10-octave, ±13dB, low distortion and noise . . .

Playmaster stereo Graphic Equaliser

This 10-band stereo graphic equaliser will complement our highly successful Playmaster Twin-25 and 40/40 amplifiers and the Playmaster AM/FM tuner with digital readout. It has performance to equal or better that of the finest commercial models, but can be built for a fraction of the price.

by LEO SIMPSON

Most readers would agree that while the average modern stereo amplifier or receiver appears to have a plethora of controls, most of these are relatively coarse and inflexible in operation. This applies particularly to the tone controls, which generally make a large adjustment to a major part of the audible spectrum.

While typical tone controls are adequate for making slight overall changes to the tonal values of a program, they are almost useless for correcting typical deficiencies of listening rooms and loudspeakers.

In typical high fidelity systems, the loudspeakers and the listening room interact to produce a frequency response which is very rough and ragged. By comparison, a profile of the Andes would look like a series of gentle inclines! In fact it is a marvel that human ears can derive much pleasure from systems which are patently so non-linear. That the human ear does succeed in extracting pleasure in such a situation is a tribute to its outstanding ability to integrate!

With the advent of the graphic equaliser, the high fidelity enthusiast has a great opportunity to effect a positive improvement in his overall system. In fact, for the money spent, it is fair to say that a graphic equaliser, skillfully used, can provide a system benefit which far outweighs its modest cost. Note that proviso "skillfully used".

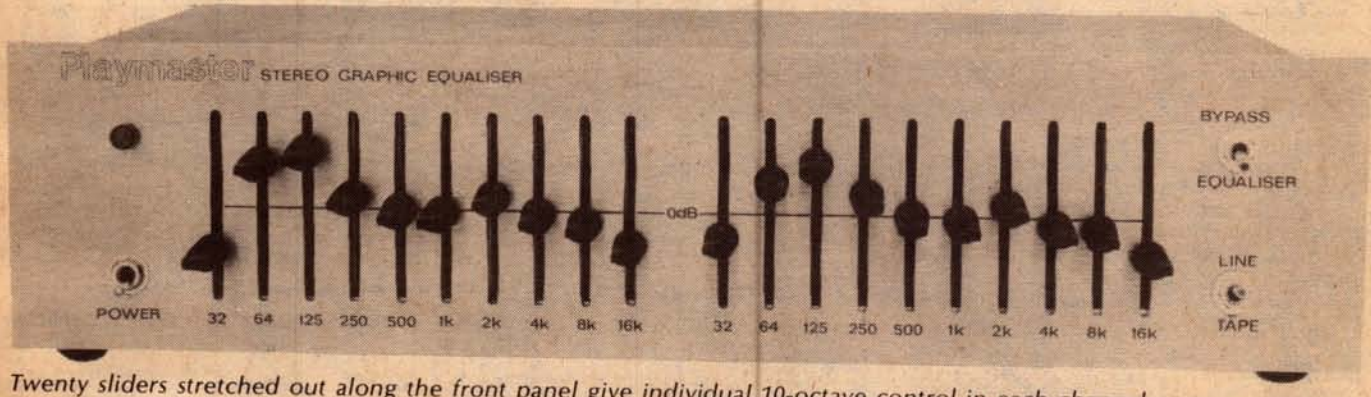
Since the frequency response of a typical loudspeaker has many deep troughs and high peaks, a graphic equaliser, by nature of its segmented response characteristics, is far more able to provide a suitable correction than the usual coarse bass and treble tone controls. The majority of graphic equalisers are also referred to as "octave equalisers". The two names are explanatory. Octave refers to the effective region of response adjustment provided by each control knob. Graphic refers to the pictorial effect of the slider control positions. The overall contour of the slider knob positions shows the approximate tonal correction provided by the equaliser.

Our Playmaster Equaliser, in common with the better examples of graphic equaliser, splits the audio spectrum into 10 octave bands, each centred on what have become the standard frequencies: 32Hz, 64, 125, 250, 500, 1k, 2k, 4k, 8k and 16kHz. Each band can be adjusted up or down in amplitude by approximately 13dB.

In all, there are 20 slider controls, 10 for each channel. This provides an enormous degree of flexibility in tonal control. Apart from providing a very useful tool in correcting room and loudspeaker deficiencies, a graphic equaliser is a boon to the keen tape recordist as it can provide a wealth of special effects. The Playmaster Equaliser is eminently suitable for either use.

When used for correcting room and loudspeaker deficiencies, the Playmaster Equaliser can be connected to a stereo amplifier or receiver in two ways. First, it can be interposed in the "Tape Monitor" loop provided on most amplifiers and receivers. The Playmaster Equaliser duplicates this loop facility, so that it can still be used in conjunction with tape decks or noise/ambience signal processors. Alternatively, where possible, the equaliser may be interposed between preamplifier and power amplifiers.

When used for enhancing tape



Twenty sliders stretched out along the front panel give individual 10-octave control in each channel.

recordings, the Playmaster equaliser is connected in series with the recording input to the tape deck.

In any of the above cases, the Playmaster Equaliser will produce negligible degradation in signal quality in terms of signal to noise ratio, dynamic range or distortion performance. With a dynamic range of well over 100dB and harmonic distortion typically less than 0.05%, the Playmaster Equaliser will be compatible with almost any system.

There is a catch of course. This fine performance and value for money will initially be available only to those who can build the instrument themselves. However we have made this job as simple and as rewarding as it could possibly be. For a start, the front panel matches the fine finish obtained with the recent Playmaster amplifiers and AM/FM tuner (available from Dick Smith Electronics). This panel will be precision punched with a large die similar to that used for the AM/FM tuner panel. It enables the production of consistent high quality panels.

Black knobs for the sliders complement the champagne-finished panel and provide a high degree of control visibility.

The chassis and wrapover cover have the same overall dimensions as the Playmaster equipment mentioned above.

Inside, virtually all the wiring is taken care of by the easily assembled PC boards. There are three PC boards, one for the 20 slider pots, one for the power supply and one for the actual equaliser circuitry itself. These three boards are soldered together, to completely eliminate inter-board wiring.

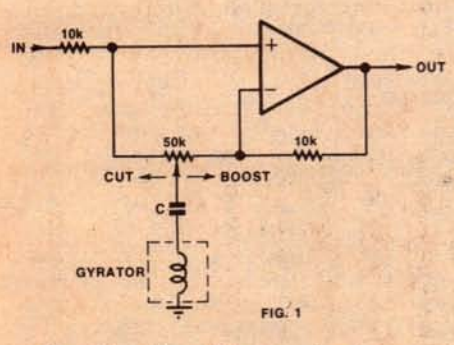


FIG. 1

The Equaliser has minimal power consumption. In fact, we used the smallest readily available transformer which was suitable. Combine the visual effect of the small transformer and the compact PCB assembly in the relatively large chassis and the Playmaster equaliser looks remarkably uncomplicated. And so it is.

The circuit is based on a simple principle which is illustrated by Fig 1. This shows an operational amplifier connected in the non-inverting mode, with negative feedback to the inverting input. The circuit is simplified in that it shows only one of the 10 slider controls and its associated circuitry.

Performance of prototype

FREQUENCY RESPONSE

Equaliser out	Flat
Equaliser in (all controls centred)	10Hz to 10kHz ± 0.25dB and —1dB at 20kHz

SIGNAL HANDLING

Gain	Unity
Maximum input and output voltage (with 10k load)	9 volts RMS
Boost and cut	±13dB

SEPARATION

	100Hz	1kHz	10kHz
with respect to 1V RMS and 4.7k across undriven input	-93dB	-74dB	-55dB

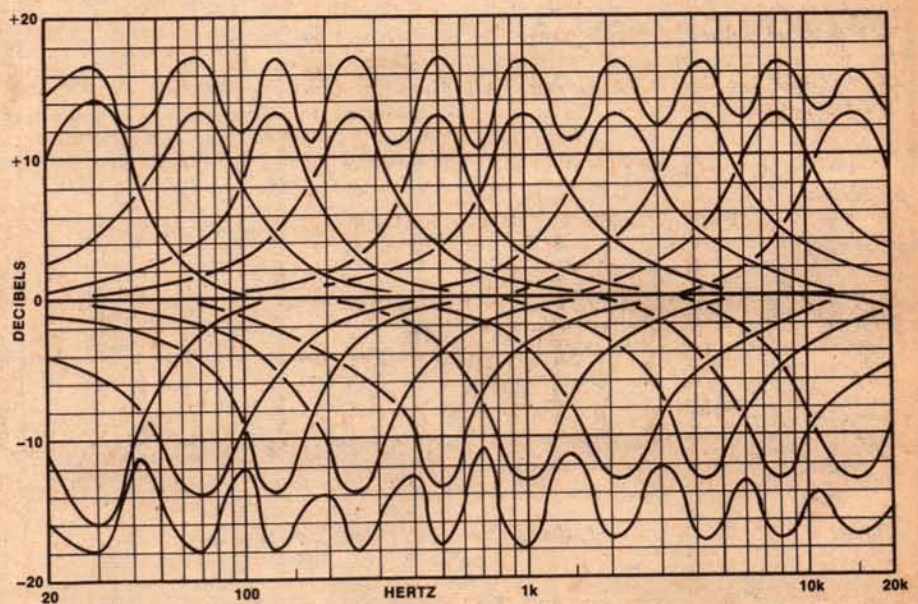
DISTORTION

	100Hz	1kHz	10kHz
with respect to 1V RMS	0.027%	0.03%	0.04%

SIGNAL-TO-NOISE RATIO

with respect to 1V RMS	94dB unweighted
with respect to 100mV	74dB unweighted

INPUT IMPEDANCE	100k
OUTPUT IMPEDANCE	1k



The overlapping curves show the maximum boost and cut available from each slider; the upper and low curves show the response "ripple" with all controls set at maximum or minimum.

The circuitry connected to each pot acts like a series tuned circuit, so that is how it is shown in Fig. 1. With the slider control centred, the op amp provides unity gain and the tuned LC circuit has negligible effect. When the slider pot is set to the boost end, the negative feedback signal tends to be shunted to ground by the tuned LC circuit which increases the gain at the resonant frequency. With the slider set to the cut end, the negative feedback is at maximum and the gain is at a minimum, at the resonant frequency. As might be

imagined, the multiple tuned LC networks tend to produce some interaction with each other, but this has been kept to a reasonable limit in our circuit.

First generation equalisers of a few years back did actually use inductors in this circuit configuration. These worked well, but the inductors are expensive and tedious to wind, and can be prone to hum induction. More modern designs use gyrators, as we have used.

As used here, the word "gyrator" refers to an op amp circuit which effectively transforms a capacitor into an inductor. This is illustrated in Fig. 2.

Consider an AC voltage source, Vi, connected to the op amp circuit of Fig. 2. This forces a current Ic through the capacitor, which develops a proportional voltage across R1. The voltage across R1 is reproduced at the output of the op amp. The voltage across R2 is equal to the difference between Vi and Vo and this causes current Io to flow through R2 and into the input voltage source!

An analysis of the phases of these currents and voltages will show that while Ic leads the voltage Vi, as would be expected for a capacitive circuit, the net input current, which is the vector sum of Ic and Io, actually lags the voltage Vi. So, in effect, capacitor C has been transformed into an inductor by

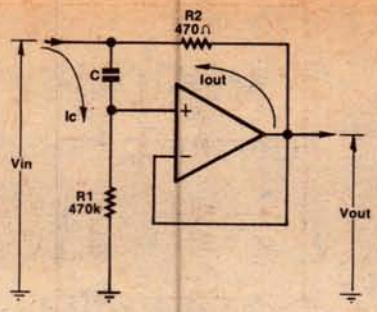


FIG. 2

the op amp. The inductance is given by the formula

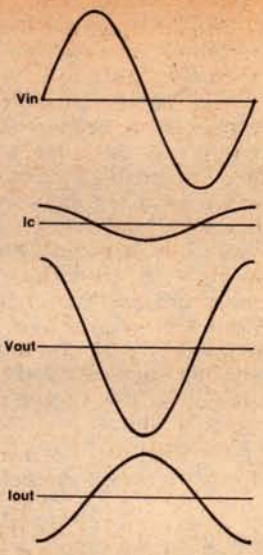
L = R1 x R2 x 3,

where C is in Farads, and R is in ohms and L is in Henries.

When you consider the fact that more than one op amp can be fitted into an integrated circuit package, the gyrator application can replace bulky inductors with very compact circuitry.

Now refer to the main circuit diagram.

We have used Fairchild uA4136 quad operational amplifier ICs. These op amps can be regarded as upgraded 741 op amps, with superior noise characteristics. This last factor is most important because it allows the Playmaster equaliser to be used in the Tape Monitor circuit of amplifiers where the signal level is nominally



about 100 to 200 millivolts or so.

IC1/3 functions as an input buffer stage while IC/1/4 performs the function described in Fig. 1. Six uA4136 quad op amps provide the entire active device complement for the complete equaliser.

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

$95

This includes sales tax.

Because the 4136 op amps have good supply ripple rejection, the power supply can be simple and inexpensive. Two half-wave rectifiers provide positive and negative supply rails, which are further filtered and decoupled via 47 ohm resistors and 100uF capacitors. Six 0.1uF capacitors on the main circuit board provide high frequency decoupling.

A light-emitting diode (LED) fed from the positive supply rail via a 1k resistor functions as the front panel pilot. The supply has fuse protection. Mains switch-off transients are suppressed by the .0047uF/250VAC capacitor across the transformer primary. The chassis is earthed via the mains, but does not connect to any part of the signal circuitry, to avoid earth loops.

Now to the construction. We have used slider pots imported by Dick Smith Electronics. Besides arranging for the supply of well finished front panels and chassis, as mentioned above, Dick Smith Electronics have also obtained a supply of matching black knobs, of suitable size and shape.

Construction is quite a straightforward process. Start with the slider pot board. This is drilled with suitably large holes to take the slider pot terminals. The PCB thus provides a firm

EQUALISER PARTS LIST

CHASSIS & HARDWARE

1 plated steel chassis, 370 x 80 x 245mm, with wrapover cover or timber sleeve
1 front panel
20 knobs to suit slider pots
3 miniature DPST switches
1 LED for pilot light
2 6-way RCA socket panels, Ralmar M421 or equivalent.
1 4-way insulated terminal block
6 25mm tapped nylon spacers (see text)
1 grommet
1 cord clamp
1 solder lug
1 .0047uF/250VAC capacitor
4 rubber feet
1 3-pin mains plug and three-core mains cord
1 transformer, Ferguson 2851, A&R 6474, DSE 2851 or similar with 12.6VAC centre-tapped secondary
Plus: screws, nuts, washers, shielded cable, hook-up wire, shrink tubing, tinner copper wire.

SLIDER PCB

1 PCB, 296 x 73mm, 79eq2a.
20 slider pots to suit, 50k linear taper.

MAIN PCB

1 PCB, 296 x 70mm, 79eq2b
6 uA4136 quad op amps
6 pc pins

CAPACITORS
(10% tolerance)
Tantalum: 2 x 10uF, 2 x 2.2uF 4 x 1uF
Metallised polyester (greencap): 2 x 0.47uF, 2 x 0.27, 8 x 0.1, 2 x .068, 2 x .056, 2 x .033, 2 x .027, 4 x .015, 2 x .0082, 2 x .0068, 4 x .0039, 2 x .0033, 2 x .0018.
Polystyrene: 2 x 820pF, 2 x 470pF, 2 x 220pF, 2 x 150pF, 2 x 120pF.

RESISTORS
(¼W, 5% tolerance)
2 x 1M, 20 x 470k, 4 x 100k, 4 x 10k, 2 x 1k, 20 x 470 ohms, 4 x 330 ohms.

POWER SUPPLY PCB

1 PCB, 78 x 70mm, 79eq2c
2 fuse clips, Swann FC1 (part no 1397-01-18)
1 250 milliamp 3AG fuse
2 1N4001 silicon diodes
2 1000uF/25VW electrolytic capacitors
2 100uF/16VW electrolytic capacitors
Resistors (¼W): 1 x 1k, 2 x 47 ohms.
4 pc pins.
NOTE: Capacitors and resistors with higher ratings may be used, if physically compatible. Other substitutions are not recommended.

mounting and precise location. Mount each slider pot flush against the PCB, bend the terminals over to hold it and solder. To enable flush mounting of each pot it will be necessary to bend over the vestigal lug associated with the wiper terminals (the inner pair).

With the slider pot PCB completed, put it away where it will be safe from being dropped on the floor or otherwise seriously stressed — it is a fragile assembly at this stage. The power supply and main PCBs are equally straightforward and require little comment regarding their assembly.

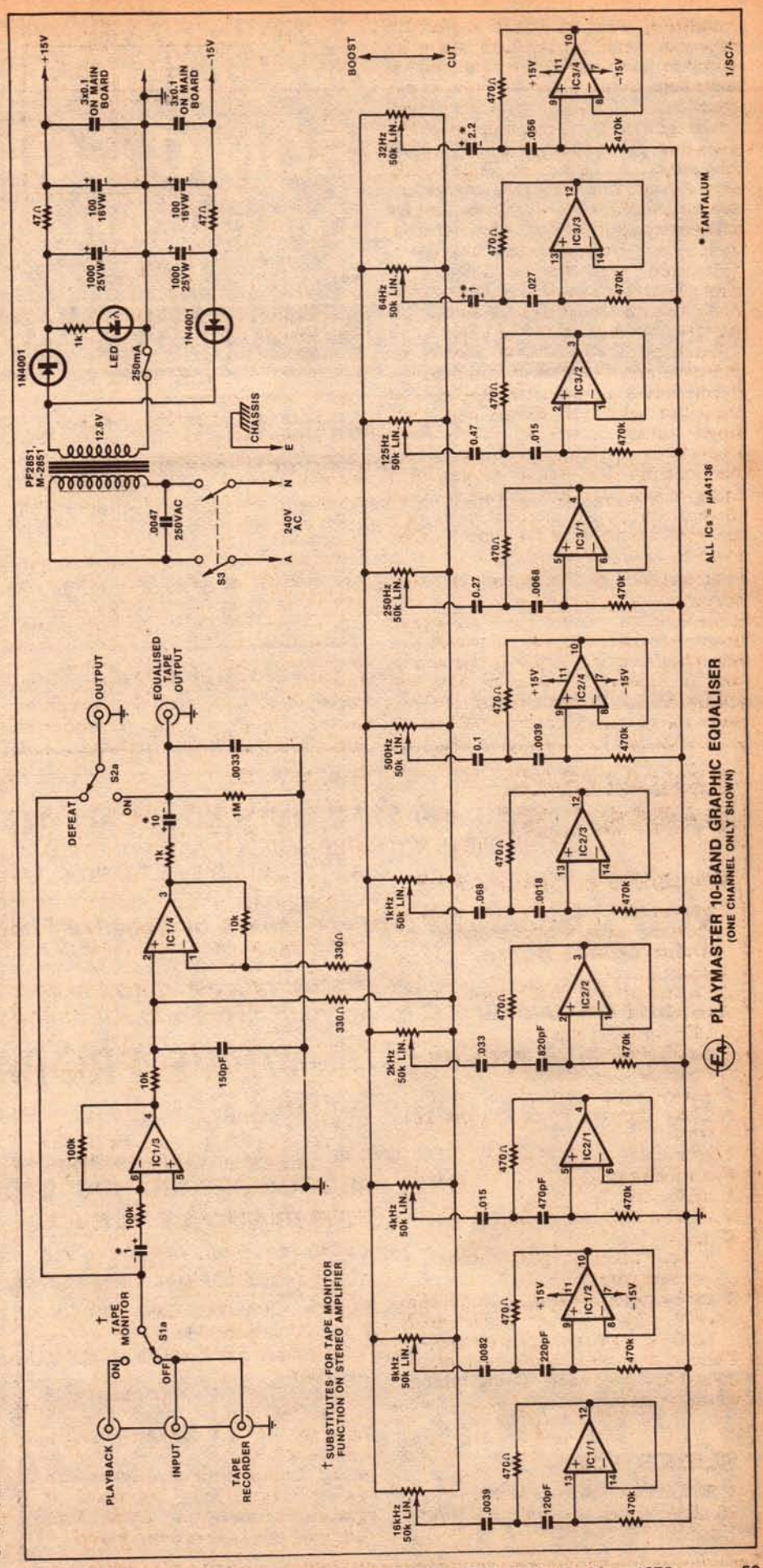
Use PC pins for the input and output connections. Those with square shanks are the most suitable.

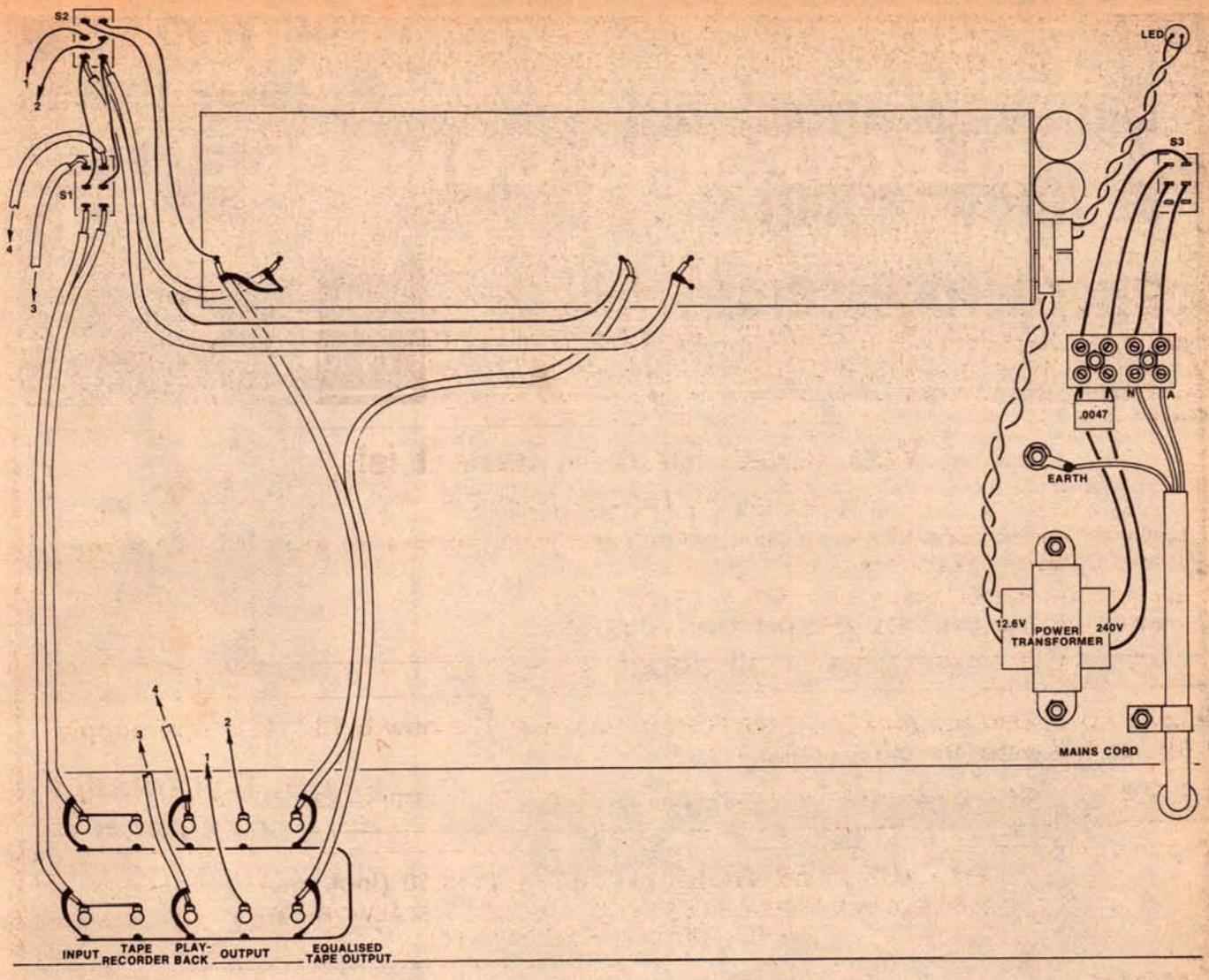
With all PC boards completely assembled, soldered and inspected for soldering defects, they are ready to be soldered together. The slider pot PCB should be firmly supported on a small carton, vyce or other mount so that its copper side is horizontal. Now sit the main PCB on the slider pot PCB so that it is perpendicular and its front edge lines up with the index marks on the slider pot PCB pattern. With both boards held in this position, use a soldering iron and solder to "tack" the boards together at several places along their length. This will hold them temporarily while each of the respective pads is soldered together. With the task complete, solder the power supply PCB to the end of the PCB assembly. The three output pads on the supply PCB contact the corresponding three pads on the main board to complete the supply connection.

The complete PCB assembly is supported from the front panel of the chassis via six insulating spacers which are 20mm long. Since we could not obtain spacers of this length we purchased six tapped nylon spacers 25mm long and cut them to the desired length of 20mm. Fix the spacers to the PCB assembly first and then mount the complete assembly in the chassis using countersunk screws.

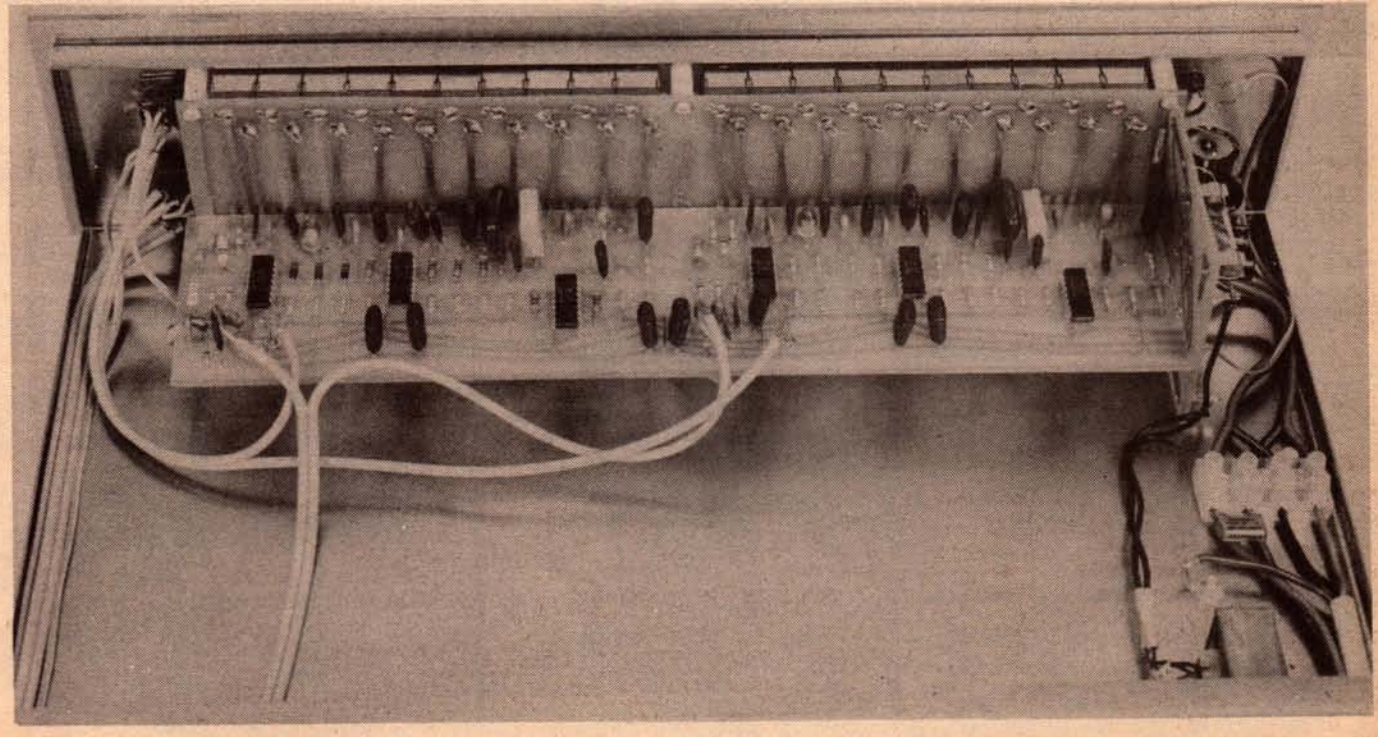
Do not fit the front panel at this stage. Instead, temporarily mount the toggle switches and complete the wiring inside the chassis. These details are shown in the chassis wiring diagram. Note that the mains and power supply wiring is kept as far as possible from the signal circuitry. Dress the mains leads to the on-off switch away from the power supply electros and sheath the switch with a piece of shrinkable plastic tubing for safety.

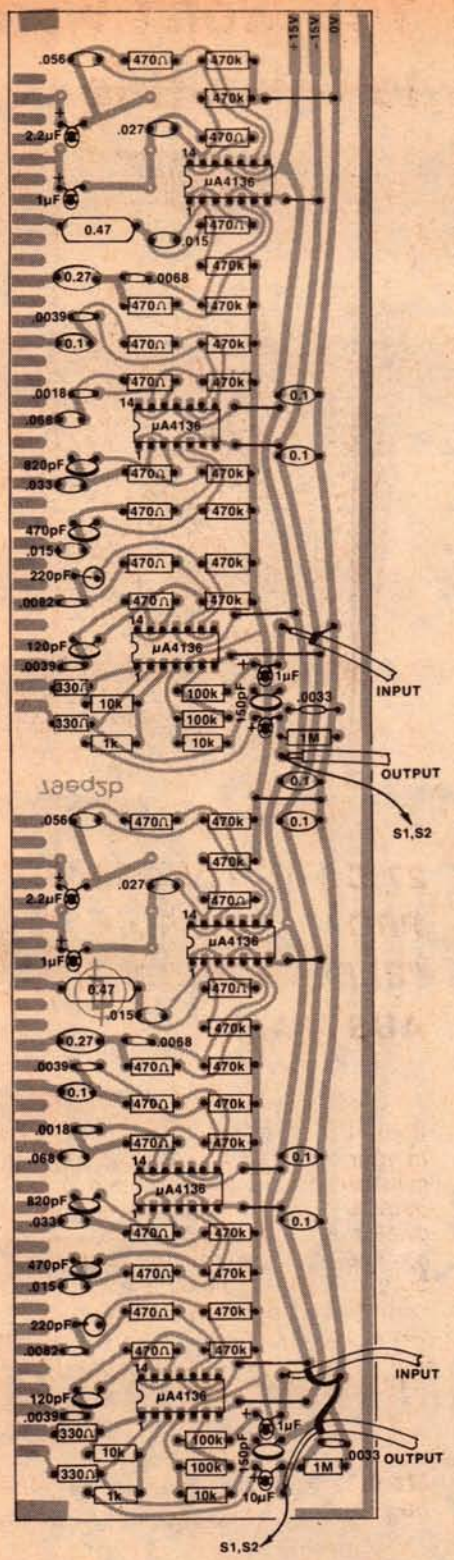
Similarly, sheath the mains connections to the power transformer and make sure that all other mains wiring and connections are safe. Do not fit the LED pilot at this stage. If you desire, it can be temporarily wired across the appropriate pins on the power supply. Now you are ready to switch on. Having checked all connections, apply power and check voltages. Make sure that approximately plus and minus 15 volts is





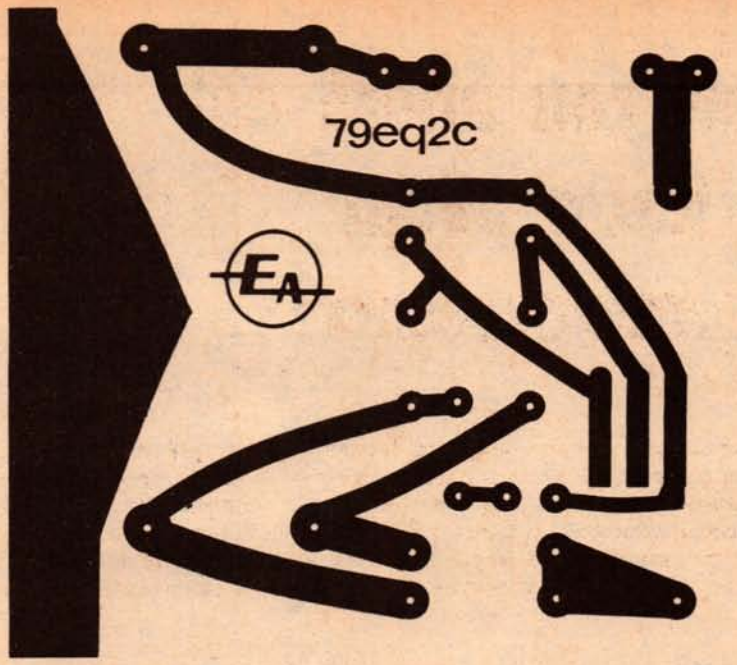
There is relatively little wiring within the chassis as this diagram and accompanying photograph show.





present at pins 11 and 7, respectively, of each 4136 IC.

Then check that each op amp output is close to zero volts. From the circuit, these are pins 3, 4, 10 and 12 and they should be within ±100mV of OV. If a particular op amp output is not within that narrow range, check that its inputs are at OV. Unless there is a PCB fault, this should be case anyway since all the inverting inputs are tied to the outputs and all non-inverting inputs (with the exception of IC1/4 in each channel, which is biased from IC1/3) are tied to and biased from OV.



If the voltage checks are okay, the time is ripe for a listening session. Connect the Equaliser to the Tape Monitor terminals of your amplifier and turn on. The volume control should be turned well down to start with. Feed a music signal in and check that each slider has an appropriate boost and cut effect.

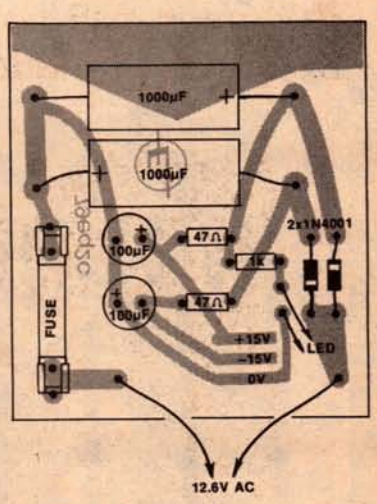
If a particular slider has no boost or cut, check that the wiper is not open circuit, or shorted to one terminal of the pot.

With all the sliders accurately centred, there should be negligible difference in sound quality whether the Equaliser is switched in or out of circuit. A slight difference in apparent sound quality is possible though, because the Equaliser will not have exactly unity gain, due to component tolerances. With all the sliders centred, the frequency response of the Equaliser is very flat except for a slight roll-off at the high frequency end — which amounts to 1dB at 20kHz.

With the volume control well advanced and no signal applied to the amplifier, listen to the residual noise of the amplifier. With most good amplifiers the residual noise of the Equaliser will be comparable with that of the amplifier. This can be confirmed by switching the Equaliser in or output of circuit. When each slider is set for boost or cut, there will be an increase in noise and it will take on a "formant" quality which is to be expected as the overall frequency response changes.

(The word "formant" is usually applied to the shaping filters used in electronic organs and synthesizers.)

Avoid switching the Equaliser on or off while the amplifier volume control is set at a high level, otherwise there

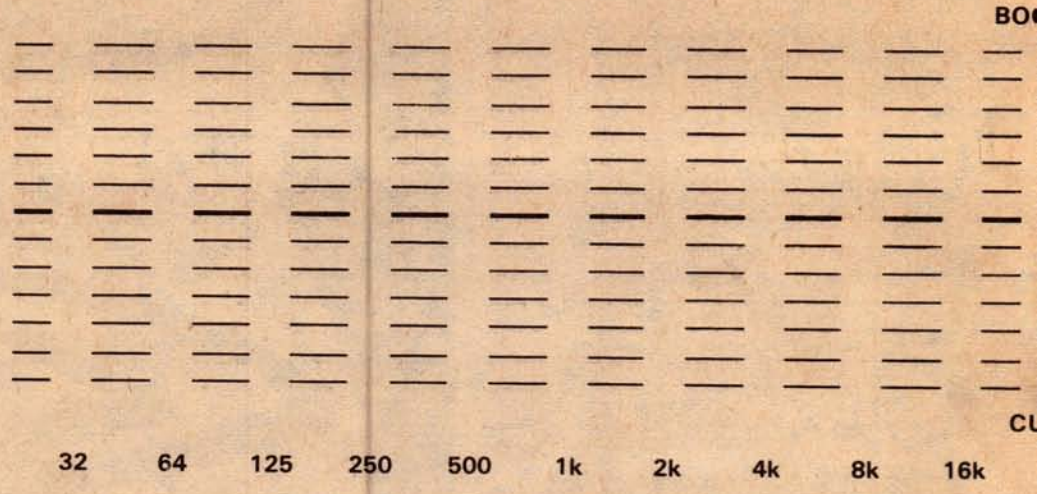


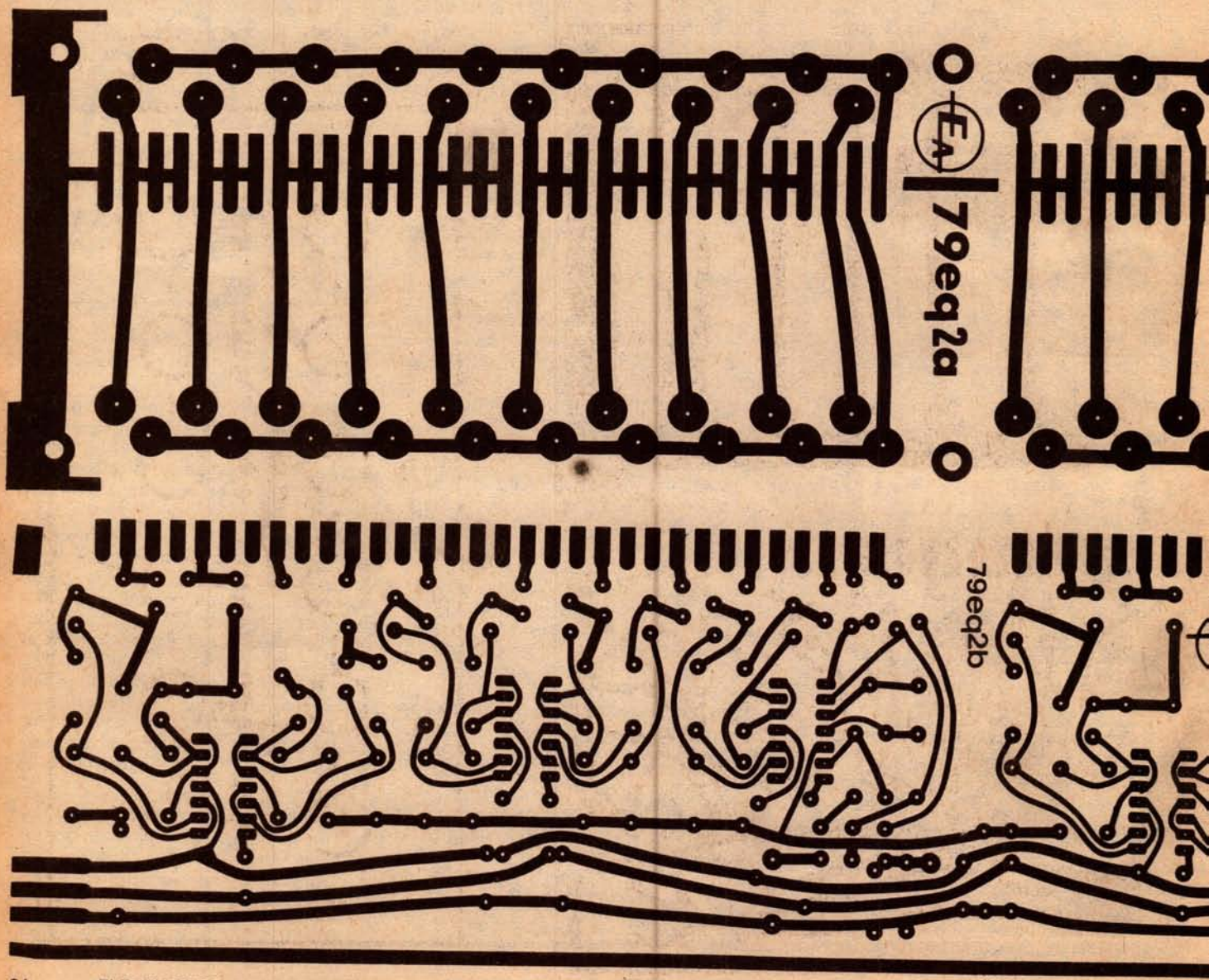
will be quite a loud turn-on thump from the loudspeakers and not as loud but more disconcerting, a "chirp" from the loudspeakers about two seconds after turn-off. (This is quite normal, by the way.)

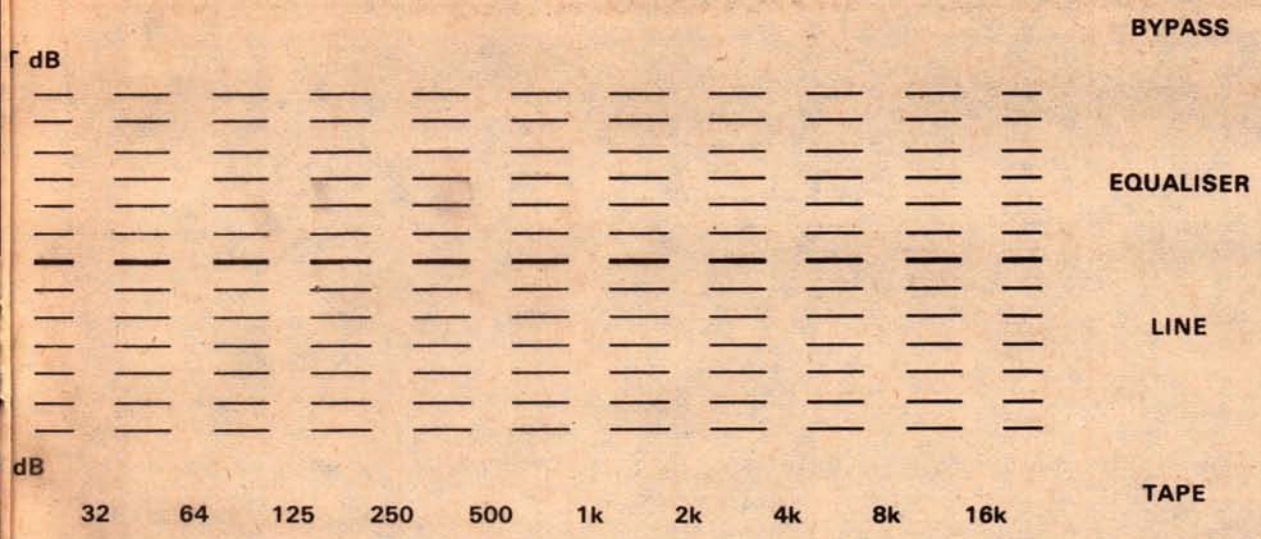
One other effect may be noticed when the amplifier volume control is fully advanced. There may be a noticeable hum difference when the Equaliser is switched into circuit. Note that this should not be noticeable at normal listening levels. This is actually a fault or characteristic of the amplifier concerned, and is due to the input of the amplifier being connected to its common earth point via a low impedance (eg, the source impedance of the Equaliser).

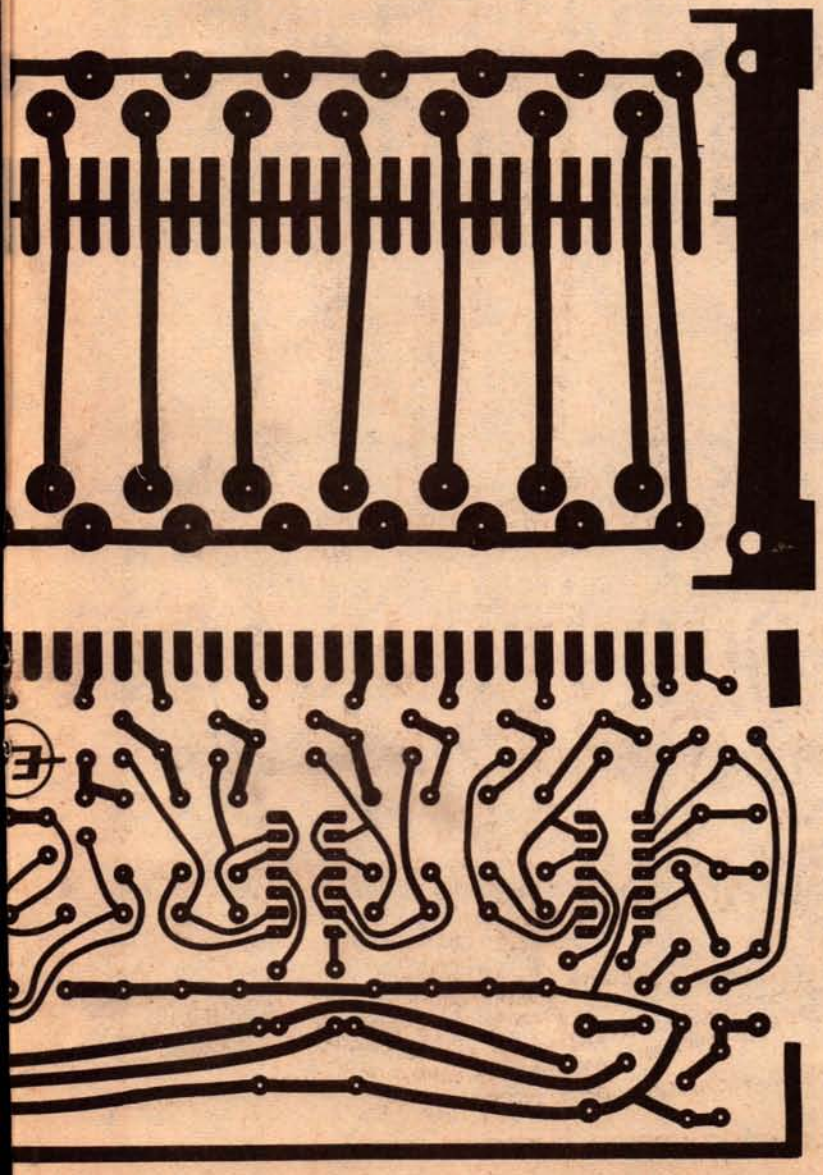
The effect may be duplicated by shorting the high level inputs of the amplifier. The effect can be mitigated by connecting a 10k resistor in series with the inputs of the amplifier or more conveniently, in series with the output of the Equaliser. Most people will find this modification unnecessary. We

Playmaster STEREO GRAPHIC EQUALISER

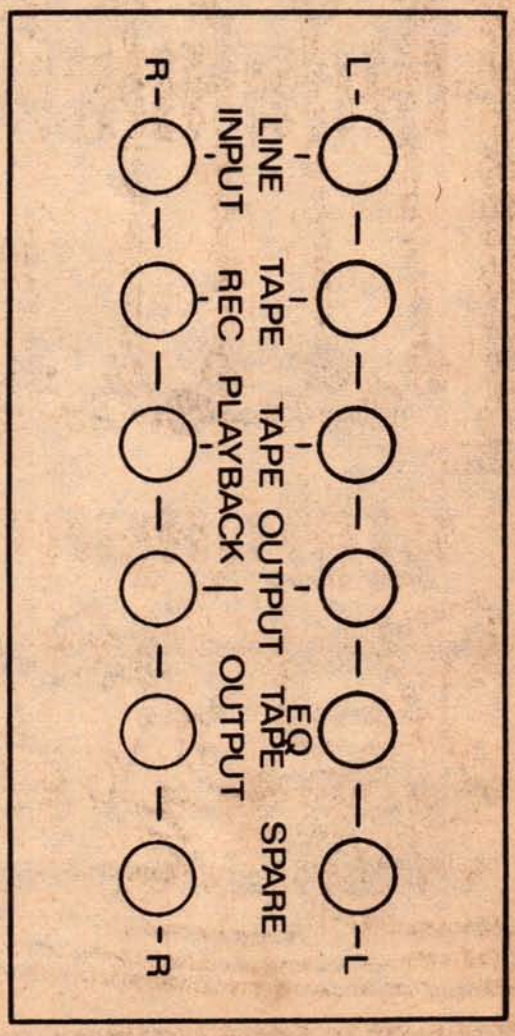


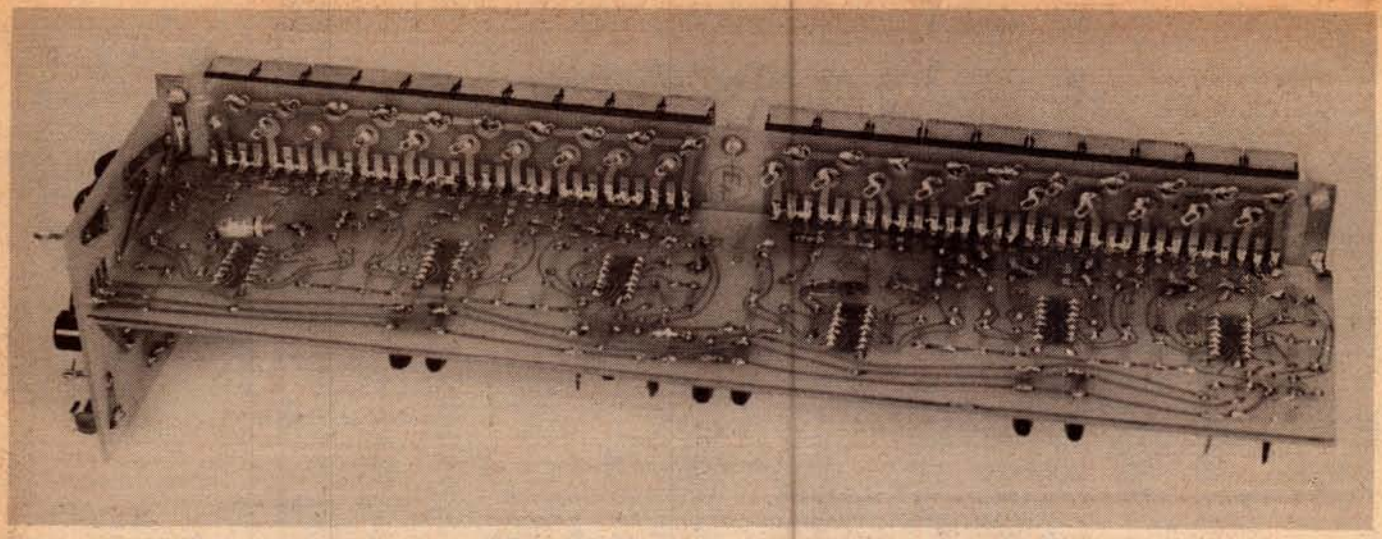




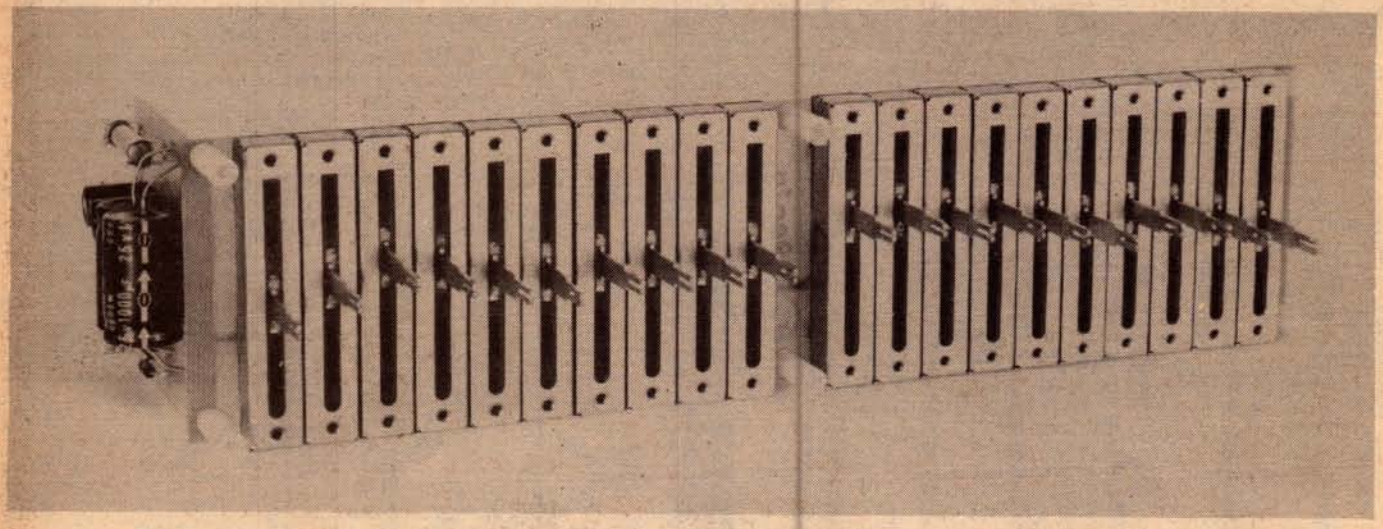


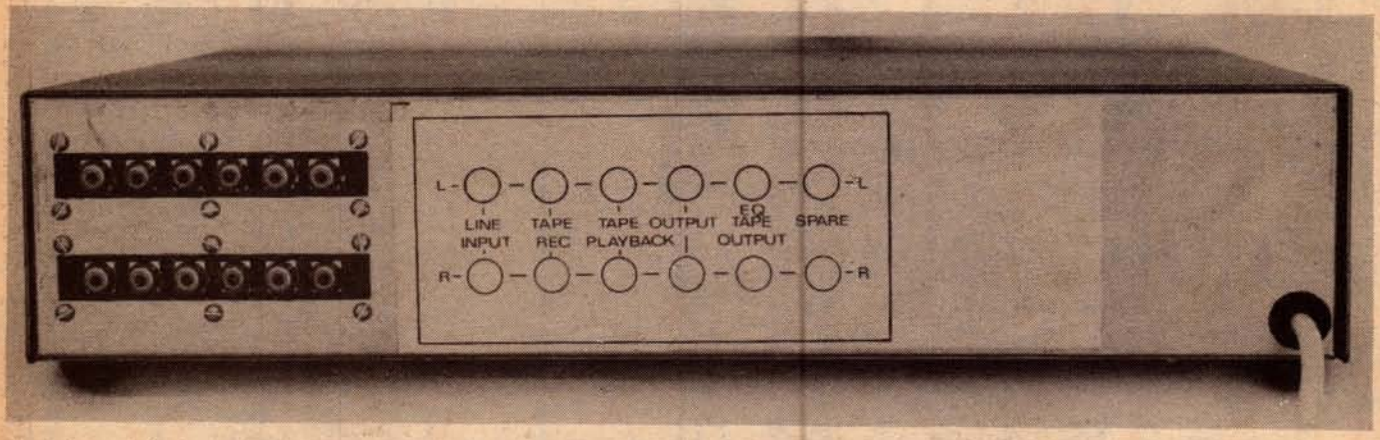
Displayed on these two pages is the full size artwork for the front panel, stick-on rear label and the two large PC boards.





These two photos show the PCB assembly before installation in the chassis. Noté that the six standoff spacers are fitted.





A stick-on label is affixed to the rear panel to identify the input and output sockets.

mention it to avoid having constructors concluding that their Equaliser has a fault!

With the foregoing checks complete, the Equaliser front panel may be fitted and the rear panel label stuck on.

The front panel is secured to the chassis via the nuts of the three toggie switches. Make sure that the sliders mate well with the front panel before finally securing it. The LED pilot light (as supplied by Dick Smith Electronics) is a push-fit in the front panel. Our prototype actually used a Cliplite LED bezel which snaps into a ¼-inch hole. It is supplied by C&K Electronics (Aust) Pty Ltd.

Do not fit the knobs to the sliders until you are quite sure that the Equaliser is complete and operating properly. The knobs are quite easy to push on to the sliders, but are very difficult to remove and there is a risk of marking that expensive panel.

We think that most people will agree that the Playmaster Equaliser with a cost of less than $100 is a real bargain. Add that to the fact that we plan to produce a matching Octave Analyser to enable users to get the best out of their systems, and you have an attractive and interesting path to improved sound quality.