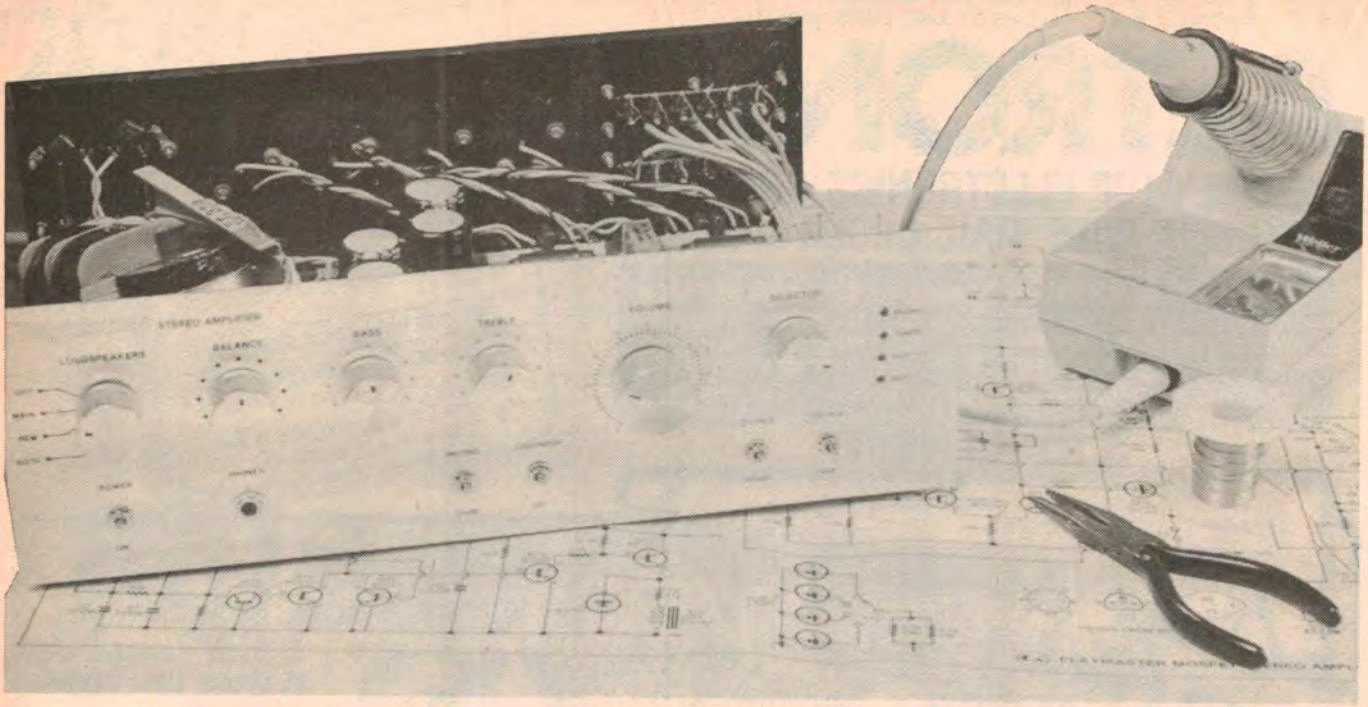


Playmaster Mosfet Stereo Amplifier

In this third and final article on the Playmaster Mosfet Stereo amplifier, we complete the details of construction, detail a number of options and give a trouble-shooting procedure.

By LEO SIMPSON

Several points concerning the PC board remain to be discussed before we can proceed to the chassis assembly.

Some holes on the PC board layout provided last month appear to be unused. However, only two of these, behind the relay are actually unused. We can account for all the others. Those adjacent to terminal 41 on the PCB should be used for loudspeaker (earth) returns. And those underneath the reservoir capacitors are provided for the additional securing lead on each 2500μF capacitor.

Similarly, alternative mounting holes are provided under the trimpots for standard upright types. We used Bourns tenturn trimpots because they are less critical to adjust and less likely to be knocked out of adjustment by clumsy handling of the PC board. Regardless of which type of trimpot is used, you will have to use a small screwdriver with an insulated shaft to make the adjustments.

Two tasks remain in the assembly of the PC board. First, install a length of figure-8 shielded cable between the balance control connections and the power amplifier input connections, pins 1, 2, 3 and 34, 35, 36 and 37, respectively. This cable is shown on the chassis wiring diagram and should be routed as shown in the chassis photographs.

Finally, solder a 100Ω/5W resistor across each pair of fuseholders on the PC board (the fuses should not be installed). These resistors perform two functions during setting up of the amplifier. First, they provide a convenient means of monitoring the quiescent current of the amplifier output stages. Second, they provide safe current limiting in the event of a circuit fault in the amplifier.

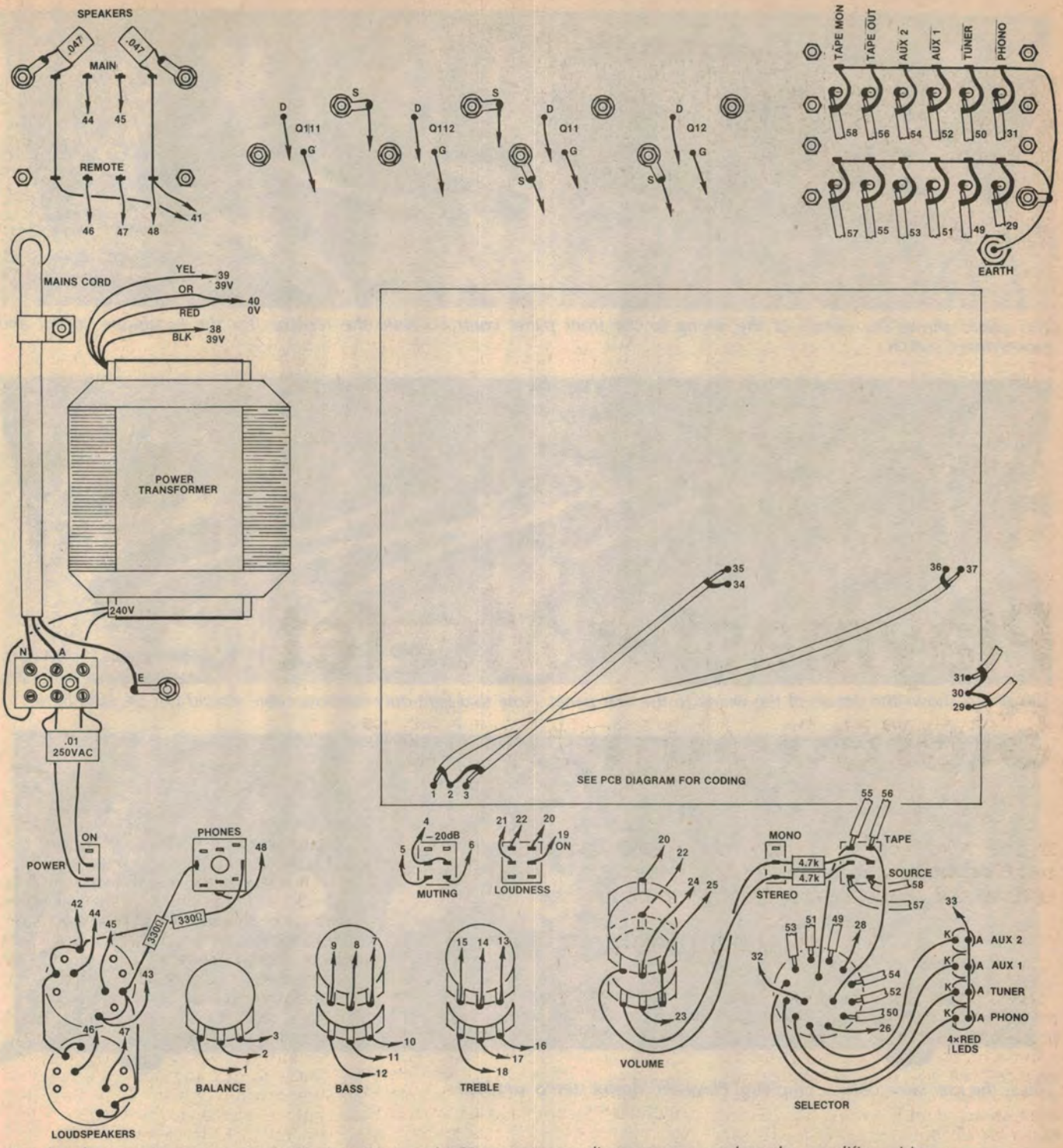
With the circuit board complete, go over it very carefully to check that all components are correctly installed as far as their values and polarity are concerned. Do the same on the copper side of the board, checking that each and every solder joint is good. That done, put the board aside and start work on the chassis.

A first step in the chassis assembly is to check, as far as possible, that all holes are correctly placed and of correct size. For example, you can check that all controls and switches actually fit in their respective holes and that the transformer mounting holes are correct. Check too, that the dress front panel holes line up with those on the chassis. The idea behind these checks at this point is to drill and debur any required holes now rather than later when metal swarf may find its way into potentiometers or other components.

Start by mounting the smaller hardware first, such as the RCA phono input panels and the spring-loaded loudspeaker terminals. Note that a number of solder lugs are attached at the same time as these panels. The chassis wiring diagram shows where these are located.

Swap one pair of red and black terminal covers on each spring loaded terminal panel so that the red terminals are in the centre of each panel. The idea behind this is to minimise the possibility of damaging shorts between the output leads.

A binding post terminal should be installed just below the phono inputs to



Use this diagram, in conjunction with the circuit and PCB component diagram, to complete the amplifier wiring.

provide an earthing point for those turntables which have a separate earth lead for the tone arm.

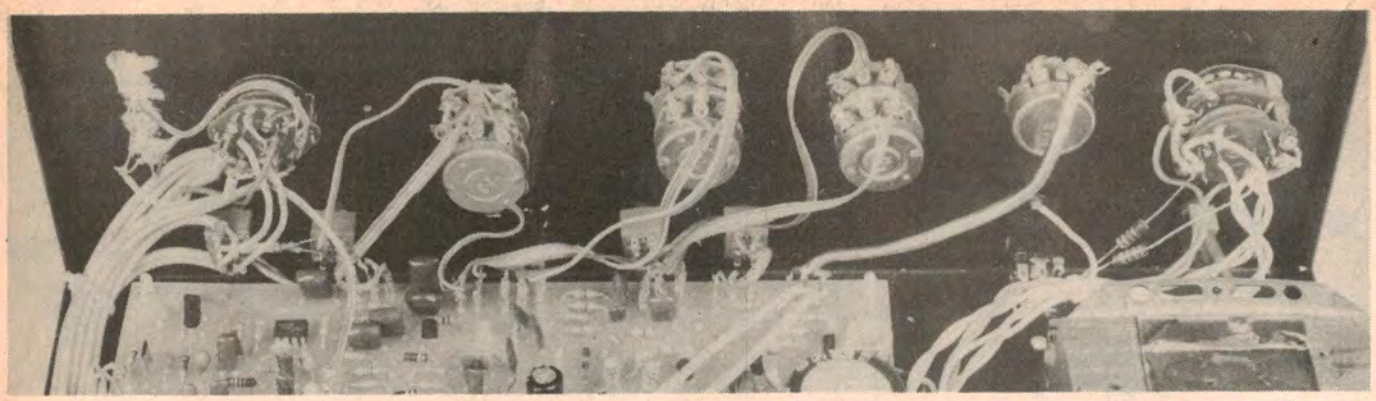
Do not mount the dress front panel until the amplifier has been completely checked out and is working satisfactorily. By leaving the dress panel until all other work has been completed you avoid the possibility of scratches on the panel.

Cut the shafts of the potentiometers and rotary switches to a length about 11 or 12mm, before they are installed in the chassis. Note that each of these controls should be spaced away from the inside of the chassis by the thickness of one nut so that, when the dress panel is finally installed, the potentiometer and switch bushes do not protrude unduly.

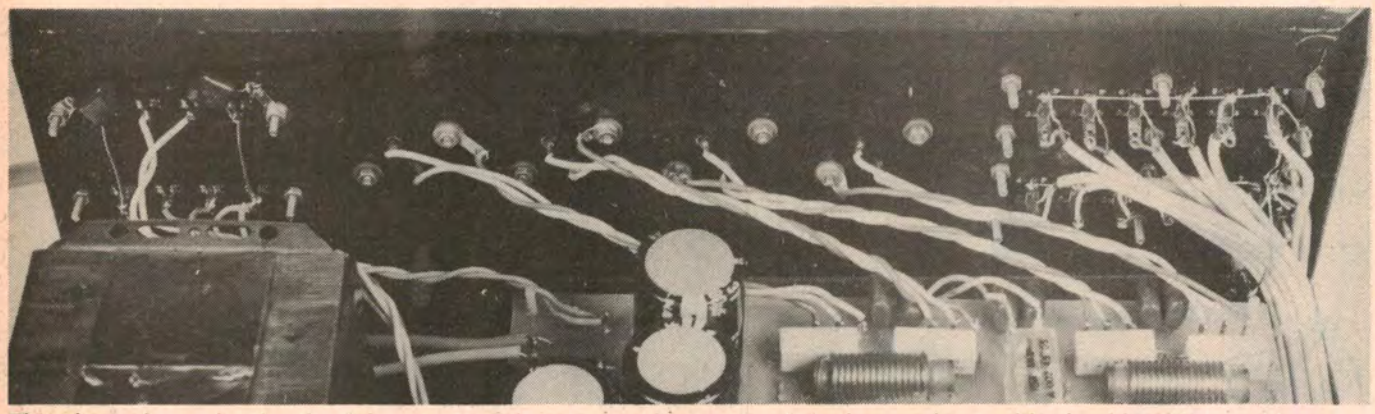
The loudspeaker switch is a 4-pole, 4-position type. At present, two types are available: One is a Lorlin type RA, distributed by C&K Electronics (Aust) Pty Ltd and available from most parts suppliers; the other is from Dick Smith Electronics. The switches may employ make-before-break or break-before-make contacts – it is not critical. Neither switch is intended to switch heavy currents although they can both carry the relatively high currents involved.

The headphone socket can be a non-switching type instead of the switching type which we used (because we had it on hand). The 330Ω resistors to the headphone socket are wired directly between the relevant terminals on the speaker switch and the socket itself. These resistors should be ½W or 1W types, to avoid the possibility of overheating when listening at high levels to the headphones.

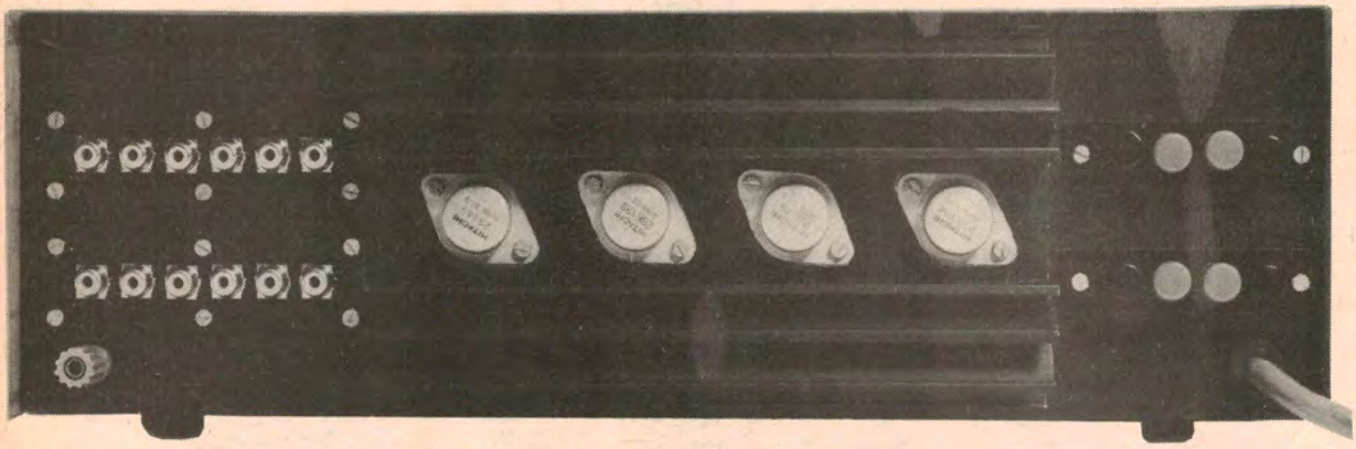
The headphone socket should be in-



This photo shows the details of the wiring to the front panel controls. Note the resistors for the headpone socket and mono/stereo switch.



This photo shows the details of the wiring to the rear panel. Note that light-duty rainbow cable should not be used here.



This is the rear view of the completed Playaster Mosfet stereo amplifier.

sulated from chassis and a separate earth return run back to the loudspeaker terminal panel (shown as connection 48 on the chassis wiring diagram). Insulate the headphone socket using two fibre washers and insulating tape. Alternatively, you can make your own washers out of suitable plastic sheet. The insulation tape is wound around the bush of the socket where it passes through the chassis and, ultimately, through the front panel.

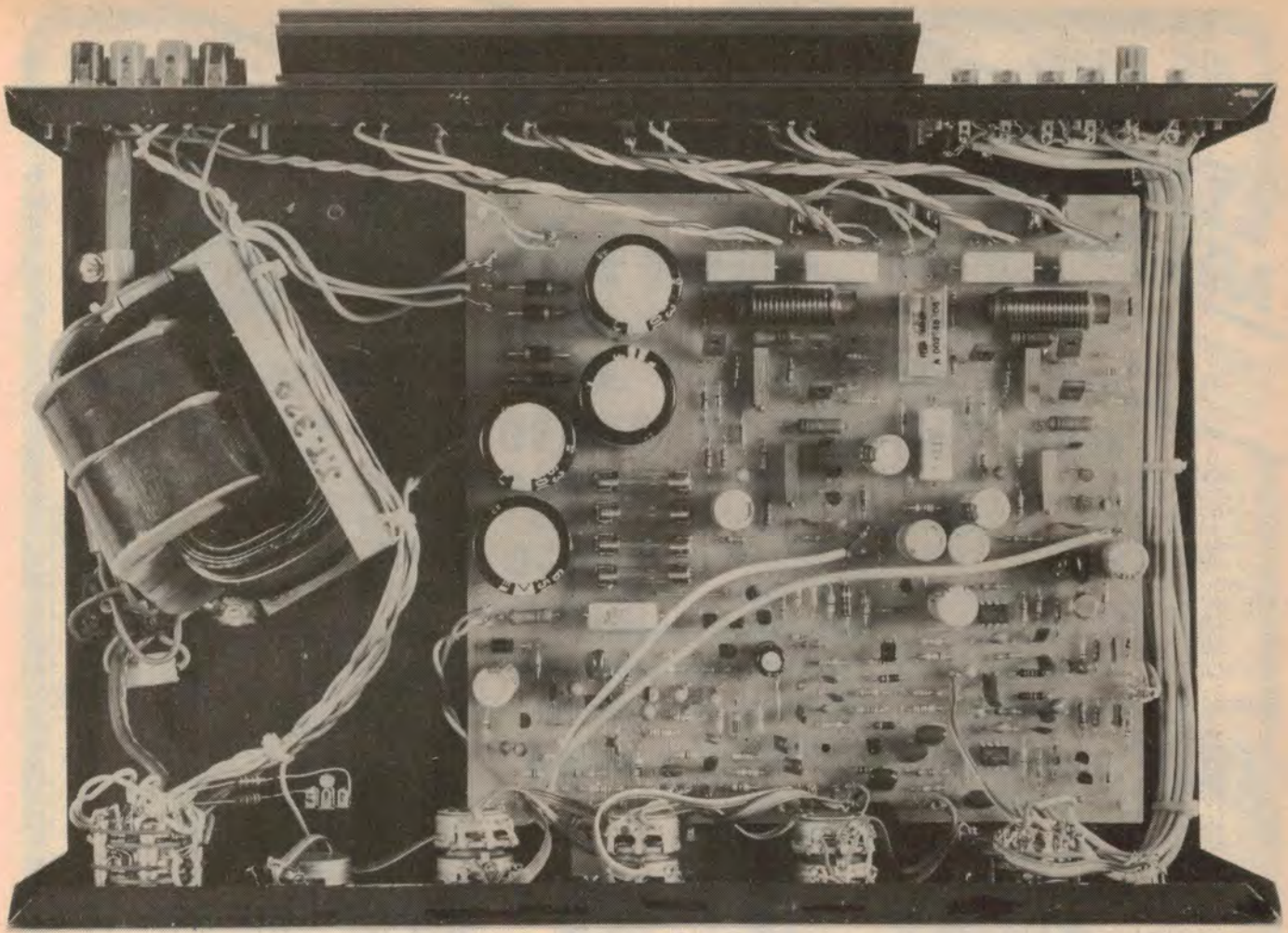
When the headphone socket is mounted and connected, check that it is, in fact, isolated from chassis by using a multimeter switched to one of the high resistance ranges.

Similarly, the 4.7KΩ resistors between the Tape Monitor and Stereo-Mono switches are wired directly between the switches themselves. In this case, the resistors should be sleeved with spaghetti or Nylex tubing to prevent the likelihood of shorts.

The output transistor heatsink is secured to the chassis via the various mounting screws of the TO-3 output transistor packages. Once again, you should carefully examine the heatsink to ensure that all holes line up exactly with the corresponding holes in the chassis. Also make sure that the transistor mounting surfaces are flush and free of any metal swarf or burrs.

The Mosfet output transistors are mounted in the same way as conventional bipolar transistors having TO-3 cases. Use mica washers and insulating bushes to isolate the transistors from heatsink and chassis, as depicted in the diagram on page 61.

Note that the Mosfet output transistors do not have the connections you might expect if you are familiar with bipolar power transistors. The Source is in fact connected to the transistor case rather than the Drain, as you might expect. Take great care not to transpose the Gate and Drain connections otherwise you are sure to end up with damaged transistors.



This photo shows how the wiring from the Speaker Selector to the Speaker terminals is attached to the C-core transformer.

The mains cord should be passed through a grommetted hole in the rear of the chassis and anchored with a cord clamp. Terminate the mains active (brown or red) and neutral (blue or black) wires to the insulated terminal block and solder the earth (green or green with yellow stripe) wire to a solder lug near the transformer.

The mains switch has a 0.01μF interference suppression capacitor wired across it, at the insulated terminal block. Keep the leads to this capacitor reasonably short and sleeve them if necessary with Nylex and spaghetti to prevent them from contacting the chassis (or the user). This interference suppression capacitor must be rated for 250VAC operation. This means that it must either be a metallised paper or dual dielectric (paper plus polyethylene terephthalate) type rated at 250VAC, a metallised polypropylene type with a rating of 250VAC or 1kV or 1600VDC or a ceramic disc capacitor rated at 2kV or higher.

Do not use polyester or polypropylene capacitors rated at 630VDC or 220VAC. They could be a potential fire hazard.

Mount the transformer as shown in the photographs and chassis wiring diagram. Note that the Jones C-core transformer has an odd orientation, to minimise hum. Whichever transformer is used, the primary connections should be near the on/off switch while the secondary connections are to the rear.

Wiring from the input sockets to the Selector and associated switches can now be installed, with the shields all terminated to the common earth "bus" around the input sockets. This bus is soldered to a solder lug retained by the input panel mounting screw close to the binding post terminal. The cable shields are not terminated at the Selector switch. The cable shields for the phono input are terminated at the PC board, when it is installed. Note that the phono input cable must be run first, before that for the tuner and auxiliary inputs.

Cut and dress the input cables so that they lie together neatly, as in the photographs. Use three cable ties to hold the cables in position.

Flat ribbon cable can now be run from each potentiometer section, and from the associated toggle switches. Each cable should be of an appropriate length and stripped and tinned at the free end, ready for termination to the PC board.

By way of explanation, flat ribbon cable usually comes in 10 strand form – just peel off as many strands as needed and cut to length.

On the loudspeaker terminal panels, connect the two outside earth connections together with 16-gauge tinned copper wire and then install two .047μF capacitors from the "earths" to solder lugs on the chassis. These capacitors must not be omitted as they help maintain amplifier stability and suppress mains-radiated interference.

Now you can mount the PC board into the chassis. Terminate the transformer secondary wires directly to the PC board (do not use PC pins for these three connections) and then mount the PC board using six Richco plastic supports. Both the board and chassis should be drilled for these supports.

Make all connections exactly as shown in the chassis wiring diagram. Do not use ribbon cable to make the connections to the Mosfet output transistors or the loudspeakers – it does not have sufficient current rating. Instead, use conventional hook-up wire such as 10 × 0.2mm or heavier.

Connecting leads to the output transistors should be kept as short as possible and twisted together for neatness. Keep these leads away from the input socket panels, or instability could result.

If you are using the Jones C-core

transformer do not dress and bind the loudspeaker wiring permanently at this stage. You will have to find the optimum wiring dress in a procedure we will outline later.

With all the wiring complete, double-check all your work to ensure that no mistakes have been made. You are now almost at the stage where power can be applied. Set the trimpots associated with the power amplifier inputs to midpoint and the trimpots for quiescent current adjustment (between the collectors of Q9 and Q10) to minimum resistance. Do not connect loudspeakers or dummy loads at this stage. Disconnect the power amplifier inputs at pins 35 and 37 on the PC board.

Now apply power and measure the supply voltages which are shown on the circuit diagram. Note that these are approximate only. Now check that the amplifier output voltages, at the junction of the 0.56Ω/5W resistors in each channel, are close to 0V. That being the case, you can set the quiescent current. This is done by measuring the voltage across one of the 100Ω 5W resistors installed across the fuseholder clips.

Adjust the appropriate trimpot to obtain 7.0 volts across the resistor, coinciding with a quiescent current of 70 milliamps. Later checks of this voltage will probably show that the current drifts but provided it stays within about ±10mA or so there is no cause for worry.

Note that it is immaterial whether you measure the voltage across the 100Ω resistor in the positive or negative supply rails to each power amplifier – the reading will be the same. Just make sure that you measure the voltage across one of the appropriate resistors, dependent on which channel you are adjusting. Looking at the PC board from the front, the two fuseholders for the righthand power amplifier are closest to the front, with that closest being in the negative supply rail.

The quiescent output voltage at the output of the power amplifiers should preferably be adjusted with the aid of an accurate digital multimeter which has polarity indication, so that the voltage can be adjusted to within a few millivolts of 0V. Failing that, a conventional multimeter switched to the lowest available DC voltage range will do the job, although the final setting will probably not be as good. (Note that, in theory, greater sensitivity could be obtained from a conventional multimeter when switched to the lowest available current range, eg, 50μA, but the strong possibility of inadvertently damaging the meter movement makes it inadvisable!)

This adjustment is fairly touchy in nature but it should be possible to set the quiescent output voltage to within ±5mV of 0V. The trimpots in question are the ones associated with Q6 and Q7 in each channel.

Now connect loudspeakers and the connections on the PC board at pins 35 and 37. With the volume control set fully anti-clockwise, listen closely to the loudspeakers for any extraneous hum and noise. With typical loudspeakers and in a quiet room, the noise level should be very low. Turning up the volume control should not increase the noise level markedly, except in the case of the phono input which should have a magnetic cartridge connected (or be short-circuited) for minimum noise output.

As noted previously, it is possible to optimise the loudspeaker wiring "dress" for minimum hum output, if the C-core transformer has been used. Reference to the relevant chassis photo will show that the loudspeaker wiring is bound into a cable form with ties and attached to the topmost edge of the transformer clamp (with a suitable adhesive). The best position for this cable form can be found by monitoring the residual hum output from both channels by using a pair of stereo headphones (the more sensitive, the better).

Those who have access to an audio oscillator will be able to orient the tone control potentiometers accurately so that when set to zero they are flat. For the treble control the "flat" position is very close to the mechanical centre of the resistance element but for the bass control, the flat setting is closer to "2".

If these checks are okay, turn off the power and wait until the reservoir capacitors discharge, as indicated by one of the LEDs. Now install the 2A fuses and you are in business. Select program source and listen to your heart's content.

Providing that all these checks are to your satisfaction, you may then install the front panel.

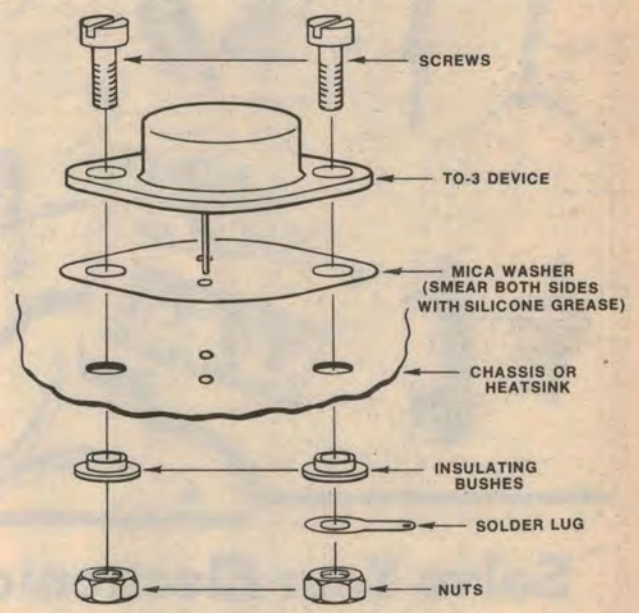
For those who have been unlucky enough to be unable to obtain correct operation, we sympathise with you and now provide some notes on trouble-shooting.

Trouble-shooting in the power amplifiers should be performed with the 100Ω 5W resistors wired across the fuseholders in place of the 2-amp fuses. If a fault is present which causes heavy current drain, the resistors will get very hot but they will generally prevent damage to the ourput stage. This means that you can work on the amplifier without worrying about burning up expensive output devices.

Even so, you should take care while trouble-shooting. The total DC voltage in the power amplifiers is 100 volts or so, which can give you a nasty belt! By the same token, avoid touching the output transistor cases when the amplifier is delivering high power.

Tabulated below are the voltages at all the key points in the circuit. These were taken with the amplifier under no-signal conditions, with volume control at minimum setting, tone controls and balance control centred and with 240VAC input. Note that small changes in the mains voltage will cause equivalent changes in the power amplifier voltages while in the preamplifier, normal component tolerances will cause voltage changes of up to ±10%.

First, we will assume that the positive and negative supply rails are operational. If the negative or positive 15V rails are less than 1V, the likely cause is a short-circuit or reverse-connected zener diode. On the other hand, if these supplies are substantially higher than 15V, then it is likely that the associated zener diode is open circuit. Note that the 15V rails are actually slightly less, at about +13.9 and −14.4V.



This diagram shows the method of mounting the power transistors.

	emitter	base	collector
Q 1	−0.57	−0.015	1.2
Q 2	−0.57	−0.015	1.2
Q 3	6.6	7.2	13.9
Q 4	0.68	1.3	7.5
Q 5	6.8	7.5	13.9
Q 6	0.75	0.15	−47.9
Q 7	0.75	0.15	−47.9
Q 8	−48.6	−47.9	−20.1
Q 9	−48.6	−47.9	−0.5
Q10	48.9	48.3	0.6
Q13	0.0	0.0	0.2
Q14	0.68	0.2	0.0
Q15	0.0	0.0	0.68
Q16	0.0	0.68	0.26
Q17	51.0	50.4	50.9

These are the key voltage readings in the circuit of the new amplifier.

These voltage readings were taken with a digital multimeter having an input impedance of 10 megohms. Readers should note that loading effects of conventional multimeters with a sensitivity of 20,000 ohms per volt will prevent accurate voltage measurements from being taken around Q1 and Q2, and at the bases of Q3 and Q4. The voltages given at the bases and emitters of Q6 and Q7 are notional only and will depend on the matching between the transistors and the setting of the balance trimpots.

A difficulty in using voltage measurements to diagnose faults in amplifier circuits is that negative feedback can often cause the fault conditions to be "reflected" throughout all stages. Worse still, negative feedback may enable an amplifier with a faulty transistor to produce very-close-to-correct operating conditions in all stages. Still, careful analysis of the operating voltages can often give a clue to where the fault lies.

A useful point to remember is that all conducting transistors will have a base-emitter voltage drop of 0.6 to 0.75V. It is also useful to remember that if one channel is fully operational, it can serve as a basis for comparison with the faulty channel.

Trouble-shooting in the power amplifiers should be done with the amplifier inputs at pin 35 and 37 on the PC board disconnected.

If the amplifier output voltages cannot be set to zero, check the base-emitter voltages of Q6 and Q7 (0.6V) and their collector voltages — approximately −48V and equal. If no fault is evident here, continue voltage checks through the stages of the amplifier. If the voltages around Q8, 9 and 10 are wildly askew, check that you have not inadvertently swapped Q10 with Q8 or Q9.

If the amplifier offset voltage is close to zero and the 100Ω protective resistors are dissipating excessive voltage it is likely that the amplifier is oscillating supersonically or drawing excessive quiescent current. Check that the gate connections to Q11 and Q12 are okay. If no variation of the quiescent current can be obtained by varying the appropriate trimpot, try shorting the gates of Q11 and Q12 together. This should drop the quiescent current to zero. If not, one of the Mosfets is probably faulty. If so, the relevant trimpot wiper is probably open-circuit.

Instability in the power amplifiers in the form of supersonic oscillation could be due to the following causes: faulty RLC network in the output stage; faulty 100μF bypass capacitors; open-circuit 100pF capacitor associated with Q8; poor lead dress associated with Q11 and Q12 or with the loudspeaker wiring.

Faulty or open-circuit capacitors can generally be checked by bridging with a capacitor of equivalent value.

Trouble-shooting in the preamplifiers follows similar procedures to those used in the power amplifiers. Remember to leave the 100Ω protective resistors in circuit just in case you drop a meter prod on the PC board or a similar untoward event occurs.

Note that while the output voltage at pin 6 of the TL071 op amps is nominally zero, it can be as high as ±200mV, dependent upon the matching of Q1 and Q2 and the match of the input stage transistors in the TL071. If the output offset is higher than this figure, it is likely that Q1, Q2 or the TL071 op amp is faulty. Do not fall for the trap of forgetting that the op amps are orientated in different directions. You were warned previously!

If any transistors are removed from the circuit as suspect, it is handy to be able to check them with the aid of a multimeter. The range which is usually appropriate is "R × 100 ohms". First check the transistor from collector to emitter in both directions. Each measurement should produce a high resistance reading. Similarly, check the base-emitter and base-collector junctions. These should give high readings in one direction and low readings in the other.

Excessive hum in the amplifier may be a problem caused by some of the abnormal operating conditions already described, or by incorrect layout. But the latter should not occur if the wiring diagrams have been followed explicitly.

ERRATA:

A number of errors have come to light in the parts list for this project, published last month on page 47. In the list of capacitors, delete the 2 x 33uF/50VW electrolytics, and one 47uF non-polarised electrolytic. In the list of resistors, add one 15kΩ/¼W and change the 4 x 0.47Ω/5W to 0.56Ω.