Series 5000 stereo control preamplifier

Part 3

This is the final article describing the design and construction of the Series 5000 preamp. Last month we described the low-level amplifiers — the moving magnet and moving coil input stages. In this article we concentrate on the high-level switching, line and monitor amplifiers, muting and power supply, and complete the construction details.

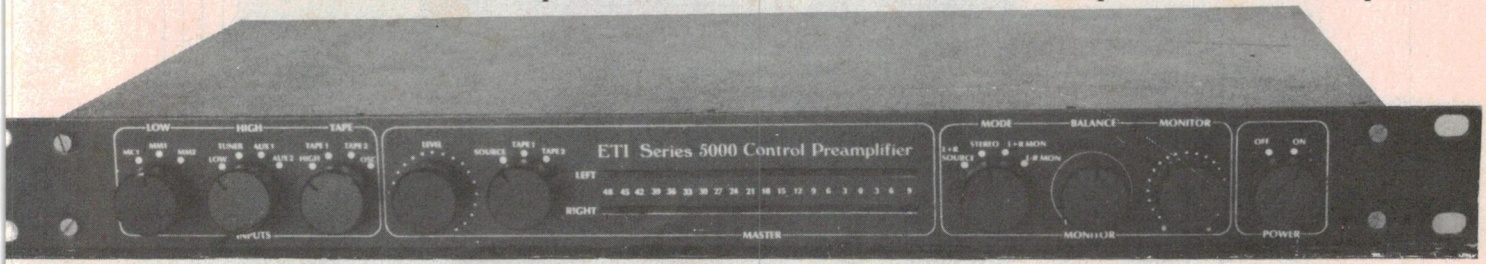
David Tilbrook

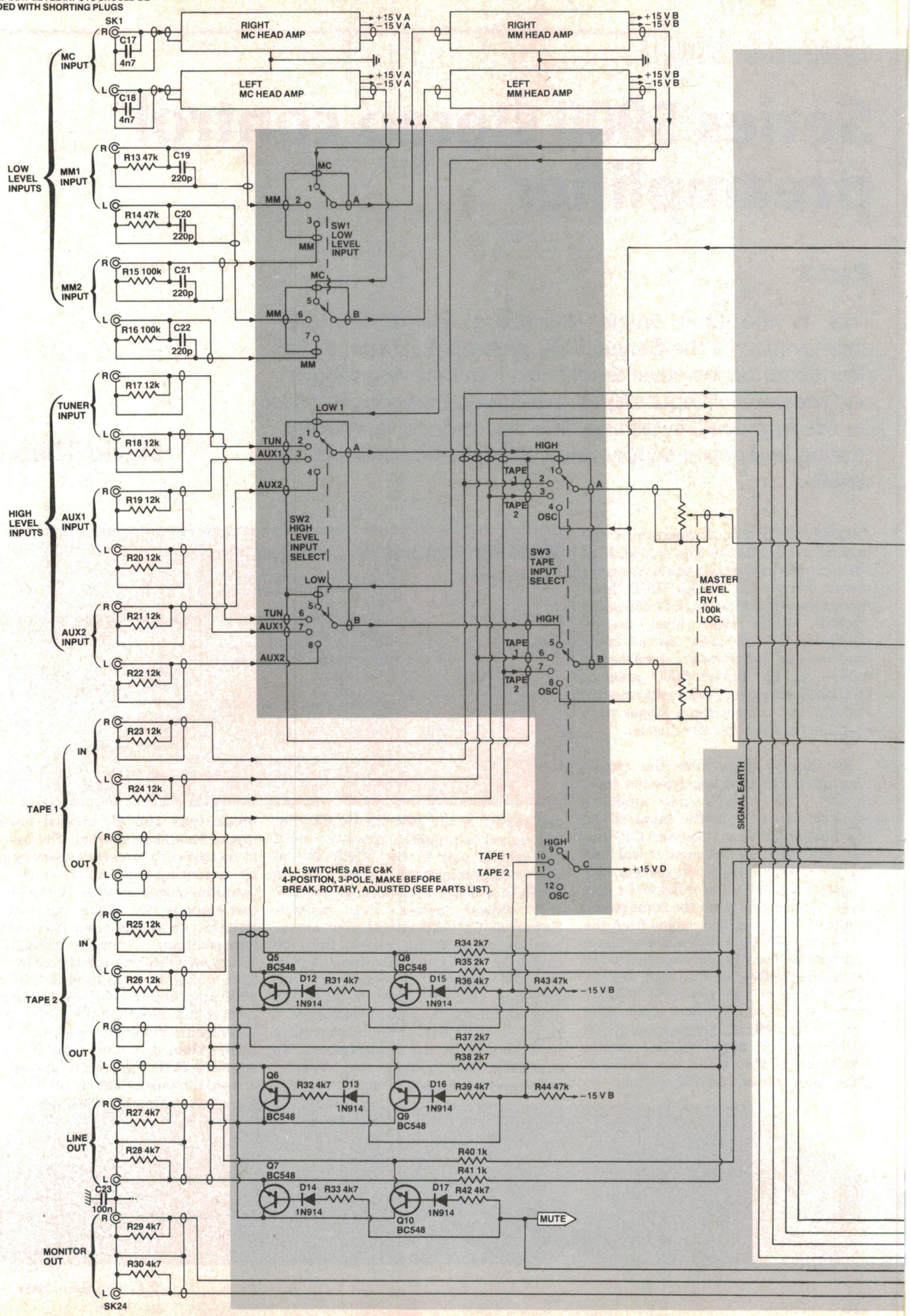
A COMPLETE circuit diagram of the preamp is included in this article, with the sections described in previous issues shown simply as blocks (LED level meters were described in 'ETI-458 peak/average audio LED level meter', published in June 1981; overall block diagram and features were described in part 1 of the Series 5000 preamp, published in the July issue; moving coil and moving magnet input stages were described in the September issue).

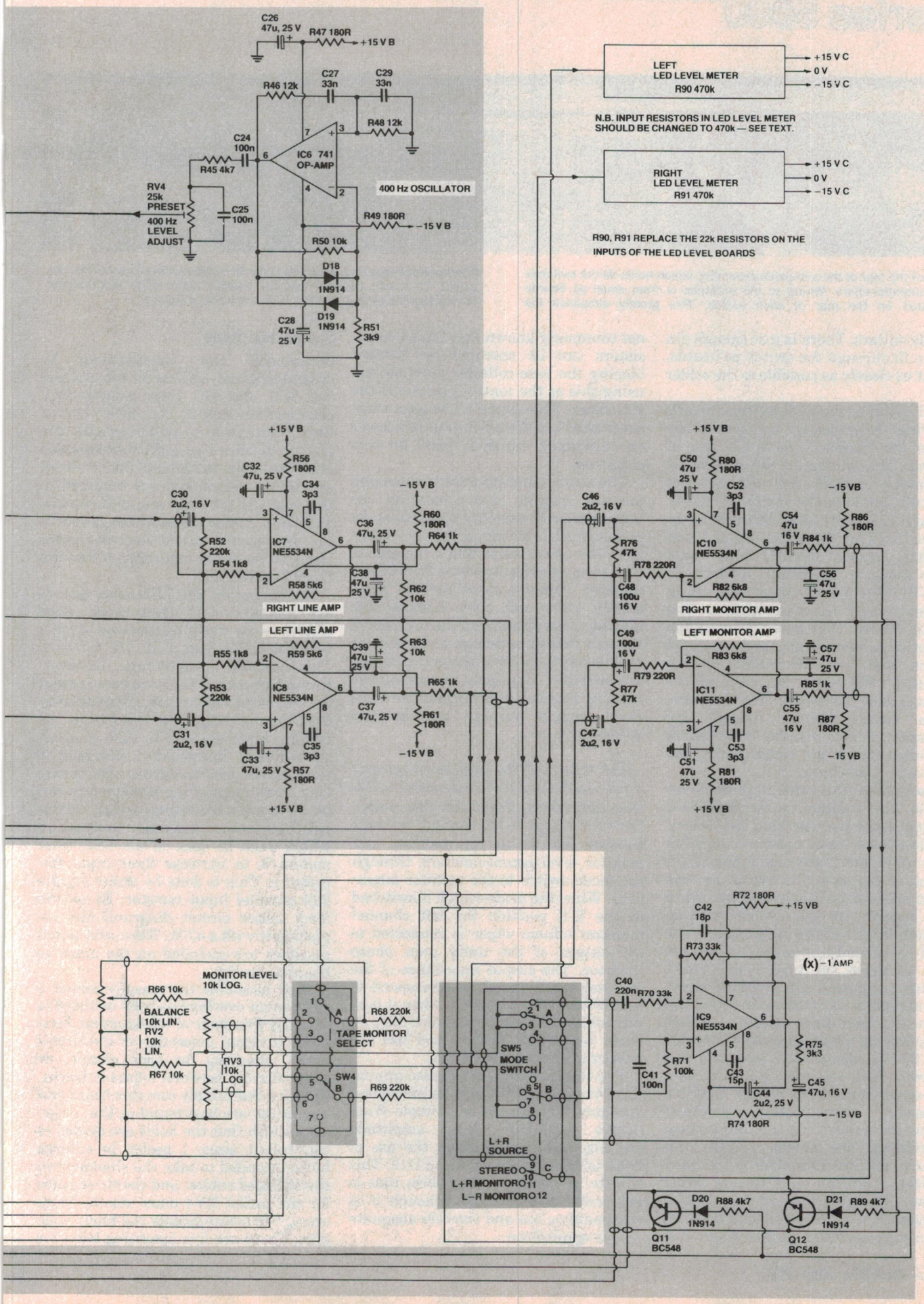
SERIES 5000 PREAMPLIFIER — SPECIFICATIONS

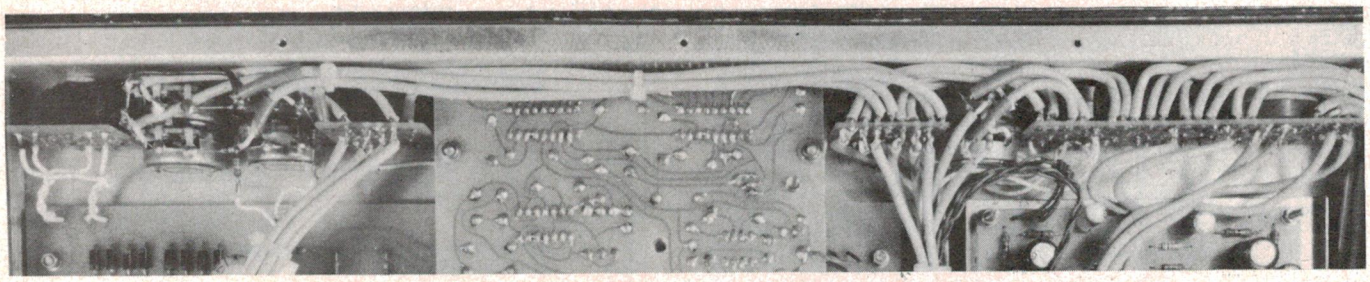
Frequency response:	High-level input: 15 Hz-130 kHz, +0, −1 db Low-level input — conforms to RIAA equalisation, ±0.2 dB (see text).
Distortion:	1 kHz ‹0.003% on all inputs (limit of resolution on measuring equipment due to noise limitation).
S/N noise:	High-level input, master full, with respect to 300 mV input signal at full output (1.2 V): ›92 dB flat ›100 dB A-weighted
	MM input, master full, with respect to full output (1.2 V) at 5 mV input, 500 ohm source resistance connected: ›86 dB flat ›92 dB A-weighted
	MC input, master full, with respect to full output (1.2 V) and 200 μV input signal: ›71 dB flat ›75 dB A-weighted

As can be seen from the circuit diagram the preamp has three low-level inputs. The moving coil input is connected directly to the input of the MC head amp. The capacitors C17 and C18 are soldered between shield and active on each of the input sockets. The output of this amplifier is fed to the low-level selector switch on the front panel, together with shielded cables from the two moving magnet inputs. Once again resistors R13 to R16 and capacitors C19 to C22 are soldered on the input sockets. The output of the low-level selector switch is fed to the input of the MM input stage, which incorporates RIAA equalisation as described last month. The input of this stage has an input impedance around 470k, defined by resistor R2 in the MM circuit diagram (published last month). Since the input differential pair in the NE5534N requires approximately 200 nV into its bases, a voltage drop around 100 mV will appear across this resistor. Capacitor C2 (MM circuit diagram) is used to isolate this dc voltage from the cartridge. If the source resistance is changed rapidly, however, by unplugging the cartridge or otherwise open circuiting the source resistance, a rapid dc shift will occur, producing a loud thump in the loudspeakers. To overcome this problem the low-level input selector should be a make-before-break type and all unused low-level inputs should be shorted. The best way to do this is to construct shorting plugs by soldering the active and earth terminals together on an RCA plug. For convenience we have specified all switches in the preamp as three-pole four-position, make-before-break, rotary switches, manufactured by C&K. This was the switch used in the Series 4000 amplifier so availability should be no problem, although the most common type seems to be that with solder lugs rather than pc mount pins. If you are supplied with the solder lug type, the ends of the pins can be cut off with a pair ▶




UNUSED LOW LEVEL INPUTS SHOULD BE PROVIDED WITH SHORTING PLUGS
SK1
MC INPUT
C17 4n7
C18 4n7
RIGHT MC HEAD AMP
LEFT MC HEAD AMP
RIGHT MM HEAD AMP
LEFT MM HEAD AMP
+15 V A
−15 V A
+15 V B
−15 V B
LOW LEVEL INPUTS
MM1 INPUT
R13 47k
C19 220p
R14 47k
C20 220p
MM2 INPUT
R15 100k
C21 220p
R16 100k
C22 220p
SW1 LOW LEVEL INPUT
MC
MM
HIGH LEVEL INPUTS
TUNER INPUT
R17 12k
R18 12k
AUX1 INPUT
R19 12k
R20 12k
AUX2 INPUT
R21 12k
R22 12k
SW2 HIGH LEVEL INPUT SELECT
LOW
HIGH
TUN
AUX1
AUX2
SW3 TAPE INPUT SELECT
TAPE 1
TAPE 2
OSC
MASTER LEVEL RV1 100k LOG.
TAPE 1
IN
R23 12k
R24 12k
OUT
TAPE 2
R25 12k
R26 12k
ALL SWITCHES ARE C&K 4-POSITION, 3-POLE, MAKE BEFORE BREAK, ROTARY, ADJUSTED (SEE PARTS LIST).
+15 V D
SIGNAL EARTH
Q5 BC548
Q8 BC548
D12 1N914
D15 1N914
R31 4k7
R34 2k7
R35 2k7
R36 4k7
R43 47k
−15 V B
Q6 BC548
Q9 BC548
D13 1N914
D16 1N914
R32 4k7
R37 2k7
R38 2k7
R39 4k7
R44 47k
LINE OUT
R27 4k7
R28 4k7
C23 100n
Q7 BC548
Q10 BC548
D14 1N914
D17 1N914
R33 4k7
R40 1k
R41 1k
R42 4k7
MUTE
MONITOR OUT
R29 4k7
R30 4k7
SK24


C26
47u, 25 V
R47 180R
+15 V B
R46 12k
C27
33n
C29
33n
R48 12k
C24
100n
IC6 741
OP-AMP
R45 4k7
400 Hz OSCILLATOR
RV4
25k
PRESET
400 Hz
LEVEL
ADJUST
C25
100n
R49 180R
−15 V B
R50 10k
D18
1N914
D19
1N914
C28
47u
25 V
R51
3k9
LEFT
LED LEVEL METER
R90 470k
+15 V C
0 V
−15 V C
N.B. INPUT RESISTORS IN LED LEVEL METER
SHOULD BE CHANGED TO 470k — SEE TEXT.
RIGHT
LED LEVEL METER
R91 470k
+15 V C
0 V
−15 V C
R90, R91 REPLACE THE 22k RESISTORS ON THE
INPUTS OF THE LED LEVEL BOARDS
+15 V B
C32
47u, 25 V
R56
180R
C34
3p3
C30
2u2, 16 V
IC7
NE5534N
R52
220k
R54 1k8
R58 5k6
C36
47u, 25 V
−15 V B
R60
180R
R64 1k
C38
47u
25 V
R62
10k
RIGHT LINE AMP
LEFT LINE AMP
R55 1k8
R59 5k6
C39
47u
25 V
R63
10k
R53
220k
IC8
NE5534N
C31
2u2, 16 V
C37
47u, 25 V
R65 1k
R61
180R
C33
47u, 25 V
C35
3p3
R57
180R
+15 V B
+15 V B
C50
47u
25 V
R80
180R
C52
3p3
−15 VB
C46
2u2, 16 V
R76
47k
IC10
NE5534N
C54
47u
16 V
R84 1k
R86
180R
R78 220R
C48
100u
16 V
R82 6k8
C56
47u
25 V
RIGHT MONITOR AMP
LEFT MONITOR AMP
C49
100u
16 V
R83 6k8
C57
47u
25 V
R79 220R
R77
47k
IC11
NE5534N
R85 1k
C55
47u
16 V
R87
180R
−15 VB
C47
2u2, 16 V
C53
3p3
C51
47u
25 V
R81
180R
+15 V B
R72 180R
+15 VB
C42
18p
R73 33k
(x) −1 AMP
C40
220n
R70 33k
IC9
NE5534N
R75
3k3
R71
100k
C41
100n
C43
15p
C45
47u, 16 V
C44
2u2, 25 V
−15 VB
R74 180R
MONITOR LEVEL
10k LOG.
R66 10k
BALANCE
10k LIN.
RV2
10k
LIN.
R67 10k
RV3
10k
LOG
R68 220k
TAPE MONITOR
SELECT
SW4
R69 220k
SW5
MODE
SWITCH
L+R
SOURCE
STEREO
L+R MONITOR
L−R MONITOR
D20
1N914
R88 4k7
D21
1N914
R89 4k7
Q11
BC548
Q12
BC548



View of the rear of the sub-panel assembly, which holds all the switches and potentiometers. Wiring to the switches is from small pc boards mounted on the rear of each switch. This greatly simplifies the interconnecting wiring, which must be via shielded cable (I used 3 mm dia. cable). This also ensures that the correct signal earth is preserved throughout the wiring, avoiding hum and noise problems.

of side cutters. There is just enough pin left to fit through the switch pc boards, so cut as closely as possible to the solder eye.

All switches are soldered to pc boards to bring the necessary contacts to the top of the chassis to facilitate ease of wiring. The wiring in the preamp is reasonably complicated, although not difficult thanks to the switch pc boards. I tried it originally by soldering directly to the back of the switches, but the resulting maze of shielded cable would have made it extremely difficult to fault-find and placed excessive strain on the centre lead solder connections. The circuit boards overcome this problem and provide a secure anchor for both the centre lead and the shield on the shielded cable used for most of the wiring inside the preamp. Furthermore, these circuit boards connect the necessary shields together to maintain the integrity of the signal earth, but more about this later.

The output of the MM amplifier is fed to the 'low' position on the high-level input selector (i.e: selecting 'low' selects the low-level input selector), together with tuner, aux 1 and aux 2 inputs. The output of the switch is fed to the tape input selector on the switch pc board and appears at the switch position marked 'high' on the front panel. The third set of contacts on this switch are used to drive the tape 1 and tape 2 muting transistors Q5 to Q9. If tape 1 for example is selected as an input, pin 10 on the tape input selector is taken high, driving the bases of transistors Q5 and Q8 via diodes D12 and D15 and resistors R31 and R36. R43 acts as a pull-down resistor to ensure that the transistor base-emitter junctions cannot be forward biased by large signal excursions. The diodes prevent this reverse voltage from driving the base-emitter junctions into reverse zener action. The operation of the muting transistors is a little unusual since the transistors are used 'upside down'. It is not commonly known that bipolar transistors can be operated by forward biasing the base-collector junction and using this as the control junction of the transistor. This forms a low gain transistor that has the advantage of a lower on resistance, which is ideal for this situation.

The mute transistors for the line and monitor outputs are driven by the muting control circuitry that senses the presence of the 30 volt ac supply voltage from the power amp. When the amp is turned on, the circuit mutes the line and monitor outputs, turns on the main supply rails and then releases the muting. This eliminates the problem of turn-on thump, although a slight click will be heard as the muting transistors are switched. Similarly at turn-off the muting circuit mutes outputs until the main supply voltage has dropped sufficiently.

The output of the high-level selector is fed via the master level control to the line amplifiers. From the line amplifiers the signal is fed through the tape monitor switch to the balance and monitor level potentiometers, through the mode switch to the monitor amplifiers. When the mode switch is switched to the L-R position the left channel monitor volume wiper is connected to the output of the unity gain phase inverter. The output impedance of the inverter has been set to correspond to that of the left monitor pot when it is at full volume, so turn the monitor fully up when using this facility and use the master as the volume control.

The 400 Hz oscillator is based around the 741 op-amp IC6 and its associated circuitry. The design is a simple Wien bridge oscillator with amplitude stability achieved through the use of back to back diodes, D18 and D19. This results in an output waveform that is not really a sine wave although it is reasonably close and entirely adequate in this application.

Construction

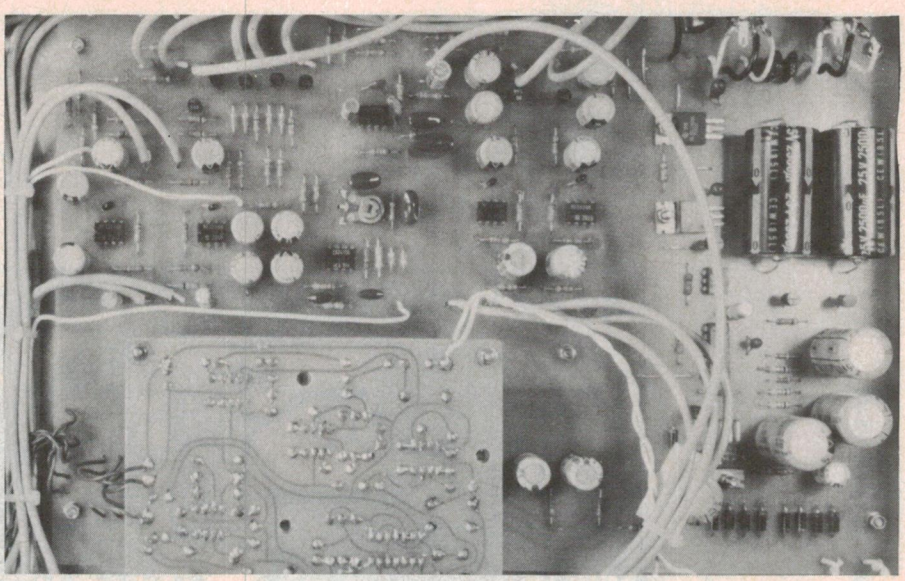
Commence the construction by assembling the LED level meters and the MM and MC input stages. Full construction details for these boards have been given in earlier articles (see above). Ensure that sufficient shielded cable has been soldered to the low-level amplifiers before they are mounted in the separate low-level amp sub-chassis. The bolts used to mount these pc boards are also used to mount the sub-chassis itself, so leave the mounting of the sub-chassis until later.

In this project the LED level meters are mounted with their track sides closest to the top of the preamp. In this way the LEDs run from left to right. This has the disadvantage, however, that calibration of the level meters must be done before mounting. Alternatively drill holes through the level meter pc boards, large enough to take a small screwdriver, immediately behind the three preset pots on each board. In this way adjustment of the level meters can be done after mounting, which is considerably easier. A second modification which must be done to the LED level meters is to increase their input impedance. This is done by removing the 22k parallel input resistor, R1 on the level meter circuit diagram, and replacing it with a 470k. These additional resistors are included on the main pc board parts list.

Next assemble the main pc board; a component overlay has been included to simplify this stage of construction. First make a visual inspection of the circuit board, checking for open circuits or short circuits between adjacent tracks. This is a reasonably complex board and any faults are best found at this stage. Check also that the holes are drilled to convenient sizes. I prefer to enlarge holes intended to take the shields from the shielded cables, and the three holes for the preset RV4 must also be large anough to accommodate the fairly wide pins. There are five mounting holes for

the circuit board itself; these should be 6BA clearance (approx. 3 mm). Similarly, the mounting of the IC regulators is done with 6BA nuts and bolts. The LED level meters mount on their own pillars, two of which pass through the main pc board. These holes (see overlay) should be large enough to allow a 6BA bolt without interference from the main pc board.

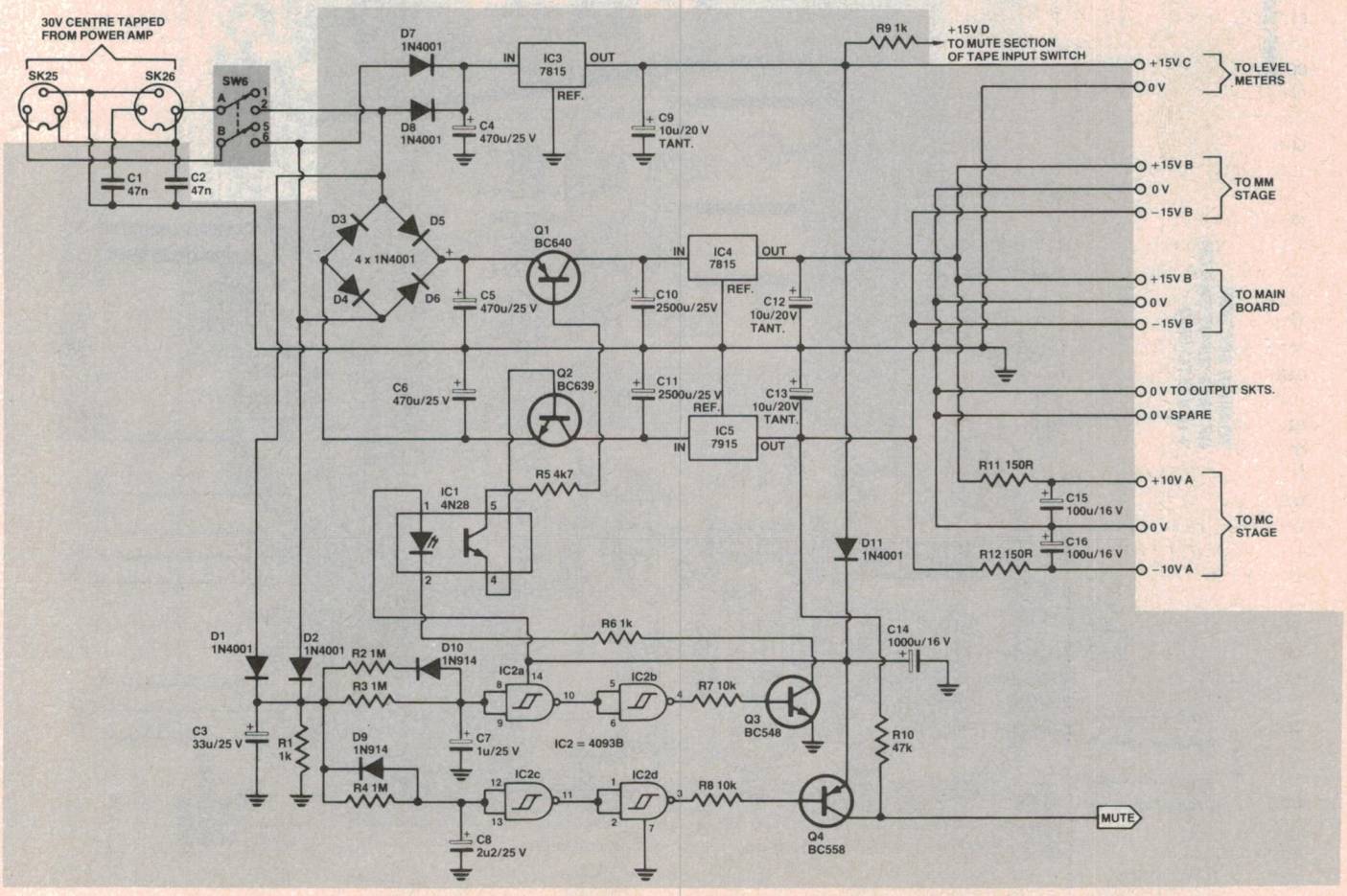
If all is correct mount the wire links, resistors and nonpolarised capacitors such as greencaps and ceramics. Next mount the transistors and diodes, ensuring that they are inserted the correct way around. Note that in the row of diodes near the power switch, diodes D3 and D4 are mounted in the reverse direction to the other diodes. Mount the integrated circuits, again making sure the orientation is correct. The voltage regulator ICs are best mounted by bending the leads with a pair of side cutters first, then inserting the pins through the pc board and securing the regulators with 6BA nuts and bolts. Pass the bolts through the pc board from the underside (i.e: nut on top). Finally solder the pins. The regulator IC3 runs the warmest of these regulators since it supplies the positive rail to the LED level meters.



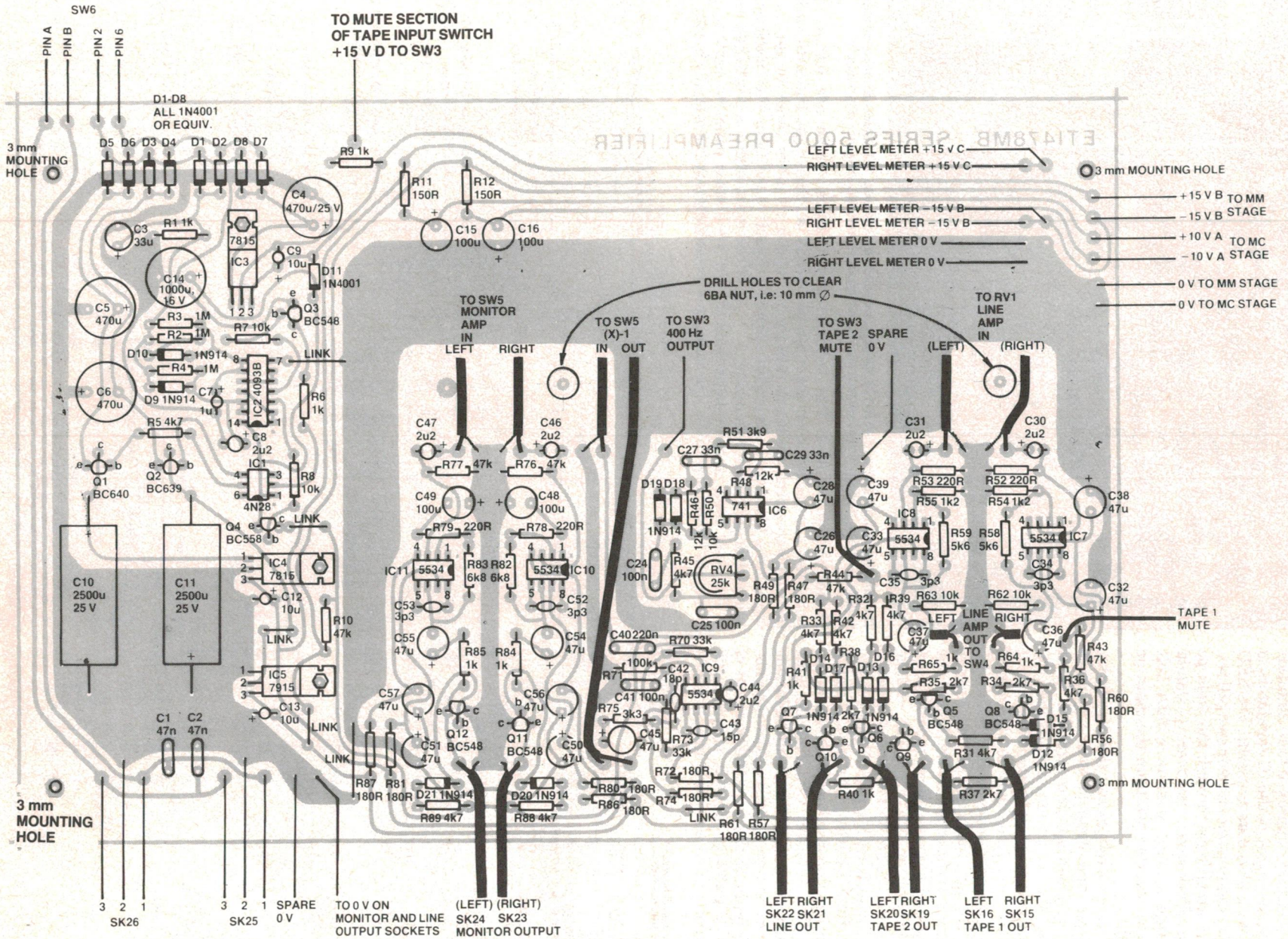
The completed motherboard (ETI-478 MB) assembled in the chassis. This board contains all the power supply circuitry, muting, line amplifiers and the unity gain inverting amplifier ('(x)−1 amp').

Mount the preset RV4. The last components to be mounted on the main pc board are the electrolytic and tantalum capacitors. Once again be careful of the orientation of these components.

The final stage in the construction of the main board is to solder the connecting cables. These are left as 'flying leads' at this stage but with sufficient length to allow them to run to their respective positions within the preamp. If the main board is positioned roughly on the bottom panel an estimate of the necessary lengths is easily made. ▶



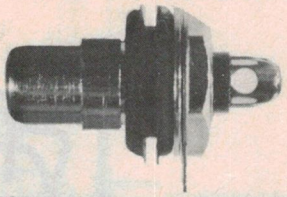
COMPONENT OVERLAY FOR THE MOTHERBOARD ETI-478 MB



The connections marked +VA, −VA, +VB, −VB and the two 0 V connections at the extreme right edge of the pc board supply power to the MC and MM input stages. These leads are already soldered to the MC and MM pc boards, so leave them empty at this stage. The power supply leads to the LED level meters, however, should be soldered to the main board and left flying for the time being. Notice that all signal-carrying leads are shielded cable, and provision has been made on the pc board to accommodate the shields. The connections to the mute lines and the 400 Hz oscillator are done with conventional hookup wire (see overlay and relevant photographs).

Next construct the rear panel assembly. Start by disassembling the chassis so that you can work on the panel without interference from the bottom panel or side bars. All inputs and outputs are done with RCA-type sockets, with the exception of the two three-pin DINs. The RCA sockets must be insulated from the chassis. This is done by first fitting rubber grommets to the drilled holes in the rear panel and then mounting the sockets through the grommets. Ensure that the earth lug points toward the top of the rear panel. This was the technique used for the input sockets to the Series 5000 power amp and forms an effective and inexpensive insulated socket.

Once all the RCA sockets have been mounted, fit the two three-pin DIN sockets. All the leads to the rear panel come from either the main board or the front panel assembly so no leads need to be soldered to the rear panel at this stage. Instead solder all the resistors and capacitors as shown in the rear panel assembly drawing. Note that all the sockets with the exception of the four tape outputs have parallel resistors and/or capacitors. The overlay drawing included shows the position of these components.

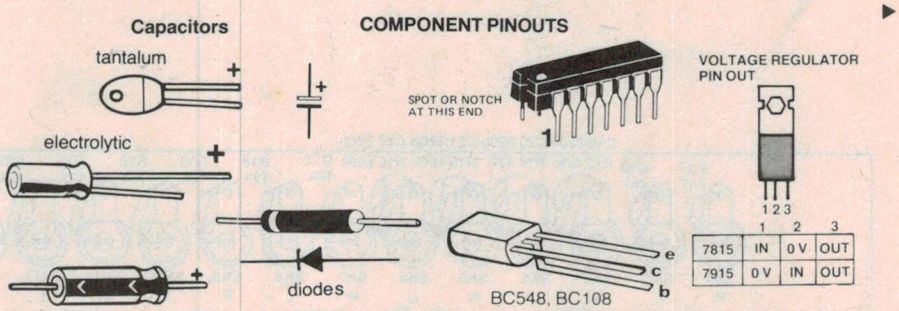


The RCA sockets mount through the hole of rubber grommets fixed to the rear panel, electrically isolating them from the panel.

The next stage is the assembly of the front panel. Once again start by disassembling this part of the chassis; the wiring is fairly complicated and is much easier to do with the sub-panel separate. ▶

PC BOARD ARTWORK AND CABINET DRAWINGS

We do not have sufficient room to reproduce the pc board artwork (boards are ETI-478 MB, SA, SB, SC, SD) and the cabinet metalwork drawings. A complete set may be obtained by sending a 300 x 250 mm stamped, self-addressed envelope to:
SERIES 5000 ARTWORK & DRAWINGS
ETI MAGAZINE
15 BOUNDARY ST
RUSHCUTTERS BAY NSW 2011



PARTS LIST ETI-478MB SERIES 5000 PREAMP MOTHERBOARD AND CASE ASSEMBLY

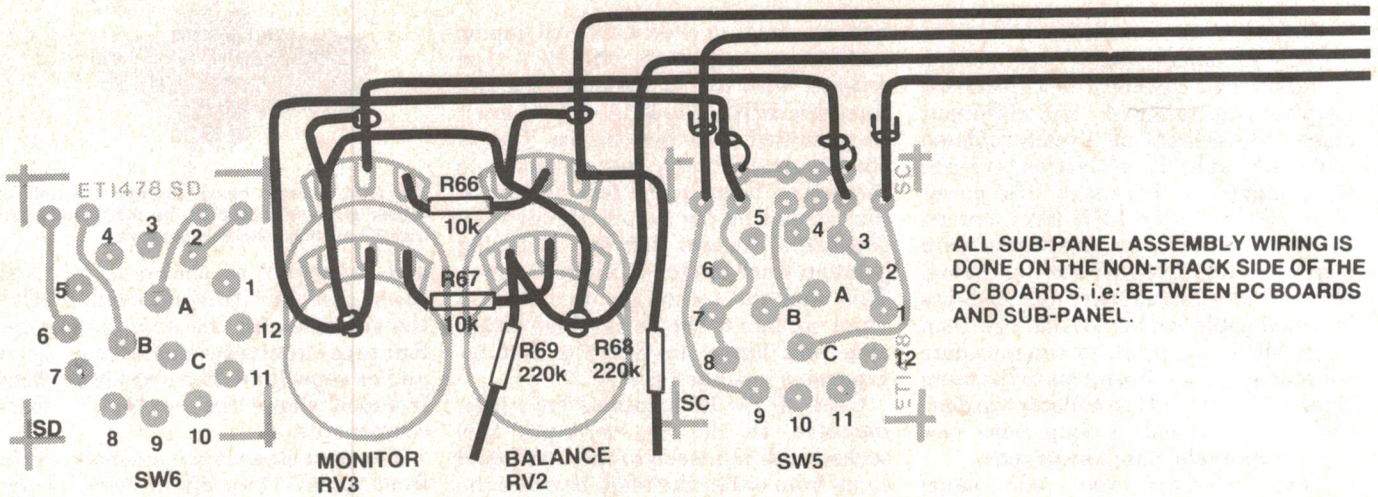
Resistors ..... all ½W, 5%
R1,6,9,40,41, 64,65,84,85 ..... 1k
R2,3,4 ..... 1M
R5,27 to 33,36, 39,42,45,88,89 .... 4k7
R7,8,50,62, 63,66,67 ..... 10k
R10,13,14,43, 44,76,77 ..... 47k
R11,12 ..... 150R
R15,16,71 ..... 100k
R17 to 26,46,48 .... 12k
R34,35,37,38 ..... 2k7
R47,49,56,57,60, 61,72,74,80, 81,86,87 ..... 180R
R51 ..... 3k9
R52,53,68,69 ..... 220k
R54,55 ..... 1k8
R58,59 ..... 5k6
R70,73 ..... 33k
R75 ..... 3k3
R78,79 ..... 220R
R82,83 ..... 6k8
R90,91 ..... 470k NOTE: R90,91 replace R1 (22k) in each ETI-458 LED level display.
RV1 ..... 100k/C dual log. pot.
RV2 ..... 10k/A dual linear pot.
RV3 ..... 10k/C dual log. pot.
RV4 ..... 25k trimpot.

Capacitors
C1,2 ..... 47n greencap
C3 ..... 33u/25 V RB electro.
C4,5,6 ..... 470u/25 V RB electro
C7 ..... 1u/25 V RB electro.
C8,44 ..... 2u2/25 V RB electro.
C9,12,13 ..... 10u/20 V tantalum
C10,11 ..... 2500u/25 V axial electro.
C14 ..... 1000u/16 V RB electro.
C15,16,48,49 ..... 100u/16 V RB electro.
C17,18 ..... 4n7 greencap
C19,20,21,22 ..... 220p mica or styroseal
C23,24,25,41 ..... 100n greencap
C26,28,32,33,36, 37,38,39,50, 51,56,57 ..... 47u/25 V RB electro.
C27,29 ..... 33n greencap
C30,31,46,47 ..... 2u2/16 V RB electro.
C34,35,52,53 ..... 3p3 ceramic
C40 ..... 220n greencap
C42 ..... 18p ceramic
C43 ..... 15p ceramic
C45,54,55 ..... 47u/16 V RB electro.
NOTE: electrolytic and tantalum capacitors have been specified with the minimum working voltage rating and the pc board has been laid out to suit. Higher voltage rating capacitors may not fit. RBLL types may be substituted where we have specified electrolytics, but where tantalums are specified no substitiution may be made.

Semiconductors
D1 to D8,D11 ..... 1N4001, 1N4002 etc.
D9,10,12 to 21 ..... 1N914, 1N4148 etc.
IC1 ..... 4N28 opto isolator
IC2 ..... 4093B quad Schmitt NAND
IC3,IC4 ..... 7815 +15 V 3-terminal reg.
IC5 ..... 7915 −15 V 3-terminal reg.
IC6 ..... 741 op-amp.
IC7 to 11 ..... NE5534N op-amp.
Q1 ..... BC640
Q2 ..... BC639
Q3,Q5 to 12 ..... BC548
Q4 ..... BC558

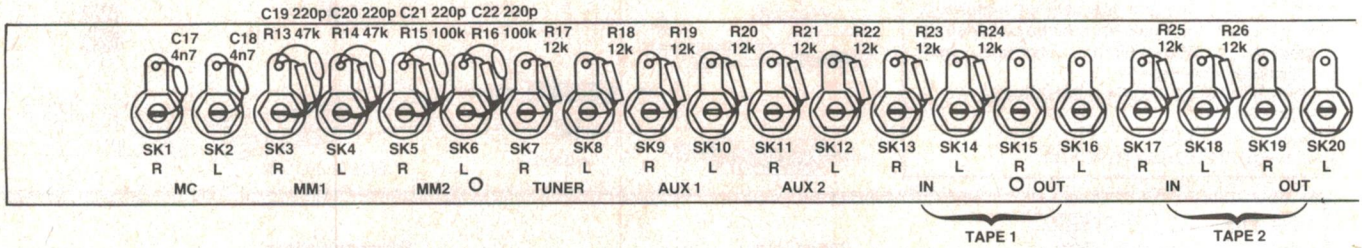
Miscellaneous
SW1,SW4 ..... 3-pole, 3-position rotary
SW2,SW3,SW5 .... 3-pole, 4-position rotary
SW6 ..... 3-pole, 2-position rotary
All switches are C&K Lorlin 3-pole, 4-position rotary make-before-break types with stops set as

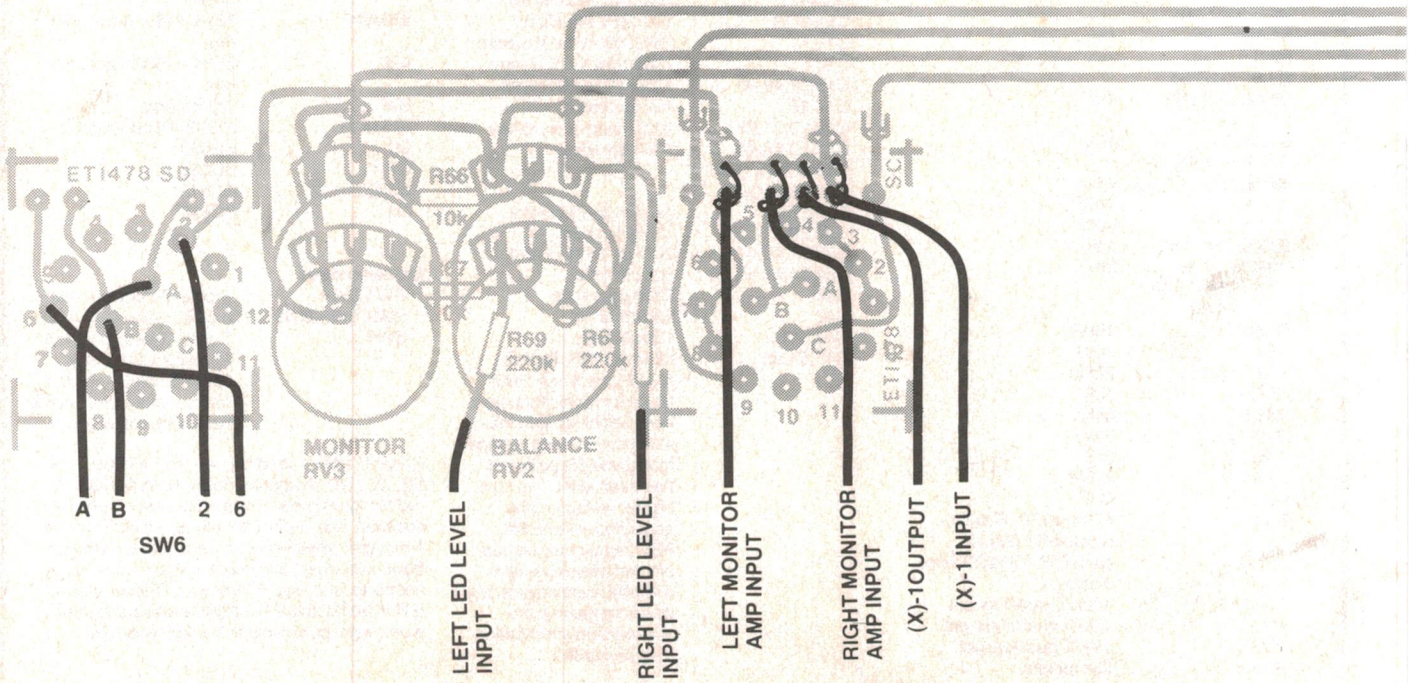
Printed circuit boards — ETI-478MB, SA, SB, SC, SD; 24 panel-mount RCA sockets; 24 rubber grommets 6 mm bore; two 3-pin DIN sockets; two 3-pin DIN plugs; shielded cable 4 mm dia.; metalwork as per cabinet drawings; front and rear Scotchcal panels; nine fancy knobs to suit; two ETI-458 LED level meters; ETI-478MM and ETI-478MC stages and metalwork; nuts, bolts, solder, hookup wire, etc.

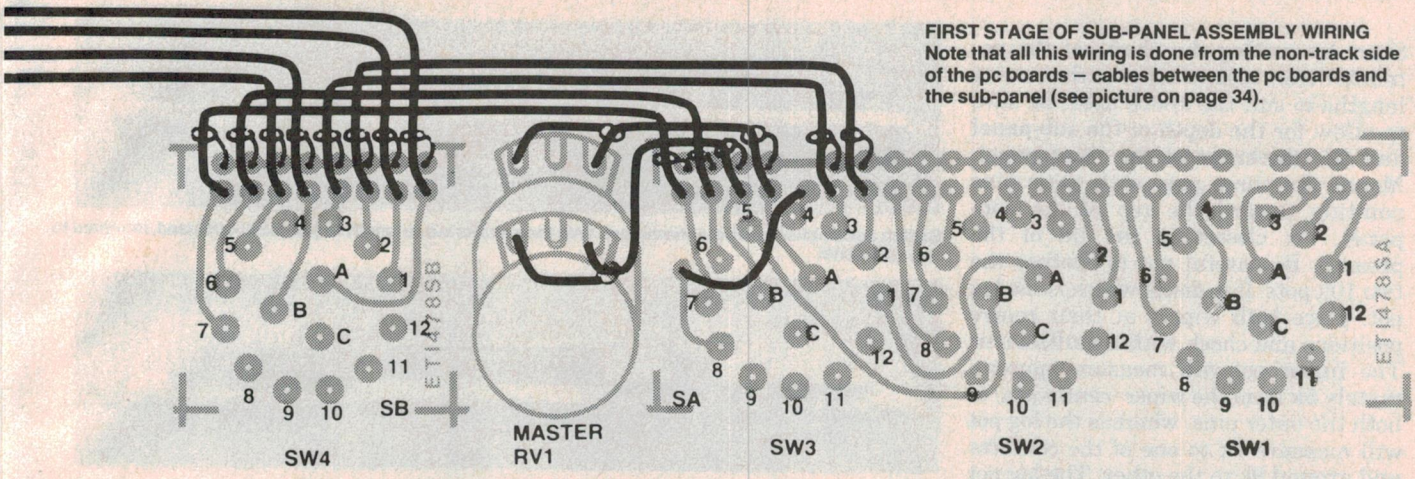


ALL SUB-PANEL ASSEMBLY WIRING IS DONE ON THE NON-TRACK SIDE OF THE PC BOARDS, i.e: BETWEEN PC BOARDS AND SUB-PANEL.

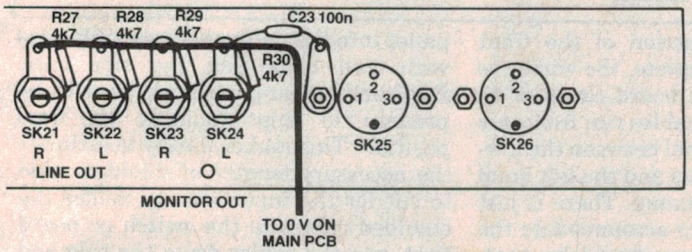
REAR PANEL ASSEMBLY

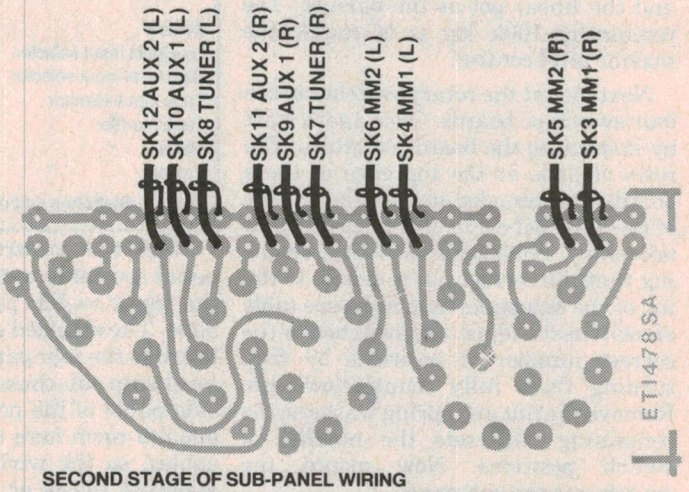




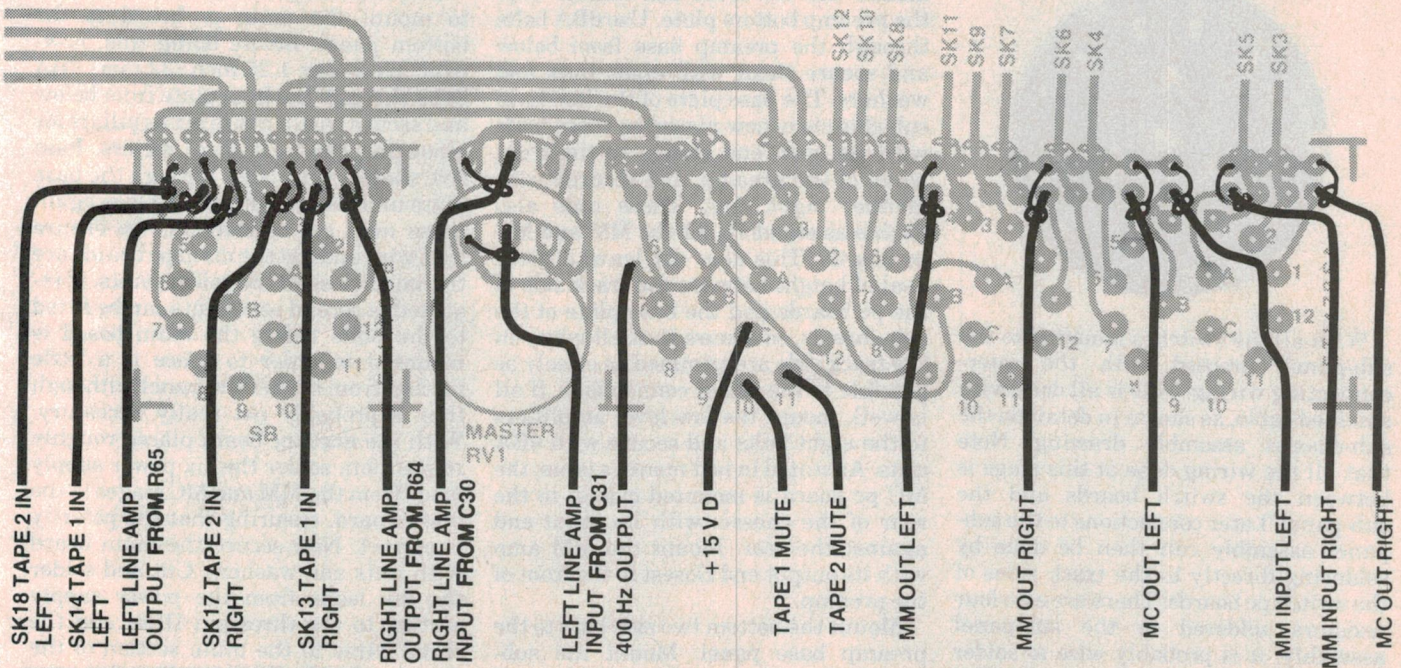


FIRST STAGE OF SUB-PANEL ASSEMBLY WIRING
Note that all this wiring is done from the non-track side of the pc boards – cables between the pc boards and the sub-panel (see picture on page 34).





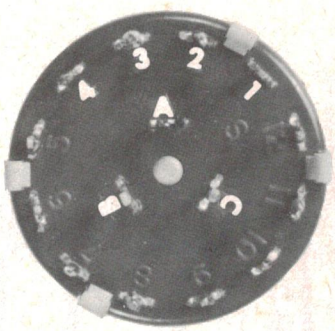
SECOND STAGE OF SUB-PANEL WIRING
This too is done from the non-track side of the board (refer also to picture on page 34).



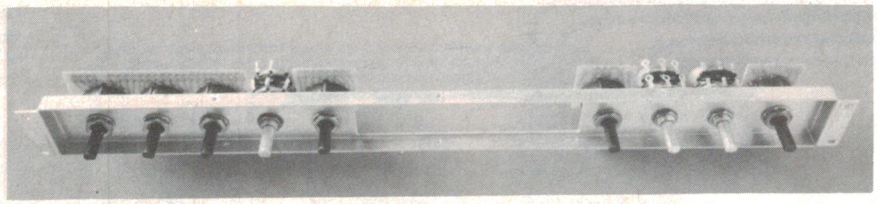
THIRD STAGE OF SUB-PANEL WIRING
This is done from the track side of the pc boards (see also picture on page 34).

Start by cutting the shafts of the potentiometers and switches to the correct lengths to suit the knobs used. Be sure to allow for the depth of the sub-panel and the thickness of the front panel. Mount the three pots with their pins pointing toward the top of the sub-panel, i.e: closest to the lid of the preamp. Be careful not to confuse the two 10k pots. If in doubt which is the log pot, place both wipers at their centre positions and check with a multimeter. The linear pot will measure approximately 5k from the wiper (centre pin) to both the outer pins, whereas the log pot will measure 1k to one of the contacts and around 9k to the other. The log pot is used for the monitor volume control and the linear pot as the balance. The remaining 100k log is of course the master level control.

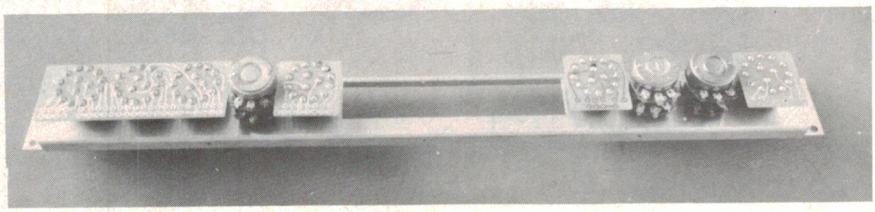
Next mount the rotary switches to the four switch pc boards. Once again start by inspecting the boards carefully. The rows of pads at the top edge of these boards are intended to take the shields of the shielded cable, so enlarge them if necessary. Solder the switches, ensuring that the correct pin is closest to the top of the sub-panel assembly (see table of switches). Adjust the switches to the correct number of positions by first turning them fully counterclockwise. Remove the nut and spring washers; the remaining ring sets the number of switch positions. Now mount the switches to the sub-panel.



With all the switches mounted to the sub-panel, proceed with the interconnecting wiring. This is all done with shielded cable, as shown in detail on the sub-chassis assembly drawing. Note that all the wiring done at this stage is between the switch boards and the sub-panel. Later connections to the sub-panel assembly can then be done by soldering directly to the track sides of the switch pc boards. There are also four resistors soldered to the sub-panel assembly; it is probably wise to solder the two 10k resistors before the shielded cables. (See pages 40-41).



Switch assemblies and potentiometers, with their shafts cut to length to suit the knobs used, mounted to the sub-panel.



Rear view of the sub-panel assembly, prior to wiring.

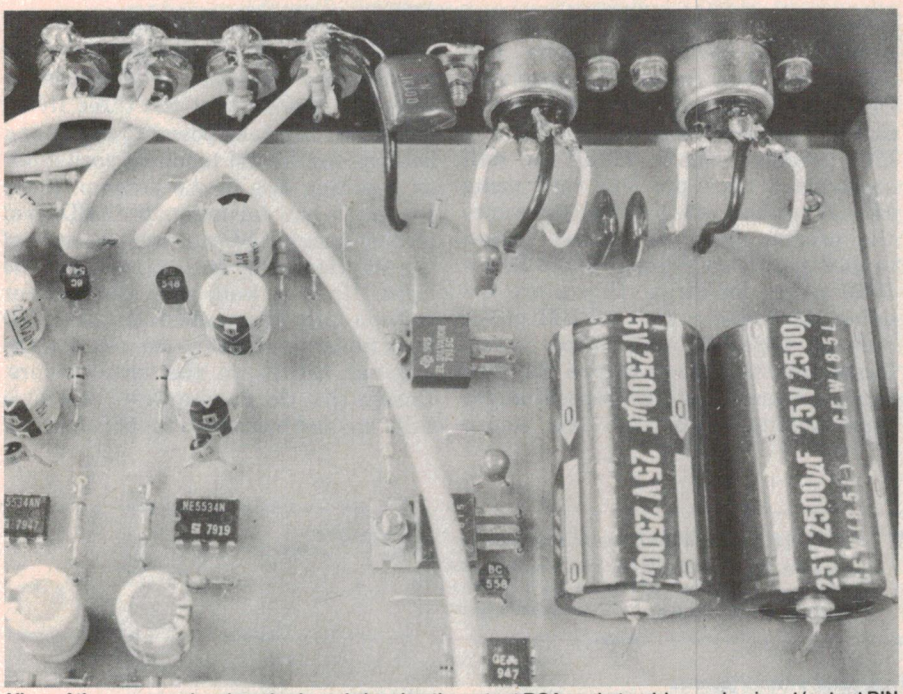
Switch	Number of Positions	PC Board	Pin Closest to Top
Low level input selector	3	SA	3,4
High level input selector	4	SA	4
Tape input selector	4	SA	4
Tape monitor	3	SB	3,4
Mode	4	SC	4
Power	2	SD	3

Table 1. Switches and positions.

With the construction of the front panel assembly complete, the wiring to the input switch pc board can now be done. The shielded cables run from this board to the rear panel between the low-level amp sub-chassis and the left hand side panel of the preamp. There is just enough room here to accommodate the cables, so the wiring should be neat, avoiding twists or crossovers between cables. The best way to do this is to first mount the low-level sub-chassis onto the preamp bottom plate. Use 6BA bolts through the preamp base from below and secure them with eight nuts and washers. The base plate of the low-level sub-chassis is now placed on these bolts with its open end closest to the front panel of the preamp, and secured with another eight nuts. These nuts also double as standoffs for the MM and MC pc boards. This does not leave a great deal of height between the track side of the pc boards and the base plate of the sub-chassis, so ensure that all wires on the track side are trimmed as closely as possible to the solder connections. If all is well, mount the low-level amplifiers to the eight bolts and secure with 6BA nuts. As stated in last month's issue, the MC pc board is mounted closest to the rear of the chassis with its input end against the rear. Mount the MM amp with its output end closest to the front of the preamp.

Mount the bottom two side bars to the preamp base panel. Mount the sub-panel assembly onto the bottom panel using three self-tappers through the panel into the sub-panel assembly, and with two bolts into the side bars. Position the rear panel at the back of the preamp in approximately its final position. This makes it easy to estimate the necessary lengths of shielded cable to cut for the input wiring. Solder the shielded cables to the switch pc board first, run the cables down the side and behind the sub-chassis, trim and solder to the input sockets.

The next stage in the construction is to mount the main pc board to the bottom panel. Before doing this, however, pass four 1.25 inch (32 mm) 6BA bolts through the base plate from below and secure with a nut to act as pillars for mounting the LED level meters. Pass five shorter 6BA bolts through the base plate and secure with nuts. Once again these nuts act as standoffs, so ensure that wire ends on the main pc boards are trimmed close to the solder joints. If required, a second set of nuts can be fitted to the bolts before the main board is mounted in order to space it a little further from the bottom panel, although this is probably not really necessary. With the main pc board placed roughly in position, solder the six power supply leads from the MM and MC stages to the main board, ensuring that the polarity is correct. Now secure the main board with nuts and washers. Cut and solder the six leads from the power supply section to the three-pin DINs and the three wires to the mute section of the tape input selector, as well as from the output of the 400 Hz oscillator (see

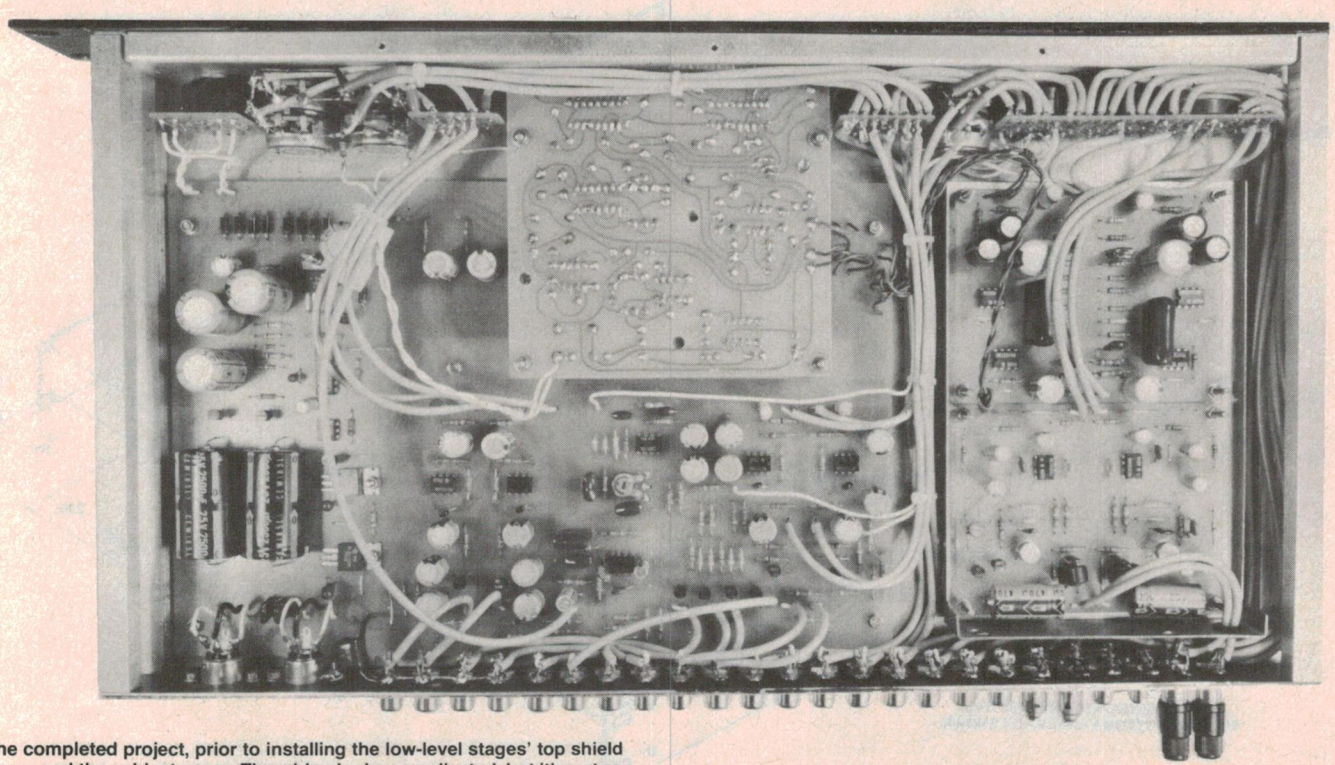


View of the rear panel and motherboard showing the output RCA sockets wiring and ac input/output DIN sockets wiring.

overlay diagram). Solder the leads to the power switch and the 0 V connection to the output socket earth.

The remaining wiring to the pc board consists of shielded cables. Before soldering these, however, run cable from the rear panel tape input sockets to the tape monitor switch. These cables are terminated directly to the track side of the switch pc board. The connections are shown in the rear panel and sub-panel assembly(p.40-41), followed by the monitor amp inputs and the unity gain inverter's input and output leads. As above, all of these cables solder to the panel assembly drawings. Then solder the line amp inputs and outputs to the track side of the switch boards. Cut and solder the output leads from the main pc board to the rear panel. Pass the input leads to the MC stage through the hole in the rear of the sub-chassis, which should be fitted with a rubber grommet, and solder to the MC input sockets. With all the wiring done to the rear panel it can be bolted to the chassis, together with the top two side bars. Solder the remaining shielded cables to the low-level amps to the track side of the input switch pc boards.

The final stage in the construction of the preamp is to mount and calibrate the LED level meters. If the added holes have been drilled to allow calibration through the pc board, the first level meter can be mounted. The height of the pc board is set by four nuts and washers, which can be adjusted to the correct height on the bolts. Alternatively, screw a further three nuts and a washer onto each mounting bolt. This is close to the correct height and ensures that strain is not placed on the pc board by different-height nuts. Secure with a further four washers and nuts. The mounting holes should be drilled well oversize so that ▶



The completed project, prior to installing the low-level stages' top shield cover and the cabinet cover. The wiring looks complicated, but it's not as bad as it looks! Note the holes drilled in the top LED level meter board so that the adjustments may be easily reached (see text).

final adjustment of the position of the LEDs can be carried out.

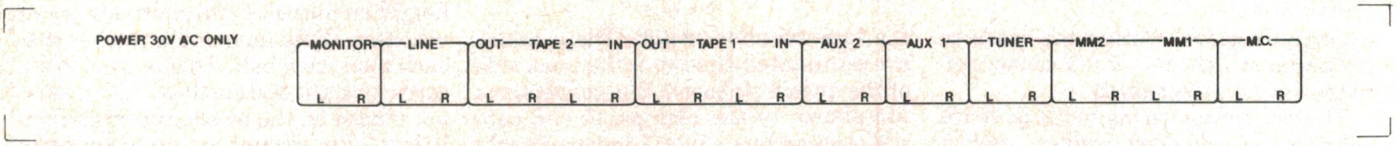
Now mount the front panel. If the LEDs are not in a perfectly straight line it is extremely difficult to get the front panel on, so it is well worth the effort of getting these as straight as possible. Solder the power supply wiring to the board and the input connection to the appropriate resistor on the sub-panel assembly.

Powering up

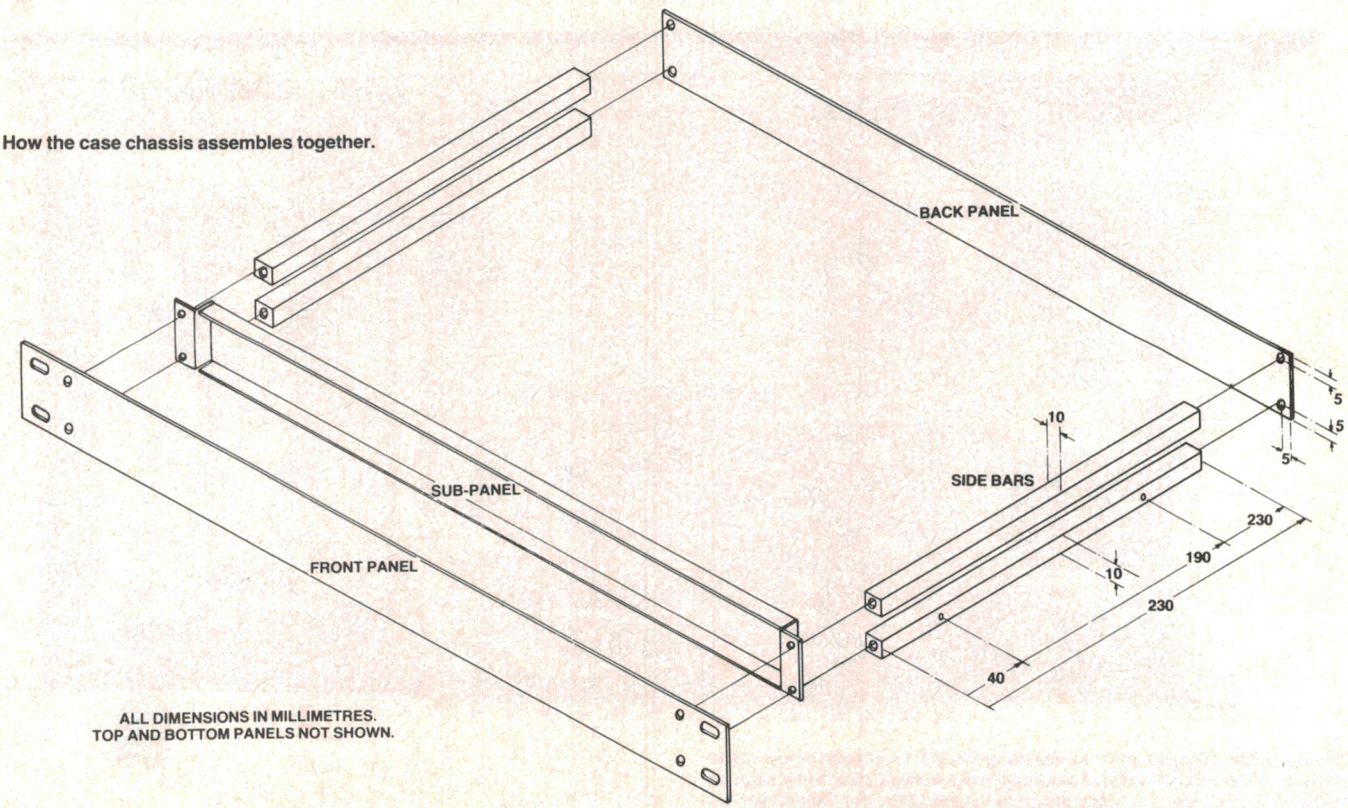
At this stage the preamp must be powered up, so check as much as is possible. In particular check the polarity of diodes, transistors and electrolytic and tantalum capacitors. Check also the power supply connections, especially those to the MM and MC preamp stages. If all is well construct a three-pin DIN lead using twisted hookup wire and apply power to the preamp from the 30 volt centre-tapped supply on the rear of the Series 5000 power amplifier. If you are not using the preamp with an ETI power amp, a separate 15-0-15 volt transformer must be used. Switch the tape input selector to the 400 Hz position, the tape monitor switch to the source position and the mode switch to stereo. Centre the balance pot and turn both master and monitor volume control fully on. Ensure that the three flying leads that will take power to the second level meter are not touching each other or anything else in the preamp. If the preamp is now turned on, the LED level meters should indicate the presence of the 400 Hz tone by moving swiftly to the right. If all is well, turn the monitor volume fully down and adjust the LED level meter dc offsets as described in the original article on the level meters. Ensure that the monitor level control is fully up, and by using a multimeter and

▶

Reproduction of the front panel artwork (above) and rear panel artwork (below).



How the case chassis assembles together.



ALL DIMENSIONS IN MILLIMETRES.
TOP AND BOTTOM PANELS NOT SHOWN.

LM394

GENERAL DESCRIPTION

The LM194 and LM394 are junction-isolated ultra-well-matched monolithic NPN transistor pairs with an order of magnitude improvement in matching over conventional transistor pairs. This was accomplished by advanced linear processing and a unique new device structure.

Electrical characteristics of these devices such as drift versus initial offset voltage, noise, and the exponential relationship of base-emitter voltage to collector current closely approach those of a theoretical transistor. Extrinsic emitter and base resistances are much lower than presently available pairs, either monolithic or discrete, giving extremely low noise and theoretical operation over a wide current range. Most parameters are guaranteed over a current range of 1 μA to 1 mA and 0 to 40 V collector-base voltage, ensuring superior performance in nearly all applications.

To guarantee long term stability of matching parameters, internal clamp diodes have been added across the emitter-base junction of each transistor. These prevent degradation due to reverse biased emitter current — the most common cause of field failures in matched devices. The parasitic isolation junction formed by the diodes also clamps the substrate region to the most negative emitter to ensure complete isolation between devices.

The LM194 and LM394 will provide a considerable improvement in performance in most applications requiring a closely matched transistor pair. In many cases, trimming can be eliminated entirely, improving reliability and decreasing costs. Additionally, the low noise and high gain make this device attractive even where matching is not critical.

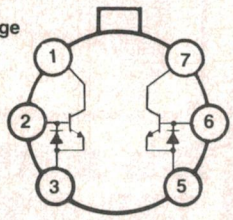
The LM194 and LM394/394B are available in an isolated header 6-lead TO-5 metal can package. The LM194 is identical to the LM394 except for tighter electrical specifications and wider temperature range.

FEATURES

- Emitter-base voltage matched to 50 μV
- Offset voltage drift less than 0.1 $\mu V/^{o}C$
- Current gain (h_{FE}) matched to 2%
- Common-mode rejection ratio greater than 120 dB
- Parameters guaranteed over 1 μA to 1 mA collector current
- Extremely low noise
- Superior logging characteristics compared to conventional pairs

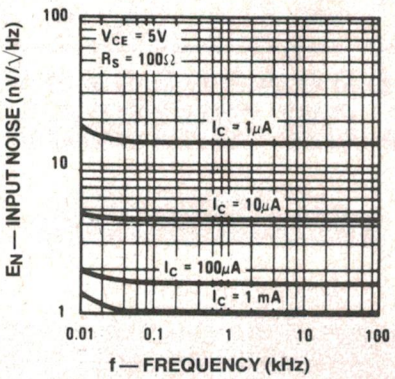
CONNECTION DIAGRAM

Metal Can Package

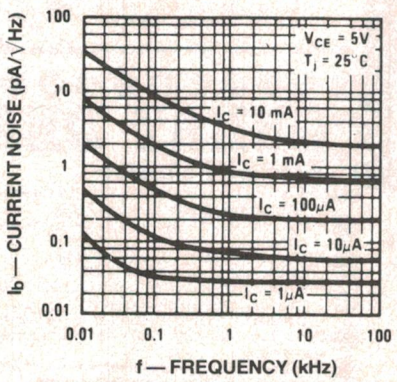


TOP VIEW

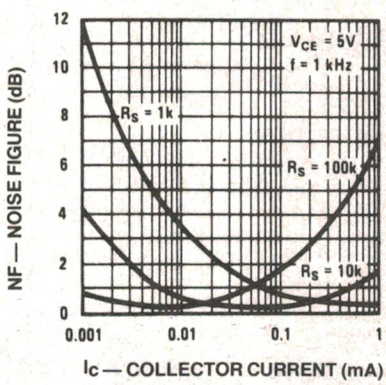
INPUT VOLTAGE NOISE vs. FREQUENCY



BASE CURRENT NOISE vs. FREQUENCY



NOISE FIGURE vs. COLLECTOR CURRENT



NE5534

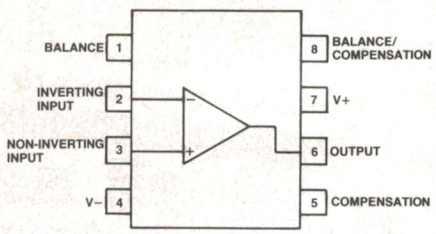
DESCRIPTION

The 5534 is a single high-performance low-noise operational amplifier. Compared to other op-amps, such as TLO83, it shows better noise performance, improved output drive capability and considerably higher small-signal and power bandwidth. This makes the device especially suitable for application in high quality and professional audio equipment, in instrumentation and control circuits and telephone channel amplifiers. The op-amp is internally compensated for gain equal to or higher than three. The frequency response can be optimised with an external compensation capacitor for various applications (unity gain amplifier, capacitive load, slew rate, low overshoot, etc). If very low noise is of prime importance, it is recommended that the 5534A version be used, which has guaranteed noise specifications.

FEATURES

- Small-signal bandwidth: 10 MHz
- Output drive capacility: 600R, 10 V (RMS) at V_S = ±18 V
- Input noise voltage: 4 nV/√Hz
- dc voltage gain: 100 000
- ac voltage gain: 6000 at 10 kHz
- Power bandwidth: 200 kHz
- Slew rate: 13 V/μs
- Large supply voltage range: ±3 to ±−10 V
- Pinout: 741
- Configuration: Single

N PACKAGE



ABSOLUTE MAXIMUM RATINGS

	PARAMETER	RATING	UNIT
V_S	Supply voltage	±22	V
V_{IN}	Input voltage	±V supply	V
V_{DIFF}	Differential input voltage[1]	±.5	V
T_A	Operating temperature range		
	SE5534/5534A	−55 to +125	°C
	5534/5534A	0 to 70	°C
T_{STG}	Storage temperature	−65 to +150	°C
T_J	Junction temperature	150	°C
P_D	Power dissipation at 25°C[2]		
	5534N	500	mW
	5534T	800	mW
	Output short circuit duration[3]	indefinite	
	Lead temperature (soldering 10 sec)	300	°C

NOTES

1. Diodes protect the inputs against over-voltage. Therefore, unless current-limiting resistors are used, large currents will flow if the differential input voltage exceeds 0.6V. Maximum current should be limited to ± mA.
2. For operation at elevated temperature T package must be derated based on a thermal resistance of 150° C/W junction to ambient, 45° C/W junction to case. Thermal resistance of the N package is 240° C/W junction to ambient.
3. Output may be shorted to ground at V_S = ±15V, T_A = 25° C. Temperature and/or supply voltages must be limited to ensure dissipation rating is not exceeded.

ELECTRICAL CHARACTERISTICS T_A = 25° C, V_S = ±15 V unless otherwise specified.

PARAMETER	TEST CONDITIONS	5534			5534A			UNIT
		Min	Typ	Max	Min	Typ	Max	
Input noise voltage	f_o = 30 Hz f_o = 1 kHz		7 4			5.5 3.5	7 4.5	nV/√Hz nV/√Hz
Input noise current	f_o = 30 Hz f_o = 1 kHz		2.5 0.6			1.5 0.4		pA/√Hz pA/√Hz
Broadband noise figure	f = 10 Hz — 20 kHz, R_S = 5 kR					0.9		dB
Channel separation	f = 1 kHz, R_S = 5 kR		110			110		dB

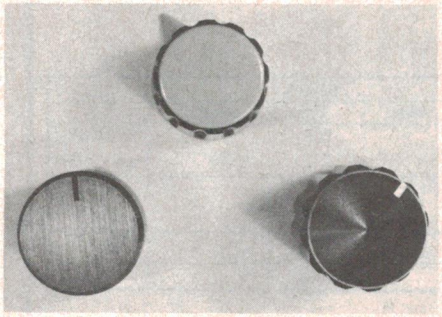
AC ELECTRICAL CHARACTERISTICS T_A = 25° C, V_S = ±15 V unless otherwise specified.

PARAMETER		TEST CONDITIONS	SE5534/5534A			5534/5534A			UNIT
			Min	Typ	Max	Min	Typ	Max	
R_{OUT}	Output resistance	A_V = 30 dB closed loop f = 10 Hz, R_L = 600R, C_C = 22 pF		0.3			0.3		R
Transient response T_R	Rise time Overshoot	Voltage follower, V_{IN} = 50 mV R_L = 600R, C_C = 22 pF, C_L = 100 pF		20 20			20 20		ns %
Transient response T_R	Rise time Overshoot	V_{IN} = 50 mV, R_L = 600R C_C = 47 pF, C_L — 500 pF		50 35			50 35		ns %
AC	Gain	f = 10 kHz, C_C = 0 f = 10 kHz, C_C = 22 pF		6 2.2			6 2.2		V/mV V/mV
	Gain bandwidth product	C_C = 22 pF, C_L = 100 pF		10			10		mHz
	Slew rate	C_C = 0 C_C = 22 pF		13 6			13 6		V/μs V/μs
	Power bandwidth	V_{OUT} = ±10 V, C_C = 0 V_{OUT} = ±10 V C_C = 22 pF V_{OUT} = ±14 V, R_L = 600R C_C = 22 pF, V_{CC} = ±18 V		200 95 70			200 95 70		kHz kHz kHz

C ELECTRICAL CHARACTERISTICS T_A = 25° C, V_S = ±15 V unless otherwise specified. [1,2]

PARAMETER		TEST CONDITIONS	SE5534/5534A			5534/5534A			UNIT
			Min	Typ	Max	Min	Typ	Max	
V_{OS}	Offset voltage	Over temperature		.5	2 3		.5	4 5	mV mV
I_{OS}	Offset current	Over temperature		10	200 500		20	300 400	nA nA
I_B	Input current	Over temperature		400	800 1500		500	1500 2000	nA nA
I_{CC}	Supply current Per op amp	Over temperature		4	6.5 9		4	8	mA mA
V_{CM}	Common mode input range		±12	±13		±12	±13		V
CMRR	Common mode rejection ratio		80	100		70	100		dB
PSRR	Power supply rejection ratio			10	50		10	100	μV/V
A_{VOL}	Large signal voltage gain	R_L ⩾ 600R, V_O = ±10V Over temperature	50 25	100		25 15	100		V/mV V/mV
V_{OUT}	Output swing	R_L ⩾ 600R R_L ⩾ 600R V_S = ±18V	±12 ±15	±13 ±16		±12 ±15	±13 ±16		V V
R_{IN}	Input resistance		50	100		30	100		kR
I_{SC}	Output short circuit current			38			38		mA

NOTES
1. For 5534/5534A. T_{MIN} = 0°C, T_{MAX} = 70°C
2. For SE5534/5534A. T_{MIN} = −55°C. T_{MAX} = + 125°C



You can make your choice of knobs to suit yourself. A wide variety is available and just three different styles are shown here. At left is an anodised aluminium knob with a slot – this is the type we used, simply because we had nine on hand! At top is a plastic collet knob with pointer (C&K and Associated Controls handle collet knobs), and at right is a fluted, anodised aluminium knob with white indicators, which is very common.

adjusting the master and balance controls obtain a voltage of 1.2 Vac at the monitor output sockets. Adjust the LED level meters to read 0 dB. The preamp can now be turned off and the other level meter fitted. Once again the height of the pc board can be set by nuts on the bolt, adjusting to give the correct height. Alternatively, fit two nuts and another washer to all four bolts. This should give the correct height. Solder the input and power supply connections. Note that this board can be difficult to get through the slots on the front panel unless the mounting holes have been drilled large enough.

Power up the preamp again, and with the master turned fully down adjust dc offsets as before. Once again adjust the master and balance pots to achieve 1.2 V at the monitor output sockets with the monitor volume control set at full. Adjust the second level meter calibration control to read 0 dB. This aligns the two level meters approximately only. If the master is now varied slowly the LEDs on each display will probably turn on at slightly different times. Adjust the top level meter calibration preset so that the LEDs come on at the same time. With the preamp set in this way the level meters indicate dB below full power when the monitor volume is set at full and the master is used as the volume control. Although this is not the usual mode of operation it is a useful feature, especially when running power amps near their maximum output powers. The usual mode of operation is to adjust the master level to give a reading on the level meters around 0 dB and then use the monitor as the volume control.

All that requires to be done at this stage is to fit the sub-chassis top panel and the preamp top panel. Don't forget to use shorting plugs on all unused low-level inputs in order to avoid thumps in the loudspeakers when the low-level input selector is switched.

Performance

The aim of this project has been to design a high-quality preamplifier suitable for home construction that will not degrade the performance of the best available power amps. To do this the conventional parameters of frequency response, noise and distortion must be good. In these respects the Series 5000 is extremely good, as can be seen from the specifications quoted elsewhere in this article. Of equal importance, however, are the less-known parameters such as cartridge impedance interaction. This problem is overcome through the use of a separate linear gain stage at the input to the MM amplifier.

The final test of any audio amplifier is of course subjective, but for me the Series 5000 preamplifier offers a significant improvement over many other designs, offering a detail and clarity that is seldom heard. ●