128 NOTE

Can be added to Minisonic for sequencing melodies or rhythm pattern

THE sequencer circuit to be described will enable a voltage controlled synthesiser to automatically play a pre-programmed tune, consisting of up to 32 pitches, in a sequence up to 128 notes long. All programs are keyboard initiated.

BLOCK DIAGRAM

The heart of the sequencer is an NMOS RAM (random access memory) capable of storing 128 eight bit words of data. The circuit operation can best be understood by referring to the block diagram of Fig. 1. Here the RAM is driven from a clocked binary counter. The binary number at the output of this defines the position in the memory that is present at the data terminals. The sequence is written into the memory via a modified 49 note keyboard which converts the 32 possible pitches into five bit words.

The 128 note sequence is built up by stepping the counter each time a new note is written in. When a sequence is complete, it is played by clocking the counter at a steady rate by means of the clock oscillator. The five bit words are then read out from the memory into a digital to analogue converter (D–A) which produces a 32 level output. This is used to drive the v.c.o. in the synthesiser.

SEQUENCE LENGTH

Although the maximum sequence length available is 128 notes, it is often desirable to use a shorter sequence. For example, if the tune to be written consists of 32 bars with three beats to the bar, it is obvious that the total number of beats would be only 96. To cope with this type of situation the circuit was designed so that the counter could be reset at any desired point in a sequence, thus producing tunes of any length from 1–128 beats.

Only five of the eight bits of memory are used to produce a control voltage for the v.c.o., the other three bits are available to perform other functions. One of these spare bits is used to provide the variable reset function, and the other two bits are used to generate trigger pulses for envelope shapers, thus adding rhythm to the generated melody.

CLOCK OSCILLATOR AND COUNTER

The complete circuit is shown in Fig. 2. Here clock pulses are produced by a simple transistor astable multivibrator. The frequency may be varied over a wide range by adjusting VR1. Clock pulses are fed to the binary counter via S1, the stop/run switch.

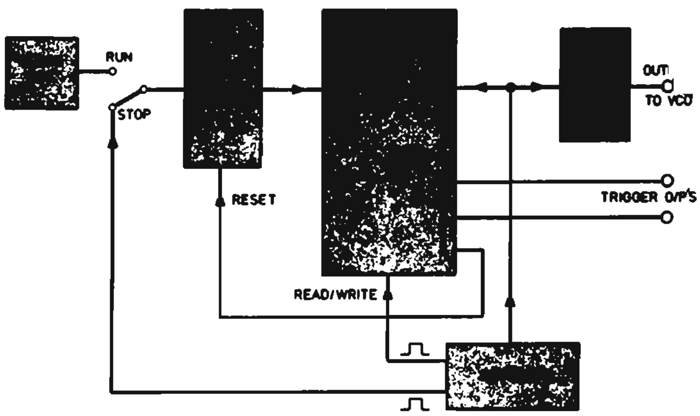

Fig. 1. Block diagram of sequencer

SEQUENCER

[illegible]. EVANS

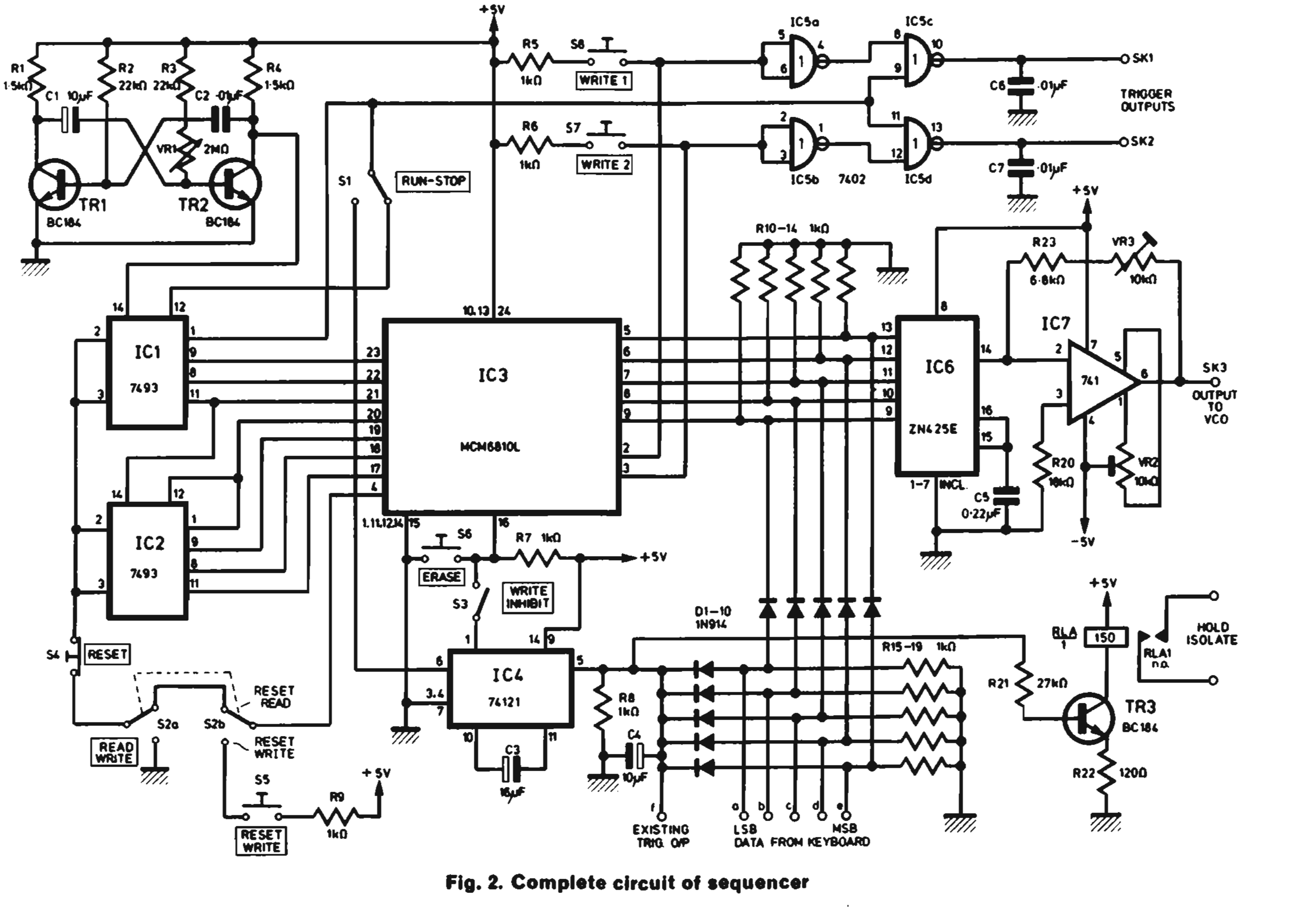

Fig. 2. Complete circuit of sequencer

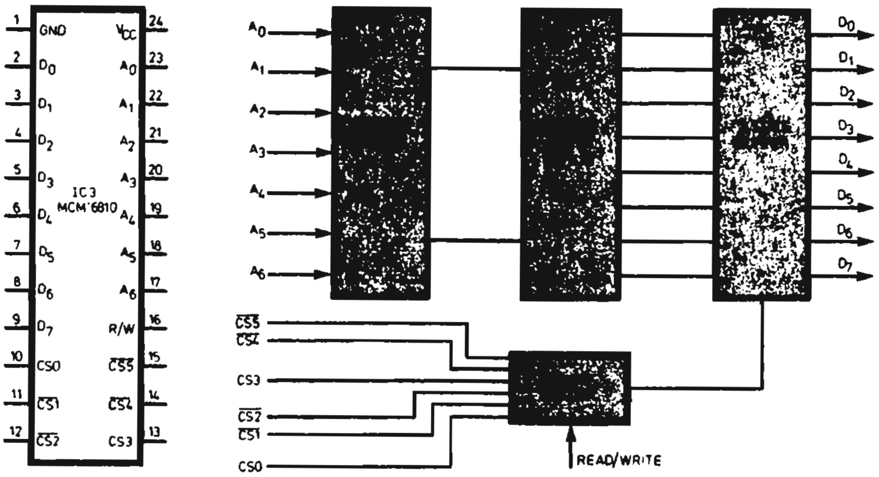

Fig. 3. IC3 pin-outs and internal block diagram

IC1 and 2 are cascaded to form a seven bit binary counter which drives the address inputs of the RAM. The stop/run switch disconnects the first stage of the counter and instead provides the counter with pulses from the keyboard. The reset inputs of IC1 and 2 are connected via S4 and S2 to one of the data lines of the RAM, the automatic reset pulse is written into this line by selecting "Reset Write" with S2 and depressing S5.

Returning S2 to the "Reset Read" position reconnects the data line to the counter resets. Thus, when the end of a sequence is reached, the reset data line goes high and the counters reset to zero.

COMPONENTS...

Resistors

R1	1·5kΩ	R20	18kΩ
R2	22kΩ	R21	27kΩ
R3	22kΩ	R22	120Ω
R4	1·5kΩ	R23	6·8kΩ (see text)
R5–19	1kΩ (14 off)		

All ¼W 5% carbon

Capacitors

C1	10μF elect. 25V	C4	10μF elect. 25V
C2	0·01μF	C5	0·22μF
C3	16μF elect. 25V	C6, 7	0·01μF

Integrated Circuits

IC1	7493	IC5	7402
IC2	7493	IC6	ZN425E
IC3	MCM6810L	IC7	741
IC4	74121		

Transistors and Diodes

TR1–3 BC184 or similar
D1–90 Any general purpose type

Relay

RLA D.i.l. reed relay, single pole (R.S. Components)

Variable Resistors

VR1 2MΩ pot. (lin.)
VR2 10kΩ min. preset
VR3 10kΩ min. preset

Switches

S1 s.p.c.o. miniature toggle
S2 d.p.c.o. miniature toggle
S3 single pole miniature toggle
S4 miniature push to break switch
S5 miniature push to make switch
S6 miniature push to make switch
S7 miniature push to make switch
S8 miniature push to make switch

Miscellaneous

PCB board, front panel material
Veroboard for diode mounting

RANDOM ACCESS MEMORY

Integrated circuit IC3 is a RAM, type MCM6810 designed for use with the M6800 microprocessor system. The block diagram and pin outs of the device are shown in Fig. 3. Pins 4–9 are data input/output terminals, the state of pin 16 deciding whether the device is in the read or write mode.

Pins 17–23 are the memory address inputs. The binary code fed to these pins determines which of the 128 memory cells is connected to the data terminals. Thus, when the clock and counter are running, each memory cell in turn is presented at the data terminals of the chip.

KEYBOARD BINARY CODER

In the prototype synthesiser a four octave keyboard is used to write the required sequence of notes into the memory. This accomplished by diode keying circuitry of Fig. 4. It will be seen from this that each contact connects the five data lines to the five volt rail via a combination of diodes.

These are arranged so that a binary number corresponding to the number of the key pressed appears on the data lines. The five data lines, plus an extra line for key one are also routed through diodes to a monostable IC4 which generates a read/write pulse at pin 16 of the RAM, so that whenever a key is pressed, the binary code appearing on the data lines is written into the memory.

IC4 also produces a clock pulse which drives the counter.

Therefore operation of any key causes three things to happen:

1. A binary number corresponding to the number of the key will appear on the data lines.
2. A write pulse will occur at pin 16 of IC3.
3. The trailing edge of the pulse from IC4 will clock the counter and hence step the memory on one position.

ENVELOPE TRIGGER OUTPUTS

There are eight data lines in the RAM. As already mentioned, five of these are used to produce pitch information, and one to provide the automatic reset facility. The two spare data lines are used in the prototype to store trigger pulses for the synthesiser's envelope shapers.

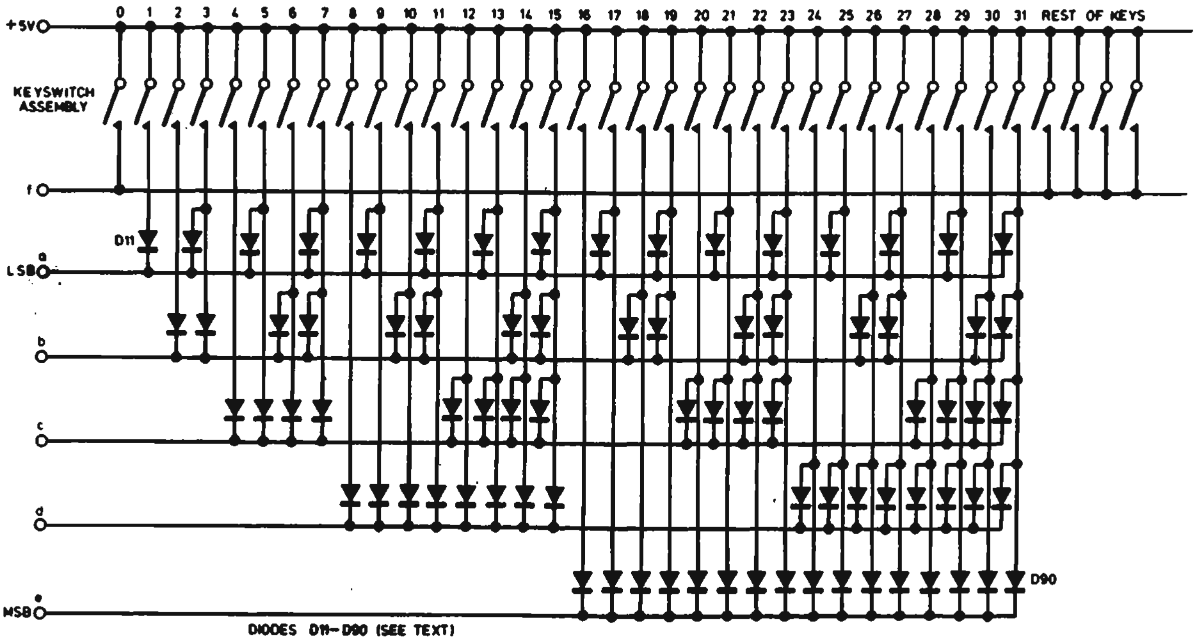

Fig. 4. Diode keying from keyboard to main sequencer circuit

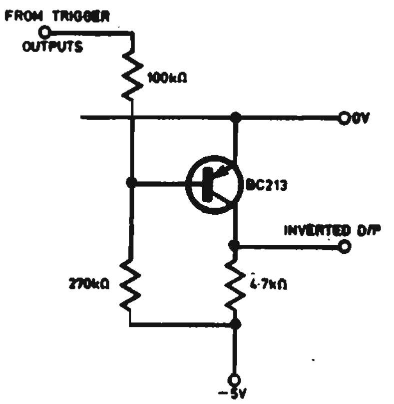

Fig. 5. Trigger inverter

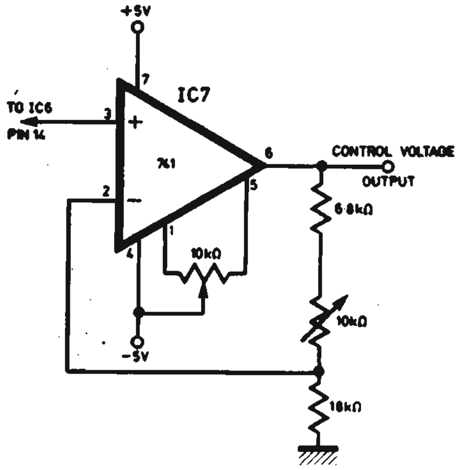

Fig. 6. Alternative output circuitry

Push button switches S7 and S8 are used to write in the trigger pulses when required. When the circuit is in the read mode, the outputs from pins 3 and 2 of IC3 are gated in IC5 with clock pulses. This ensures that whenever two consecutive pulses are written, two separate pulses appear at the output. Without the gating, only one long pulse would be produced.

It should be noted that the trigger pulses produced are positive-going, and are suitable for driving either of the ADSR envelope shaper circuits that have appeared recently in this magazine. The ES/VCA circuits of the Minisonic however, require negative-going pulses. These can be produced, if necessary, by the simple circuitry of Fig. 5 (three of these are needed).

The keyboard is fitted with two sets of contacts, one being used to drive the coding diodes, the other to drive a resistor chain for normal playing. For normal playing, a separate envelope trigger output is provided from the point which drives IC4. If the keyboard isolating relay (Minisonic Mk. 2) is being used it can be driven as shown in the main circuit diagram. (If not TR3 and associated components may be omitted.)

D–A CONVERTER

Early versions of the prototype utilised a number of different D–A converters, all of them using discrete components. All the circuits tried suffered from one problem or another, and all had the disadvantage of needing close tolerance resistors to function accurately. The integrated circuit D–A finally decided upon solved all these problems, although at somewhat increased cost.

The D–A chip feeds an inverting op-amp with gain and offset controls. The voltage at the output of the op-amp is of the correct sense for the Minisonic v.c.o.s, i.e. it is negative going for increasing pitch. For oscillators requiring positive-going control voltages the alternative output circuitry of Fig. 6 can be used.

NEXT MONTH: Construction and programming detail.

PART 2

128 NOTE

D. G. EVANS

IN this second and final part describing the 128 note sequencer, details will be given for constructing the three sub-assemblies making up the unit together with testing procedures and patching examples for use with a synthesiser.

POWER SUPPLY

The power requirements for the sequencer are positive five volts at about 200mA and five volts negative at a very low current for the 741 op amp. The circuit for this is given in Fig. 7 and provides both regulation and stabilisation for the two lines.

Constructional details for realising this are given in Fig. 8 which shows the majority of components mounted on a 76 × 54mm printed circuit board. When assembled both this and the transformer are mounted on a simple angled aluminium sub-frame. The p.s.u., main and counter display boards should be mounted on the baseboard adjacent to the control panel.

MAIN BOARD

The p.c.b. and component layout for the circuit of Fig. 2 is given in Fig. 8. Here i.c. sockets are used throughout to obviate the possibility of chip damage in assembly. They also facilitate the replacement of i.c.s.

When this board is assembled all i.c.s apart from the RAM should be inserted. This will enable the clock oscillator, counter and D-A converter to be checked for correct functioning.

First the control panel is made up from a piece of 135 × 235mm aluminium. This should be drilled and cleared to suit the components shown annotated in the photograph.

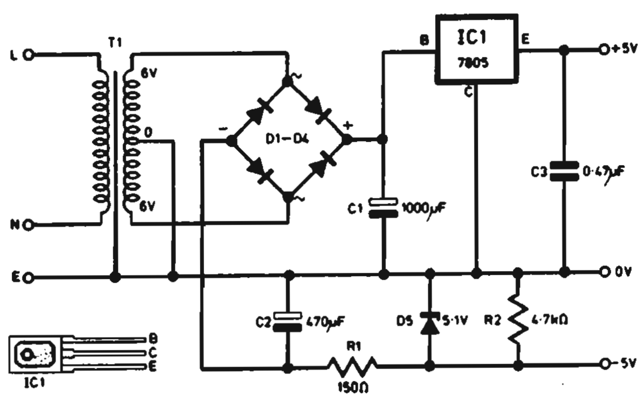

Fig. 7. Circuit of power unit

The Letraset legends were layed on a black paint background and then secured with a clear polyurethane spray.

After this preparation and finishing the control components should be fitted and wired according to Fig. 10 to the main board.

DIGITAL READOUT OF COUNTER

It was found when operating the prototype sequencer that it was often helpful to know what position in the memory had been reached when writing in a tune. It was considered that a full numerical display of the counter state was not necessary, and should greatly increase the cost of the unit. Fig. 9 shows an alternative arrangement which was used in the prototype. In this the binary number at the memory address inputs of IC3 is displayed on seven l.e.d.s, driven via buffer transistors.

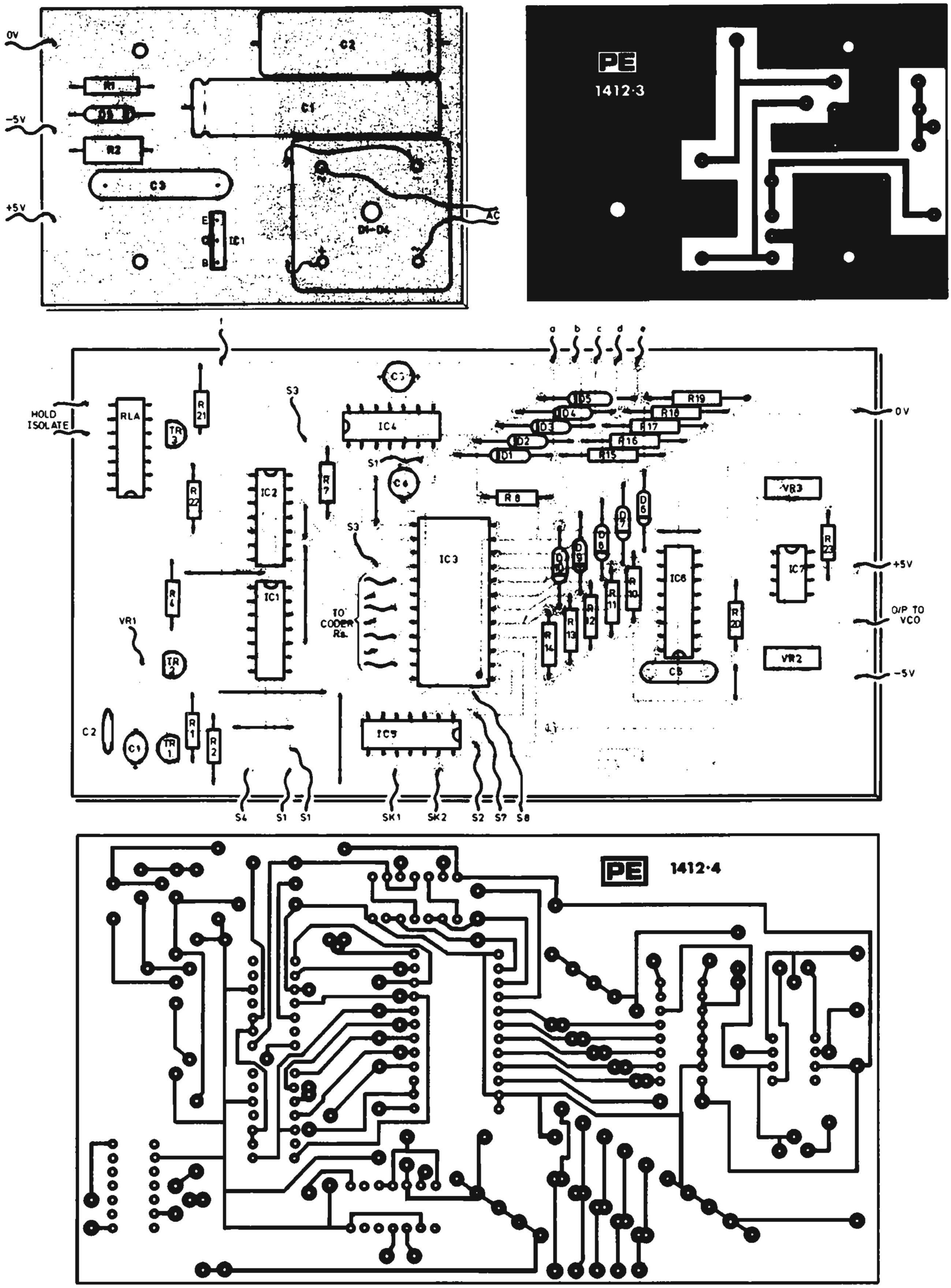

Fig. 8 (top). Showing component layout and p.c.b. for main components of power unit and (below) component board and etching details for the main circuit (Fig. 2)

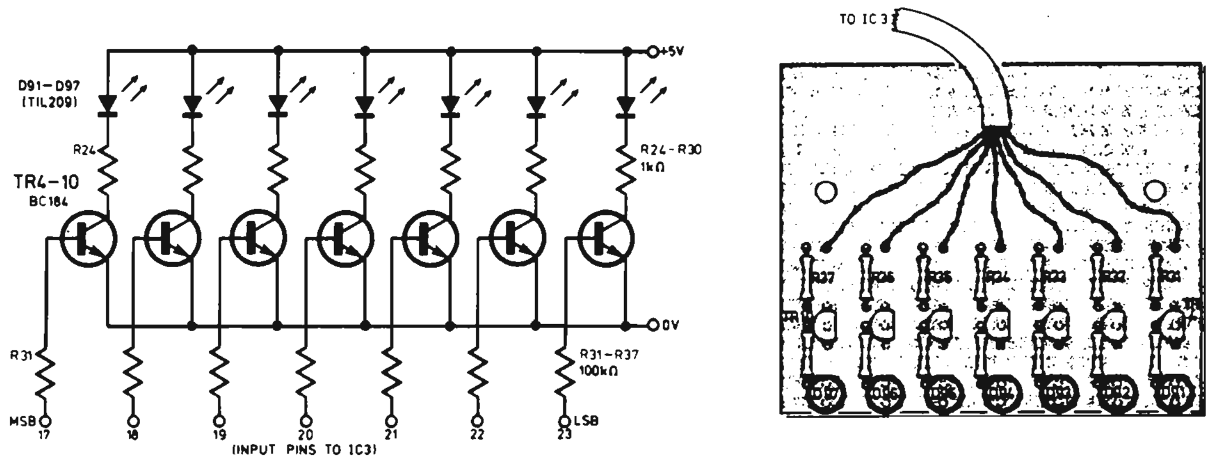

Fig. 9. Circuit of counter and prototype Veroboard layout

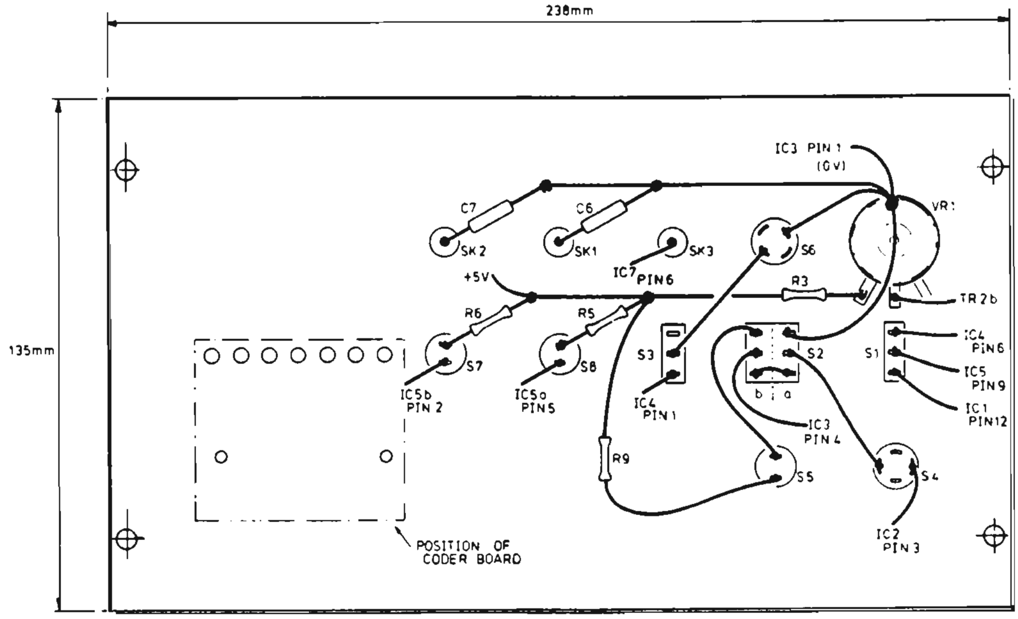

Fig. 10. Interwiring and component layout for control panel

On the prototype unit this circuit was assembled on a 45 × 55mm 0·1in matrix Veroboard (Fig. 9) and fixed with two screws and bushes to the control panel so that all the l.e.d.s are visible via cut-outs from the front.

To check circuit functioning set the "Stop/Run" switch to "Run" and apply power. With a voltmeter or oscilloscope examine whether the clock oscillator is producing pulses and the correct binary count appears at the l.e.d. "Count" display.

Set the "Stop/Run" switch to "Stop" and check that depressing a key causes the counter to step, and also that it causes a pulse to appear at pin 1 of IC4.

Still with the MCM6810 out of circuit, connect the D-A output to a synthesiser v.c.o. Adjust the offset control VR2 (Fig. 2) until the sequencer output is zero with no keys depressed. Now adjust the gain control VR3 so that playing consecutive octaves on the keyboard produces the correct pitch change in the v.c.o. (It may be necessary to adjust the value of the feedback resistor R23 to obtain the correct pitch span.)

If all is correct so far, switch off the power and insert the MCM6810.

On reapplying power, a random series of notes should be sounded by the v.c.o. when the clock is running. Pressing the "Erase" switch while running the clock at a fast speed will clear the memory. The sequencer is now ready for use.

PROGRAMMING THE SEQUENCER

A certain amount of practice is needed to programme the sequencer correctly, the user should familiarise himself fully with the working of the device before attempting to write complicated tunes into the memory.

The operating procedure is as follows:

(1) Clear the memory by running the clock at a fast speed with the "Erase" button held down.

(2) Select "Stop" with the "Stop/Run" switch.

(3) Press the counter "Reset" button.

(4) Set the "Reset Read/Write" switch to "Write".

(5) Write the required notes in by depressing the appropriate keys (go fairly slowly to avoid mistriggering the circuit). If a note is to be held for more than one beat, the key should be pressed more than once.

If the envelope trigger outputs are being used, the trigger button (1 or 2) should be pressed at the same time as a key whenever a trigger pulse is required.

(6) When the last note of the tune has been written in, hold the "Reset Write" button, and press the last key again.

(7) The tune is now ready to be played. Reset the counter, put the "Reset Read/Write" switch to "Read" and select "Run". The tune should now be played through the synthesiser v.c.o.

USING THE SEQUENCER

Even when used with fairly simple synthesisers, the sequencer is capable of producing quite startling results.

Some typical patching arrangements are shown in Fig. 11. The sounds produced by Fig. 11(d) are extremely entertaining if the two v.c.o.s are tuned to a musically related interval.

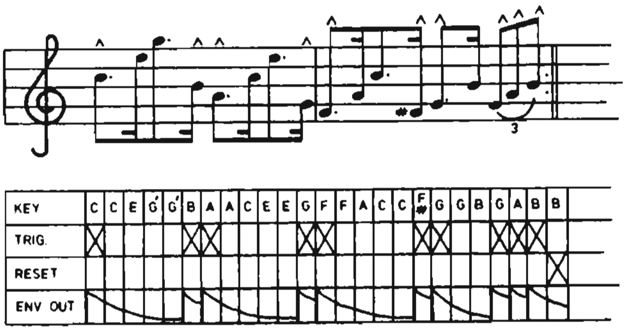

Fig. 12. Demonstrating a simple tune for the sequencer

COMPONENTS . . .

P.S.U.

Resistors
R1 150Ω ¼W
R2 4·7kΩ ¼W

Capacitors
C1 1,000μF 25V elect
C2 470μF 25V elect
C3 0·47μF

Semiconductors
D1–D4 Bridge rectifier (2A, 200V) (R.S. Components)
D5 BZX85–5·1 5·1V, 1·3W Zener (R.S. Components)
IC1 7805 5V, 1A regulator (R.S. Components)

Transformer
T1 6–0–6V 250mA mains transformer

L.E.D. COUNTER
(Optional to main board)

Resistors
R24–R30 1kΩ (7 off)
R31–R37 100kΩ (7 off)

Semiconductors
TR4–TR10 BC184 (7 off)
D91–D97 TIL209 (7 off)

KEYBOARD

49 note keyboard C to C
4 s.r.b.p. strips 169 × 51mm for mounting contact blocks
Contact blocks type GB2 (49 off)
(All keyboard items available from Maplin Supplies)

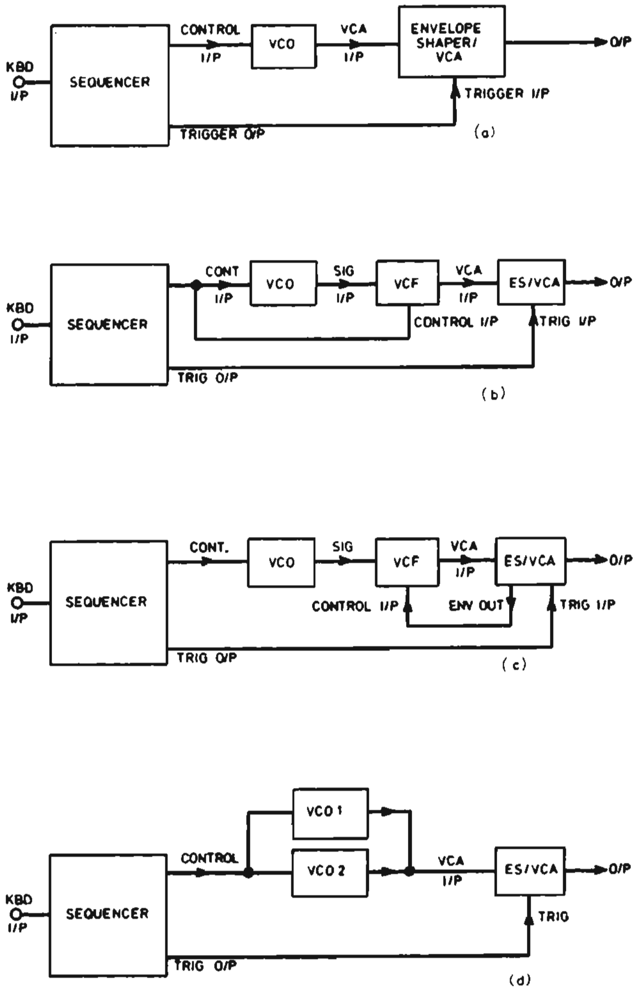

Fig. 11. Some typical patching arrangements with a synthesiser

Fig. 12 demonstrates how a simple tune can be played. Here each bar is divided into 12 beats, a close approximation of the dotted notes is given by using the 1st, 3rd, 4th, 6th, 7th, 9th, 10th and 12th beats only. By writing trigger pulses only on the accented beats the impression is given of a separate bass and melody line being produced by only one oscillator!

It is interesting to note that this tune only uses 25 positions in the memory, less than a fifth of the unit's capacity!

It must be realised that this is a very simple example; the full capabilities of the sequencer are really only limited by the imagination of the user.

EXPANSION

More ambitious constructors should have no difficulty expanding the unit in a number of ways, for example, two or more memories could be connected in series to give longer sequences. Alternatively, two memories could be paralleled to provide more outputs (two tunes could be played at once!).

Even in its basic form, the 128 note sequencer is a very useful addition to a synthesiser, making possible effects and sounds that are very difficult to produce manually. ★