THE MATRICON CATHODE-RAY TUBE

by **D. S. HILLS** and **G. HEFTMAN**, B.Sc.(Eng.), A.C.G.I.

The conventional cathode-ray tube has many disadvantages when used for the display of alphanumeric data—mainly because of its dimness. It has been estimated that the brightness produced by a Matricon display is 20 times higher than is possible using an ordinary cursive system. Recently, c.r.t.s containing line-Matricon-type guns have been used to produce linear displays from thermographic equipment.

FOR MANY years the cathode-ray tube (c.r.t.) has provided a means of displaying information derived from electronics systems. Such information can be in the form of a television picture, a diagram, or an alphanumeric presentation. The increasing application of computers in recent years has led to a considerable interest in the c.r.t. as a means of presenting alphanumeric data. In an industrial computer installation, a supervisor may need to be fully informed about the state of his plant, and be updated when a change takes place so that he may take appropriate action. The printout of such data, using conventional electromechanical printers, is both slow and inconvenient, and often a paper record is unnecessary. For such applications, the c.r.t. provides the best means of presenting information to an operator.

Inadequate brightness

At present, most data-display systems use conventional c.r.t.s to trace out a character by the cursive movement of an electron beam controlled by a complex character generator. A typical character display may consist of 40 lines, each having 64 characters. For a frame rate of $40\,s^{-1}$, about $10\,\mu s$ is available for the complete writing operation. With delays in scanning circuits, only a fraction of this time can be used to expose the phosphor, and adequate brightness cannot be achieved.

It is therefore usual to reduce the frame rate, thus increasing the character-writing time and enabling phosphor exposure to occur over a larger fraction of the time available. Since the frame rate is lower, a long-persistence phosphor must be used to avoid flicker. Such phosphors are less efficient and are unable to produce a display bright enough for viewing in high ambient light. In addition, they have a greater tendency to burn.

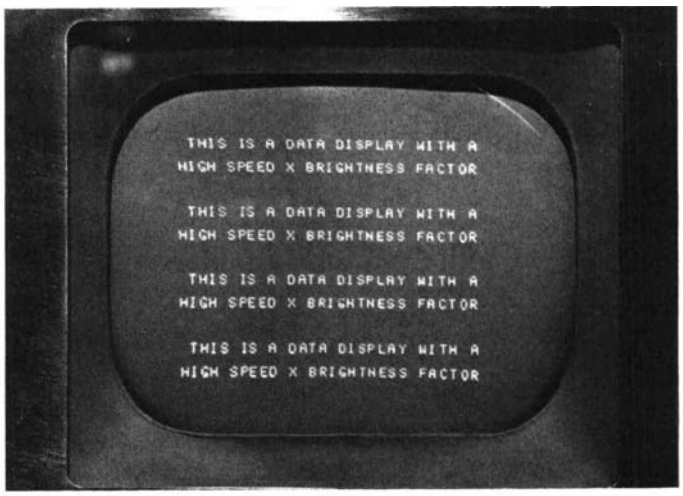
It was to overcome this problem that the Matricon c.r.t. was developed. In its form as an alphanumeric-display tube, the Matricon can focus onto its screen 35 beams in a seven-column by five-row matrix. Each beam can be individually switched on or off, so that, by the selective switching of beams, a character pattern may be produced on the screen. With a display formed in this way, each of the elementary beams comprising the pattern can pass as much current as a beam in a conventional c.r.t. Thus a high speed × brightness factor is achieved. It has been estimated that the brightness produced by a Matricon display of this type is 20 times higher than is possible with conventional cursive systems. An example of characters formed in this way is shown in Fig. 1.

Inside the Matricon

Since the invention of the Matricon tube by A. T. Starr in 1962, it has performed different functions, and recently has been used in analogue displays. Fig. 2 shows a gun structure suitable for any multibeam display. The gun consists of a flat cathode with a parallel accelerating electrode, called the baffle, a short distance away. This electrode, which is held near to cathode potential, consists of a thin metal plate containing one aperture for each beam to be formed. The individual beams are thus formed close to the cathode surface and pass through the baffle.

The next electrode is the modulating electrode; this contains a large number of apertures all electrically isolated from one another but held to precise mechanical limits of positional accuracy. This electrode is called the grid matrix, and can modulate—either digitally or continuously—all beams or any one separately. A conductor to each grid aperture is provided in the base of the tube. The arrangement of the cathode, baffle and grid matrix is such as to almost collimate all the beams; the degree of collimation is enhanced rather than degraded by increasing modulation.

The beams emerge from the grids and are further accelerated by the first and second anodes, each of which contains apertures with the same geometry as the baffle and grid matrix. An image of the aperture array in the second anode is focused onto the phosphor screen, and the electron-optical arrangement is such as to produce an image of reduced size. Thus the current density in the beams on arrival at the screen is much greater than in the apertures of the gun, and a high-brightness display is produced.



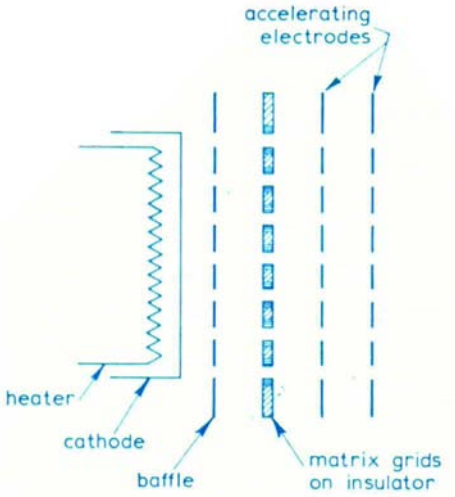
1 Alphanumeric characters on a Matricon cathode-ray tube

Tubes have been made with an additional aperture alongside a 7 × 5 matrix. The aperture can produce a video display, while the matrix can produce annotation by symbols without interrupting the scan.

Bright display

The grid-drive characteristics are not identical for all grids within a matrix. To obtain an even illumination of a displayed character, it is usual to drive the grids 'hard on', so that all the beams saturate the phosphor. The brightness of

the display may now be adjusted by controlling the duration of a character exposure. This can be done conveniently by applying a strobe pulse of controlled width to the baffle electrode. The scan is normally held stationary during the display period when the tube is strobed, so that, if a line of characters is to be generated, a 'staircase' waveform must be fed to the deflection coils. The length of each step may be 5 μs. With scanning-circuit delays, this will allow a maximum of 2 μs for the exposure period; this is sufficient to produce a bright display.



2 Gun structure suitable for multibeam display

For printing, where higher-quality characters may be required, the 7 × 5 matrix is unsuitable. Larger matrices are impracticable because of difficulties in wiring each of the considerable number of control grids. To overcome this difficulty, the line Matricon, which is a variant on the Matricon principle, was developed. In the line Matricon, instead of a 7 × 5 array of apertures, the gun has 14 grids arranged in two staggered rows of seven holes each. On selectively pulsing these grids while the beam is linearly scanned across the screen, characters are produced on what is effectively a 14 × 10 matrix of overlapping dots.

The line Matricon can produce characters of good quality and, with a reasonable optical system, can produce enough light to print 30000 characters per second on a film of speed ASA2 (Fig. 3). The line Matricon can be easily extended to accommodate lower-case characters and several sizes of upper-case characters, by the addition of further apertures.

Simple circuits

Character-generating circuits for driving Matricon tubes are entirely digital and are consequently extremely simple. To expose a character formed on a 7 × 5 matrix, all that is required is an encoding circuit, which, with an input on a character-demand line, will produce on its 35 output lines the 'on' and 'off' levels representing the desired pattern of dots in the character to be displayed. Fig. 4 shows such an encoder suitable for 64 characters.

Encoders for driving a line Matricon are more complex, since more information is required to define a character shape on a 14 × 10 matrix. Also the encoding process must be distributed in time. Such circuits are still simpler than those required with cursive systems, and have the advantage that close-tolerance components are unnecessary in their construction.

Thermographic displays

Recently, c.r.t.s using line-Matricon-type guns have been used in Britain and America to produce linear displays from thermographic equipment. Until the introduction of this tube, thermographic systems—capable of producing a picture from the heat radiated by a scene at room temperature—have depended on a single cooled receptor. A picture was formed by scanning the receptor, which has suitable scanning optics, across the scene, and using the amplified sensor signal to modulate a display device such as a scanning recorder or c.r.t.

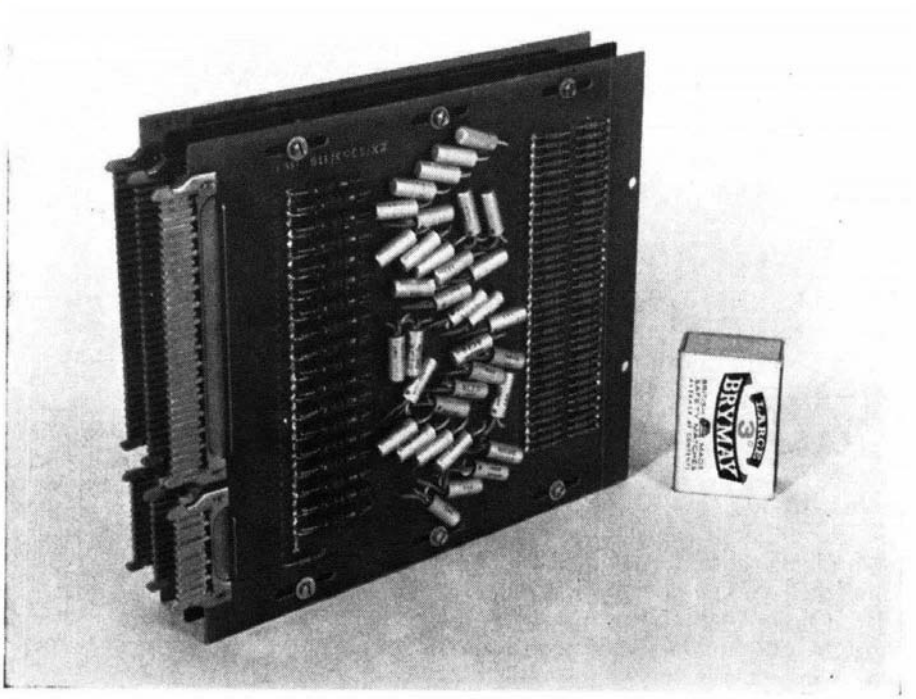
Such a system can be built using a multiple array of sensors in place of a single sensor, with a line-Matricon tube providing an array of beams which reproduce the geometry of the sensors on the screen. These beams are scanned in step with the scene-scanning optics. The signals from each sensor can be amplified separately and made to modulate the corresponding tube grid, providing what is effectively a multiple-'pen' display. Because there are now many sensors, the frame rate can be increased without sacrificing signal/noise ratio. Or the frame rate can be unchanged, so that the scanning rate per sensor is reduced; this gives an improvement in signal/noise ratio. This gain can be used to improve the temperature discrimination or spacial resolution of the system.

Single-receptor systems cannot, because of the speeds of sensors and their insufficiently high detectivities, produce a useful picture at high frame rates. Multi-sensor systems using line-Matricon tubes have been built to produce a real-time thermographic display, of useful resolution and sensitivity, at a frame rate of 40 s^{-1}, providing a continuous moving picture.

In such linear applications of the Matricon tube, similarity between the grid-drive characteristics is desirable in order to obtain an accurate display. Careful design and manufacture can improve matching. It is still necessary to provide trimming facilities in the circuitry driving the grids. Normally, two trimmers are provided for each grid. These match the beams for cutoff potential and slope. Once these are set, adequate tracking between grids at all brightness levels can be achieved.

Matricon tubes can be made with any pattern of emergent beams. Beam patterns are determined only by the formation of apertures in the gun. Matricons with up to 100 separately modulated beams are now possible in certain configurations. The gun can be used in any size of glass envelope and with any phosphor.

3 Line Matricon capable of producing enough light to print 30000 characters per second



4 Encoder suitable for generating 64 characters