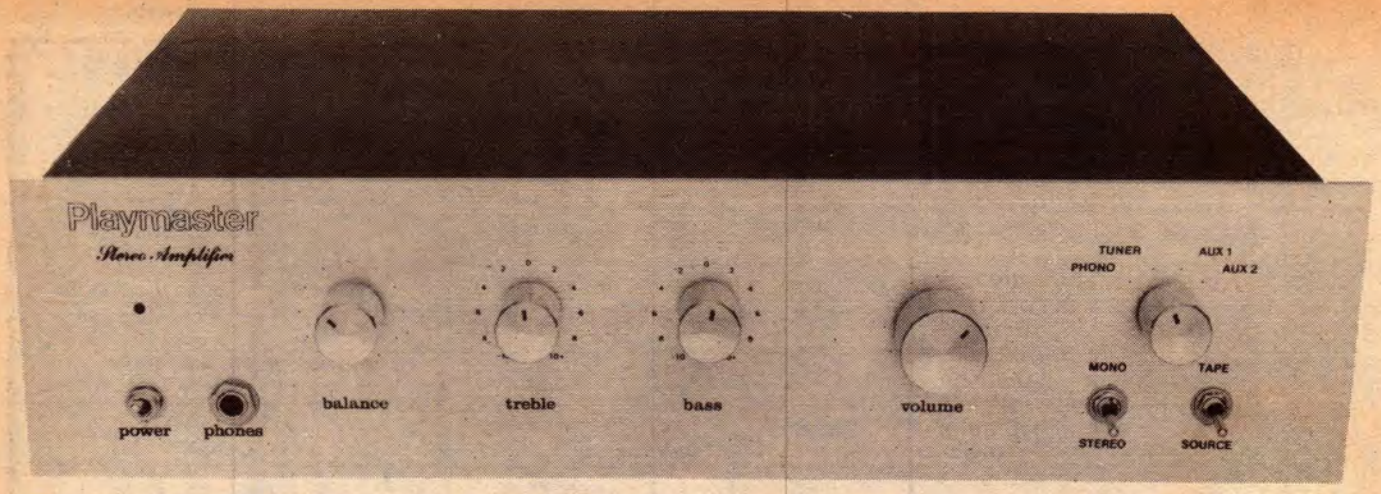


A Playmaster Amplifier for flats and home units

Second article gives the construction details

Last month we introduced our new Playmaster Twin Ten stereo amplifier, explaining the basic design concept and discussing the circuit details of the input and control stages. In this issue, we cover the power stages and present the remainder of the constructional information.

by RON De JONG

The configuration of the output stage is well established for amplifiers of modest power and uses no more components than is necessary for good design.

The output transistors TIP31 and TIP32 are arranged in complementary symmetry. They are driven by a class-A stage composed primarily of a BD140 transistor and four 180-ohm resistors in series-parallel as its collector load circuit.

The particular transistors in each channel — driver and output pair — are of flat plastic pack construction, intended for direct attachment to a heat sink. We mounted them underneath the PC board in such a way that they could be bolted directly to the chassis base. Accordingly, the transistor leads are bent upwards and soldered to the track side of the board.

The arrangement is simple and economical and has the advantage that the PC board can be removed from the chassis without having to unsolder the power transistors — an important consideration should access for servicing be required.

Comparison with the output stage of the Twin 40 shows that, whereas a constant current load was used for the driver in the Twin 40, a bootstrapped arrangement is employed here. Besides using one less transistor, in line with the basic philosphy of this amplifier, the available supply voltage is utilised to better advantage.

The role of the 220uF boostrapping capacitor deserves special mention.

Under quiescent conditions, the minus side of the capacitor is at chassis potential, while the plus side is at about +10V DC. The value of the capacitor is such that it tends to maintain this charge, even under full signal conditions.

During one half of the output cycle, the output stage emitters will fall from an approximate 20V (quiescent) towards 0V, thereby cycling the voltage at the loudspeaker output terminal from 0V towards -20V. At the same time, the bootstrapping capacitor will cycle the junction of the 180-ohm resistors from +10V towards -10V, thereby extending the effective supply to the driver and augmenting the available voltage drive to the TIP32.

If the output transistors were to operate from a true zero ambient current condition, "switching" or "crossover" distortion would assume major proportions. In practice, it is normaly to arrange the bias so that both output transistors draw a small amount of current under no-signal conditions. With drive, and on the respective half-cycles, one transistor is driven towards saturation, while the other passes into full cut-off.

To be pedantic, one should really describe the condition as "class AB".

Estimated cost

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

$85

This includes sales tax.

Not surprisingly, crossover distortion tends to fall as the quiescent current is increased — but at a price: higher average dissipation in both the output transistors and the power supply. The designer must therefore aim for a value of quiescent current which represents an acceptable trade-off between distortion and power dissipation.

In a complementary configuration, as here, the two output transistors take their signal drive from a common source but, to meet the foregoing bias requirement, each base must be referenced to a DC potential slightly positive or negative with respect to the common emitter potential. This means that they must be separated by a resistor or network such that each can assume its own required bias.

A purely resistive network is seldom favoured because the critical bias voltage may vary with supply. Again, it offers no easy way of countering possible "runaway" if high ambient temperature causes the output transistors to draw more current than they should.

It is for this reason that such bias networks often include one or more diodes between the two bases: Not only do diodes afford a measure of regulation but, in reacting to high ambient temperature, they can reduce bias and counter possible output stage runaway.

In the Twin Ten, we have taken the further step of bridging the bases of the output pair with a transistor (Q10), exactly as in the two earlier amplifiers. In this configuration the biasing transistor is often referred to as an "amplified diode" but we prefer the term "Vbe multiplier" as being rather more descriptive of its role.

The transistor configuration has the merits of the diodes mentioned earlier but, in addition, the collector/emitter voltage drop can be varied by means of the 100-ohm pot in the base circuit. This, of course, represents the voltage between the bases of the output pair, so that the 100-ohm preset pot provides a ready means of setting the quiescent current.

Ahead of the class-A driver is a BC549 voltage amplifier (Q6), with the input signal fed to its base and feedback to its emitter.

Because the stages are DC coupled with overall DC feedback, the bias applied to the base of the BC549 determines the mean potential at which its own emitter will stabilise, along with that of the bias network and the emitters of the output stage. In fact, the input bias network (100k, 100k and 220k) was selected with the aid of a CRO for symmetrical clipping and maximum power output. You can verify the choice if you want to but, in practice, and with the use of 5% resistors, voltages should work out closely enough, without further ado.

Incidentally, the 47uF capacitor between the two 100k bias resistors provides essential decoupling to minimise hum injection into the base of the Q6. The capacitor must be rated to operate at more than 30V and must not be old or leaky, otherwise it will upset the bias levels.

Overall gain of the power amplifier is set by the ratio of the two emitter resistors connected to Q6. For the values specified, 1.5k and 150 ohms, the gain is about 11.

To ensure stability of the amplifier at supersonic frequencies, a 180pF capacitor was added between the emitters of Q6 and Q7. In addition, there is a "Zobel" R/C network across the output and an L/R combination to help cope with the highly reactive nature of typical loudspeaker loads.

Headphone sockets have also been provided as in the Twin 25 and Twin 40 but the resistors in series with the headphones have been decreased from 330 ohms to 220 ohms to provide a higher proportion of the available power. The sound level with headphones, in fact, subjectively approaches the author's threshold of pain and should satisfy even the most masochistic pop music enthusiast!

As stated earlier, the power output into loudspeakers is about 10W per channel continuous, or 12W on intermittent music peaks. This can sound very loud indeed if fed into loudspeakers of medium (or better) efficiency. Low efficiency loudspeakers

Performance of prototype

POWER OUTPUT

	One channel	Both channels
4 ohms	8W	7W
8 ohms	12W	10W
16 ohms	8W	7W

FREQUENCY RESPONSE

Phono inputs	RIAA equalisation within 1dB from 30Hz to 20kHz
High level inputs	30Hz to 30kHz ±1dB

CHANNEL SEPARATION

(with respect to 8W into 8 ohms)
1kHz -51dB; 10kHz -43dB

INPUT SENSITIVITY

Photo (1kHz)	2.8mV
Overload at 1kHz (.4% distorition)	150mV
High levels inputs	115mV

HUM & NOISE

(with respect to 10mV)

Phono	68dB unweighted
High level inputs	68dB unweighted with 4.7k input load

TOTAL HARMONIC DISTORTION

(Both channels driven into 8 ohms)
1kHz: 0.14% at 1W; 0.3% at 4W; 1.5% at 10W.

TONE CONTROLS

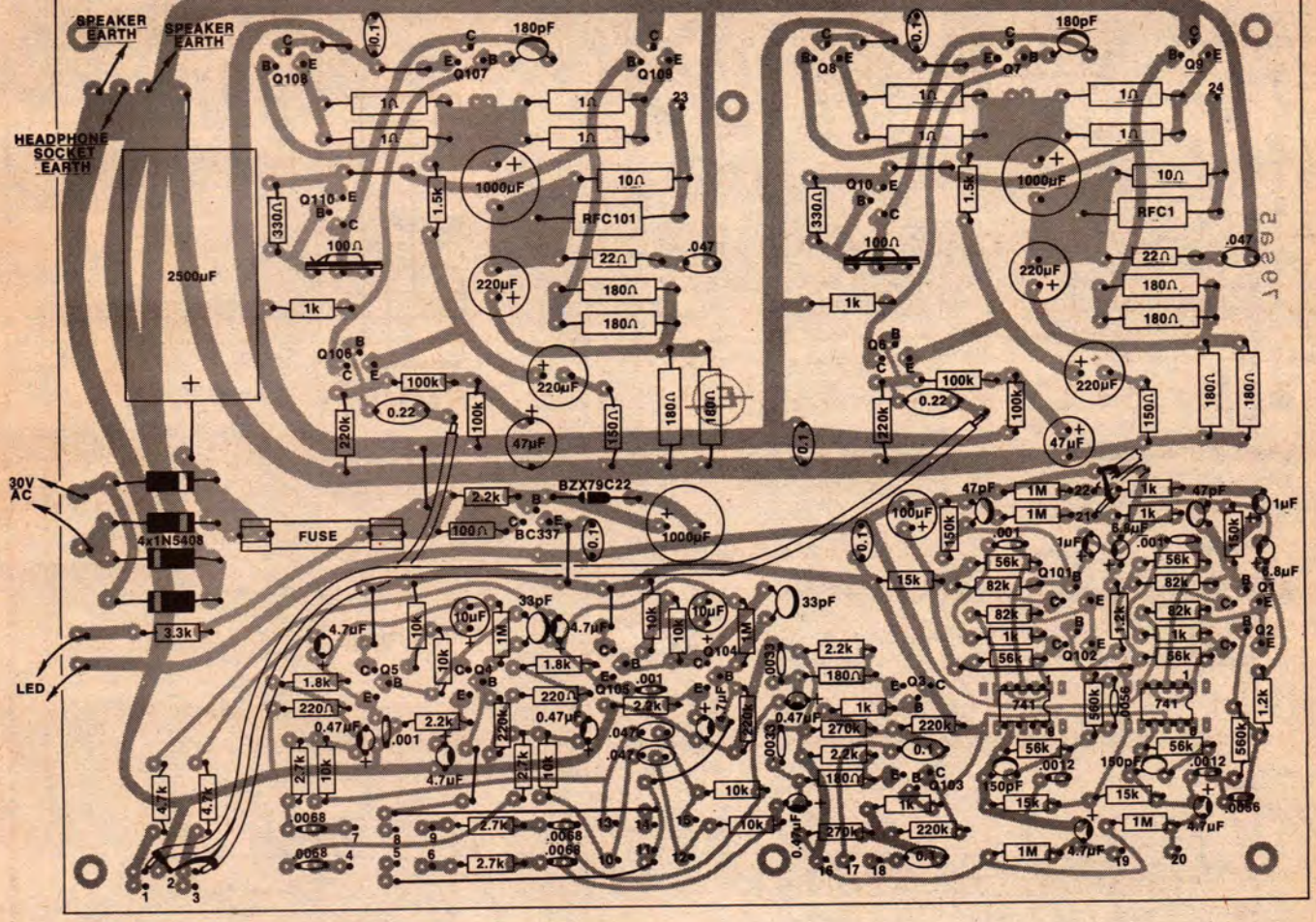
Bass	±12, -13dB at 50Hz
Treble	±13dB at 10kHz

DAMPING FACTOR

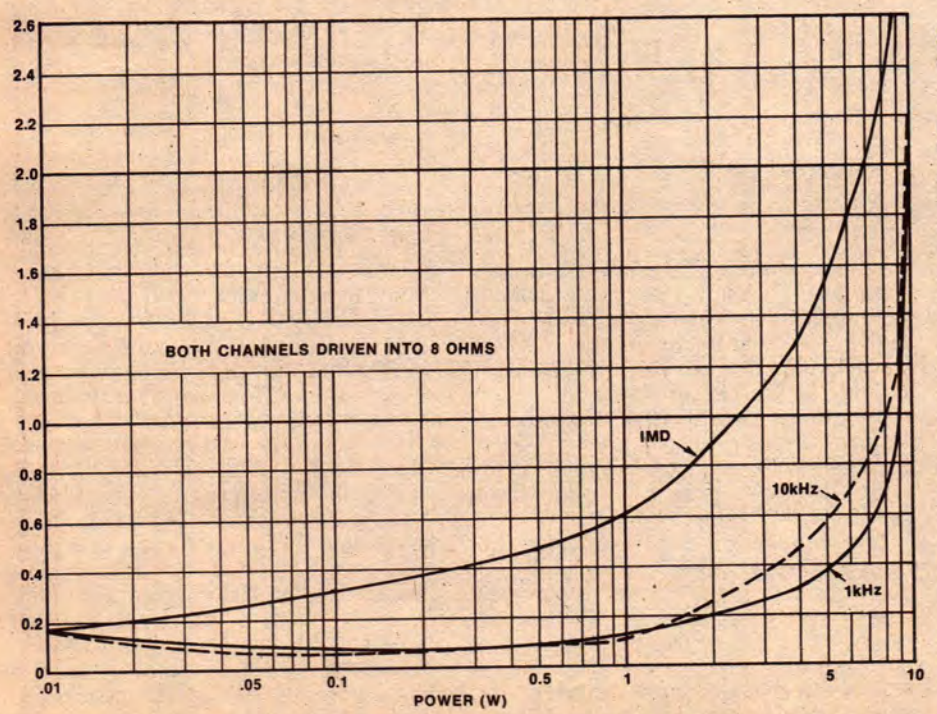
at 1kHz	24
at 50Hz	8

STABILITY

Unconditional



The PC board layout for the Playmaster Twin 10 amplifier. Exercise care when inserting polarised components.



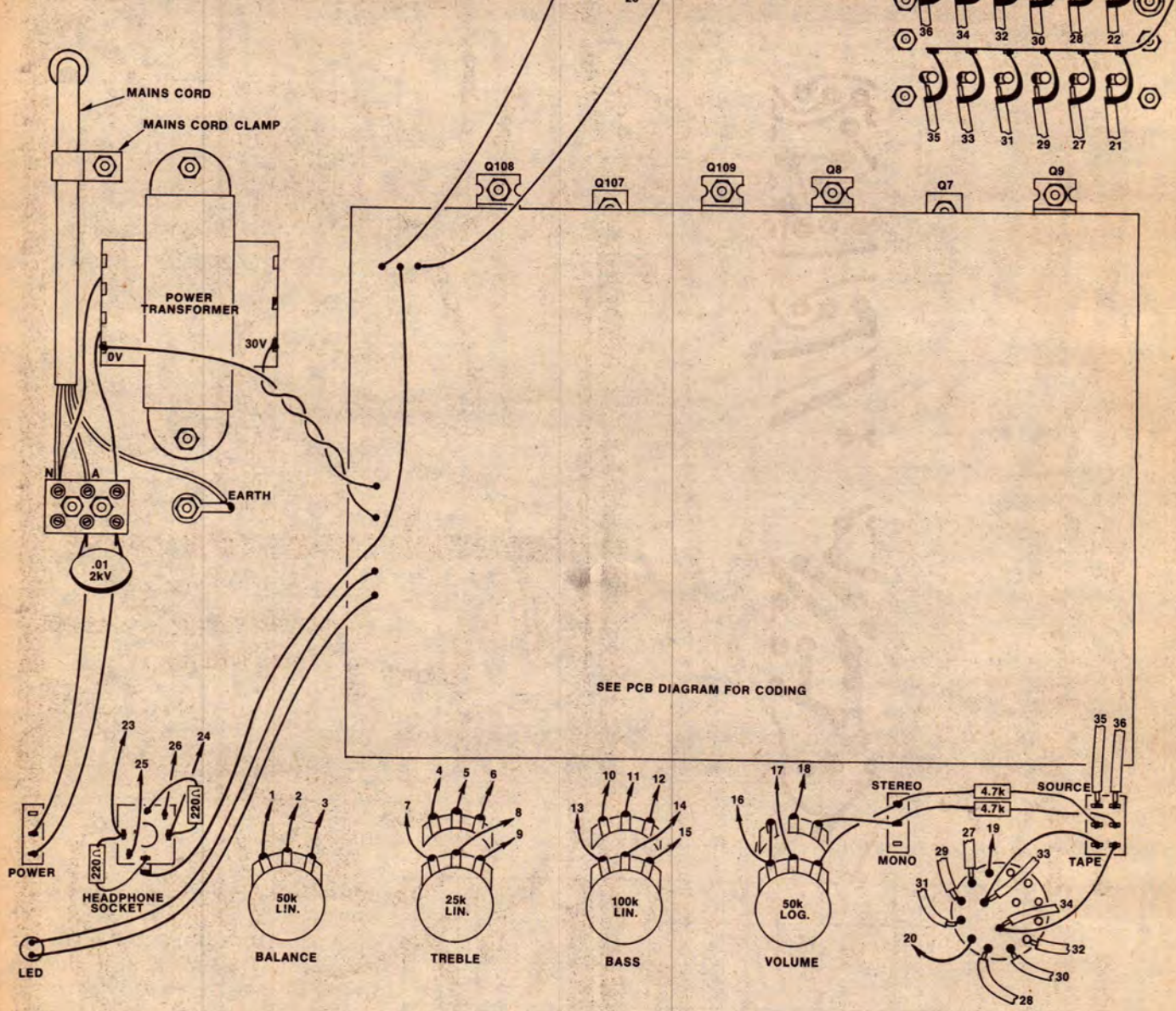
This shows harmonic distortion at 1kHz & 10kHz, also intermodulation distortion.

intended for high-powered amplifiers would not be a good choice.

As indicated by the accompanying curves, the harmonic distortion at typical listening levels is likely to be around 0.1%, which would be well below the level likely to be imposed by the program source and peripheral equipment. In fact, it is not all that long since "point one" was a target for the world's big-name amplifiers!

Looking now to a few general features of the amplifier, inspection of the PC board layout will indicate that three separate earth conductors have been used: one each to the low level stages, the input stage to the power amplifier, and to the output transistors. This precaution minimises common earth paths, and hence the possibility of interstage feedback and ripple injection.

For similar reasons, the circuitry is earthed to the chassis at one point only, namely at the phono inputs. Since the headphone jack has to be connected to the PC board earth system, it should be insulated from the chassis metalwork



Use this diagram in conjunction with the PCB layout to complete the amplifier wiring.

with appropriate plastic washers. If these cannot be obtained, cut a suitable thickness of plastic sheet to shape and wrap the bush of the headphone socket with insulating tape.

Although two 1 ohm 1W resistors have been specified for the emitter resistors of the power transistors, holes are provided on the PC board for single .47ohm higher wattage resistors if these are more convenient.

The choke referred to as RFC1 in the circuit diagram is constructed by winding one and a half turns of insulated wire on a 13mm balun core. Use normal hookup wire for the choke and bring the leads out on either side, as in the photograph.

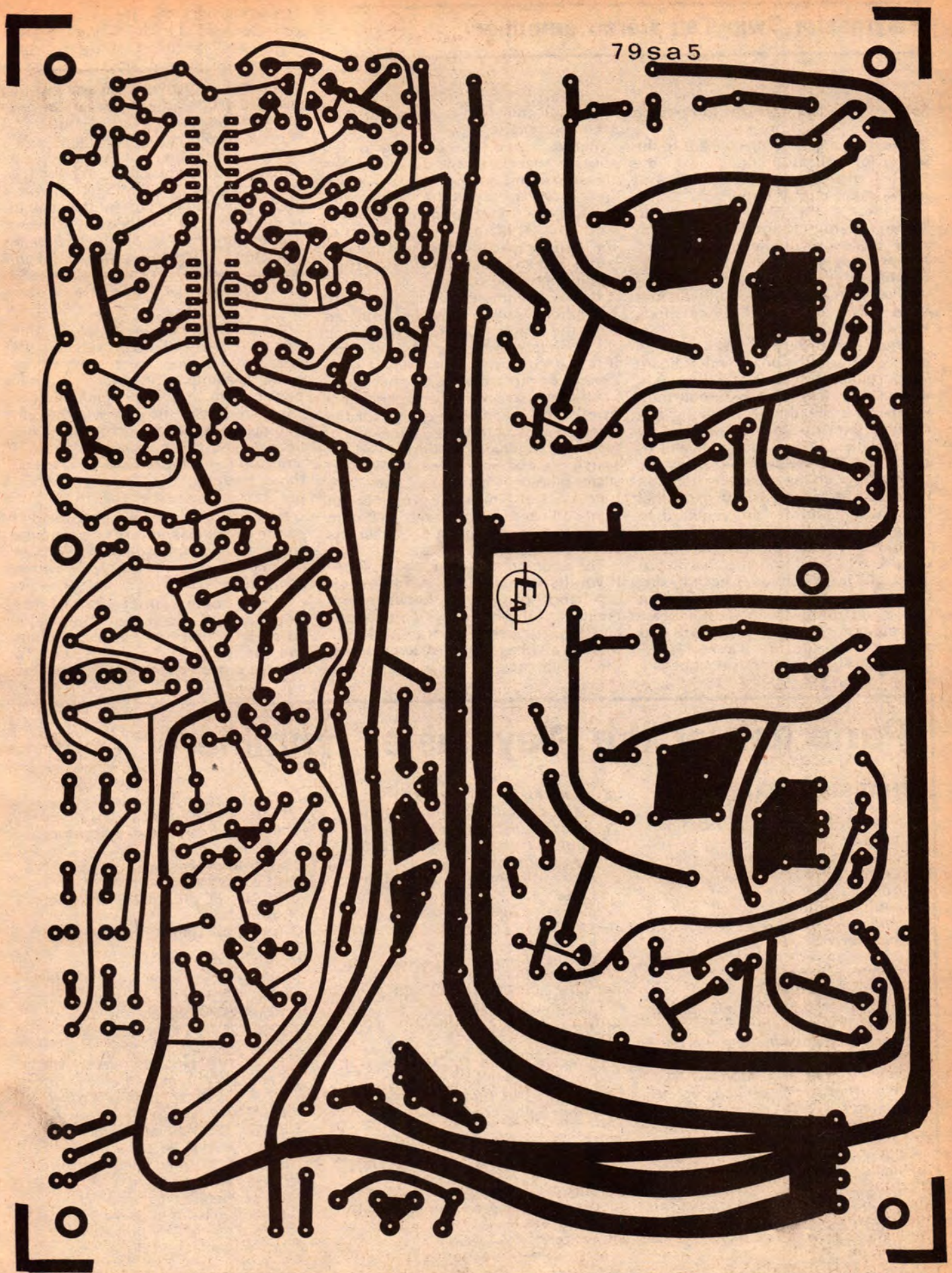
Construction should begin by mounting all components on the PC board. Particular attention should be paid to connecting the tantalum and electrolytic capacitors with the correct polarity (refer to the component overlay or the circuit diagram).

Mounting the transistors should present no special problem, unless you get involved with equivalent types. In this case, double-check the connections before wiring them into circuit.

The power diodes must also be oriented, so check these carefully. If you are still unsure "fire up" the power supply with the fuse and electrolytic removed to check the polarity of the DC output.

Next solder the power and driver transistors to the PC board. These should be oriented so their metal faces come into contact with the chassis when the board is mounted. Bend the leads up about 2mm from the body and insert them through their respective holes in the PC board so that the leads just emerge from the top of the board; solder only one of each of the transistor leads.

Insert the board supports in the holes provided on the PC board, then manipulate the transistors so that their metal faces are all at the same level as the base of the plastic supports and the mounting holes of the transistors are aligned wilth those on the chassis. Mount the board temporarily on the chassis to check that the transistors are properly positioned and, if all is well,



Here is an actual size reproduction of the PC board pattern.

solder the remaining leads to hold the transistors firmly in place.

The next step is to attach leads to the board for ultimate connection to the tone controls, transformer and loudspeaker output terminals.

The lead to the tone controls should be kept as short as possible and " rainbow" cable is recommended both for a neater appearance and to aid lead identification. The use of PC stakes is also recommended, since this permits wires to be reconnected without lifting the whole board.

After all the external leads have been attached, insert the board and its board supports into the chassis and prepare to anchor the driver and output transistors. This should be done by first sticking the TO-220 mica washers in place with silicone grease if this is available. Then push the insulating bushes through the mounting holes on the chassis and the transistor. (Note that no insulating bushes are required to mount the BD140 transistors).

Hopefully the power transistors should be isolated from the chassis, but don't take it for granted. Check by disconnecting the phono inputs from the chassis and testing with a multimeter for continuity between the chassis and any part of the circuitry. If a short is discovered, unbolt the transistors one at a time until the short is removed; then take appropriate action.

Before wiring up the spring loaded speaker sockets, swap two of the terminals around so that the two active (red) terminals are in the middle. This reduces the risk of accidental shorts to earth and facilitates the connection of the .047uF capacitors between speaker earths and chassis via the lugs attached to the mounting screws.

It was mentioned earlier that the headphone socket must be insulated from the chassis so, before connecting the earth lead to the socket, check that it is in fact insulated by using a multimeter or other continuity checker.

Add the mains wiring and check that every thing is complete except for the shielded cabling to the selector switch. Now the amplifier can be readied for switch-on and setting of the output stage quiescent current. Centre the tone controls, turn the volume pot right off and adjust both 100-ohm preset pots so that the BC547 collectors are shorted directly to base.

The optimum current is about 30mA. If you have an accurate millivoltmeter on hand, connect it between the emitters of the respective output pairs and adjust the relevant trim pots until there is a voltage drop of 30mV across the 1 ohm circuit.

Alternatively, cut the link in the collector lead of each TIP31 and bridge it with a milliammeter. Adjust the trimpot for a reading of 30mA.

Yet again, a 100 ohm resistor can be inserted temporarily in place of the link and the current adjusted to produce a drop of 3 volts across 100 ohms.

There is a tendency for the quiescent current to drift after being set but this is quite normal and is nothing to worry about provided the current stays within reasonable limits. Check the current again after the amplifier has been operated for 10 minutes with the lid on. If the current is now above 50 milliamps, reduce it back to 30 and leave it.

If your amplifier doesn't work, note that there are two links provided on the board which allow the supply voltage to the pre-amp, tone controls and the power stage to be independently disconnected. With the power to the output stage removed, the board need not be mounted to the chassis, so the preamp and tone controls can be checked through without the danger of the output transistors overheating.

Note also that the voltages provided on the circuit diagram are only nominal and that the actual voltages measured in your amplifier need only be within about 10%.

When correct operation of the amplifier has been verified, the shielded cables to the tuner auxiliary inputs and tape should be connected. To achieve a neater appearance bind the

Parts list for the Playmaster amplifier

CHASSIS & HARDWARE

- 1 transformer A&R 6672, Dick Smith M-6672
- 1 plated steel chassis 370 x 80 x 245mm (W x H x D) with cover
- 1 front panel
- 5 knobs to suit front panel
- 2 miniature SPST toggle switches
- 1 miniature DPDT toggle switch
- 1 6.5mm stereo jack socket with switch contacts
- 1 LED for pilot light
- 2 6-way RCA socket panels, Ralmar M421 or equivalent
- 1 4-way spring loaded terminal panel, Ralmar ST3 or equivalent
- 1 rotary 2-pole, 4 position switch
- 1 100k (lin) dual ganged potentiometer
- 1 50k (log) dual ganged potentiometer
- 1 50k (lin) potentiometer
- 1 25k (lin) dual ganged potentiometer
- 2 100 ohm large vertical trim pots
- 6 Richo CBS-6N PC board supports
- 4 rubber feet
- 8 solder lugs
- 1 mains cord clamp and grommet
- 1 3 way insulated terminal block
- 1 three pin mains plug and three core mains cable
- 1 metre of 10 conductor rainbow cable
- 2 metres of figure-8 shielded cable
- 6 sets of TO-220 mounting hardware, ie, mica washers, insulating bushes, plus screws and nuts
- 2 .047uF/100VW ceramic or polyester capacitors
- 1 .01uF 1kV ceramic
- 1 PC board, 79sa5
- 2 fuseclips, Swan (McMurdo) FC1 Part No. 1397-01-18
- 1 1.5 amp 3AG fuses
- 2 13mm balun cores

PRINTED CIRCUIT BOARD

SEMICONDUCTORS

- 4 IN5408 or 100PIV 2 amp silicon diodes
- 1 BZX79/C22 zener diode
- 2 TIP31 silicon power transistors
- 2 TIP32 silicon power transistors
- 2 BD140 silicon power transistors
- 12 BC549, BC184 NPN low noise transistors
- 1 BC337 NPN transistor
- 2 BC547, BC107, BC182 NPN transistors
- 2 uA741 op amp ICs

CAPACITORS

- 1 2500uF/50VW pigtail electrolytic
- 3 1000uF/25VW PC electrolytic
- 2 100uF 25VW PC electrolytic
- 4 220uF 25VW PC electrolytic
- 2 47uF/35VW PC electrolytic
- 2 10uF/25VW tantalum electrolytic
- 2 6.8uF/25VW tantalum electrolytic
- 6 4.7uF/25VW tantalum electrolytic
- 2 1uF/25VW tantalum electrolytic
- 4 0.47uF/25VW tantalum electrolytic
- 2 0.22uF metallised polyester
- 7 0.1uF/60VW metallised polyester (greencap) or ceramic
- 4 .047uF metallised polyester
- 4 .0068uF metallised polyster
- 2 .0056uF metallised polyester
- 2 .0033uF metallised polyester

Special points to watch

- ☆ *transistor lead configuration*
- ☆ *insulation of the output transistors from chassis*
- ☆ *single point earthing at the point specified*
- ☆ *insulation of the headphone socket*
- ☆ *setting up procedure*

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cables together with cable ties, or if this is unavailable lace the cables together with ordinary hookup wire.

In use, and operating with no signal or at very low volume, the amplifier base will become merely warm to the touch. If it becomes hot under these conditions, there would be clearly something amiss, with the chance that the quiescent current has been inadvertently set too high. With protracted high level operation, the chassis will become noticeably warmer but certainly not such as to be described as "hot".

But there it is: having listened at some length to the prototype, both in the laboratory and in the home, one can only say that its performance completely belies its modest power rating.

2 .0012uF metallised polyester or polystyrene
4 .001uF metallised polyester or polystyrene
2 180pF ceramic or polystyrene
2 150pF ceramic or polystyrene
2 47pF ceramic or polystyrene
2 33pF ceramic or polystyrene

RESISTORS
(5% tolerance ¼W, unless otherwise noted) 6x 1M, 2 x 560k, 2 x 270k, 6 x 220k, 2 x 150k, 4 x 100k 4 x 82k, 6 x 56k, 8 x 10k, 4 x 4.7k, 1 x 3.3k, 4 x 2.7k, 5 x 2.2k, 2 x 1.8k, 2 x 1.5k, 2 x 1.2k, 8 x 1k, 2 x 330 ohms, 4 x 220 ohms, 2 x 180 ohms, 2 x 150 ohms, 2 x 100 ohms, 2 x 22 ohms 1W, 8 x 180 ohms 1W, 2 x 10 ohms 1¼, 8 x 1 ohm 1W, or 4 x 0.47 ohm 5W.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Where voltage ratings are not quoted, they should be 50V or more. Components with higher ratings may also be used provided they are physically compatible.