Headphone amplifier

Practise without annoying the family

If you play any type of electronic musical instrument, this headphone amplifier will surely interest you. It will let you practise for hours without upsetting the household, or you can use it to monitor your own instrument in the midst of a rowdy jam session.

Whenever a number of musicians are playing together, a problem arises with their relative volumes. Each musician wants to hear his own instrument or voice above the others. The problem is more severe with instruments which are intended only as background – the musician simply can not hear himself. "Live" bands usually overcome this problem by using "foldback", with a small speaker aimed at each performer in addition to the larger units aimed at the audience. This allows each performer to monitor his own sound without the need for excessive volume.

A different approach is used in recording studios where each performer wears a pair of headphones. This virtually eliminates direct ambient sounds. The console operator can then control exactly how much ambient and how much foldback each performer gets. We are not suggesting that this headphone amplifier has a place in recording studios, but it is an economical way for low budget bands to derive more pleasure from their activities.

If the circuit for this project looks familiar, you're right – it's virtually the same as the one used for the parabolic microphone project described in November 1983. In fact, this type of low power amplifier has a multitude of uses. With a maximum output of 1W, it can drive a loudspeaker or headphones. For the stated objectives of this project, though, 1W into a loudspeaker would be virtually useless. For this reason we have designed for headphones exclusively. A pair of headphones driven at only a hundred milliwatts would prove deafening for most people so a 1W capability is ample.

Construction is simple, with most of the parts mounted on a small printed circuit board. This is mounted together with the various input/output jacks and front panel controls in a small plastic "Bimbox" case measuring 105 × 135 × 55mm (W × D × H). With its sloping front panel, the case looks just right for this project – certainly better than a zippy box.

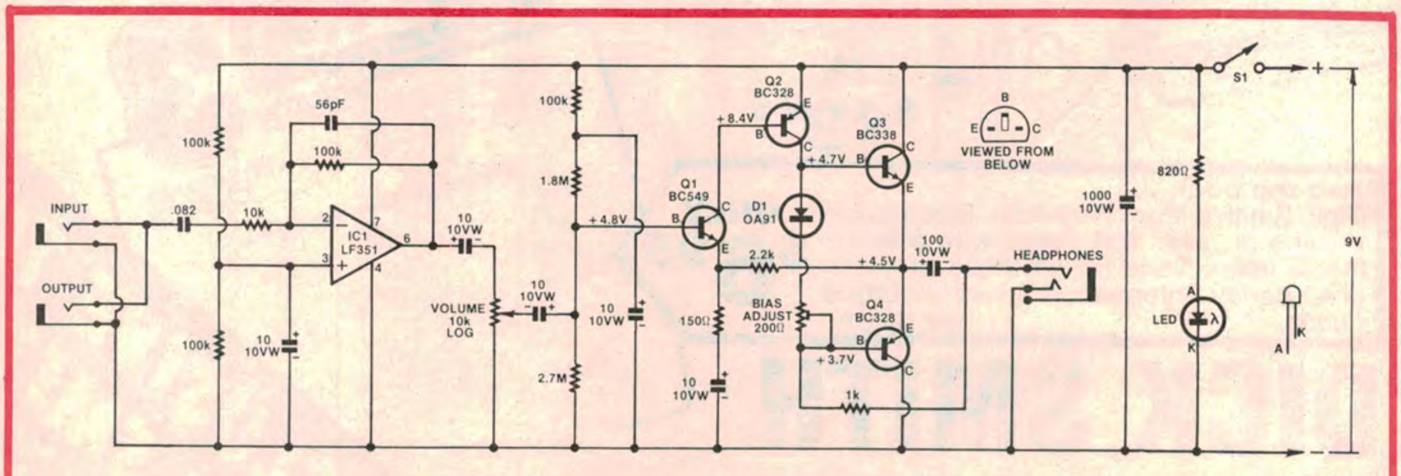
Front panel controls and facilities have been kept to a minimum. On the sloping panel of the case, we have an on/off switch, a LED indicator and, to the right, a volume control. Above these, on the top of the case, are three RCA jack sockets – input, output and headphones. The input and headphone labels are self-explanatory while the output socket is simply wired in parallel with the input.

This latter feature enables the Headphone Amplifier to be patched into circuit between the instrument and a power amplifier and thus provide foldback. The instrument is simply plugged into the input socket while the signal for the power amplifier is taken from the output socket. Operation of the instrument/amplifier combination is unaffected by the Headphone Amplifier.

Modern lightweight headphones are the most suitable when using the amplifier in the foldback or monitor role. Those of "open-air" construction only partially exclude ambient sounds and thus offer the musician the best effect. Watch the power rating though, as many have a very low rating and are easily driven into overload by the high signal transients generated by the plucked strings of a guitar.

How it works

As stated, the circuit is essentially the same as that used for the parabolic microphone project – an op amp input stage followed by a direct coupled transistor power amplifier. There are, however, a few minor changes to adapt



HEADPHONE AMPLIFIER

1/MA/-

for musicians

by COLIN DAWSON

PARTS LIST

1 PCB, code 83 ma11, 68 × 51mm
1 plastic project box ("Bimbox" No. 6005 or similar)
1 Scotchcal front panel label, 102 × 140mm
1 SPST toggle switch
6 1.5V batteries (Eveready AA or equivalent)
1 battery holder to suit
1 battery snap connector
1 stereo audio socket to suit (3.5 or 6.5mm)
2 mono audio sockets (6.5mm)
1 3.5mm socket for plugpack transformer (see text)
1 knob to suit volume control
1 rubber grommet

SEMICONDUCTORS
1 LF351, TL071 FET input op amp
2 BC328 PNP transistors
1 BC338 NPN transistor
1 BC549 transistor
1 OA91 germanium diode
1 red LED

CAPACITORS
1 1000μF/10V electrolytic
1 100μF/10V electrolytic
4 10μF/10V electrolytic
1 10μF/10V axial electrolytic
1 .082μF metallised ployester (greencap)
1 56pF ceramic

RESISTORS (¼W, 5% unless noted)
1 x 2.7MΩ, 1 x 1.8MΩ, 4 x 100kΩ, 1 x 10kΩ, 1 x 2.2kΩ, 1 x 1kΩ, 1 x 820Ω, 1 x 150Ω, 1 x 10kΩ log potentiometer, 1 x 200Ω small horizontal trimpot

MISCELLANEOUS
Hook-up wire, shielded hook-up wire, screws, nuts, scrap aluminium, solder etc.

the circuit to its new role. In particular, the electret microphone and its associated 4.7kΩ bias resistor have been deleted.

Signals from the instrument are AC coupled to the inverting input of IC1 via a .082μF capacitor. The non-inverting input (pin 3) is connected to the mid-point of a voltage divider consisting of two 100kΩ resistors connected across the supply. This biases pin 3 at half the supply voltage.

IC1, an LF351 FET-input type, operates as an inverting amplifier with a gain of 10. A 56pF capacitor connected in parallel with the 100kΩ feedback resistor restricts the bandwidth of the op amp so that it will not respond to RF signals picked up by the input leads. The output from pin 6 is AC-coupled to a 10kΩ volume potentiometer and applied to the base of transistor Q1.

The base of Q1 is biased to around 4.8V by a divider network consisting of 1.8MΩ and 2.7MΩ resistors. There is also a 100kΩ resistor connected in series with these bias resistors and this, in conjunction with the 10μF capacitor, decouples the bias network from any signal present on the supply line.

The series resistor and capacitor in the emitter circuit of Q1 provide AC negative feedback, limiting the response below 100Hz. DC negative feedback is provided by the 2.2kΩ resistor between Q1's emitter and the output.

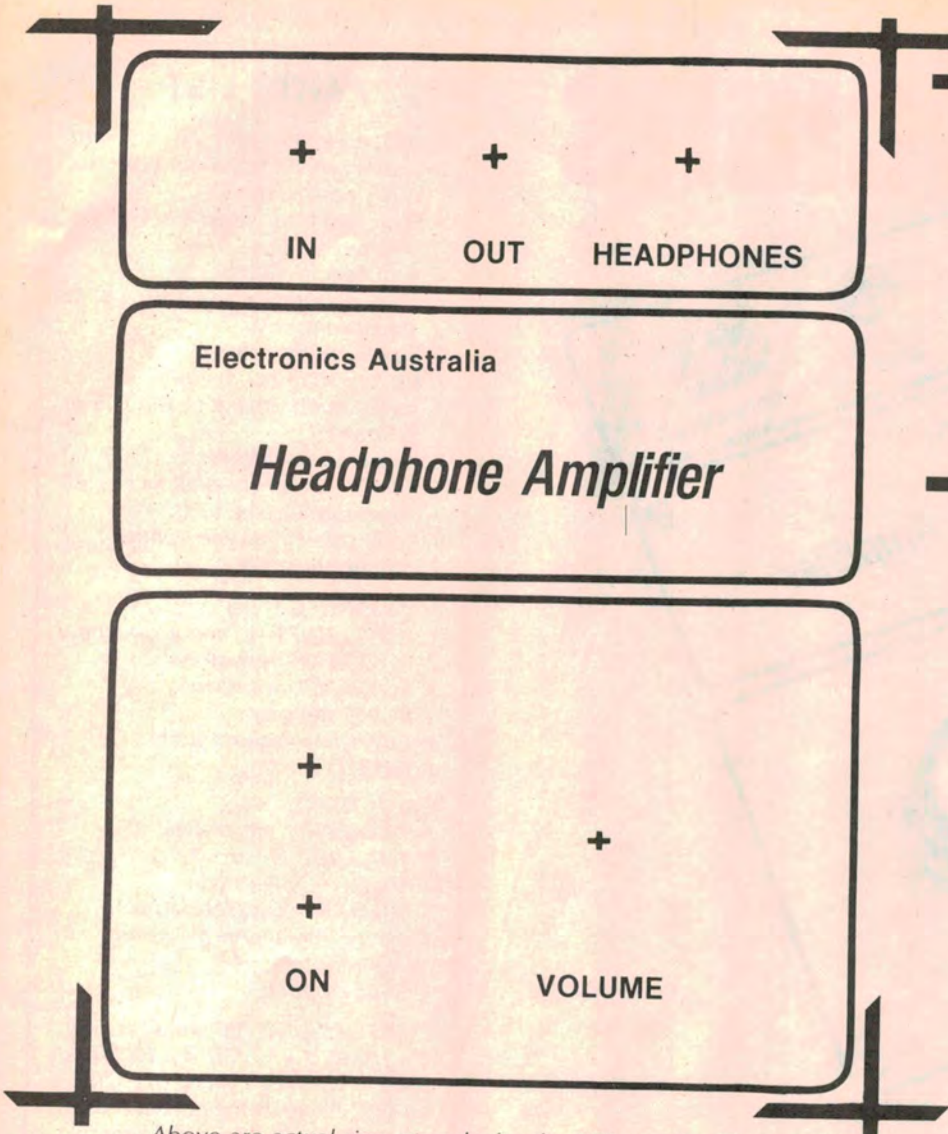
Q1's collector is direct coupled to the base of Q2, a BC328 NPN transistor. This in turn drives a complementary output stage consisting of transistors Q3 and Q4. An adjustable bias control consisting of a 200Ω trimpot and a series germanium diode (D1) is connected between the bases of Q3 and Q4 and allows the quiescent current in the output stage to be adjusted for minimum crossover distortion.

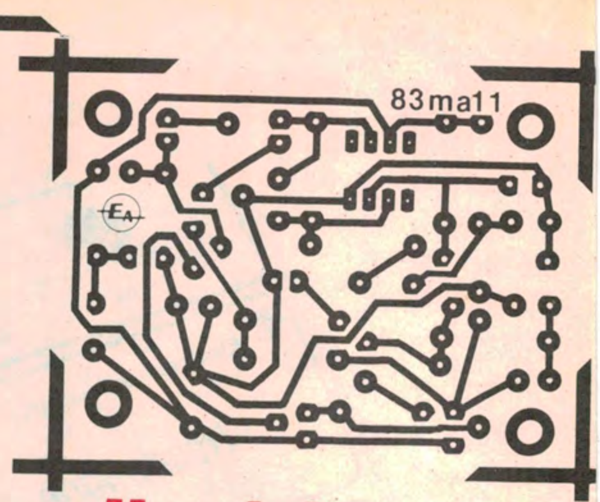
With the trimpot set to least resistance, the quiescent current will be at a minimum and the overall current consumption will be around 15mA. At this setting however, crossover distortion will be quite apparent. This problem can be overcome by adjusting the trimpot to give an overall consumption of about 20mA.

The output signal is taken from the junction of the emitters of Q3 and Q4 and AC-coupled via a 100μF capacitor to the headphone socket. This arrangement prevents any current from flowing in the load unless there is an input signal.

Power for the circuit is derived from a 9V plugpack supply or from a 9V battery pack consisting of six 1.5V penlight cells. The supply is filtered by a 1000μF capacitor while power on/off indication is provided by a LED wired in series with an 820Ω resistor across the supply. Do not use a single 9V "transistor" battery — it service life will be much too short.

One point worth considering here is that the LED accounts for almost half the





Above are actual size artworks for the PCB and the front panel.

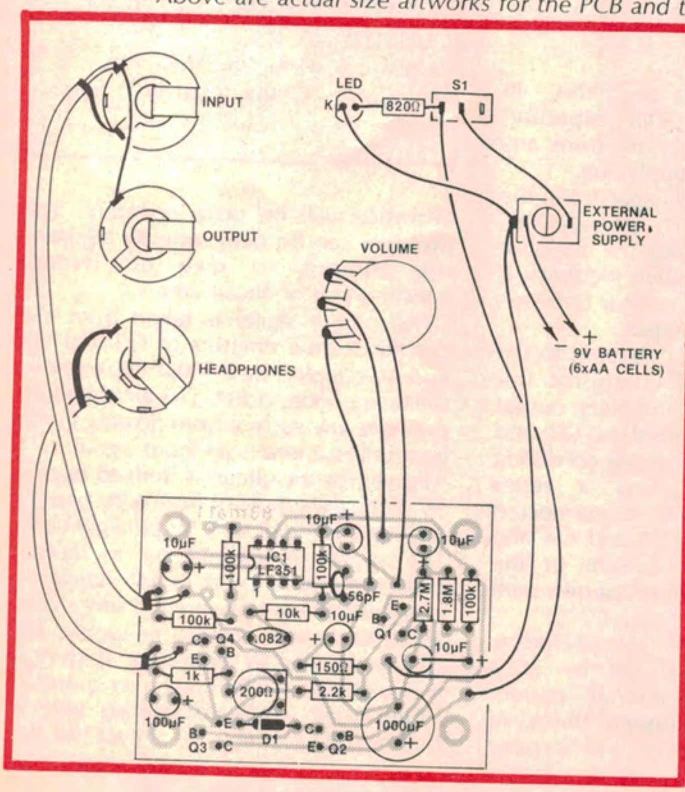
Headphone Amplifier

total current drain of the circuit. Some readers may therefore prefer to delete the LED, particularly if the unit is to be operated for long periods on battery power alone.

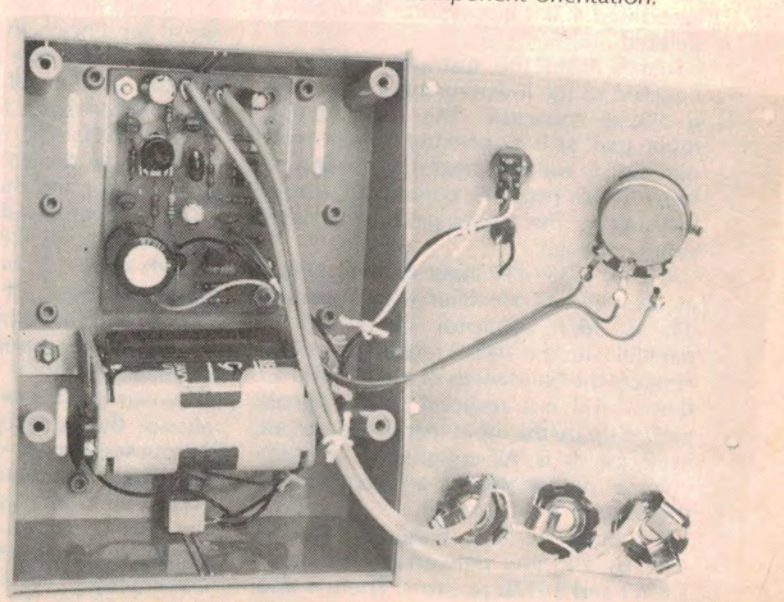
Construction

Most of the parts are mounted on a small printed circuit board (PCB) coded 83ma11 and measuring 68 × 51mm. Begin construction by mounting the parts on the PCB according to the overlay diagram, with particular attention to polarised components.

This done, spray the Scotchcal label with a hard setting lacquer, then carefully attach it to the front panel of the box. The front panel holes can now be drilled and the various hardware items mounted in position.



Note the use of shielded cable for connections to the input and headphone sockets. Take care with component orientation.



We estimate that the current cost of parts for this project is approximately

$28

This includes sales tax.

The input and output sockets should both be 6.5mm mono types, but the headphone socket should be selected to suit your headphones. In most cases this will be 6.5mm stereo, although some lightweight headphones use a 3.5mm stereo plug. Note that the load impedance should not be less than 8Ω. This means that the headphone socket must be wired so that, when the headphones are plugged in, the transducers will be in series.

Make sure that none of the terminals on the headphone socket contact the front panel, otherwise an earth loop will develop, possibly resulting in instability. Usually, the fascia of the socket is connected to its earth terminal – unless it is a plastic body type socket. We used a conventional metal socket but isolated it from the front panel with a large rubber grommet.

We used a 3.5mm jack socket to suit our plugpack supply, but this may not necessarily suit other plugpacks. Note that the plugpack socket must be a changeover type which disconnects the batteries when the plug is inserted. Mount it low on the rear panel to ensure sufficient clearance for the front panel jack sockets.

The wiring can now be completed according to the wiring diagram. Shielded cable must be used for connections between the PCB and the front panel jack sockets while light duty hookup wire or rainbow cable can be used for the remaining connections. Once the wiring is completed, the PCB can be mounted on the floor of the case using machine screws and nuts. The battery pack sits between the PCB and the rear of the case and is secured by a bracket made from scrap aluminium.

Before switch on, set the 200Ω bias trimpot fully anti-clockwise and set the volume to minimum. Now check that the LED illuminates when the unit is switched on. If not, trace the problem before proceeding. Plug in a guitar and advance the amplifier volume control until the volume is at a comfortable level.

Finally, the bias control should be used to reduce the crossover distortion by adjusting the trimpot in a clockwise direction. In practice, it is sufficient to simply advance the trimpot until the ear can no longer detect distortion. Advancing the control further will only serve to shorten the battery life.