Volume 9 Number 2 March/April 1972

Information Display

The Journal of Data Display Technology

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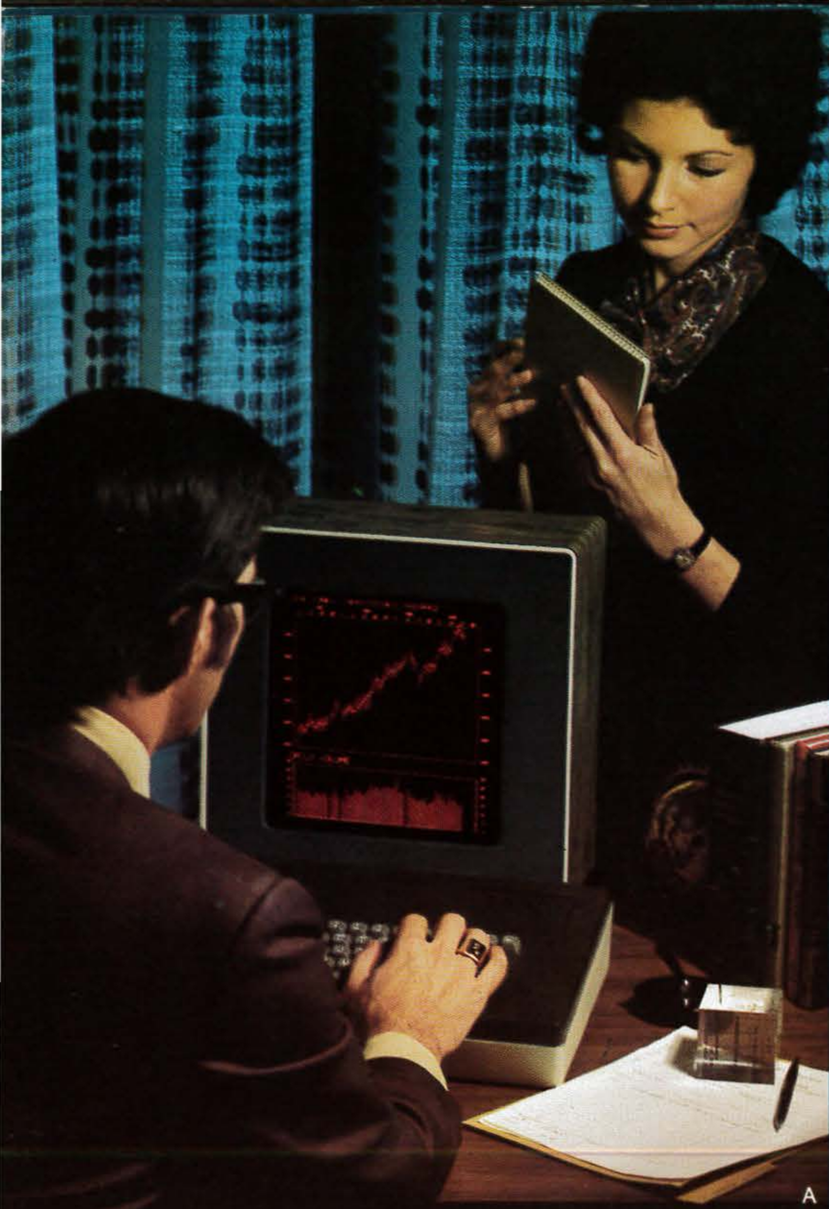

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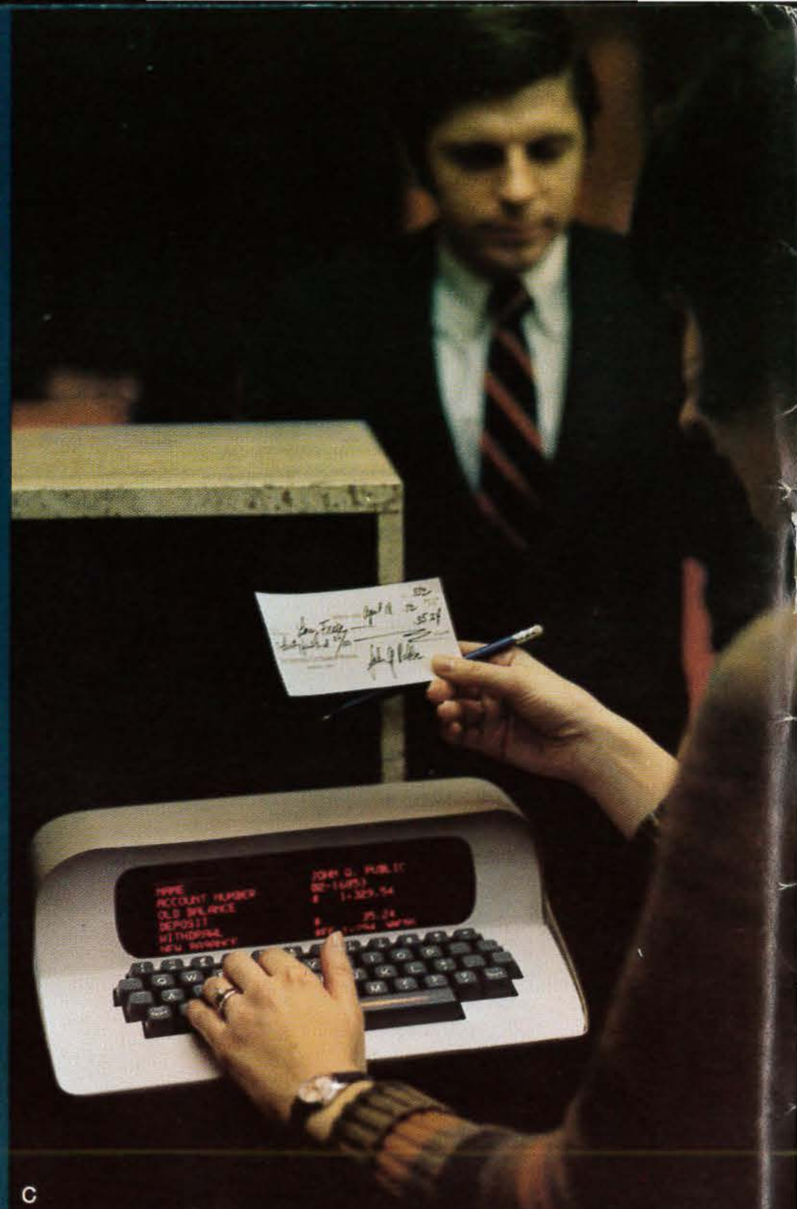

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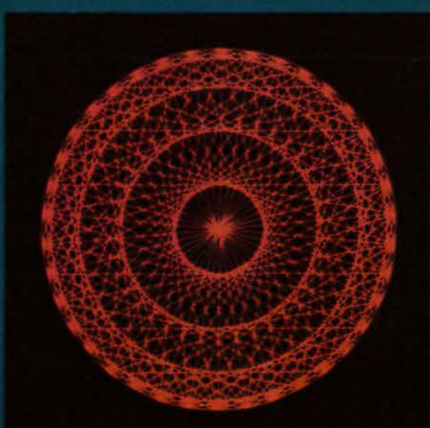

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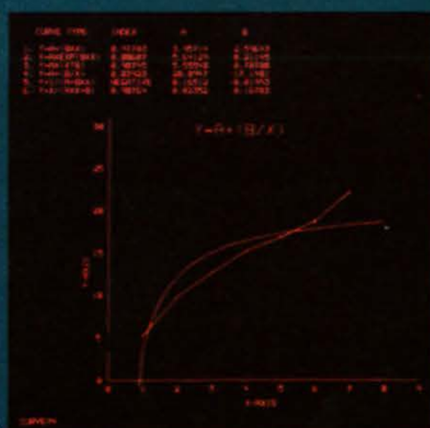

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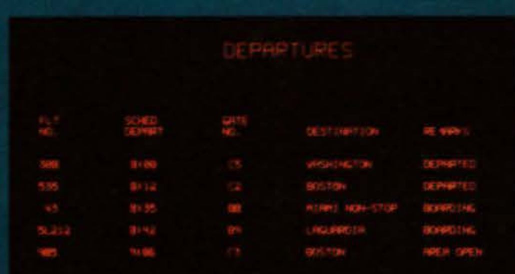

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A. Digivue 512-60 Display/Memory Unit. An 8½" x 8½" square panel of 512 x 512 lines at 50 lines per inch resolution.

B. Digivue 256-50 Display/Memory Unit. A 5½" x 10¼" panel of 256 x 512 lines at 50 lines per inch resolution.

C. Digivue 64-33 Display/Memory Unit. A 2" x 8" panel of 64 x 256 lines at 33.3 lines per inch resolution.

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Information Display

The Journal of Data Display Technology

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Published bimonthly by
Information Display Publications, Inc.
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Editorial

A Unified Approach

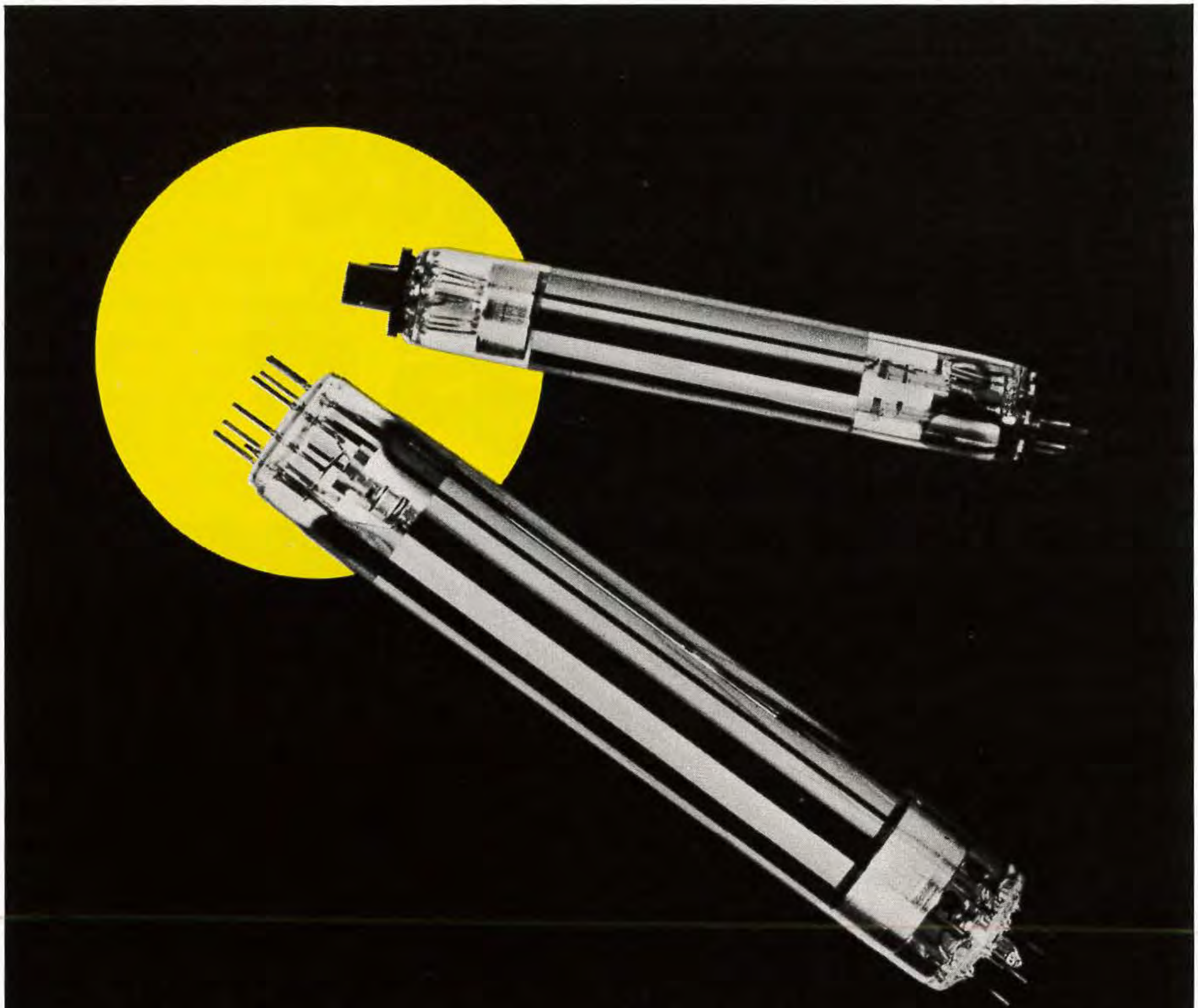
The interfaces between many technologies are frequently ill-defined, particularly when cross-disciplined fields are involved. Consequently, we may well ask whether or not display systems and certain classes of image systems require substantially identical engineering skills. Certainly, most image systems include some form of visual output or "display."

The question raised is not specious if one considers the number of engineering divisions and subdivisions now recognized in our technological base. Whenever additional fractionation can be avoided the entire technical community must benefit, to say nothing of the recipients of its output.

It may be a moot point whether a system is called "image" or "display." On the other hand, if the required technologies are for the most part the same, then it would be a disservice to develop separate terminology, standards and all the other accoutrements of a subfield. That such does happen is not necessarily a result of chauvinistic adherence to one's area of specialization, but rather, the communications difficulties which inevitably arise among different groups dedicated to their own causes and interests.

In this age of computers, the output of imaging sensors — even of the photographic variety — is being increasingly processed and displayed using techniques that are fundamentally like those that have evolved in computer-based display systems. Analytic evaluation of systems producing images, from whatever source, is a process that has been highly refined. The tools which are required to specify, design, produce and test systems primarily concerned with image data are available. It remains for us to recognize that sufficient commonality is present in those systems which handle images that a unified engineering approach is not only possible, but highly desirable.

R.L. Kuehn



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A Logic Character Generator for Use in a CRT Text Display

P.A.V. THOMAS and W.E. MENNIE

Abstract

As part of a general graphics facility currently being developed around a DEC PDP 8/S, this character generator uses only standard logic modules to produce the necessary brightening pulses for a 5 X 7 dot matrix presentation. The matrix raster itself is generated by means of counter-registers and D/A converters which facilitates the generation of three sizes of characters, provision for subscripting and superscripting, carriage return to the left hand side or a user set margin, and line feed with single or double spacing. The 60 ASCII character set is available and an extended character set could be generated by an extension of the same principles.

Introduction

During recent years it was decided to develop a general computer graphics facility about an existing DEC PDP 8/S which would be capable of generating vectors and alphanumeric characters. This paper is concerned only with that portion of the system involved in the character generation and some possible alternatives are included at the end.

Basic Method of Character Generation

The basic method used is the well known 5 X 7 dot matrix presentation on the screen of a CRT as indicated in Figure 1. Different methods have been used in the past to produce the necessary brightening pulses applied in synchronism with suitable vertical and horizontal deflections of the beam. In the particular case the entire generation is produced using logic gates in conjunction with counter-registers. For convenience of reference let us assume that the dots are generated time sequentially in the order indicated in Figure 2 so that it now becomes apparent that to produce the letter "A" of Figure 1, it is necessary to generate brightening pulses at relative dot times, 1, 2, 3, 4, 5, 10, 13, 17, 21, 24, 27, 29, 30, 31, 32, 33. These brightening pulses are obtained by applying the pulse train of Figure 3(c) to the CRT brightness modulator in

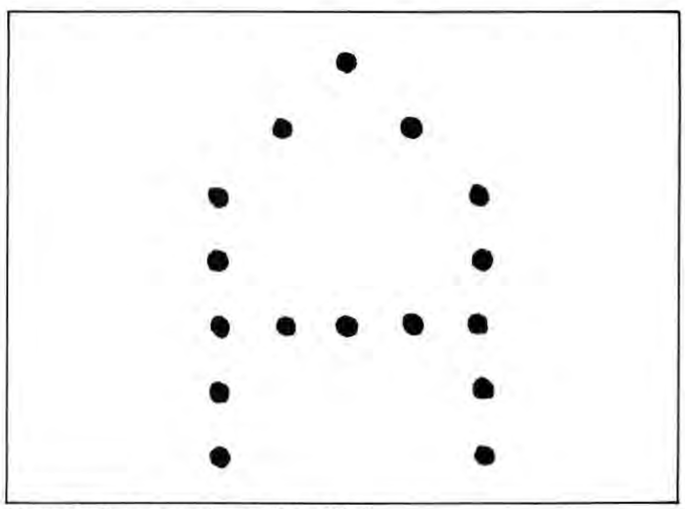

Figure 1: Dot generation of letter "A."

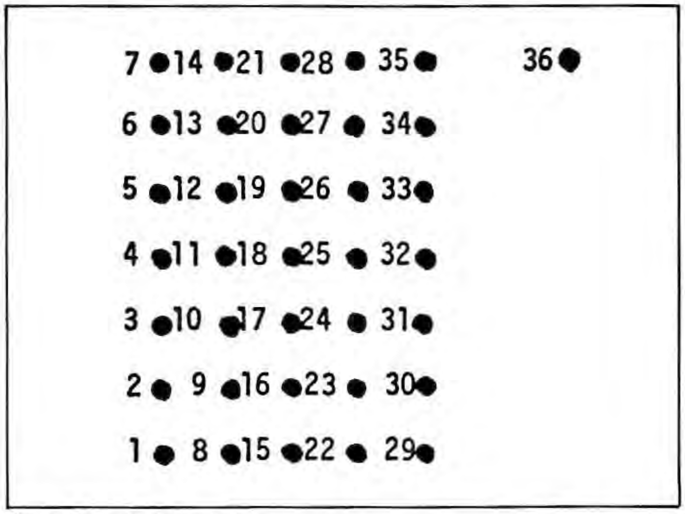

Figure 2: Basic dot matrix.

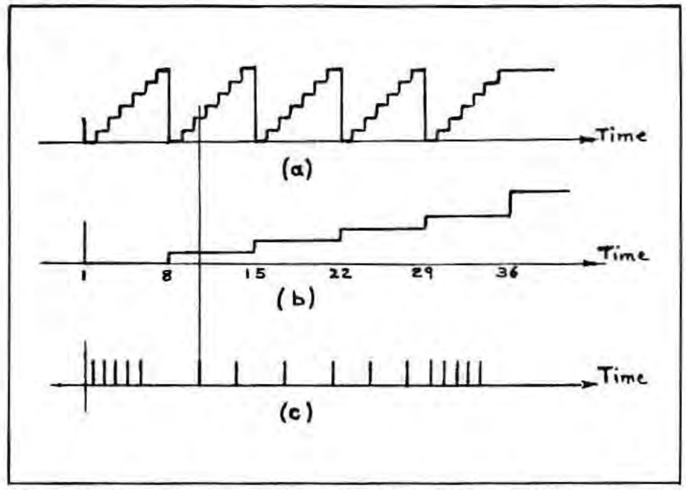

Figure 3: Wave-forms to generate the letter "A": (a) Y-deflection; (b) X-deflection; (c) brightening pulse train.

synchronism with the X and Y staircase deflections shown in Figure 3(a) and (b). These staircase wave-forms are conveniently generated by means of X and Y counter-registers feeding D/A converters as described later.

The basic brightening pulse generator is shown in the block diagram of Figure 4. When a character code is loaded into the Buffer Register, a Clock oscillator is initiated whose output feeds a Dot Counter counting up to 36 (the total number of matrix points plus one used for character spacing). The outputs of this counter together with a delayed clock pulse to give the counter time to settle down, are fed into the Dot Decoder consisting of a set of 35 AND-gates generating the 35 discrete dot time pulses (1 to 35) as shown in Figure 5. To generate the pulse train for a particular character, it is now necessary to select and combine the required pulses into a single output; this is achieved by the Character Encoder consisting of a series of OR-gates (one for each different character to be generated) as shown in Figure 6. The final section is the Character Selector which decodes the 6-bit stripped ASCII character in the 6-bit Buffer Register and gates the corresponding Character Pulse Train to the CRT brightness modulator; a simplification is achieved here by combining the Character Pulse Train AND-

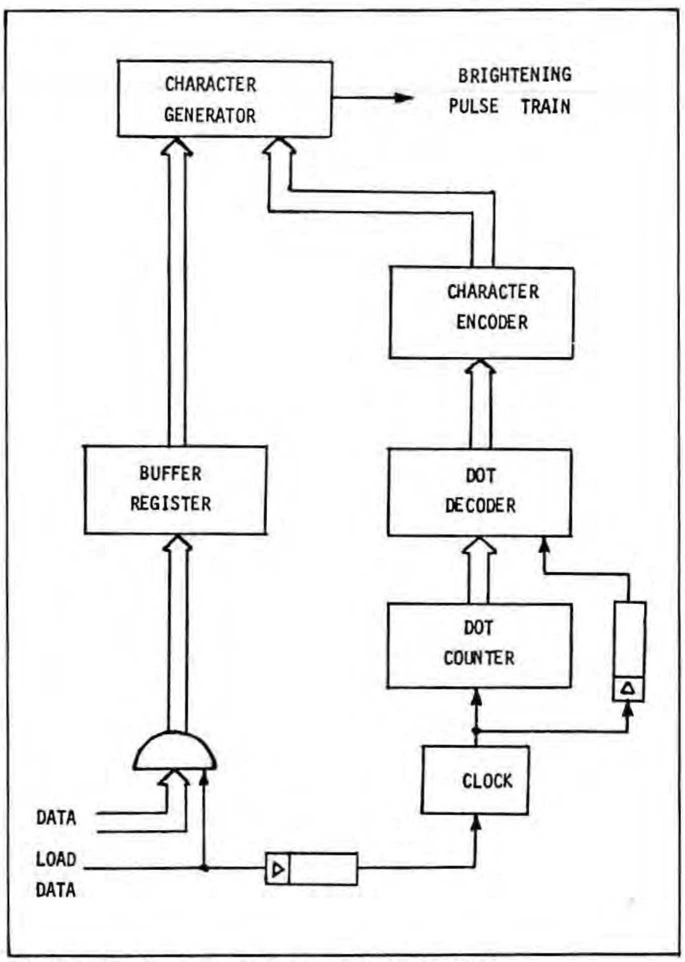

Figure 4: Block diagram of basic character generator.

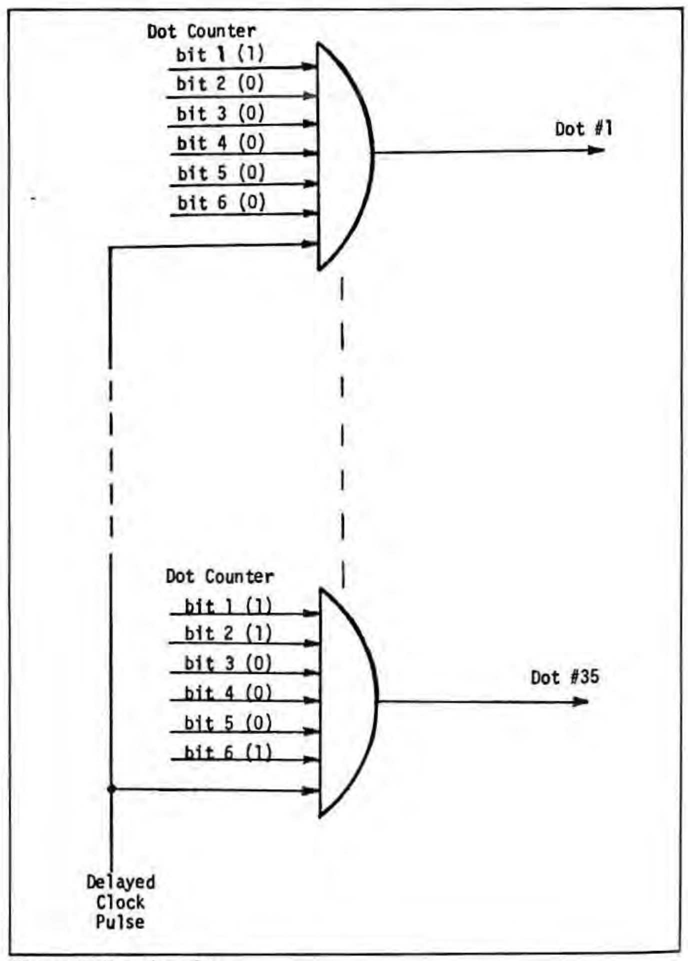

Figure 5: Dot decoder.

gate and decoder AND-gate into one gate as shown in Figure 7 which also shows the final OR-gate which permits any selected pulse train to be fed to the CRT. Thus the entire logic is a succession of AND-OR logic which is easily implemented with standard NAND (or NOR) logic modules.

Reverting back now to the X- and Y-deflections, these are conveniently produced by using two counter-registers with DAC's as shown in Figure 8. The initial value of the X- and Y-registers must locate the 1st dot position and to achieve this we have the Y-value set equal to XXXXX000 and the X-value equal to Zero, where XXXXX may be any binary number. The clock (used to generate the character brightening pulse train) now counts in the Y-direction using the Y-register until the count of 7 is reached, at which time the Y-value is reset to the previous value of XXXXX000 and the X-value is incremented by unity. This is continued by resetting Y and incrementing X at count times 14, 21 and 28 to complete the character matrix deflections at count 35. If now a second character were to be loaded it would commence with dot No. 1 lying on top of No. 29 of the previous character. To avoid this, at the end of the previous character, a space of two dots is generated at an additional pulse time No. 36 (indicated on Figure 2) by incrementing the X-register in the 2's position.

Modification to the Basic Generation

So far nothing has been said concerning the scale factor or size of characters. Naturally the size of a character will depend

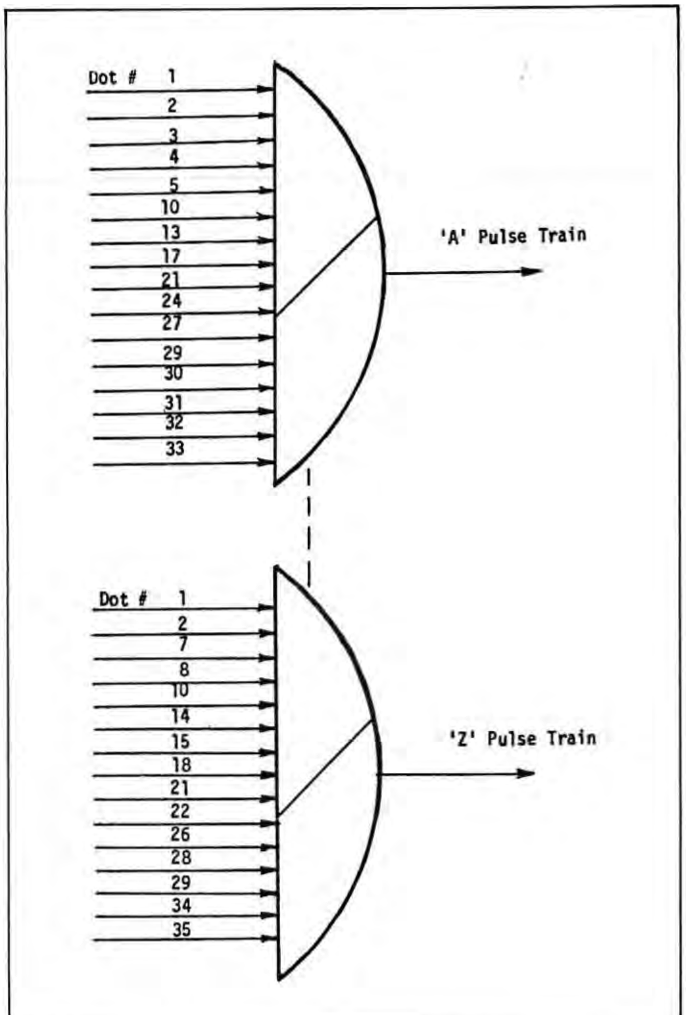

Figure 6: Character encoder.

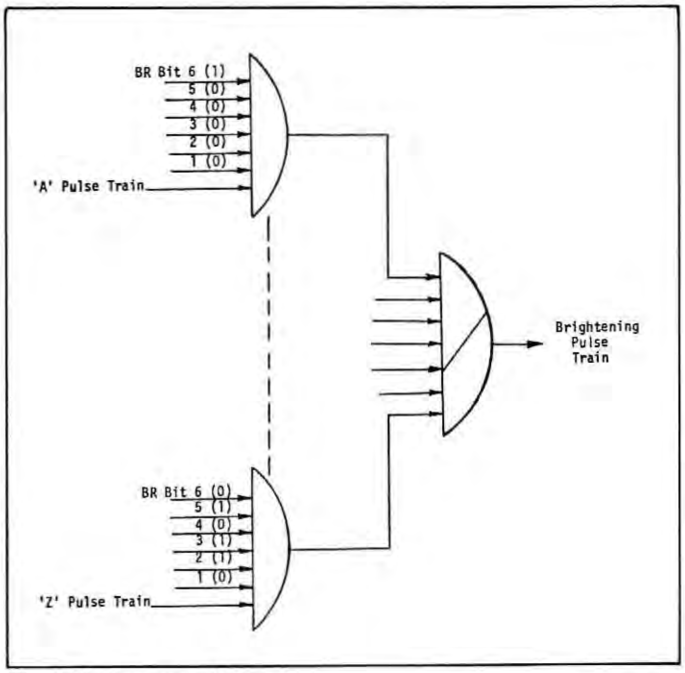

Figure 7: Character selector.

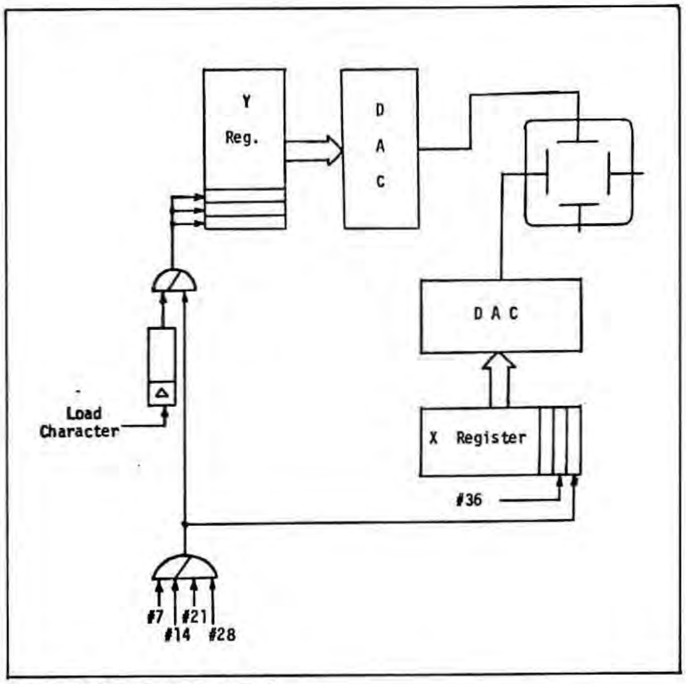

Figure 8: Staircase generators.

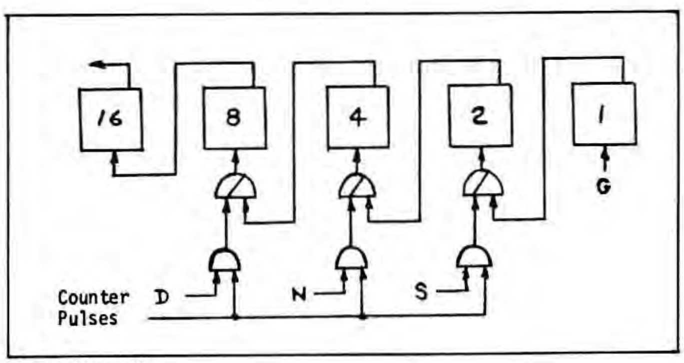

Figure 9: Scaling.

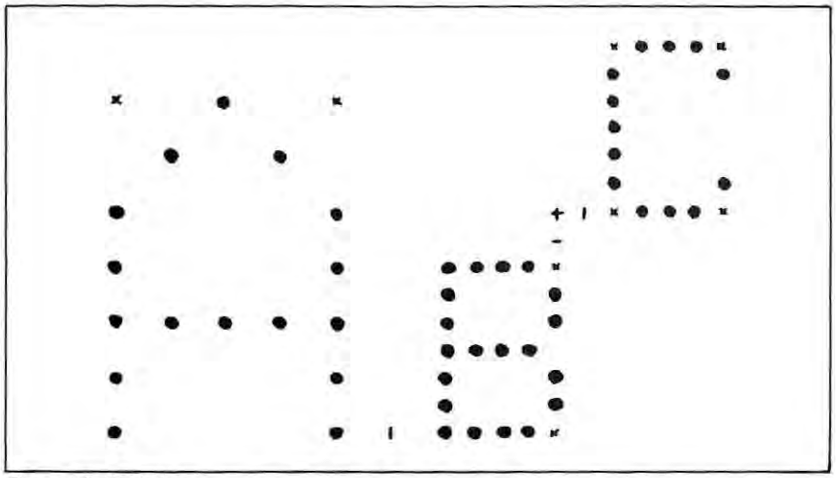

Figure 10: Scripting.

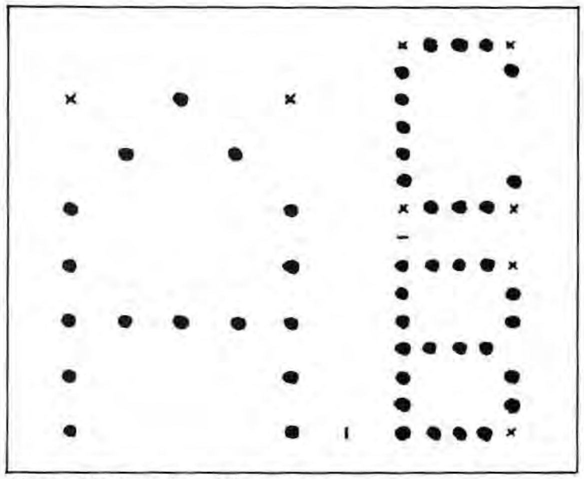

Figure 11: Scripting with back space.

on the raster unit of the display terminal. In the particular case the overall design is based on a screen display area of 1024 X 1024 raster units, which is considered reasonable for a text facility. If each character generation step on the X and Y counter-registers was only 1 raster unit, this would result in a character size of only 5 X 7 units or approximately 1/16 in. high on a 10 in. square display which is impractically small. If, however, counting is carried out at the 2's input of the counters the size is doubled giving a character of about 1/8 in. height and about 85 characters/line, considered to be a reasonable minimum. By further changing the position of the counter inputs to the 4- or 8-input points, shown schematically in Figure 9, the size may be doubled or quadrupled (up to approximately 1/2 in. high) giving any one of 3 sizes, for convenience referred to as small, normal or double size. Figures 10 A and B show the basic matrices for two adjacent sizes from which it can be seen that A may be used as a capital for the B size or B may be considered as a subscript for the A size. If now the position of B is moved up to that shown at C then the character generated may be used as a superscript or as a mathematical exponent to the character at A. In fact, the logic required to accomplish this is relatively trivial – the only requirement being to preset the next higher Y-counter bit to '1' prior to the character generation so that the dot count becomes effectively 8, 9, 10, 11, 12, 13, 14 rather than 0, 1, 2, 3, 4, 5, 6 in each vertical count. Furthermore it will be observed that the C character is automatically spaced two dot positions above the top of the subscript B so that one such character might be placed above the other rather than to its right, as shown in Figure 11. This is achieved by means of a non-printing "back-space" character.

Special Characters

This naturally leads to a number of special non-printing characters that are provided and greatly assist the user of the textural display, viz, Back-space (BS), Carriage Return (CR), Line Feed (LF) and Tabulate (TAB). Before considering these characters, however, we have to realize that there is one complication, namely, duplication of 6-bit stripped codes; for example the 6-bit codes for BS and the letter X are both 011000 (30_8); however if we consider the 7-bit codes for these two characters, they are 0011000 (30_8) and 1011000 (130_8) respectively. Thus, if we load the 7-bit code into an extended Buffer Register (of Figure 4) of 7-bits then the normal characters need still use only the six least significant bits, the 7th bit only being used to detect the special characters and take the necessary action. As these characters are all non-printing (non-displayed) and their corresponding normal characters will be generated the brightness modulation must be inhibited. Considering first the Back-space; when this code is detected the only requirement is that the X-counter is made to count down instead of up while a blanked out "X" is generated; the net result is that the final position (dot No. 36) now corresponds to the previous dot No. 36 so that the next normal character generated is spaced back one character position. If this next character were to be a superscript then the result would be as shown in Figure 11. Note that this also enables the operator to generate special printing characters by super-imposition of standard characters, if this is desired. The other three non-printing characters, the Carriage Return (CR), Line Feed (LF)

Instruction Word

1	0	0	1	0	Ma	R	S	L	Int

Data Word

0	B	SS	M	7 Bit ASCII Code

Combined Word

Ma	M	B	SS	7 Bit ASCII Code

Ma: 0 - No Action
1 - Load bits 2,3,4, of next data word into Margin Register

R: 0 - Normal Character
1 - Rotate 90° Counter-clockwise

S: 0 - Normal A/N Mode
1 - Double A/N Mode

L: 0 - Light Pen Insensitive
1 - Light Pen Sensitive

Int:00- Normal Intensity
01- Dim
10- Bright
11- Blanked

B: 0 - No Action
1 - Blink

SS:00 - Normal Position
01 - Superscript
10 - Subscript
11 - Capital

M: 0 - Normal CR or Double Spaced LF
1 - CR to position in Margin Register or Single Spaced LF

Figure 12: Instruction and data words.

and Tabulate (TAB) will be considered together as there is a similarity in their mode of operation, that is, they involve a similar type of change in the contents of their respective registers and also make use of a special Margin Register. Under normal conditions, the CR causes the X-counter to be reset to zero so that the next character is generated at the left hand edge of the display area. Similarly the LF causes the Y-counter to be decremented by two character heights (16 dot positions) to move to a new line, leaving a one character-height space in between lines. A further extension of these two non-printing characters is made available to the user by the use of a "margin bit," M, in the data word of the display file shown in Figure 12. Specifically, consider the CR function with this bit set to '1'; in this case the return, instead of being made to the left hand edge of the display area, is made to a position corresponding to a multiple of 10 small characters from the left hand edge, the exact multiple being dependent on the content of a 3-bit Margin Register. The choice of 10 small characters per margin position was based arbitrarily on the fact that there are 85 small characters/line and 8 was a convenient number of margin positions (a 3-bit register being able to contain 8 different values). By analyzing the required contents of the X-register for each of the values of the margin register, as shown in Figure 13, it is easily established that the following rules must be applied:

Bits 1, 2, 4, = Zero
Bit 8 = MR1
Bit 26 = MR2
Bit 32 = MR3
Bit 64 = One
Bit 128 = MR1
Bit 256 = MR2
Bit 512 = MR3

where MR1, MR2 and MR3 are the margin register bits of weight 1, 2, and 4 respectively.

The above is easily implemented by clearing the X-register, loading the bits, as indicated above, from the margin register and setting bit 64 to '1.'

The other similar non-printing character, Tabulate, which uses the same positions poses a more difficult problem as the tabulation requires a different incrementation of the X-counter to a particular tabulation position from any one of the 10 small character positions (120 raster units) at which the last character was placed. One method would be to read the contents of the X-register into the computer, determine the next tabulate position and load this value back into the X-register. However, this would be too slow and a hardware algorithm was developed to correctly generate the necessary stepping in one character generation cycle.[1]

A number of algorithms were tried with varying success and the one ultimately used is similar to that used for the Margin Return in that the appropriate binary value in the X-register must be one of those in the table above. Thus if we can determine the 3 most significant bits, the remaining bits may be set in the same manner as the Margin Return, using these 3 bits in place of the contents of MR1, MR2 and MR3.

Recalling that the smallest character is 12 raster units wide means that we can ignore the 4, 2 and 1 bits as their sum is always less than 12. However, the algorithm shown in Figure 14 was developed which incorporates two gates which detect three cases where the general algorithm fails and makes the necessary corrections. The logic circuit required to place the correct values in the 512, 156, 128 and 64 bit positions by means of counting in the 64 bit position is shown in Figure 15. Having set these four bits correctly, the remaining bits are set in exactly the same manner as in the Margin Return and in fact use essentially the same circuitry.

If the margin bit is set to '1' in an LF data word the next line is placed immediately under the previous line without leaving a character height space between lines. Thus by changing this bit, the user has the facility of single or double spacing of lines of text.

In the previous paragraphs reference was made to the Margin Register without stating how this was set. In the display file of data to be displayed, prior to this data there will be a Mode Control Instruction also shown in Figure 12 which has

DECIMAL VALUE	OCTAL VALUE	BINARY VALUE 512	256	128	64	32	16	8	4	2	1	MARGIN REGISTER CONTENTS
0	000	0	0	0	0	0	0	0	0	0	0	N/A
120	170	0	0	0	1	1	1	1	0	0	0	0
240	360	0	0	1	1	1	1	0	0	0	0	1
360	550	0	1	0	1	1	0	1	0	0	0	2
480	740	0	1	1	1	1	0	0	0	0	0	3
600	1130	1	0	0	1	0	1	1	0	0	0	4
720	1320	1	0	1	1	0	1	0	0	0	0	5
840	1510	1	1	0	1	0	0	1	0	0	0	6
960	1700	1	1	1	1	0	0	0	0	0	0	7

Figure 13: Tabulate and margin positions.

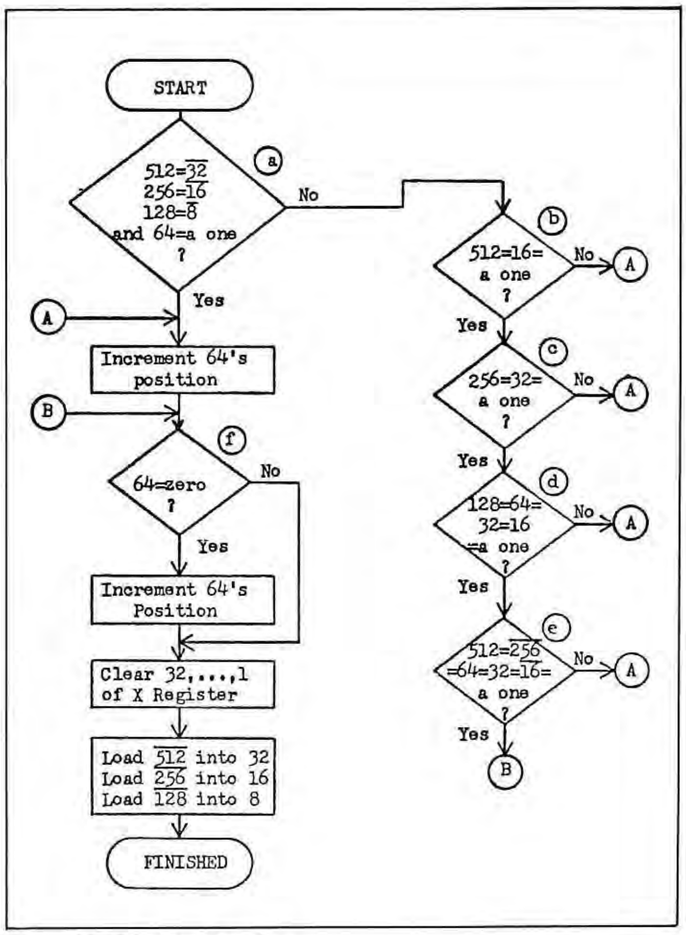

Figure 14: Tabulate algorithm.

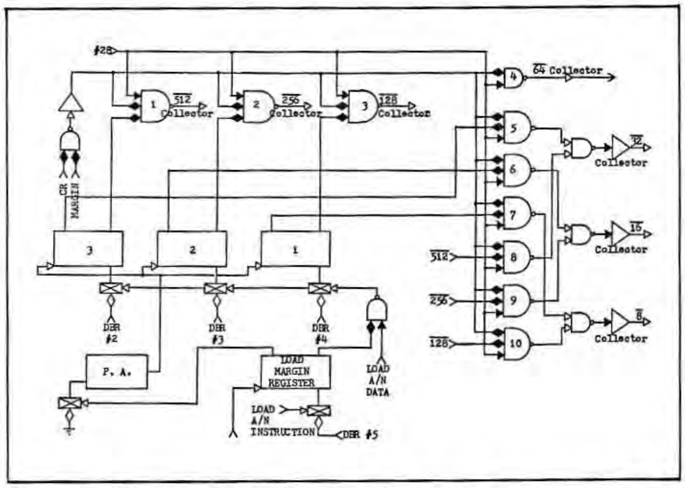

Figure 15: Circuitry for loading X register during carriage return and tabulate.

one bit Ma which when set to '1' takes the content of bits 2, 3, and 4 of the next word (data) and loads it into the margin register; from then on all margin returns are to this same margin until its content is changed by another Mode Control Instruction having Ma = 1. So that this item of data is not displayed the corresponding 7-bit ASCII code portion of the data is set to zero (Null Character) which causes no character generation to take place by inhibiting the counting in the X-register.

No special pointer character is provided but one is easily generated by using a standard character, such as a minus sign (-), as a "superscript" on the next single spaced line.

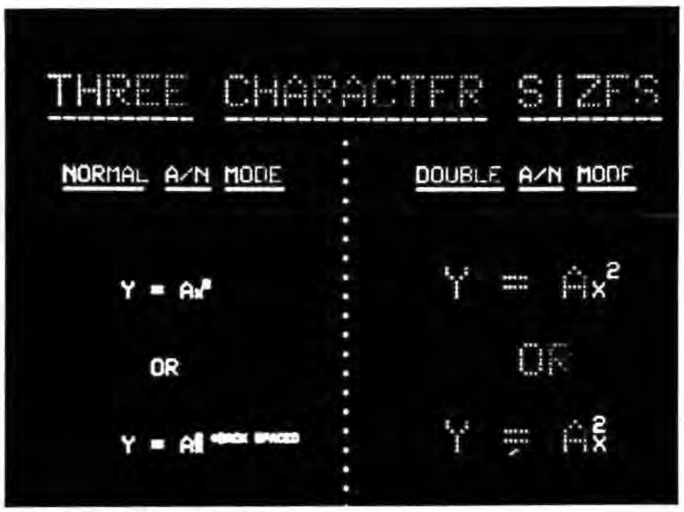

Figure 16 (a): Character sizes.

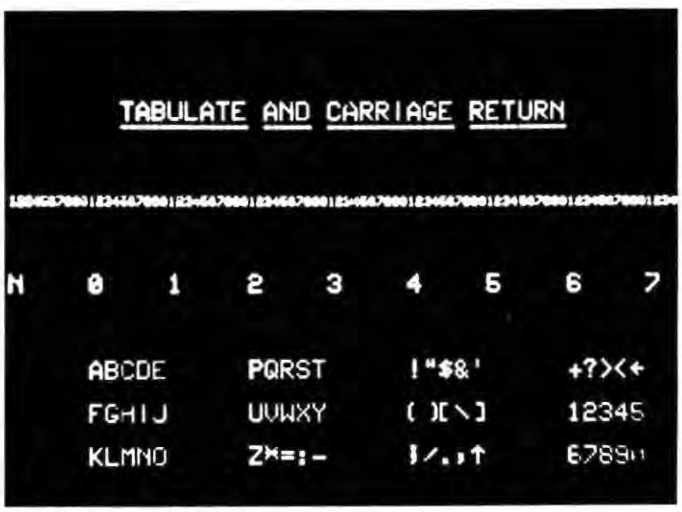

Figure 16 (b): Tabulation.

Display Control

The entire system is intended to be operated in an interactive mode so that a non-storage CRT is used. As the hardware is capable of generating characters at a rate of about 53,000 characters/second it could be directly driven from a fast I/O computer but with a PDP 8/S, due to its upper transfer rate of about 4,500 characters/second, the amount of information that could be displayed would be limited. For this reason a separate buffer memory has been developed but is not described here. However, some typical results, to show the capability of the display generator, are given in Figure 16. Figure 16(a) shows essentially the 3 character sizes and the subscripting and superscripting capability (with and without backspacing the latter). Figure 16(b) shows the tabulate and margin return facilities, the numbers 0 to 7 being located by tabulation and the four columns of characters below being formed using 4 different margin settings. These four columns also illustrate the 60 possible printing characters available.

Further Possible Modifications

As described, the above hardware is part of a general graphics facility and if only textural display was required the Instruction and Data Words could be combined as shown in Figure 12. By the addition of more NAND (or NOR) modules a full 128 character set could be easily implemented; and by increasing the number of bits representing a character more characters could be generated. The main problem then is intelligent representation of the characters and it would become necessary to change to a 7 X 9 dot matrix rather than the existing 5 X 7; this however should not pose any serious problems.

Conclusions

The authors claim to have developed a completely logic hardware alphanumeric character generator with some novel features that assist in manipulation of text. Although the complete logic and registers require approximately 215 modules, it provides flexibility for the generation of other printing characters very conveniently and also is relatively easy to service due to the nature of the logic design. Furthermore, if desired, it should not be difficult to considerably reduce the physical size if LSI techniques were applied.

Acknowledgement

The authors wish to thank the National Research Council of Canada for financial assistance to this project.

Reference

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Using Interactive Graphics for Fighter Pilot Training

KEVIN J. KINSELLA and ANDREW J. MATTHEWS

Abstract

The use of interactive computer graphics promises to revolutionize the military's system of training fighter pilots for combat and save millions of tax dollars at the same time. The Navy has recently contracted with Cubic Corporation of San Diego to provide a new all-electronic system, called the Air Combat Maneuvering Range (ACMR). Adage Inc. in Boston is subcontracted to provide the display facilities which include a "three-dimensional," real-time CRT display of air combat maneuvers and accompanying dynamic data on interactive graphics terminals. The display system accepts a three-dimensional image description, in this case the maneuvering range and aircraft within it, and displays it as a precise drawing from any viewing orientation, scale and position. The perception of dimensionality is aided by intensity depth cuing and aircraft scaling; and aircraft closer to the observer, at any viewing orientation, is brighter and larger than one further away. The display will permit an air-combat instructor on the ground to view tactical dog-fights with simulated missile firings from almost any vantage point by a flick of his wrist; will cut down the hardware expense of practice missile firings at drone targets; will give the pilot much more missile-firing practice through simulation and will immensely aid flight-test range safety officers in their efforts to identify and repair aircraft which have suffered damage as the result of undue strain. This paper describes the implementation of the real-time graphical display system developed by Adage.

Introduction

At present, tactical fighter pilots take to the air in pairs with the instructor following in a chase plane. Maneuvers are carried out – simulated dog fights, etc. – while the instructor follows the action making a running commentary to either pilot and/or retaining in memory the sequence of events for a later debriefing on the ground. The limitations of such a method are obvious: (1) The airborne instructor has only one vantage point to view the action from, plus being occupied with piloting his own craft; (2) In a fast-changing, complex situation such as an aerial dog fight, instructors should not be burdened with remembering entire action sequences; (3) The feedback to the trainee pilot is delayed and he obviously cannot view himself in action; (4) Actual missile firings cannot occur in this dog fight enactment, and when missiles are fired at drones, the procedure is extremely costly and unrealistic since drones are incapable of realistic aerial maneuvers – much as a duck hunter sneaking up on a wooden decoy is far removed from taking aim at a fast-moving mallard.

With the ACMR system, a number of improvements will result: (1) The instructor need only sit at the CRT console (see Figure 1) observing the air action from a wide range of rotational angles or even cause the display to register the pilot's cockpit view. (2) Afterwards, for the debriefing, the instructor can rerun the entire sequence giving pointers as he proceeds,

Figure 1: Photograph of observer at the AGT/150 "3-D" console observing the ACMR.

and better yet, each trainee can see his own action from the instructor's viewpoint (much like athletes view the films of their games) – an immensely helpful link in the educational process. (3) The system, in one operating mode, will transmit radio tones to the trainee pilot when he is in effective cannon/missile firing position, so he will learn directly from this Pavlovian experience what these relative positions are. (4) The ACMR provides the facilities to test pilots' missile firing abilities a much greater number of times than at present. Currently, each Navy pilot is rated annually on the basis of only two missile firings. There is also a potential major saving from avoidance of air combat accidents – mid-air collisions and aircraft going out of control – since the instructor will monitor aircraft position and altitude and notify pilots of impending hazards.

ACMR System Description

The ACMR system (see Figure 2) consists of four major subsystems:

1. An Airborne Instrumentation Subsystem (AIS) carried on each plane on the combat range which monitors aircraft performance parameters and weapons data and telemeters these to the ground.
2. A Tracking Instrumentation Subsystem (TIS) consisting of remote unmanned stations covering the range area and tied to a master station. This network very accurately measures the distance to the aircraft, and communicates with the airborne system and the computation system.
3. A Control and Computation Subsystem (CCS) to receive the incoming data and prepare these for display. The CCS also monitors the system operation and performs missile trajectory simulations.
4. A Display and Debriefing Subsystem (DDS) which displays the range situation graphically and in alphanumerics on three CRT's and is used as a training aid for range control, and to replay previously recorded flight exercises. It is this system that is the subject of this paper.

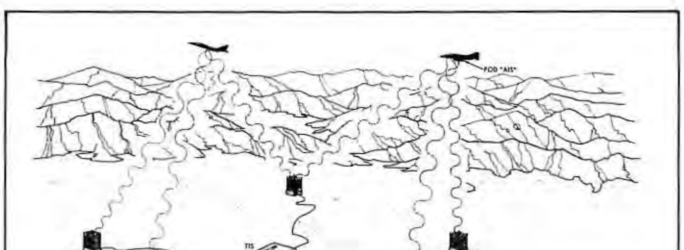

Figure 2: Diagram of ACMR system.

The Display and Debriefing Subsystem

The DDS (see Figures 3a and 3b) consists of two identical consoles, each of which has three separate CRT displays (see Figures 4a and 4b): 1) a storage tube summary display of static text messages; 2) a dynamic alphanumeric and a 2-D

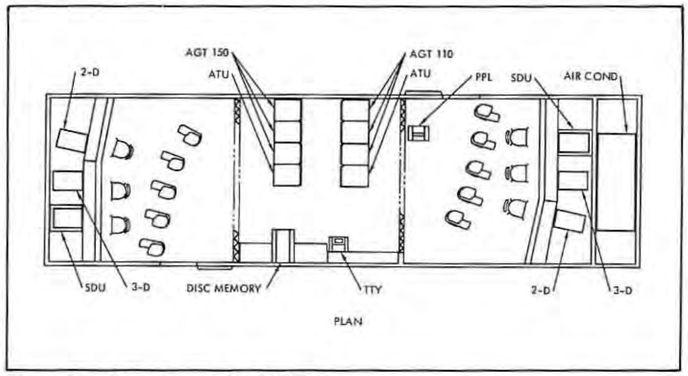

Figure 3a: Top view of the DDS van.

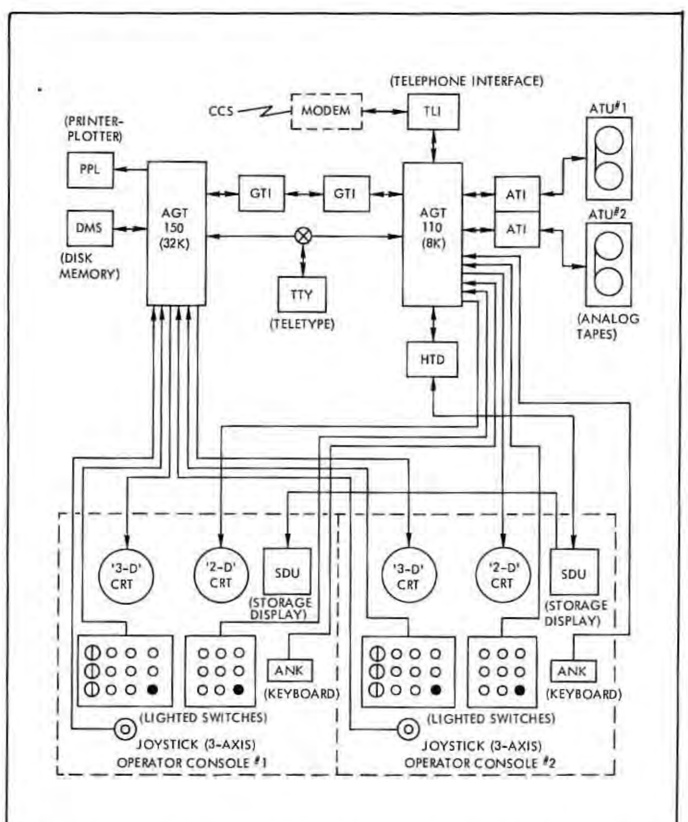

Figure 3b: Diagram of the DDS van hardware configuration.

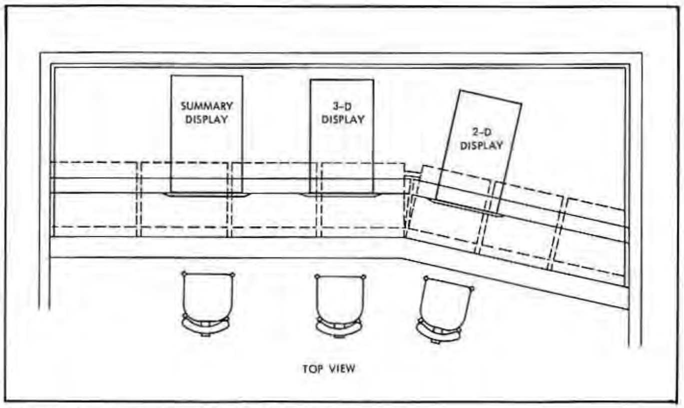

Figure 4a: Top view of a DDS console.

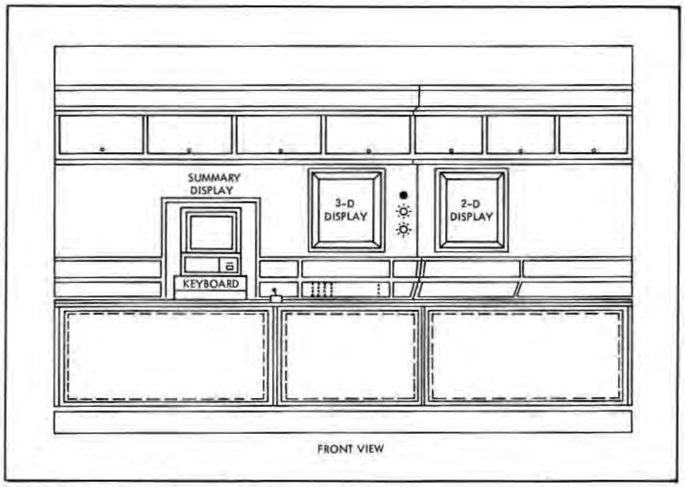

Figure 4b: Plan view of a DDS console.

graphic display of critical aircraft parameters; 3) a realistic dynamic display of the 3-D combat range air-space.

During actual training exercises, the first console would be occupied by an instructor pilot monitoring the 3-D range display, a range safety officer monitoring the alphanumeric display and a system operator at the controls of the storage tube. The personnel at this console control are responsible for the safety of the air combat maneuvering range.

The second console for the DDS is functionally identical to the first, but will appear to the user as entirely independent. Normally this console is used to replay previously recorded exercise tapes, although the tasks for the consoles can be reversed. The replay operation and its display is identical to the live display with the additional facility of freezing the action, backing up the tape and the ability to produce hard-copy of any of the displays including the 3-D range display.

Every 100 ms, the Control and Computation System transmits to the DDS the position and orientation information for each of up to four maneuvering aircraft, a position update on one of the 12 additional support aircraft and extensive additional information about the maneuvering aircraft (closing angles, hazard conditions, etc.). At the DDS, these incoming data messages and the voice communication channels to and from the airborne pilots are simultaneously recorded on one magnetic tape (voice in analog form; data in digital). The displays are generated from the data almost instantaneously.

Status Display

The Status Display is a storage tube unit to provide the observer with static information such as pilot name, aircraft types, exercise name, range status, hazards, pilot performance errors and evaluation of missile firing results (hit or miss, and why). Some displays are automatically presented, others are optionally available by depressing a control push button.

Alphanumeric Display

The alphanumeric display (see Figure 5) is a dynamic display of the altitude, g-force, angle of attack, and true air speed, for each of up to four maneuvering aircraft. "Thermometer" displays were chosen, rather than alphanumerics, because this type of analog presentation conveys the overall situation to the observer most rapidly, and as it is updated every 100 ms, it also gives the observer an accurate impression of the rate of change of these important aircraft parameters. The observer can display the exact alphanumeric values by holding down a push button. When hazardous conditions are detected by the system, the appropriate indicator blinks and the alphanumeric value is added to the display. Serious hazards and range degradation conditions are indicated by warning lights and buzzers.

By monitoring these displayed data, an instructor can, for example, warn a pilot to bottom out of a dive before his altitude is so low that a fast climb would put undue stress on an aircraft or worse, before his altitude dips below the minimal altitude required for a climb out a steep dive. To alert the instructor, warning lights can be triggered at any parameter value up to the maximum for the plane; thus a trainee would initially have very "safe" hazard parameters. Similarly, the range safety officer will watch the g-force level on the aircraft to insure that if it exceeds its maximum allowable limit, the plane may be examined for possible structural damage before its next flight. Thus, pilots who try to push their aircraft to the limits of endurance, will be restrained from doing so.

The 3-D Range Display

The three-dimensional range display (see Figures 6a, b and

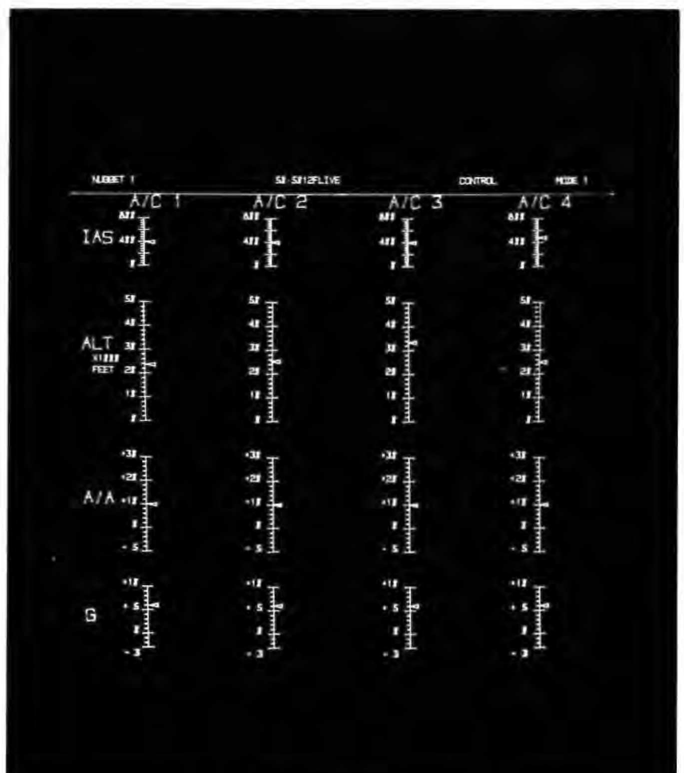

Figure 5: Photograph of the AGT/110 alphanumeric display.

Figure 6a, b, c: Sequential photographs of a rotation of the AGT/150 "3-D" display.

c) presents a realistic picture of the acitivity in the ACMR airspace. The ground terrain shows the major geographic features recognizable by airborne pilots over the forty mile square range. The true ground position of each maneuvering aircraft is indicated by a small cross on the ground. The maneuvering aircraft are represented as accurate drawings of the specific aircraft model that each represents. These aircraft are identified by a numeric label which accompanies the plane on the CRT. When hazard conditions are detected, a flashing label of the hazard and the pilot's name also accompany the aircraft. Attempted missile firings detected by the airborne equipment trigger a simulation in the CCS so that a trajectory for the missile and hit/miss information is generated which is also displayed on the CRT.

3-D Hardware Capability

The three-dimensional display hardware is an Adage Graphics Terminal Model 150 (AGT/150). In the AGT/150 system, picture items which are represented by lists of coordinates in core are not routinely translated into a display list for each refresh frame. Instead, the absolute coordinates are passed through the coordinate transformation hardware to create the analog output values for the vector generator driving the CRT. Figure 7a illustrates the display of an absolute coordinate list of an aircraft, and in 7b, the same coordinate list after three rotations have been composed into the coordinate transformation array. The following equations would describe this type of transformation:

Figure 7a: AGT/150 display of the absolute coordinate list of an aircraft.

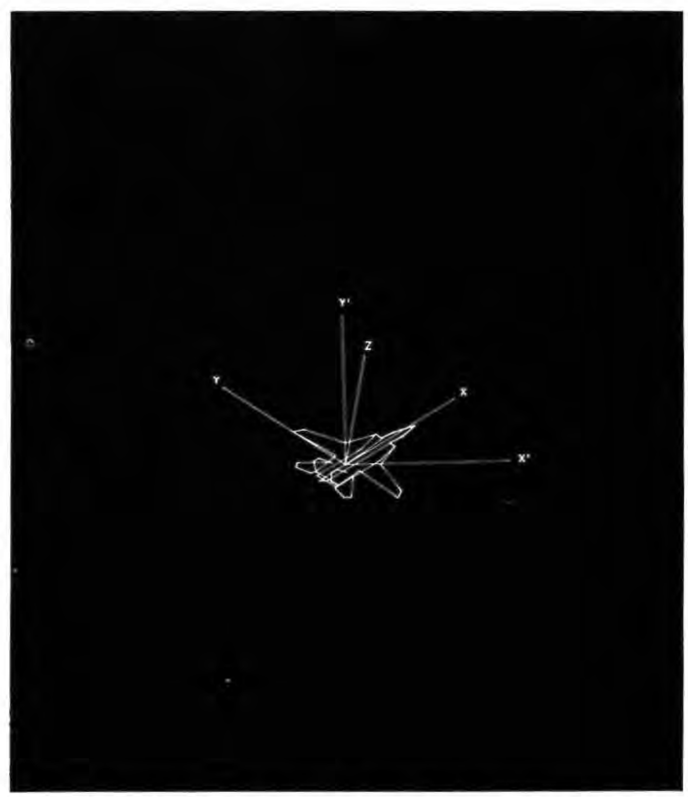

Figure 7b: AGT/150 display of the absolute coordinate list of 7a after three rotations.

$$X' = R11*X + R12*Y + R13*Z$$
$$Y' = R21*X + R22*Y + R23*Z$$

In order to compose multiple sequential rotations, it is also necessary to compute Z'. The hardware in this system utilizes the Z' output to control the intensity depth cuing of the CRT display.

$$Z' = R31*X + R32*Y + R33*Z$$

To include provision for picture scale (PS), individual scale (SC), and translations (DX, DY and DZ), the hybrid operator hardware in the AGT/150 actually implements the following equations:

$$X' = PS*\,[DX + SC*\,(R11*X + R12*Y + R13*Z)]$$
$$Y' = PS*\,[DY + SC*\,(R21*X + R22*Y + R23*Z)]$$
$$Z' = PS*\,[DZ + SC*\,(R31*X + R32*Y + R33*Z)]$$

In block diagram form, the organization of these elements is shown in Figure 8. The program that is processing an image

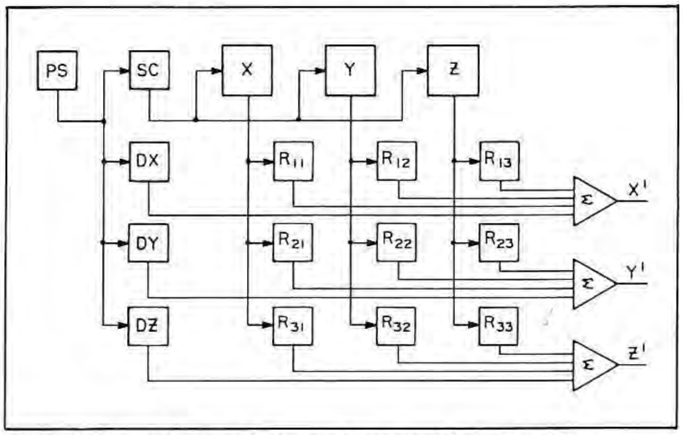

Figure 8: Block diagram of the coordinate transformation array.

list to generate the CRT picture computes the matrix coefficients (R11 to R33), the translations (DX, DY and DZ), scales (PS, SC) and intensity gradient control values, and loads these digital values into the hybrid operator. All subsequent vector items in the display frame are then passed through the hybrid array operation. The hybrid operator is capable of performing the 16 multiplications and 12 additions indicated in four μs. New values can be loaded into the array at any time within a list, so that portions of an image can be separately rotated and translated by hardware operations. In order to position and orient the ACMR aircraft image, this hardware facility is essential.

To display the image transformed as in Figure 7b, the standard software display operator GRAFX would, for each refresh frame, process a list similar to:

IMAGE:	ROTATE about X†	Value 1
	ROTATE about Y	Value 2
	ROTATE about Z	Value 3
	2-D TABLE	F-14 Aircraft Image Coordinates
	END OF LIST	

The GRAFX routine is a sequential list processor, and will compose each rotation item when found onto the current transformation, which at the start of each frame is set to an identity transform. For example, the mathematical operation performed to compose a ROTATE-X item onto an existing transform is a matrix multiplication of the incremental matrix of the new angle and the current matrix.

$$\begin{matrix} 1 & 0 & 0 \\ 0 & \sin X & \cos X \\ 0 & \cos X & \sin X \end{matrix} \quad \begin{matrix} R11 & R12 & R13 \\ R21 & R22 & R23 \\ R31 & R32 & R33 \end{matrix} = \text{NEW ARRAY}$$

The composition of rotation items is not commutative; if two rotations were composed in reverse order, a considerably different final result might be achieved.

The position of an aircraft in the ACMR air space is accurately described by knowing its X-position and Y-position on the ground plane, Z-position (elevation), compass heading, pitch angle, and bank angle. A basic image list to display a one-aircraft situation, with the user having overall control of image scale and rotation would be as follows:

1	IMAGE:	SCALE	Zoom factor
2		ROTATE-X	Altitude viewing angle
3		ROTATE-Y	Azimuth viewing angle
4		3-D TABLE	Ground image coordinates
5		DX	X ground position
6		DY	Y ground position
7		DZ	Elevation
8		ROTATE-Z	Compass heading
9		ROTATE-Y	Pitch angle
10		ROTATE-X	Bank angle
11		3-D TABLE	F-4 aircraft coordinates
12		END OF LIST	

In this list, only items 4 and 11 are actually causing the vector generator to draw visible lines. All other items are generating the array composition operations. Note that the position for the aircraft is composed onto the current overall transform established by items 1 through 3. The ordering of the composition items is essential. For example, the overall transform is scaled about the center to which it has been offset, and not the reverse.

The positioning information for a second aricraft added to the list would also have to be composed onto the array that existed after the completion of item 3 (not including any of the positional information of the first aircraft). This can be achieved by adding a SAVE TRANSFORM item between items 3 and 4. This stored transform can later be reinstated by a RESTORE TRANSFORM item, and further composition made upon it. In this form, if this image list were expanded to 4 aircraft, it would then comprise 5 vector drawing items, 27 array composition items, 1 SAVE and 3 RESTORE's.

It becomes apparent that in this type of application, the image processing routine might be spending a majority of the available time within a frame (only 25 ms for 40 frames/sec) in composing changes to the array, and that a significant increase in the vector drawing capability could be achieved by removing this composition load to the background processing level. This is true because the image processing routine is operating on the display interrupt level; in other words, no vectors are being drawn while the processor is composing the new array items.

Processing of vectors continues entirely on an interrupt basis. Background processing goes on between vector starts, and utilizes all the available time between the completion of an image list and the frame clock to start the next frame (process the image list again). This is an oversimplification of the problem since the AGT/150 has 16 interrupt levels and at times many of them are interleaved to accomplish the necessary communication, hard-copy ouput, disk access, etc. In ad-

† Hereafter referred to as ROTATE-X

dition, there are a large number of tasks which must share background processing in this application, so it is necessary to minimize the time required for the array composition computations.

Significant savings have been achieved by combining the three translations and three rotations to orient an aircraft into one background composition operation, and by adding a tolerably accurate sine/cosine routine requiring 25 μs. Special items have been added to the GRAFX display operator to permit loading, in 36 μs, of the entire transformation computed in the background, in comparison to the 200+ μs to compose one rotation within the image list. The net saving of computation instructions per display frame is very small, but the computation can now be performed concurrently with the display operation, rather than sequentially with it.

With this type of display requirement, the background computation technique has more than doubled the quantity of separately oriented items that can be displayed. This is entirely subjective, as it is a trade-off between the time used for composition and the time used drawing vectors. Longer coordinate list, or fewer transformations, reduce the possible saving. The revised image list for two planes would appear as:

1	IMAGE:	SCALE	
2		ROTATE-X	Altitude viewing angle
3		ROTATE-Y	Azimuth viewing angle
4		3-D TABLE	Ground image coordinates
5		LOAD TRANSFORM	Plane 1
6		3-D TABLE	F-4 aircraft coordinate list
7		LOAD TRANSFORM	Plane 2
8		3-D TABLE	A-4 aircraft coordinate list
9		END OF LIST	

Changing the rotation of the three-dimensional picture, as shown in a sequence of photographs in Figure 6 of a static range situation, represents no additional burden to the processor. The same amount of processor time is utilized for each frame, without consideration of the amount of coordinate change from a previous frame.

Maintaining the Aircraft History Trails

The history trail ribbon for each maneuvering aircraft shows the wing-tip positions for the previous 40 seconds of flight (max.). The photographs here show various preliminary trail designs. In the final system, to help resolve any front-back ambiguity, the right wing tip is dashed unless the aircraft is visible from its belly side. In that case, the dash is replaced by a hash-mark across the trail. When the image viewpoint is changed by turning a control dial, the history trail is corrected to portray the top or bottom situation from the new viewpoint. The realism of the display is enhanced by down range scaling applied to each aircraft causing them to decrease in size when flying away. Hardware intensity depth cuing is also applied so that nearer vectors are brighter than more distant vectors.

The history trails are described in ground and elevation coordinates and are computed from the aircraft location by computing the wing-tip position from the three orientation angles and the span of the wing. The length of the history trail can be varied from 0 to 40 seconds, controlled by an input dial on the control panel. The maximum of 40 seconds of history trail is retained in core at all times, even though only a portion may be currently displayed.

In order to make the decision to add a hash-mark or a dash, it must be determined when the belly of the plane is visible. If the surface defined by the aircraft wings is visible from its upper side, a dash is added; if from the lower side, a hash-mark. This surface can be defined by a line segment perpendicular to it, possibly a line from the base to the tip of the tail. If the Z' output of the array shows that the base of the tail is logically closer to the observer than the Z' value for the tip, then it is easy to show that the aircraft is visible from its belly side regardless of the orientation or viewing angles.

In the coordinate definitions for the aircraft, the wings lie in the X-Y plane. And the tail extends positively in Z. The equation given previously that is implemented by the hybrid operator to produce Z' is:

$$Z' = PS\,(DZ + SC\,(R31*X + R32*Y + R33*Z))$$

A line defining the wing surface plane could run from a tail base of (X=0, Y=0, Z=0) to a tip of (X=0, Y=0, Z=100). The Z' ouput for the base and the tip can be found by solving the equation and the two values compared. Analysis of the equation, however, shows that the PS, DZ and SC terms are constants, and that the X and Y terms are 0 in each case, reducing the equation to:

$$Z' = R33*Z$$

and Z is either 0 or a positive number. For the Z' for the tip to be greater than the Z' for the base, the sign of the R33 term must be positive.

It can be determined, therefore, whether the X-Y plane is visible from the +Z or -Z sides by simply looking at the sign of the R33 matrix coefficient; if positive, the top, and if negative, the belly, of the aircraft is visible. This same technique can also be used for X-Z and Y-Z planes by using R32 and R31 respectively.

Additional 3-D Features

Three optional three-dimensional display modes may be selected by depressing buttons on the control panel.

1) A plan view of the 100-mile square area that surrounds the range will replace the normal display when a button is held down. This is necessary to monitor the activities of combat and support aircraft approaching the range, and as a quick over-view of the entire range situation.
2) A "centroid zoom" mode allows the instructor to select any group of aircraft and to see a display of a portion as small as 1/64 of the range area containing the selected aircraft group. The center of the enlarged display may be continuously adjusted to the centroid of the selected group; in other words the display will follow the maneuvering planes around the range. This mode is particularly important because at the largest magnification, the aircraft can be displayed at true scale, and their maneuvers and interrelationships are even more realistic.
3) The view from any pilot's cockpit of his selected target may be requested. This display includes the outline of the pilot's canopy, and the target aircraft oriented and scaled as it would appear to a trained pilot. The dynamic motion of the cockpit viewpoint, which is computed at the DDS, can cause disconcerting display effects such as aircraft apparently flying backwards through the field of view. Various methods of indicating the dynamic motion and orientation of the cockpit are being investigated and may later be added. The ultimate extension of the cockpit display could be to utilize the joystick at the computer console as the aircraft controls, and to run a flight simulator program in the DDS. **Continued on page 31**


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Our Projected Map System is fully qualified for the A-7D/E.
06

Integrated Displays for Multicrew Military Aircraft

JOHN FROST and
NORMAN F. SULLIVAN

The avionics complex provides the Multicrew Military Aircraft with capabilities for precision worldwide navigation, penetration of sophisticated enemy defenses, and all-weather target acquisition and flexible weapon delivery. A battery of specialized sensors provide information to centralized data processing centers for automatic and semiautomatic conduct of mission operational functions. Controls and displays are required to provide the interface between the human operators comprising the crew and the electronic equipment associated with the functional segments of the avionics configuration. The displays afford a monitoring capability for the augmentation and/or override of automatic controls and provide the means for effecting decisions and manual operations regarding navigation update and weapon delivery, reconnaissance and bomb damage assessment, threat and terrain avoidance and numerous ancillary and supplementary functions.

The following discussion outlines some of the considerations involved in design of these displays and points up certain problem areas common to airborne displays in general.

Sensor Data

Radar, television and infrared sensors may be used to provide the avionics system with information regarding terrain, location of targets and navigational checkpoints, and the location and activity of enemy defensive equipment under a broad range of environmental conditions. Requirements for rapid and accurate threat identification and employment of countermeasures relegate much of the defensive capability of the avionics system to automatic functioning. Penetration aids equipment detects the threats, identifies their nature, and implements the appropriate countermeasures without the requirement of human intervention. Computer mediation of these operations is utilized to provide the defensive operator with a concise, meaningful synthetic display of these ongoing processes, where he may augment or override any of the automatically selected functions.

The navigation and weapon delivery subsystem requires precise high resolution displays be provided to the offensive operator to afford the acquisition of targets and checkpoints and accurate delivery of weapons under varying conditions of illumination and visibility. The multiplicity of sensor configurations and operational modes required to provide this full capability present a variety of data acquisition formats and usually require an intermediate processing stage to prepare the information for appropriate visual presentation. This function may also be employed to store the data to provide a display freeze for accurate and precise cursor laying.

One rather straight forward implementation of these requirements is shown in the block diagram of Figure 1. Information flow is separated into two paths comprising the sensor and synthetic data presentations. The central computer provides the symbol generator with instructions regarding symbol selections and destinations, whereas processed sensor data is routed directly to the displays upon computer command. Switching (not shown) is provided to route any selected presentation to any commanded display surface.

The design philosophy incorporated in this mechanization of avionics sensor data display is based on the fact that information content is more fully preserved when the data presentation format corresponds to the sensor data acquisition format. This criterion requires the sensor displays to be stored and reconstructed with a scan corresponding to the sensor scan. Thus, for example, PPI data is received and stored in range units ordered into azimuth dwell data groups, and subsequently transmitted to the selected display in similar format, eliminating resolution losses associated with format conversion.

Displays

General requirements imposed on the displays are those of brightness, resolution, contrast, dynamic range, writing speed, etc., required for the generation and presentation of information with parameters concordant with mission objectives. The displays must exhibit sufficient brightness to permit satisfactory viewing over the range of ambients to be encountered. An upper figure of 50 F.L. has been assumed for controlled-ambient avionics crewstation lighting, affording satisfactory lighting for moving about the area, writing, and reading fine print. In certain cases commonality of equipment may be achieved with the forward cockpit configuration affording sizeable cost and logistics savings. The forward station ambients may exceed several thousand F.L., however, requiring compromises in equipment design to accommodate to these requirements.

Resolution parameters specified for the equipment must be compatible with requirements for the operators to recognize targets and checkpoints in accordance with fine detail in the presentations and to afford positioning of the cursors with sufficient accuracy to meet mission objectives. A 735 line system resolution appears to be adequate to satisfy these requirements within the display size, viewing distances, and visual acuity constraints of the display/observer interface and the limitations imposed by the sensors. Resolution on the order of 1000 lines is within the state-of-the-art, but may not be cost-effective for most applications, particularly when considering the storage capacity required to preserve the image.

The prime viewing surface available to the offensive operator will characteristically present sensor derived information, suitably processed for CRT display, and overlaid with sym-

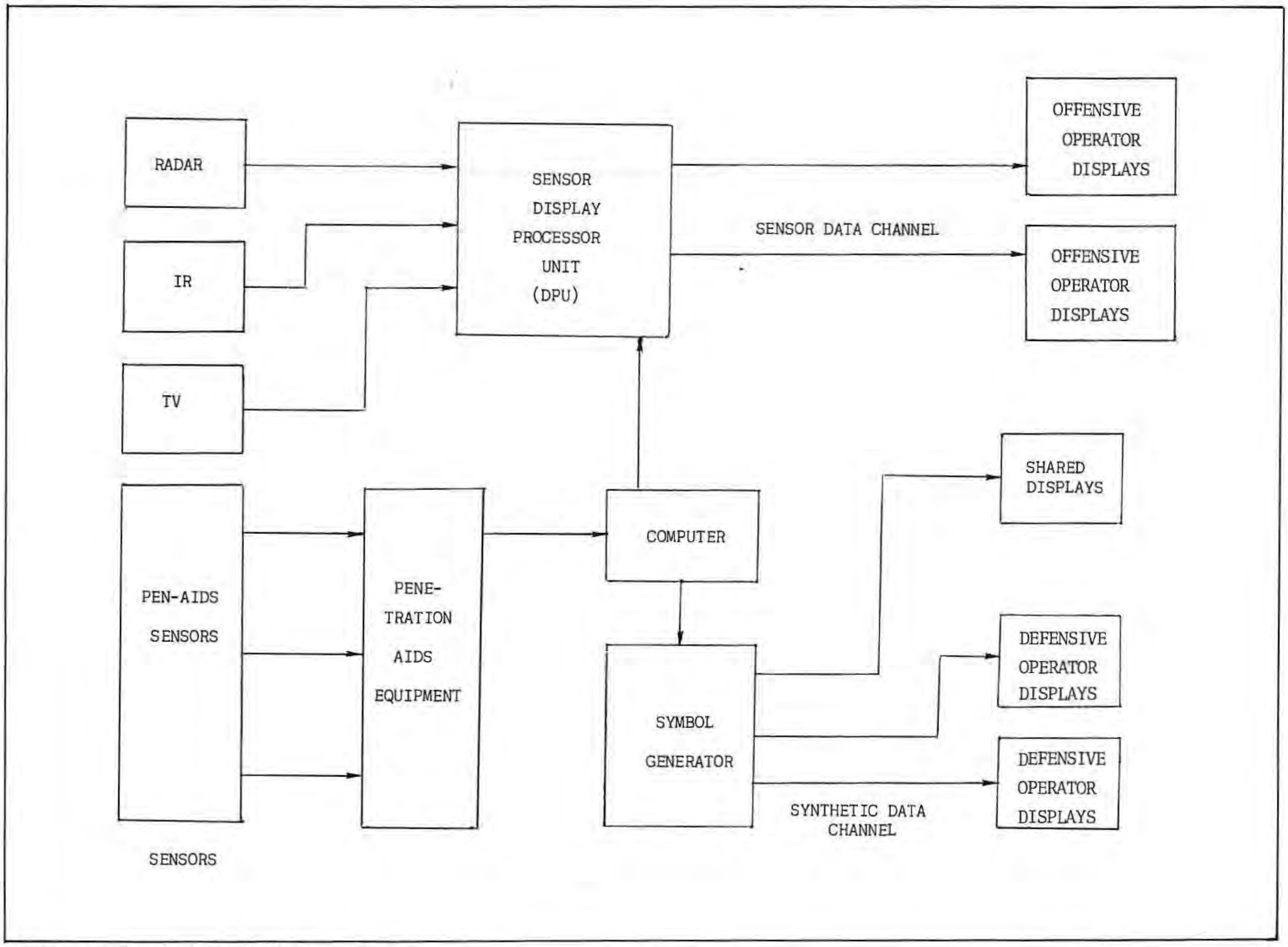

Figure 1: Integrated avionics displays flow diagram.

bology as selected to indicate priority threats, flight path, cursors, and position coordinates. The defensive operator must characteristically view threat situation data in symbolic format against a background representing the surrounding air and ground environment. Threat type, categories, and range of interest are operator selectable. Auxiliary displays are provided both operators for the presentation of supplementary data and to act as backup for the primary display. These auxiliary surfaces are utilized to show alternate sensor presentations, written instructions or routines, numeric readouts describing selected parameters, or data concerning status of selected systems or functions. The various modes of operation are manually initiated via selections adjacent to the viewing surface, or may be automatically selected in accordance with preestablished routines.

The reliability and flexilibility available from this arrangement assures compatibility with operational requirements for backup capability and operator task-sharing.

Display Processor Unit (DPU)

The DPU comprises the sensor data processing center for the avionics displays. Its function is to accept data from the sensors in a variety of forms and prepare it for CRT presentation in a comprehensible format with a minimum loss in information content. The DPU must refresh the display within the flicker fusion envelope and be capable upon external command of freezing sensor data inputs. These requirements dictate the basic functional elements of the unit, i.e., a high capacity bulk storage capability with flexible input and output formatting modules. Digital mechanization appears to offer the greatest promise for meeting typical requirements of accuracy, flexibility, reliability, and resolution. Trends toward radar preprocessing associate digital outputs from the sensor complex with high resolution modes. In addition the intrinsic reliability and noise immunity of digital systems appears more attractive for most applications.

Of the available alternates to digital mechanization of the DPU, the scan converter tube and the direct view storage tube have been considered in detail. Of this latter option, the most outstanding candidate appears to be a four-gun device accommodating flood, write, selective erase, and write-through functions through the use of separate elements. Off-axis electron optics and multiple field interactions, however, currently degrade cursor positional accuracy beyond the limits of standard operational requirements. In addition, electrostatic storage mesh energy requirements limit maximum write rates to about 70,000 in/sec precluding direct freeze of high resolution TV and IR presentations.

The scan converter tube is also regarded as less than optimum for this application due to the highly inflexible design tradeoff framework the available hardware imposes. Unavoidable storage mesh non-uniformities restrict the range of charge density in providing for requisite brightness variation, resulting in inherent dynamic range limitations. In addition, long term storage requirements are incompatible with dynamic high-speed selective erase modes.

Among the available digital mechanizations, the leading contenders appear to be rotating electromechanical memories (magnetic drum or disc) and discrete element arrays consisting of MOS shift registers. The drum approach offers a low per-bit cost which becomes attractive for high capacity systems. The fixed speed and limited periodic access nature of the device imposes problems in formatting the data for CRT presentation, however, and requires the design of a fairly complex input buffer to bridge this incompatibility. The MOS mechanization affords a high degree of flexibility in memory organization, and can be cycled over a range of clock speeds to accommodate the diverse requirements of the sensor input formats. In addition, MOS designs appear more attractive from the standpoint of reliability when contrasted with the single point failure vulnerability of the mechanical device.

MOS per-bit costs, however, are currently on the order of 1 or 2 orders of magnitude higher than drum costs. While the prognosis is encouraging, it is doubtful if MOS memories will cost competitive in the near future for capacities in excess of 1.5×10^6 bits. This conclusion is derived from consideration of candidate designs comprising fixed costs relative to packaging and peripheral circuits and variable costs as a function of memory capacity. Figure 2 illustrates this case for one specific mechanization.

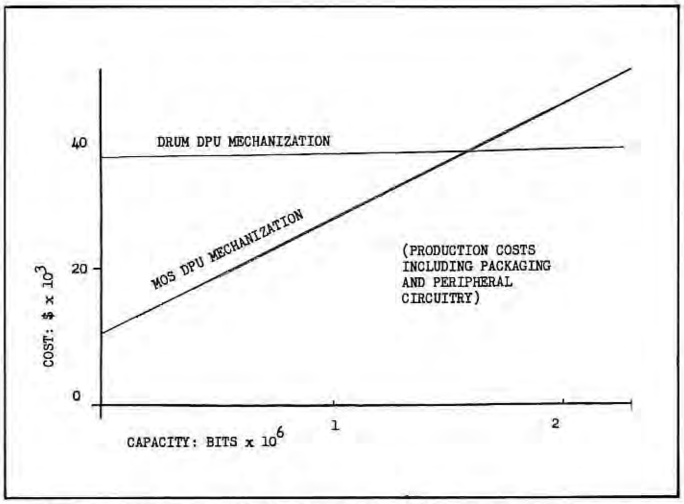

Figure 2: Comparison of MOS vs drum display processor costs for one specific candidate mechanization.

Basic functional elements of the DPU include the main memory and associated input and output buffers. Additional functions include precision cursor implementation, data compression and expansion, self-test and reporting, analog-digital data conversion, and basic timing elements. The adoption of a digital mechanization offers the advantage of precise insertion of the cursor symbol into the quantitized data, reducing the one sigma error below the level of digital resolution. In one candiate mechanization the symbol is positioned by a computer controlled index register. As the operator moves the cursor across the display, outputs are fed to the central avionics computer, which notes current address and controls the register. Comparators detect coincidence of the index and the DPU video, and route high intensity instructions to the output buffer superseding the stored data at the cursor location.

Compression of intensity data appears to be a prequisite for any digital DPU mechanization in order to bring the design to a point of optimum cost effectiveness. Drum designs require compression to reduce the number of read-write heads and data channels. The MOS implementations undergo a 30 percent reduction in memory parts-count when using standard data-compression techniques. The method involves the derivation and storage of intensity differences rather than utilization of the absolute level of signal amplitude. The data is reconstituted in approximately original form prior to display.

The variety of compression schemes that have been advanced can be ordered in a hierarchy of fidelity of reconstructed presentation, with increasing cost running roughly in the same direction. A popular scheme (delta modulation) encodes the $\log_2$ of the difference between successive picture elements. The rationale for this approach is based on the eye's

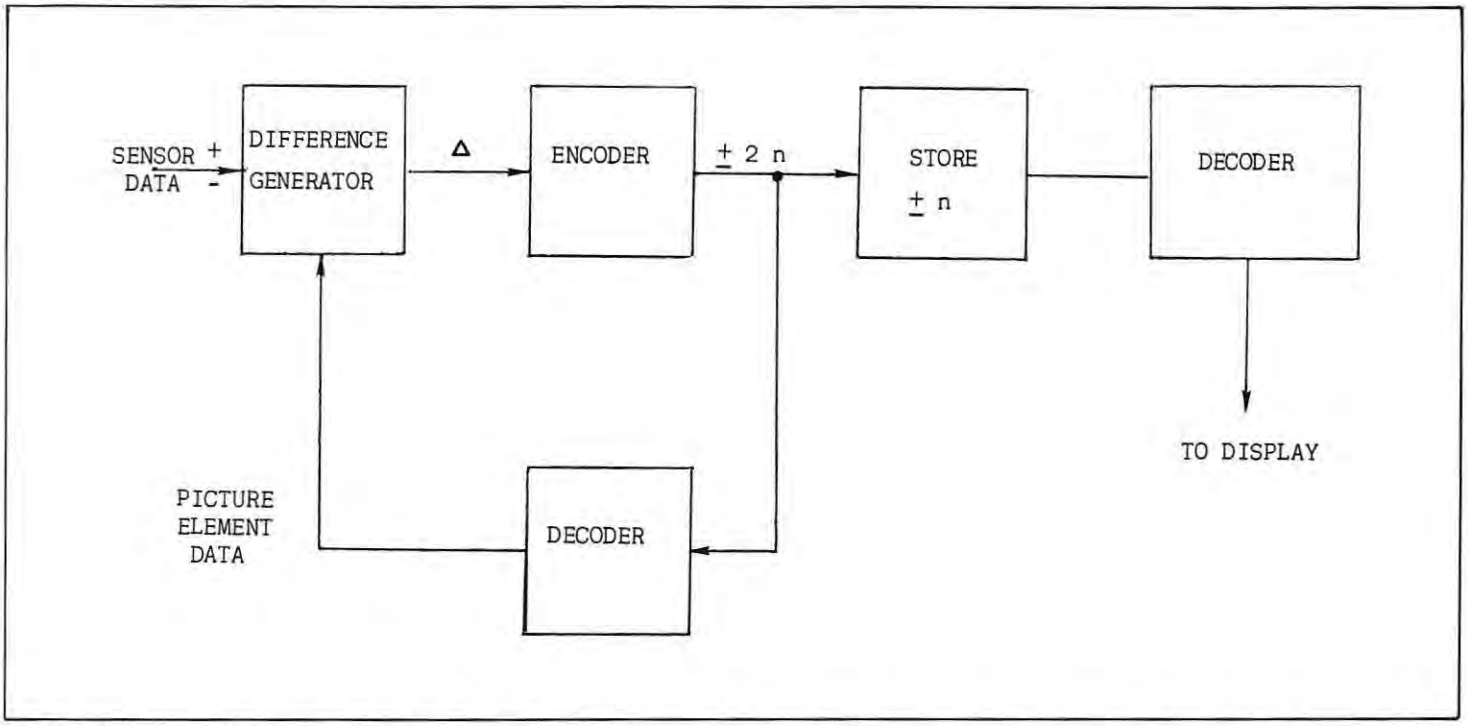

Figure 3: Delta modulation compression scheme.

sensitivity to intensity differences and its log response characteristic. The encoded data is limited to 3 bits to minimize storage capacity, thus restricting the ability of the system to respond with precision to large intensity changes. Discrepancies are resolved in succeeding iterations, however, and the effect minimized by the eyes accentuation of the leading edge of the step. A fourth bit is added to carry the sign of the change. To prevent errors from propagating, the memory is reset each line during horizontal retrace. A block diagram of the scheme is shown in Figure 3. While more complex approaches are available, the cost effectiveness of the additional circuitry involved is questionable. Operational simulations using human subjects are recommended to judge the efficacy of these designs and generate the data required to arrive at an optimum configuration.

Synthetic Data Channel

Symbolic information representing threat type, location, and lethal range must be provided to the defensive operator to assist in the task of threat avoidance, degradation, or destruction. An adjacent display surface is utilized to provide data regarding the automatic countermeasures employed against priority threats. The observer can alter the mode of defense as desired through keyboard entry located on the console. The revised message is then displayed, verifying computer acknowledgement of the change. Symbolic formats are also used to indicate the type and status of on-board weaponry for the advisement of both offensive and defensive operators. Any of these displays can be selected on any display surface, affording a maximum of operational flexibility and task-sharing capability among the crew members.

This extensive use of symbolic data imposes requirements, directly or indirectly, on all segments of the display system. Maximum symbol display requirements are determined from the ability of the operators to derive meaningful information from a cluttered display representing a dense threat environment and by the definition of optimum formats for the presentation of tabular data.

Other considerations involve development of a symbol repertoire acceptable to the user and possessing the characteristics of legibility and intrinsic information content. A font must be derived to yield a maximum of discriminability while avoiding excessive CRT deflection bandwidth requirements associated with highly complex characters.

High quality symbology may be generated on the face of the CRT's by linear Class A beam deflection techniques. These symbols are written in calligraphic style much in the same manner as a pen is used to form English language script. Calligraphic techniques are a natural fallout of the flexible sensor display format philosophy which initiated the requirement for Class A deflection. The absence of a standard raster precludes the generation of overlay symbology through precision timing of beam unblank signals (i.e., in-raster symbol generation techniques) and forces the choice of stroke symbology for all symbol presentations.

Certain advantages are inherent to stroke symbology, including greater legibility and flexibility and simplified circuitry associated with the symbol library. Calligraphic writing is insensitive to interlace jitter and small symbols are not constrained by the inherent limitations of raster geometry. Hardware requirements tend to be somewhat simpler and are not sensitive to precision timing and delay problems peculiar to in-raster symbol generators.

Disadvantages of the calligraphic approach center around high power requirements and basic limitations in CRT beam deflection bandwidth capability. Care must be used in equipment design to minimize power consumption and provide adequate cooling to the hardware enclosure. Bandwidth limitations may be attacked from several viewpoints, including the use of specialized coil design techniques.

Moderate to low ambients in the crewstation environment make the eye sensistive to flicker and require the symbols be refreshed 50-60 times a second. A message comprising some 400 characters for example allots an average time per character of about 40 μsec including beam positioning and setting time. Tabular data presentations may be written position sequentially in a fixed page format, minimizing positioning times. Threat situation information is positioned randomly, however, and involves requirements for long position and settling times. Consideration must be given to tradeoffs between the high power required for fast deflection and the additional size and weight associated with a vernier write coil. This latter arrangement involves the use of two separate electrically isolated deflection coils per CRT gun to simultaneously accomplish rapid, large deflection excursions, and accommodate the precision required for high resolution calligraphic symbology. The main coil positions the beam (using moderate power) and the index point, where a vernier low inductance coil moves the beam rapidly to write the symbols (the main coil is also used to generate the various sensor displays and write the required vectors).

The Symbol Generator Unit (SGU) accepts computer derived data regarding symbol type, size, position, orientation and destination and converts the information to beam deflection instructions appropriate to the CRT of interest. The information may be transmitted in analog (x, y, z) format provided line lengths are short and the local EMI environment is not severe. Digital transmission is less sensitive to noise, but requires the installation of high speed A/C converters at each display destination.

Buffers must be provided to store the computer messages and provide the refresh capability to maintain a flicker-free display. Since the computer instructions consist of significantly fewer words than the complex beam deflection instructions, the refresh buffers are located upstream of the symbol library, requiring, in effect, a dedicated library per display. This arrangement is shown in Figure 4. Since the buffers comprise a large fraction of SGU cost and bulk, a desirable option involves utilization of the computer memory to provide the refresh function, effectively updating every symbol at the refresh rate. Computer cycle stealing considerations must be traded off against this option, however, and may well preclude its adoption.

A number of symbol generator mechanization schemes are available. A 16 dot matrix can be used to represent stroke termination points, readily identified by incremental instructions of 0, 1, 2, or 3 bits in x and y directions. Strokes may be generated in sub-microsecond periods, and joined at these points in sequence to form the desired character. An alternate scheme involves the positioning of the beam through a predetermined course with unblanking at critical points in the matrix. Simple patterns have been proposed, yielding stylized characters at minimal expense. Human factors considerations require at least 16 stroke options be available, however. Characters thus generated offer few ambiguities, but legibility is less than optimum. The nature of the threat display function requires all commanded symbology be presented to the operator without error. Failure to display threat information or the display of misinformation may have serious consequences and requires the use of redundancy and self-test techniques in the design of the hardware. Redundant libraries are recommended, with automatic switching effected in the absence of positive self-test results. Several alternates are possible, including the periodic presentation of the entire repertoire to the operator for examination.

Displays in the Radiation Environment

The avionics displays must be designed to meet system specification requirements for the nuclear environment. Computer/display interface activity is suspended during critical periods and controls are required to maintain the selected state during this time. Control panel input/output logic and mechanization circuitry must be designed and components selected to meet this criterion. Temporary loss of the display presentation for a period of less than 16 ms will not be detected by the eye.

Specific areas of concern are limited to the physical aspects of the cathode ray tube (in particular the phosphor screen), MOS circuit mechanizations, and general requirements attendant to the Electromagnetic Pulse (EMP) environment.

The relatively low ionizing deposition rates of the prompt and delayed ionizing radiation do not seriously degrade CRT performance. Tests indicate the prompt gamma pulse causes CRT phosphors to emit a rather subdued, extremely fast flash of light which does not interfere appreciably with the observer's mission performance. The total ionizing dose may result in a 10-20 percent decrease in light transmission of the faceplate. This loss is comparable to that sustained during the normal CRT lifetime due to the action of the electron guns. In addition, radiation received while examining targets previously

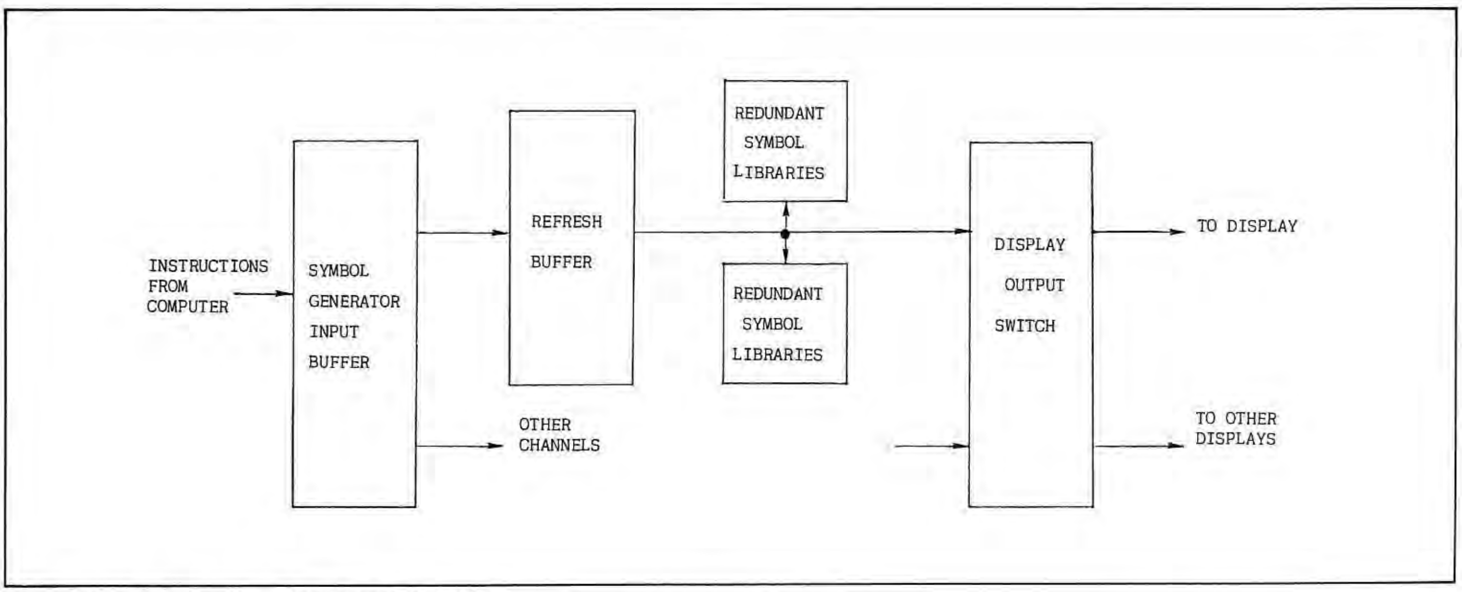

Figure 4: Symbol generator – internal refresh option.

subjected to nuclear attacks may be sufficient to cause loss in contrast if targets are examined too close and too soon after a nuclear strike.

CRT phosphors are considered relatively insensitive to neutron bombardment due to the noncrystalline structure of the material. Fluence levels are significantly below the levels required to cause the coating to flake off the inner surface of the CRT face. Thresholds for damage to CRT glass and internal electron optics components are well above anticipated dosage.

EMP's may penetrate the interior of the device but will be appreciably attentuated by the presence of electrically conducting panels in the vicinity. Additional protection will be provided by the addition of magnetic shielding around the backside of the CRT. Higher frequencies may penetrate, inducing small voltages and/or currents in the interior conductors, causing temporary spurious beam deflections. The internal elements, including cathode, gun, and supporting structure are too small to pick up much signal, and are ordinarily capable of withstanding much larger signal than those induced.

MOS hardware is currently under consideration for the display processor main storage block, as well as for the associated buffers. Major stores in other components, in particular the refresh buffers in the symbol generator, are envisioned as MOS shift registers. These devices are relatively resistant to neutron radiation, but may be damaged by exposure to ionizing radiation. The major effect is an increase in the gate threshold which is cumulative with increasing dose and is dependent on gate bias applied during irradiation. Tests conducted on typical MOS transistors indicate a worst case shift of less than 1 V at dose levels comparable to upper limits for manned systems. Well designed digital circuits should accommodate this change with no significant performance degradation. MOS components utilized in linear applications must be reviewed carefully for susceptibility to the ionizing radiation environment. Transient effects may prove to be of more significance, generating photo-currents at the source and drain pen junctions of MOS transistors.

The EMP problem is offset by the incorporation of total cable shielding including connector conductive finish and shield-to-connector bonding. Equipment housing is conductive and capable of bare metal-to-metal contact with the connector.

Conclusion

High performance military aircraft designed to negotiate complex flight profiles using precision all weather navigation, counter sophisticated enemy defenses, and accurately deliver weapons pose a specialized set of problems to the display systems designer. While it is not possible to outline all of the engineering tradeoffs associated with this design area, this discussion should serve to illustrate the complexity of the system and the ramifications of early engineering decisions. Trends are evident in the choice of digital techniques both for data transmission and processing, in the adoption of high speed CRT's for versatile and flexible employment of data display mode options, and in the use of linear Class A deflection techniques to preserve sensor presentation information content and generate symbols of superior legibility. It is also evident that the necessity for initially considering the avionics system as an integrated unit will result in a display subsystem optimized for cost-effectiveness. ■

John Frost and Norman Sullivan are with Autonetics of North American Rockwell, Anaheim, Calif.

ID Readout

Computer and Data Exhibition

More than 60 United States manufacturers of computers, peripheral equipment and related electronic gear have applied for participation in an exhibition exclusively for U.S. made computers and data equipment to be held in Moscow, April 10-18, 1972. The exclusive showing of the data processing and communications equipment has been arranged by International Media and Exhibits Inc., Newark, N.J., in cooperation with the Foreign Trade Ministry and government purchasing agencies of the U.S.S.R.

Equipment to be shown will include: general purpose digital computers, data communications terminals, facilities and processing equipment, graphic data systems, hybrid and analog computers, internal memory systems, peripheral systems and semiconductors and MSI circuits.

Further information about the exhibition is available from Melville Morris, International Media and Exhibits Inc., 231 Johnson Ave., Newark, N.J. 07109, or call (201) 242-3320.

CADEX '72

Following the conference and exhibition held in 1969 on the subject of computer aided design, it was generally acceded by all who took part that another such event be planned. This even is now being organized and will take place at Southampton University April 25-28, 1972.

The exhibition will be housed in the electronics block and associated buildings. The scope of the exhibition will cover all aspects of engineering-oriented computer programs intended as an aid to design processes in spheres of electrical/electronic engineering covering the range from power to circuit applications and mechanical engineering for both machinery and structure.

Inquiries and application forms for space should be directed to the Information Office, Electronic Engineering Assn., Leicester House, 8 Leicester St., London WC2H 7BN. Conference information can be obtained from Ann Cook, Conference Dept., Institution of Electrical Engineers, Savoy Pl., London WC2R OBL, England, or phone 01-240-1871.

NMA Seminar

Six industry spokesmen will assume the seer role to launch the educational aspect of the National Microfilm Association's 21st annual convention May 9-12, 1972, in New York City.

In a theater-in-the-round setting, seminar chairman George Bernstein's lead-off program will focus attention on the future immediately ahead. Participants in the unstructured, unrehearsed, give-and-take session will include Ian Mallender, David R. Wolf, Milton Mandel, Allen Veaner and Franklin Bolnick. Moderating the program will be John R. White.

On Tuesday, May 9, an issues and answers seminar will take place in the morning, and a seminar on basic microfilm technology will be conducted in the afternoon. On Wednesday morning, May 10, there will be seminars on systems analysis, new developments in film technology, microfilm marketing techniques, microfilm as a mass medium and microfilm in the classroom. Afternoon seminars will include micropublishing, systems design, large scale production, data handling, and spectrum of the reader. Thursday, May 11, will offer computer animation, computer output microfilming, standards, trained manpower, real time vs on-time, and microfilm in research libraries. On Friday, May 12, four workshops will be conducted: storage and retrieval, scientific and engineering uses, office records and computer output/computer input microfilm.

For further information write to the National Microfilm Assn., Suite 1101, 8728 Colesville Rd., Silver Spring, Md. 20910.

Joint Computer Conference

Computer specialists and EDP users from the U.S. and abroad will convene in Atlantic City, May 16-18, for a review of recent developments in computer technology and expected trends for the 1970s. Sponsored by the American Federation of Information Processing Societies (AFIPS), the 1972 Spring Joint Computer Conference will be held in the Atlantic City Convention Hall.

According to Dr. Jack Bertram, Conference general chairman, the program will include 37 sessions covering innovations and state-of-the-art in computer hardware, software, systems and applications. The program has been structured to allow the attendee maximum flexibility in selecting sessions relating to his specific needs. Whether he elects to register for the entire three-day program, or selects the one-day registration, he will be able to choose from a variety of sessions designed to keep him abreast of the latest developments in his areas of interest.

The program has been divided into six general categories: general applications, scientific applications, general and special purpose hardware, programming and software, computer education and computer theory and administrative issues. Included are 130 formal presentations supplemented by panel sessions.

For further information, including pre-registration and housing forms, contact AFIPS at 210 Summit Ave., Montvale, N.J. 07645, or phone (201) 391-9810.

INTERACTIVE GRAPHICS—Continued from page 20

Summary

The ACMR promises to set an entirely new direction for combat pilot training. In recent years, the bill for pilot training for the U.S. military services has come to well over $2 billion a year.* Such rising costs and budget scrutiny of them have resulted in training cutbacks which serve to make pilots much less confident of their ability in the aircraft. The economical attempts to remedy this situation have largely been confined to using simulators, which, though marginally effective, are really technological training products of the 1960's. The ACMR harnesses the electronics and computer display technology of the Seventies to the task of controlling the spiraling costs of weapons training and it promises to be an effective tool in producing capable instructors and skilled pilots.

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**Rand Symposium on Pilot Training and the Pilot Career: Final Report*, December 1970, p 3.

Kevin J. Kinsella is Applications Engineer at Adage Inc., Boston, Mass. Mr. Kinsella received his M.A. in International Relations from John Hopkins University, Washington, D.C., and his B.S. in Management from the Massachusetts Institute of Technology, Cambridge, Mass. Previous to his employment at Adage, he was a research writer for Stockholm International Peace Research Institute, a mathematics teacher for the American Community School, Beirut, Lebanon, and did systems research in the Factoring Department for the First National Bank of Boston.

Andrew J. Matthews is the Project Leader at Adage Inc., Boston, Mass., responsible for the design and development of the 3-D displays for the ACMR system. Mr. Matthews received his B.S. in Engineering from Boston University, and joined Adage in 1969 after working on computer applications in the U.S. Navy. His previous projects have included a 3-dimensional drawing and editing system, a contour map display and editing system, and a variety of real-time simulation displays.

New Literature

Magnetic Shielding

An eight-page two-color catalog has been issued by Ad-Vance Magnetics Inc., Rochester, Ind., describing its facilities and products. AD-MU magnetic shielding materials and components described include seven types of round tape data protectors and seven types of square tape data protectors; 312 types of quality magnetic shields for photomultiplier tubes; a table of physical characteristics of AD-MU shielding alloys and available dimensions of these alloys; and a description of the various steps in fabricating AD-MU alloys.

Circle Reader Service Card No. 9

Health Care Services

"Patient Monitoring" and "Frontiers in Health Care," two brochures describing Xerox Data Systems' products and services for the health care industry, are available from XDS, El Segundo, Calif. "Patient Monitoring" explains where XDS computer-based monitoring systems can be applied, the types of physiological signals they can monitor and the beneifts of using these systems. The other brochure describes Xerox computer applications in the areas of hospital services, administration and health care, including examples of computer-assisted ECG analysis and clinical laboratory automation techniques.

Circle Reader Service Card No. 10

Display/Memory Units

An illustrated brochure describing their line of Digivue display/memory units has been issued by Owens-Illinois Inc., Toledo, Ohio. The brochure discusses such features as inherent memory, selective write, rear projection and hard copy potential. Also provided is a description of available size and resolution characteristics. Photographs show suggested applications for the display/memory units. Illustrated descriptions of the first three available modes, a schematic diagram and discussion of the operating principles of the Digivue display/memory technique also are included.

Circle Reader Service Card No. 11

Neon Indicator Lights

A catalog describing a line of neon indicator lights for warning devices has been published by Dialight Corp., Brooklyn, N.Y. The catalog (L-211) lists snap-in mounting lights of both flashing and permanent type. Designed for operation on 110-125 VAC, the lights flash at a nominal rate of 130 flashes per minute. Dialight claims that complete information on size and mounting of the indicators is given. Ordering information includes choice of black or gray bezel with red, yellow (amber) or white transparent lenses. The lights are supplied as sealed units containing all necessary components and circuitry on a printed circuit board. The end of the board extending from the back of the unit has eyelets for soldering connections. The styling of these indicators makes them suited for applications in warning systems where space is at a premium.

Circle Reader Service Card No. 12

Light Sources

Dr. John F. Waymouth of GTE Sylvania Inc., New York, N.Y., is the author of "Electric Discharge Lamps," a book on light sources. Mathematical formulas, chemical equilibriums, types of electrodes, reignition voltages, measures of thorium removal rates, arc-tube geometry, temperature variations, evaluation of theory, and electrolysis are some of the subjects covered. Dr. Waymouth discusses fluorescent lamps; high pressure mercury lamps; low and high pressure sodium lamps, and metal halide arc lamps, including the operating circuitry of discharge lamps.

Circle Reader Service Card No. 13

Pollution Monitoring

A multi-paged technical report, "Monitoring Environmental Pollution," is available in reprint form from Spatial Data Systems Inc., Goleta, Calif. Focusing on the Santa Barbara channel oil-pollution disaster, the report sets forth an economical way to scientifically monitor the aerial extent and amount of pollutants and, in addition, provide early-detection services. The article, co-authored by Dr. John Estes and Dr. Berl Golomb, presents enhanced images produced on Datacolor film reader system, a color densitometer which represents the density values of a given photograph as analog voltage levels of a video signal which can be displayed in color.

Circle Reader Service Card No. 14

Selection Guide

A six-page product selection guide covering highlight parameters on the company's standard lighted pushbutton switches and indicators, fiber-optic readouts, illuminated word indicators and unlighted switch assemblies is available from Master Specialties Co., Data Distribution Dept., Costa Mesa, Calif. The selection criteria are organized in tables and each product category is referenced to specific catalog numbers. Included in the selection guide are comparative design and performance data on some of the MSC lines.

Circle Reader Service Card No. 15

Officials Directory

The National Microfilm Assoc., Silver Spring, Md., has ready for distribution a directory of their officials. The directory lists names and addresses for all officers, directors, committee members and chapter presidents. The publication shows two more permanent and two more ad hoc committees than last year. The ad hoc committees created in the past year include one on Rehabilitation and one on Professional Certification.

Circle Reader Service Card No. 16

Information Systems

Computer Communications Inc., Culver City, Calif., announces the availability of a 16-page brochure that describes and illustrates its information systems, products and services. Each of the computer/communication systems and products discussed is accompanied by a description of the equipment together with pictures, diagrams and specifications.

Circle Reader Service Card No. 17

ID Products

Solid State Display

A seven-segment solid state display that requires low power and has a character height of 0.19 in. is available from the Monsanto Co., New York. The MAN 4 is claimed to provide a visible display with inputs as low as 1 mA and 1.65 V. The unit is a common-cathode device with a built-in red lens for improved contrast between the display and its package. The MAN 4 emits 400 fL at 10 mA per second. The display is contained in a standard, dual-in-line, 14 pin package which permits mounting on printed-circuit display boards. The dip configuration allows several units to be mounted with 0.35 in. center-to-center spacing. Applications for the MAN 4 include digital displays for desk calculators, instruments and portable equipment, as well as in film-annotation systems.

Circle Reader Service Card No. 18

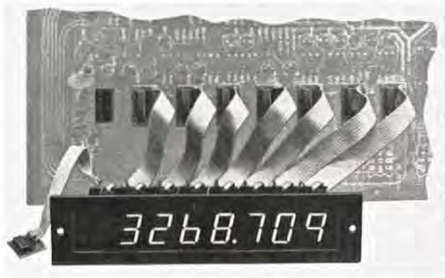
Digital Counters

Electronic Digital Counters, designed for industrial applications, have been introduced by Electronic Research Co., a Textron Co., Overland Park, Kans. The panel mounted counters, designated Series 2300, feature numerical displays and provisions for remote control and BCD outputs. The company states, both up/down and uni-directional units are offered with up to 6 units of display. The units are 3 lbs. with power requirements of 115V, 50-400 Hz and 5 watts.

Circle Reader Service Card No. 19

Display Interconnection

Industrial Electronic Engineers Inc. (IEE), Van Nuys, Calif., has developed a system interconnection feature for their bar segment displays.



An option ancillary to IEE's Series 1020, 1040 and 1060 incandescent lamp 7 bar segment displays, the feature consists of either 6 in. or optional lengths of flat flexible cable soldered (or fastened by a terminal) to the display's lamp assembly at one end and a circuit board adapter at the other. IEE says that the adapter board is configured to accept a choice of hybrid or monolithic driver/decoders in a DIP socket of the circuit board.

Circle Reader Service Card No. 20

Flight Information System

Dayton Communications Corp., Dayton, Ohio, introduces an airline flight information display system featuring a cassette tape system. According to Daycom, the information storage system needs only one operator for all controls including cassette control operation from a single keyboard. 500,000 character systems storage capacity provides flight schedules for up to 3,000 flights on a single cassette, the company says, and features automatic inserting of all new flights.

Circle Reader Service Card No. 21

Numeric Indicator

Hewlett-Packard Co., Palo Alto, Calif., offers their Model 5082-7300 Solid State Numeric Indicator. The display has its driver-decoder and memory along with 21 light-emitting diodes mounted on the ceramics substrate, the company claims, and can only be addressed with a 4-line, BCD positive logic input. Characters are 0.290 inches high and the displays come in a 0.4 by 0.6 inch, dual in-line package configuration.

Circle Reader Service Card No. 22

Advertisement Package

A software package for compiling newspaper classified advertisements has been announced by Digital Equipment Corp., Maynard, Mass., for the company's Typeset-8 computer-based typesetting system. The firm claims the program scans all advertisements on a character-by-character basis until a complete sort is achieved, then sorts and places each advertisement in proper sequence at the same time it is stored on magnetic tape. The unit is designated Classified Ad Storage II and accepts paper tape output from a DEC Typeset-8 hyphenation and justification program.

Circle Reader Service Card No. 23

Computerized Plotting Language

Tymshare Inc., Palo Alto, Calif., announces a non-programmer application language called EASYPLOT, developed to simplify computerized plotting. According to Tymshare, the language features program editing from an existing data file and/or the terminal with editing; the ability to plot data generated by programs written in any computing language; automatic, semi-automatic and manual scaling options; log, semi-log and linear scaling; and instructions for drawing grids and axes.

Circle Reader Service Card No. 27

Interactive Graphics Terminal

Princeton Electronic Products Inc., North Brunswick, N.J., announces the PEP-801 interactive graphics terminal. According to Princeton, the terminal, which utilizes the Lithicon silicon storage tube as a refresh memory, offers high density alpha-numeric (as many as 6,000 characters on a 14 in. screen), electronic zoom, selective editing of characters or vectors, high resolution vectors, long image retention and ability to refresh additional slave terminals.

Circle Reader Service Card No. 28

CRT Power Supplies

Venus Scientific Inc., Farmingdale, N.Y., has introduced a trio of high voltage power supplies said to fulfill the requirements of 95% of preci-

sion CRT display applications. These units, designated: D-16, an adjustable anode supply 8-16 kV @ 1 mA; E-10, a 0-1 kV @ 10 mA focus supply; and E-30, a 0-3 kV @ 5 mA focus supply, are regulated dc to dc converters featuring 100 PPM stability. According to Venus, input power requirements are +24 to +31 Vdc, and all power supplies will regulate to .003% for variations over this range.

Circle Reader Service Card No. 29

Mini-Computer Printer

The Shepard Div. of Vogue Instruments Corp., New York, N.Y., introduces the 880E, a printer designed to meet mini-computer printing requirements. The company claims the unit is intended for both on-line and off-line applications, has a full line 80 character buffer and has a speed of 400 lines a minute at a print line width of 80 characters. The system includes IC Logic and MOS memory and can be installed in mini-computer locations.

Circle Reader Service Card No. 30

Top-of-Page Formatting

Versatec Inc., Cupertino, Calif., offers electrostatic printers with top-of-the-page formatting on fan-fold paper. According to Versatec, top-of-paper formatting increases the effective operating speed of the Versatec Matrix 300 printer by providing rapid paper advancement at the end of text, and enables matrix printers to produce standard 8½ x 11 in. formatted pages. The Matrix 300 prints at 300 lines per minute and has over 3 ips slow speed and produces 80 characters per line on 8½ in. wide paper.

Circle Reader Service Card No. 31

Fiber-Optic Readout

A miniature 7-segment readout with a fiber-optic dot pattern character has been announced by Master Specialties Co., Costa Mesa, Calif. The company claims Model 903 readouts are housed in precision molded enclosures, utilize 30-mil diameter optical fibers to transmit light to the 0.32 high by 0.19 wide character pattern, have individual standard plug-in bulbs to simplify maintenance and crimp type connectors to permit fast panel wiring.

Circle Reader Service Card No. 32

Data Modems

Phonocopy Inc., Stamford, Conn., announces the introduction of a series of digital and analog data modems, designated the PH4000 Series; the family includes the 4000 A (analog version), the PH4000SD (synch digital), and the PH4000ND (non synch digital). According to Phonocopy, the models are designed with an automatic gain control which compensates for line attenuation, and specifically for the transmission of pictorial information. The units are compatible with Western Electric Series 500 hard sets, DAA hard wire for DDD lines or hard wire to leased lines.

Circle Reader Service Card No. 33

Numeric Display

The Microwave and Optoelectronics Div. of Fairchild Camera & Instrument Corp., Palo Alto, Calif., offers a solid-state six-digit numeric display – the FND21. The model has individual monolithic digits, with decimals after each, on a common ceramic substrate. The unit can be plugged into standard DIP sockets or soldered to a pc board. The FND21 is designed for multiplex drive applications only. Said to be IC compatible, the product houses six digits, and power usage is less than 5 mA per segment at 1.8 V. The characters are .122 in. in height and feature a viewing angle of 160°.

Circle Reader Service Card No. 34

CRT Terminal

The introduction of a message-oriented CRT computer terminal has been announced by the Interactive Terminals Corp., a subsidiary of The

Bendix Corp., Southfield, Mich. The Model 4390 Communications Terminal is compatible with teletypes and has an on-site editing capability. Features include the following: an alphanumeric keyboard; numeric key pad; non-glare, 40 or 80 character/line display; switch-selectable transmission control; multiple interface capability; protected formats, field data manipulation, tabbing and line and character insertion/deletion, according to the company.

Circle Reader Service Card No. 36

Communication Terminal

Computer Communications Inc., Inglewood, Calif., announces the CC-30 Communications Station, featuring the capability to generate and display the full APL Character Set on a standard black and white or color television set. The company states, the units consist of a CC-300 TV receiver, a CC-301 TV Display Controller, a CC-302 Telephone Coupler or Dataphone Interface and a CC-303 APL Keyboard designed to resemble a common APL keyboard.

Circle Reader Service Card No. 37

Macro-Assembler

A relocatable macro-assembler for minicomputers has been introduced by Proprietary Software Systems Inc., Los Angeles, Calif. Designated Mini-Dual, the company claims the software will operate in extremely small memory environments — as low as 8K bytes. The unit includes external symbols, relocation, data definition directives, macro definition directives and intrinsic functions to scan arguments of source statements.

Circle Reader Service Card No. 38

Solid State Light Diode

Bowmar Canada Ltd., Ottawa, Ontario, Can., announces a line of solid state devices. The firm says red light emitting diodes emit a visible radiation when biased in the forward direction, and are available with typical intensities of 300 ft. Lamberts at 20ma. The devices are available in standard TO-18 or lead frame packages with plastic lenses and are suited for pilot lights, indicator lamps and point light sources.

Circle Reader Service Card No. 39

Correspondence

Nov/Dec Issue

Sirs: I liked the Nov/Dec article on plotters.

P. Campoli
MIT
Cambridge, Mass.

Sirs: The article on "Discernibility of CRT Gray Shades" in the Nov/Dec issue was very informative.

J. Gailhard
Norden
Norwalk, Conn.

Sirs: I was very pleased with your articles on display fonts and gray shades.

E. Potter Jr.
Norden Div. UAC
Norwalk, Conn.

Starting the New Year

Sirs: The technical content of the articles "An Autostereoscopic Three Dimensional Display" and "Transparent, Conductive Coatings of Indium Oxide" were excellent and timely — a good way to start the new year!

K. Wadman
Mitre Corp.
Bedford, Mass.

Sirs: I liked the article about three-dimensional displays in the Jan/Feb issue.

A. Bell
Hughes Aircraft Co.
Oceanside, Calif.

Sirs: I was delighted with the guest editorial and the article on "An Autostereoscopic Three Dimensional Display" by Stover in your Jan/Feb issue.

F. Lewis
James Millen Mfg. Co. Inc.
Malden, Mass.

Good Work

Sirs: I think your articles are great. Keep up the good work.

H. Peprnik
Ferranti Packard Ltd.
Toronto, Canada

Sirs: The articles in the Nov/Dec issue were very good as usual.

C. Messer
NASA
Marshall Space Flight Center, Ala.

Sirs: All I can say is "Very good!"

S. Ostu
Fujitsu Ltd.
Kawasaki, Japan

Sirs: Your publication is generally very good.

T.W. Kaplan
COM Display Systems Co.
Lowell, Mass.

Advertising

Sirs: A breakthrough in trade publication advertising! You have the honor, as far as I know, of being the first trade magazine to show a woman nude from the waist up — and on the editorial page, no less. (I like your choice of editorial headline.) Hugh Hefner, watch out!

E.W. Lord
Burroughs Corp.
Plainfield, N.J.

[Research-minded readers who may have missed our Nov/Dec '71 issue, referred to above, may order a copy (while the supply lasts . . . it's fast becoming a collector's item). The unintentionally risque headline cited by Mr. Lord reads, "Unified Display Measurements." — Ed.]

Sirs: I enjoy each issue of *ID*, and I particularly enjoy the ads.

J.B. Allen
Texas Instruments
Dallas, Tex.

We Want More

Sirs: There are not enough technical articles in *ID*. I also think your print has poor readability.

G.R. Spencer
Raytheon Co.
Quincy, Mass.

Erratum

Sirs: Recently, the guest editorial on p 8 of the Jan/Feb issue was brought to my attention. In describing a series of inventions in the display field, the author lists "charactron" in an apparently generic manner without capitalization or other trademark identification.

I am sure that the failure to properly identify "Charactron" as a trademark was inadvertent, since other trademarks mentioned in the editorial were capitalized. However, it is important that the trademark be used properly since excessive use in a generic manner could cause a loss in value of the trademark, which is a valuable company asset.

J. Duncan
Stromberg DatagraphiX Inc.
San Diego, Calif.

Advertisers

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256-character display subsystems are available from stock for immediate delivery. Call or write Burroughs Corporation, Electronic Components Division, Box 1226, Plainfield, New Jersey 07061, Phone: (201) 757-3400. Ask to have a Burroughs sales engineer stop by your office and show you his 256-character SELF-SCAN panel, keyboard, and power supplies packaged in a standard Samsonite® briefcase.

Burroughs