to take the signal for the external amplifier from this point. Ideally, the signal should be taken from across the volume control so that distortion caused by the internal amplifier of the set is not added to the signal. However, to do this would require modifications to most sets and these would be difficult because of lack of accessibility and space to run shielded cable and install an output socket. One could modify the external speaker socket so that it carried the signal from the volume control instead, but we feel that most people would rather not tamper with their sets.

The power supply, as shown, is suitable for use with either NPN (negative chassis, positive supply rail) or PNP (positive chassis, negative supply rail) systems, simply by connecting its positive and negative terminals to the corresponding input terminals of the device. The fact that one side of the power supply, the negative side, is "earthy" as far as the external amplifier is concerned is of no consequence while ever this is the only connection to the device.

However, as soon as we consider the situation where the speaker terminals of the device are to be connected to the input of the external amplifier, we face the possibility of conflicting polarities. Where the device has a negative chassis and positive supply rail, as for the external amplifier, there is no real problem. The chassis of the device can connect to the chassis of the external amplifier without complications.

On the other hand, a device with a positive chassis and a negative supply rail presents the problem that the two chassis must not be connected together, at least in the DC sense. For this reason, only one lead, the "hot" lead, is provided to convey the audio signal from the speaker circuit of the

Parts List

1 case and lid, inside dimensions, 7 x 4 x 4 inches.
1 loudspeaker system (see text).
1 printed board, 68/a8 (see text).
1 2M (log) potentiometer with power switch.
1 3-pin DIN plug and socket.
2 4-pin plug and socket (different pin patterns).
1 power transformer, with secondary tapped at 6.3, 7.5, 8.5, 9.5, 12.6 and 15 volts AC at 1 amp DC (A & R 2155 or equivalent).

SEMICONDUCTORS

1 AC188/187 complementary germanium pair (with flag heatsinks).
1 BC109, SE4010 or similar, high-gain, silicon NPN transistor.
1 2N3638 or similar, high-gain, silicon PNP transistor.
1 LT91 selenium bridge rectifier or MB1 silicon bridge rectifier.
1 B8-320-01/50E thermistor.
1 BZZ15 or BZZ17 or BZZ19 zener diode for 6, 7.5 or 9 volt supply, respectively.

RESISTORS

(¼ or ½ watt unless specified)
1 x 470K, 1 x 270K, 1 x 150K, 3 x 100K, 1 x 22K, 1 x 18K, 1 x 1.5K, 1 x 470 ohms, 1 x 47 ohms/½W, 1 x 39 ohms/3W, 1 x 27 ohms/½W, 2 x 1 ohm/½W.

CAPACITORS

(Higher voltage ratings may be used.)
2 x 2000uF/25VW electrolytic.
1 x 500uF/10VW electrolytic.
1 x 400uF/12VW electrolytic.
1 x 10uF/12VW electrolytic.
1 x 0.33uF/25VW ceramic or metallised polyester.
1 x 0.22uF/25VW ceramic or metallised polyester.
2 x 0.022uF ceramic or polyester.
1 x 470pF polystyrene or ceramic.

SUNDRIES

1 knob, spacers, screws, nuts, mains cord and plug, mains cord clamp, 2 grommets, shielded cable, 1 8-terminal tagstrip, spaghetti sleeving, hook-up wire, solder.

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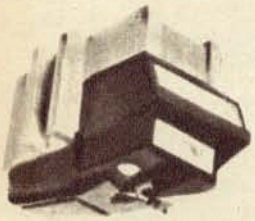

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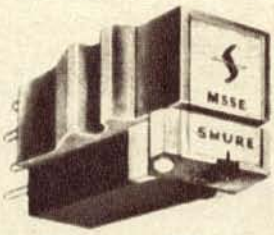

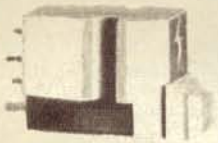

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device to the input of the amplifier. The return circuit for the signal is provided, in the case of a negative chassis device, via the negative DC supply lead. In the case of a positive chassis device it will be via the positive supply lead and the 500uF capacitor to the chassis of the amplifier. Thus the system is suitable for use with a device of either polarity, simply by ensuring that DC power terminals are connected correctly.

For correct operation the internal amplifier's output should be correctly loaded. In this application the load can, with advantage, be higher than the impedance value of the internal speaker. This will give a lower current drain and, usually, a slight reduction in distortion. We used a value of 27 ohms, and this appears to be a good compromise.

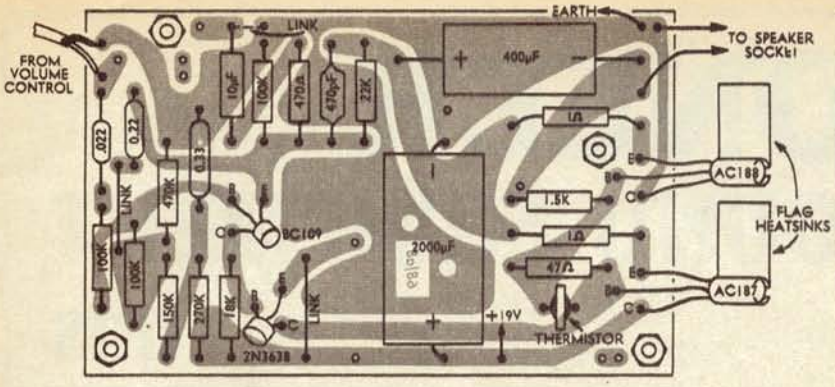
Originally, we thought to connect this resistor across the input socket of the external amplifier, but we realised that this would create a permanent low impedance input and prevent the use of other signal sources, such as a ceramic pickup. We solved the problem by wiring the resistor inside the three-pin DIN input plug for the external amplifier. The other end of the cable attached to this plug is fitted with a plug appropriate to the player or radio involved.

Motor noise superimposed on the amplifier signal can be a problem with some cassette players. The 500uF capacitor across the zener diode reduces this to a level that is not noticeable on normal program material. It can also be minimised by operating the external amplifier with its volume control set at a low level while the volume control on the cassette player is set at a fairly high level, but well short of overload.

The prototype amplifier was constructed in a small metal box measuring 7 x 4 x 4 inches and fitted with a biscuit tin lid. The box has a volume of 112 cubic inches, and this means it can be installed in speaker enclosures of more than about three quarters of a cubic foot with little effect on the performance of the speaker. The box could be installed in smaller enclosures without the biscuit tin lid fitted so that it occupied less volume in the enclosure. The use of the metal box is a much better way of accommodating the circuit components than mounting them on the rear panel, inside the enclosure.

The layout is such that the volume control, the four-pin DC output socket, the three-pin DIN input socket, and the grommeted hole for the power cable are all fitted to holes in the bottom of the box. A cut-out is provided in the back of the speaker enclosure measuring approximately 5¼in x 3in and the bottom of the box is mounted against this from the inside. The box is secured by four wood screws, one in each corner, and an airtight seal provided by means of a thin felt gasket.

The only other fitting on the speaker box is a miniature four-pin speaker socket mounted directly on the wooden back. The purpose of this socket is to provide a convenient means of connecting the speaker to either the amplifier inside the speaker box, or an external amplifier, such as part of the domestic stereo system. A dummy plug



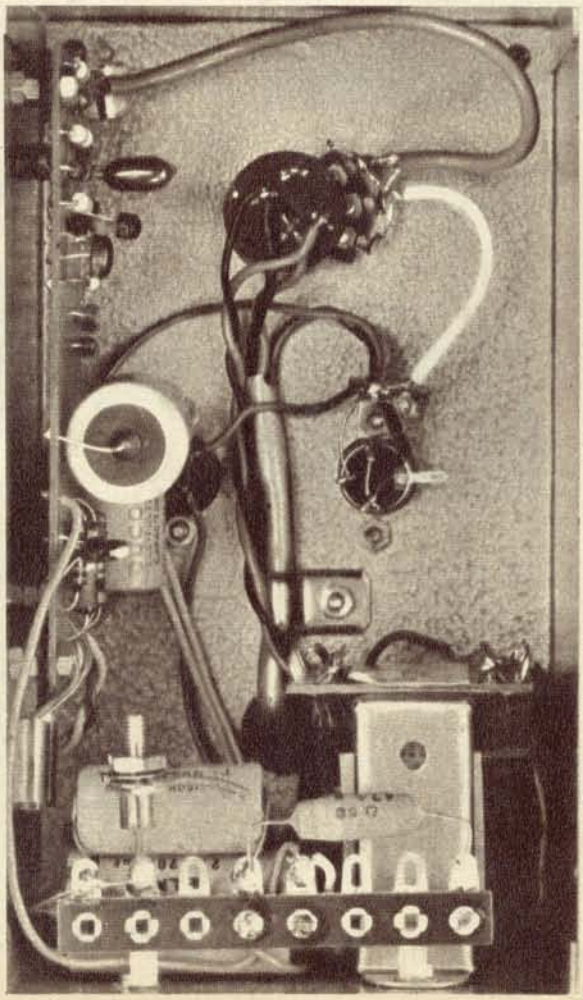
Above is the component layout on the printed board with the grey overprint showing the copper pattern on the reverse side.

is used to connect the speaker to its own internal amplifier, while external signals may be fed directly into the socket. Note that this four-pin socket has a different pin configuration to that used for the DC output socket, for obvious reasons.

The presence of these various sockets in the back of the cabinet will inevitably result in some air leakage in the enclosure, mainly via the holes in the four-pin sockets, the DIN socket being essentially airtight. While this is theoretically undesirable, it must be realised that the amount of leakage is quite small; nothing like the kind of leakage which can occur when an ill fitting back can leave a gap along one complete side. As far as any application involving tape players, portable radios etc., are concerned, the effect on performance would be negligible.

Where higher quality signal sources are concerned, such as a stereo channel, some users may feel that even this is undesirable. Most of the leakage, such as it is, will be prevented if there is a plug in the socket and it would be worthwhile fitting a dummy plug in any otherwise unused socket. The alternative is to use a completely different system of connections, possibly based on terminals mounted directly on the wooden back of the box.

Use good quality components for the amplifier. The resistors should be carbon film types for best results, rather than carbon composition types. The latter tend to increase their value



At right is a view inside the case. Of the two sockets, the one on the right is the DIN input socket and the other is the DC output. A .022uF capacitor is wired between the DIN socket and the two-way tagstrip. Note the flag heatsinks which are screwed to the lower left side of the case. The grommetted hole for the speaker leads is obscured by the heatsinks. The bridge rectifier is mounted behind the 8-terminal tagstrip, next to the transformer.

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after a period of service and this can play havoc with the amplifier's performance. The author recently had real cause for regret when he had to trace a fault in a high-power direct coupled amplifier. The fault was caused by three carbon resistors which had gone high. All the other resistors were carbon film types!

All the components within the dotted line on the circuit diagram are mounted on a printed circuit board. This board is actually one half of that for the 3-plus-3 Stereo Amplifier referred to above. The board is coded and is available from most kitset suppliers. Mounting the components on the board is straightforward and requires little comment except for a caution to avoid overheating the components when soldering.

The need to provide half a standard printed board warrants some comment. It is not clear at the time of writing whether any of the supply houses will be able to supply half boards, or whether, if they do, that the saving will be worthwhile. We suggest that the constructor should be prepared to buy a complete board and divide it himself. It may be possible for two constructors to share such an arrangement.

The most satisfactory way of dividing the board appears to be by scoring and breaking. An ideal scoring tool is a Laminex knife, available from most hardware stores. Score the board neatly down the centre, then clamp one half firmly between two pieces of board with their edges flush with the score mark. The board should then break cleanly.

The board is mounted by means of ¼-inch long ⅛-inch Whitworth screws and nuts or shorter screws and spacers.

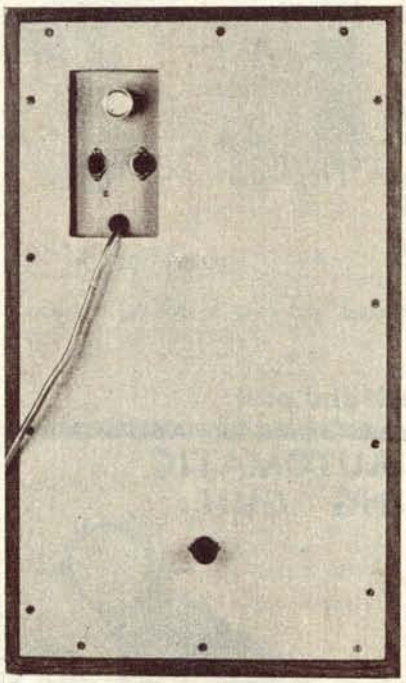
The output transistors, which have a TO-1 metal case, are wired directly into the amplifier board, leaving a lead length of about 1 inch. The leads should be insulated with spaghetti sleeving to minimise the risk of short circuits. The transistors are fitted with flag heatsinks (Miniwatt part No. 56200) which are normally supplied with each complementary pair. These metal flags are firmly secured to the case, as shown in the photograph, by means of ⅛-inch screws and nuts. The flags should be secured individually to the case to ensure the best heat transfer. — not two flags by one screw. If the box has been painted, the area to which the flag heatsinks are attached should be stripped to the bare metal to ensure efficient heat transfer. This is not to say that the transistors are dissipating a lot of power but it is desirable to keep the temperature as low as possible.

The speaker leads are brought out through a grommeted hole in the side of the case and run down to the four-pin speaker socket. The filter capacitors and the zener diode network can be seen in the photograph. The zener diode is soldered directly to a tag strip and requires no auxiliary heat-sink.

The mains cord should be anchored by a clamp as shown in the photograph. When terminating the mains cord the earth lead should be left longer than the active leads so that if the cord is strained to the limit the earth lead will the last to break.

The bridge rectifier we used was a selenium type, Westinghouse LT91, which sells at a very economical price. As an alternative, an encapsulated silicon bridge rectifier, type MB1, is marketed by STC: it is more compact than the LT91, but there is a price difference of almost one dollar.

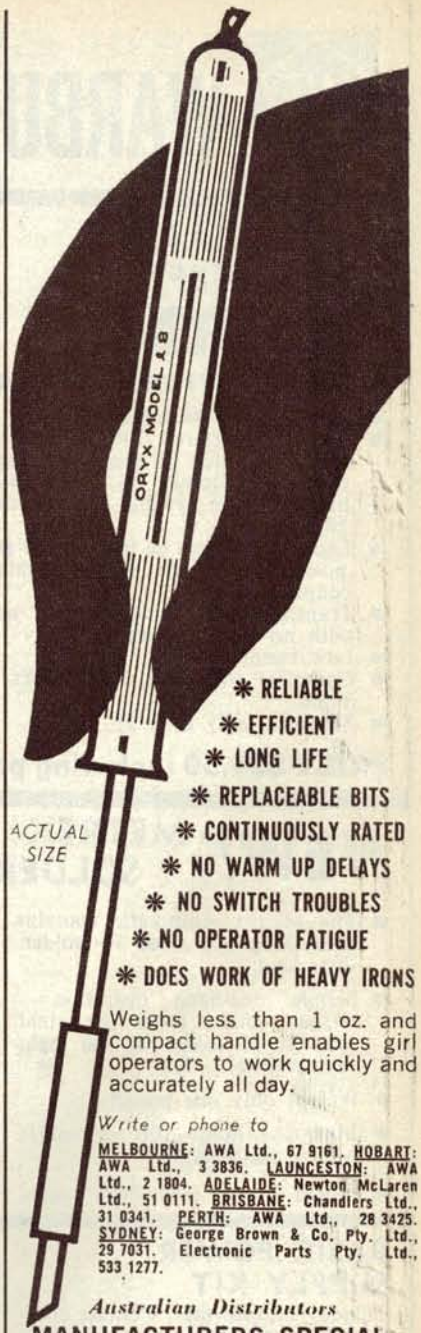
Assembly will be made easier if a suitable order is followed. First mount the power transformer and bridge rectifier. Then mount the tagstrip, input and output sockets and volume control. Wire the components into the tagstrip and connect the wires to the DC output socket. Wire the mains cord to the switch on the rear of the volume control, and connect the shielded cable from the volume control to the small tagstrip which accommodates the .022uF capacitor and chassis terminations. Lastly, the board is mounted and connected into circuit.



Above is the rear view of the enclosure. The case is mounted behind a cut-out in the rear panel and a felt gasket is used to ensure an airtight seal. The dummy plug at the base of the enclosure is inserted when the amplifier is in use, and is replaced by another when the loudspeaker is used with an external stereo system.

At no signal the amplifier should have a current drain of 8 to 10mA. If this is not the case, the quiescent current should be adjusted by varying the 47-ohm resistor. Increasing the resistor will increase the current and vice versa. For maximum power output at the point of clipping, the DC voltage at the positive connection of the 400uF output capacitor should be slightly less than half the supply voltage. Normally there should be no need to adjust this but it can be set by varying the bias resistors for the input stage.

The final step is to put the lid on the case, reinstall the back panel of the enclosure and connect up your cassette recorder, or other program source. ■



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