Benchmate: utility amplifier/power supply

As its name suggests, Benchmate is a handy piece of equipment for your test bench. It incorporates an audio amplifier capable of delivering a little over one watt RMS together with a variable regulated power supply which can deliver voltages between 1.25V and 16V at currents of up to one amp.

by GERALD COHN

Although the concept of this project is not new (a similar project was published in March, 1972 File No. 1MA/49) we thought it was about time for a fresh presentation of what can be one of the handiest pieces of gear to have on the workbench.

The circuit is a simple one using three low-cost ICs (one of them is a three-terminal adjustable voltage regulator). Add to these a few resistors, capacitors, diodes, etc and you have a useful piece of test equipment.

The circuit diagram gives an indication of the simplicity of the design. A pre-amplifier consisting of a TL071 op amp provides a gain of 100 (40dB) and is used with microphones and other low level sources. The power amplifier uses an LM380 power-amp IC. This has a fixed gain of 50 (34dB).

Two input sockets are provided, one for low input levels such as those from low impedance dynamic or electret microphones and the other for higher level input signals such as from a tape deck or audio oscillator. A single changeover switch is used to select the input, ie either high or low level input. The only other control as far as the amplifier is concerned is the volume control.

The power supply section of the project uses an LM317 variable output voltage regulator. The output voltage which appears at a pair of terminals on the front panel is controlled by a potentiometer which is also mounted on the front panel. The ability to vary the output voltage of the supply is the major advantage that this new design has over its predecessor.

Looking at the circuit diagram we can see that the preamplifier uses the TL071 in the inverting mode, the gain being set by the combination of the 1kΩ and 100kΩ resistors. The non-inverting input is biased to half the supply so that equal positive and negative voltage swing can be achieved. The 150pF capacitor across the 100kΩ feedback resistor is used to roll off the high frequency response thus reducing the possibility of high frequency interference or instability.

The output of the preamplifier is AC-coupled to the power amplifier stage via switch S1, used to select high or low level input modes. The coupling capacitor at the ouput of the preamplifier has a 1MΩ bleed resistor to charge it. This eliminates the switch-on "pop" when the low level mode is selected while the unit is switched on.

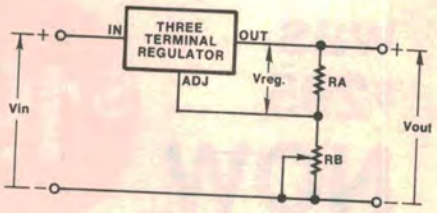


FIG. 1

The supply to the preamplifier has been decoupled from the main supply using a 2.7kΩ resistor and a 100uF capacitor. This augments the supply rejection ratio of the TL071 as does another decoupling capacitor used at the non-inverting input.

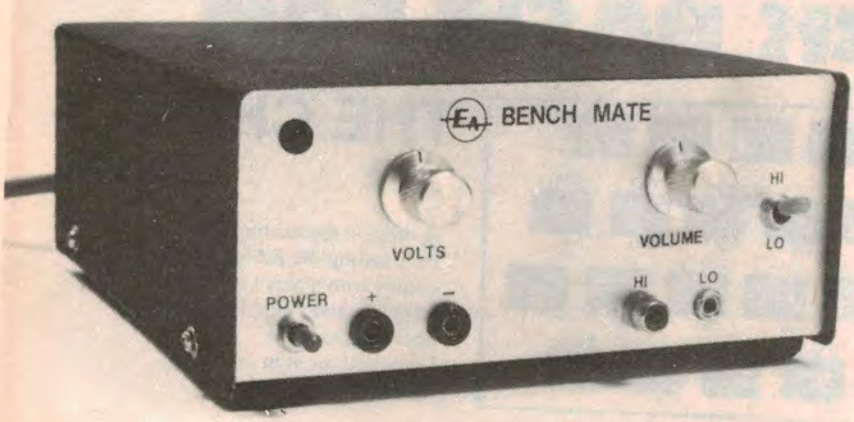
The LM380 power amplifier is used in the inverting mode, with the non-inverting input tied to ground via a 47kΩ resistor. The inverting input is AC-coupled from the volume control potentiometer via a 2.2uF capacitor.

A 10uF capacitor connected between pin 1 and ground is a bypass capacitor used to assist in stabilizing an on-chip current source in the input-stage bias network. The power supply pin is pin 14 while pins 3, 4, 5, 10, 11 and 12 are all ground pins. Apart from being used as the ground termination pins, they also provide a thermal path for the heat dissipated by the chip.

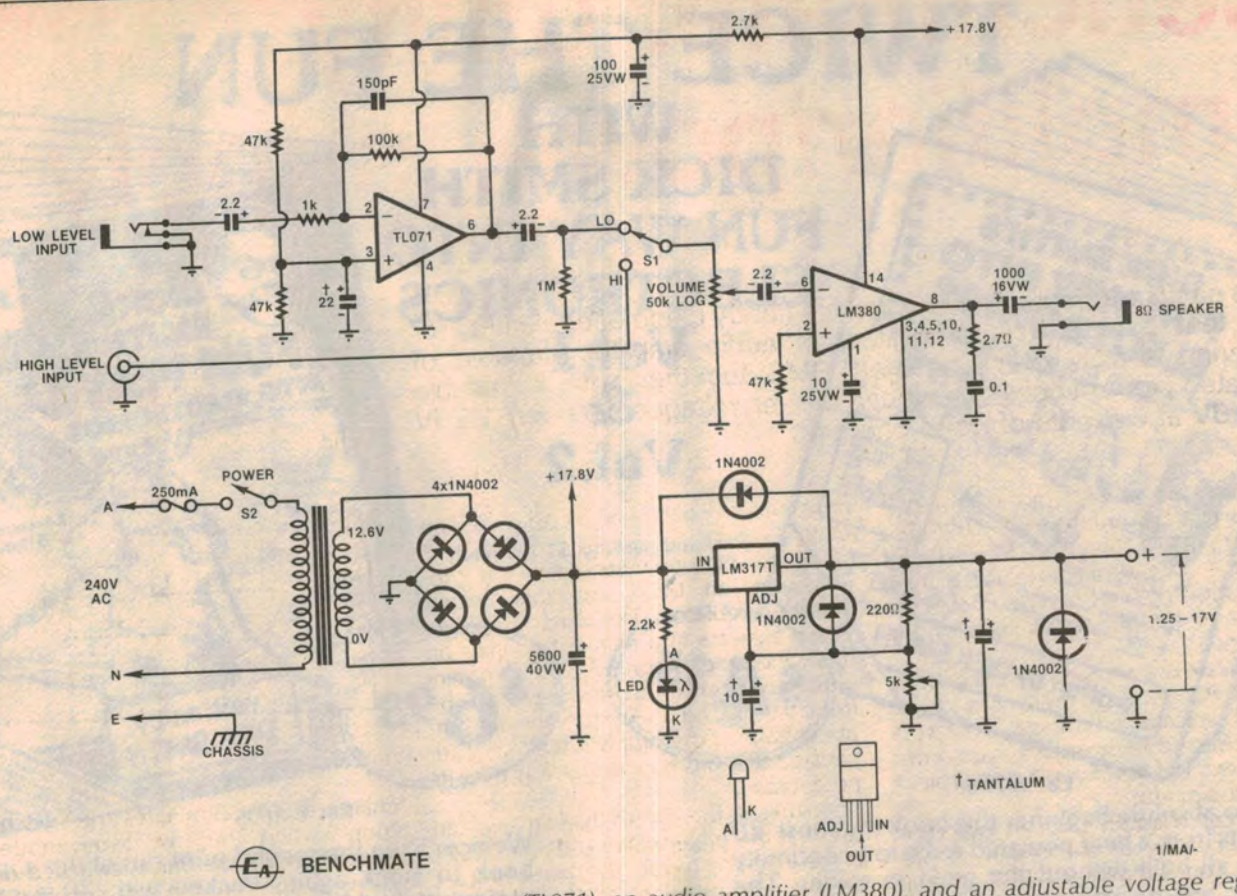
The output (pin 8) is AC-coupled to the load via a 1000uF capacitor. A Zobel network consisting of a 2.7Ω resistor and a 0.1uF capacitor is connected directly to the output pin to ensure amplifier stability at high-frequencies.

The variable power supply makes use of an LM317, three-terminal adjustable voltage regulator. The basic principle of operation of the power supply can be seen by referring to Fig 1. It should be noted at this point that the LM317 has a minimum or "fixed" output voltage of 1.25V (Vreg).

What the circuit of Fig 1 does is to apply the fixed ouput voltage, Vreg, across resistor Ra. Assuming that no current is



The prototype can deliver 1.25W RMS audio output and includes a variable 1.25-16V regulated power supply (see specification panel).



BENCHMATE

The circuit consists of an audio preamplifier stage (TL071), an audio amplifier (LM380), and an adjustable voltage regulator (LM317T).

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

$45.00

This includes sales tax.

drawn by the adjustment terminal, then all the current flowing in Ra must flow in Rb.

The result of the current flowing in resistor Rb is to "jack up" the adjustment terminal so that the total output voltage is Vreg+VRb. As we have seen, the voltage across Rb is defined by the current through Ra, which in turn is set by the regulator output voltage, Vreg.

So we can define the output voltage for the circuit of Fig. 1 merely by the selection of the two resistors, Ra and Rb.

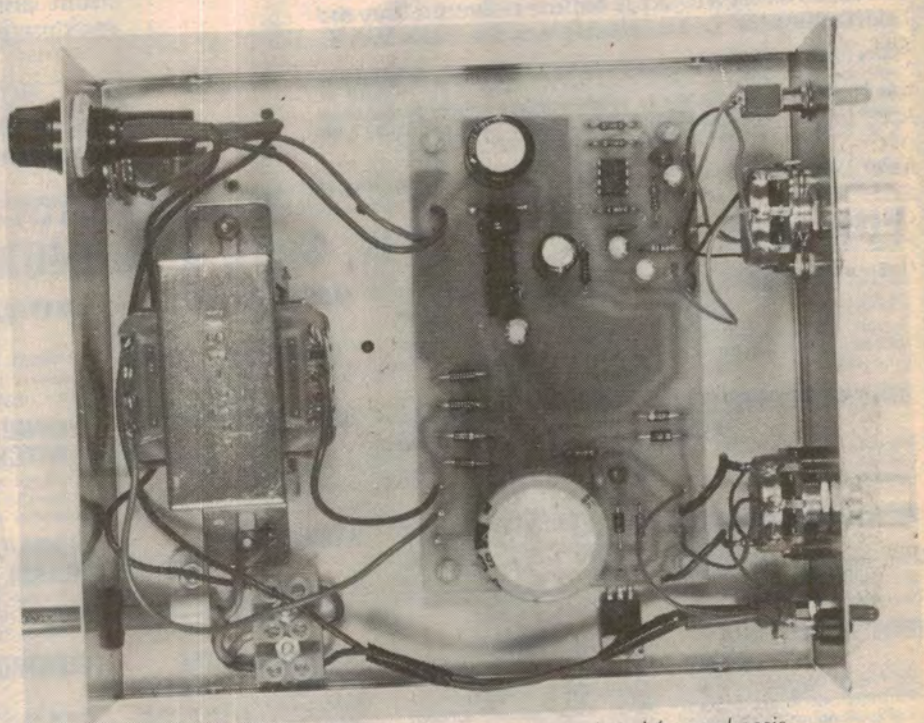
The formula to express this relationship is:

Vout = Vreg + (Vreg.Rb)/Ra

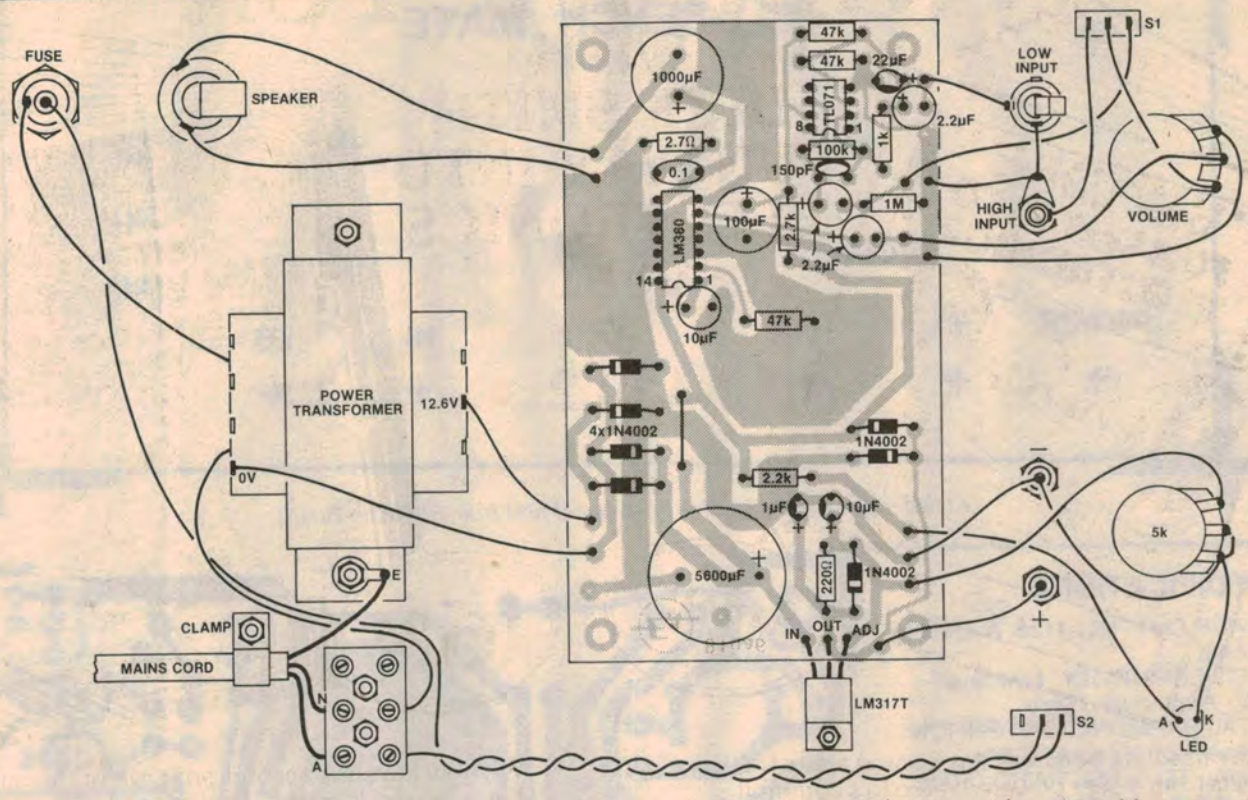
This is the principle behind the circuit used here for the general purpose adjustable power supply.

We have given Ra a fixed value of 220Ω while Rb has been made variable using a 5kΩ potentiometer. A 10uF capacitor is connected between the adjust terminal and ground to improve the stability and to remove any ripple that may still be present at the output. The 1uF capacitor at the output is also used for improved stability.

The three diodes around the regulator (not those in the bridge) are used to protect the regulator in the event of a capacitive load being connected to the output while the power is switched off and also to protect against connection of another voltage source which could



Note that the LM317T voltage regulator must be isolated from chassis.



Follow this diagram in conjunction with the circuit when wiring up the Benchmate. Take care with mains wiring.

otherwise discharge via the regulator and damage it.

The rectifier section of the power supply is shown in the circuit diagram as a full wave bridge, but we have made available the option of using a centre-tapped transformer and only two diodes. Just which configuration you use will depend largely on the type of transformer that you happen to have to hand.

We have designed a printed circuit board which contains all of the electronics. The board measures 120x70mm and is coded 81ua6. At first sight it may appear as though a lot of space has been wasted on the board but this is necessary because the extra copper is needed to provide heatsinking for the LM380 power amplifier IC.

The voltage regulator is mounted on the underside of the board so that it can be bolted down to the chassis when the board is mounted. This provides the heatsinking required when a lot of current is being drawn from the regulator. It should be noted here that the output terminal and the tag on the regulator package are at the same potential so that the regulator must therefore be insulated from the chassis when it is bolted down.

The usual procedure should apply when assembling the circuit board, such as starting with the resistors and the capacitors, and leaving the semiconductor devices until last. Make sure that all polarised components such as electrolytic capacitors and diodes are properly oriented before soldering them to the board.

The next step after the board has been assembled is to prepare the chassis for assembly. All the holes for the sockets, switches, binding posts, etc, have to be drilled and a front panel fitted. We have come up with a suitable front panel artwork, a full-size reproduction of which appears elsewhere in this article. Scotchcal panels should be available from

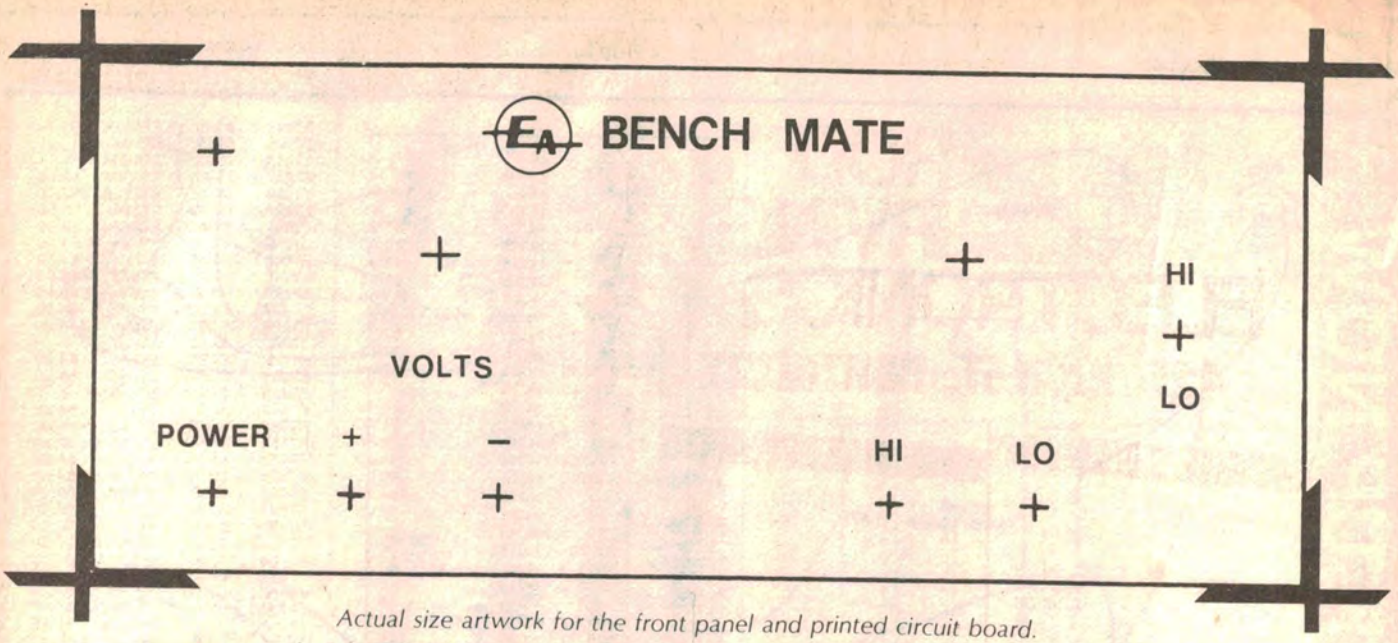
PARTS LIST

1 metal case 184x60x170mm
1 6.3mm insulated jack socket (see text)
1 panel-mounting fuseholder
1 250mA fuse
1 2155 power transformer
1 3-way terminal block
2 miniature single-pole, double-throw toggle switches
1 red binding post
1 black binding post
1 chassis-mounting RCA socket
1 3.5mm jack socket
4 8mm nylon PC board supports
2 knobs to suit potentiometers
1 PC board 120x70mm (81ua6)
2 rubber grommets
1 3-core mains cable with moulded 3-pin mains plug
1 cable clamp
1 solder lug for earth connection
1 5kΩ potentiometer
1 50kΩ potentiometer

SEMICONDUCTORS
7 1N4002 rectifier diodes
1 LM317T adjustable voltage regulator and insulating washer
1 LM380 14-pin power amplifier IC
1 TL071 operational amplifier IC
1 red LED and mounting bezel to suit

CAPACITORS
1 5600uF/40VW PC electrolytic
1 1000uF/16VW PC electrolytic
1 100uF/25VW PC electrolytic
1 22uF/25VW tantalum electrolytic
1 10uF/25VW PC electrolytic
1 10uF/25VW tantalum
3 2.2uF/16VW PC electrolytic
1 1uF/25 VW tantalum
1 0.1uF metallised polyester
1 150pF ceramic

RESISTORS (¼W, 5%)
1 x 1MΩ, 1 x 100kΩ, 3 x 47kΩ, 1 x 2.7kΩ, 1 x 2.2kΩ, 1 x 1kΩ, 1 x 220Ω, 1 x 2.7Ω



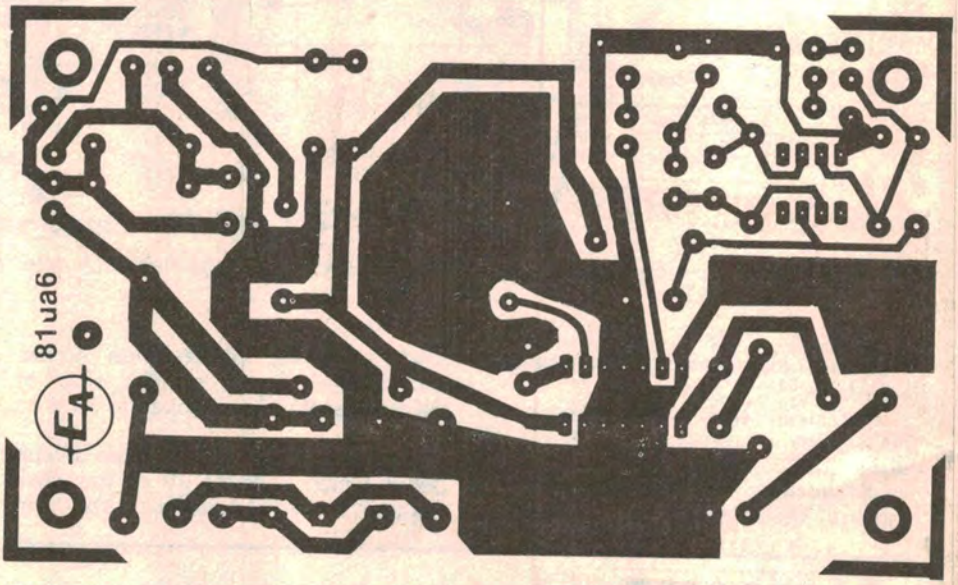
Actual size artwork for the front panel and printed circuit board.

SPECIFICATIONS

POWER OUTPUT: 1.25 Watts into 8 ohms
INPUT SENSITIVITY: Low level 1mV; High level 70mV
TOTAL HARMONIC DISTORTION: (at onset of clipping) 0.3%
SIGNAL TO NOISE RATIO: 50dB with respect to 1mV
INPUT IMPEDANCE: Low level input 1kΩ; High level input 50kΩ. ohm

POWER SUPPLY SECTION

REGULATOR OUTPUT: (Hum and noise) typically 3mV peak-peak
MINIMUM OUTPUT VOLTAGE: 1.3V
MAXIMUM OUTPUT VOLTAGE: Typically more than 16V (no load)



the usual suppliers.

The case we used came from Dick Smith Electronics and consists of a bent aluminium chassis and a crackle-finish steel cover. The overall dimensions of the case are 184x60x170mm. These cases are now also available from other kitset suppliers.

We have specified an insulated 6.3mm socket for the speaker connector, but these are not always readily available. Another simple method of insulating the socket from the chassis is to use a rubber grommet. We have in fact used this approach in our prototype.

After all of the switches, pots and sockets, etc, have been mounted, turn your attention back to the printed circuit board. Check the board once more and make sure there are no solder bridges or dry joints, and also check the orientation of all polarised components again. It pays to take that extra care at this stage, as it can save frustration later on.

If you are satisfied that there are no errors on the board, proceed to mount it in the chassis. After the board has been mounted, make all the necessary connections to the pots, etc. Again, we advise you to check the wiring, as mistakes are easily made. The final step is to check the operation of the project. In order to carry out the tests you will need a loudspeaker, a signal source and a multimeter.

We will start the testing by having a look at the power supply section first. Connect the multimeter to the output terminals of the power supply and switch the unit on. Now slowly rotate the voltage adjust potentiometer in a clockwise direction. You should see the voltage rise, up to a maximum of around 16.5 volts. Now rotate the pot in an anticlockwise direction and note that the voltage falls down towards zero. The minimum output voltage should be around 1.25 volts. Having confirmed that this section of the circuit is functioning properly, proceed to the amplifier test.

The amplifier test requires the use of a signal source. This can be in the form of an audio sine wave oscillator with adjustable ouput or could even be a tape deck.

Connect the signal source to the high level input of the amplifier and make sure that the input has been selected by the switch on the front panel. Now connect a loudspeaker and switch the amplifier on. Slowly increase the volume and note that the signal can be heard in the loudspeaker. If the input signal level is not greater than 70 or so millivolts, then no audible distortion should be evident.

The same test can now be carried out with a suitable signal being fed into the low level input. Note that the preamplifier is now being used and that the input sensitivity is now in the order of 1mV.

Once all of these tests have been carried out you will have successfully completed another piece of test equipment for the work bench. We think you will agree that this is a very handy piece of gear.