Constructional Project

GUITAR PRACTICE AMP

BART TREPAK

A low-cost amplifier that will allow the budding guitarist to improve his playing technique, without annoying the household or neighbours!

COMMERCIAL guitar amplifiers, even those intended for practising, tend to be fairly expensive and have many features such as gain and tone controls which are seldom used, while lacking more useful ones such as an extra input for a microphone or another guitar. The budding musician's money could be better spent on other accessories or even a better guitar, especially as a simple practice amplifier for use with headphones can easily be built around a cheap integrated circuit.

Even a more ambitious version for driving a speaker providing an output of a few watts, which would be quite loud enough to annoy the neighbours or for playing in a small hall, only requires the addition of a cheap power amplifier i.c and a few more components.

EASY-BUILD

Although the cost and number of components required is small, audio power amplifier circuits do not lend themselves to a simple stripboard layout and the problems associated with designing and making a suitable printed circuit board are likely to put off all but the most cost conscious or determined constructors. The simple project to be described here solves this problem and has been designed for easy construction with virtually no off-board wiring apart from the mains transformer, speaker and an optional headphone socket.

Since the printed circuit board is readily available, the circuit can be "knocked up" in a very short time and you should have some change from £25. The finished circuit can be mounted in the same cabinet as the speaker (these can be salvaged from a defunct hi-fi unit) and even if a speaker has to be purchased separately it should not set you back very much.

AMPLIFIER CIRCUIT

The full circuit diagram of the Guitar Practice Amp shown in Fig.1 is very conventional and consists of an inverting preamplifier stage, IC1, feeding a single chip power amplifier, IC2. The op.amp preamplifier IC1 has a variable gain set by preset VR1 to enable this to be set to any required level (up to 100) and should, therefore, be suitable for even the most inefficient guitar pick-ups.

Many small commercial guitar amps often feature tone controls but these are really superfluous as most electric guitars have perfectly adequate tone controls fitted and so these have not been included in this design.

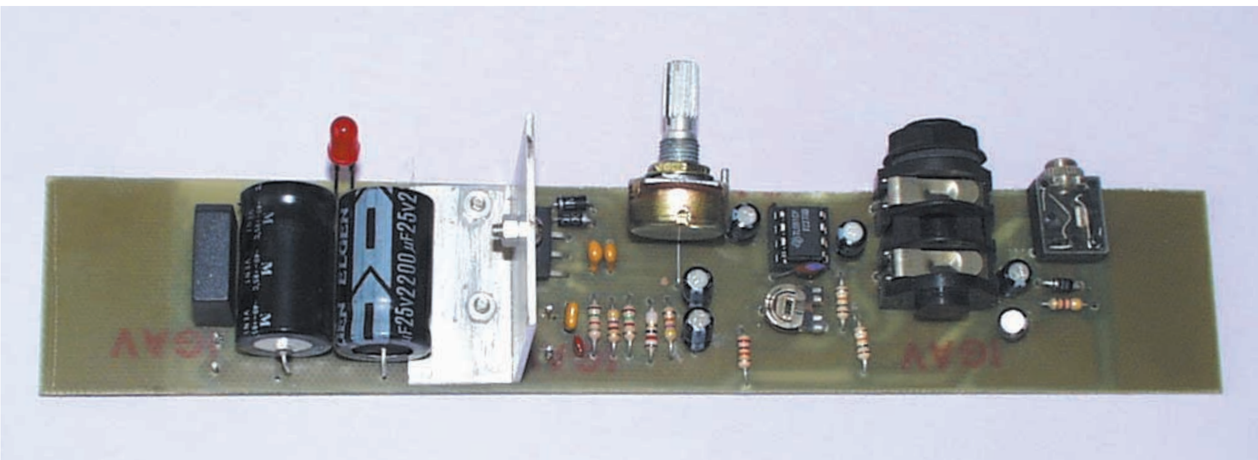
The output of the preamplifier stage (IC1 pin 6) is fed via Volume control VR2 to the power amplifier IC2, which is based around the popular TDA2030. This device can supply up to 24W of audio power depending on the supply voltage and speaker impedance used, provided we are not too bothered about the distortion which in this application can almost be considered to be an advantage.

With the lower supply voltage specified, a more reasonable output power would be about 6W to 10W which should be more than sufficient for our purpose. The power output can be easily increased if required by reducing the speaker impedance or increasing the supply voltage, and no changes in the component values are required.

It should, however, be remembered that the maximum supply voltage for both i.c.s is 36V. The TDA2030 is a very well protected device featuring both short circuit and over dissipation protection although from a reliability point of view it is certainly not advisable to run the device in either of these conditions.

Music generally tends to have many peaks while the average power dissipated remains low so that in practice, despite the use of the relatively small heatsink specified, the temperature of the device will remain well within its safe limit even with prolonged loud playing. Also, as the circuit is permanently connected to the speaker (except when in headphone mode) the possibility of a short circuited output is much reduced.

An (optional) output socket SK3 is also wired in circuit to enable headphones to be connected in place of the speaker LS1.



This is arranged so that inserting the headphone jack plug automatically disconnects the speaker. It also switches in a resistor, R11, in series with the headphones to prevent overloading, see Fig.1 and Fig.3.

Both the resistor and the headphone socket are mounted off the board and it will be noticed that the headphones which normally have an impedance of 32 ohms (each) are connected in series.

POWER SUPPLY

The circuit is completed by a conventional power supply consisting of mains transformer T1, bridge rectifier REC1 and smoothing capacitors C12, C13. It provides a d.c. supply of +12V and –12V and although a single rail supply could have been used, the advantage here is that the usual large speaker coupling capacitor is not required.

This may not seem to be such an advantage when it is realised that two capacitors are now required in the power supply, but it does mean that the annoying "switch-on thump" normally associated with these amplifiers (due to the speaker coupling capacitor charging up) is eliminated. The relatively low impedances in the circuit mean that hum and noise pick-up is low so that an l.e.d. D4 Power On indicator has been included to remind the user to switch off!

ELECTRET MICROPHONE

Most of today's top hits are songs and playing chords on their own does not sound very good, it is far better if the "artist" can sing along while playing. With an electric guitar a microphone is required to avoid having to shout rather than sing.

Nowadays headphones which include a microphone are available from any computer store for around £5 and these are eminently suitable for this application. Many practice amplifiers however, have only one input and cannot easily accommodate a microphone but this deficiency has been rectified in this design by adding a simple mixer.

The microphones incorporated in these cheap headsets are usually "electret" types. The microphone element constitutes in effect a very high impedance source and a buffer amplifier (consisting of a field effect transistor or f.e.t.) is normally incorporated within the microphone capsule as shown inset in Fig.1.

This requires a small supply voltage (between 1·5V and 5V) and a load resistor to operate and so the components associated with the microphone input have been added to supply this. A nominal 5V supply is derived from the main supply rail via resistor R1 and Zener diode D1 while R2 forms the load resistor for the f.e.t. inside the microphone capsule.

Note that a stereo jack socket (SK2) is used for the microphone with the second terminal supplying the +5V while the signal is picked up from the centre pin (tip) and the outer earth (0V) connection in the normal way. (The centre pin and the second terminal are connected inside the microphone). This allows a different microphone such as a dynamic type for example, which does not need a supply voltage or resistor, to be connected and in this case the 5V supply will simply be

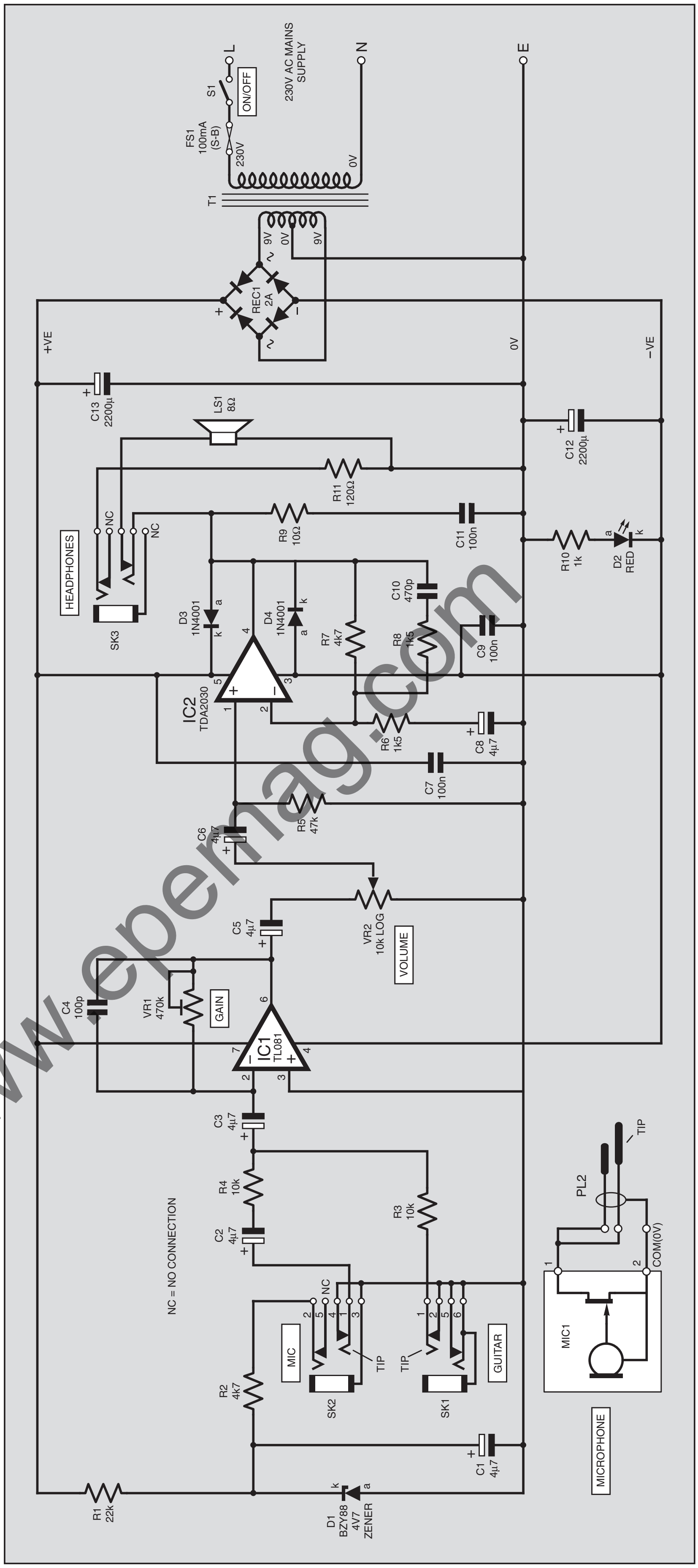


Fig.1. Complete circuit diagram for the Guitar Practice Amp.

shorted to earth by the microphone's mono jack plug causing no damage to either the microphone or amplifier.

ALL MIXED UP

The signal from the microphone is fed to the input of the amplifier via another input resistor R4, the value of which together with the feedback control (resistor) VR1 defines the gain of this channel. A 10 kilohms resistor was found suitable in the prototype but this may be changed if required, a higher value resulting in a lower gain and vice-versa.

This stage (IC1) of the circuit forms an ideal signal mixer since the inverting input (pin 2) of the amplifier is a "virtual earth" so called because the op.amp IC1 maintains the voltage at its inverting input at zero volts. It does this by changing its output voltage when a change in the input voltage tries to upset this and as the feedback preset VR1 has a higher value than the input resistor R4, the output voltage change is higher resulting in a voltage gain.

Another way to visualise this is to realise that an op.amp always tries to maintain both of its inputs at the same potential which in this case is 0V. This means that the microphone channel will not be affected by any changes in the volume or tone settings of the guitar which is also connected to this point via its own resistor R1.

VIRTUAL EARTH

A general circuit of a "virtual earth" mixer is shown in Fig.2. and there is nothing to stop you connecting another guitar or other signal source such as a tape or CD player in the same way simply by adding another input socket, connected to IC1's inverting input by its own resistor as shown. The values of the resistors would, of course, have to be chosen carefully to avoid over driving the amplifier. The output of a CD player for example would be much larger than that of a guitar so that its resistor would need to have a higher value.

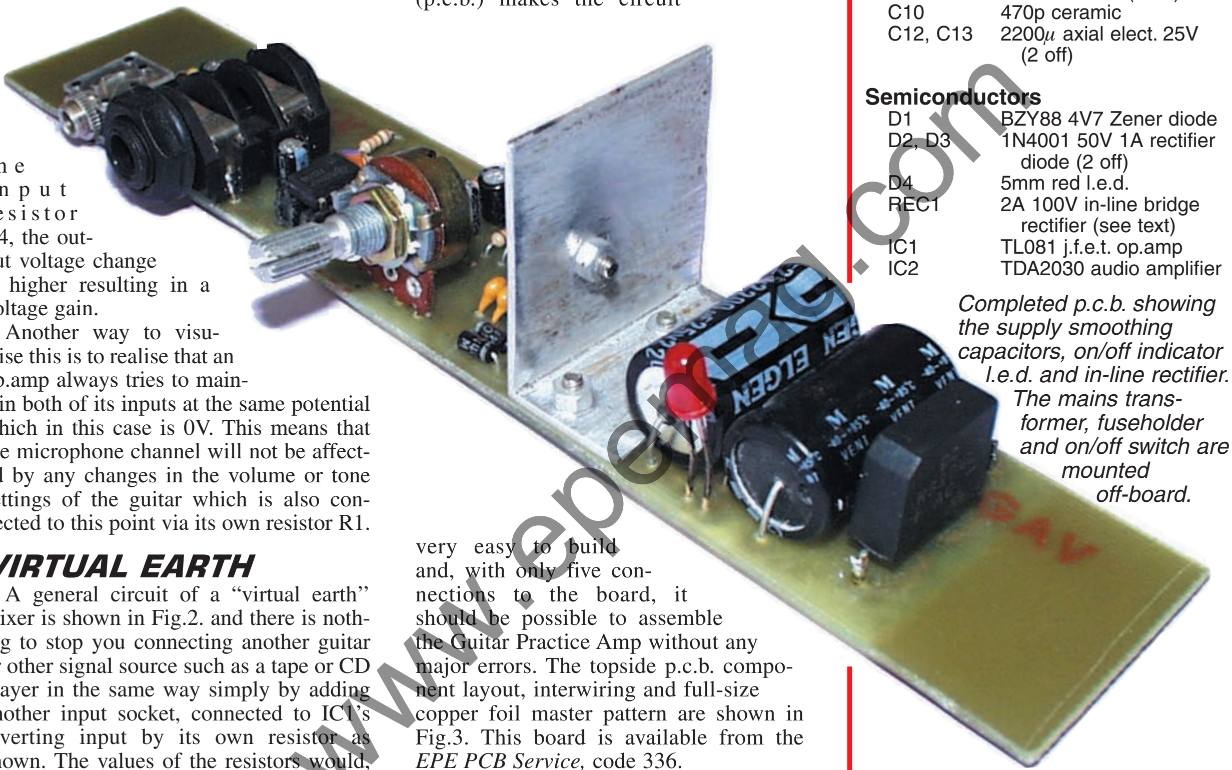
Alternatively, each channel could have a separate volume control fitted as shown. It would also be a good idea to fit d.c. blocking capacitors to prevent any d.c. on the output of the CD player or other device upsetting the bias conditions of the op.amp.

No separate provision for controlling the volume of the microphone channel has been made in this version as the relative volume of the guitar can be controlled at the instrument itself while VR2 controls the overall volume.

CONSTRUCTION

This is a mains operated circuit and its construction should not be attempted by those who are not suitably experienced or supervised.

The use of a printed circuit board (p.c.b.) makes the circuit very easy to build and, with only five connections to the board, it should be possible to assemble the Guitar Practice Amp without any major errors. The topside p.c.b. component layout, interwiring and full-size copper foil master pattern are shown in Fig.3. This board is available from the *EPE PCB Service,* code 336.



Completed p.c.b. showing the supply smoothing capacitors, on/off indicator l.e.d. and in-line rectifier. The mains transformer, fuseholder and on/off switch are mounted off-board.

COMPONENTS

See SHOP TALK page

Resistors

R1	22k
R2, R7	4k7 (2 off)
R3, R4	10k (2 off)
R5	47k
R6, R8	1k5 (2 off)
R9	10Ω
R10	1k
R11	120Ω

All 0·25W 5% carbon film or better

Potentiometers

VR1	470k carbon preset, lin.
VR2	10k rotary carbon, log.

Capacitors

C1 to C3, C5, C6, C8	4µ7 radial elect. 50V (6 off)
C4	100p ceramic
C7, C9, C11	100n ceramic (3 off)
C10	470p ceramic
C12, C13	2200µ axial elect. 25V (2 off)

Semiconductors

D1	BZY88 4V7 Zener diode
D2, D3	1N4001 50V 1A rectifier diode (2 off)
D4	5mm red l.e.d.
REC1	2A 100V in-line bridge rectifier (see text)
IC1	TL081 j.f.e.t. op.amp
IC2	TDA2030 audio amplifier

Miscellaneous

SK1	6·35mm (¼in.) moulded mono jack socket, with 2 switched break contacts
SK2, SK3	3·5mm stereo jack socket, with 2 switched break contacts (2 off)
MIC1	sub-min. omni-directional electret microphone insert
S1	s.p.s.t. mains rated on/off toggle switch
FS1	100mA 20mm slow-blow fuse
T1	18VA 230V a.c. mains transformer, 9V-0V-9V secondaries (see text)

Printed circuit board available from the *EPE PCB Service*, code 336; 8-pin d.i.l. socket; panel mounted fuseholder; aluminium heatsink, size 38mm x 58mm approx.; control knob; multistrand connecting wire; mains cable; 8Ω speaker, type to choice; solder pins; solder etc.

Approx. Cost Guidance Only **£24** *excluding speaker & case*

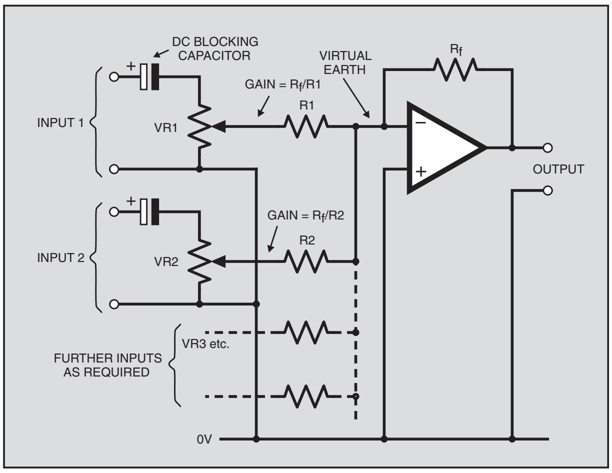


Fig.2. Adding extra inputs to the "virtual earth" mixer circuit.

Assembly of the board should begin by inserting the terminal pins which will be used to connect the speaker and transformer to the p.c.b. These usually require a certain amount of force to insert into the board which could damage adjacent components if this were done at a later stage.

Once the solder pins have been fitted, the board may be completed by mounting resistors, diodes, capacitors etc. in ascending order of height. Care should, of course, be taken to ensure that diodes and electrolytic capacitors are inserted the correct way around. Note also that a wire link (made from a discarded component lead) and a resistor (R10) are mounted under C12 and C13 so that these components must obviously be fitted before the electrolytic capacitors are mounted on the board. A second wire link is also required between C6 and VR2.

Although IC1 is not a CMOS device, and thus not particularly sensitive to static, it is worth fitting an i.c. socket to prevent any possibility of overheating it during the soldering operation this will also facilitate its easy removal should this be required.

POWER AMP

The audio power amplifier IC2 is more difficult to fit and before this is done it is best to prepare the small heatsink according to Fig.4. In the prototype this was made from a piece of L-shaped aluminium extrusion normally sold in DIY shops but should this not be easily obtainable a suitable piece of sheet aluminium bent to shape and drilled as shown will do just as well.

IC2 should be mounted on the board but its leads should not be soldered for the moment. Once this has been done, the heatsink can also be mounted on the board and secured to it using two nuts and bolts. When it is secure, IC2 should be bolted to it, via its metal tab, and it is here that the

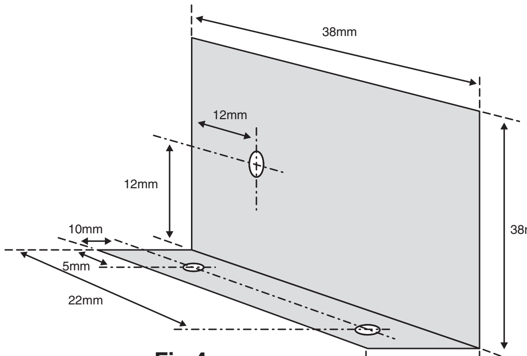


Fig.4

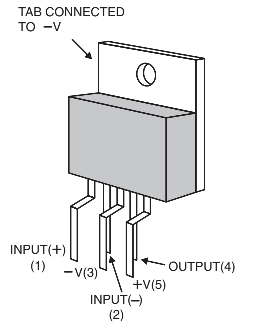
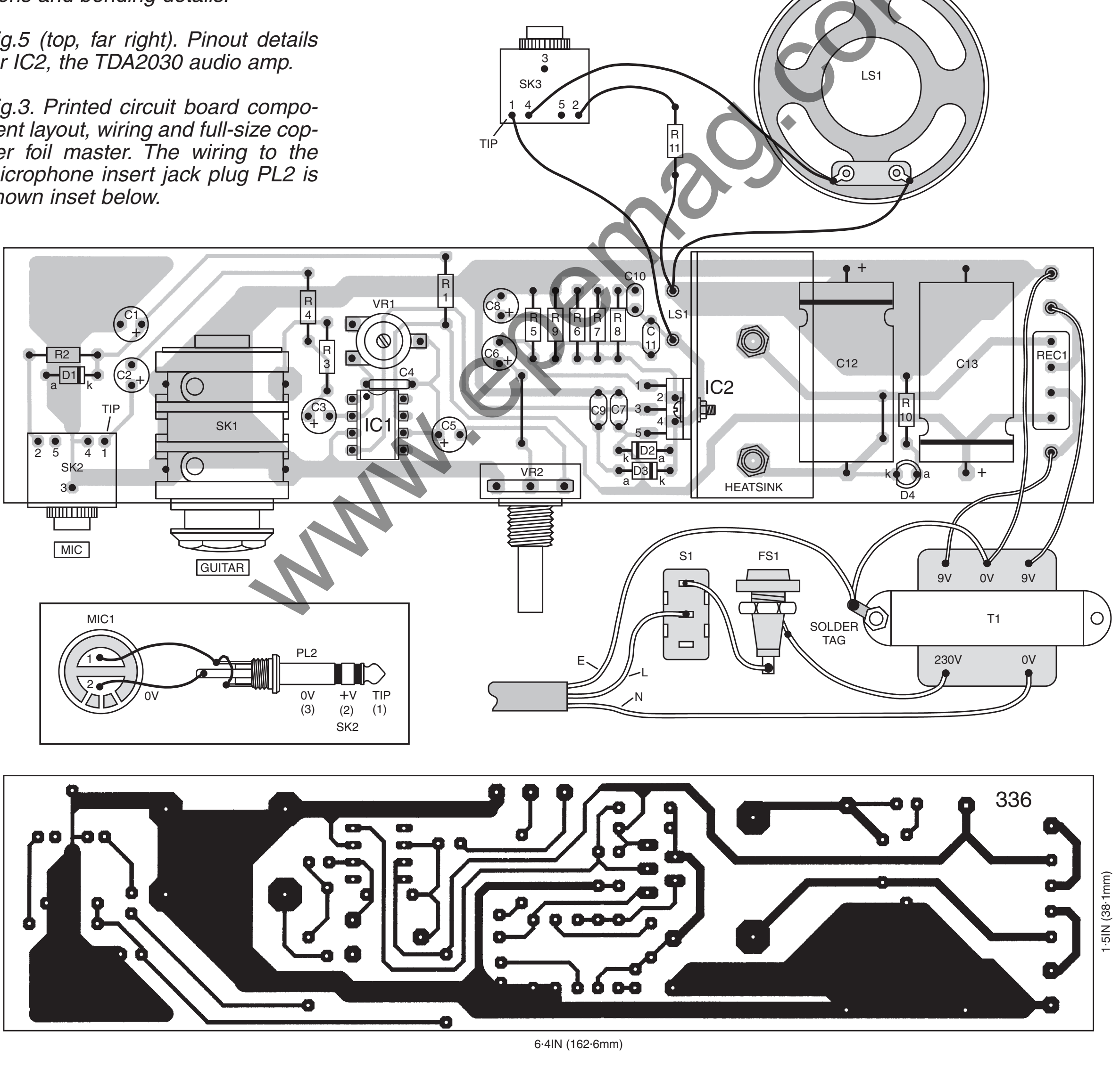


Fig.5

Fig.4 (top right). Heatsink dimensions and bending details.

Fig.5 (top, far right). Pinout details for IC2, the TDA2030 audio amp.

Fig.3. Printed circuit board component layout, wiring and full-size copper foil master. The wiring to the microphone insert jack plug PL2 is shown inset below.



advantage of delaying the soldering of this device will be seen as this will allow a certain amount of tolerance in the final positioning of the device relative to the heatsink.

Once IC2 is secured to the heatsink, its leads can be soldered and trimmed in the normal way. Note that it may also be necessary to bend the leads slightly to enable it to fit the holes in the board, see Fig.5.

Most devices are supplied with the leads already pre-formed although it should be noted that the TDA2030 is available with the leads formed for both vertical and horizontal mounting. Both types are identical but the vertical device is to be preferred as quite a lot of lead bending would be required to fit the horizontal device.

A smear of silicone grease between the heatsink and IC2's tab will help to conduct heat away from the i.c. but this was not found necessary on the prototype. What is important however is to ensure that there is a good *electrical* path between the tab and the negative supply p.c.b. copper track. For this reason no mica washers or any other insulation should be fitted between the tab of IC2 and the heatsink.

The heatsink is used as a negative supply connection to the chip and it ***must not*** be earthed or connected to any other part of the circuit. The pinout details of the TDA2030 are shown in Fig.5 for reference.

The only other component worthy of individual mention is the bridge rectifier where a 2A device is specified. A 1A device could also be used but this was not available in the author's spares box. These are available in many variants and shapes and although any of these devices will do, the board has been designed for an in-line package and so this type should be purchased if possible to avoid a lot of lead bending.

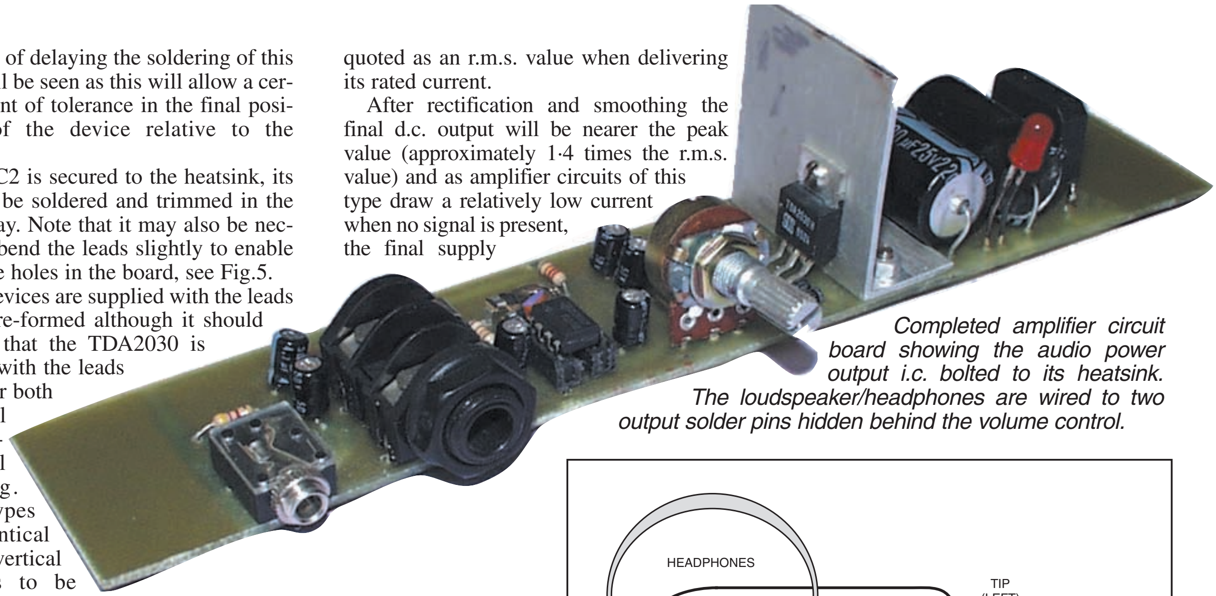
PRELIMINARY CHECKS

After careful checking of the board to ensure that there are no solder splashes between the tracks and that all the joints are sound, the speaker and mains transformer connections should be made to the board. The transformer used in the prototype had wire leads but if another type is used, then wires may need to be fitted.

Printed circuit board mounting types should be avoided as these usually lack mounting brackets and in this case the transformer will need to be mounted on a chassis or in the wooden cabinet containing the speaker. The final arrangement will depend to a large extent on circumstances and is therefore left to the individual to solve.

Care should be taken to ensure that a transformer with a centre tapped secondary (or with two secondary windings which can be connected in series) is used and although a voltage of 9V-0V-9V is specified, a slightly higher output could also be used. It should be remembered that the output of a transformer is always quoted as an r.m.s. value when delivering its rated current.

After rectification and smoothing the final d.c. output will be nearer the peak value (approximately 1·4 times the r.m.s. value) and as amplifier circuits of this type draw a relatively low current when no signal is present, the final supply voltage could be even higher depending on the transformer used. The supply voltage should, therefore, be measured to ensure that it does not exceed the ratings of the i.c.s (i.e. plus and minus 18V). The centre tap of the secondary must be connected to the 0V rail (corner terminal of the p.c.b.) while the other two leads may be connected to the other two terminals either way around.



Completed amplifier circuit board showing the audio power output i.c. bolted to its heatsink. The loudspeaker/headphones are wired to two output solder pins hidden behind the volume control.

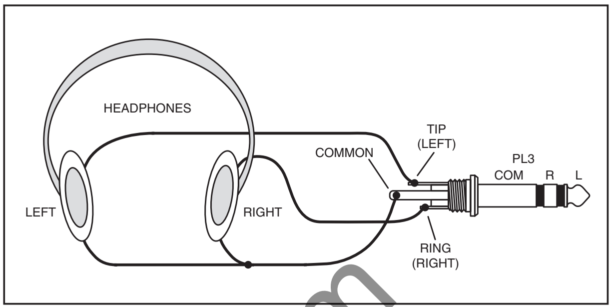


Fig.6 (right). Headphone jack plug PL3 wiring. The headphone jack socket (SK3) contacts break when the plug is inserted, disconnecting the loudspeaker LS1.

FINAL ASSEMBLY

The mains wiring should be carried out carefully and all joints well insulated to ensure that they cannot be touched inadvertently when the unit is in operation. A mains On/Off switch and a fuse should also be fitted in the live mains lead and the mains cable securely clamped to the box or cabinet using a suitable strain relief mounting bush.

The speaker will also need to be connected to the output terminals using suitable lengths of wire. If a socket for headphones is to be included, this should be arranged to disconnect the speaker when the jack plug is inserted so that a switched socket will be required (see Fig.1 and Fig.6).

The finished p.c.b. is quite light and so no special mounting hardware is required. It should be adequately supported by the potentiometer spindle and the input jack sockets but the final details of this are left to the constructor and will depend to a large extent on the cabinet in which the p.c.b. and speaker are mounted.

FINAL TESTING

When fully assembled, check the wiring again, especially around the headphone socket and transformer primary and if all is well, connect the unit to the mains and switch on. The voltage across each of the two smoothing capacitors can be measured and this should be about 12V d.c but no higher than 17V.

A slight hum or hiss may be audible from the speaker if the Volume control VR2 is turned up fully. Turn down the volume and connect a guitar which should now be heard.

The only adjustment to be made is to set the gain of the preamplifier stage (IC1) and this should be done with the volume turned up to maximum on VR2 and the guitar. Starting with preset VR1 turned fully clockwise the gain should be increased until distortion is heard when a string is played. An oscilloscope is useful here but not necessary as it is the final sound that is important and not the apparent purity of the output waveform.

If required, the headphones can be plugged in and, provided the wiring has been done correctly, this should switch off the speaker. With this "adjustment" complete, the stage act can be perfected without interference from the rest of the household. Take it away Eric . . . □