talking dice

hear spots before your eyes

Dice are not just old, they are positively ancient! Their origin must lie somewhere in the mists of antiquity. Roman soldiers used them; gamblers from all over the world use them; even Chancelors of the Exchequer use them. Well, at least it seems that way!
Over all this time dice have hardly changed. They are still cubes with spots. With the advent of speech synthesisers, however, the road lies open to revolutionary dice: talkers!

So far we have not found an argument to justify the existence of talking dice. So what! They make an ideal christmas gift, 'something for the man or woman who has everything'.

We are not going to bore you with the finer details of the theory behind speech synthesis. Anyone who is interested can refer to back issues of Elektor. A list of the more useful ones is given at the end of the article.

The TMS 5100 is a sophisticated 'Voice Synthesis Processor (VSP)'. In a nutshell, it generates human speach and other sounds by digitally processing encoded data, which has been stored in non-volatile memory. The processed data is converted into an audio signal by the on-chip D/A converter and push-pull amplifier.

The circuit

Figure 1 shows the circuit diagram of the complete unit.
Starting with the section around the VSP: T1 and T2 form an audio amplifier. This is necessary because the internal amplifier of the IC delivers insufficient power to drive a loudspeaker. C2 acts as a ripple filter. Potentiometer P2 adjusts the volume. The TMS 5100 contains an oscillator that provides the necessary clock pulses (160 kHz at pin 3 of IC1). Only three external components are required (R5, C1 and P1). The setting of P1 determines the clock frequency.
The rest of the circuit consists of a control interface (IC2); the memory that contains the vocabulary (IC5); the address decoder/counter IC4; and finally the counter IC6 and the data selector (the actual number generator) IC7.

Counting and initialisation

As a result of depressing S2 a sequence starts, as shown in figure 2a. First IC1 is initialised by pulses coming from IC2. IC2 is reset (line Q0 becomes logic 1). The pulse from S2 is inverted by T3 (logic 0) and fed to the $\overline{CI}$ input of IC6. This IC now 'selects a random number' by counting the pulses supplied by the ROM/CLK output of IC1.
Releasing S2 stops IC6, since the 'carry in' input of IC6 (pin 5) is returned to logic 1.
Now we come to the second phase. This starts with the initialisation of IC1 by the combined pulses supplied by IC2 (see figure 2a). Two PDC pulses are followed by a third, and between the second and third pulse IC4 is reset to zero. Going back to the circuit, the address counter IC4 is reset as a result of a logic 1 at pin 11 caused by a pulse from line Q5 (pin 1) of IC2. Output Q9 of this IC is connected to its clock enable input. As a result when Q9 goes 'high' IC2 stops counting, until S2 is pressed again.

Now you're talking

So far so good, but the VSP is still at loss for words. At this point, the I/O output from IC1 sends a 'burst' of pulses to IC4; the latter then outputs a series of addresses to the EPROM. This EPROM contains the data shown in table 1: all speech information for the six words in a kind of 'parallel serial' format. Line DØ gives data for the word 'one', D1 corresponds to 'two' and so on.
As described earlier, the outputs of IC6 specify the desired number. The demultiplexer IC7 now selects the correct data output line from IC5 and passes this bit stream to output X. The VSP receives this data on line ADD8, whereupon it pronounces the random number.
We have made repeated references to the fact that the number is picked at random. The reason for this is that IC6 is counting the clock frequency (160 kHz), which is high enough to deter would-be cheaters. The counter is set to count from 2 to 7, as shown in figure 2b. When output Q3 (pin 2) of IC6 goes 'high', the preset enable input (pin 1) is activated. Preset inputs P0 . . . P3 are wired in such a way that

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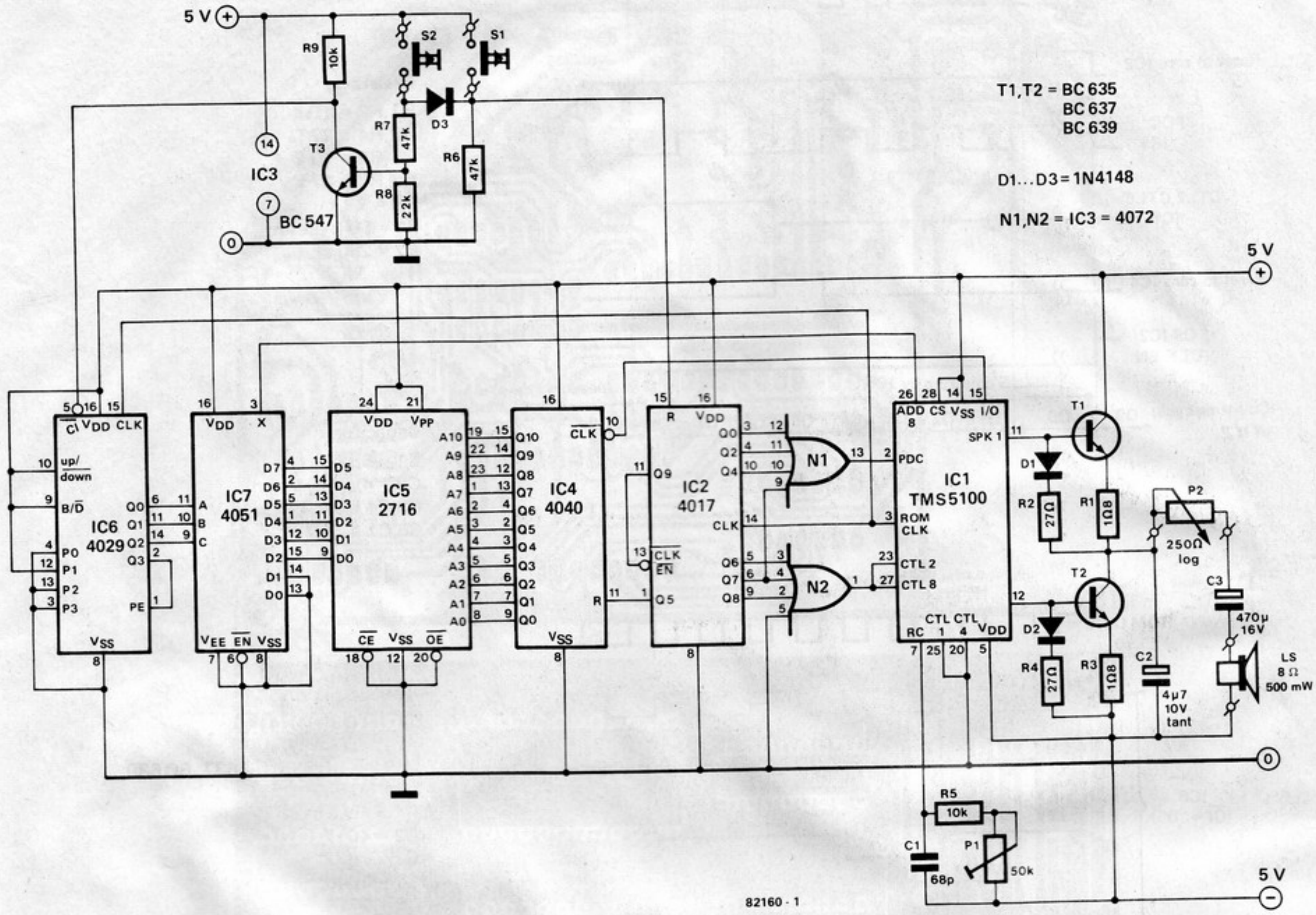

Figure 1. The circuit diagram of the Talking Dice using the TMS 5100 speech synthesiser. A ready prepared EPROM 2716 with the vocabulary is available. Switch S2 picks a random number, and S1 gives an instant replay.

Table 1. The Hexdump of the 2716 EPROM.

HEXDUMP:

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
000:	FF	C0	F3	CD	CD	C0	C1	C0	C1	C0	C0	C2	FE	F8	FD	DA
010:	C1	DF	C6	DB	C6	C1	FE	DD	D0	E9	D6	C7	F2	C0	FA	DE
020:	E7	C0	C1	C0	C1	C1	C0	E2	FC	E6	DB	FF	C0	E7	FF	C8
030:	F7	C3	DD	F6	FB	C2	FE	ED	D0	C0	FF	F0	EE	CC	C1	C0
040:	C0	C1	C1	ED	F3	FE	D5	D0	E2	DD	FD	DC	FA	C1	F6	F8
050:	DE	C1	FF	E0	FD	DA	FF	E8	D3	C0	DF	CC	C9	C4	D9	E1
060:	F6	E5	EC	E7	F8	C3	F9	CE	C1	D2	E0	EC	E1	FA	CC	D5
070:	DB	D4	EB	EB	EF	E3	DC	C7	D2	C0	DF	DD	EE	FB	C2	F6
080:	C8	D2	DD	CD	DA	D7	F6	DF	F9	C2	CF	D0	CF	CB	C6	EB
090:	E2	F6	E1	EC	D5	F8	E7	F6	EB	C3	FC	EE	EC	DC	F3	FC
0A0:	E7	F9	C0	FD	F6	DC	C0	FE	E6	F1	D2	CE	EC	FB	DD	E0
0B0:	D6	EA	F3	DC	DC	CB	E7	FC	F2	DB	E0	EA	D5	CD	ED	E2
0C0:	C0	E2	D7	C9	E4	F5	D0	FF	C6	EA	F6	D9	C2	ED	DD	DF
0D0:	EC	E3	F1	E9	F7	C2	FC	D0	E6	EF	F4	D3	ED	FC	F9	DA
0E0:	E6	C7	EE	F2	E9	D8	EE	E6	F5	DA	CF	C2	F8	F3	EA	EC
0F0:	C3	E9	F6	F2	C1	C8	F6	F1	EB	EF	CE	F2	F2	DF	CD	E8
100:	F5	DA	C1	EC	FC	C2	F5	DA	E5	F7	EF	D1	EC	C3	F6	F1
110:	C2	D4	E5	FD	C2	FD	FE	E1	E9	DB	C0	DC	F6	DD	D3	C8
120:	CC	DB	E9	F4	F2	CE	F2	C7	D0	F9	FD	C2	CE	D2	FF	CC
130:	E8	E2	FF	E8	F5	CA	CE	F3	DB	D0	E0	E9	D7	CC	F6	E1
140:	D7	CC	D7	D4	EE	DF	D5	E8	E6	D4	FB	E4	FF	F6	C7	D2
150:	EF	DC	C9	EF	F8	F1	E5	FF	C5	E3	DC	DC	C2	C5	DC	D2
160:	DC	C6	CB	DC	C3	FF	CA	CE	DE	DD	D6	CA	DD	D3	E8	F7
170:	F2	CE	DD	F7	D0	EE	DF	F0	D8	E7	E2	CD	D8	FB	E3	F2
180:	CA	FD	FE	C6	E7	C8	C1	D9	D7	D5	CE	F7	E8	E5	D6	CB
190:	CB	CD	D6	D3	F9	F7	E6	CF	EB	DA	F9	E4	DA	E4	D7	C8
1A0:	F7	EE	C3	F8	F3	C4	F9	CA	D1	CF	F1	CC	CD	DC	D7	CB
1B0:	DA	FA	F8	F3	EF	C7	CC	D5	D9	C6	D4	FE	FC	D9	C5	CF
1C0:	C3	D6	D9	C2	E7	ED	F3	F3	EA	EF	CA	EA	D7	D3	C9	F0
1D0:	FD	ED	E4	C3	CB	C4	C1	DC	FC	D5	FD	CD	CF	D1	CA	C5
1E0:	E9	FE	E2	ED	C3	D5	CE	DB	D0	D5	DF	DA	C0	C4	F1	D7
1F0:	EB	C8	D5	E9	C0	D0	C8	D0	DB	CE	C9	FB	EC	F2	F3	C0
200:	F6	D8	CB	E6	C5	CC	E3	CA	F4	C1	F6	F9	CA	C6	E5	D9
210:	D0	C5	DD	C6	CD	CB	D3	E0	F9	EA	F3	C3	F1	C8	DE	C1
220:	C7	D9	F2	CD	EF	C0	EA	E8	C0	D1	EB	EB	E4	C7	CD	CC
230:	CB	C7	DB	EF	F0	E1	CC	D7	C8	F4	E1	CA	F9	E9	C7	C6
240:	D0	E2	C9	C1	C3	D0	EB	E2	EC	C9	CE	C7	CB	C9	D4	F7
250:	E9	E0	CE	D3	F4	DA	C6	DE	C8	E1	D7	D9	E6	EC	C3	D9
260:	F0	FB	D8	CF	CB	C4	C2	CA	C9	CC	CE	EE	E7	C2	D0	E6
270:	D7	E1	FD	C2	E6	E7	C4	C6	C2	E1	C5	C6	FF	D9	FF	E9
280:	C3	E9	C5	CA	C6	C0	DE	EE	C8	F0	E8	C4	DA	E6	FF	E8
290:	D5	C0	E7	E4	C6	C2	C4	F2	FA	D0	CE	DD	E5	F6	DA	E3
2A0:	DE	C1	ED	FD	DF	C0	DB	F4	CE	C2	DF	F9	D7	E6	C1	E5
2B0:	E3	C2	C2	D4	F8	DC	EA	EB	F6	E9	FF	CD	DC	C5	F9	FE
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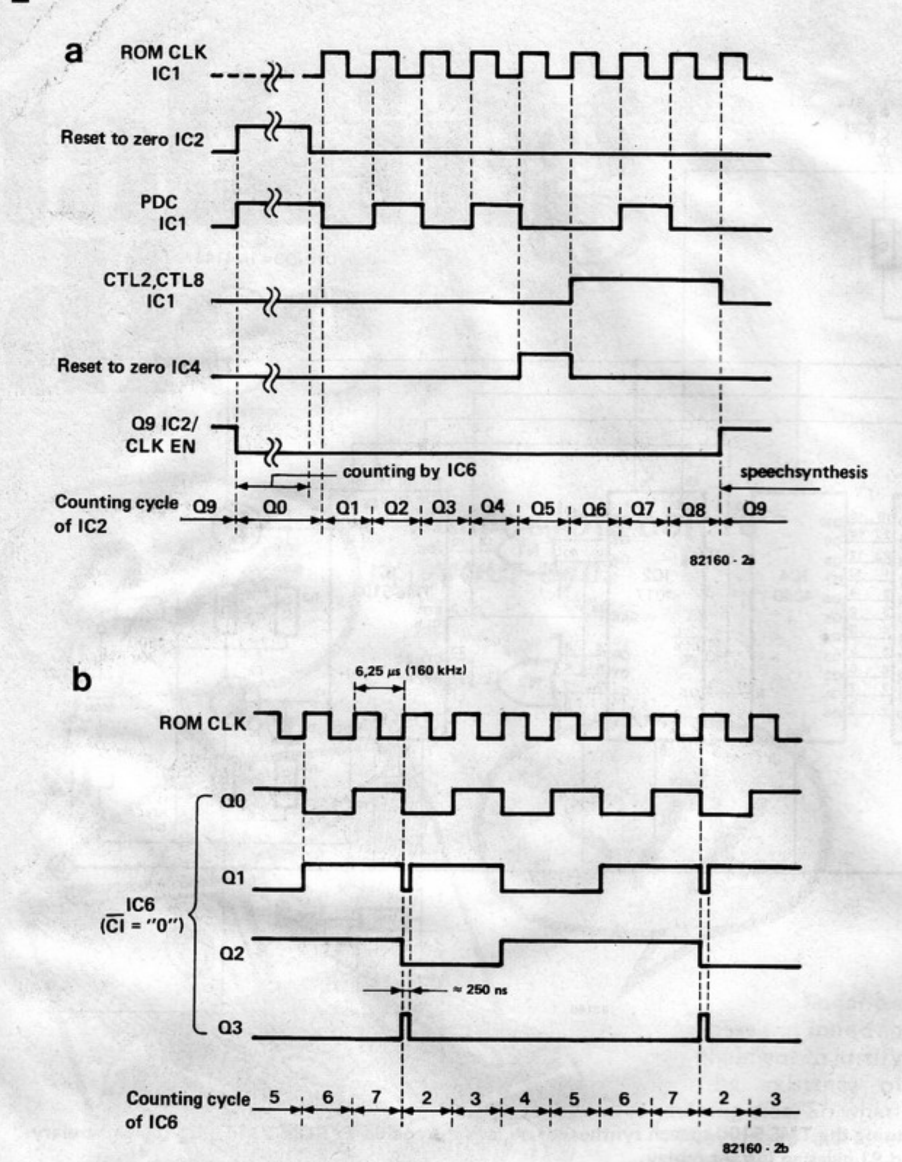

Figure 2. The various control signals, which must be applied to enable the circuit to work effectively.

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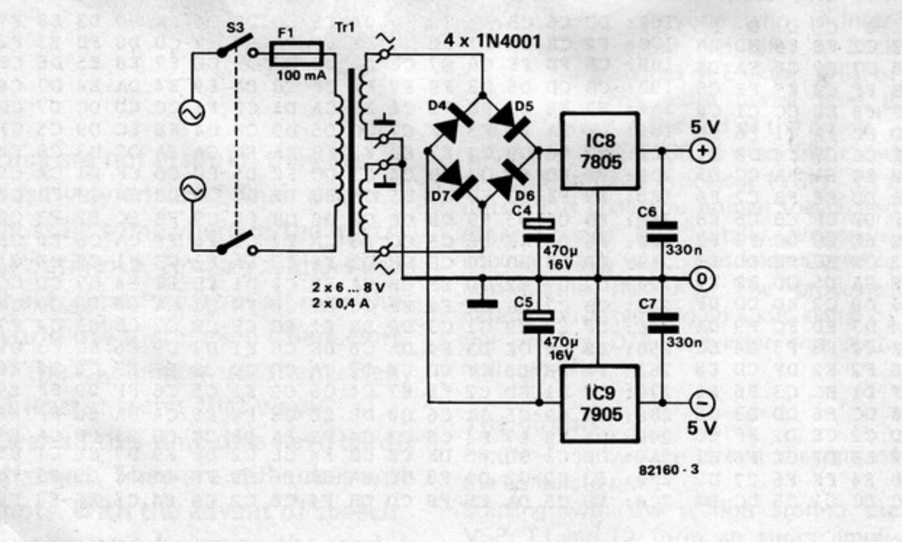

Figure 3. The circuit diagram of the power supply.

Parts list

Resistors:
R1,R3 = 1Ω8
R2,R4 = 27 Ω
R5,R9 = 10 k
R6,R7 = 47 k
R8 = 22 k
P1 = 50 k preset
P2 = 250 Ω log.

Capacitors:
C1 = 68 p
C2 = 4µ7/10 V tant.
C3,C4,C5 = 470 µ/16 V
C6,C7 = 330 n

Semiconductors:
D1 . . . D3 = 1N4148
D4 . . . D7 = 1N4001
T1,T2 = BC635, BC637, BC639
T3 = BC547
IC1 = TMS 5100
IC2 = 4017
IC3 = 4072
IC4 = 4040
IC5 = 2716
IC6 = 4029
IC7 = 4051
IC8 = 7805
IC9 = 7905

Miscellaneous:
S1,S2 = pressbuttons
S3 = 2 pole - 2 way
F1 = 100 mA slow-blow fuse
Tr1 = transformer 2 x 6 . . . 8 V/2 x 0,4 A
loudspeaker 8 ohm/0.5 W

the counter always returns to the number two. This method using a synchronous counter, ensures that all numbers have an identical (one in six) chance of occuring.

Say that again!

If in the heat of the moment (while playing), someone does not hear the answer from the dice, simply depress S1 and the number just 'thrown' will be repeated. In effect, S1 does the same job as S2, as far as IC2 and the speech synthesiser are concerned. However, D3 prevents it from enabling T3, so the

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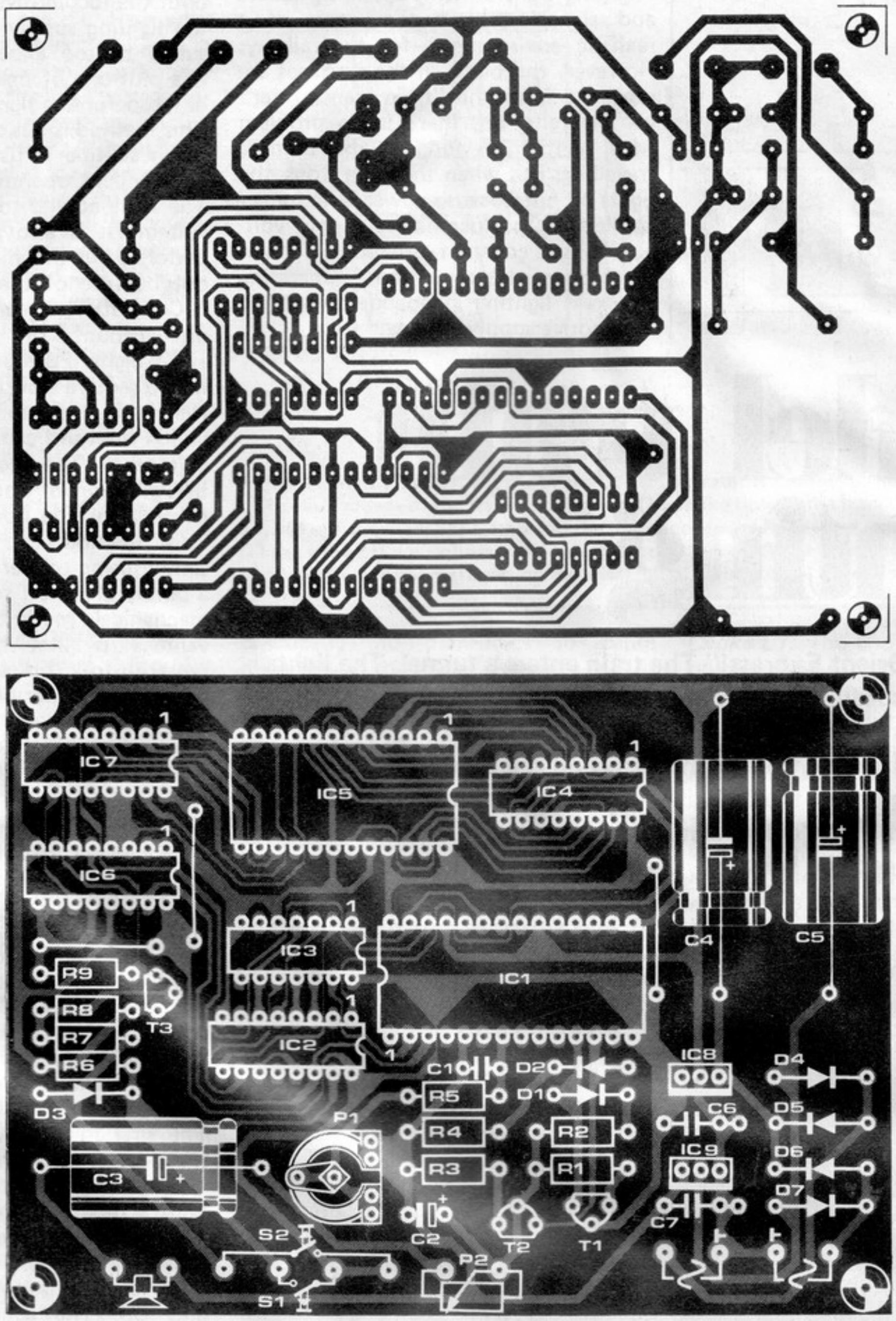

Figure 4. The printed circuit board for the talking dice and the power supply, as shown in figures1 and 3.

counter (IC6) remains in its current position.

Power supply

Figure 3 shows the power supply, using a normal three-pin voltage regulator. The CMOS ICs and the EPROM only require a positive 5 V supply, but the TMS5100 needs a negative supply as well.

Construction and calibration

Figure 4 shows the printed circuit board for the complete circuit. No provision has been made for mounting the transformer, switches S1 . . . S2 and the volume control. We suggest that constructors start with mounting the power supply components, checking that the voltages and polarities are correct before going further. If you use a transformer with two secondaries, ensure they are connected the correct way round.

Calibration is a straightforward case of simply adjusting P1 (the clock frequency) until the pitch of the voice sounds human. Alternatively, you can have a 'donald duck' sound if you prefer.

To make life easier a loaded EPROM is available from Technomatic Ltd (see their advertisement).

One suggestion put forward for a suitable case is to construct a cube from perspex.

As the saying goes 'the die is cast'.

Useful back issues for the theory of speech synthesis.
September 1981 Talking chips.
December 1981 Talking board.
February 1982 Talking board interface.