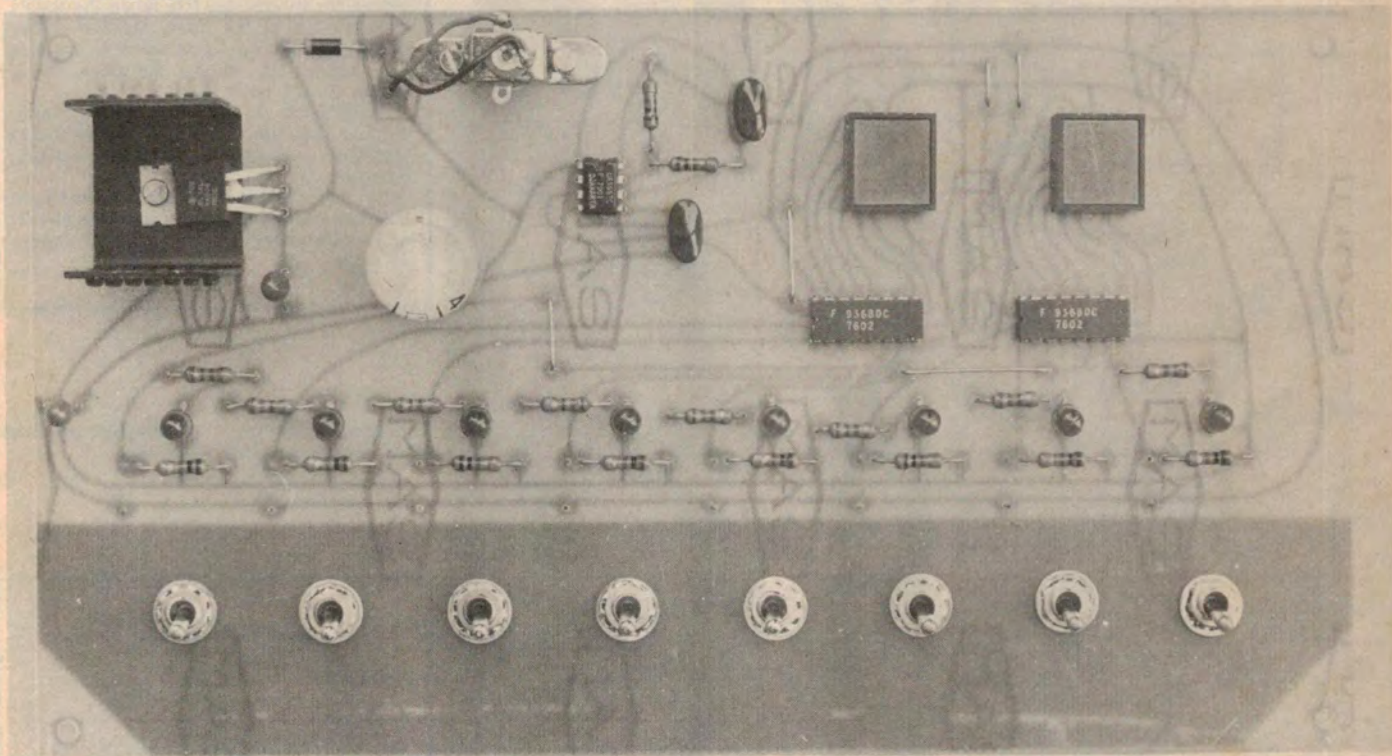
SEE OUR 'NUMBER SYSTEMS' FEATURE – PAGE 138

Project 651

# Binary to hex number converter

For those enthusiasts ploughing their way through the number systems used in microprocessor equipment, or for those attempting the tedious chore of converting binary numbers into microprocessor opcode instructions, this project should prove very handy.

David Tilbrook



IN MANY digital systems information is handled in groups rather than as individual bits. These groups are called words and they vary in size according to the needs of the particular job. If it is necessary to display or calculate using the normal decimal digits, a four digit binary word (four bit word) would be needed to represent each single decimal number. A four-bit binary word gives 16 possible different combinations. For a decimal number we only need ten, so the largest six combinations are ignored.

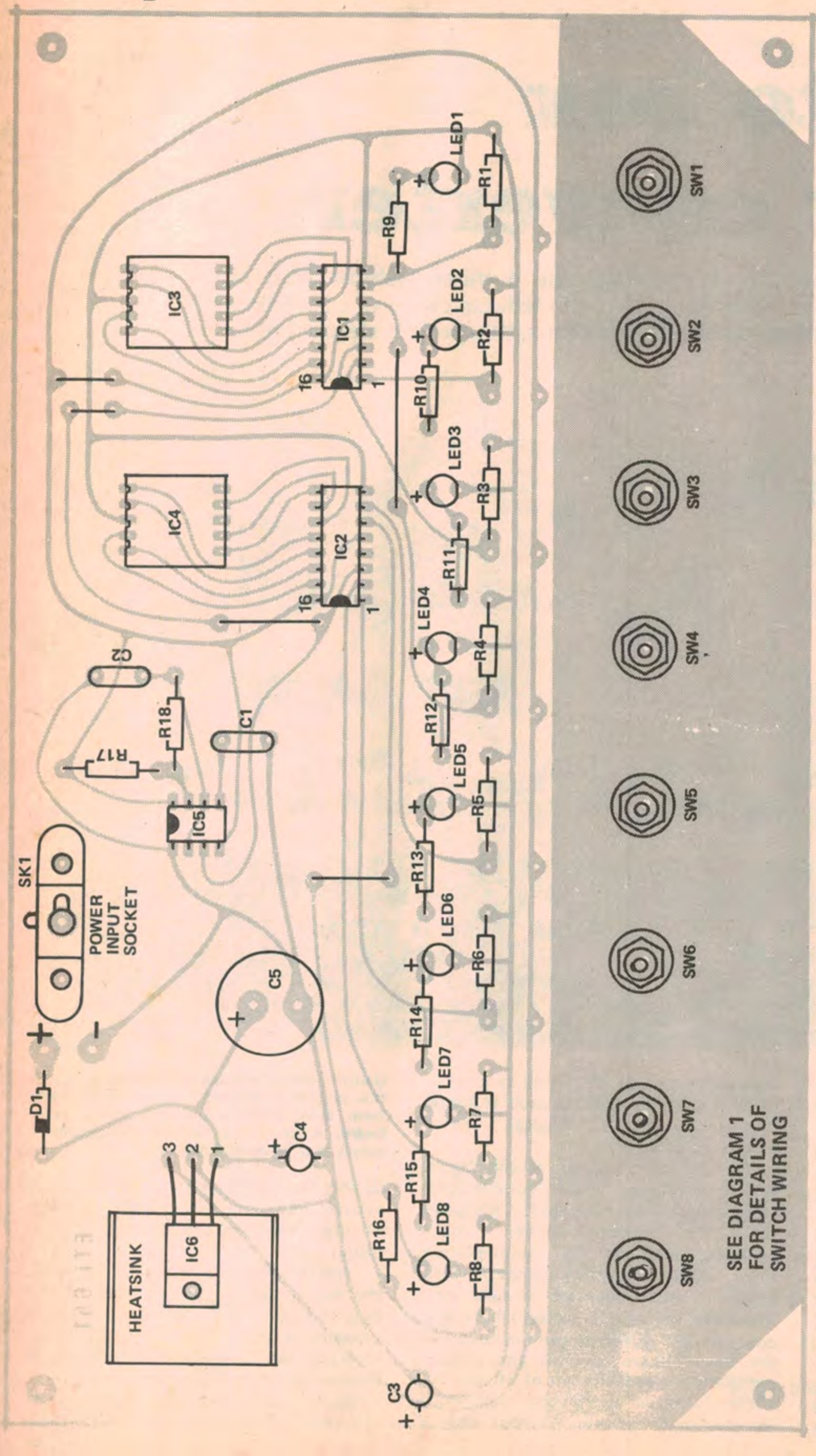
The number 0 is represented as 0000, 1 as 0001, 2 as 0010, 3 as 0011, 4 as 0100 and so on. This is called binary coded decimal or BCD and is used in many digital applications such as digital frequency meters, digital multimeters, calculators, etc.

As the job required of the digital system becomes more complicated, word lengths are increased. This gives the circuit the ability to handle more complex numbers by manipulating single words. The most common word length in microprocessors is eight bits. The eight bit word is called a byte and contains 256 different combinations. In the bigger microprocessor and smaller computers a word length of 16 is used, while full-scale computers use word lengths of 32 or even 64 bits! This is all very fine for computers, but for mere mortals like ourselves calculating with 64 digit numbers can become a little tiring!

**Constructed on a single printed circuit board, this project is intended to mount vertically from small brackets screwed onto a baseboard. A 'plugpack' or small bench power supply may be used to power it.**

This project was designed to assist the newcomer in getting used to the hexadecimal and binary number systems. It can also be used by those working out opcode (microprocessor instructions) from binary numbers.

Some mini-computers and microprocessors, such as the 2650, have their ▶




## ETI 651 – HOW IT WORKS

The heart of the circuit consists of the two 9368 ICs. These are BCD to hexadecimal seven segment decoder-drivers. On receipt of a low on the clock input-pin 3, they load the binary word present on their inputs into latches, decode them into hexadecimal numbers and drive the appropriate segments in the FND500 displays. The binary number is reloaded into the input latches each time the clock input is taken low.

The 555 timer IC is operating as an astable multivibrator and generates a pulse used to trigger the clock input. The repetition rate is around 5 kHz, determined by the two 1k resistors connected to pin 7 and the 0.1 μF capacitor connected to pin 5 of the timer.

The inputs of the 9368's are connected via 1k pull-down resistors to zero volts to ensure the inputs stay low when the toggle switches are in the open position. When the binary number is selected, by closing the appropriate toggle switches, these input lines are taken high.

LED's are used to display the binary number and are connected to the toggle switches via 220R current limiting resistors.

A 7805 voltage regulator IC has been included on the board to allow the circuit to be run from a variety of DC supply voltages.

Component overlay. See diagram on page 82 for switch connection details.

## PARTS LIST – ETI 651

**Resistors**
R1-R8 . . . . .1k0
R9-R16. . . . .220R
R17, 18 . . . .1k0

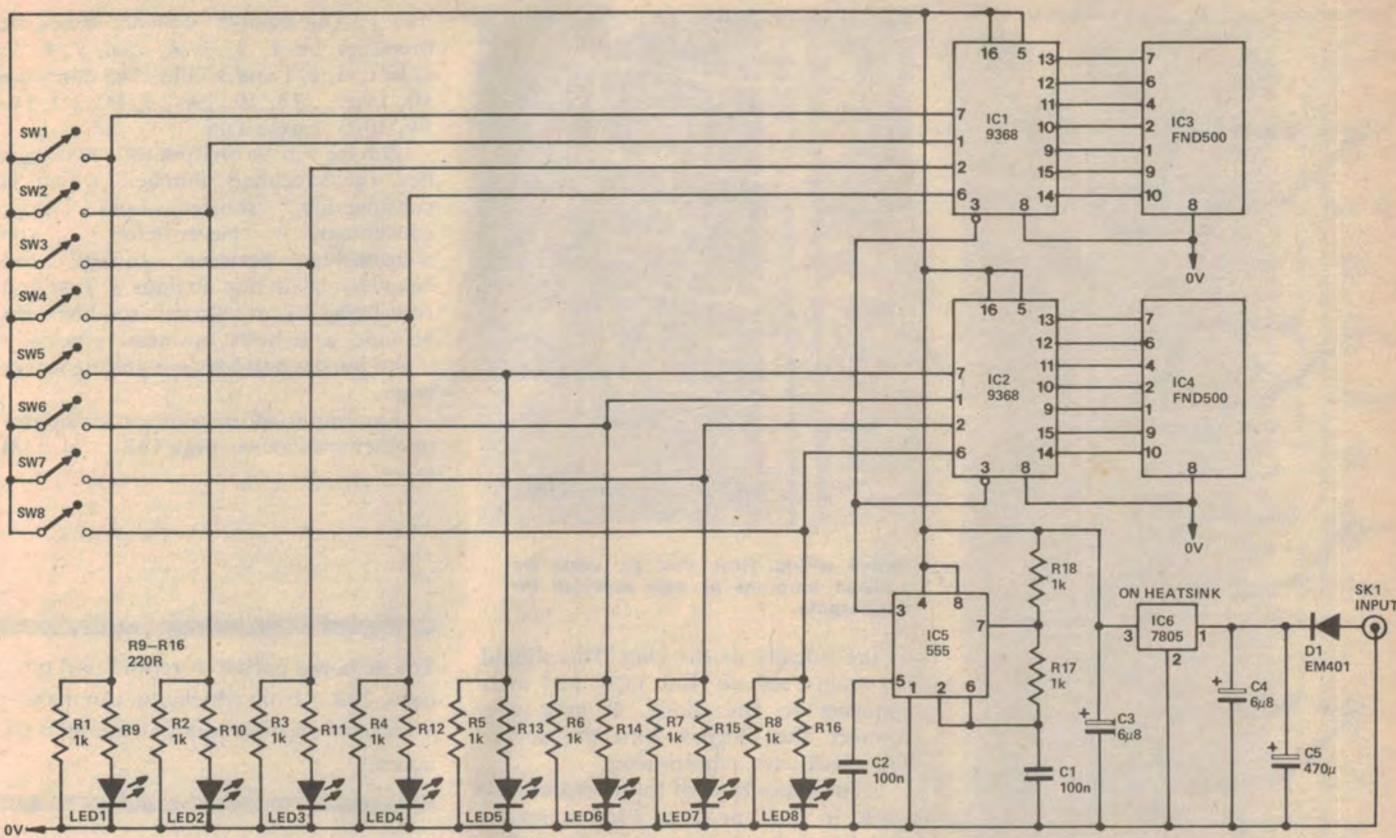
**Capacitors**
C1, 2 . . . . . .100n greencap
C3, 4 . . . . . .6μ8 16V tantalum
C5. . . . . . . .470μ 25V electrolytic

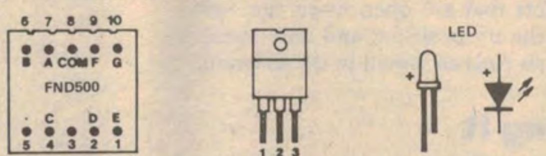
**Semiconductors**
IC1, 2. . . . . .9368
IC3, 4. . . . . .FND500
IC5 . . . . . . .555
IC6 . . . . . . .7805

D1 . . . . . . .EM401 or equivalent

LED1-LED8. .red LEDs

**Miscellaneous**
SW1-SW8. . . .spst toggle
SK1. . . . . . .9V power socket
pcb . . . . . . .ETI651
heatsink for 7805




Circuit diagram

instructions written in the form of binary numbers, with some of the digits missing. Depending upon the particular variation of the instructions required, the missing 0s and 1s are filled in. When the total binary word has been formed it must be converted into hexadecimal form for keying into the microprocessor. A relatively large program for a microprocessor might have one or two thousand opcodes to be evaluated — this is one application where the binary to hex converter could be put to good use.

## Construction

The entire trainer is made on a single printed circuit board and construction is fairly non-critical.

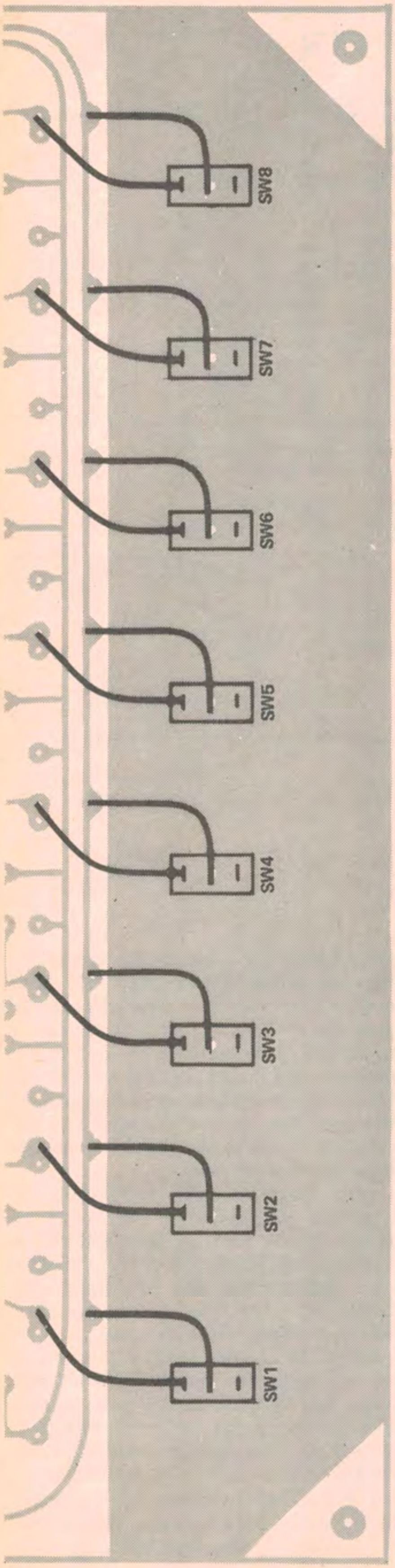
Start by mounting the resistors on the pcb. Next, mount the capacitors, with the exception of the big 470 μF electrolytic. Be sure to orient the tantalum capacitors correctly. If they are not marked with a +ve symbol they will probably be the type marked with coloured bands and a dot. With the dot facing towards you and the leads pointing down the positive lead is usually the one on the right. The IC's and displays should be soldered onto the board using reasonable care not to overheat the pins. Make sure they are oriented correctly also. If they are installed incorrectly and the board is powered up, they will probably be destroyed. The pads for the IC's are relatively close together and care should be taken to avoid bridging solder to adjacent pads.

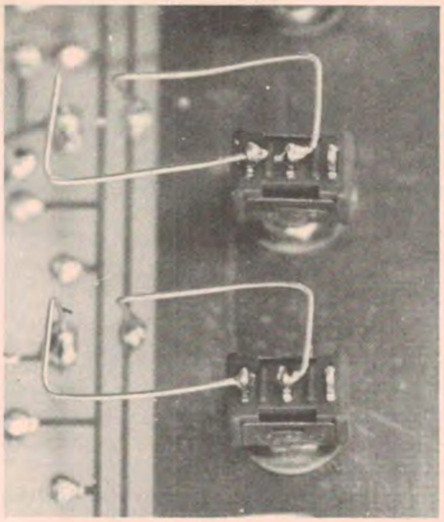
The LED's and diodes can be fitted next and once again make sure these are put in the right way around.

The voltage regulator IC should be mounted onto a heatsink and secured to the pcb by a single nut and bolt. Insulation between the regulator and heatsink is not needed but some type of thermal paste compound should be used.

Mount the regulator first and then solder its leads onto the board, this avoids straining these solder joints. Fit the remaining electrolytics and wire links. Often cut-off resistor leads can be used for these links. All that remains is to fit and wire the switches and power sockets. The board requires an external DC supply, the regulator makes sure the IC's get the correct voltage. The DC supplied to the board should be greater than about seven volts.

As this voltage increases, the regulator dissipates much of the excess power in the form of heat and this is why the heatsink is necessary. On 12 V the regulator on the prototype gets quite hot, but not excessively. The board requires 450 mA worst case, so some of the bigger plugpaks should do the job well. The socket for the power input can be a bit tricky to work out. The centre point on the socket is usually negative. Solder a wire from the centre terminal to the negative pad on the pcb. This is the pad not connected to the diode. The positive terminal on the socket is ther terminal connected ▶



Switch wiring. Note that the wires are soldered onto the pc pads provided for this purpose.

to the outside of the plug. This should be connected to the PCB pad that connects to the diode. If in doubt, connect the plugpak into the socket and check with a multimeter.

Almost any type of toggle switch will work in this project. Find a set of contacts that are open when the switch is in the up position, and wire these to the pcb pads as shown in the diagram.

## Using it

Before applying power to the board check the capacitors, LEDs and IC orientations. When the board has been completely checked it can be tried out. Place all the switches in the up position and apply power. Immediately the seven segment displays should show '00'. As the toggle switches are changed the LEDs will light and the displays should change to indicate the correct hexadecimal number corresponding to the binary number shown on the LEDs.

## The hexadecimal number system

We've already mentioned that a four bit binary word had sixteen different combinations. If we defined sixteen characters and let them be equal to these sixteen combinations we would write any four bit binary word using a single character.

This is the basis of the hexadecimal number system. The first ten digits are the same as in BCD, i.e: the normal decimal numbers. The six extra combinations not used in the BCD system are given the characters A, B, C, D, E and F. The number sequence would be therefore be 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f and would then continue 10, 11, . . . 18, 19, 1A, 1B, 1C, 1D, 1E, 1F, 20, . . . and so on.

A byte can be written as a two digit hex (hexadecimal) number, which is considerably shorter and more convenient. Nevertheless the relationship between binary and hexadecimal is not obvious at first and converting from binary to hex can become a tedious business, especially if the binary numbers are getting rather large.

For more information on computer number systems see page 138. ●

**The pc board pattern is reproduced on page 193 – from which you can make a Scotchal negative to etch your own pc board.**

### PET POKE PROBLEMS

In the Commodore PET review, we showed the instruction:

**POKE 59500, 72**

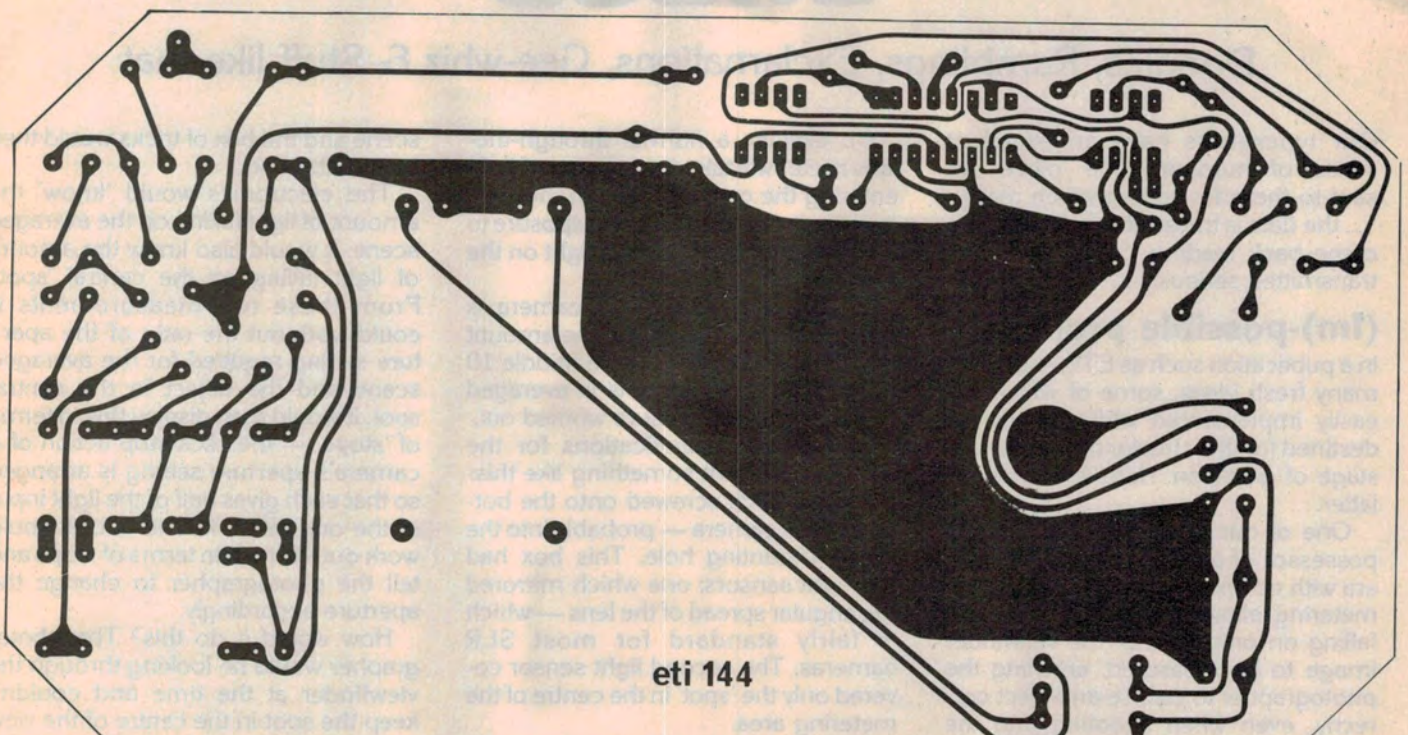
for changing the display from graphics to lower case (ETI May 79, p 76). This works on the PETs in the UK and Canada, but Commodore have contacted us to point out that it doesn't work with Australian PETs. The instruction used for Australian machines is:

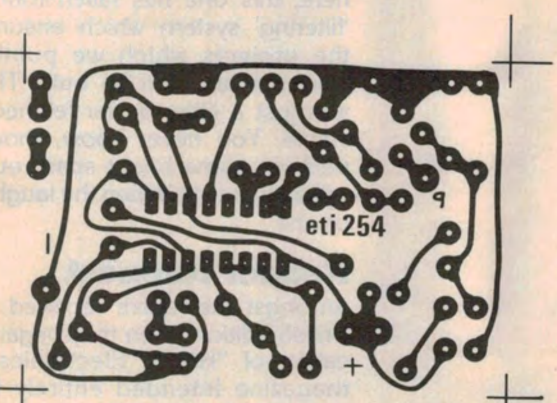
**POKE 59468, 14**

and to revert to graphics again:

**POKE 59468, 12**

Thanks, Commodore.




## Using ETI PCB Artwork

This method can be used to make negatives of ETI artwork from October 1977 on, provided the reverse of the page is printed in blue. The film used is Scotchcal 8007 which is UV sensitive and can be used under normal subdued light.

Cut a piece of film a little larger than the PC board and expose it to UV light through the magazine page. The non emulsion side should be in contact with the page. This surface can be detected by picking the film up by one corner - it will curl towards the emulsion side. Exposures of about 20 minutes are normally necessary.

The film can now be developed by placing it emulsion side up on a table, pouring some Scotchcal 8500 developer on the surface and rubbing it with a clean tissue.

Further information on Scotchcal and PCB manufacture can be found in the September and December 1977 issues of ETI. Please note also, that occasionally pressure on space may unfortunately prohibit the printing of blue type behind all PCB's, in which case the reader must resort to more conventional photographic techniques for PCB manufacture.