MTX 8 Channel A to D

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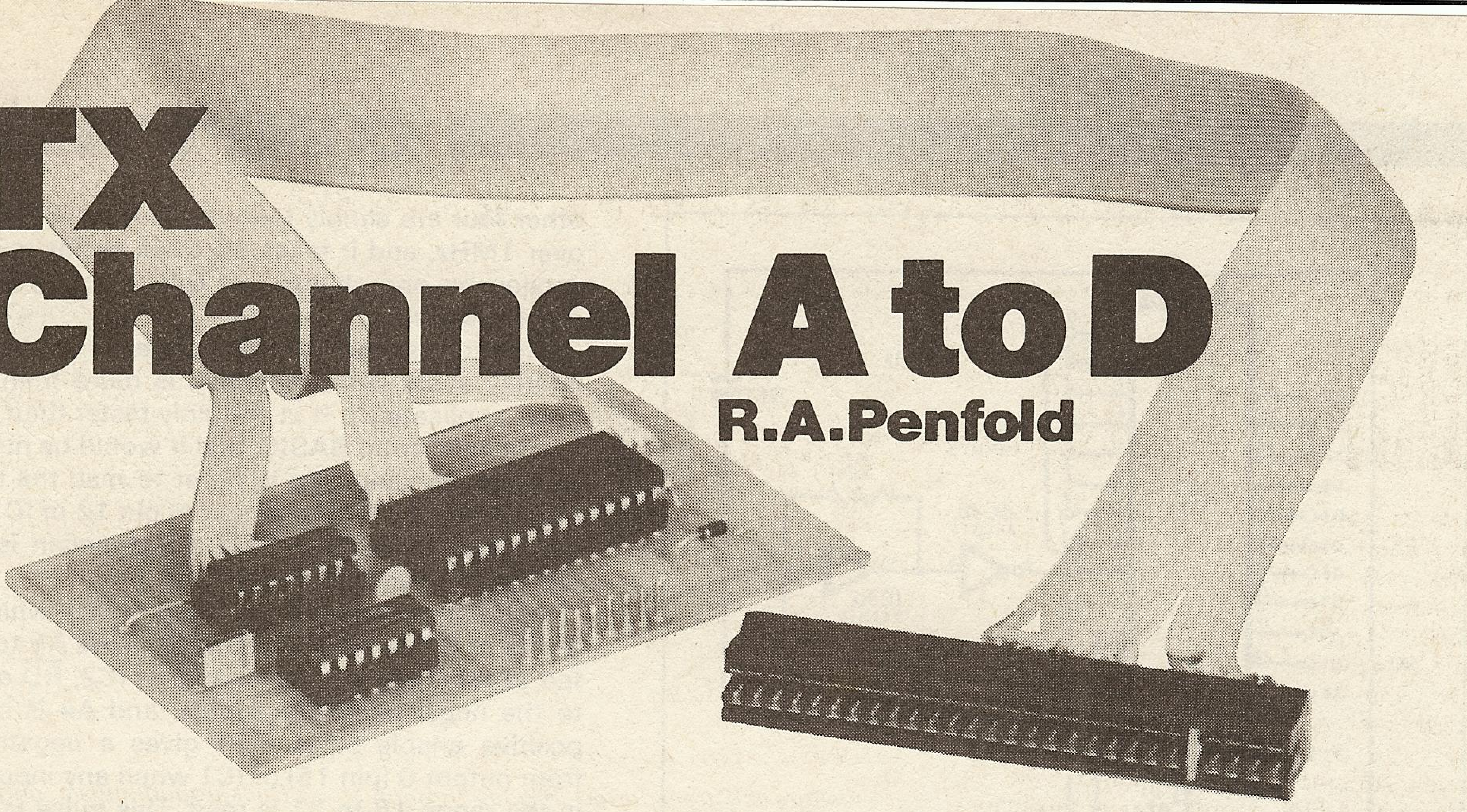

The Memotech MTX500 and MTX512 computers have features which make them an attractive proposition for anyone wishing to use a computer in control or measurement applications. Two features of this type are the built-in assembler and the user port which provides eight digital inputs and eight digital outputs. One obvious omission from the specification is any form of analogue to digital converter (ADC). Although these machines have two Atari/Commodore type joystick ports, they do not have a simple resistance sensitive A to D converter of the type fitted to Atari and Commodore computers.

It is not difficult to add an analogue to digital converter to the MTX computers though, and a circuit of this type can be added to either the user port or the expansion port. This design is for an eight channel converter which connects to the expansion port. Using the expansion port rather than the user port has the advantage of leaving all 16 user port lines free for use, and gives the computer a formidable interfacing capability. Fitting the converter to the expansion bus rather than the user port does not result in a significant increase in its complexity, and the unit is in fact very simple.

7581 ADC

The simplicity of the circuit is facilitated by the use of a sophisticated ADC, the 7581. Fig. 1 shows the block diagram for this CMOS chip.

At the heart of this device is a fairly conventional successive approximation converter. This compares the input voltage with the output of an 8-bit DAC. Initially the eight inputs to this converter are set low, apart from the most significant bit (bit 7). If the output voltage from the DAC is greater than the input potential bit 7 is set low by the comparator, but if not it is left high. Then bit 6 is set high, and this bit is reset by the comparator if the output potential of the DAC is higher than the input voltage. Next bit 5 is set high and the same basic procedure is repeated. In fact this routine is repeated, in turn, for all 8 bits, until at the end of

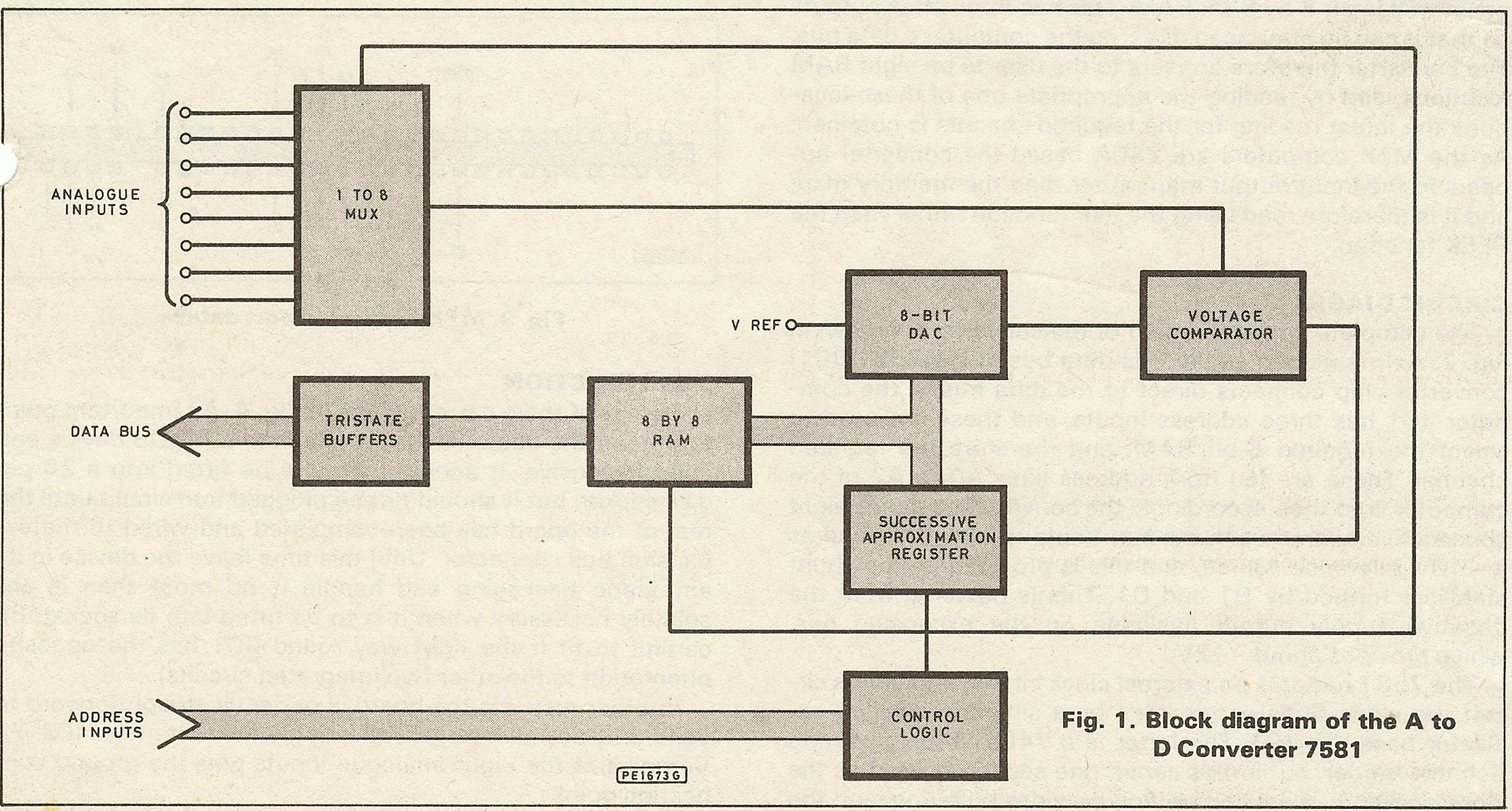

Fig. 1. Block diagram of the A to D Converter 7581

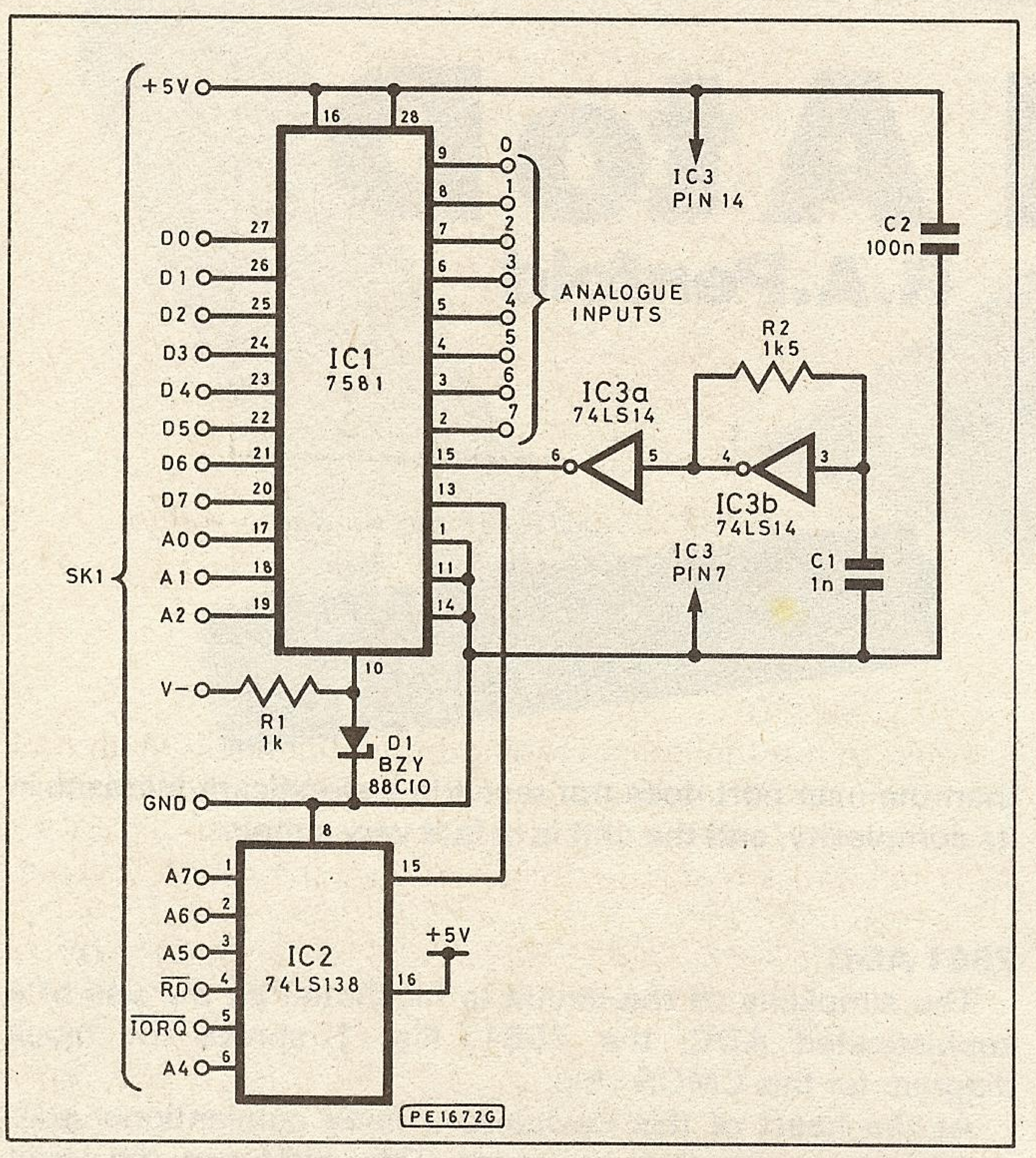

Fig. 2. Complete circuit diagram of the 8–Channel A to D Converter

the process the 8-bit number in the successive approximation register is a valid digital representation of the input voltage.

The 7581 has a built-in 8-channel multiplexer, but this is controlled by the built-in control circuit and not by the user. Each channel is read in turn by the converter, and the results are stored in an 8 by 8-bit RAM. This has three state outputs so that it can be interfaced direct to the computer's data bus. The converter therefore appears to the user to be eight RAM locations, and by reading the appropriate one of these locations the latest reading for the required channel is obtained. As the MTX computers are Z80A based the converter appears in the input/output map rather than the memory map, and it is therefore read using the INP function rather than the PEEK function.

CIRCUIT DIAGRAM

The complete circuit diagram of the converter is shown in Fig. 2. As mentioned earlier, the data bus of the 7581 (IC1) converter chip connects direct to the data bus of the computer. IC1 has three address inputs, and these are used to select the required 8-bit RAM, and therefore the required channel. These are fed from address lines A0 to A2 of the computer, and then accordingly the converter occupies eight consecutive addresses in the input/output map. IC1 requires a −10V reference source, and this is provided by the shunt stabiliser formed by R1 and D1. This is powered from the negative supply output available on the expansion bus, which provides about −12V.

The 7581 requires an external clock circuit, and in this circuit the clock signal is provided by a simple relaxation oscillator based on IC3. The latter is a 74LS14 hex inverting Schmitt trigger, but in this circuit one section is used as the clock oscillator, a second section provides buffering, and the other four are simply ignored. The clock frequency is a little over 1MHz, and it takes 80 clock cycles to complete a conversion on one channel, or 640 clock cycles to convert all eight channels.

This corresponds to a complete set of conversions approximately every 0·5 ms, which is more than fast enough for most applications. It is certainly faster than just one channel can be read from BASIC, and it would be necessary to resort to assembly language in order to read the device at the full rate. There is a status output at pin 12 of IC1 which provides an output pulse each time a conversion is completed, but this is left unused in this circuit.

Address decoding is provided by IC2 which is a 74LS138 3-line to 8-line decoder. Address lines A5 to A7 are connected to the three address inputs of IC2, $\overline{RD}$ and $\overline{IORQ}$ are fed to the negative enable inputs, and A4 is connected to the positive enable input. This gives a negative output pulse from output 0 (pin 15) of IC1 when any input/output address in the range 16 to 31 is read. This pulse is used to activate the negative chip enable output of IC1, where it enables the tristate buffers which then place an output onto the data bus. This positions the converter at addresses from 16 to 23, but as address line A3 is not decoded it also appears at addresses from 24 to 31. Address 31 is used for automatic control of the cassette recorder (although the necessary hardware is not included in either version of the computer). Data written to address 31 by the built-in software during LOAD and SAVE operations does not affect the converter which only responds to read operations.

All eight channels of the converter have an input voltage range of 0 to 10V. An internal resistor ties the input of the converter to earth and gives an input resistance of about 20 kilohms. This resistor can effectively be eliminated by omitting the earth connection to pin 1 of IC1. In addition to the reference voltage mentioned earlier the circuit also requires the normal 5V supply, and this is available on the MTX expansion port (Fig. 3).

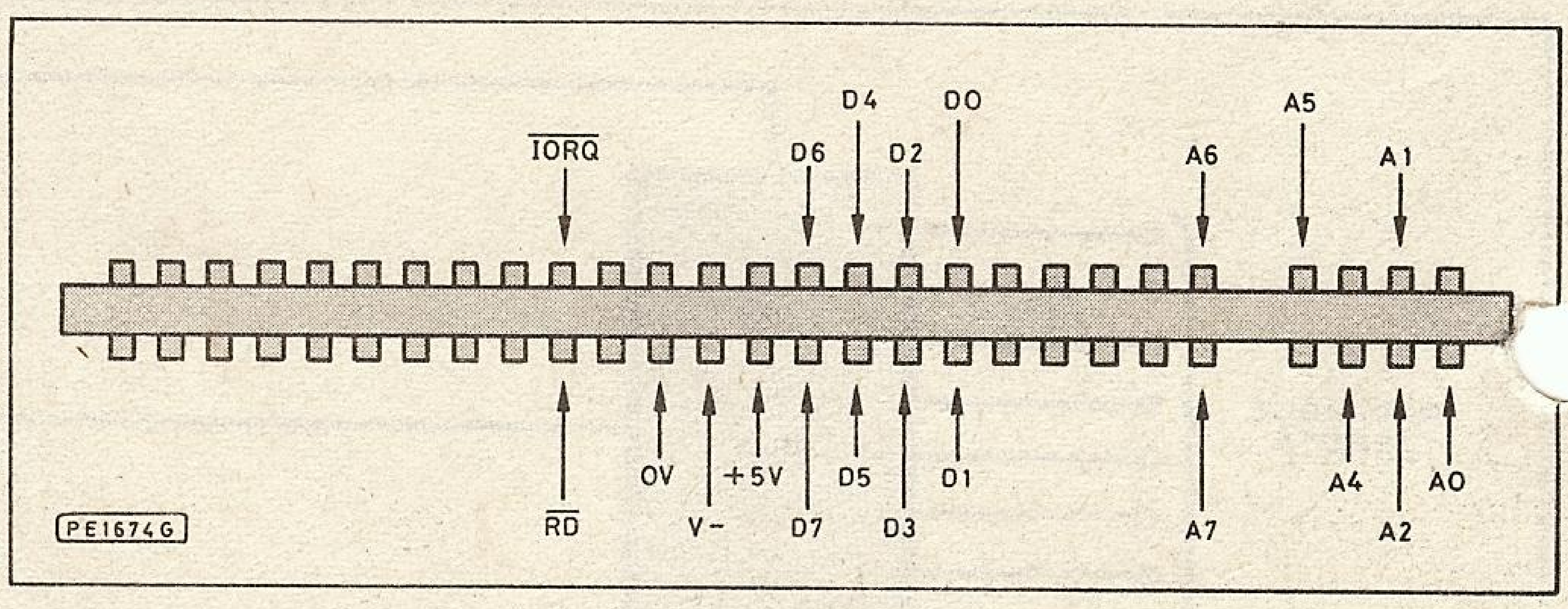

Fig. 3. MTX expansion port details

CONSTRUCTION

Details of the p.c.b. are given in Fig. 4. An important point to note at the outset is that IC1 is both a CMOS device and quite expensive. It should therefore be fitted into a 28-pin d.i.l. socket, but it should not be plugged into circuit until the rest of the board has been completed and wired to the expansion bus connector. Until this time leave the device in its anti-static packaging and handle it no more than is absolutely necessary when it is to be fitted into its socket. Be careful to fit it the right way round (IC1 has the opposite orientation to the other two integrated circuits).

In other respects the board is perfectly straightforward to build, but do not overlook the single link wire near IC2. Fit Veropins at the eight analogue inputs plus the ground connection point.

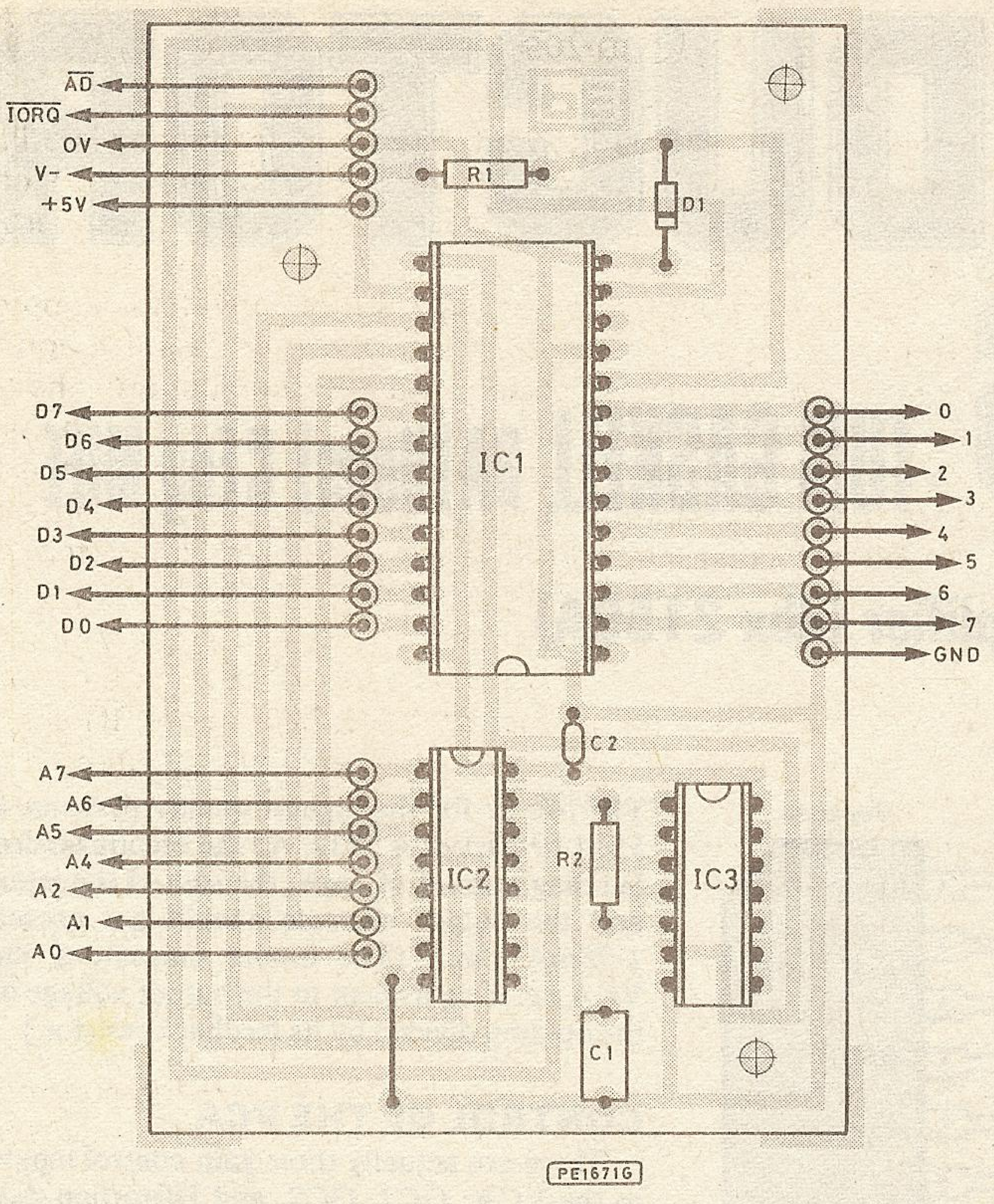

Fig. 4. P.c.b. design and component layout of the MTX A to D Converter

Connection to the expansion port of the MTX computer is via a piece of 20-way ribbon cable about 0·5 metres or so in length. There should not be any difficulty in connecting one end of the cable to the printed circuit board provided a short piece of insulation is removed from the end of each lead, and the bare ends are then tinned with a small amount of solder prior to making the connections. The other end of the cable is fitted with either a 2 by 30 way 0·1" pitch edge connector, or a Spectrum type 2 by 28 way edge connector. The MTX expansion bus is a 2 by 30 way male edge connector, but at the time of writing it is not possible to obtain a matching female connector that includes the polarising key. The Spectrum connector does have the necessary polarising key, and is also more readily obtainable. It does not reach all the contacts of the expansion bus, but the four that are missed are not used in this application anyway. The Spectrum connector is therefore probably the more practical option, and is the one adopted for the prototype.

Fig. 4 gives details of the connections to the edge connector, and it is assumed here that a 2 by 28 way connector is used. Obviously great care to avoid errors must be taken, and the use of rainbow ribbon cable is helpful here. The connection on the p.c.b. have been arranged to match up well with the expansion bus, and provided reasonable care is exercised there should be no problems when wiring the cable to the edge connector.

IN USE

Connect the unit to the computer before the latter is switched on, and ensure that the connector is fully pushed home and in the correct position. The completed converter does not require zero adjustment or any other setting up. When the computer is switched on it should behave in the normal way, delivering the Ready message and the flashing cursor after the set-up period. If it does not, switch off immediately and thoroughly recheck the wiring.

Each channel of the converter can be read using the INP function plus the appropriate address. A list of the channels and the corresponding addresses is in Table 1.

CHANNEL	ADDRESS
0	16
1	17
2	18
3	19
4	20
5	21
6	22
7	23

Table 1. Channels and addresses used in the MTX A to D Converter

Thus, the command:—
PRINT INP(20)
would return the latest reading from channel 4. With no input connected reading any of the channels should return a value of 0. However, if an input is connected to the 5V supply rail and a reading is taken this should return a value in the region of 128.

Although each input has a full scale sensitivity of 10V, this can be modified by adding either an amplifier to give a lower full scale value or an attenuator/series resistor to give a higher value. If a series resistor is used this should have a value of 2kΩ per volt above the basic 10V full scale sensitivity. For example, a full scale value of 30V requires a 20V decrease in sensitivity. 20V × 2kΩ gives a series resistor value of 40kΩ. Of course, where high accuracy is needed a preset resistor should be used so that the full scale voltage can be trimmed to precisely the required value.

Although the converter has only 8-bit resolution this should prove to be more than adequate for most purposes. It permits greater accuracy than many people imagine, and it actually corresponds to an accuracy of considerably better than 1%. ★

COMPONENTS . . .

Resistors

R1	1k
R2	1k5

All $\frac{1}{4}$W 5% carbon

Capacitors

C1	1n carbonate
C2	100n ceramic

Semiconductors

D1	BZY88C10V
IC1	7581
IC2	74LS138
IC3	74LS14

Miscellaneous

2 × 28 way 0·1 inch (Spectrum) edge connector; P.c.b. PE 507-01; 28-pin d.i.l. socket; 16-pin d.i.l. socket; 14-pin d.i.l. socket; 20-way ribbon cable; Veropins, etc.