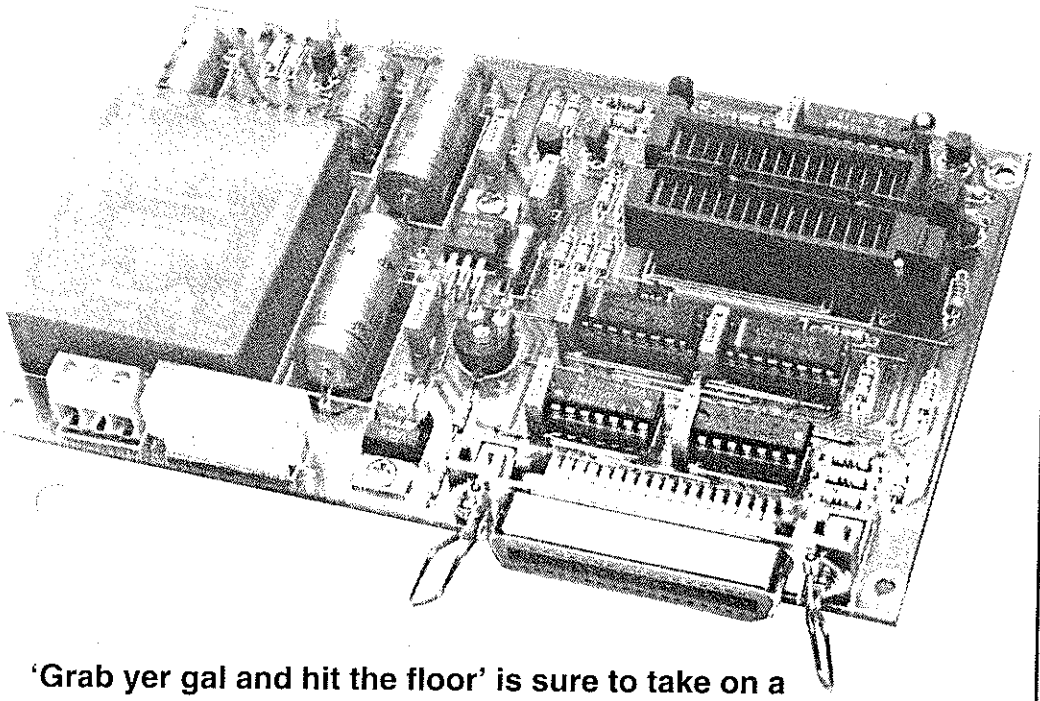
GAL PROGRAMMER



'Grab yer gal and hit the floor' is sure to take on a completely new meaning before long. Now while gals in the more traditional sense of the word are often pretty difficult to control, let alone to be forced into 'tailor-made' behaviour (which adds considerably to their charm), the electronic versions we are dealing with here (identified by three capital letters, GAL) are admittedly less exciting, but much more easy-going. The GAL programmer described in this article offers everything needed to burn complex logic functions into today's most popular GALs. The software used to control the programmer is menu-driven, and can be run on all IBM PCs and compatibles.

Design by M. Nosswitz

FOLLOWING last month's introductory article on features and functions of GALs (general array logic) we now take more a practical look at things with the description of a powerful, low-cost, GAL programmer for use with PCs.

The advantages of GALs over discrete logic circuits are significant. At reasonable cost, you obtain a piece of programmable logic that can be erased, too! Apart from their remarkable flexibility, GALs offer the possibility to 'stamp' them electronically with an identification code, as well as to protect them from being read out (and copied). Further, GALs are pretty fast, A-versions achieving propagation delays of the order of 10 ns only.

The operation of the programmer described here is strictly controlled via the Centronics port of an MS-DOS compatible computer running the software developed for the programmer. The control software was developed with the aid of Turbo Pascal 6.0, and is capable of programming GAL Types 16V8, 20V8, 16V8A and 20V8A. The control software is available ready-programmed, and comes on a diskette supplied through the Readers Services.

The programmer and the computer communicate via the Centronics port, using a serial format to exchange data and commands. Remarkably, only five lines are required to handle all functions. At the programmer side, a shift register is used to convert the serial data into parallel. Despite this converter, the total circuit of the programmer is not too complex.

MAIN SPECIFICATIONS

Software:
- Programs 16V8, 20V8, 16V8A, 20V8A
- Protection against wrong GAL selection
- Simple to control
- Menu driven
- For XT/AT and compatible PCs
- Reads and writes normalized JEDEC-Files
- In colour
- Integrated line editor
- Hard copy of cell matrix on printer
- Configuration file to adapt software to personal needs
- Opal Junior ™ EQN-to-JEDEC converter and GAL programming utilities supplied free of charge with control software ESS1701

Hardware:
- Eurocard PCB 160 ×100 mm
- Communication via 5 lines on Centronics port
- Internal power supply
- Only one ZIF socket required
- Based on standard components only

GAL:
- Electrically erasable and reprogrammable logic
- Maximum flexibility for complex logic design
- Read protection
- Electronic signature
- Speed: 10ns maximum propagation delay (A-Types)
- Inexpensive

The hardware

Just like almost any other electrically programmable component, a GAL needs a programming voltage that is higher than the normal supply voltage. As shown in the circuit diagram (Fig. 1), this has been taken into account in the design of the power supply of the programmer, which caters for the normal board supply voltage of 5 V as well for an auxiliary voltage of 16.5 V. Preset P1 serves to adjust the latter voltage accurately. Fortu-

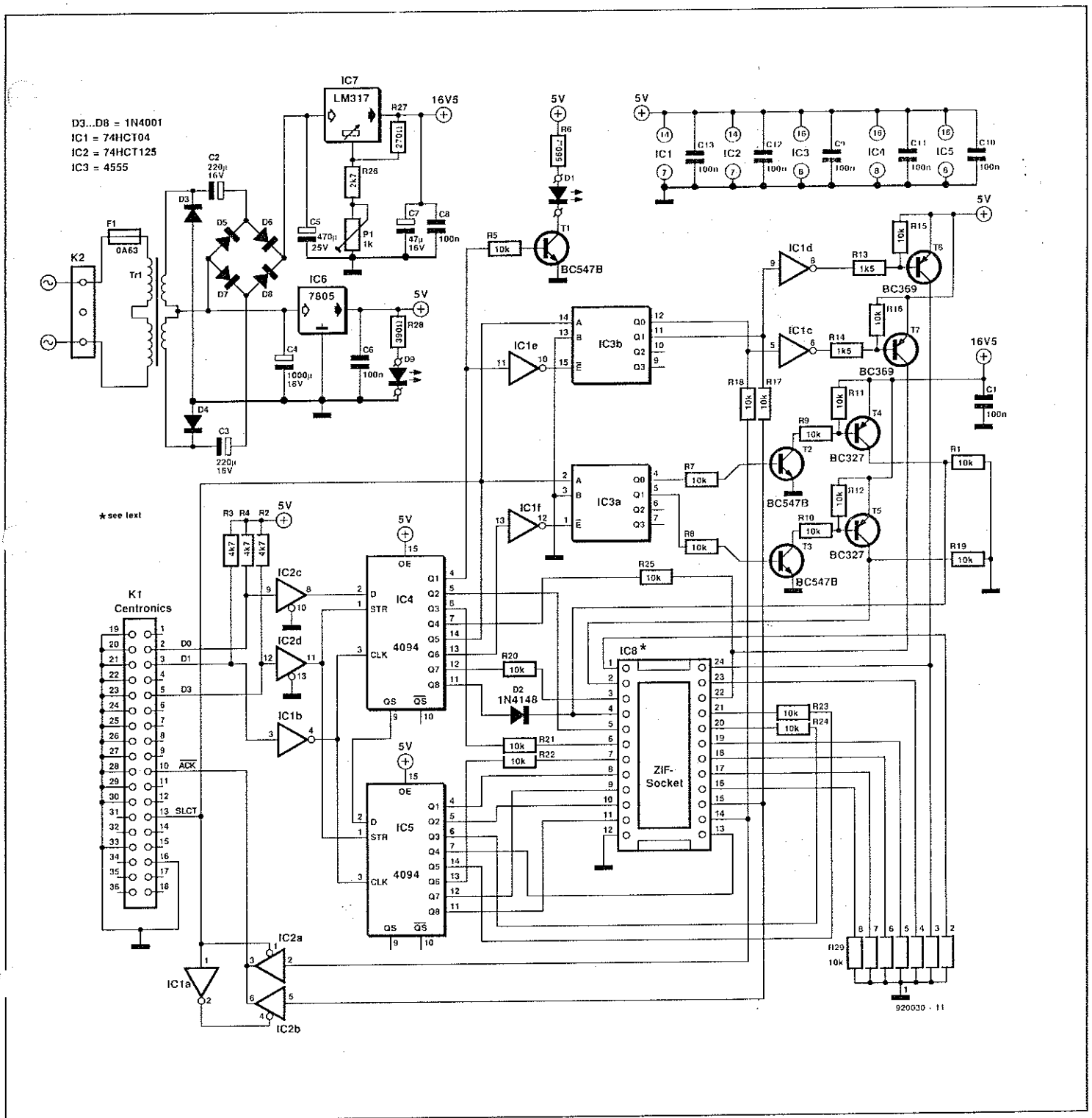


Fig. 1. Circuit diagram of the GAL programmer. The programmer communicates with the computer via the Centronics port using a serial protocol.

nately, the current consumption of the programmer is low, so that a small (4-VA) mains transformer may be used, while the two regulators can make do without heat-sinks.

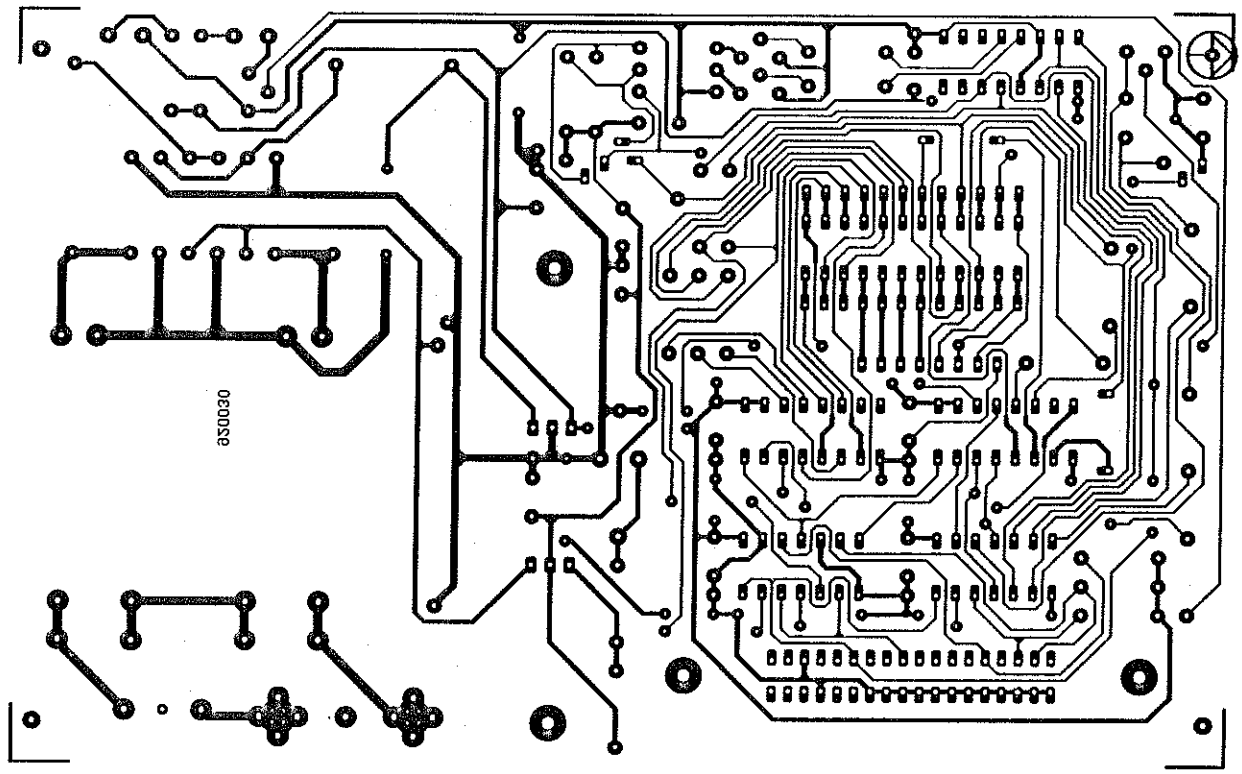
The control signals needed for shift registers IC4 and IC5 are supplied via three of the eight data lines on the Centronics interface. Dataline D0 carries the serial data, while D1 and D3 supply the shift register clock and strobe signal respectively. Pull-up resistors R2, R3 and R4 ensure correct signal levels during the data exchange. The two shift registers are connected in series via the serial output Q8 (pin 9 of IC4) and the data input (pin 2 of IC5). The three-state outputs of IC4 and IC5 are always active because the OE (output enable) inputs are tied to +5 V. The 16 databits at the parallel outputs Q0-Q8 of IC4 and IC5 determine the operation of the rest of the circuit.

One half of a dual 2-of-4 decoder, IC3b, switches the supply voltage via transistors T6 and T7. The other half, IC3a, controls the presence of the programming voltage at the respective pins of the GAL socket, via transistor pairs T2-T4 and T3-T5. This is possible only if the decoder outputs have been enabled beforehand by a low level at the ENABLE ($\overline{E}$) inputs.

Resistors R20-R25 reduce the short-circuit currents at the register and GAL outputs to safe values when these are switched to the read mode. R1, R19 and R29 are the pull-down resistors needed for the programming mode. Diode D2 protects output Q8 of IC4 against the programming voltage.

The computer can read the GAL data matrix via Centronics handshaking line $\overline{ACK}$. This requires a selection operation via the select (SLCT) signal. By virtue of SLCT, the software is capable of checking if the programmer hardware is connected, and if a GAL is fitted. If desired, this function may be switched off by modifying the file GALCFG (Fig. 6). If hardware checking is not required, the SLCT line may be omitted.

The GAL is fitted into a zero-insertion force (ZIF) socket. Finally, LED D9 lights



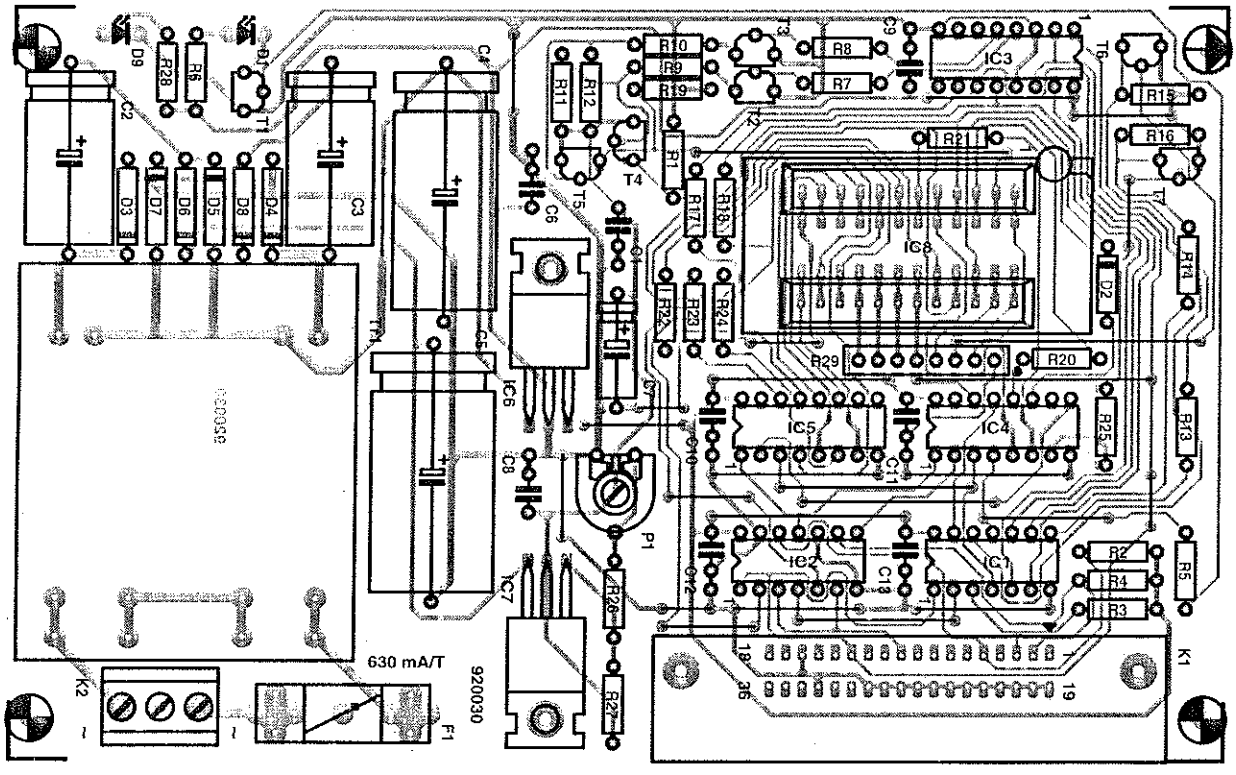
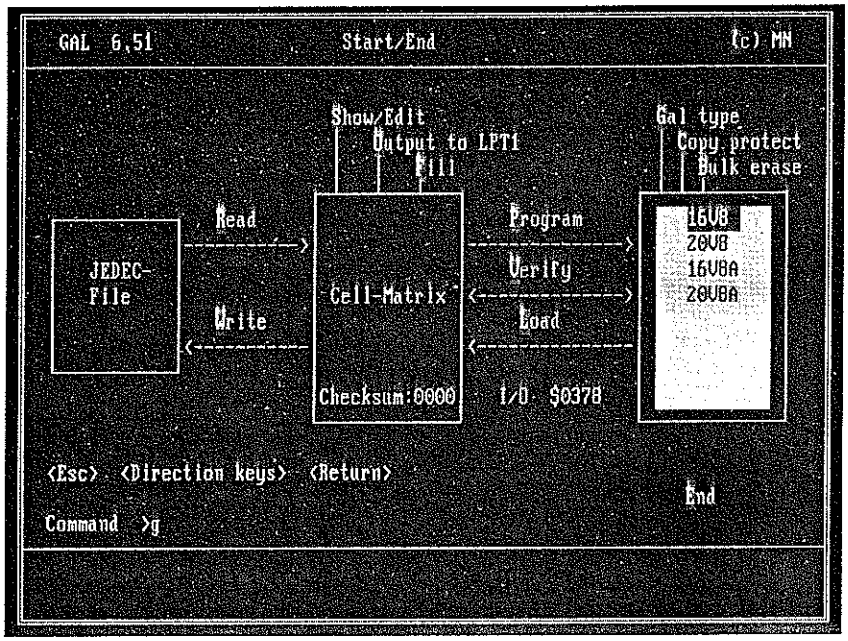


Fig. 2. Track layout (mirror image) and component mounting plan of the single-sided PCB for the GAL programmer.



when the programmer is active, and D1 when the GAL receives its supply voltage. It is recommended to insert the GAL only when D1 is out.

Software development for GALs

To begin with, use any ASCII-compatible word processor to produce an equations file that describes the desired function of the GAL. 'GALDEMO.EQN' (Fig. 3) contained on the disk supplied for this project is such a file, and may serve as an example. Basically, variables are assigned to the inputs and outputs, and the logic function is described by a Boolean equation. If desired, an 8-bit identification code ('signature') can be burned into the chip.

Next, run a check on the program syntax. This requires an auxiliary program such as 'EQN2JED' included in the Opal Junior ™ GAL programming software package from National Semiconductor (this package is supplied free of charge with your GAL programmer software, how's that?). When no errors are detected, EQN2JED generates the documentation file GALDEMO1.DOC (Fig. 5), and the associated JEDEC file, GALDEMO1.JED (Fig. 4). The JEDEC file produced with the aid of EQN2JED contains all information on the cells contained in the GAL, and serves to actually program the device.

The software

After starting the control program, GAL651AE.EXE, the screen shows the start and end indicators. Further, the screen graphics indicate three blocks: the JEDEC file, the matrix memory and the GAL's hardware environment. The command names are shown in between the blocks, and can be selected by typing the highlighted letter. Command abbreviations may also be used. An error 'beep' sounds when you enter a non-existing command.

The **GAL TYPE** command allows you to select the device type to be handled. This selection must be completed before the GAL is inserted into the ZIF socket on the programmer board. While executing the GAL commands, the software automatically checks if the right GAL type is being used.

The **READ** command is used to transfer the JEDEC file into the matrix memory. After entering '1' and a return, the listing is displayed of the JEDEC file in the selected subdirectory. Alternatively, you may enter the full path and file name. After requesting a file list (for instance, A:*.*), the screen shows all JEDEC files found. The desired file is selected by moving to it using the PageUp and PageDown keys and the arrow keys. The return key activates the selected command, which then operates on the selected file.

The use of the **WRITE** command is similar to that of the READ command described above. An 'overwrite?' alert is shown if you save a file under a name that is already in use in the selected (sub-) directory. All file names are automatically saved with the '.JED' extension appended.

Selecting **PROGRAM** from the menu

COMPONENTS LIST

Resistors:

19	10kΩ	R1;R5;R7-R12; R15-R25
3	4kΩ7	R2;R3;R4
1	560Ω	R6
2	1kΩ5	R13;R14
1	2kΩ7	R26
1	270Ω	R27
1	390Ω	R28
1	7-way 10kΩ SIL	R29
1	1kΩ preset H	P1

Capacitors:

8	100nF	C1;C6;C8;C9-C13
2	220µF 16V	C2;C3
1	1000µF 16V	C4
1	470µF 25V	C5
1	47µF 16V	C7

Semiconductors:

1	LED 3mm red	D1
1	1N4148	D2
6	1N4001	D3-D8
1	LED 3mm green	D9
3	BC547B	T1;T2;T3
2	BC327	T4;T5
2	BC369	T6;T7
1	74HCT04	IC1
1	74HCT125	IC2
1	4555	IC3
2	4094	IC4;IC5
1	7805	IC6
1	LM317	IC7
1	24-way ZIF socket *	IC8

Miscellaneous:

1	36-way Centronics socket for PCB mounting	K1
1	3-way PCB terminal block	K2
1	Mains transformer 2×6V @4VA, e.g., Monacor (Monarch) FTR46	Tr1
1	Fuse 630mA slow, with PCB mount holder and cap	F1
1	Printed circuit board	920030
1	Control software package	ESS1701

* Aries Electronics. Distributor info from Aries Electronics (Europe), Unit 3, Furtho Court, Towcester Road, Old Stratford, Milton Keynes MK19 6AQ. Tel. (0908) 260007, Fax (0908) 260008.

```
title Basic gate
pattern GATES
revision A
author Nosswitz
Date 05.02.92

chip GATES GAL16V8

;pin 1  2  3  4  5  6  7  8  9  10
     C  D  F  G  M  N  P  Q  IX GND
;pin 11 12 13 14 15 16 17 18 19 20
     JX KX L  RX O  H  E  B  A  VCC

@UES MB123456

equations
     B = /A
     E = C * D
     H = F + G
     L = /IX + /JX + /KX
     O = /M * /N
     RX= P * /Q + /P * Q


; end of GATES
```

Fig. 3. Example of a GAL equation file.

```
GAL16V8
EQN2JED - Boolean Equations to JEDEC file assembler (Version V003)
Copyright (R) National Semiconductor Corporation 1990,1991
Assembled from "galdemo1.eqn". Date: 2-19-92
title Basic gate
pattern GATES
revision A
author Nosswitz
Date 05.02.92
*
QF2194*QP20*F0*
L0256
11111101111111111111111111111111*
L0512
01011111111111111111111111111111*
L0768
11110111111111111111111111111111
11111110111111111111111111111111*
L1024
11111111111110111011111111111111*
L1280
11111111111111111111011110111111
11111111111111111111101101111111*
L1536
11111111111111111111111111111011
11111111111111111111111111111110
11111111111111111111111111011111*
L2048
01111110*
L2056
0100110101000010001100010011001000110011001101000011010100110110*
L2120
10000001*
L2128
0000000010000000100000001100000010000000110000001110000000000000*
L2192
10*
C2B31*
0000
```

Fig. 4. JEDEC output file produced by the EQN2JED utility from National Semiconductor.

sets off a sequence of activities. First, a 'bulk erase' operation is performed. Next, the device is programmed. Finally, the contents of the GAL are verified against the program file. If an error is found, the relevant cell in the GAL is indicated, along with the relevant data in the GAL and in the file.

The **COPY PROTECT** command may be used to actuate the copy protection ('security bit') in the GAL. When the security bit is set, it is impossible to read anything from the GAL except the identification code and the GAL configuration.

The **BULK ERASE** command may also be used on its own, i.e., not as part of a programming sequence, to clear the contents of a GAL. This obviates the need for an erase operation before programming.

OUTPUT TO LPT1: directs the matrix contents to a printer connected to the LPT1: output of the PC. Needless to say that hard copy of the matrix contents may be very useful for documentation purposes.

The **SHOW/EDIT** command allows you to examine, on the screen, the content of the selected location. If a specific cell is selected, the cursor starts to flash at this location. At the same time, the identification code, if given in the source code, is shown in hexadecimal as well as ASCII notation.

The F10 key takes you to the edit mode, which makes it possible to change the cell contents with the aid of the cursor keys. The 'Fill' function may be used to fill a block in the GAL with ones or zeroes.

Selecting the **Program, Verify** or **Load** commands causes the number of programmed cells, the GAL manufacturer, and the checksum to be shown in the GAL symbol on the screen.

The function of the **End** command will be obvious.

Finally, any command entered may be terminated with the aid of the ESC (escape) key. ■

```
EQN2JED -- Boolean Logic to JEDEC
file assembler (Version 1.00)
Copyright (R) National Semiconductor
Corporation 1990

Document file for galdemo1.txt
Device: 16V8


Pin    Label      Type
---    -----      ----
1      C          com input
2      D          com input
3      F          com input
4      G          com input
5      M          com input
6      N          com input
7      P          com input
8      Q          com input
       IX         com input
10     GND        ground pin
11     JX         com input
12     KX         com input
13     L          pos,com output
14     RX         pos,com output
15     O          pos,com output
16     H          pos,com output
17     E          pos,com output
18     B          pos,com output
19     A          com input
20     VCC        power pin

EQN2JED -- Boolean Logic to JEDEC
file assembler (Version 1.00)
Copyright (R) National Semiconductor
Corporation 1990

          Chip diagram (DIP)

            ______\__/______
           |                |
       C   |  1          20 |  VCC
       D   |  2          19 |  A
       F   |  3          18 |  B
       G   |  4          17 |  E
       M   |  5          16 |  H
       N   |  6          15 |  O
       P   |  7          14 |  RX
       Q   |  8          13 |  L
      IX   |  9          12 |  KX
     GND   | 10          11 |  JX
           |________________|
```

Fig. 5. Example of a documentation file produced by EQN2JED.

```
GAL.CFG
{licence number}
{user number}
$378  Adress of Centronics port for GAL data exchange
2000  error display time in ms
2000  error beep frequency in Hz
75    beep length in ms
1     Check if GAL hardware accessible              no=0    yes=1
0     Switch for general RESET (EPROM, PROM, GAL)   no=0    yes=1
1     Basic GAL type selection  16V8=1, 20V8=2, 16V8A=3, 20V8A=4
1     Background colour: Text (blue)
7     Foreground colour: Text (bright grey)
5     Background colour: Error reports (magenta)
7     Foreground colour: Error reports (bright grey)
5     Background colour: Letters (magenta)
15    Foreground colour: Figures (white)
7     Background colour: Selection window (bright grey)
1     Foreground colour: Selection window (blue)
5     Background colour: Selection bar (magenta)
14    Foreground colour: Selection bar (yellow)
4     Background colour: Changed cells (red)
7     Foreground colour: Changed cells (bright grey)
12    Line distance to upper paper edge (printing)
12    Line distance between page 1 and page 2 (printing)
20    Empty lines after page 2 (printing)
8     Character distance from left-hand paper edge (printing)

Addresses of Centronics ports
LPT2: 278H
LPT1: 378H
LPT1: 3BCH (on Hercules-compatible card)
```

Fig. 6. The control program for the GAL programmer reads 25 parameters from a configuration file called GAL.CFG. This file can be produced or edited with any simple word processor, such as EDLIN or the one in PCTools. All 25 parameters must be present in the order shown here. The meaning of the values is apparent from the comment in each line.