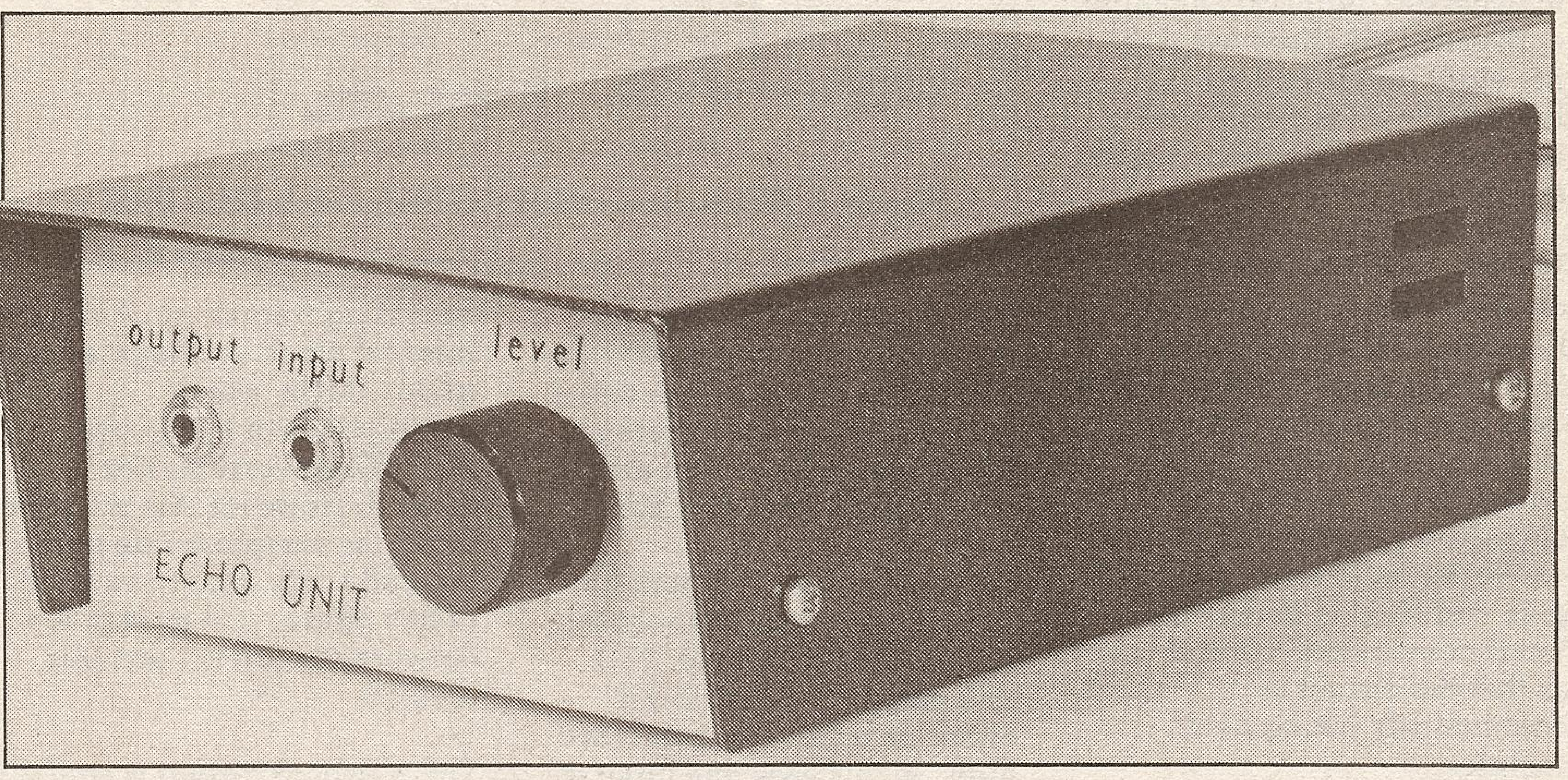
Digital Echo Unit For The Memotech Micro

A simple and effective echo unit for your Memotech computer.

R.A. Penfold



An echo unit based on the BBC Model B computer was featured in a previous issue of D&ME. This article describes **a version of that unit,** together with a suitable software routine for use with a Memotech MTX500 or MTX512 computer.

Both the software and the hardware could probably be used with other Z80 based computers that are fitted with a suitable input/output port, although in this article only the use of the system with the Memotech machines will be considered in detail. Like the original (BBC) version, a maximum delay of something approaching one second can be acheived. but the software can be used to alter the amount of memory utilised in the delay loop, and much shorter delays can be achieved if required. The system is thus capable of providing dual tracking and other effects in addition to a long echo effect.

In this article only a simple software routine is provided, but there is plenty of scope for Z80 assembly language programmers to modify and improve this aspect of the system.

In fact with suitable software, and in some cases a slight modification to the hardware it should be possible to obtain effects such as vibrato, phasing, and flanging.

System Operation

The system operates in the same basic manner as the BBC version of the Echo Unit, as can be seen from the block diagram of **Figure.1.**

First the input signal is taken **to a mixer stage, and the** output signal is taken from the output of this stage. Some of the output signal is therefore just the straightforward unprocessed input signal. However, some of the output from the mixer is taken to a lowpass filter (to prevent serious distortion) and then to a compressor. The latter provides standard compander type noise reduction in conjunction with an expander in another section of the circuit.

The output signal from the compressor is taken to the input of an analogue to digital converter, and the digitised version of the signal provided by this stage is fed into a section of memory in the computer. When the block of memory is full the system simply goes back to the beginning of the block and overwrites the original digitised samples. This process continues indefinitely, but a digital to analogue converter is used to reconvert each sample back to the original signal voltage before it is overwritten.

Obviously there is a delay between each sample being stored in RAM and being converted back to a signal voltage again, and the delay obtained is dependent on two factors. These are; the size of the RAM block, and the sampling rate. With the MTX computers 28k of RAM is readily available, and in order to obtain a reasonable audio bandwidth a sampling rate of **about 30kHz or more is** required. This enables delays of up to about one second to be achieved.

The output of the digital to analogue converter is not a true replica of the original signal in that the output is a stepped waveform. A lowpass filter is used to attenuate high frequency components on the output signal and give a closer representation of the original signal. With a resolution of only eight bits the performance of the system is still less than HiFi though, but the distortion level is quite acceptable, and comparable to many analogue delay lines, and the use of noise reduction helps to give a good signal to noise ratio.

The delayed signal is mixed with the input signal at the mixer stage, and a level control enables the strength of the delayed signal to be varied. Apart from controlling the relative strength of the first echo, this also controls the number of echos that are obtained before the signal decays to an inaudible level — bearing in mind that the echo signal is repeatedly recirculated through the system.

With the BBC version of the Echo Unit the output of the analogue to digital converter is fed into the user port. This has two handshake lines in addition to the eight data lines, and these two lines enable the flow of data from the converter to the port to be properly synchronised.

The digital to analogue converter is fed from the eight data lines of the printer port, and no handshaking is needed here. In this case all the inputs and outputs are provided by the user port which provides eight inputs and eight outputs. The eight outputs can be used to drive the digital to analogue converter, but there are only the eight inputs and no handshake lines available for use with the analogue to digital converter.

What the MTX user port can offer instead of conventional handshake lines is a strobe input. **This can be used to latch** data into the port if it is fed with a short positive latching pulse. In this case the "end of conversion" status output of the converter is inverted by a NOR gate and used to drive the "start conversion" control input so that the circuit is continuously taking new samples.

The positive output pulses from the gate are used to latch each conversion into the port, and the result of the latest sampling is therefore obtained whenever the port is read.

A C/R timing network feeds the other input of the NOR gate, and this simply ensures that a start conversion pulse is produced at switch-on and the continuous conversion process is initiated.

Circuit Description

Figure 2 gives the circuit diagram of the mixer and recording section of the unit while **Figure 3** shows the circuit diagram of the playback section.

Taking **Figure 2** first. This closely follows the BBC echo unit circuit, with an operational amplifier summing mode mixer, IC1a, a 110kHz 18dB per octave lowpass filter, IC1b, one half of an NE571 as the compressor, IC2a, and a ZN449, IC4 as the analogue to digital converter.

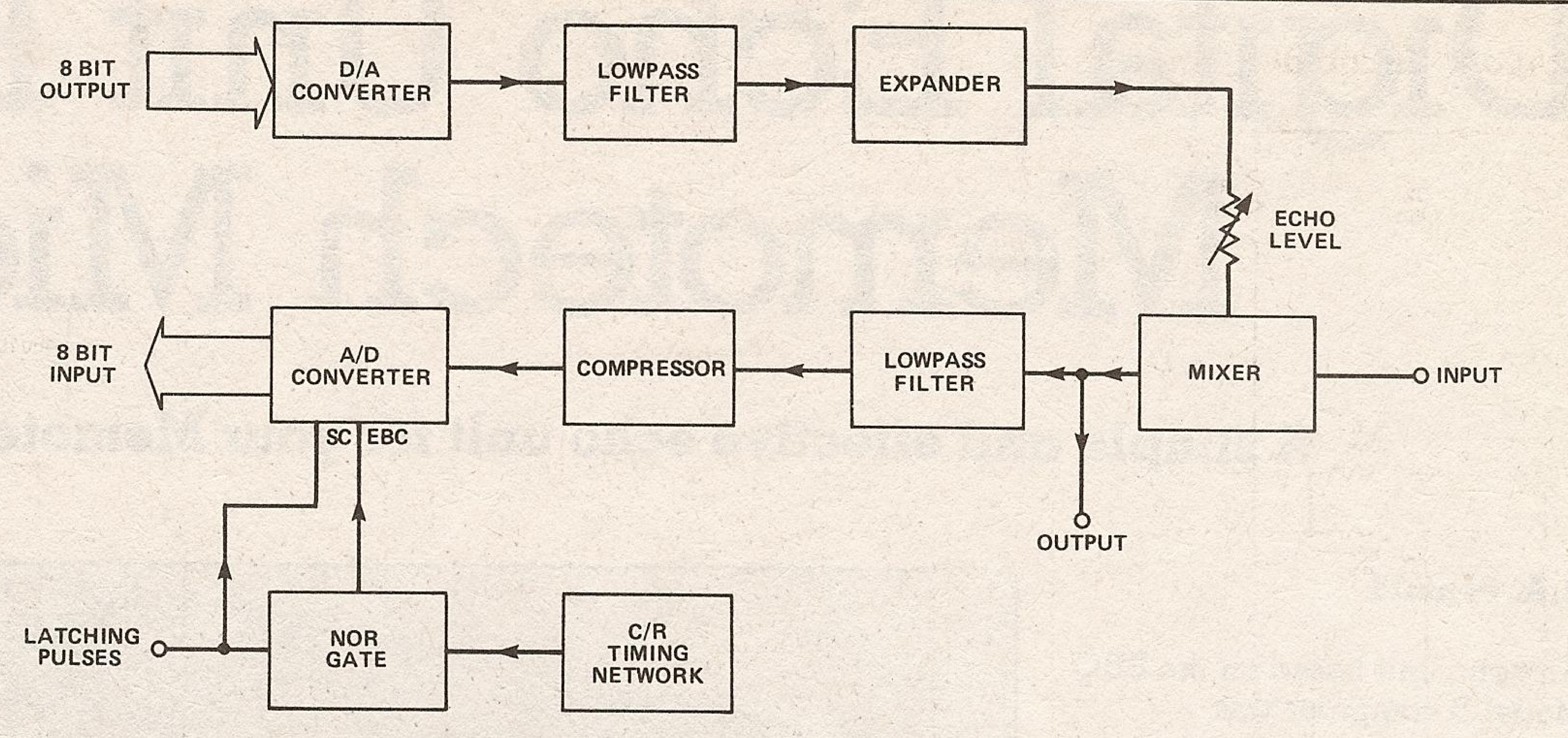


Figure 1. Block diagram of the Memotech Echo Unit.

This circuit and the way that the noise reduction is provided will not be described in detail as this ground was covered in **the previous Echo Unit article *(See D&ME issue 6 — Ed).***

Where the circuit differs from the original is in the inclusion of a 2-input NOR gate, IC3. The output of IC3 is low if either or both of its inputs are high. In this case one input is briefly taken high at switch-on **by the C/R timing circuit, C16/R12, and this provides the** initial "start conversion" pulse to IC4. The other input of the gate is fed from the "end of conversion" output of IC4, and this goes low during a conversion. This signal is inverted to give a low "start conversion" pulse to IC4 at the end of each conversion, thus giving the required continuous conversion action.

This signal also gives suitable negative pulses for the INSTB (input strobe) line of the user port. **Figure 4** is the timing diagram for the continuous conversion circuit.

IC3 is a CMOS device and is therefore slow in relation to the 74LS * *TTL device used for the input port of the MTX computers. this ensures that the latching pulses are sufficiently long to give reliable latching without having to resort to a pulse stretching circuit.

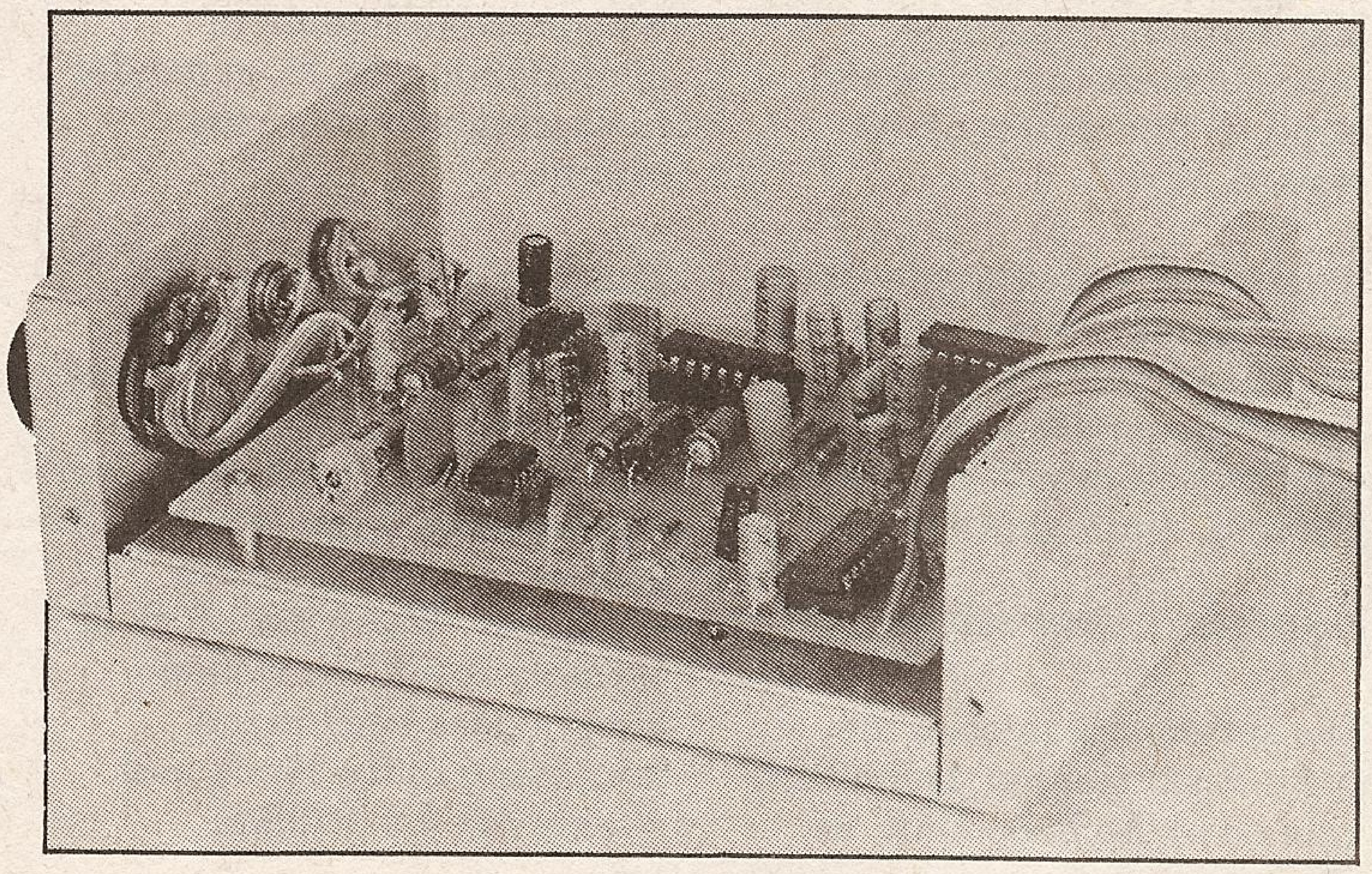
Capacitor, C19 sets the operating frequency of IC4's internal clock oscillator at just under 1MHz, which corresponds to a little over **100,000 conversions per** second. However, the software limits the sampling rate to typically only about one third of this figure, and most of the conversions are not actually utilized.

The playback circuit is actually the same as the one used in the previous Echo Unit. IC2b is the expander of the noise reduction circuit, IC5 is the 10kHz 18dB per octave lowpass filter, and IC6 is the digital to analogue converter.

The unit requires +5 volt, +12 volt, and a negative supply. The MTX computers can provide both of the required positive supply voltages, plus a **negative supply of about −12** volts which is adequate to feed the tail resistor of IC4.

Construction

Figure 5 provides details of the printed circuit board. The only MOS device used in the unit is IC3, but as IC2, IC4, and IC6 are fairly expensive components it is strongly **recommended that these** should also be fitted in integrated circuit holders. A few link wires are needed and it is probably best to fit these before adding the resistors and capacitors to avoid the possibility of overlooking them altogether. It is advisable to use radial, **(printed circuit mounting) and** axial capacitors, as specified in the components list, as the capacitors should then fit onto the board with ease. Be careful to fit the semiconductors and electrolytic capacitors the ri[illegible] way round. Veropins are fitted to the board at the points where connections to RV1, SK1, and SK2 will be made.



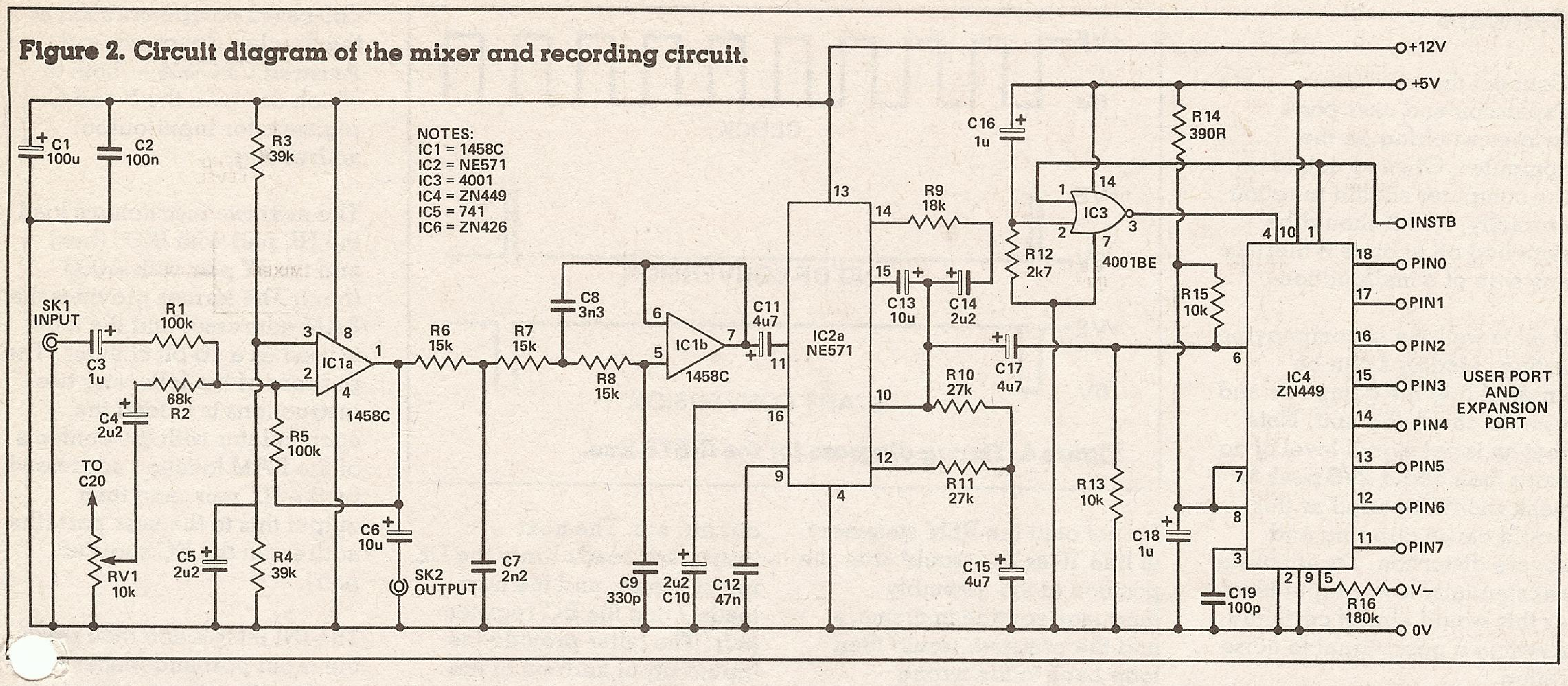


Figure 2. Circuit diagram of the mixer and recording circuit.

Power for the unit is taken from the expansion port at the left hand side of the computer. This requires a 2 by 30 way 0.1 inch pitch edge connector with the appropriate polarising key. In practice it is unlikely that a suitable connector will be available, but the connections **can be made via a Spectrum** type, 2 by 23 way 0.1 inch pitch edge connector.

The user port is the vacant 20 pin DIL integrated circuit holder on the printed circuit board of the computer. It is necessary to remove three screws at each end of the case using a small Allen Key before the keyboard can be hinged carefully upwards to give access to the holder. Unfortunately, 20 pin DIL plugs do not seem to be obtainable and what is probably the most convenient way of making the connections to the use port is to cut down two 14 pin DIL plugs to 10 ways each. One can then be used to carry to the connections to the input half of the port while the other takes the connections to the output section.

Pieces of ribbon cable about 0.5 to 1 metre long are used to wire the unit to the connectors. Connection details for both the expansion and user ports are shown in **Figure 6.**

A metal instrument case having approximate dimensions of 150x100x 50mm makes an attractive and practical housing for this projet. As can be seen from the photographs, RV1 and the two sockets (which are both 3.5mm jacks) are mounted on the front panel.

The printed circuit board is mounted on the aluminium chassis supplied with the case using 6BA or M3 fixings. Spacers about 6mm in length are used over the mounting bolts to prevent the connections on the underside of the board from short circuiting through the metal chassis.

To complete the unit the connections to RV1 and the two sockets are completed using ordinary insulated connecting wire. It will probably be possible to take the ribbon cables between the base and top sections of the case without having to modify the case in any way. However, if the gap between the two sections of the case proves to be inadequate a suitable notch must be cut in the base section of the case.

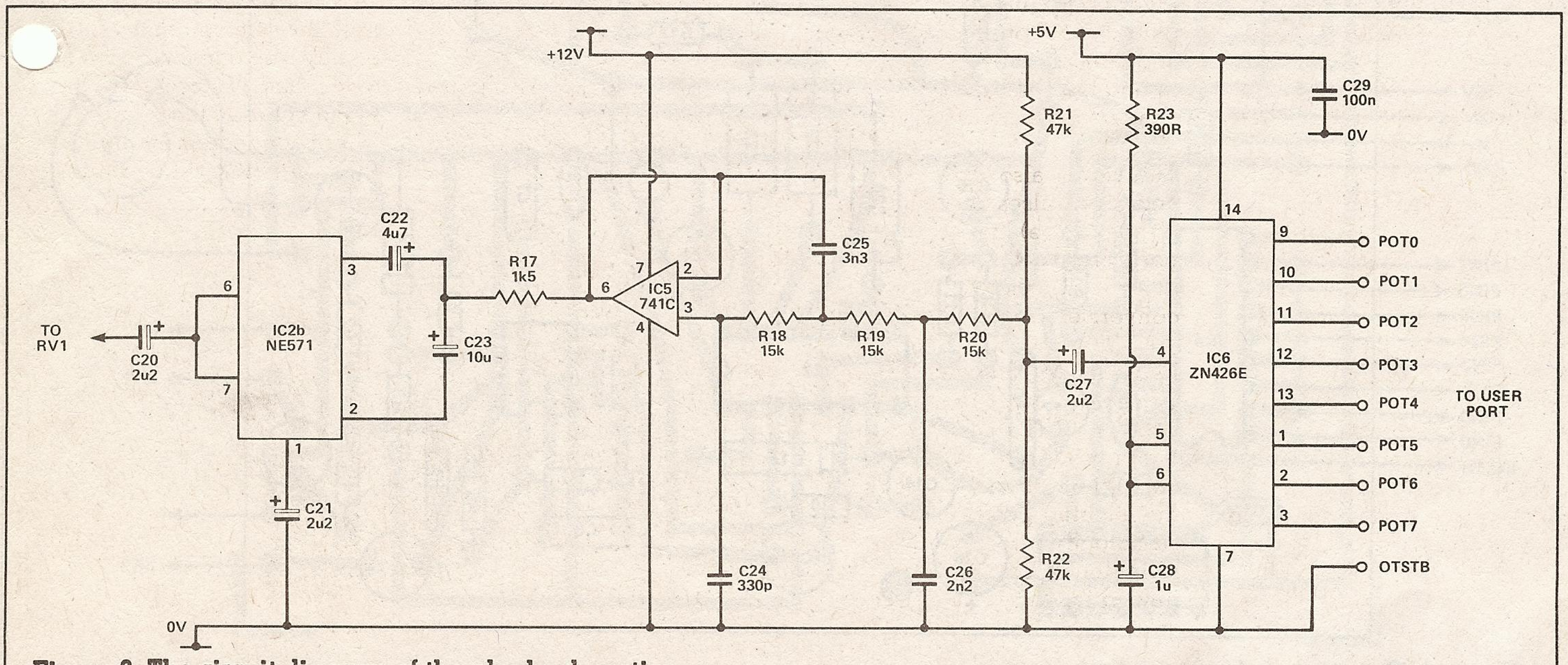


Figure 3. The circuit diagram of the playback section.

Software

Connect the unit to the expansion and user ports before switching on the computer. Once switched on, the computer should function normally, and it should be switched off at once if there is any sign of a malfunction.

If all is well the accompanying listing, **Listing 1** can be entered into the computer and used to check the unit. Note that an input signal level of no **more than about 2V5 peak to** peak should be used as this would cause clipping and severe distortion. Do not use a substantially lower input level as this would almost certainly result in a poor signal to noise ration.

The software is fairly straightforward in operation and has been kept as simple as possible. Note than an assembly language program has to be used as even a fast BASIC such as MTX BASIC is far too slow for this application.

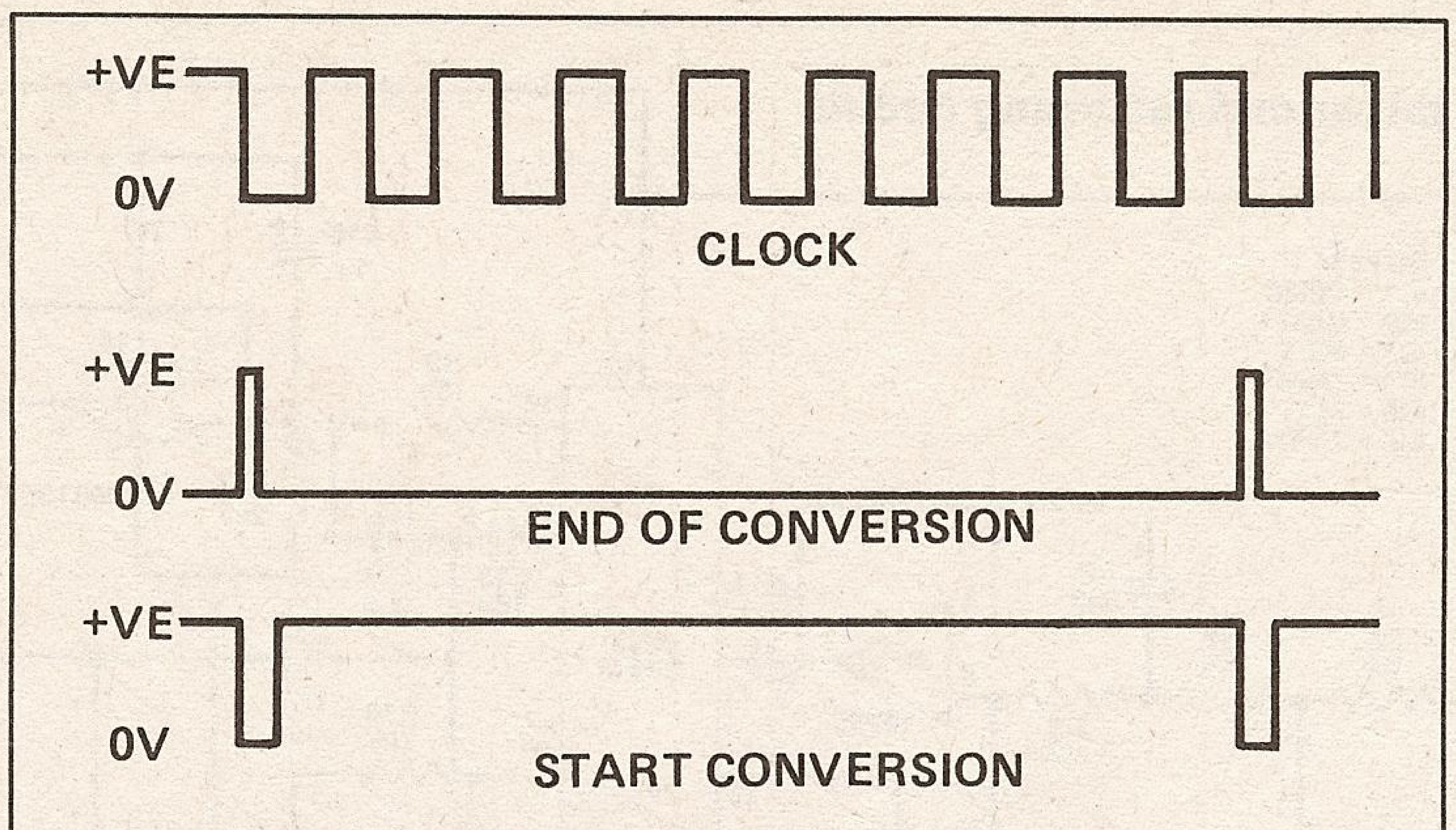


Figure 4. Timing diagram for the INSTB line.

Do not omit the REM statement at line 10 as this would alter the position of the assembly language routine in memory, and the program would then loop back to the wrong addresses at the jump instructions. The MTX500/512 manual gives details of how to use the built-in assembler.

The first instruction disables interrupts, and this is essential since the audio output would otherwise be modulated due to frequent interrupts by the timer circuit, etc. The next instruction loads 1 into the DE register pair, and the next loads 7 into the BC register pair. The latter provide the input/output address of the user port.

Although with the MTX computers only the C register is used for addressing input/output devices, the ability to use the B register as well has been included in the routine so that is could be easily changed to suit other Z80 based computers such as the Sinclair Spectrum and Amstrad CPC464 — both of which use both the B and C registers for input/output addressing.

The next two instructions load the HL pair with 9000 (hex) and the IY pair with A000 (hex). The former provides the RAM addresses and the latter is used as a 16-bit counter. The purpose of the following two instructions is to load the accumulator with the contents of the RAM location addressed by the HL pair, and then output this to the user port (the address in the BC register pair).

The INI instruction then reads the input port and places the result in the memory location addressed by the HL pair. This instruction automatically increments the HL pair, moving the program onto the next RAM location. Note also **that it decrements the B** register, which would therefore need to be incremented back again if the routine was to be

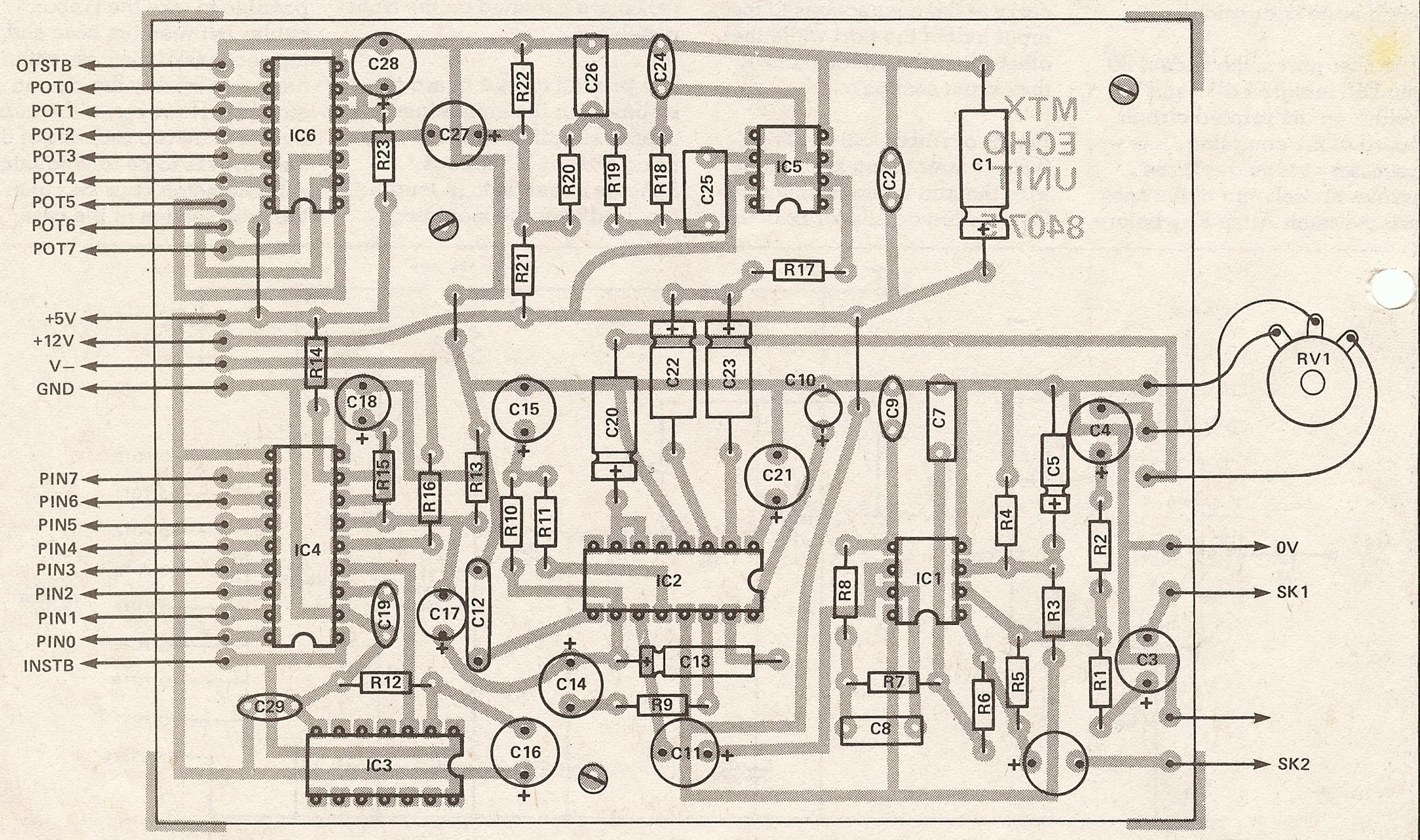


Figure 5. The printed circuit overlay.

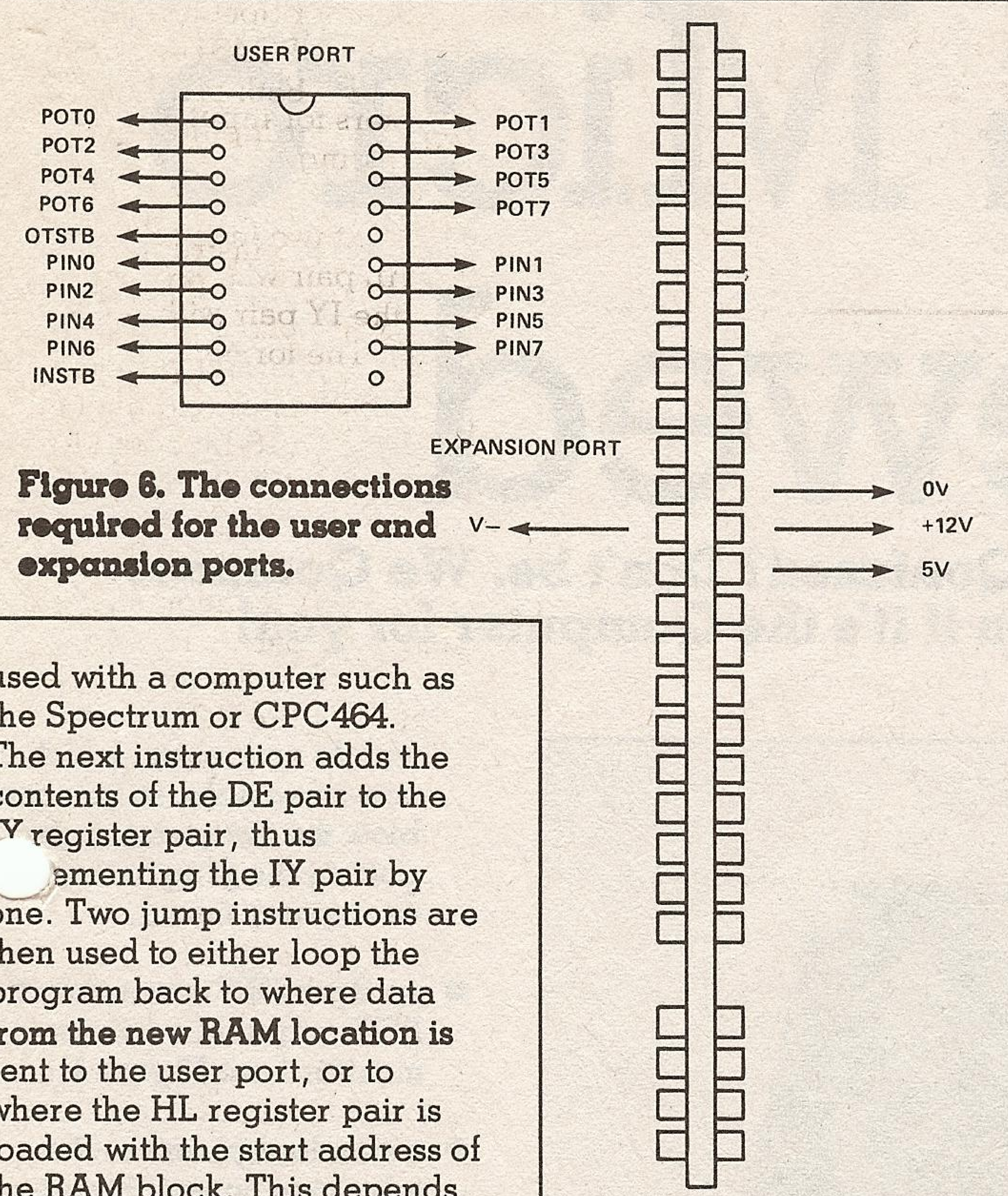


Figure 6. The connections required for the user and expansion ports.

used with a computer such as the Spectrum or CPC464. The next instruction adds the contents of the DE pair to the IY register pair, thus incrementing the IY pair by one. Two jump instructions are then used to either loop the program back to where data from the new RAM location is sent to the user port, or to where the HL register pair is loaded with the start address of the RAM block. This depends on whether or not the carry flag is set (it is set when the IY register is incremented from FFFF to 0000).

The loading of the IX register is just a "dummy" instruction so that the program takes the same number of clock cycles regardless of which loop it takes.

```
10 REM ECHO

20 CODE

8012        DI
8013        LD DE,1
8016        LD BC,7
8019        LD HL,#9000
801C        LD IY,#A000
8020        LD A,(HL)
8021        OUT (C),A
8023        INI
8025        ADD IY,DE
8027        JP C,#8019
802A        LD IX,#8888
802E        JP NC,#8020
8031        RET

Symbols:
```

Listing 1. The program (!) for the Echo Unit.

It will probably be apparent from this description that the start address of the block of RAM which is used as the delay line is controlled by the number loaded into the HL register pair, and is equal to this number. The upper limit is controlled by the number loaded into the IY pair. Taking this number from FFFF gives the number of RAM locations that are used. Of course, these numbers can be modified to give more or less RAM in the delay line in order to give the desired delay, but care must be taken not to stray outside the area of free RAM.
The sampling rate is somewhat higher than is absolutely necessary, and it should be possible to obtain slightly longer delays by adding some NOP instructions or other delaying instructions to the routine.

Note that as interrupts are disabled by the routine, once the program is running the only way to exit from it is to press the two reset keys.

Part List

RESISTORS
(All 1/4 watt 5% carbon)

R1,5	100k
R2	68k
R3,4	39k
R6,7,8,18,19,20	15k
R9	18k
R10,11	27k
R12	2k7
R13,15	10k
R14,23	390R
R16	180k
R17	1k5
R21,22	47k

POTENTIOMETER

RV1	10k log pot

CAPACITORS

C1	100u 25V axial electro
C2,29	100n ceramic
C3,16,18,28	1u 63V radial electro
C4,10,14,20,21,27	2u2 63V radial electro
C5	2u2 63V axial electro
C6	10u 25V radial electro
C7,26	2n2 carbonate
C8,25	3n3 carbonate
C9,24	330p ceramic plate
C11,15,17	4u7 63V radial electro
C12	47n polyester
C13,23	10u 25V axial electro
C19	100p ceramic plate
C22	4u7 63V axial electro

SEMICONDUCTORS

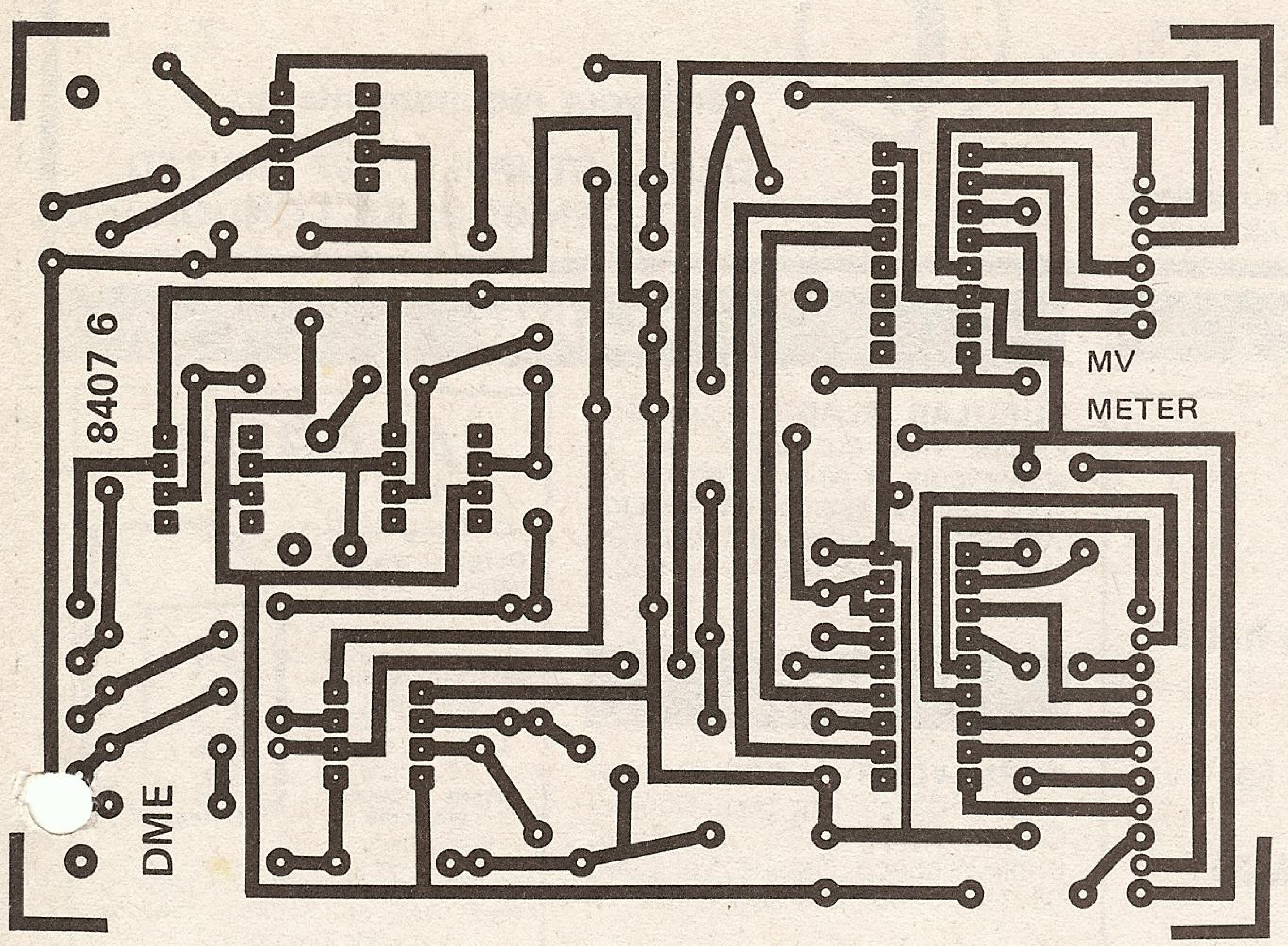
IC1	LM1458C dual op-amp
IC2	NE571 compander
IC3	4001BE 2 input NOR
IC4	ZN449 converter
IC5	741C op-amp
IC6	ZN426E A-D converter

MISCELLANEOUS

SK1,2	3.5mm jack socket

Printed circuit board: case about 150x100x50mm; control knob; DIL IC sockets: 1x18pin, 1x16 pin, 2x14 pin; two 14 DIL plugs; 2x28 way 0.1 inch pitch (Spectrum type) edge connector; ribbon cable; wire; etc.

Foil Patterns



To the left is the foil for the Audio/ Millivoltmeter project. Below is the pattern for the Memotech Echo unit.