The "Series 4000" stereo amplifier

Here's how to assemble a high-performance 60 watts per channel stereo amplifier using our ETI-470 modules and the ETI-471 preamp control unit.

Circuit design
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Mechanical design/layouts
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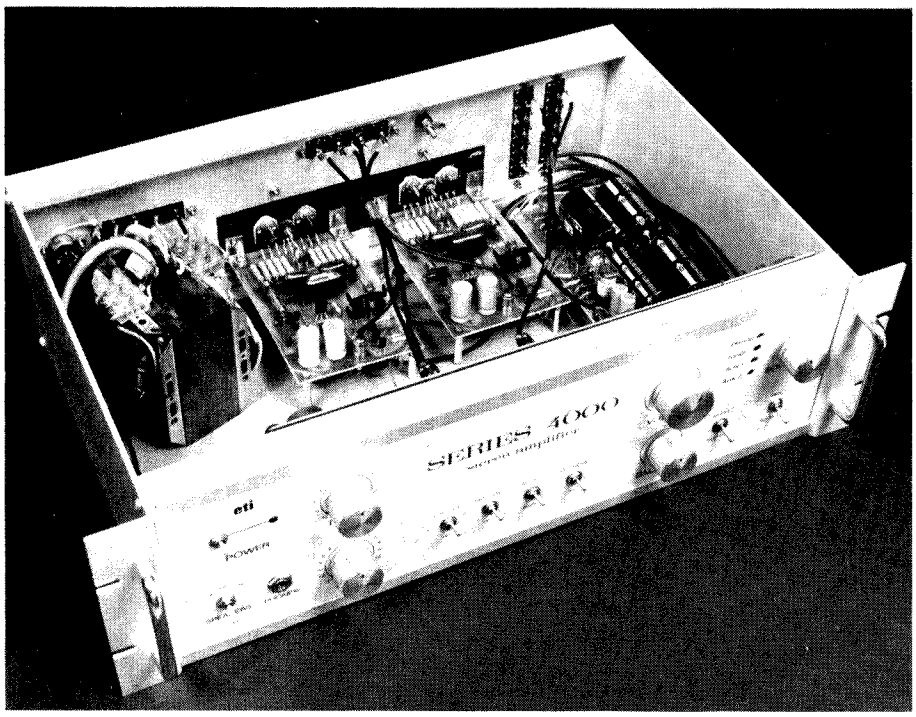
Front panel art
Bill Crump



The completed stereo amplifier is shown here mounted in a handsome rack-mounting case. This particular style of case is also available with wooden end cheeks if that is what you prefer.

WE HAVE ALREADY described the ETI 470 60 watt module (May 79) and the ETI 471 preamplifier (June 79) which have proved very popular as individual designs. This article presents the complete Series 4000 amplifier, made from these modules.

We chose to build the amplifier into a single box, being the most economical method as only one box and power supply is used for the preamp and both power amplifiers. However, this method has several drawbacks. Firstly, since the preamp and power amp share the same power supply, the regulation for the preamp must be very good, otherwise low frequency instability can occur, caused by the drop in supply line voltage when the outputs draw high current getting back into the preamplifier.

Hence we have chosen IC regulators for the preamplifier supply lines.

Secondly, the magnetic field from the large transformer and associated AC wiring required to supply the power amplifier modules is quite large and almost impossible to keep out of the sensitive preamp stages. Therefore you will notice that the specification for hum in the completed amplifier is lower than that of the individual units. We took this measurement using a standard EI lamination transformer (Ferguson PF 3577) after rotating it for minimum hum to the position shown in the wiring diagram.

The hum induced by the transformer can be further reduced by using a C-core

ETI 4000 SERIES STEREO AMPLIFIER

Specifications of prototype

Power output	60 watts @ 0.1% THD one channel driven 55 watts @ 0.1% THD both channels driven
Distortion	0.05% THD @ 30 V p-p output across 8 ohm load, both channels driven.
Hum	–70 dB on full output using standard transformer
Noise	–80 dB on full output
Damping factor	57 (measured at 100 Hz, 1 kHz and 10 kHz).
Frequency Response	Phono: Within 0.5 dB of RIAA from 20 Hz to 20 kHz (Follows new IEC curve). Other inputs: 20 Hz to 20 kHz ± 0.5 dB Subsonic rolloff: 6 dB/octave below 20 Hz
Tape output	150 mV RMS
Sensitivity	For 500 mV RMS output phono: 3 mV RMS other: 150 mV RMS (Phono overload level is 400 mV p-p).
Tone controls	Bass: ± 13 dB at 50 Hz Treble: ± 11 dB at 10 kHz
Filters	High: 6 dB/octave, –3 dB at 5 kHz Low: 6 dB/octave, –3 dB at 100 Hz
Loudness	8 dB boost at 150 Hz and 10 kHz.
Mute switch	20 dB attenuation

type, or better still a toroidal transformer, which have a contained field, but these are often hard to get and expensive to the hobbyist.

We feel that the specifications of the amplifier are very good, however the purist (with plenty of money) may like to do it this way:

The two power amplifier modules, together with individual power supplies using say, 30 000 uF capacitors, could be mounted in a separate box to the preamplifier, which could then be powered from the ETI 581 (June 77) regulated supply.

This would no doubt improve the power output and transient performance of the amplifier but the cost would be much greater.

Construction

Construction details for the preamplifier and power amplifiers have been described previously, all that remains is to house them together, with the power supply, in a suitable box. As we said before, many variations are possible – here is how we did it.

Assemble the power supply board first, taking care to correctly orientate the semiconductors, IC regulators and capacitors. To simplify construction we used pc pins for all terminations to the boards.

The photo of the rear panel shows the position of the input and output connections. Slots are cut in the panel for the connector blocks and a large cut running across the back panel is used to inset the power amplifier modules from the rear. Holes then must be drilled for the earth terminal, external power socket, power cord, mounting screws for the terminal blocks and holding screws for each power amplifier – which pass through the top of each heatsink fastening it to the panel.

The case measures 420 mm x 135 mm x 285 mm and is made from aluminium extrusion with easily removable panels. Available with either metal rack mounting or wooden sides, it can be purchased from suppliers listed at the end of this article.

One thing to watch though is that anodised aluminium does not conduct electricity and, after assembling the box, the various metal parts will probably not be connected to each other, causing a multitude of problems. To overcome this, strap the rear and side panels to the common earth point at the headphone jack on the front panel. (Yes, we found this out the hard way).

After the preamplifier/front panel, power amplifiers and power supply have been mounted in the box and the input/output sockets mounted onto the rear panel the unit can be wired as shown in the wiring diagram.

Common to all amplifier designs, the earth wiring is very critical. Most instability and hum problems can be traced to earth "loops" or incorrect wiring.

The common lead from each channel speaker is returned directly to the OV point on the power supply. A wire is then taken from this point and fed to one power module, to the other, and then to the preamplifier. To avoid an earth loop the braid of the shielded cables from the preamplifier to the power amplifier is not carried through the connector block on the rear panel. OV leads for the LEDs and external power are also returned to the power supply common. The common is then earthed to the chassis at the headphone socket together with the transformer shield and mains earth. This is the **ONLY** earth point onto the chassis.

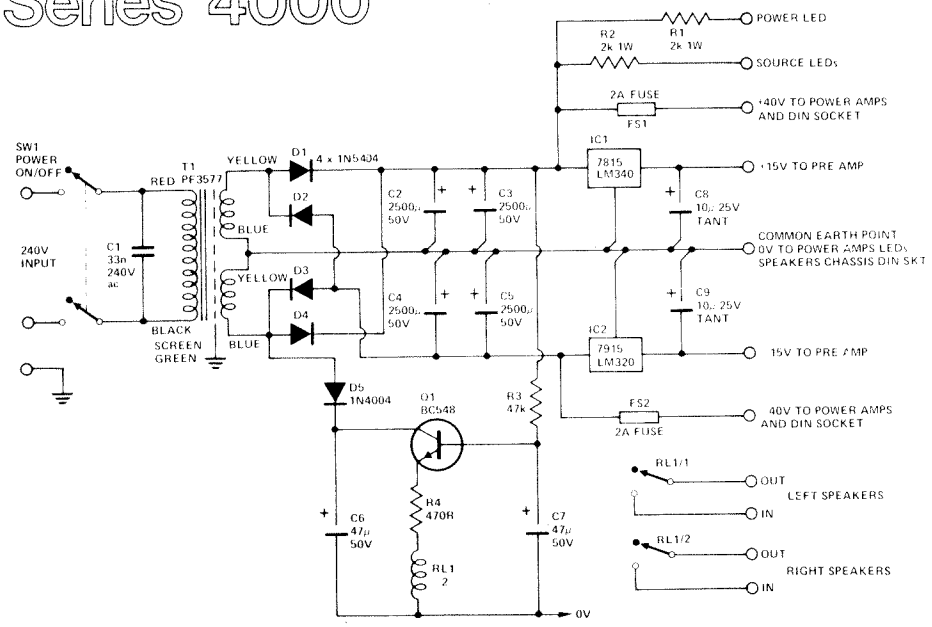
All the ac and speaker wiring is fed along the back and down the left side of the case as shown, well away from the sensitive parts of the amplifier. The dc wiring from the power supply to the preamplifier is carried along the front.

Lengths of shielded cable with RCA plugs on one end are used to connect the input sockets to the preamplifier. These can be made by cutting RCA patch cords to the appropriate length, one cord making two leads. The shields of these cables should not be connected together or to the case at the input sockets.

All that remains is to solder the 330 ohm resistors from the speaker switch to the plugs on the headphone socket.

Check that all wiring is correct and there are no frayed ends. The procedure for setting the bias current for the output transistors is given in the May issue. As soon as this is done insert the 2 A fuses and the amplifier can be switched on.

If you have the older 50 watt ETI 480 modules these could probably be used in place of the ETI 470 module, though we haven't tried it. ▶



Power supply

The power supply for this amplifier uses a 28V-0-28V transformer rated at 2 A to provide +/- 40 Vdc rails for the power amplifiers. Two regulators, IC1 and IC2, supply very stable +/- 15 V rails for the preamplifier.

Current limit resistors are mounted on the pc board to power the front panel LEDs. This permits some flexibility to allow us to think up other things to do with the LEDs later.

Fuses are also provided on the board to protect the power supply from a short circuit in the dc output lines. If the dc output facility on the rear panel is not used the fuses can be short circuited, as each power module is protected by its own fuses.

When an amplifier is first switched on, the two supply lines rarely come up to full voltage simultaneously. This causes a loud 'thump' in the speakers which may damage them. ▶

PARTS LIST - ETI 472

Resistors
R1, R2 . . . . . 2k 1W 5%
R3 . . . . . 47k ¼W 5%
R4 . . . . . 470R 1W 5%

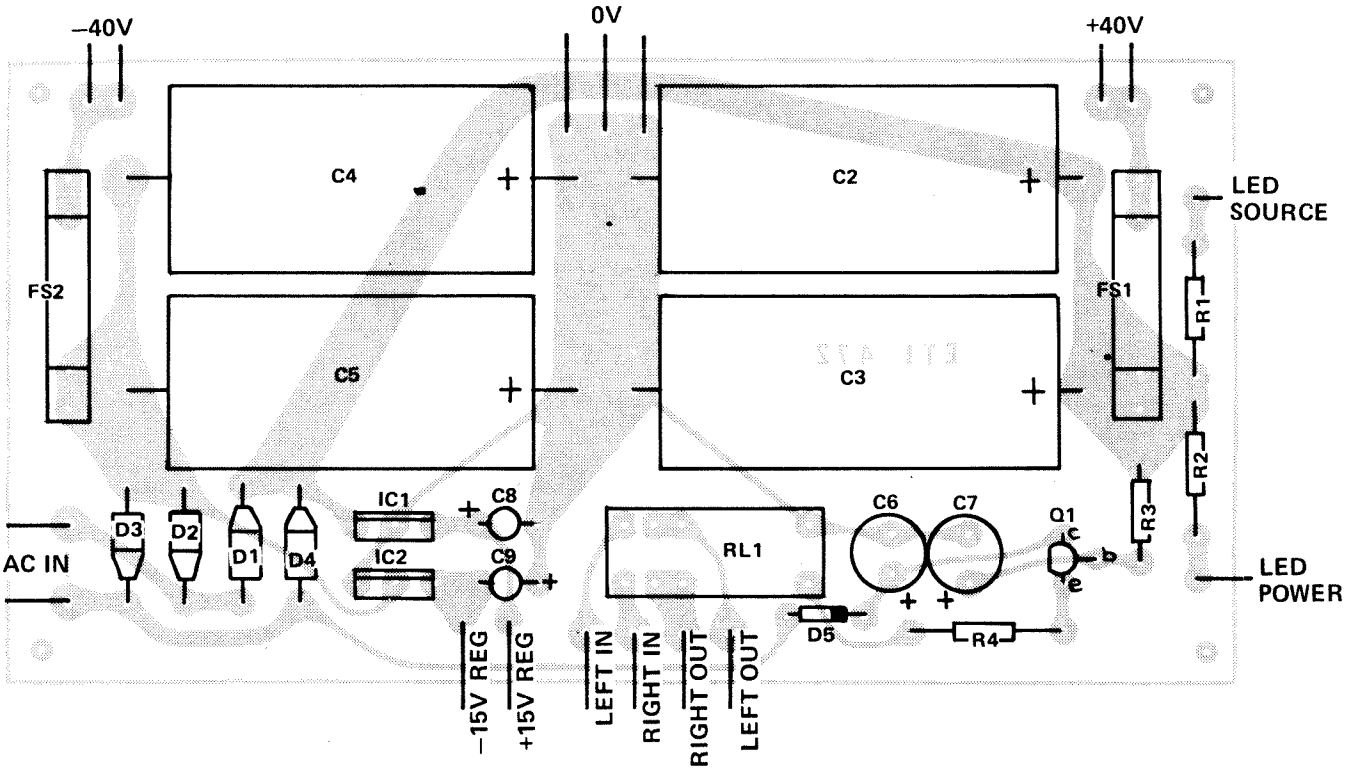
Capacitors
C1. . . . . 33n 240V ac metalized paper
C2–C5 . . . . . 2500µ 50V electro
C6, C7 . . . . . 47µ 50V electro
C8, C9 . . . . . 10µ 25V tantalum

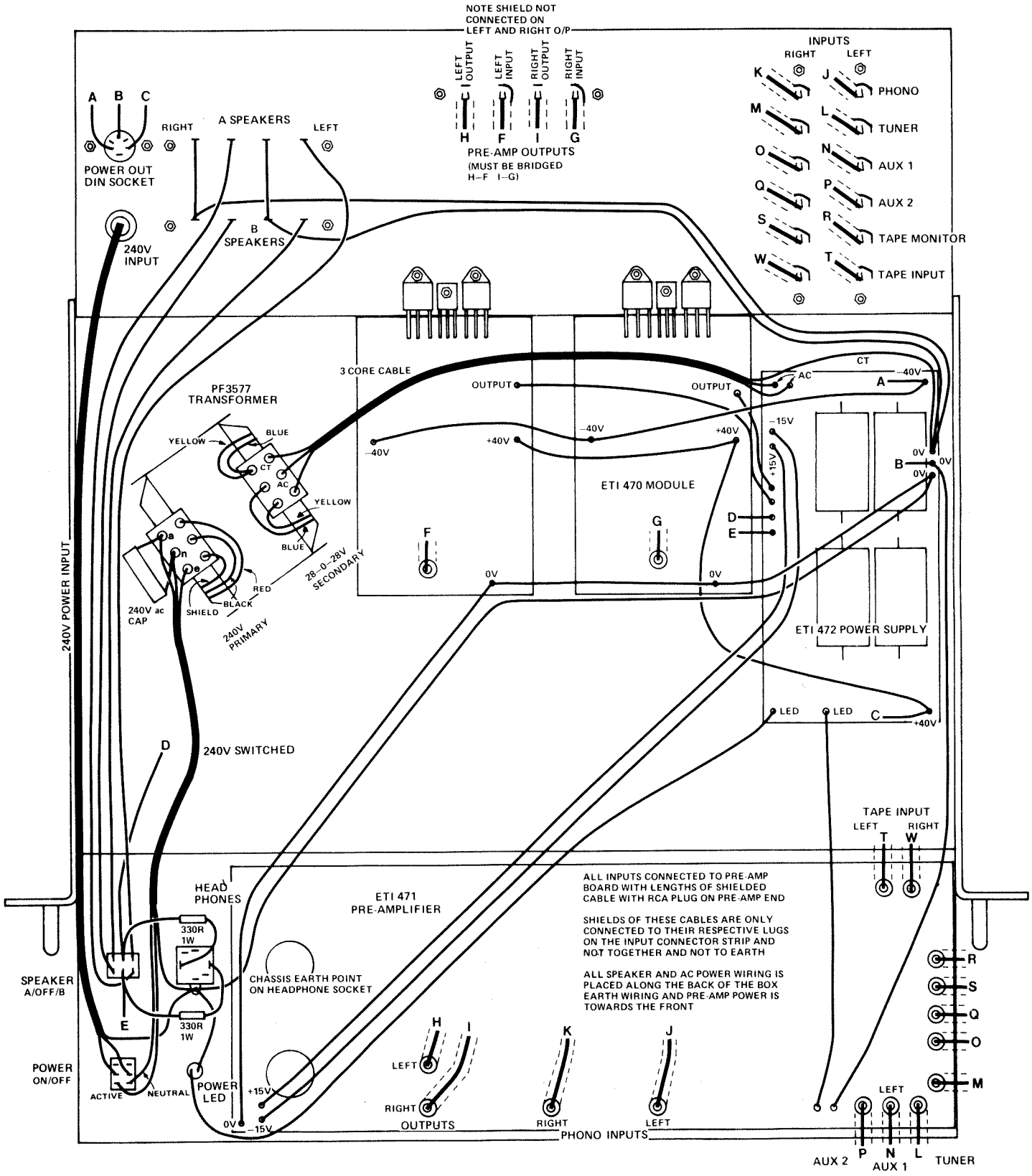
Semiconductors
D1–D4. . . . . IN5404 or sim
D5 . . . . . IN4004, A14A or sim
Q1 . . . . . BC548, BC108, DS548
IC1 . . . . . 7815, LM340-15, 15V regulator
IC2 . . . . . 7915, LM320-15, -15V regulator

Miscellaneous
T1. . . . . PF3577 or similar (Ferguson)
FS1, FS2. . . . 2 amp fuses (if used)
RL1. . . . . pcb mounting, 2 pole changeover relay, 12V coil, Pye 265/12/G2V, DS cat S7130 or sim
SW1. . . . . 2 pole 240 VAC miniature toggle switch.

CHASSIS PARTS LIST

Headphone socket . . . 6.5 mm jack skt.
Speaker switch . . two pole, two position, centre off min. toggle switch
16 RCA plugs or eight patch leads cut in half, two short RCA patch leads, power lead and clamp.
Two, 330R, 1W resistors
Two, 3-way plastic mains terminal strips
Two, 4-way speaker terminals
Two, 6-way RCA panel sockets
One, 4-way RCA panel socket
One, 5-pin DIN socket





Internal wiring and interconnection diagram of the stereo amplifier.

To avoid this an "anti-thump" circuit connects the speakers several seconds after the amplifier is turned on.

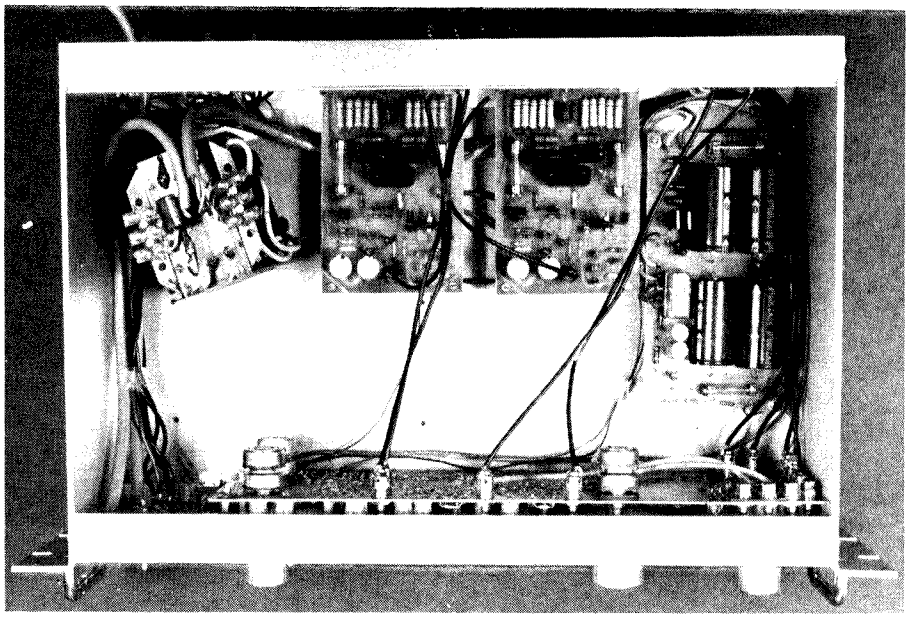
It works this way; as the power rails come up to voltage a capacitor, C7, charges via R3. Transistor Q1 conducts pulling in the relay, RL1, and connectiong the speakers after the power rails have had enough time to stabilise. ▶

At first we tried mounting the power supply board in front of the transformer near the preamplifier, but found the proximity of the speaker wiring to the tone control stage caused high frequency instability if the treble control was advanced. The power supply board is now mounted at the opposite side of the case to the transformer and the ac secondary wiring run across the back.

Two three-terminal connector strips are mounted on top of the transformer, using the holes in the mounting plates, to take primary and secondary connections. The shield (green wire) makes up the third wire on the primary side and is run together with the 240 V wiring to the front panel. We used three-core mains flex for connections from the transformer to the power switch and the power supply pc board. A suppression capacitor (C1) is mounted across the transformer primary on the connector block.

Make sure that the power switch you have is rated for 240 Vac, as some being sold are only 125 Vac rated and sometimes fail catastrophically.

Short patch leads will have to be made up to connect each of the preamplifier outputs to their respective power amplifier inputs.



This internal view shows the placement of the main modules and the orientation of the power transformer. The latter will have to be oriented individually to reduce hum levels to the minimum obtainable.

Suppliers

The following suppliers have informed us they have all special components used in this project.

NSW:

Applied Technology, Hornsby
DR Hi-Fi and Electronics, Dee Why
Electronic Agencies, Concord
Jaycar, Sydney
Radio Despatch, Sydney
Silicon Valley, St. Leonards
Mode Electronics, Botany

Victoria:

All Electronic Components, Melbourne
Ellistronics, Melbourne
Rod Irving Electronics, Northcote

Power Darlington Transistor Equivalents

Owing to the large demand for the Philips Darlington transistors used in the 60 watt power modules they may be temporarily hard to get as new orders take a few weeks to arrive. Texas Darlingtons TIP 142 and TIP 147 appear to be the same and we have tested them in the circuit without any change in performance.