A scientific computer — 5

Graphics, graph plotting and e.p.r.o.m. programming

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THE SET OF CHARACTERS chosen for the graphics option was selected to augment the standard ASCII set and also provide various shapes for constructing diagrams and pictorial displays, see Fig. 20. The characters are programmed into a 2708 e.p.r.o.m. so the set may be easily altered to suit individual constructor's requirements. To make the shapes continuous, a full 10 × 6 dot structure is used for each character cell. This is achieved by loading bit 6 of IC_{45}, which was wired to 0 and thus inserted a one dot gap in between adjacent characters, and by disabling the line from IC_{34} pin 11 to the video gate IC_{33b}. The function of the gate was to blank the ninth and tenth line scan in each row of displayed characters to provide line spacing between those rows.

The 2708 is connected in parallel with the 2513 ASCII generator while bit 6 of the v.d.u. r./w.m. is fed directly to pin 11 of IC_{47} and through an inverter to IC_{100} pin 20. This bit selects which one of the character generators is enabled as shown in Fig. 21. The pulse at IC_{45} pin 1, whose trailing edge loads the shift register IC_{45} with the character dot pattern, is inverted so that its leading edge clocks the r/w.m. bit 6 into latch IC_{102}. The latch output feeds the video gate and sets an input which, on lines 1 to 8 of the character scan, is held low by the signal from pin 11 of IC_{34} applied to the S input. On the ninth and tenth scan when the S input is high, the video gate input will reflect the D input to the latch and thus the nature of the character being displayed, i.e. ASCII or graphic. Note that the latch must be loaded ahead of IC_{45} otherwise time delays in the system will cause the bottom left-hand corner of any graphic following a non-graphic to be blanked. When IC_{100} is disabled, the inverter on its D_5 output provides a low to IC_{45} pin 6 which then retains the original character spacing on ASCII.

Using graphics

As mentioned in part 3, ASCII may be directly loaded in low level language by opening a [and then typing the characters required. To enter graphics from this mode, open another [and then type in the graphic characters required. After typing the first character, which replaces the [on the screen, a cursor appears in the next screen position (a cursor is essential for picture construction) and the / key becomes a "rub-out and backstep" key for correcting errors. Typing a] reverts the computer to the ASCII mode of loading. With the high level language the computer is already in the ASCII mode and so the first [mentioned above need not be typed in. When loading ASCII or graphics in the low level, the computer includes], 1D in hexadecimal, in the string of characters loaded into the program. This is recognised as the end-of-string marker by the low level subroutine at $03CE_H$, mentioned in part 4, and for this reason a] can not be included in an ASCII string. In graphics, the [key stands for a shape and so this restriction does not apply, also, RETURN does not function so for a new line type], RETURN, [. All of the instructions for graphics are already in the monitor r.o.ms so no re-programming is required for this optional facility. A selection of computer displays is shown in Fig. 22.

Graph plotting

In part 4, a program was described which analyses the frequency response of an RIAA equalised pre-amplifier. Fig. 22(d) shows a version of this program which displays a graph of gain and frequency. Both quantities are logged before they are plotted to produce the standard dB versus log. of frequency format. The frequency is stepped logarithmically at line 52 at four increases per decade, and for each point plotted the frequency is displayed at the top of the screen. The original reason for developing this program was to examine the low-frequency gain of my hi-fi and so, after reaching 20kHz, the program branches to line 200 where it inputs a new value for F, the 25μF capacitor, and then replots a curve super-imposed upon the original.

When the graphics option is installed, the demonstration programs at the third end of the third e.p.r.o.m. in the computer can be replaced with firmware which enables it to accept two extra high level commands;

AXIS a b

which declares the maximum values of the vertical and horizontal axes of a graph plot, and

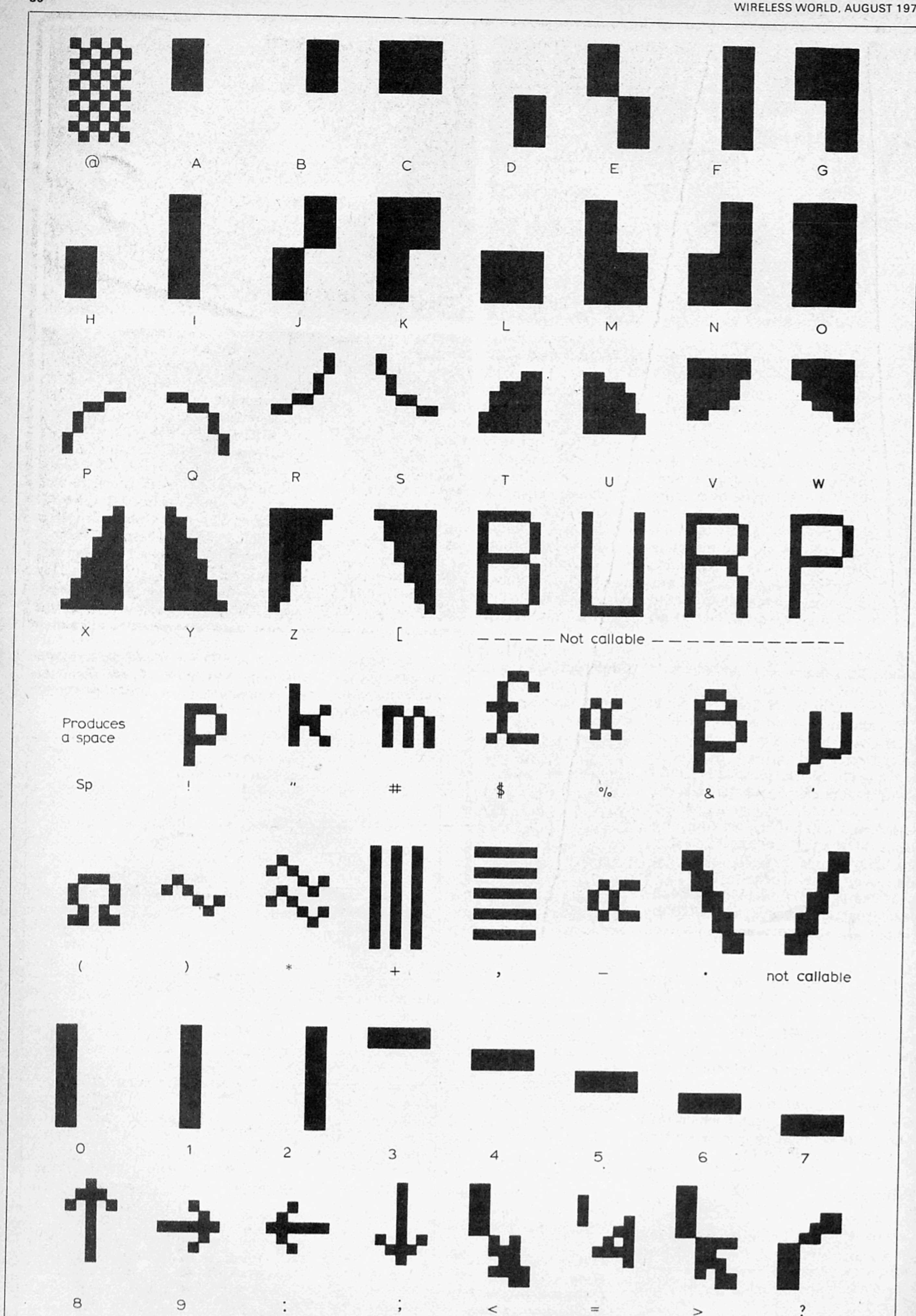
GRAPH a b

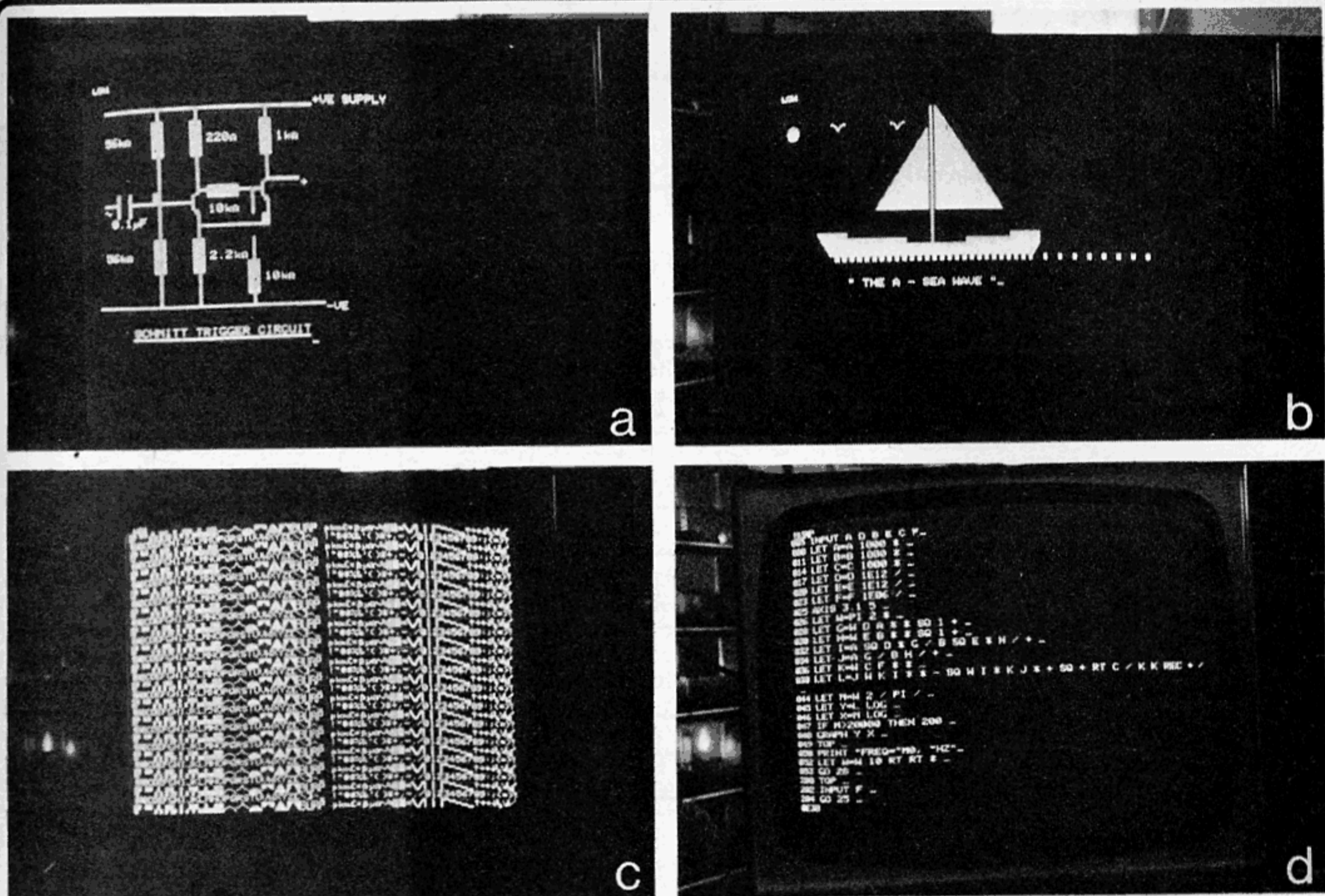
which plots the point (b,a) on a graph defined by the last AXIS statement. The terms a and b may be either variables or numbers. The plotted graph is of the first quadrant, i.e. both a and b positive, and is realised by dividing the screen into 8192 (128 by 64) cells which are selectively illuminated using graphic shapes at screen addresses obtained by scaling actual results to be plotted against the limits declared in the AXIS statement. The graph appears as discrete points, the spacing of which is usually determined by a FOR loop containing the GRAPH statement. The firmware controlling these processes ignores the sign of the variables (hence the first quadrant only) and will plot all results as positive. It also uses the variables P and Q for the scaling factors, thus only the remaining 24 are available in graph plotting programs.

E.p.r.o.m. programmer

The 2708 seems to be the most popular e.p.r.o.m. at present and this is probably due to the ease with which it may be programmed. Unlike many of its competitors, address locations and the data to be programmed at those locations are entered at the same level and polarity, and at the same pins as those obtained during read operations. Apart from the application of data to the device, the only changes made during programming are that the chip enable input is taken to +12V and a +25V pulse is applied to the programming pin 18.

It takes 100 ms to program each byte but, unfortunately, the device cannot be programmed byte by byte because pulses this long may cause spurious programming of adjacent cells on the chip. The specified maximum pulse length is only 1ms and so a programmer must make at least 100 "laps" of the device, slowly bringing up the values in each cell to their final state. The programmer requires 8 data bits, 10 address bits and a signal bit to commence the programming pulse for each byte. In Fig. 23, the two upper bits of the addresses are supplied by a four-way switch and the remaining 16 bits are fed serially to a 16-bit shift register formed by two 4015s. Data is sent out via the buffered D_7 line using OUT commands, and pulses to clock the bits into the shift


@ A B C D E F G
H I J K L M N O
P Q R S T U V W
X Y Z [
Not callable
Produces a space
Sp ! " # $ % & '
( ) * + , – .
not callable
0 1 2 3 4 5 6 7
8 9 : ; < = > ?



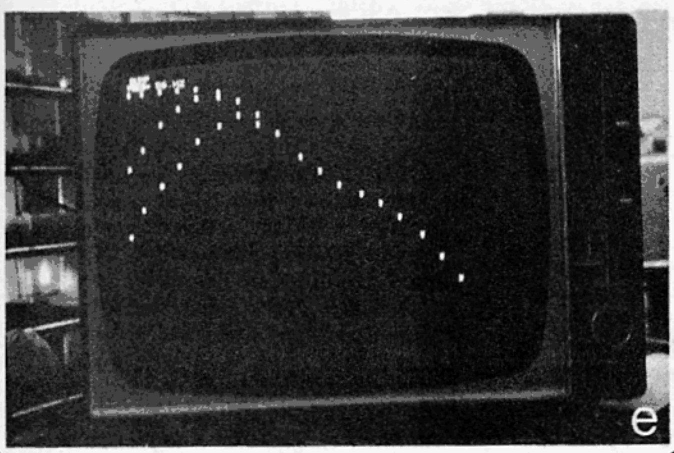
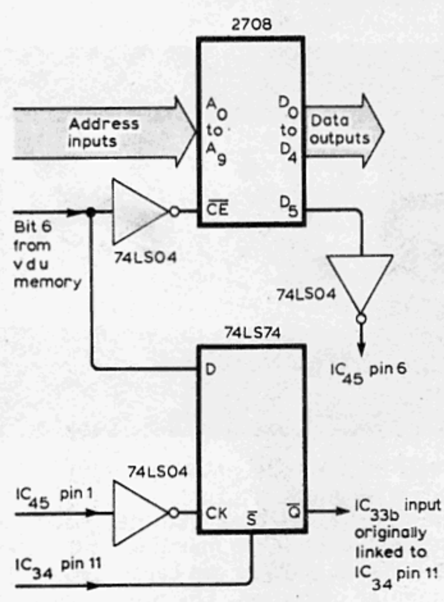


Fig 22. *(a) (b) Examples of pictorial displays, (c) alphanumeric display together with the graphics set, (d) RIAA qualisation program (e), graph of RIAA equalisation run for F = a high value, 25 μF and 10 μF.*

register are provided by the output write decoder IC_2. A second line from IC_2 triggers the 1ms monostable when the 16 bits are in place and initiates the programming. A hardware time delay leaves the Z80 free to prepare the next string of data for transmission to the shift register. This small reduction in time is important because during the programming over 100,000 operations are carried out, each with its own period of data transmission and 1ms pulse. Although it would save time to transmit the data in parallel, the extra connection complexity was considered unnecessary. For reliable programming some extra laps should be included to allow for monostable time delay variation. Unless the full 100ms per location

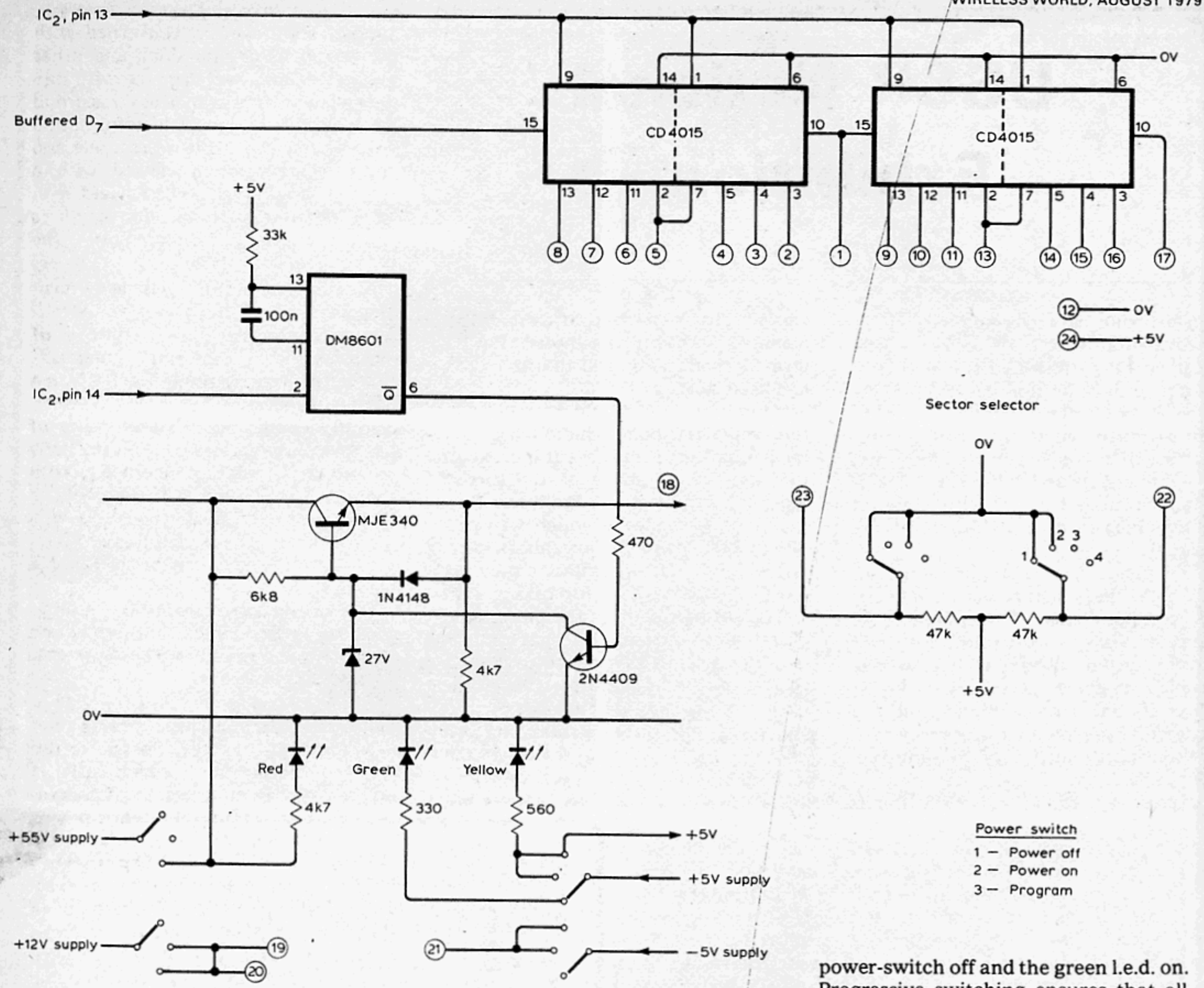
◀ **Fig. 20.** *Graphics character set.*



2708 connections

pin	connects to	pin	connects to
1	IC_{47} pin 20	9	IC_{47} pin 4
2	" " 19	10	" " 5
3	" " 18	11	" " 6
4	" " 17	13	" " 7
5	IC_{34} pin 11	14	" " 8
6	IC_{47} pin 16	18	0V
7	" " 15	22	IC_{47} pin 22
8	" " 14	23	" " 21

Fig. 21. *Optional graphics circuitry. All of the instructions for graphics are already in the monitor r.o.ms.* ▶



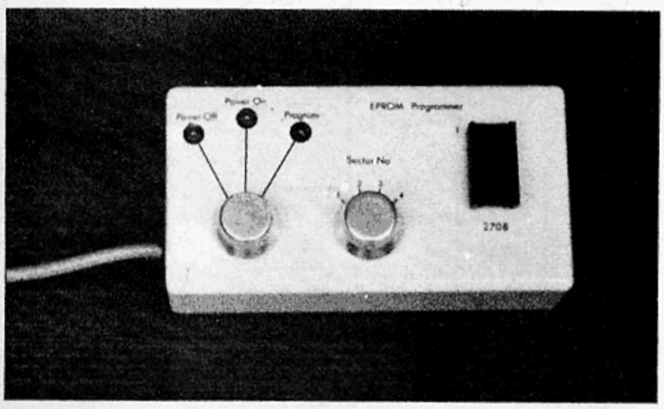


Fig. 23. *E.p.r.o.m. programmer and circuitry. Pin numbers for the i.c. socket are shown in circles.*

in applied some bytes may exhibit access times well outside the manufacturer's specification and this can cause erratic computer operation. The programming voltage is supplied through a conventional series-pass regulator and because at low levels pin 18 of the e.p.r.o.m. is a current source, the IN4148 and 2N4409 form a positive clamp.

Data to be programmed into an e.p.r.o.m. is assembled into the memory area 1C00 to 1CFF inclusive. Originally the memory was divided into four sectors and these were programmed separately which reduced the programmer address bits to 8, to match the shift registers. However, it has also proved useful when adding to or modifying small areas of r.o.ms during firmware development. When the r.o.ms are new or erased, all of the locations hold a 1, i.e. the bytes are all FF. If a sector of a 2708 is not to be completely programmed, or if a partially filled sector is to be added to, the command FILL 1C00 will fill 1C00 to 1CFF with FFs and will thus mask any areas which are not to be programmed prior to entering the data. The e.p.r.o.ms must only be inserted or removed from the programmer with the power-switch off and the green l.e.d. on. Progressive switching ensures that all of the required voltages are present before +25V is made available and prevents any chance of random programming. To program a sector, the command is PROM$_0$ but before this is used, check that the sector switch is in the required position. The programmer will also accept 2704 devices which are half the size of 2708s and only require sectors 1 and 2 although, in my experience, many 2704s are 2708s in another guise. All of the instructions for programming e.p.r.o.ms are in the original r.o.ms so no firmware changes are required for this option.

Erasing e.p.r.o.ms

For rapid erasing a high-power short wavelength ultra-violet lamp is required. Because commercial units are quite expensive I use a Philips 6 Watt u.v. lamp. The bulb should be coated in aluminium foil, except for a small window a third of the way from the glass end, to near the base. Because the base forms one of the connections, the foil must not touch it. This arrangement gives eye protection and concentrates the light at the window. The e.p.r.o.ms to be erased are placed as close as possible to the window and left for approximately three hours.

To be continued □