Build a 50W/channel stereo amplifier

Looking to upgrade your system with a new amplifier? This new stereo amplifier is easy to build & does not need setting-up adjustments. Most importantly, it will give excellent sound quality & up to 50 watts per channel into 8-ohm loads.

By LEO SIMPSON & BOB FLYNN

Our last integrated stereo amplifier design was presented in the March & April 1992 issues of SILICON CHIP but it is now obsolete because the power transistors specified are no longer available. This new design is based on the 50W per channel stereo amplifier module presented last month.

While this new amplifier offers very similar facilities to the unit referred to above, it is a completely new design with a much wider chassis and all new PC boards. And while the superseded design had an inbuilt RIAA preamplifier for phono cartridges, in the new amplifier the RIAA preamp is an optional extra board. We took this approach because many people these days do not have any vinyl records or a turntable so they don't want the RIAA preamp.

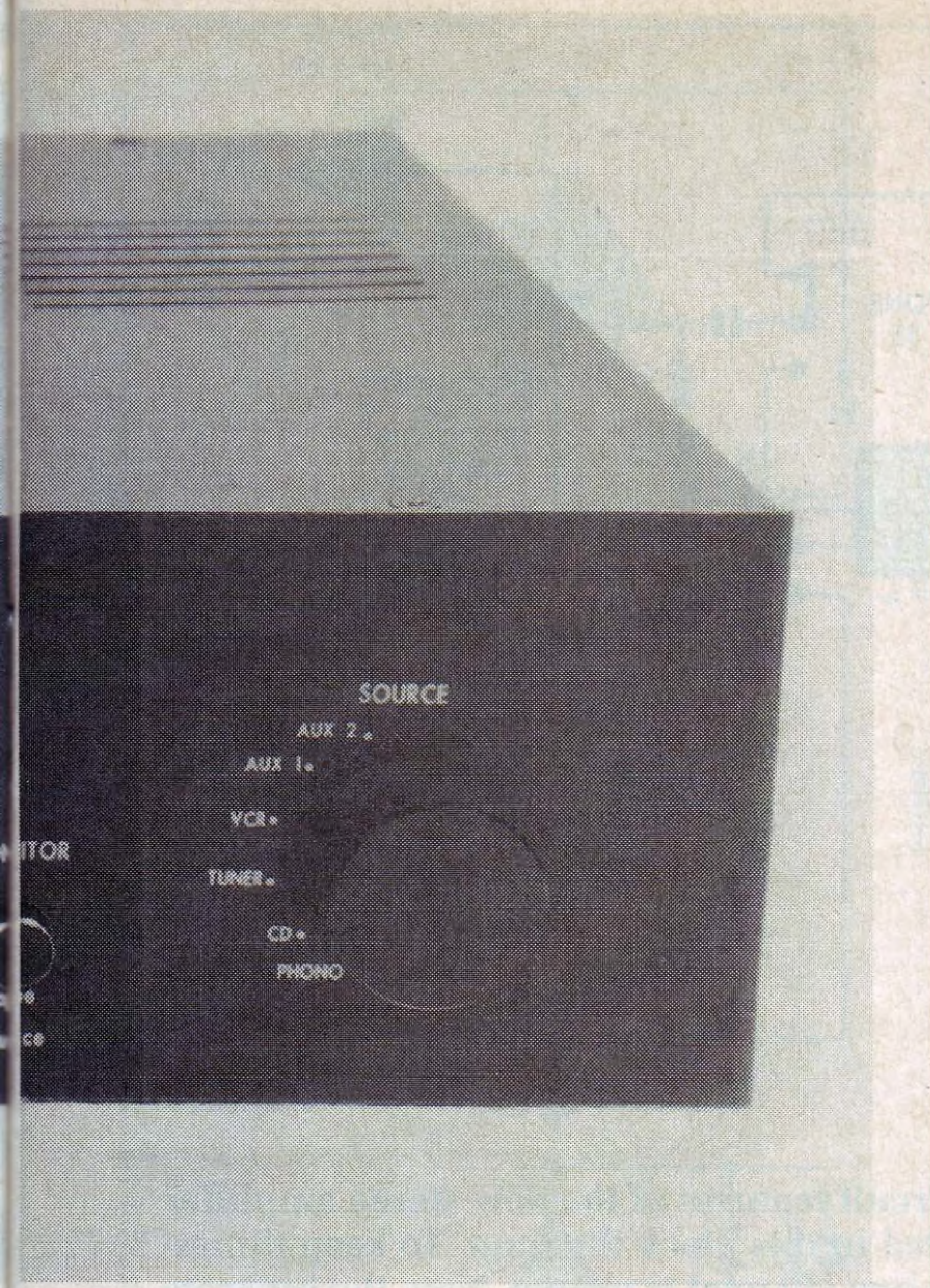
Leaving the RIAA preamplifier out also has the advantage that you have an extra pair of line level inputs (ie, suitable for CD, tuner or other program source).

The overall design approach to this amplifier has been middle of the road. We have not taken the spartan European approach with virtually no controls except for the volume knob and nor have we sought to incorporate every feature found in expensive Japanese amplifiers. Still, it does have all the features that most people want and will use. For example, while it does include tone controls, it also has a switch to disable them, to obtain a completely flat frequency response.

Let us now talk about the features in some detail.

Features

The new SILICON CHIP 50W Stereo Amplifier is housed in a low profile case measuring 435mm wide, 95mm high and 320mm deep, including knobs rubber feet and rear projections.



Above: the new SILICON CHIP 50W per channel amplifier offers all the facilities expected on a modern stereo amplifier &, in addition, it has a separate headphone amplifier.

Specifications

Power Output
47W into 8-ohm loads, both channels driven; 57W into 8-ohm loads with one channel driven.

Frequency Response
High level inputs: within ±1dB from 10Hz to 50kHz
Phono inputs: RIAA/IEC within ±0.5dB from 20Hz to 20kHz.

Total Harmonic Distortion
Typically less than .05% (see graph).

Signal-to-Noise Ratio
High level inputs (CD, Tuner, etc): 99dB unweighted (20Hz to 20kHz) with respect to rated output (with volume at maximum) with Tone Defeat switch in or out; 100dB A-weighted under the same conditions.
Phono (moving magnet): 83dB unweighted (20Hz to 20kHz) with respect to 10mV input signal at 1kHz & rated output with 1kΩ resistive input termination; 88dB A-weighted under the same conditions.

Channel Separation
-78dB at 100Hz; -81dB at 1kHz; & -61dB at 10kHz with respect to rated output & with undriven channel input loaded with a 1kΩ resistor.

Input Sensitivity
Phono inputs at 1kHz: 4.3mV
High level inputs: 235mV

Tone Controls
Bass: ±13dB at 50Hz.
Treble: ±13dB at 10kHz

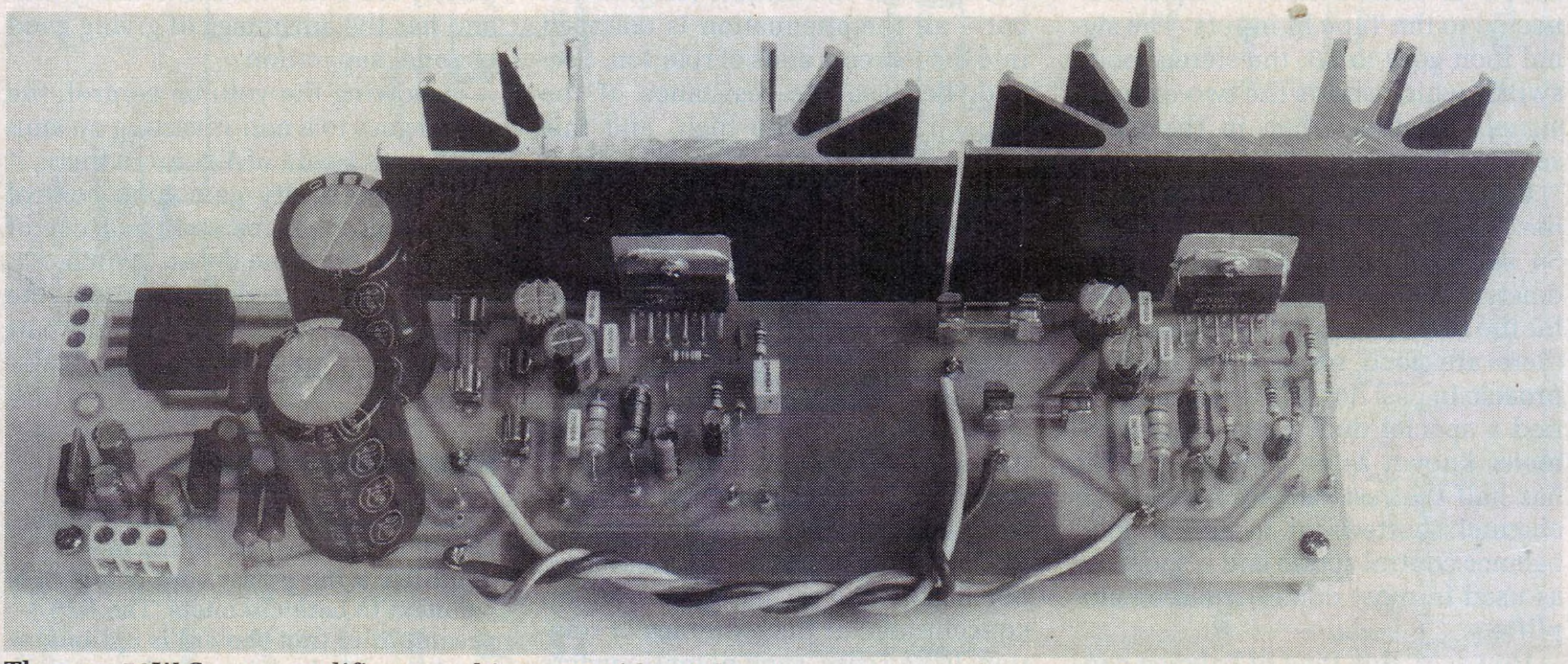
Damping Factor
>56 from 100Hz to 10kHz (for 8Ω loads)

Stability
Unconditional

It has the usual line-up of controls found on most amplifiers: bass, treble, balance, input selector, tape monitor switch, tone defeat switch and volume control. It also has a stereo/mono switch, headphone socket and power switch. Plugging into the headphone socket disables the main power amplifiers and engages a separate high quality low power stereo amplifier to drive the headphones directly. This now only gives better reproduction via headphones but it also simplifies the internal wiring.

Block diagram

Now let's have a look at the circuit features which are depicted in the



The new 50W Stereo amplifier uses this 50-watt/channel stereo power module, as described in the previous issue. It's based on two monolithic power ICs to give a rugged, compact design that requires no adjustments.

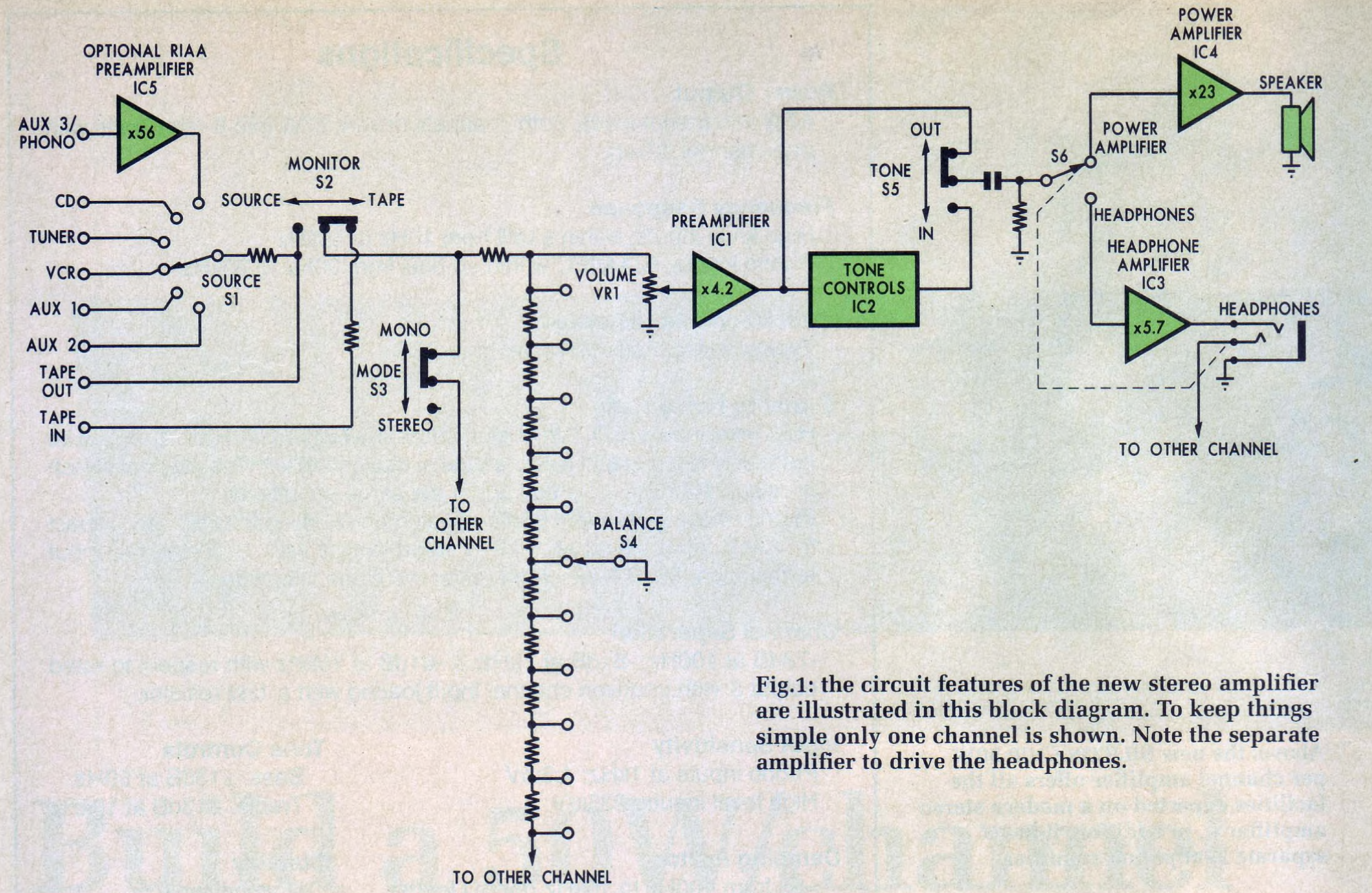


Fig.1: the circuit features of the new stereo amplifier are illustrated in this block diagram. To keep things simple only one channel is shown. Note the separate amplifier to drive the headphones.

block diagram of Fig.1. This shows only one channel, to keep things simple. All the circuit functions are duplicated in the second channel.

S1 is the 6-position selector switch and it feeds the tape output as well as the Tape Monitor switch S2. S2 selects the signal from the input selector S1 or from a cassette deck connected to the Tape In inputs. The signal then goes to S3, the stereo/mono switch which shorts the two channel signals together when in the mono setting.

Following S3, the signal is fed to the 11-position balance control switch S4 and the volume control potentiometer VR1. The use of a rotary switch for the balance control is unusual but there are good reasons for this approach. In past designs we have specified a special dual ganged potentiometer known as an M/N type. This has half the resistance track in each channel shorted out to give a good balance control action and is the same as used in most domestic stereo amplifiers.

However, this type of balance control has become difficult to obtain and so we initially took a different approach, using a single linear potentiometer with the ends connected to the signal in either channel and the wiper connected to signal earth. This approach is cheap but does not work particularly well, for two reasons. First, it has very little apparent effect over most of the middle range of the pot – all the attenuation is cramped into the extreme ends of rotation. Second, because the resistance of the wiper itself is quite high, and this resistance is common to the signal path in both channels, the separation between channels is seriously degraded, to a figure of about 25dB.

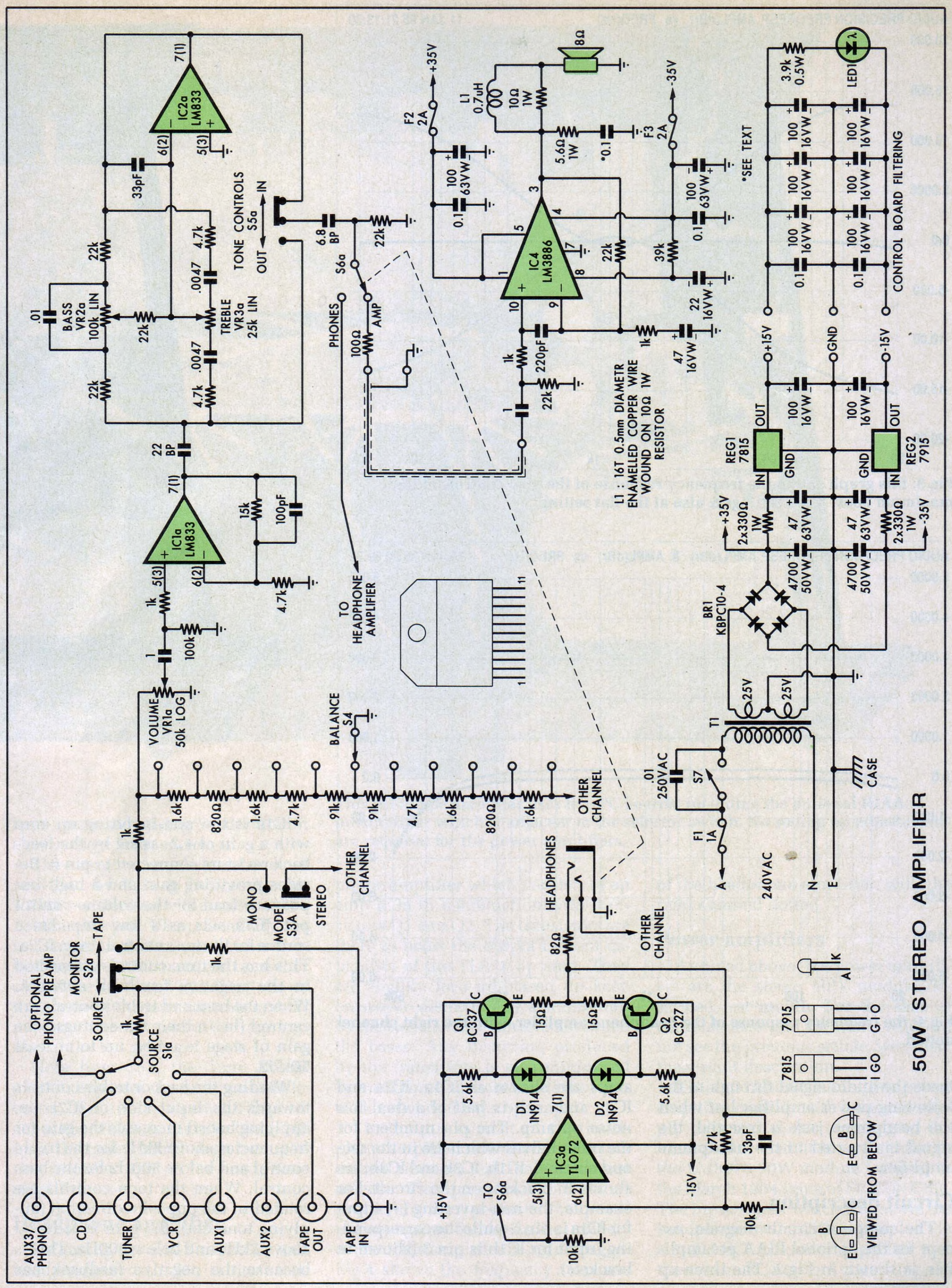
Now while -25dB separation between channels is adequate to produce a convincing stereo effect, it is far below what the circuit is otherwise capable of. One approach used by some amplifier manufacturers is to use a linear potentiometer with a centre tap connection. This gets around the problem of the wiper resistance but it still has all its control action concentrated at the extremes of rotation. In any case, such potentiometers are also difficult to obtain.

Our approach was to use an 11-position rotary switch with resistors wired around it. The resistors are arranged to progressively reduce the gain of the attenuated channel by about 2dB. So from the centre position, the gain of each channel can be varied by -2dB, -4dB, -6dB, -8dB and then completely off. This works reasonably well and has the advantage of giving good channel separation.

Following the volume control, the signal goes to a non-inverting op amp stage with a gain of 4.2. From there, it goes to the unity gain tone control stage which can be switched out of circuit by the Tone defeat switch, S5.

After the tone defeat switch, the signal goes to switch S6 which is part of the headphone socket. It normally

Fig.2 (right): this diagram shows the circuit of one channel of the new amplifier & the power supply which is common to both channels. The RIAA preamplifier (not shown) is optional & can be omitted, giving another pair of line level inputs.



50W STEREO AMPLIFIER

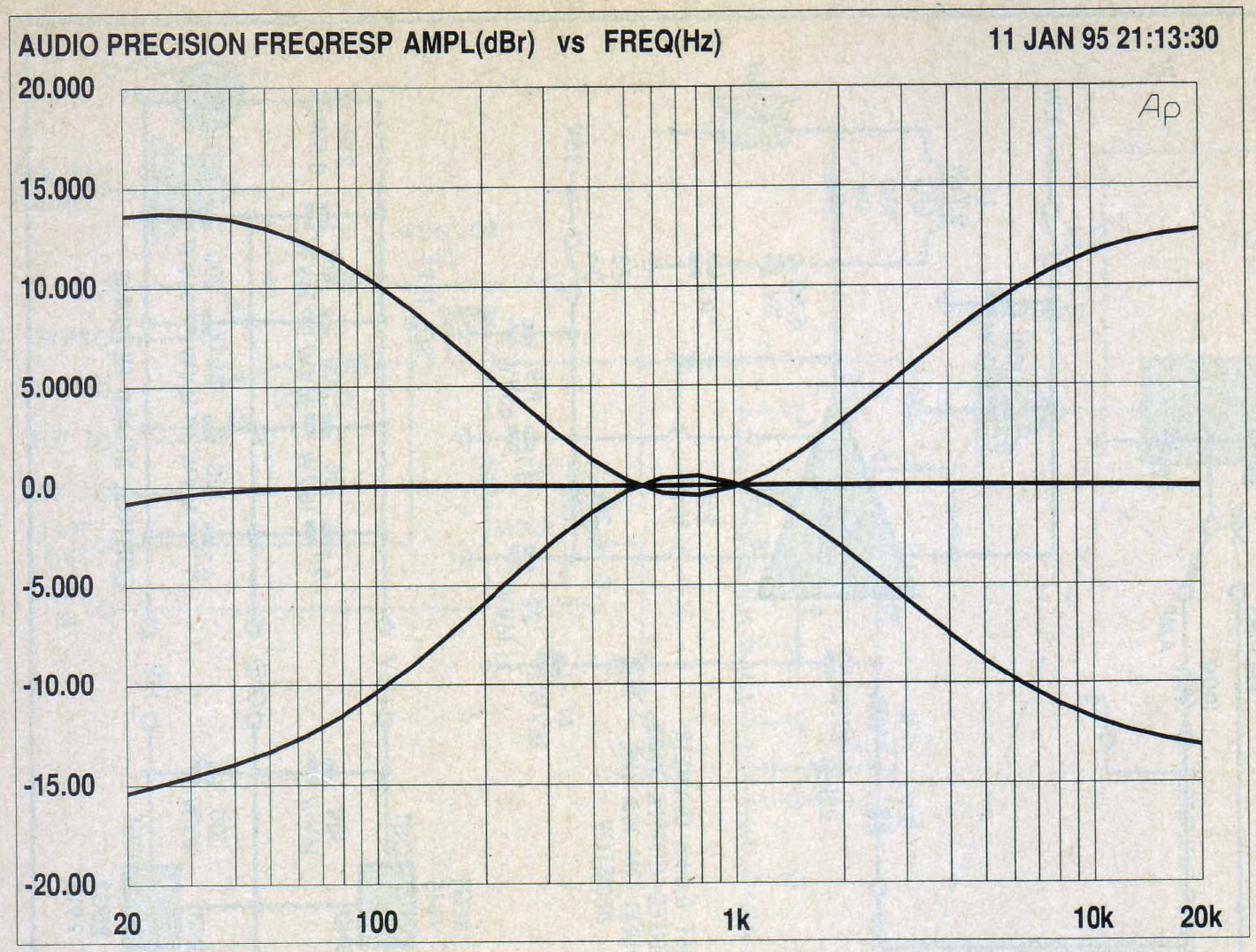


Fig.3: this graph shows the frequency response of the tone controls at their maximum boost & cut settings & also at the flat setting.

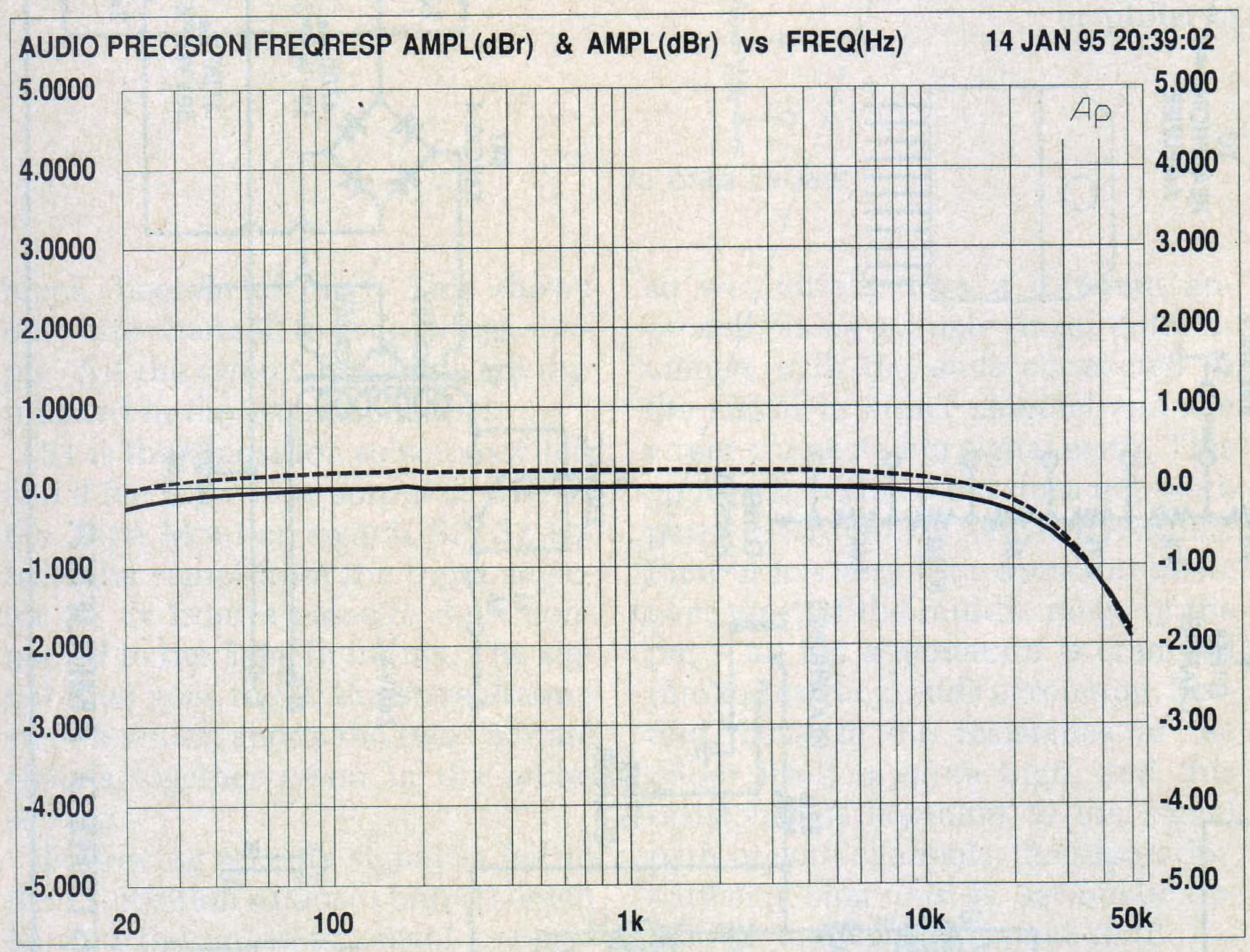
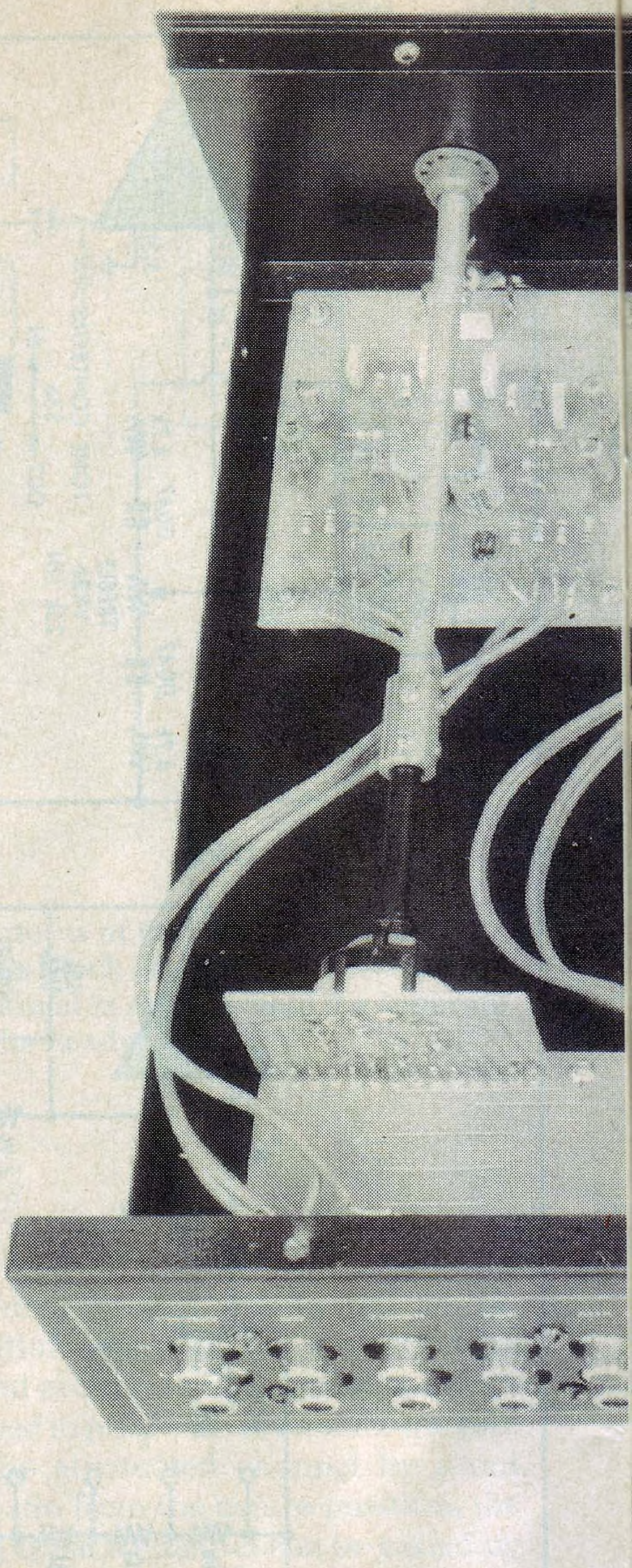


Fig.4: the frequency response of the headphone amplifier, with the right channel dotted.



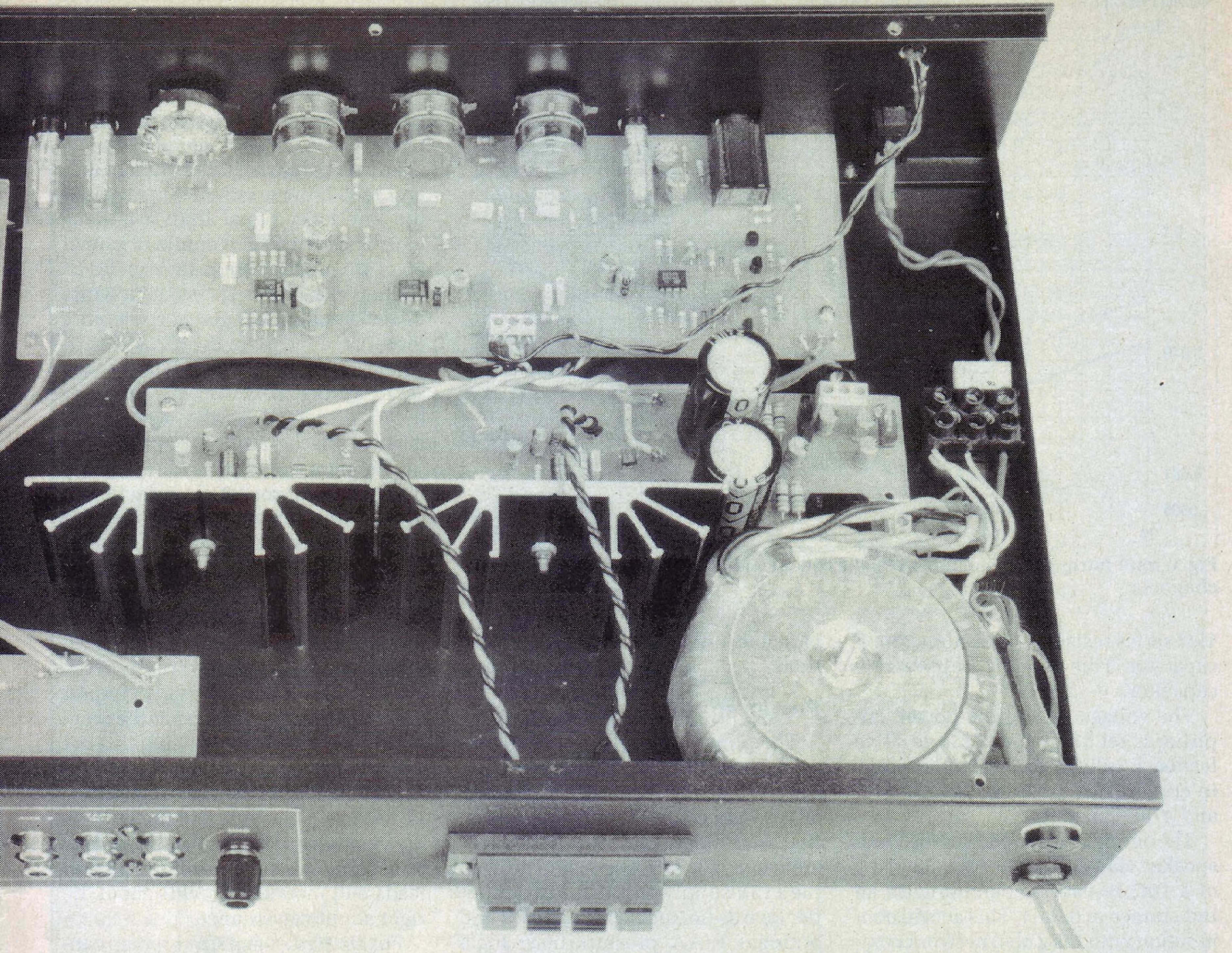
feeds the audio signal through to the following power amplifier but when the headphone jack is inserted, the signal is diverted to the headphone amplifier.

Circuit description

The complete circuit diagram, except for the optional RIAA preamplifier, is shown in Fig.2. The three op amps are shown as IC1a, IC2a and IC3a and ach is half of a dual low noise op amp. The pin numbers for the other halves which are in the second channel, IC1b, IC2b and IC3b, are shown in brackets on the circuit. For example, the non-inverting (+) input for IC1a is pin 5 while the corresponding input for IC1b is pin 3 (shown in brackets).

IC1a is the non-inverting op amp with a gain of 4.2, as set by the feedback resistors connected to pin 6. Besides providing gain and a high impedance load for the volume control pot, IC1a acts as a low impedance source for the tone control stage, IC2a. This has the tone controls connected in the negative feedback network. When the bass and treble controls are centred (ie, in their flat settings), the gain of stage is unity, up to at least 50kHz.

Winding the bass or treble controls towards the input side of IC2a (ie, applying boost) increases the gain for frequencies above 2kHz for the treble control and below 300Hz for the bass control. When the tone controls are rotated in the opposite direction (applying tone cut), the gain is reduced above 2kHz and below 300Hz. This is because the negative feedback has



This prototype amplifier uses five PC boards, including the optional RIAA preamplifier which is adjacent to the selector switch. No setting up adjustments are required for the power amplifiers.

been increased, giving a reduction in gain at these frequencies.

The amount of treble boost and cut provided by IC2a is limited by the 4.7kΩ resistors on either side of the 25kΩ treble pot, VR3a. Similarly the maximum bass boost and cut is limited by the 22kΩ resistors on either side of the bass pot, VR2a. Fig.3 shows the action of the tone controls at their maximum boost and cut settings and also at the flat setting.

Note how S5a, the Tone Defeat switch, bypasses the tone control circuitry. Its output feeds a 6.8μF bipolar capacitor which is there to block DC from the tone control stage from getting into the input of the headphone amplifier.

Headphone amplifier

Following the 6.8μF capacitor and headphone switch S6a is the headphone amplifier which consists of op amp IC3a in combination with transistors Q1 and Q2. The transistors are there to boost the output current capability of the TL072 op amp. They are slightly forward-biased (to keep crossover distortion to a minimum) by the two diodes connected between the bases. Any distortion produced by the transistors is also minimised by incorporating them inside the feedback network for the op amp.

The output current of the headphone amplifier is limited by the 15Ω emitter resistors and the 82Ω output resistor. This provides short circuit protection and protects the headphones against damage in the unlikely event of the amplifier being damaged. Fig.4 shows the frequency response of the headphone amplifier, with the right channel dotted.

Power amplifiers

As noted above, the power amplifiers are the stereo 50W module described last month. For the sake of completeness and for those who did not see the previous article, we repeat the circuit description.

IC4 is an LM3886 monolithic power amplifier module with balanced supply rails and direct coupling to the loudspeaker load. It is very similar to the LM3876 50W module featured in the March 1994 issue of SILICON CHIP. The input signal which comes via the headphone switch S6a is coupled via a 1μF MKT polyester capacitor and then via an RC network consisting of a

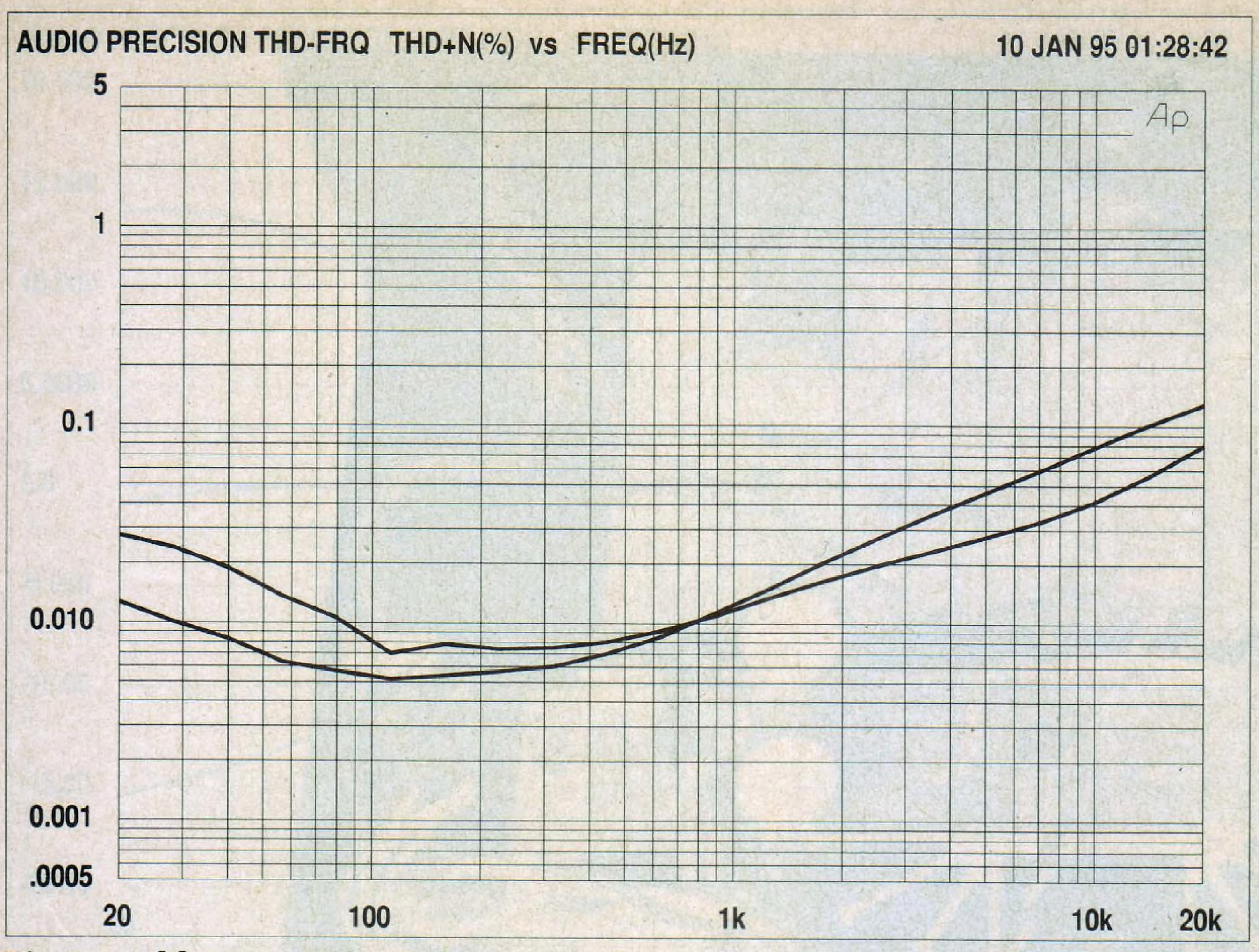


Fig.5: total harmonic distortion versus frequency at 30W into 8Ω loads, for both channels.

1kΩ series resistor and a shunt 220pF capacitor. This is an RF suppression capacitor.

The voltage gain of the power amplifier is set 23 by the 22kΩ negative feedback resistor from pin 3 to pin 9, in conjunction with the 1kΩ resistor and 47μF capacitor.

The output from IC4 drives the loudspeaker via an RL network consisting of a 10Ω resistor in parallel with an inductance of 0.7μH. This acts in conjunction with the Zobel network comprising the 5.6Ω resistor and 0.1μF capacitor to ensure that the amplifier is stable under varying load conditions.

Power supply

The power supply uses a 50V centre-tapped 160VA transformer feeding a bridge rectifier and two 4700μF 50VW capacitors. Positive and negative 3-terminal regulators fed by paralleled pairs of 330Ω resistors provide the ±15V supply rails to the preamplifier boards (ie, tone control board and optional RIAA preamplifier). Fig.5 shows another aspect of the amplifier's performance: harmonic distortion versus frequency at 30 watts into 8Ω loads.

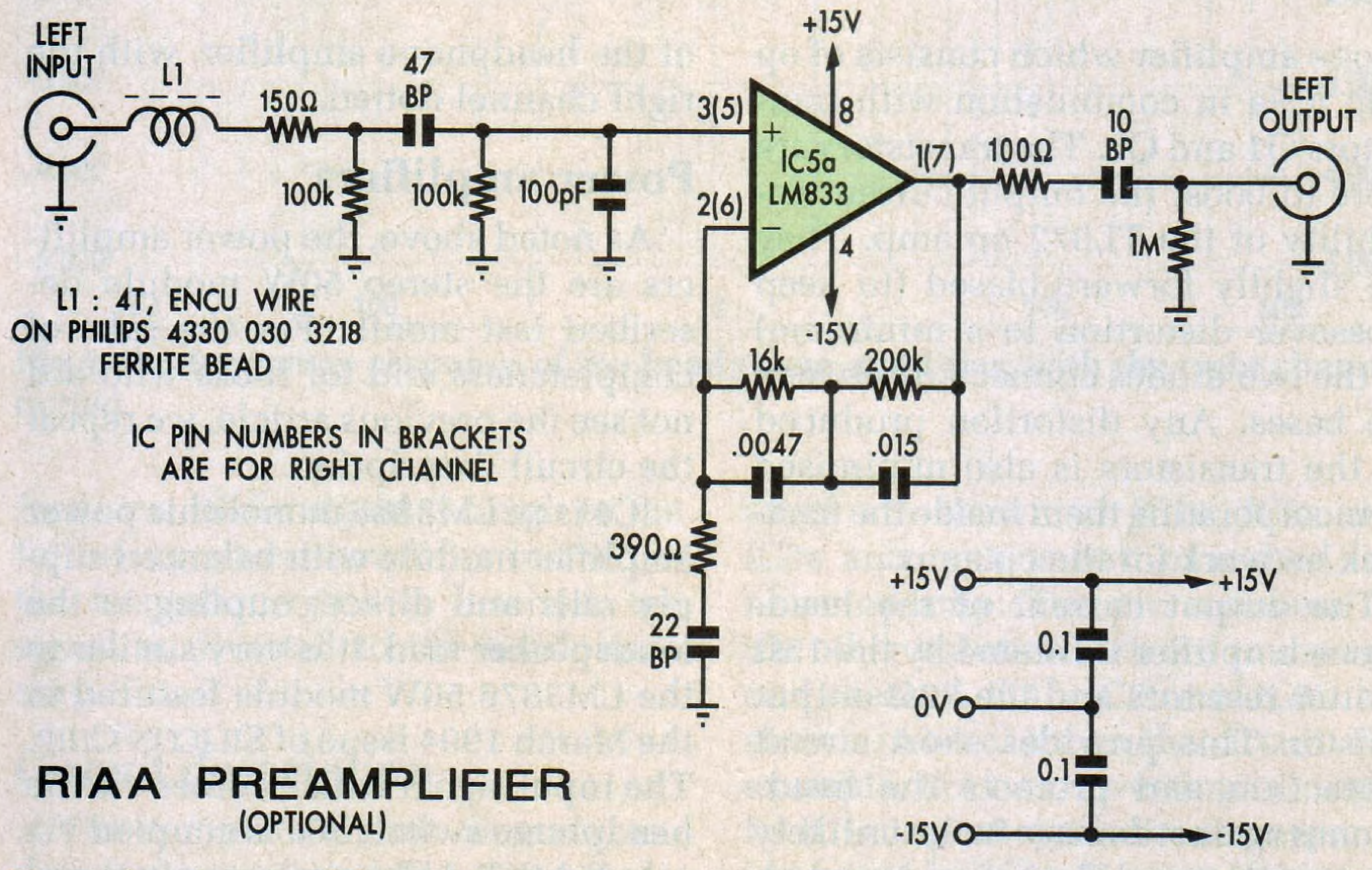


Fig.6: the circuit of the optional RIAA preamplifier is based on an LM833 dual low noise operational amplifier.

Phono preamplifier

As noted above, this phono preamplifier is optional. The circuit is depicted in Fig.6 and again, only one channel is shown. IC5a is one half of an LM833 low noise op amp. It takes the low level signal from a moving magnet cartridge and applies a gain of 56 at the median frequency of 1kHz. Higher frequencies get less gain while lower frequencies get considerably more, as called for in the RIAA equalisation. The preamplifier board is the same as the universal preamplifier board presented in the April 1994 issue of SILICON CHIP.

The phono signal is fed directly from the input socket via inductor L1, a 150Ω resistor and a 47μF bipolar capacitor to the non-inverting input, pin 3, of IC5a. The inductor, series resistor and 100pF shunt capacitor form a filter circuit to remove RF interference signals which might be picked up by the phono leads.

The 100pF capacitor is also important in capacitive loading of the magnetic cartridge. Most moving magnet (MM) cartridges operate best with about 200-400pF of shunt capacitance. The 100pF capacitance in the preamp input circuit plus the usual 200pF or so of cable capacitance for the pickup leads will therefore provide about the right shunt capacitance.

For its part, the 47μF bipolar capacitor is far larger than it needs to be as far as bass signal coupling is concerned. If we were merely concerned with maximising the bass signal from the cartridge, then an input coupling capacitor of 0.47μF would be quite adequate. At 20Hz, a capacitor of this value would have an impedance of around 15kΩ which is considerably less than the nominal 50kΩ input impedance of the preamp.

However, having a large input capacitor means that the op amp "sees" a very low impedance source (ie, essentially the DC resistance of the cartridge) at low frequencies and this helps keep low frequency noise, generated by the input loading resistors, to a minimum.

RIAA/IEC equalisation

The RIAA equalisation is provided by the RC feedback components between pins 1 and 2 of IC5a. These

PARTS LIST

1 steel case with aluminium front panel, 435 x 90 x 265mm
1 2-pole, 6-position rotary switch, Altronics S-3022 (S1
3 2-pole 2-position pushbutton switches, Altronics S-1410 (S2,S3,S5)
1 single pole 12-position rotary switch, Altronics S-3021 (S4)
1 SPST 250VAC rocker switch, Altronics S-3210 (S7)
1 dual-gang 50kΩ log potentiometer (VR1)
1 dual-gang 100kΩ linear potentiometer (VR2)
1 dual-gang 25kΩ linear potentiometer (VR3)
1 PC mounting 6.5mm switching stereo socket, Altronics P-0076
3 3 x 2-way RCA socket panels, Altronics P-0213
1 black binding post terminal, Altronics P-0264
3 22mm diameter black aluminium knobs, Altronics H-6213
2 30mm diameter black aluminium knobs, Altronics H-6224
1 3-way mains terminal strip
2 solder lugs
1 toroidal power transformer, 2 x 25V, 160VA
1 M205 panel mount fuse holder
1 2A M205 20mm fuse
8 20mm fuse clips
4 2.5A M205 20mm fuses
2 single sided heatsinks, 72mm high, Altronics H-0522
2 TA11B IC mounting kits
3 3-way PC terminal blocks, Altronics P-2035
23 PC pins
7 15mm tapped standoffs
4 3mm x 6mm untapped standoffs
4 4M x 10mm screws
11 3M x 10mm screws
2 3M x 15mm screws
10 3M x 6mm screws
9 3M nuts
6 black No.6 x 10mm self-tapping screws
1 1-metre length 0.5mm enamelled copper wire
1 1-metre length twin shielded audio cable
3 1-metre lengths 32 x 0.2mm hookup wire (three different colours)
1 3-core mains cord & moulded 3-pin plug
1 cordgrip grommet (to suit mains cord)
4 rubber feet
1 6.4mm shaft coupler
1 6.4mm dia. x 144mm long extension shaft
1 LED bezel

PC boards
1 power amplifier board, code 01102951, 247 x 58.5mm
1 input selector board, code 01103951, 132 x 58mm
1 selector switch board, code 01103952, 55 x 37mm
1 tone control board, code 01103953, 277 x 86mm
1 RIAA preamp board (optional), code 01103954, 76 x 78mm

Semiconductors
2 LM833 operational amplifiers (IC1,IC2)
1 TLO72 operational amplifier (IC3)
2 LM3886 audio power amplifiers (IC4)
4 1N914 signal diodes (D1,D2)
2 BC337 NPN transistors (Q1)
2 BC327 PNP transistors (Q2)
1 KBPC10-04 bridge rectifier (BR1)
1 LM7815T 3-terminal regulator (REG1)
1 LM7915T 3-terminal regulator (REG2)
1 red LED (LED1)

Capacitors
2 4700μF 50VW electrolytics
4 100μF 63VW electrolytics
2 47μF 63VW electrolytics
8 100μF 16VW electrolytics
2 47μF 16VW electrolytics
2 22μF 16VW electrolytics
2 22μF 50VW bipolar electrolytics
2 6.8μF 50VW bipolar electrolytics
4 1μF 63V MKT polyester
10 0.1μF 63V MKT polyester
1 .01μF 250VAC metallised paper
2 .01μF 63V MKT polyester
4 .0047μF 63V MKT polyester
2 220pF 50V ceramic
2 100pF 50V ceramic
4 33pF 50V ceramic

Resistors (0.25W, 1%)

2 100kΩ	4 1.6kΩ
2 91kΩ	12 1kΩ
2 47kΩ	2 820Ω
2 39kΩ	4 330Ω 1W
12 22kΩ	2 100Ω
2 15kΩ	2 82Ω
4 10kΩ	4 15Ω
4 5.6kΩ	2 10Ω 1W
8 4.7kΩ	2 5.6Ω 1W
1 3.9kΩ 0.5W	

Optional RIAA Preamplifier
1 RIAA preamp board, code 01103954, 76 x 78mm
11 PC pins
1 LM833 operational amplifier (IC5)
2 Philips ferrite beads, 4330 030 3218

Capacitors
2 47μF 50VW bipolar electrolytics
2 22μF 50VW bipolar electrolytics
2 10μF 50VW bipolar electrolytics
2 0.1μF 63V MKT polyester
2 .015μF 63V MKT polyester
2 .0047μF 63V MKT polyester
2 100pF 50V ceramic

Resistors (0.25W, 1%)

2 1MΩ	2 390Ω
2 200kΩ	2 150Ω
4 100kΩ	2 100Ω
2 16kΩ	

equalisation components provide the standard time constants of 3180μs (50Hz), 318μs (500Hz) and 75μs (2122Hz).

The preamplifier also adds in the IEC recommendation for a rolloff below 20Hz (7950μs). This is provided by the 22μF bipolar capacitor in series with the 390Ω resistor. The 390Ω resistor sets the maximum AC gain at very low frequencies while the 22μF capacitor ensures that the gain for DC is unity. This means that any input offset voltages are not amplified, which would inevitably cause trouble with asymmetrical clipping and premature overload in the preamplifier.

Next month, we shall continue with the construction details for the new 50W Stereo Amplifier. **SC**