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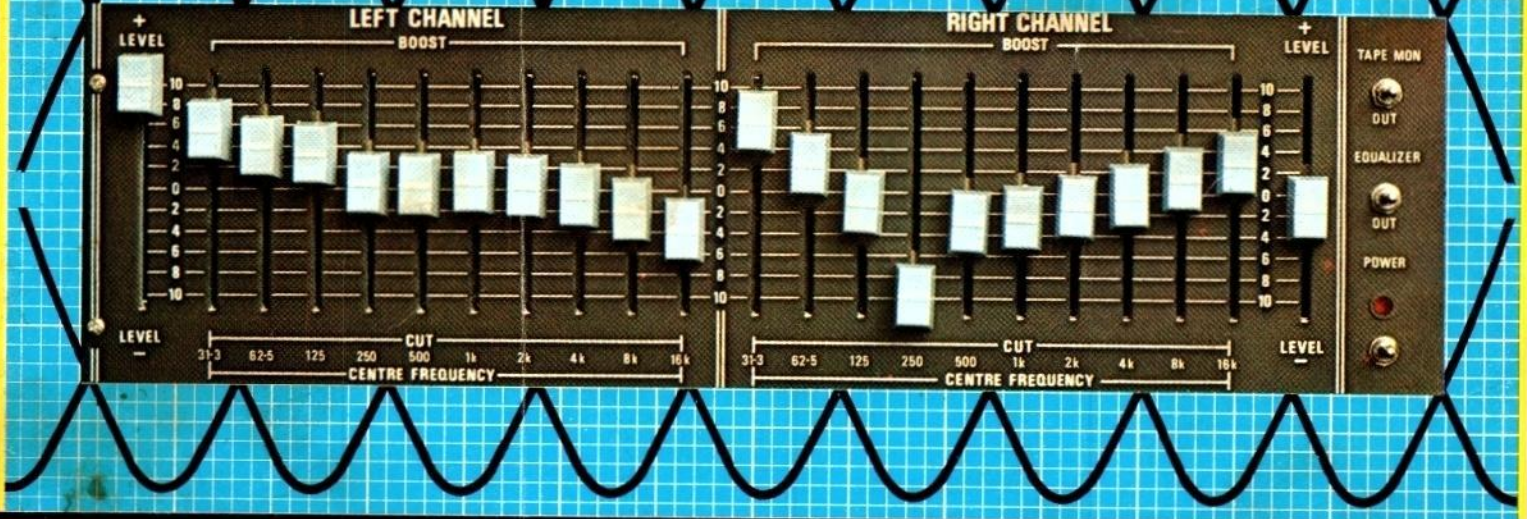
40p

GYRATOR BASED DESIGN: NO COILS TO WIND!

GRAPHIC EQUALISER



ETI SUMMER SALE – BARGAINS GALORE!

ALSO:

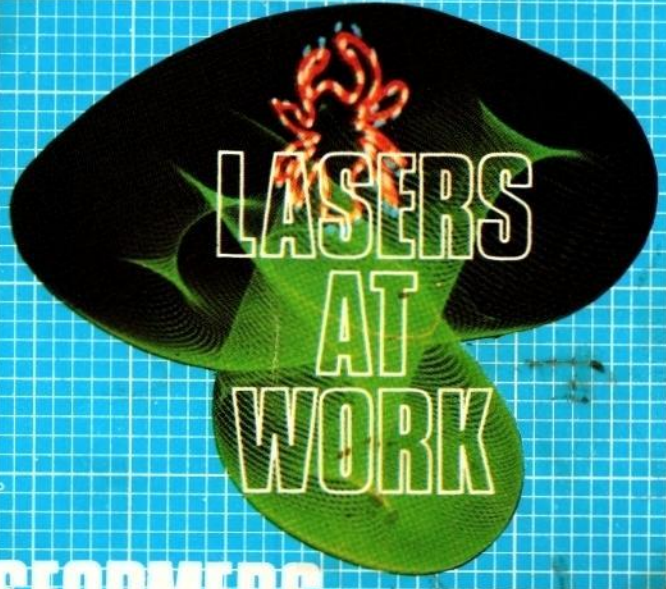
LOUDHAILER

CCD EXPLAINED

STEREO SIMULATOR

SYSTEM 68 CPU BOARD

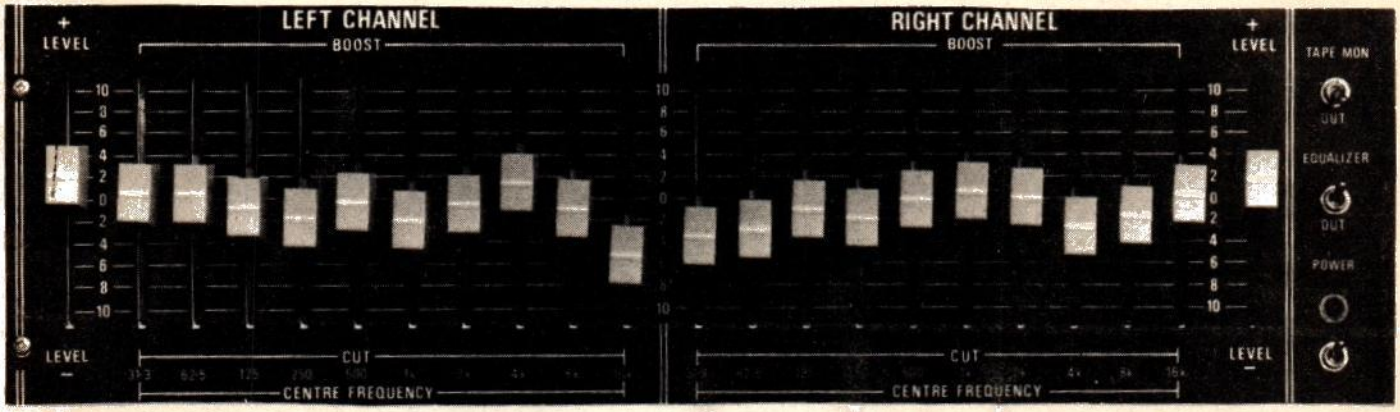
CHOOSING & USING TRANSFORMERS



NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDIO

GRAPHIC EQUALISER

GRAPHIC EQUALIZERS are popular with both the professional and domestic user alike. However until the presentation of our earlier equalizer (ETI 427) the cost of such a device was very high and this limited its wide use. We have now redesigned the equalizer to simplify the construction and it now has no coils and one additional filter has also been added.



The advantages of an equalizer are not generally well known but are as follows.

Firstly an equalizer allows the listener to correct deficiencies in the linearity of either his speaker system alone, or the combination of his speaker system and his living room.

As we have pointed out many times in the past, even the best speakers available cannot give correct reproduction in an inadequate room. It is a sad fact that very few rooms are ideal, and most of us put up with resonances and dips, convinced that this is something we have to live with.

Whilst the octave equalizer will not completely overcome such problems, it is possible to minimize some non-linearities of the combined speaker/room system.

In a concert hall it is also possible to use the unit to put a notch at the frequency where microphone feedbac occurs, thus allowing higher power levels to be used.

Thirdly, for the serious audiophile, an equalizer is an exceedingly-valuable tool in evaluating the deficiencies in a particular system. One adjusts the equalizer to provide a uniform response, the settings of the potentiometer knobs then graphically display the areas where the speaker etc is deficient.

There is a snag, however, one must have an educated ear in order to properly equalize a system to a flat response. It is not much use equalizing to your own preference of peaky bass etc in order to evaluate a speaker.

Ideally, a graphic equalizer should have filters at 1/3 octave intervals, but except for sound studios and wealthy pop groups, the expense and size of such units are too much for most people.

The equalizer described here has 10 octave spaced filters but if desired it could be modified to give 1/2 or 1/3

GRAPHIC EQUALISER

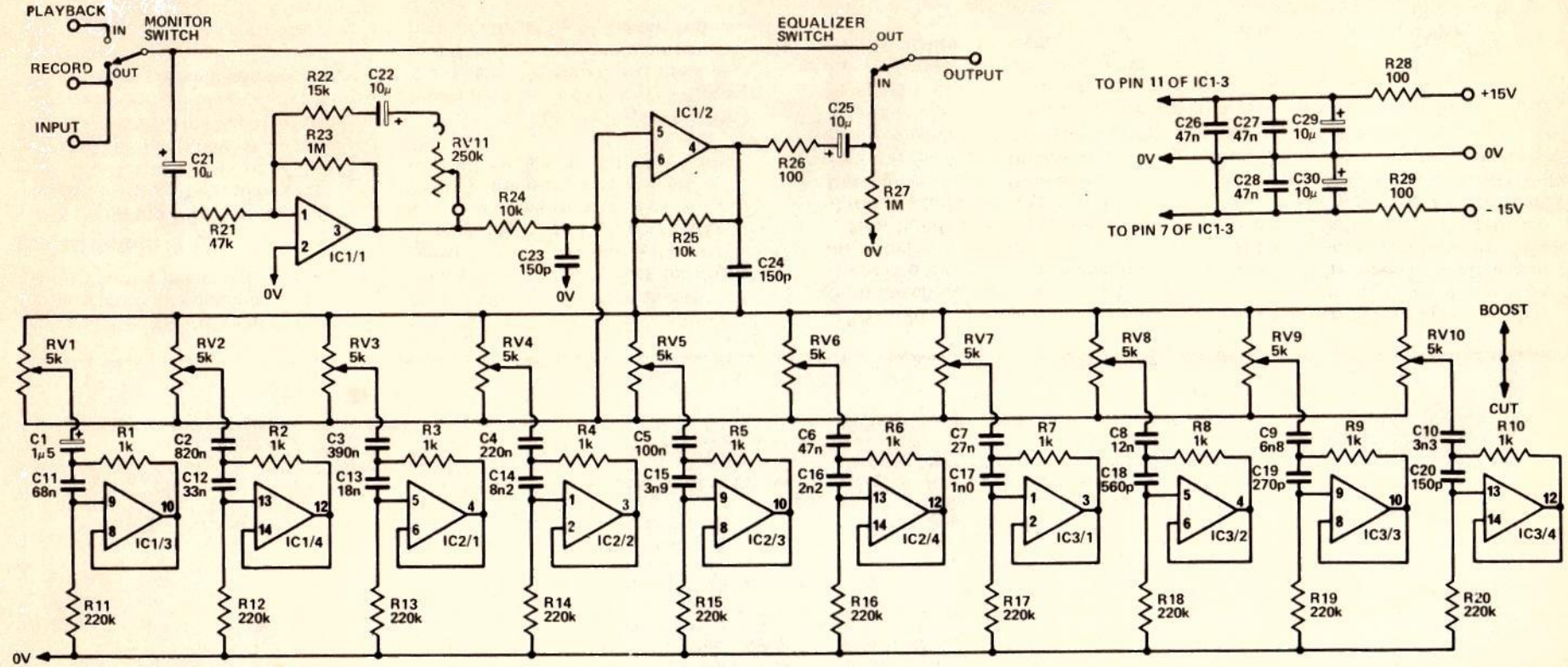


Fig. 1. Circuit diagram of one channel of the equalizer.

HOW IT WORKS

This equalizer is basically similar to that used in the previous unit with the addition of an extra filter in each channel. The previous unit also used coils (inductors) – these have been replaced by gyrators to simplify construction. We will explain more about gyrators later but at the moment just assume that they are an inductor.

The equalizer stage is a little unusual in that the filter networks are arranged to vary the negative feedback path around the amplifier. If we consider one filter section impedance of the LCR network will be 1 k ohms at the resonant frequency circuit.

With the slider of the potentiometer at the top end (Fig. A) we have 1 k ohms to the OV line from the negative input of the amplifier, and 5 k between the two inputs of the amplifier. The amplifier, due to the feedback applied, will keep the potential between the two inputs at zero. Thus there is no current through RVA. The voltage on the positive input to the amplifier is therefore the same as the input voltage since there is no current through, or voltage drop across resistor RA.

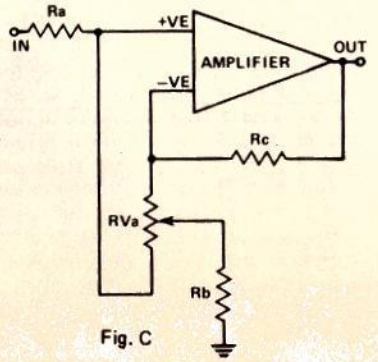
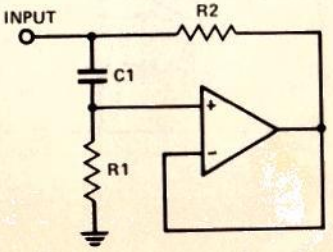


Fig. C

of the amplifier. The use of a second amplifier will increase the resistance to many megohms while the same formula holds for inductance.



of the network. At either side of resonance the impedance will rise (with a slope dependant on the Q of the network which is 3) due to the uncancelled reactance. This will be inductive above resonance and capacitive below resonance. We can therefore represent the equalizer stage by the equivalent circuit below.

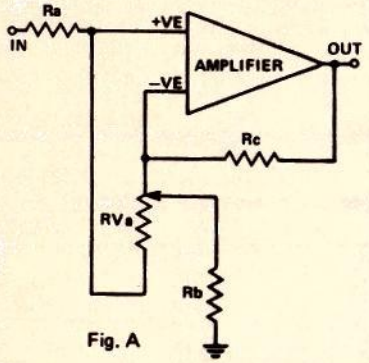


Fig. A

It must be emphasized that this equivalent circuit represents the condition with one filter only, at its resonant frequency. Additionally letters have been used to designate resistors to avoid confusion with components in the actual

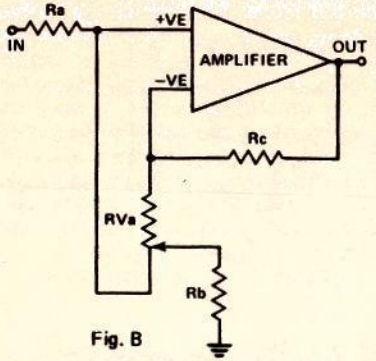


Fig. B

The output of the amplifier in this case is approximately the input signal times (10 000 + 1000)/100 giving a gain of 20 dB. If the slider is at the other end of the potentiometer, (Fig. B), the signal appearing at the positive input, and thus also the negative input is about 0.1 (1000/(10 000 + 1000)) of the input. There will still be no current of the potentiometer and in RC, thus the output will be 0.1 of the input. That is, there will be a loss of 20 dB.

If the wiper is midway, both the input signal and the feedback signal are attenuated equally, and the stage will have unity gain.

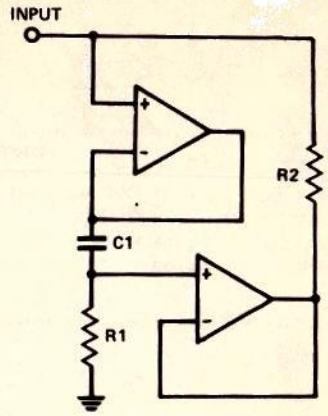
With all filter sections in circuit the maximum cut and boost available is reduced, but ± 14 dB is still available.

In the actual circuit we have used the first op-amp (IC1/1) as a buffer for the input and also as the overall gain control stage. With the values shown the gain is adjustable over a range of −9 to +14 dB. By replacing R22 by a link RV11 will act like a normal volume control. Now to the gyrator.

The only difference between an inductor and a capacitor – electrically, that is, not mechanically – is the phase relationship between the current and voltage. In the gyrator we use an op-amp to reverse the phase relationship of a capacitor and make it appear like an inductor. In the circuit below the inductance is given by the formula

$$L = R1 \times R2 \times C1 \text{ H where C is in Farads}$$

Like a real inductor there is a series resistance (winding resistance) or R2 and a parallel resistance R1 (in a coil this is due to winding capacitance). The lowest value of R2 depends on the amplifier used but for standard op-amps it would be about 100 ohms. At the high end the value of R1 is limited by input current.



octave spacing as large values of inductance are easily obtained with gyrators (active inductors).

Construction

Assemble the PCB's as per the overlays, leaving off the sliders for now. Check everything carefully to make sure it's correct, as once they are mounted onto the board you'll never be able to get to anything!

To fit these potentiometers, solder a generous 2 inch length of tinned wire to each of the end contacts, and one of the slider pins. Offer up the pot to the board, push the wire through the board from the back and solder to the pc pins, such that the board itself is spaced away from the board by about an inch.

Make sure the wire does not short across any of the tracks as it passes through the PCB. It's a good idea also now to ensure that once you've fitted all the pots, they still line up with the metalwork holes for mounting.

If you're using the Maplin kit, the sliders have to be spaced away from the chassis. We found that this was best done by using four washers between the body of the pot and chassis.

If this is not done, the tang fouls the bolt within the body, and limits the travel.

The volume controls mount straight onto the chassis, and can easily be wired in once the board assemblies are fitted into the box.

Now build up the PSU, and test it throughly before wiring it to the boards. Mount the transformer as far from the circuit boards as possible, and if possible screen it with a metal enclosure. On the original shallow metalwork shown here screening the PSU added considerably to the overall quality of sound.

Third octave filters

While we have not built up a third octave unit we see no reason why it will not work. Additional stages can simply be added except that the Q of the circuits must be changed to narrow the band. At the moment the impedance of the capacitor and inductor (gyrator) is about 3000 ohms at the centre frequency and this should be increased to about 8000 ohms for the third octave unit. The capacitors and inductors can be calculated by

$$C = \frac{1}{2\pi f X_C} \qquad L = \frac{X_L}{2\pi f}$$

where $X_C = X_L = 8000\Omega$
and f = centre frequency

It is recommended to reduce loading IC1/2 that the potentiometers be increased to 10k.

GRAPHIC EQUALISER

PARTS LIST

RESISTORS all ½W 5%

R1-R10	1k
R11-R20	220k
R21	47k
R22	15k
R23,27	1M
R24,25	10k
R26,28,29	100
R30	1k8

POTENTIOMETERS

RV1-RV10	5k lin
RV11	250k log

CAPACITORS

C1	1u5 tantalum
C2	820n polyester
C3	390n "
C4	220n "
C5,33,34,35,36	100n "
C6	47n "
C7	27n "
C8	12n "
C9	6n8 "
C10	3n3 "
C11	68n "
C12	33n "
C13	18n "
C14	8n2 "
C15	3n9 "
C16	2n2 "
C17	1n0 "
C18	560p ceramic
C19	270p "
C20,23,24	150p "
C21,22,25,29,30	10u 25V
C26-C28	47n polyester
C31,32	1000u 25V

SEMICONDUCTORS

IC1-IC3	4136
IC4	4195
LED 1	TIL 209

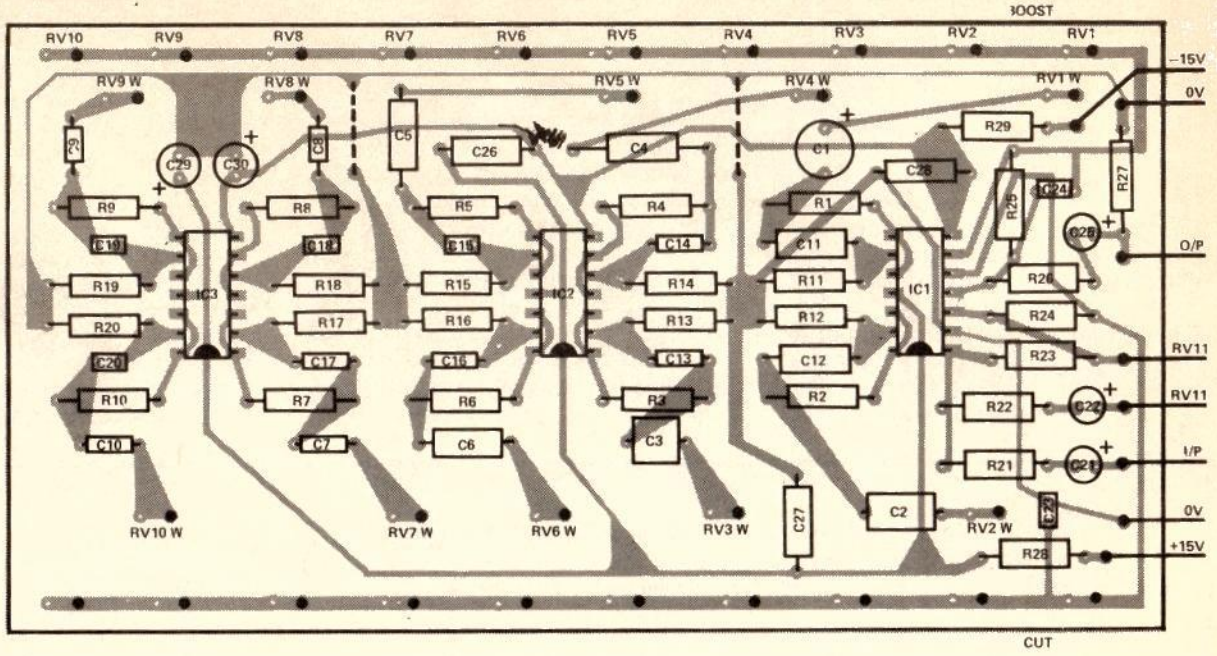
TRANSFORMER

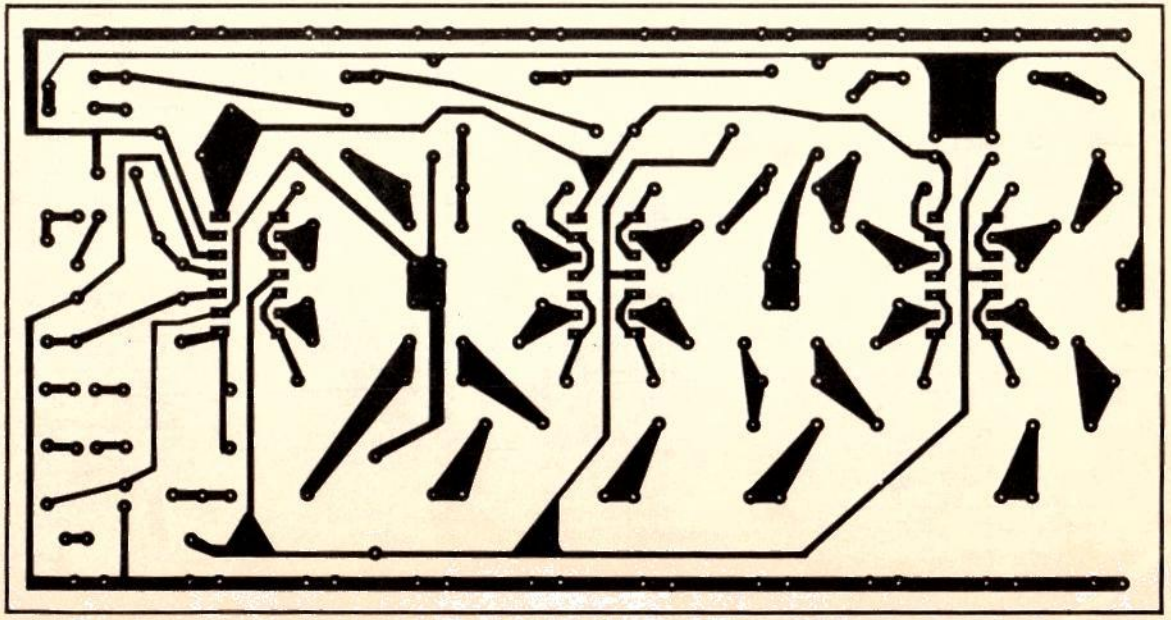
T1 240/12-0-12 at 100mA or more

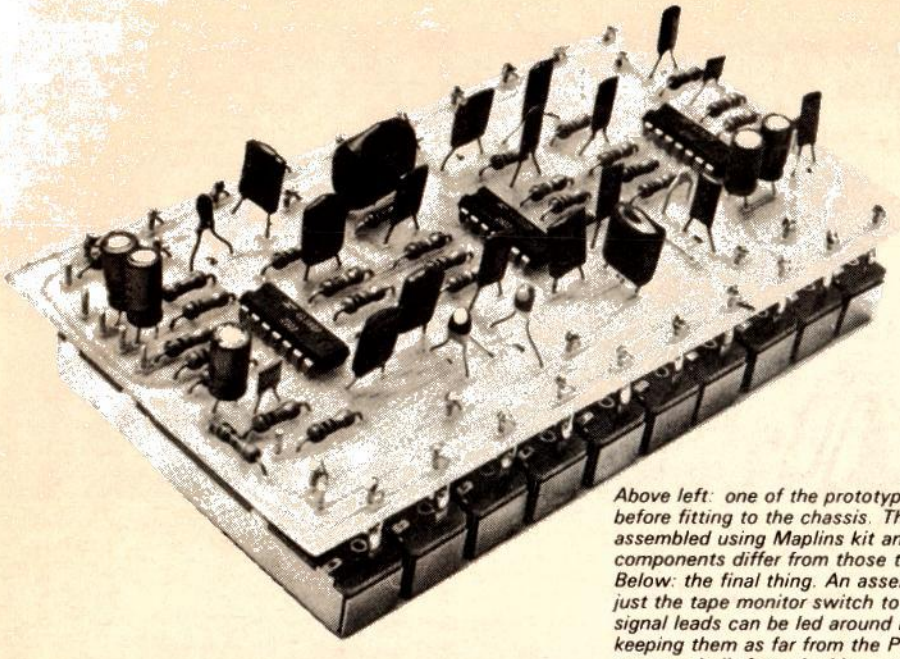
MISCELLANEOUS

Metalwork and case to suit
Three DPDT toggle switches
Three core flex and plug
For stereo operation double quantity of all components except PSU parts.

Component overlay and foil pattern for the main pcbs in the equaliser. Two of these are required for stereo. The pins are to be wired to the slider controls once everything is fitted onto the board. Foil pattern shown full size at 152mm width.



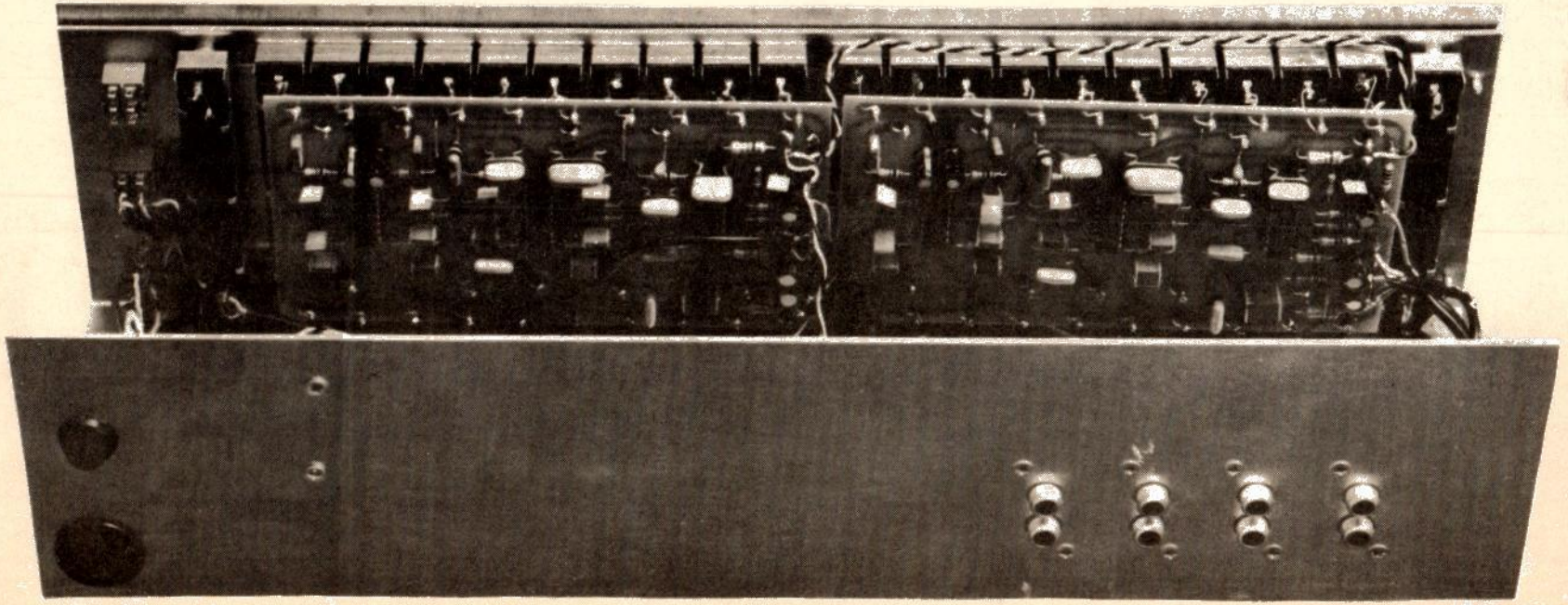




Above left: one of the prototype board assemblies before fitting to the chassis. This was not assembled using Maplins kit and so the components differ from those they will supply. Below: the final thing. An assembled equaliser with just the tape monitor switch to be wired in. All the signal leads can be led around beneath the sliders, keeping them as far from the PSU as possible. This one was built from the kit — so now you know what it looks like!

SPECIFICATION

Frequency response			
Equalizer out			Flat
Equalizer in	10Hz – 20kHz		± ½dB
and all controls at zero			
Range of controls			
Individual filters			± 13dB
Level control			+ 14dB – 9dB
Maximum output signal			
at <0.1% distortion			6 volts
Maximum input voltage			10 volts
Distortion			
at 2 volts out, controls	100Hz	1kHz	6.3kHz
flat	0.02%	0.02%	0.04%
Signal to noise ratio			
re 2 volts out, controls flat			82 dB
Input impedance			47 k
Output impedance			100 ohms



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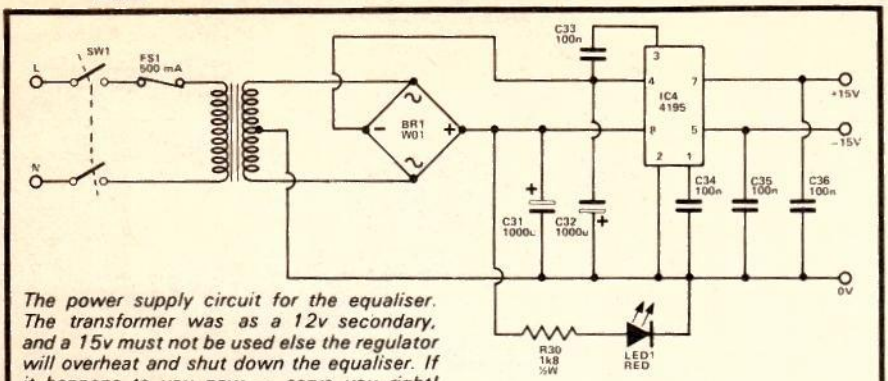
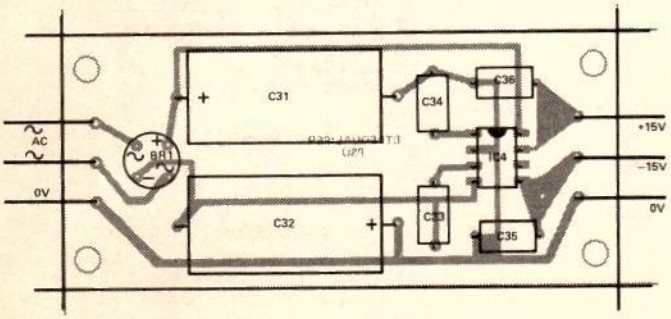


The power supply circuit for the equaliser. The transformer was as a 12v secondary, and a 15v must not be used else the regulator will overheat and shut down the equaliser. If it happens to you now — serve you right! Current drawn per rail is about 48mA.

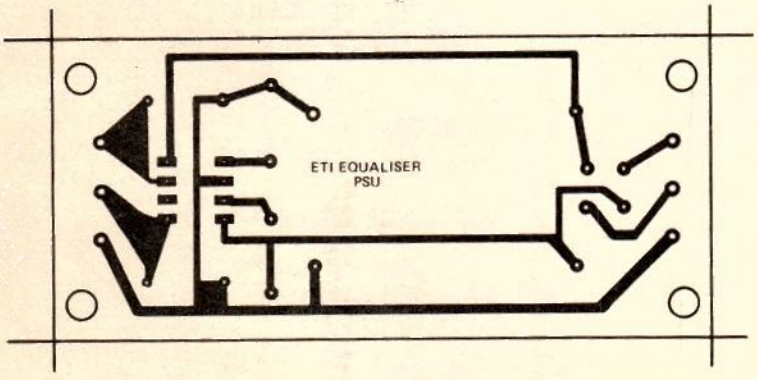
BUY LINES

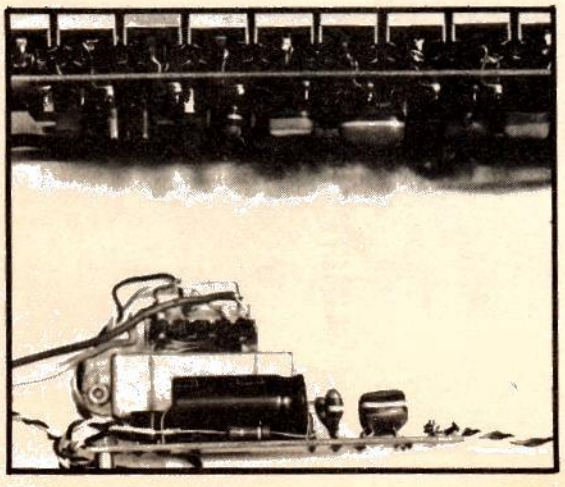
Maplin are producing a full kit, including metalwork, for this project at a cost of £65 all inclusive. All components will be available separately. Note that we have not given metalwork dimensions ourselves, since sliders vary greatly in dimensions and mounting requirements. Maplin are also working on a wooden sleeve to suit their kit, and details will be available short-ly. See ad on back cover for address etc.

The 4136 op-amp can be bought from Eurosem International Ltd., Haywood Hse., Pinner, Middx. HA5 5QA (phone or write for price) if you are one of these people who don't like kits!



Component overlay and foil pattern for the power supply. The LED dropper resistor is wired from C32. The foil pattern is shown full size i.e. 88mm width.





The power supply board in situ. Note the LED dropper resistor wired from the reservoir capacitor. The support pillars are missing from one end of the pcb here, as they help support the screen around the transformer and this had to be removed. For some reason our camera wouldn't work through aluminium.

Below: The beast assembled and lying beneath our camera. Note that here the screening has been removed from around the power supply so you can see what's gone where. The LED wiring can be seen as a twisted pair running from the regulator board top left.