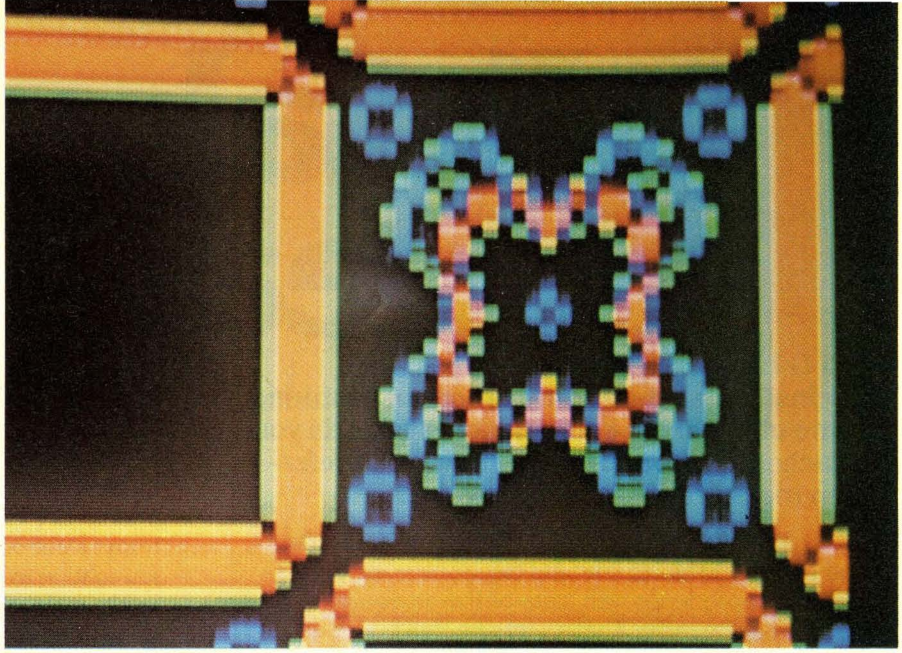
Popular Electronics®
FEBRUARY, 1976



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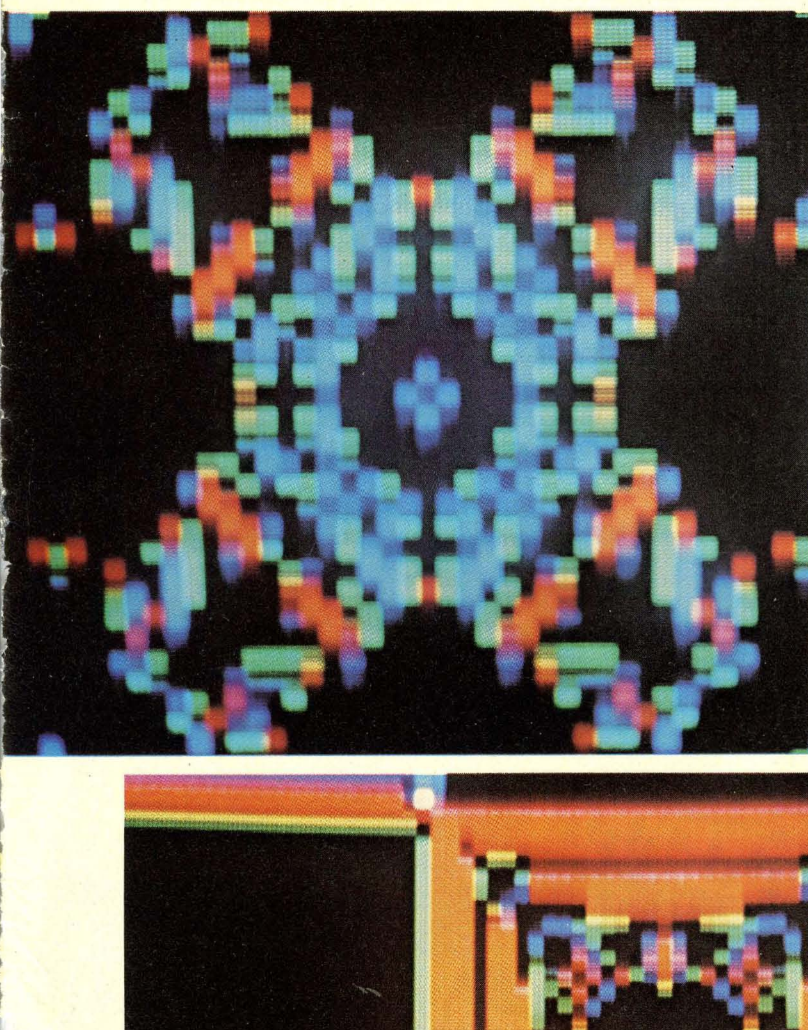
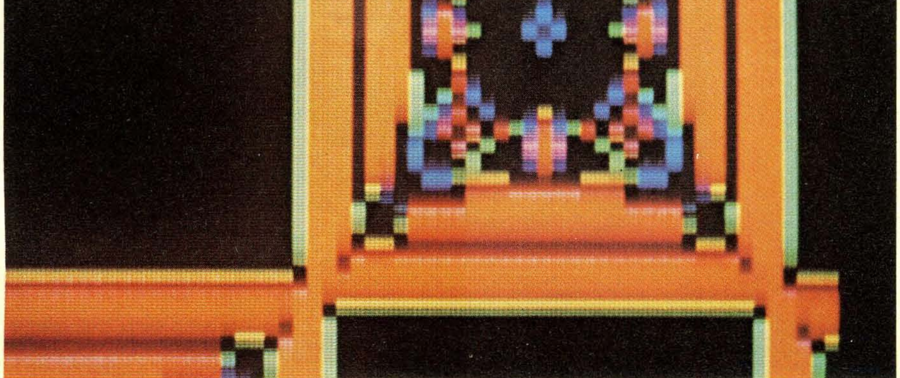
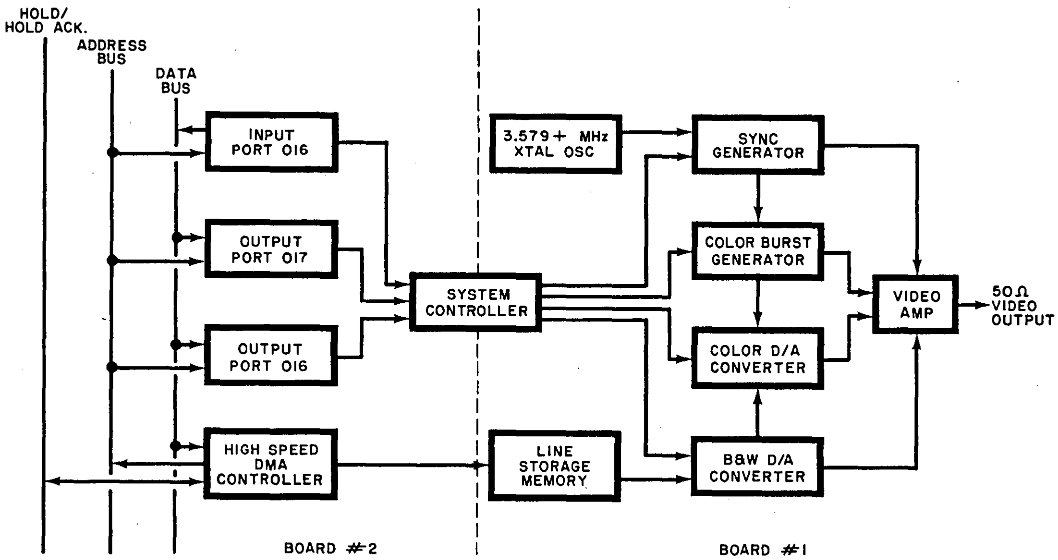


BUILD THE TV DAZZLER

Unique computer accessory provides alphanumerics and graphics in full color.



THE TV DAZZLER provides versatile electronic coupling between a small home computer and a color TV set. It can be used to generate action games, animated displays, educational learning drills, graphs, even light shows—all in *full color*! The Dazzler is designed to plug directly into the Altair 8800 computer (POPULAR ELECTRONICS, Jan. 1975); however, since it uses direct memory access (DMA) to scan the computer memory, it can easily be used with many other computers. If a Teletypewriter is your only communications link with your computer, here is a chance to build this new concept in computer peripherals at less than the



PARTS LIST

C1 through C9,C18 through C25—0.1-μF disc ceramic capacitor
C10,C11,C26,C27—47-μF, 20-volt tantalum capacitor
C12—330-pF disc capacitor
C13—680-pF disc capacitor
C14,C15,C16—470-pF disc capacitor
C17—9-35-pF variable capacitor
D1—1N914 silicon diode
D2—1N5242B, 12-volt zener diode
IC1,IC37—LM340-5.0, 5-volt regulator
IC2,IC16,IC17,IC18—SN7410N triple 3-input positive NAND gate
IC3,IC10—SN7473N dual J-K master-slave flip-flop
IC4,IC21,IC56—SN7432N quad 2-input OR gate
IC5,IC30—SN7430N 8-input positive NAND gate
IC6,IC23,IC42,IC43—SN7474N dual D-type edge-triggered flip-flop
IC7,IC19,IC35,IC40,IC48—SN7404N hex inverter
IC8,IC22,IC25,IC39,IC51—SN7408N quadruple 2-input positive AND gate
IC9,IC14,IC15,IC28—SN7400N quadruple 2-input NAND gate
IC11,IC12,IC31,IC32,IC49,IC50,IC52—SN7493N 4-bit binary counter
IC13,IC27,IC33,IC45—SN74157N quadruple 2-input data selector
IC20,IC29—SN7420N dual 4-input positive NAND gate
IC24—F3342DC 64 x 4 MOS shift register (Fairchild)
IC26—SN74151N 8-line to 1-line data selector
IC34,IC46,IC54—SN74175N quadruple D-type edge-triggered flip-flop
IC36,IC53,IC55,IC61,IC63,IC64—SN7475N quadruple bistable latch
IC38—SN7402N quadruple 2-input positive OR gate
IC41—SN74LS10N triple 3-input positive NAND gate
IC44—SN74LS30N 8-input positive NAND gate
IC47—SN74LS08N quadruple 2-input positive AND gate
IC57—SN7495N 4-bit universal shift register
IC58,IC59,IC65,IC72,IC73—SN74LSO4N register
IC60,IC62—SN7483N 4-bit binary full adder
IC66,IC67,IC74—SN7405N hex inverter with open collector
IC68,IC69,IC70,IC71—SN74367 hex tri-state buffer
Q1—2N3904 transistor
Q2,Q3—2N3906 transistor
Following resistors are 5%, 1/4 watt:
R1—150 ohms
R2,R3—1000 ohms
R4—470 ohms
R5,R6,R7,R29—1200 ohms
R8,R10—9100 ohms
R9—18,000 ohms
R11—7500 ohms
R12—15,000 ohms
R13—62,000 ohms
R14—30,000 ohms
R15 through R20—13,000 ohms
R21—820 ohms
R22—1500 ohms
R23—330 ohms
R24—220 ohms
R25—51 ohms
R26—100 ohms
R27—22 ohms
R28—680 ohms
R30,R31,R32—500-ohm trimmer potentiometers
XTAL—3.579545 MHz
Misc.—IC sockets (74), heat sinks (2), mounting hardware
Note: The following are available from Cromemco, 1 First St., Los Altos, CA 94022: complete set of parts less IC sockets at $195; with IC sockets at $215, assembled and tested Dazzler for $350. California residents please include sales tax. Prices include postage for orders shipped within the U.S. Partial kits are not available. The schematic and foil patterns are available *free of charge* by sending a stamped (for 3 oz.) self-addressed 9" by 12" envelope to Cromemco, 1 First St., Los Altos, CA. 94022.

Fig. 1. Board 1 of the Dazzler contains an NTSC color TV signal generator with output through a 50-ohm line. Board 2 communicates with the computer and modulates the TV signal.

cost of a black-and-white terminal; and you do not need an RS-232 interface. The Dazzler can be built for less than $200.

If you use your computer for business or accounting, the Dazzler can display multi-colored graphs of stored data. It can also be used to display a picture produced by the Cyclops solid-state camera (POPULAR ELECTRONICS, February 1975). With the Cyclops picture either processed or unprocessed, the system can be used for security purposes, pattern recognition tests, and measurement and control of processes.

How It Works. A block diagram of the Dazzler is shown in Fig. 1. Most of the components on board #1 are used to generate a conventional NTSC (National Television Standards Committee) color video signal. The circuit is terminated in a 50-ohm, 1-volt output. This signal can be used to drive the

OUTPUT PORT 016

D7	D6	D5	D4	D3	D2	D1	D0	
ON/OFF	A15	A14	A13	A12	A11	A10	A9	ALTAIR 8800 SENSE SWITCHES

STARTING ADDRESS OF PICTURE IN MEMORY

Fig. 2. Configuration of the data bits at output port 016.

video amplifier of a color set or to modulate a class-1 TV device connected to the set's antenna terminals (using a locally unoccupied channel).

The components on board #2 are used to communicate with the computer, with a high-speed DMA controller as the basis. The controller issues a "hold" command when it is ready to access the computer memory. When the computer is ready, it issues a "hold acknowledge" command and the DMA begins operation.

Communication between the Dazzler and the host computer is through output ports 016 and 017 and input port 016. One bit of output port 016 is used to turn the Dazzler on and off, and the remaining seven bits are used to set the starting address of the picture in the computer memory. The organization of output port 016 is shown in Fig. 2.

Output port 017, whose organization is shown in Fig. 3, is used to set the format of the TV picture. Note that bit D7 is not used. Bit D6 is used to set normal resolution (32 x 32 for 512 bytes or 64 x 64 for 2K bytes) or 4X resolution (64 x 64 for 512 bytes or 128 x 128 for 2K bytes). Bit D5 sets the amount of computer memory, starting at the location given to output port 016, allocated to the picture. When 512 bytes are selected, the computer memory must have an access time of at least one microsecond. When 2K bytes are used, the memory must have an access time of at least 500 nanoseconds.

Bit D4 is used to select either a black-and-white or color display. In the 4X resolution mode (D6 at a 1), bits D3 to D0 are used to set the color of the display when in the color mode or the intensity when D4 is in the black-and-white mode. Bits D3 to D0 are not used in the normal resolution mode.

Only two bits of input port 016 are used. When bit D7 is a 1 (high), it indicates that the Dazzler is enabled (bit D7 of output port 016 actually performs the enabling), while bit D6 goes low to indicate an end of frame. This latter bit is useful when changing frames in rapid succession.

To generate a TV picture with the Dazzler, the information that the Dazzler reads from the computer memory must be properly formatted. In the 4X resolution (output port 017, bit D6 high), each point on the TV screen is controlled by just one bit in the computer memory. This bit turns its corresponding point in the picture on or off. The color or intensity of that frame of the picture is set by bits D3 through D0 of the control word at output port 017. To get full color in the 4X mode, multiple frames of different colors must be interleaved.

In the normal resolution mode (output port 017, bit D6 low), the color and intensity of each point on the screen is controlled by a four-bit "nybble" in the computer memory. Two points of the picture are thus encoded in each byte of the computer memory. For this reason, a 64 x 64 picture requires 2K of

```
                    Output Port 017

D7 - not used

D6 { 1 Resolution X4.  Color and intensity set by D4 through D0.
   { 0 Normal resolution (32 x 32 for 512 bytes,64 x 64 for 2K
       bytes).  Color and intensity set by 4-bit words in
       computer memory.

D5 { 1 Picture in 2K bytes of memory
   { 0 Picture in 512 bytes of memory

D4 { 1 Color picture
   { 0 Black-and-white picture ---------------------+
                                                    |
D3 { 1 High intensity color }                       |
   { 0 Low intensity color  }--------Most significant bit of
                                     4-bit B/W intensity
D2 { 1 Blue
   { 0 No blue                              *

D1 { 1 Green
   { 0 No green                             *

D0 { 1 Red
   { 0 No red                        Least significant bit
```

Fig. 3. The states of seven data bits at output port 017 determine resolution of TV picture and either chroma or monochrome parameters.

Memory Location	Memory Contents	Comments
000 000	076	Move immediate into
000 001	200	the accumulator.
000 002	323	Output to port
000 003	016	number 016.
000 004	333	Input
000 005	377	from sense switches.
000 006	323	Output to port
000 007	017	number 017.
000 010	303	Jump to
000 011	000	memory location 000
000 012	000	000.

Fig. 4. A test program to be used on the TV Dazzler.

THE GAME OF LIFE

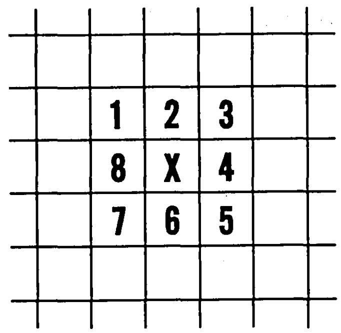
One of the most fascinating uses of the Dazzler is in playing what is known as "The Game of Life." (See *Scientific American,* October 1970, p 120; February 1971, p 112; April 1971, p 116.) The game is started by entering the program shown below. (A paper tape of the program is available for $15 from Cromemco, 1 First St., Los Altos, CA 94022.) Then a colony of cells is entered to appear on the TV screen on a 64 x 64 grid.

Each cell in the colony has eight possible neighbors, as shown at right. The evolution of the colony proceeds according to a fixed set of rules invented by John Conway at the University of Cambridge. Every cell with two or three neighbors will survive to the next generation. Every cell with four or more neighbors dies from over-population. Every cell with one neighbor or no neighbors dies from isolation. Every cell with exactly three neighbors is a birth cell—a new cell is born here in the subsequent generation.

In the Dazzler version of The Game of Life, blue represents life; birth generates a green cell; and death is shown in red. There are many surprises to be found in the game. Some colonies survive and prosper; others reach a stable state—neither growing nor lessening. Other colonies fade from existence. Some colonies, known as "gliders" sail across the screen and can be devoured by other colonies in the process.

The full-color illustrations on the first page of this article are actual photos of a TV screen several generations into a Life program.

The initial colony of cells is drawn on the TV screen using ASCII keyboard inputs as controls. Control A deposits a cell of life on the screen. Controls N, O, P, and H step the cursor up, down, right, and left, respectively. Once the initial colony is complete, Control D is initiated to start the game.



Each cell has 8 possible neighbors.

Program for Game of Life is below.

```
DAZZLE-LIFE PRØGRAM    (LØADS BEGINNING 000 000, RUNS FRØM 000 000)

ØCTAL·LISTING (000 000 = 061, 000 001 = 000, 000 002 = 010 ETC.)

——→
061 000 010 315 265 001 315 335 001 315 175 000 315 142 000 315
222 000 315 142 000 333 377 027 332 125 000 027 332 106 000 303
111 000 311 002 002 002 002 002 002 002 002 002 002 002 002 002
002 002 002 002 002 002 002 002 002 002 002 002 311 001 000 000
315 324 000 076 100 014 271 302 200 000 016 000 004 270 302 200
000 311 001 000 000 315 064 001 376 011 302 245 000 076 000 315
105 001 303 257 000 376 012 302 257 000 076 004 315 105 001 076
100 014 271 302 225 000 016 000 004 270 302 225 000 311 041 000
010 021 000 370 006 000 076 000 272 302 316 000 273 310 160 023
043 303 310 000 305 076 000 271 302 354 000 015 315 034 001 062
164 002 301 305 315 034 001 062 165 002 301 305 014 315 034 001
041 165 002 106 167 200 053 116 160 201 127 301 310 325 315 064
001 321 376 000 312 023 001 172 376 003 310 376 004 310 076 011
303 105 001 172 376 003 300 076 012 303 105 001 005 303 176 002
004 315 052 001 004 315 052 001 172 311 325 315 064 001 321 376
000 303 206 002 315 141 001 176 332 076 001 346 017 311 346 360
007 007 007 007 311 346 017 365 315 141 001 321 332 125 001 176
346 360 202 167 311 172 007 007 007 007 127 176 346 017 202 167
311 041 000 010 170 346 040 312 156 001 021 000 002 031 171 346
040 312 170 001 021 000 004 031 171 346 037 007 007 007 027 137
076 000 027 127 031 170 037 365 346 017 137 026 000 031 361 311
333 000 346 040 300 014 302 220 001 004 302 220 001 311 333 000
346 002 312 236 001 170 323 001 311 106 076 000 270 310 315 236
001 043 303 251 001 315 276 000 076 204 323 016 076 260 323 017
041 163 002 315 251 001 315 220 001 312 306 001 333 001 107 315
236 001 346 177 376 131 310 043 163 002 303 236 001 043 163 002
315 236 001 303 214 002 315 102 002 303 166 002 127 227 276 312
346 001 172 276 312 375 001 043 043 043 303 355 001 043 136 043
126 353 315 010 002 303 346 001 351 001 062 002 002 071 002 004
050 002 010 100 002 011 067 002 017 060 002 013 052 002 015 056
002 016 076 002 000 000 000 000 301 311 021 000 000 311 006 000
014 311 076 017 315 105 001 004 311 076 000 303 064 002 015 311
005 311 315 064 001 365 305 076 014 315 105 001 021 370 370 315
220 001 302 157 002 301 305 076 000 315 105 001 021 370 370 315
220 001 301 312 106 002 361 315 105 001 333 001 323 001 311 301
303 146 002 000 000 000 041 011 002 346 177 303 354 001 026 000
315 052 001 303 040 001 310 376 012 310 024 311 315 276 000 021
000 000 303 346 001 000 000 000 000 000 000 000 000 000 000 000
```

memory storage. The lowest order (D0) bit determines if the display is red, D1 is green, D2 is blue, and D3 determines either a high- or low-intensity color. In black and white, these four bits are used to determine one of 16 shades of gray.

Construction. The Dazzler consists of two adjoining pc boards that plug directly into the Altair-8800 bus connectors. The video output is taken from a pad on board #1. The schematics, etching and drilling guide and component placement diagram for the boards are too large for reproduction here. They can be obtained FREE by sending a stamped, self-addressed 9" by 12" envelope to Cromemco, 1 First St., Los Altos, CA 94022. (These items are also included with each kit as mentioned in the Parts List.)

In assembling the pc boards, note that all components are mounted on one side of the board, with all soldering on the opposite side. The sides to be soldered are those on which the foil marking can be properly read. Plated-through holes assure contact on the component side. If desired, sockets can be used for mounting the IC's. When soldering, use a low-wattage iron and fine solder. Inspect your work to make sure you have no solder bridges.

Because portions of the Dazzler operate at very high frequencies, it is important that all components be mounted close to the pc board. Be sure to use components that meet the required specifications—some untested IC's may not have the required switching speeds.

There are 36 IC's on board 1, plus the color crystal oscillator, and associated passive components. A heat sink is used for *IC1,* the 5-volt regulator on board #1. When mounting the color-burst crystal, use a small length of wire soldered from the metal case of the crystal to the ground foil immediately above the case. This reduces noise pickup.

One of the center dual in-line positions in the bottom row of board #1 is used for board-to-board interconnections rather than an IC.

There are 37 IC's on board #2. One dual in-line position is left open for interconnections. To connect the two boards, use sixteen 8" lengths of insulated wire (or a 16-conductor flat cable).

The two boards are attached using ⅝" spacers at each corner hole, with

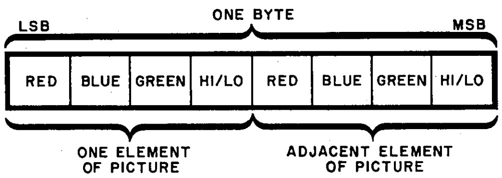


Fig. 5. In low-resolution mode, four bits of computer memory are used for each picture element.

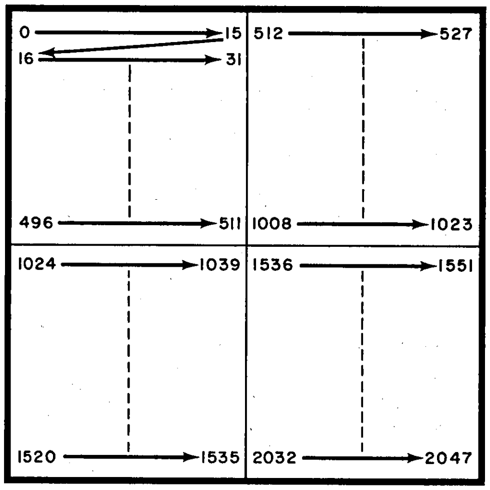


Fig. 6. Memory map of the Dazzler picture. Only first quadrant is displayed in the 512-byte display. All four are displayed in 2K-byte picture.

the component side of one facing the soldered side of the other. The two are separated by exactly the same distance as two adjacent connectors on the Altair bus.

Check-Out. Check for solder bridges and proper component orientation. Facing the component side of a board, pin 1 of each IC should be at the lower left. Check the interconnections between the boards.

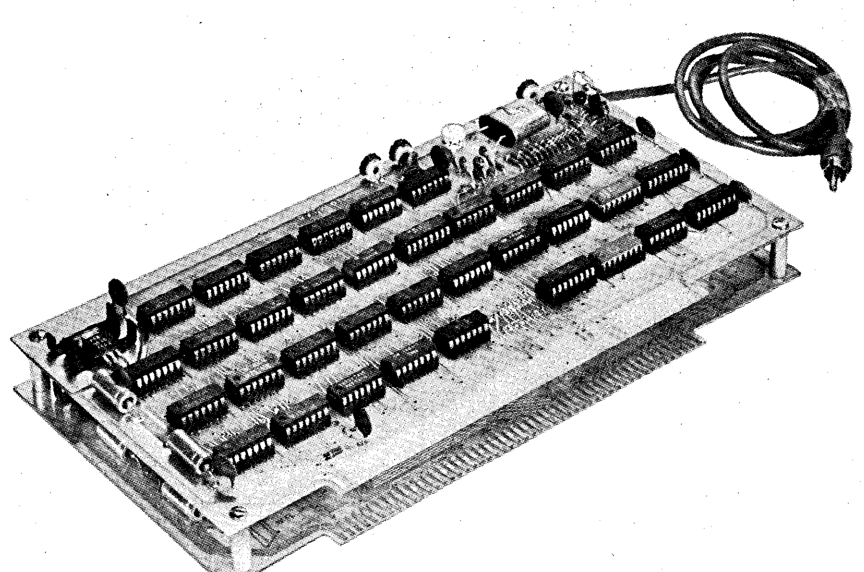
Turn off the power to the Altair and then insert the Dazzler into adjacent sockets on the bus line. Using a length of coaxial cable, connect the Dazzler video output (ground the coax braid to the adjacent ground foil) to the video input and signal ground of your color TV receiver. The connection can usually be made at the input to the video amplifier, with a switch to select the normal input or the Dazzler input.

Tune-Up. The Dazzler is activated and deactivated by software control. The simple program shown in Fig. 4 will turn the Dazzler on and display a picture that is stored starting at location zero in memory (D0 through D6 of output port 016 at zero). This short program also allows sense switch control of the word sent to output port 017. The sense switches are labelled *A8* through *A15* on the front panel of the Altair.

Load from the program in Fig. 4 into the Altair from the front panel, examine zero and run the program beginning at location zero in memory. (Be sure all sense switches are down.)

With the color TV set operating and the Altair "running", raise sense switch *A12* and note that a colorful quilt-like pattern appears on the screen. Potentiometer *R30* (bias) on board 1 of the Dazzler acts as a horizontal hold control and should be adjusted to obtain a stable picture.

Raise sense switches *A10* and *A11*, and adjust capacitor *C17* on board #1 for the most saturated blue on the screen. Now put *A10* down, raise *A9*, and adjust *R32* for the most saturated green color. Finally, set *A9* down, raise *A8*, and adjust *R32* for the most saturated red color.



The Dazzler fits in two slots on the Altair bus. Output is video and can be fed to amplifier of TV set or an FCC-approved class-1 r-f device.

Dazzler Software. When writing programs for the Dazzler, it is important to remember that the TV picture is stored as a specially coded sequence in the computer memory. The Dazzler simply interprets this code to form the TV image.

Two different codes are used depending on whether the Dazzler is in the low-resolution or high-resolution mode. This is determined by the control word at output port 017. In the low-resolution mode, four bits of computer memory are used to code each element of the picture (Fig. 5). Either a 32 x 32 or 64 x 64 element picture can be displayed. The latter is organized as quadrants within the computer memory as shown in Fig. 6.

In the high-resolution mode, each bit of memory is used either to turn on (bit=1) or off (bit=0) a single memory element. The control word output to port 017 is used to set the picture color. Figure 7 shows how one byte of memory is divided up to control eight elements of the picture. In this mode, either a 64 x 64 element picture using 512 bytes or a 128 x 128 element picture using 2K bytes can be displayed on the screen. ◈

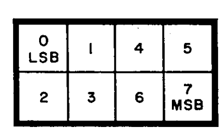


Fig. 7. In high-resolution mode, each memory byte is used to represent 8 picture elements.