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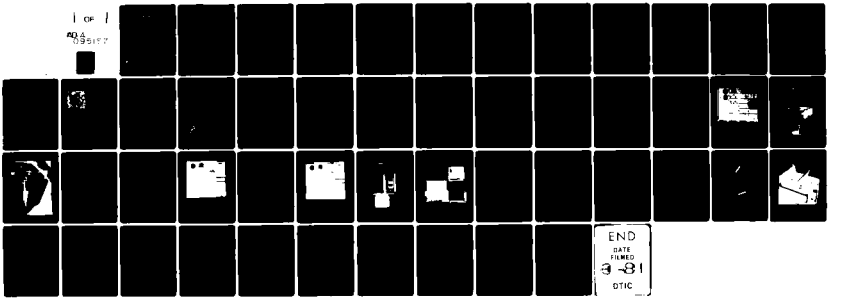

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DEVELOPMENT OF HIGH SPEED CRT PRINT HEAD SYSTEMS FOR CARTOGRAPHIC APPLICATIONS

Image Graphics, Incorporated

107 ARDMORE STREET, FAIRFIELD, CT. 06430

15 FEBRUARY 1980

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Prepared for

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
Fort Belvoir, Virginia 22060

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The CRT 2000 Print Head System is a high speed, large format, flatbed plotter photocomposition system developed for the Defense Mapping Agency (DMA) to produce color separation film masters for maps and charts from digital names/symbols and cartographic data. The color separations are used to prepare press-ready printing plates for conventional multi-color

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printing presses for the printing of color charts and maps.

Three engineering models of CRT 2000 Print Heads were developed, installed and integrated with government owned Plotter Tables at the Defense Mapping Agency's Hydrographic, Topographic and Aerospace Centers located in Washington, D. C. and St. Louis, Mo. respectively.

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Preface

The work described in this report was authorized by the United States Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, 22060, under Contract No. DAAG53-76-C-0182 and was conducted by Image Graphics, Inc. under the direction of Patrick F. Grosso with Andrew A. Tarnowski serving as the Program Manager.

The contract was performed under the technical direction of the Automated Cartography Branch, Mapping Developments Division, United States Army Engineer Topographic Laboratories under the direction of Howard Carr. John Garlow served as the Contracting Officer's Technical representative.

The following individuals made significant contributions to the success of this program.

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Mike Beno
John Breslawski
Eugene Gostomski
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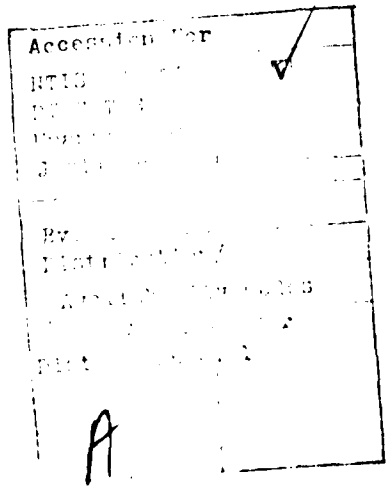

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1.0 Introduction

The CRT 2000 Print Head System is a high speed, large format, flatbed plotter photocomposition system developed for the Defense Mapping Agency (DMA) to produce color separation film masters for maps and charts from digital names/symbols and cartographic data. The color separations are used to prepare press-ready printing plates for conventional multi-color printing presses for the printing of color charts and maps.

Three engineering models of CRT 2000 Print Heads were developed, installed and integrated with government owned Plotter Tables at the Defense Mapping Agency's Hydrographic, Topographic and Aerospace Centers located in Washington, D.C. and St. Louis, Mo. respectively.

2.0 Technical Discussion

2.1 General Description of the CRT Print Head Systems

A typical CRT Print Head System consists of the following hardware and software:

Hardware:

- CRT Exposure Head
- CRT Electronics
- Symbol/Vector Generator
- Computer Controller
- Flatbed Plotter Table*
- Flatbed Plotter Controller*
- CRT to Flatbed Plotter Interface

Software

- Computer Controller Operating System
- CRT Plot Program
- CRT Font Librarian Program
- User's Font Library*
- User's Input Tapes in CRT Print Head Format*
- Conversion Programs for User's Standard Software
- Computer Controller Diagnostics
- CRT Test Mode
- Plotter Table Software*

2.2 Modes of Operation

The CRT Exposure Head is employed to electronically compose a 2" x 2" area and project the resultant image on large sheets of photographic film (up to 48" x 60") cartographic data as illustrated in Figure 1.

The CRT Exposure Head mounted on the carriage of a flatbed plotter table exposes a 2" x 2" area of the film in a fraction of a second and then is moved and positioned to expose an adjacent 2" x 2" area. The process is repeated until the entire film sheet has been exposed to form a latent image of a map or chart.

The entire recording or plotting process for a 48" x 60" sheet, typically takes less than 30 minutes. The recording process may be 10 to 50 times faster than plotting with conventional photoheads depending upon information content of the map or chart to be plotted.

* Supplied as GFE by each of the DMA Centers

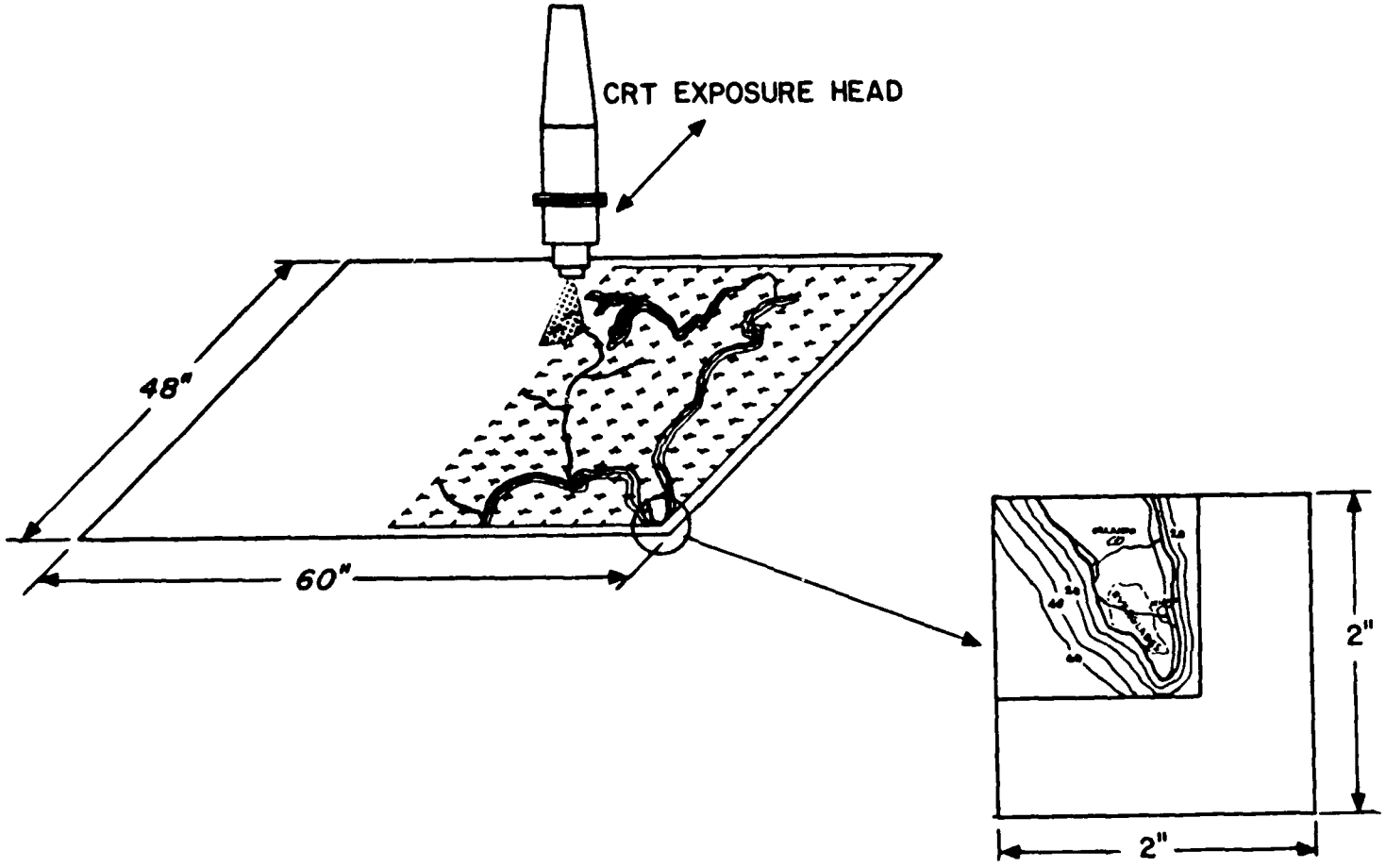

FIGURE 1 - OPERATION OF CRT PRINT HEAD SYSTEM

2.2.1 Typical Cartographic Output

Samples of the cartographic output from the CRT Print Head System are given in Figures 2a, b, c, d, e, f, g.

2.3 System Data Flow

Data flow for the CRT Flatbed Photocomposition System is illustrated in Figure 3.

Input data to the CRT Print Head Systems furnished on magnetic tape may be prepared in the CRT Print Head format with the user's host computer or may be the user's standard plotter production data tapes which can be converted in real-time or off-line using one of the software conversion packages developed for this contract.

The input data tapes, in addition to controlling plotting and names/symbol placement, also command the plotter to position the CRT Print Head, to areas on the film to be exposed.

The output is plotted directly on film with the CRT Exposure Head and/or displayed on the Tektronix 4014-1 Storage Display.

2.3.1 Line Work

The CRT Print Head System is capable of plotting variable line widths from .002" to 0.036" in .001" increments using incrementally plotted or stroke vectors which are .004" to 1.023" in length.

For plotting lines, arcs and contours, the input data files supply command codes to the minicomputer and the Symbol/Vector Generator for computing the position, the angle and the width of the florescent spot on the CRT face. Line work can be in incremental or stroke vectors depending upon the data content.

2.3.2 Names/Symbol Placement

The CRT Print Head System is capable of plotting graphic arts quality names and symbols of variable sizes from 4 to 72 points in 1 point increments and varying the angle of rotation of the characters and symbols over 360° in 1° increments from an on-line digital font library.

ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
1234567890:——
,./;* = + † ° ' ¾
"#±%&'()½¼!

FIGURE 2A

FIGURE 2B

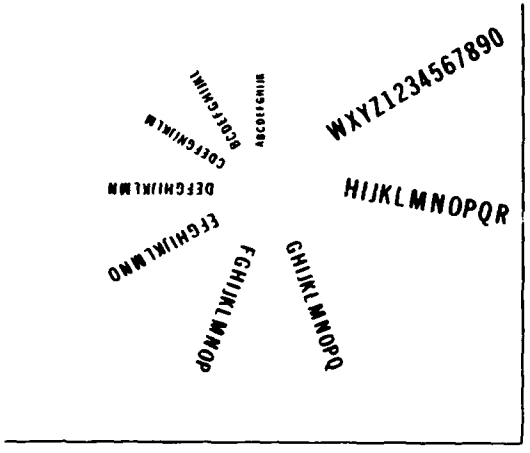

FIGURE 2C

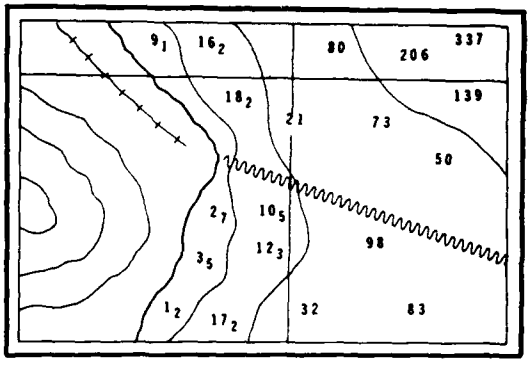

FIGURE 2D

FIGURE 2 - TYPICAL CARTOGRAPHIC OUTPUT

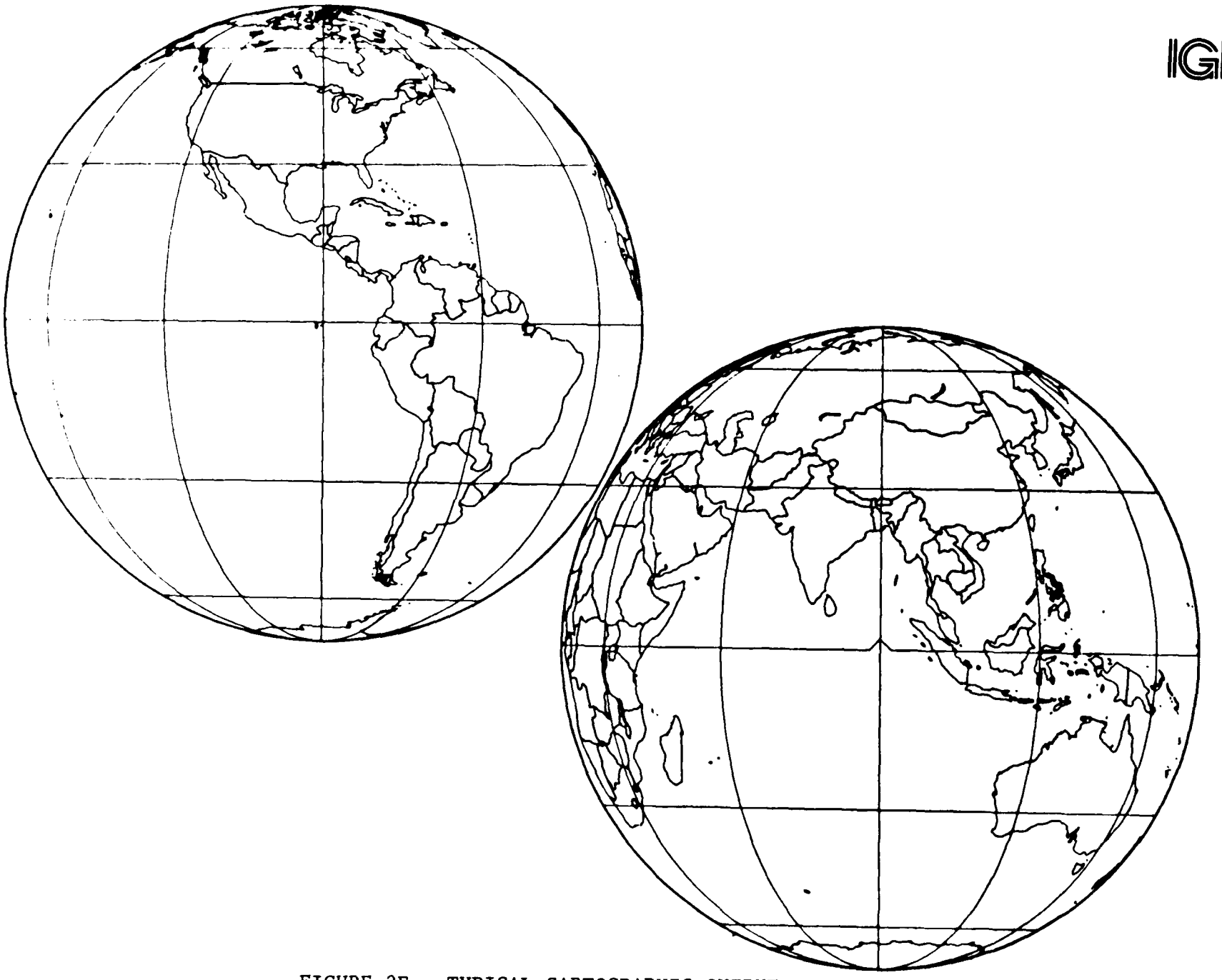

FIGURE 2E - TYPICAL CARTOGRAPHIC OUTPUT

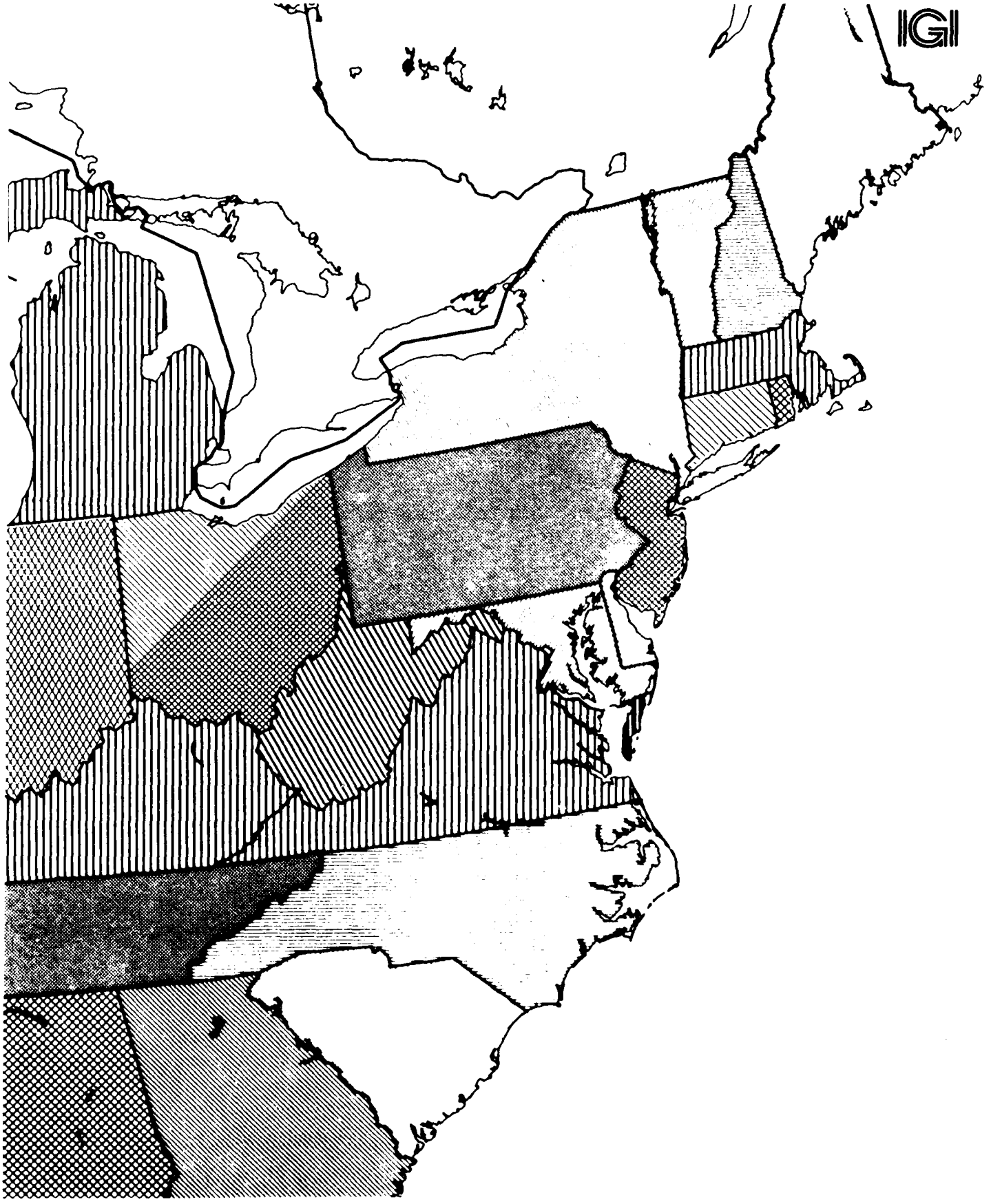

FIGURE 2f - TYPICAL CARTOGRAPHIC OUTPUT - PORTION OF 20" x 30" CHART
PLOT TIME: 7 MIN

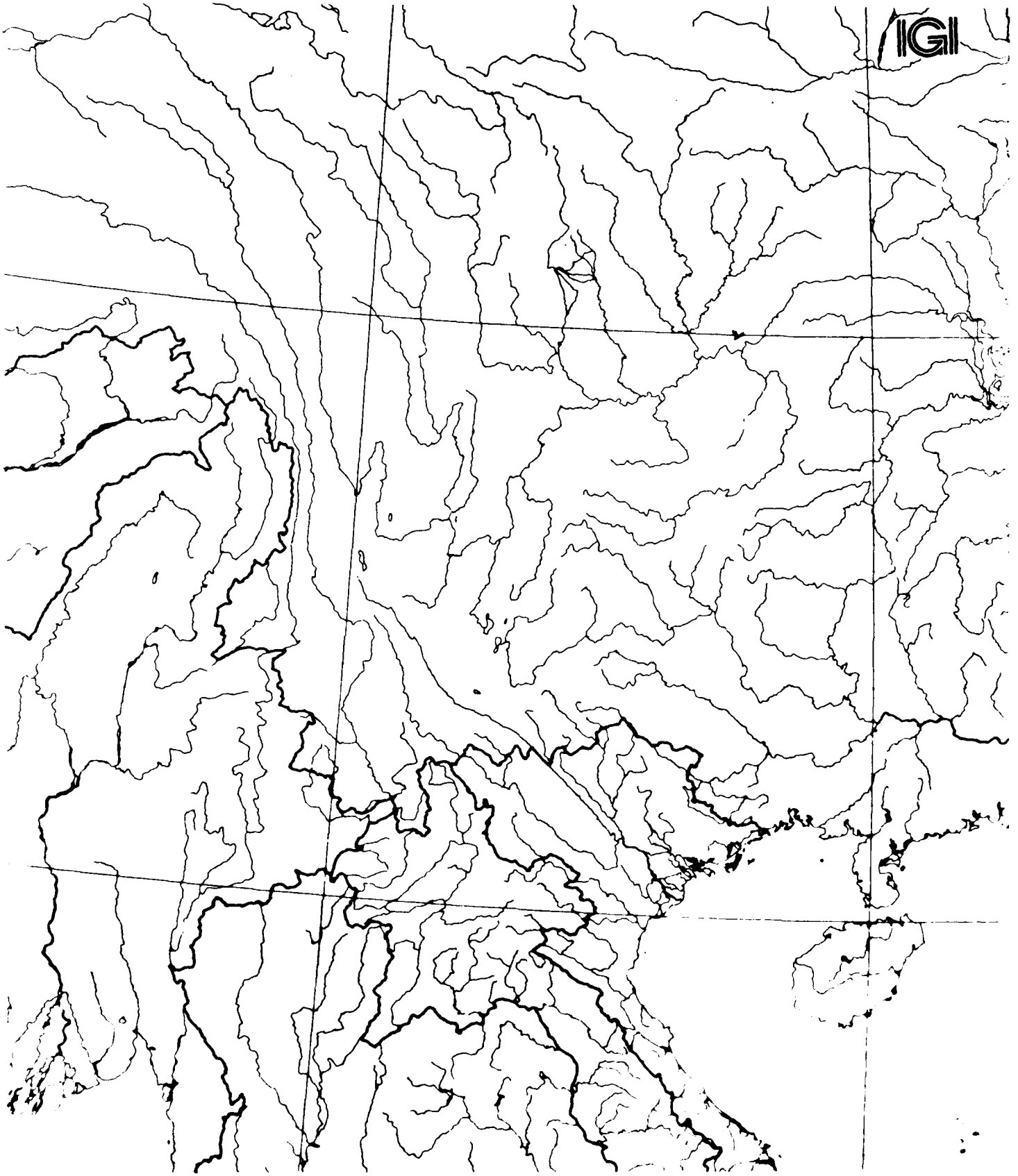

FIGURE 2g - TYPICAL CARTOGRAPHIC OUTPUT - PORTION OF 48" x 60" CHART
PLOT TIME: 20 MIN

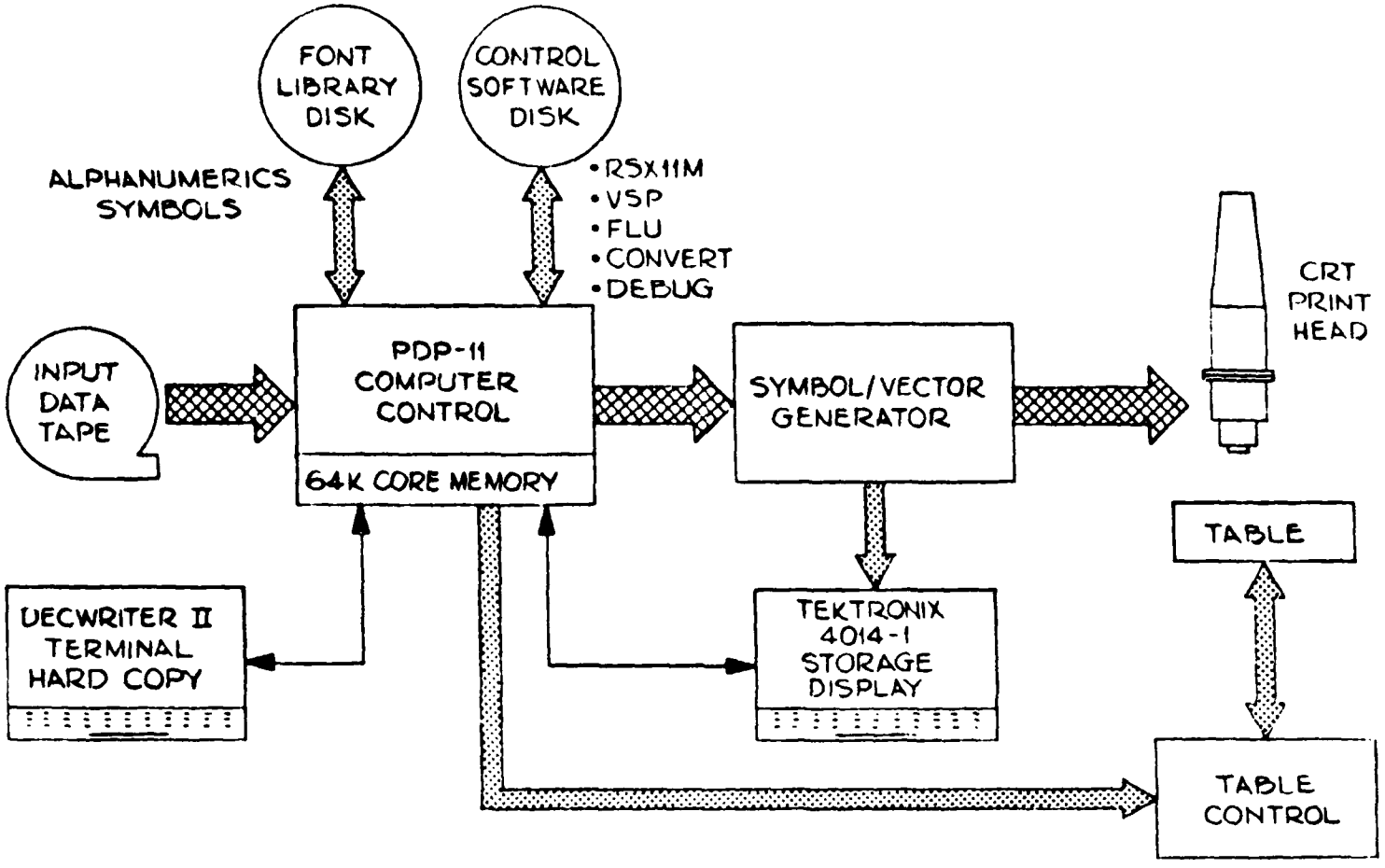

FIGURE 3 - SYSTEM DATA FLOW

For names or symbol placement, the input commands call out the type of character or symbol style, which are stored as digital font representations on magnetic disk and transfer the font data to the minicomputer memory. Relative recording parameters such as size, angle and position are assigned to the character or symbol for controlling the Symbol/Vector Generator. The Symbol/Vector Generator generates the character or symbol of proper size, angle and location on the face of the CRT using a subraster.

2.3.3 Software

Control and utility software and digital fonts are stored on-line on magnetic disks. The operating system for the PDP11 minicomputer controller is Digital Equipment Corporations RSX11M multitasking software package which will allow the operation of up to five plotters at the same time or simultaneous software development during plotting.

The utility software programs provided by IGI are:

Vector/Symbol Plot (VSP)

Font Library Update (FLU)

Convert (CNV)

Vector/Symbol Plot (VSP) - is the principle plot program which controls all plotting; and all names and text composition and placement from input data tapes formatted in the Symbol/Vector Generator command code.

Font Library Update (FLU) - is the software package which is used to create digital font libraries on magnetic disks from properly formatted font tapes. FLU can be used to add, delete, display or list symbol data and perform minor editing on the font data words.

Convert (CNV) - are conversion programs developed for converting existing data bases into Symbol/Vector generator formats for controlling plotting and names placement. The following conversion programs were prepared:

- Convert 1 - is a real-time conversion program for existing data bases in standard Gerber plot format developed for the Hydrographic Center.

- SNAPS - is a stand-alone conversion program for converting Topographic Center's existing names placement data on DECtape into the SVG format on magnetic tape for use with the CRT Flatbed Photocomposition System.

- ATPS - is a stand-alone conversion program for converting Aerospace Center's existing advanced type placement data on DECtape into the SVG format on magnetic tape for use with the CRT Flatbed Photocomposition System.

Font Library

Digital font libraries may be prepared by a variety of procedures. Fonts for this program were supplied by U.S.A.E.T.L., Ft. Belvoir, Va. and DMAAC/AD, St. Louis, Mo., through the Synectics Corporation.*

Fonts may be prepared by scanning reduced sizes of original artwork of symbols or characters on photographic film using a high resolution optomechanical or optical scanner. The scanned and digitized character data is processed and edited and formatted into a digital font input tape for the CRT Print Head System.

FLU is then used to develop and maintain a Font Library by storing two sizes of each font style on magnetic disk. All other sizes and orientation are produced with the Symbol/Vector Generator hardware.

In order to achieve graphic arts or cartographic quality the character or symbol original must be sized and scanned with a scanner of resolution to produce about 1000 scans per inch.

U.S.A.E.T.L. is presently working on an automated technique for digitizing and editing font libraries.

*Fonts developed for the Automated Air Information Production System (AAIPS) at DMAAC, St. Louis, Mo.

2.4 Descriptions of CRT Print Head System Installed at the DMA Centers

2.4.1 General

CRT Print Head Systems were installed at the following DMA Chart and Map Production Centers.

Hydrographic HTC, Washington, D.C.

Aerospace AC, St. Louis, Mo.

Topographic HTC, Washington, D.C.

Table I has a list of the hardware configuration of the CRT Print Systems at each DMA Center.

Table II has a list of the software packages delivered and installed in the CRT Print Head Systems at each DMA Center.

Table III is a list of the Fonts to be supplied by U.S.A.E.T.L. to the DMA Centers for use with the CRT Print Head Systems.

2.4.2 Hydrographic Center Configuration

A block diagram of the CRT Print Head System located at the Hydrographic Center is given in Figure 4. Figure 5 is a photograph of the computer controller.

The type of CRT Exposure Head used on the Gerber 32 Tables at both the Hydrographic Center and the Aerospace Center is shown in Figure 6. The precision CRT, its lens and magnetic shields and all of the power supplies and drivers for the CRT focus and deflection system are assembled on a modified standard Gerber aluminum casting which is accurately mounted on dowel pins on the "Y" carriage of the Gerber 32 Table.

The entire assembly, with double magnetic shields, weighs about 70 lbs. and can be easily removed and interchanged with a standard Gerber photohead or it can be mounted permanently on the "Y" carriage.

Figure 7, shows a typical CRT Print Head installed on a Gerber 32 Table.

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Table I CRT Print Head Hardware Configuration at Each DMA Center

Item	Subsystem	Hydrographic	Aerospace	Topographic
1	CPU	PDP11/45 DW	PDP11/45DW	PDP11/45DW
2	Memory	64K Words-Dec	32K Words-Dec	32K Words-Dec
3	Memory Addition	----------	64K Words Plessey	----------
4	Memory Management	KT11-C	KT 11-C	Kit 11C
5	Auto Loader	BM873-YB	BM873-YB	BM873-YB
6	DMA	Kit 11D	Kit 11D	Kit 11D
7	Expansion Cabinet	H960-DA	H960-DA	H960-DA
8	Disk Controller	RK11	RK11	RK11
9	Disk	1-RK05-F(2.4MW)	1-RK05-F(2.4MW)	1-RK05F(2.4MW)
10	Disk Mag. Tape System	1-RK05-J(1.2MW) TJU16 EA	2-RK05-J(1.2MW) TJU16 EA	1-RK05J(1.2MW) TJU16 EA
11	I/O Device	Decwriter II	Decwriter II	Decwriter II
12	I/O Device	Tektronix 4014-1	Tektronix 4014-1	Tekronix 4014-1
13	Dual Dectape	----------	TC11-GA	TC11-GA
14	Cache Memory Buffer	----------	Fabritec 9511	----------
15	Floating Point Processor	----------	FP11C	----------
16	Asynchronous Interface	DL11-W (2) DL11-C (1)	DL11W (2) DL11-C (1)	DL11-W (1) DL11-C (2)
17	Analog Adapter	Tektronix 940-C	Tektronix 940-C	Tektronix 940-C
18	Symbol/Vector Generator	100	100	100
19	CRT Print Head, Model 2000	Type A	Type A	Type B
20	Power Controller	369	369	369
21	Plotting Table	Gerber-32	Gerber-32	Concord- E113
22	Table Controller	HP2100A	Honeywell 610	DEC PDP8
23	Table Interface	EIA	EIA	20 mA current loop

Table II Software Packages Delivered to Each DMA Center

Item	Software Program	Hydrographic	Aerospace	Topographic
1	Operating System	DEC RSX11M-V3.1	DEC RSX11M-V3.1	DEC RSX11M-V3
2	Font Library Update	IGI FLU	IGI FLU	IGI FLU
3	Symbol/Vector Plot	IGI VSP	IGI VSP	IGI VSP
4	Diagnostics	IGI DeBug	IGI DeBug	IGI DeBug
5	Diagnostics	DEC Standard	DEC Standard	DEC Standard
6	On-Line Conversion	Gerber to SVG	----------	----------
7	Stand Alone Conversion	----------	ATPS to SVG	SNAPS to SVG

Table III Fonts To Be Delivered to Each DMA Center by USAETL

Item	Identification	Style
1	AAIPS Font 100	Techno Medium
2	AAIPS Font 101	Inverted Techno Medium
3	AAIPS Font 200	News Gothic Condensed
4	AAIPS Font 300	Gothic 312
5	ETL Font #10	News Gothic
6	ETL Font #11	Lightline Gothic
7	ETL Font #12	Techno Medium Italic
8	ETL Font #13	Techo Light
9	ETL Font #15	Techo Light-Italic
10	ETL Font #17	News Gothic Condensed
11	ETL Font #	Century Expander
12	ETL Font #	Techno Medium
13	ETL Font #	Formal Gothic Demibold
14	ETL Font #	Century Schoolbook
15	ETL Font #	Spartan Medium

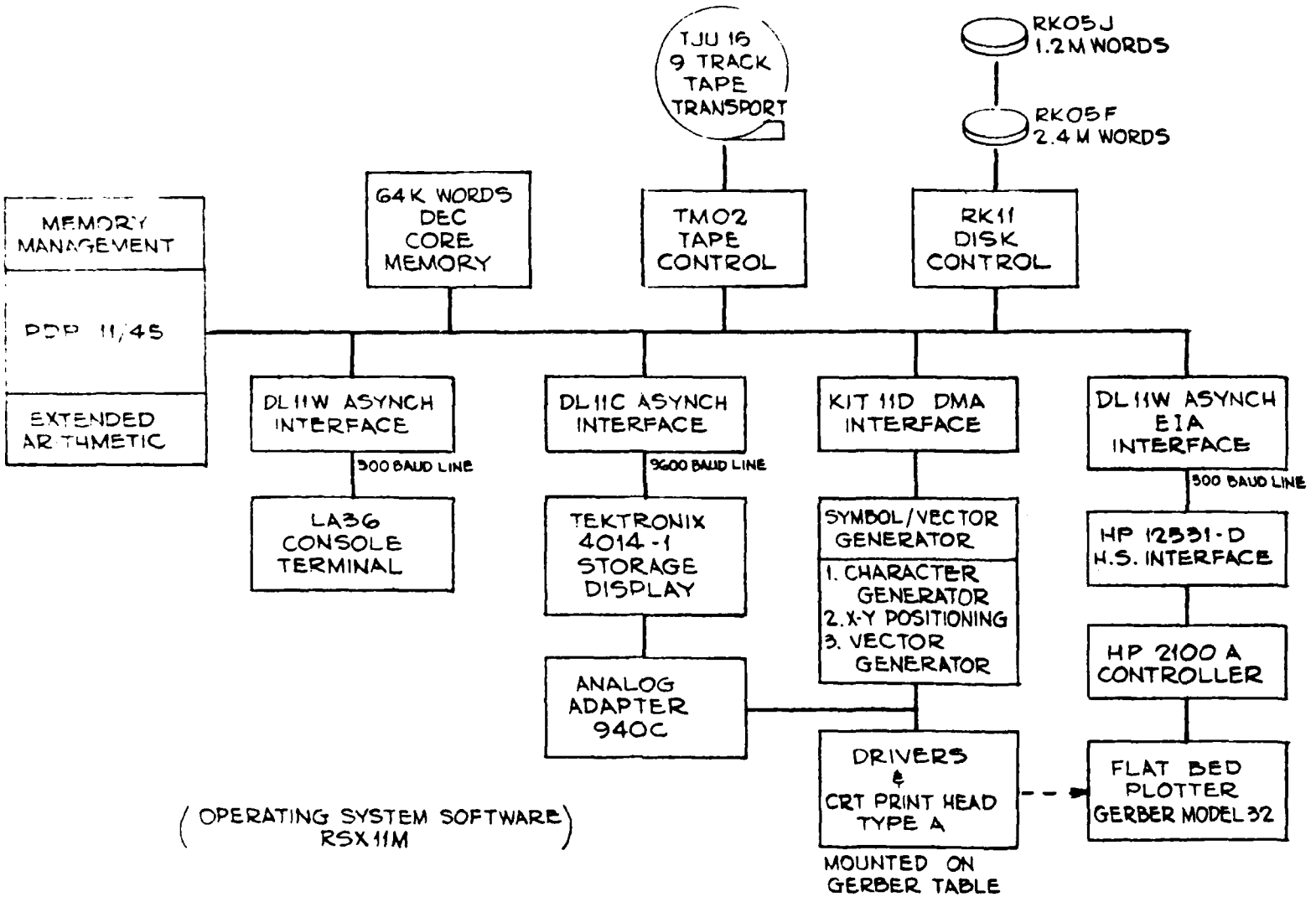
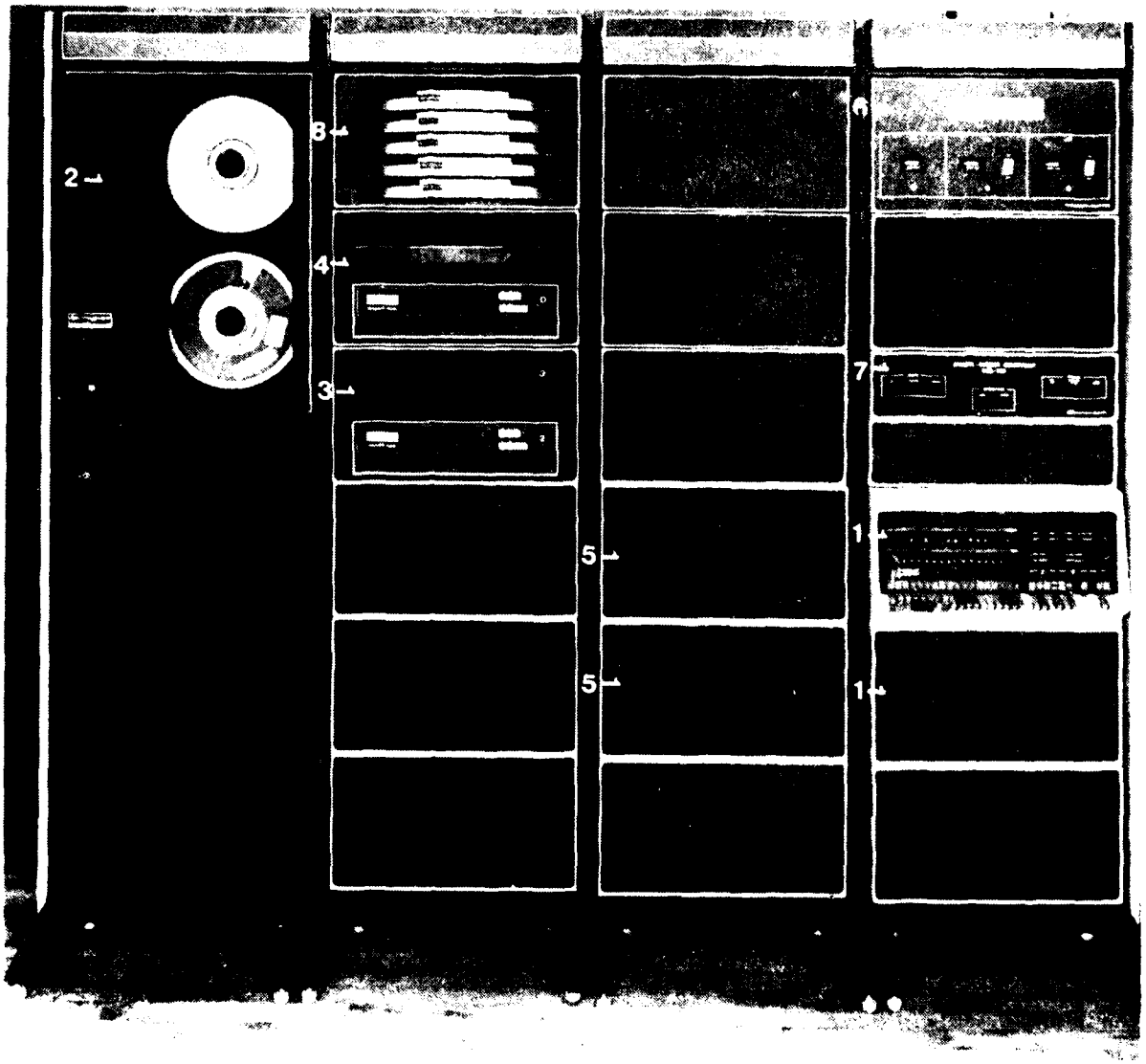


FIGURE 4 - HARDWARE BLOCK DIAGRAM - HYDROGRAPHIC CENTER



1	CPU	PDP11-45'I With 32K WORD MEM., DL 11-W, (2) RL11-0.	5	EXPANSION BOX	32K WORD MEMORY KIT 11D DL11-c
			6	OCP	MASS BUSS ADAPTER.
			7	SWG	
			8	DISK	IGI [illegible]

[illegible]

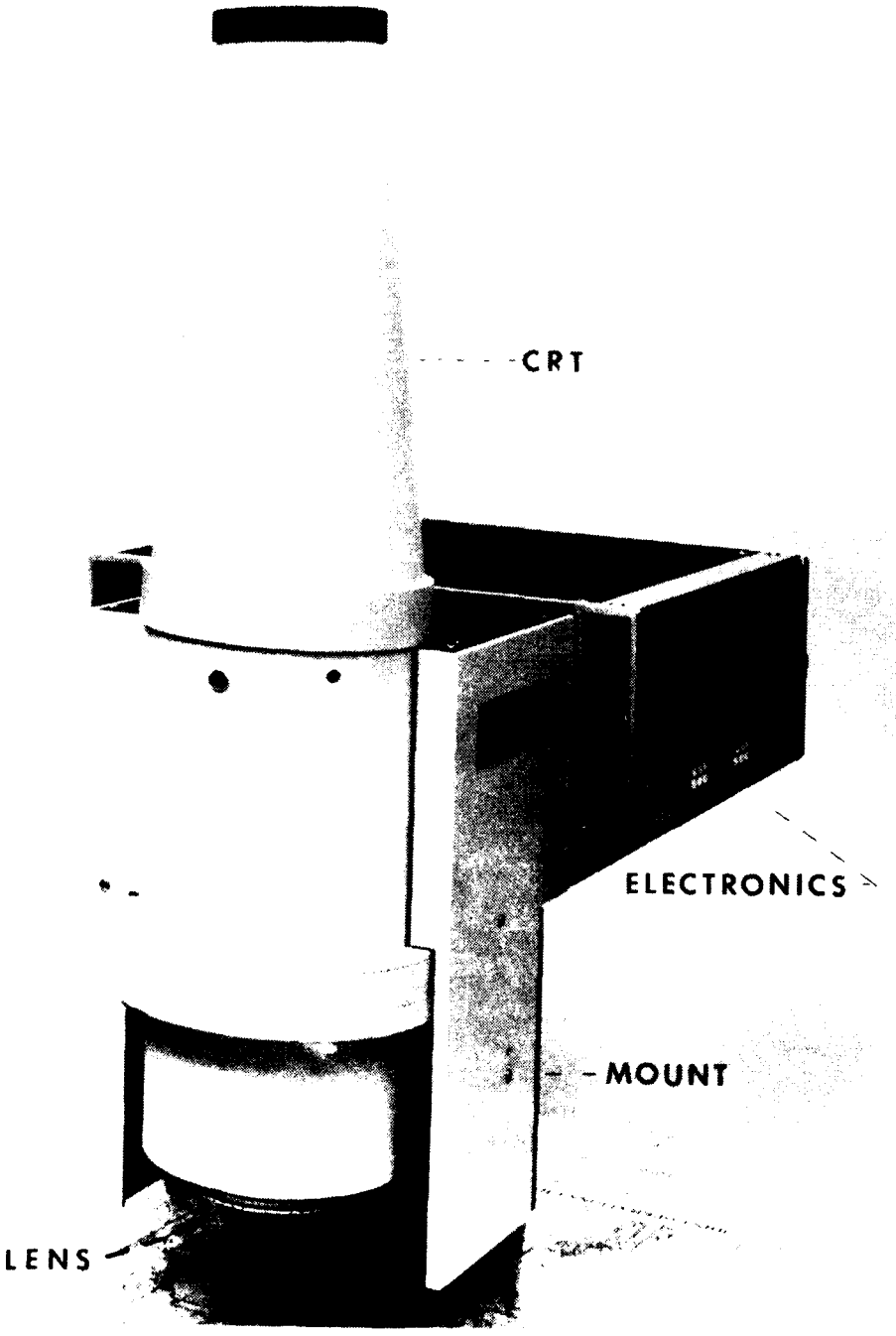


FIGURE 6 - CRT EXPOSURE HEAD COMPONENTS USED ON GERBER 32 TABLE

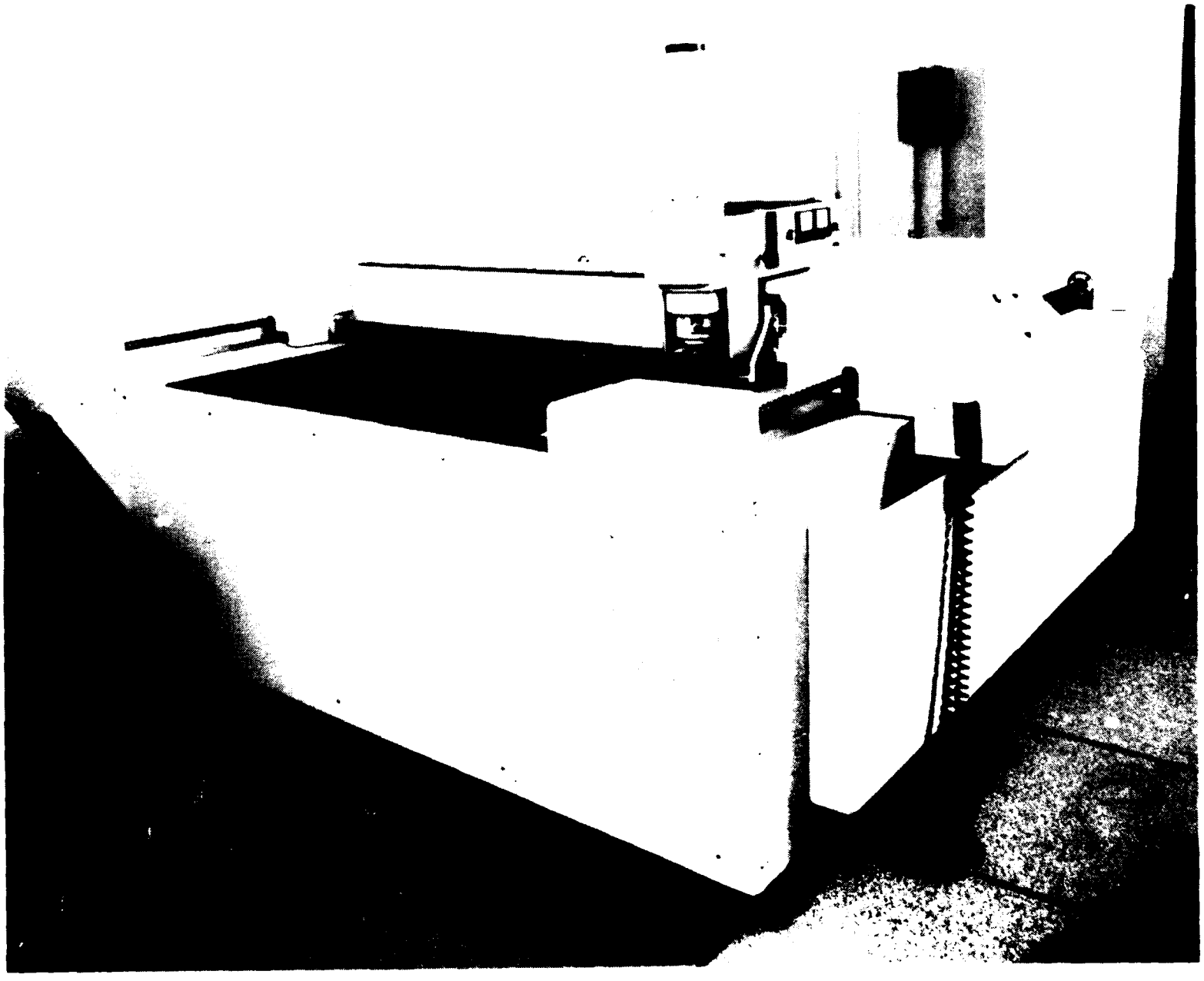


FIGURE 7 - CRT PRINT HEAD INSTALLED ON A GERBER 32 PLOTTER TABLE

2.4.3 Aerospace Center Configuration

A block diagram of the CRT Print Head System located at the Aerospace Center is given in Figure 8. Figure 9 is a photograph of the computer controller used with this CRT Print Head.

The CRT Exposure Head and its mounting arrangement on the Gerber 32 Table is identical to the one described for the Hydrographic Center and shown in Figures 6 and 7.

2.4.4 Topographic Center Configuration

A block diagram of the CRT Print Head System located at the Topographic Center is given in Figure 10. Figure 11 is a photograph of the computer controller used in this CRT Print Head System.

The type of CRT Exposure Head used on the Concord E-113 Table is shown in Figure 12. The CRT, its lens assembly, its magnetic shields and all of the power supplies and drivers for focus and deflection are assembled on a special mount designed and manufactured by Concord Control which is interchangeable with Concord's standard photohead. The entire assembly with double magnetic shields, weighing about 79 lbs. is accurately mounted on the carriage of the Concord Table.

2.4.5 Input/Output Peripherals

Inputs to the computer controller are through keyboards on either a DEC Decwriter II or a Tektronix 4014-1 Interactive Display, shown in Figure 13.

Output from the computer can be in the form of hard copy from the Decwriter II or softcopy on the Tektronix 4014-4 storage display. The Tektronix's display is also interfaced directly to the Symbol/Vector Generator which controls the CRT Exposure Head. A single 2" x 2" area or an entire plot at reduced resolution may be displayed on Tektronix 4014-1 during plotting.

The interactive storage display is useful for previewing plot tapes, software development and minor editing functions.

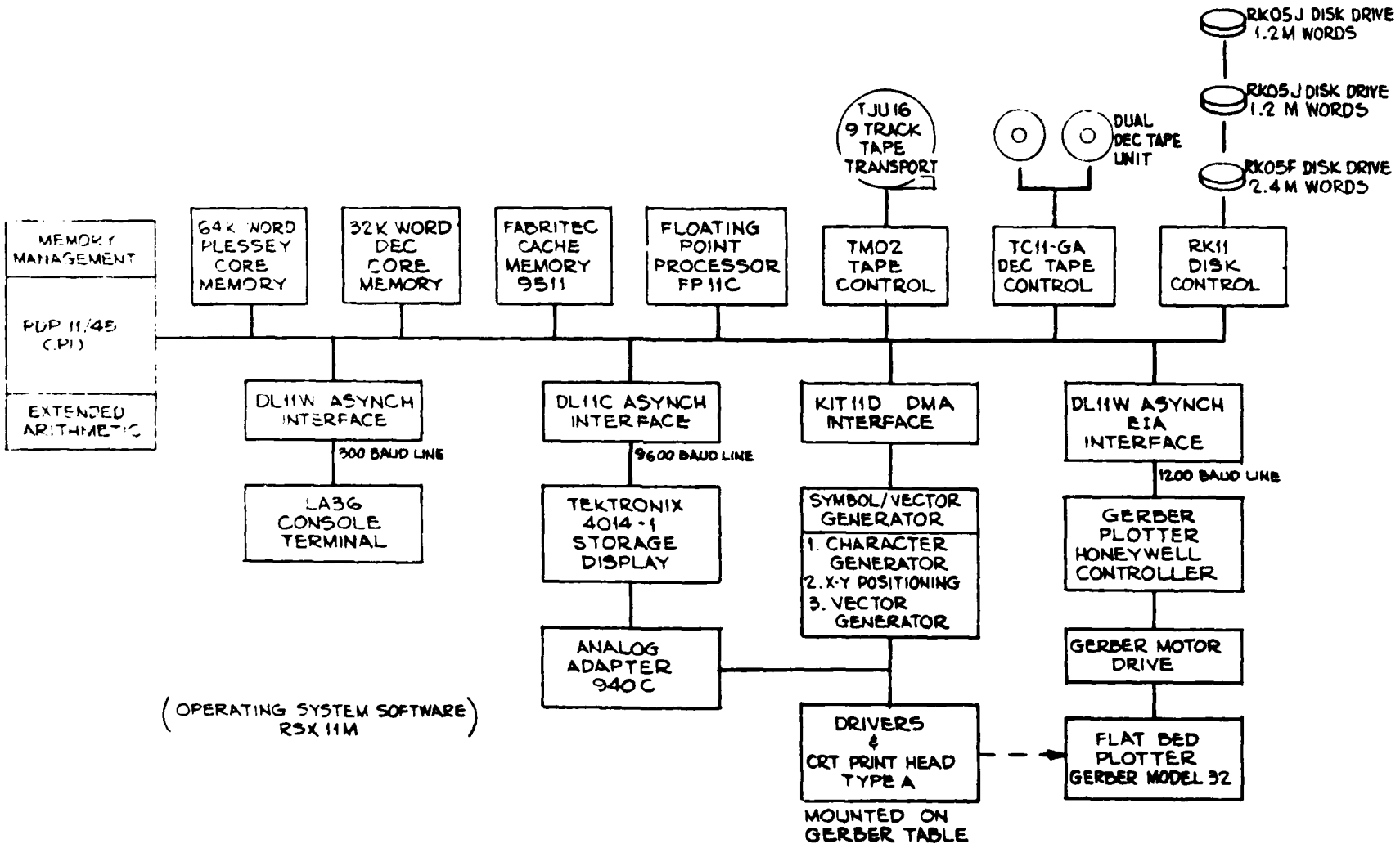
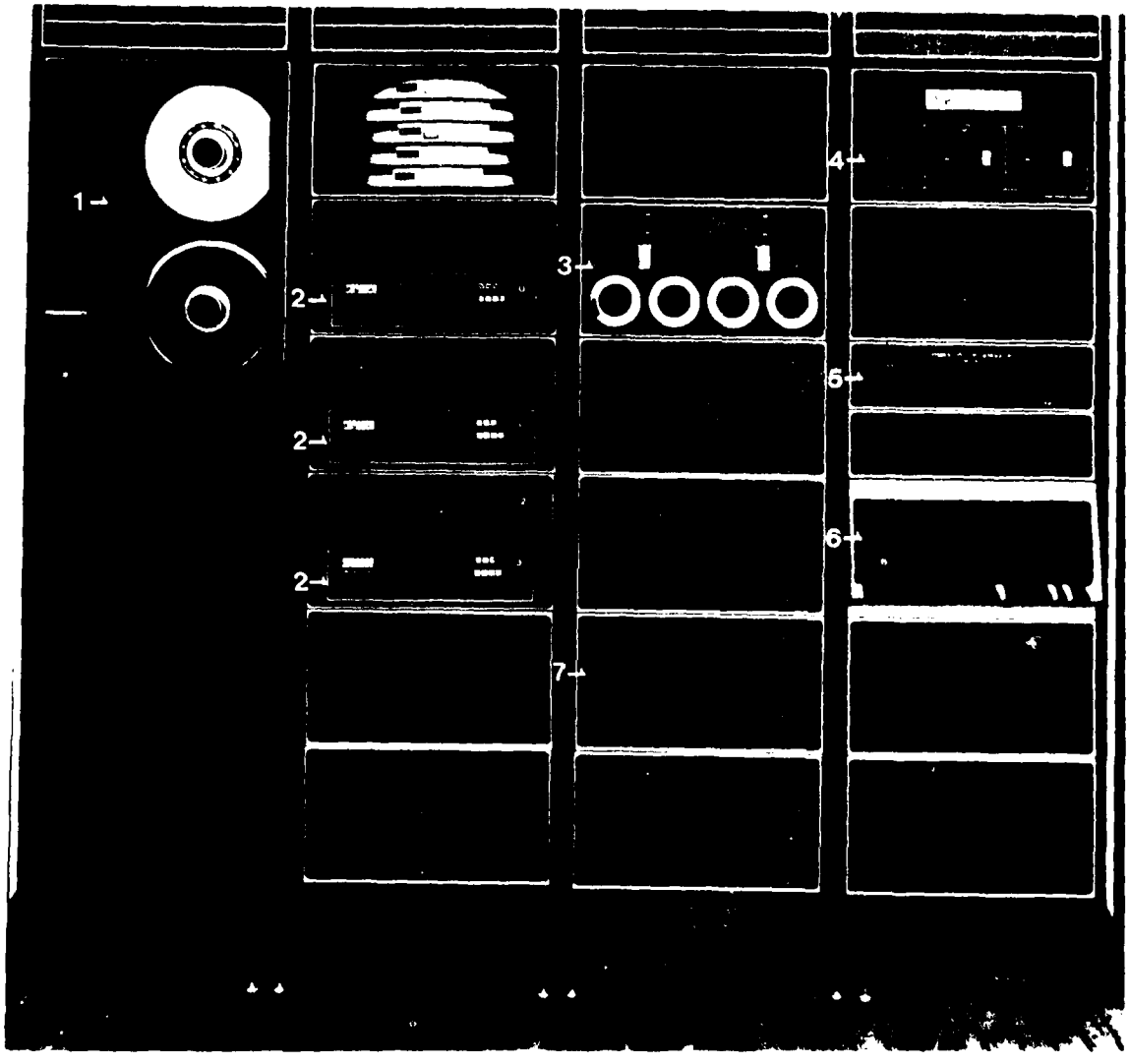


FIGURE 8 - HARDWARE BLOCK DIAGRAM - AEROSPACE CENTER



1 MAGNETIC TAPE UNIT
2 MAGNETIC DISKS
3 DEC TAPE UNIT
5 OPERATOR CONTROL PANEL
5 SYMBOL READER OR CENTRAL
6 CPU
COMPUTER MEMORY

FIGURE [illegible] [illegible] [illegible] MICROSPACE CES

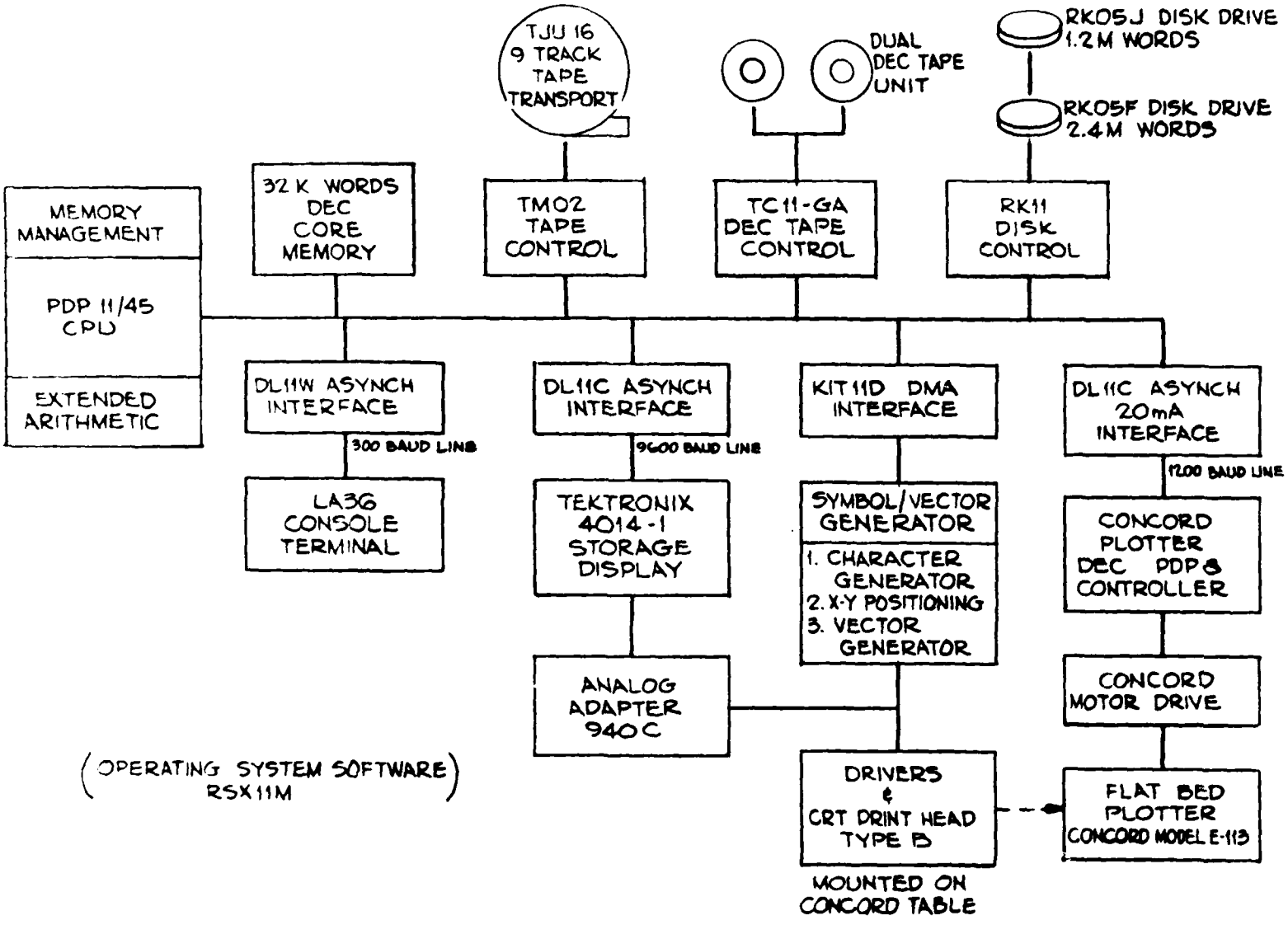


FIGURE 10- HARDWARE BLOCK DIAGRAM - TOPOGRAPHIC CENTER

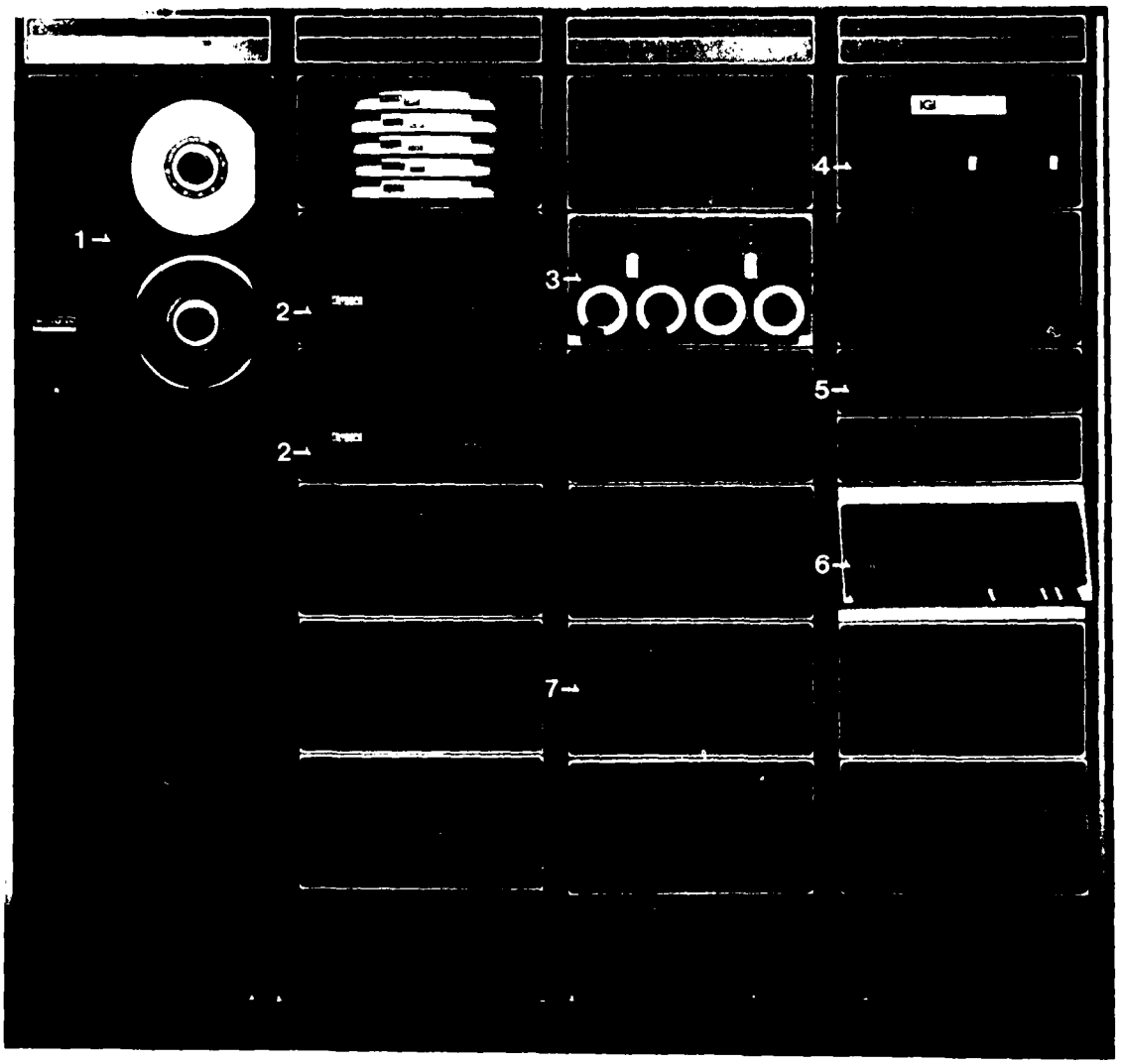


FIGURE 11 - COMPUTER CONTROLLER - TOP LOADING CENTER

1 MAGNETIC TAPE UNIT
2 MAGNETIC TAPE
3 DEC TAPE UNIT

4 POWER - CONTROL PANEL
5 SYSTEM MASTER OPERATOR
6 CD
7 LOGIC CONTROL UNIT

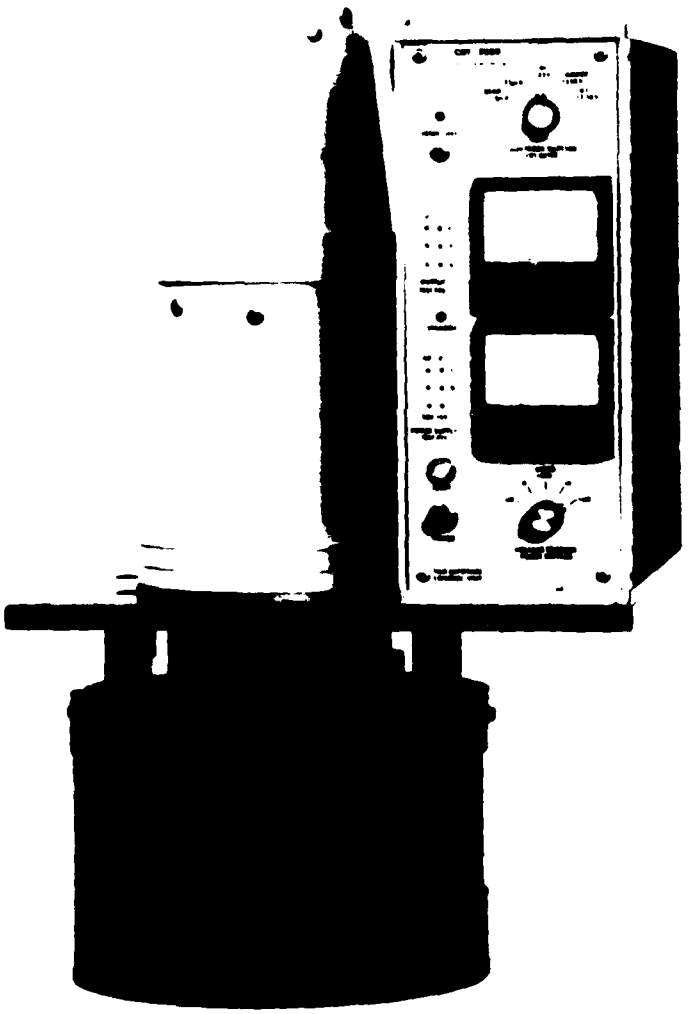


FIGURE 12 - CRT EXPOSURE HEAD COMPONENTS USED ON CONCORD - E113 TABLE

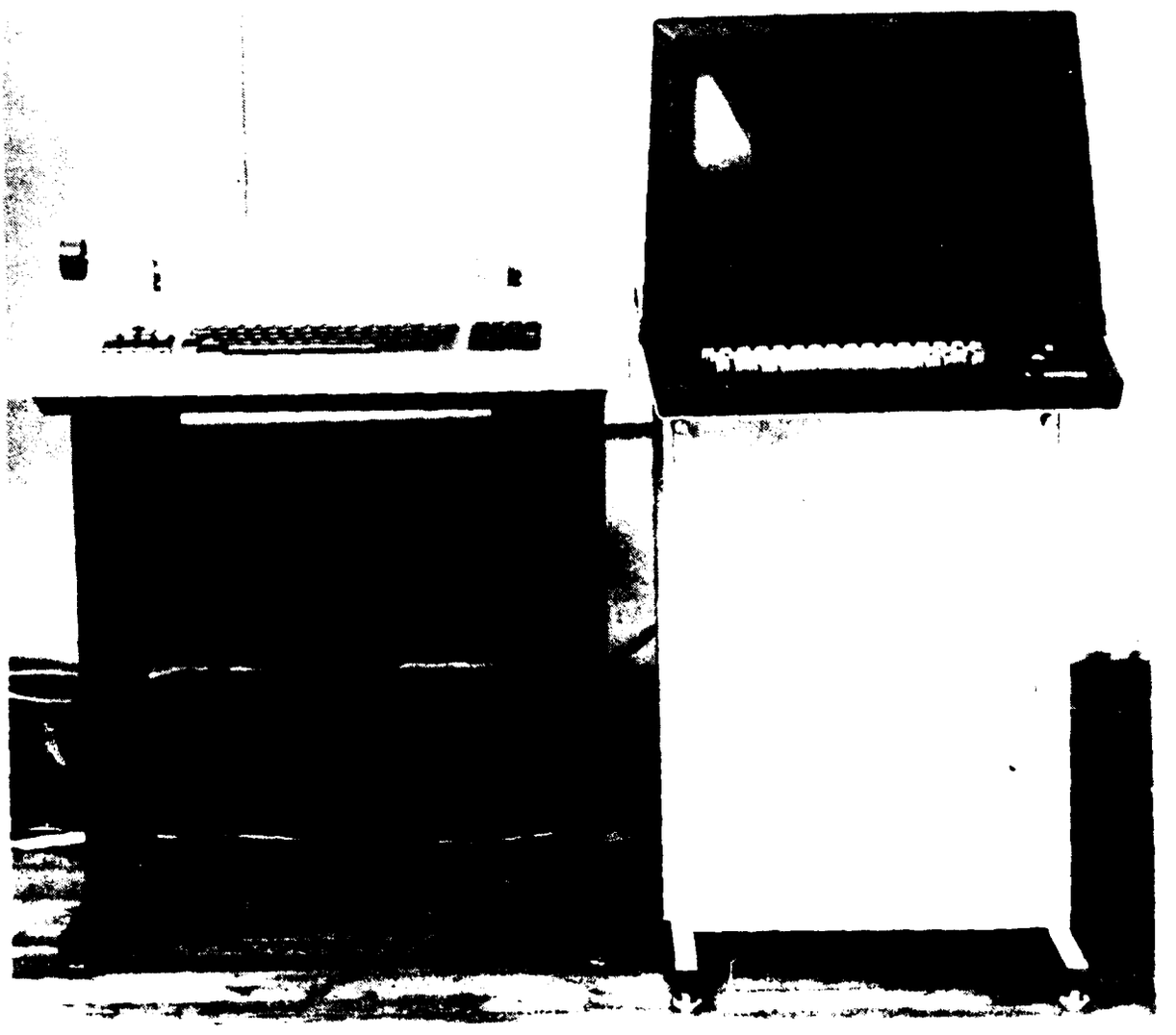


FIGURE 13 - INPUT OUTPUT PERIPHERALS

2.5 Symbol/Vector Generator (SVG)

2.5.1 General

The Symbol/Vector Generator (SVG) is an electronic subsystem capable of converting digital input commands from the PDP11 minicomputer controller into precise analog deflection and video signals which control the CRT Exposure Head to produce graphic arts quality characters; special symbols; and incremental and stroke vector plots. The SVG also produces the control signals from the CRT to position and rotate the output. The SVG controls all size, line width, and scaling factors and automatically adjusts exposure levels for density control on film. Its uniqueness lies in its ability to reduce the computer load under most operating conditions by performing these functions in an analog mode.

The SVG can compose signals which will produce straight lines, curves and symbol representations at the deflection coils of recording or plotting system. Each of its three methods of operation makes the best use of computer time to produce each of the three functions.

2.5.2 Incremental Vector Mode

To make curved lines the beam is positioned to an absolute location in the deflection yoke by a D/A converter (up to 20 bit addressibility). The beam may then be repositioned one element in X, Y or both in any one of 8 directions and pulsed ON. By successive steps any curve resolvable to this precision can be drawn. This is the Incremental Vector Mode of operation. This technique may also be used for straight lines, point by point, however a better method referred to as Stroke Vector Mode is discussed below.

2.5.3 Stroke Vector Mode

To draw a straight line up to 1446 (1023 in X, 1023, Y) positions or elements long, the beam is first positioned as in the Incremental Vector Mode (Major Position), the beam is then turned ON and a ramp is started which is fed into one or both of the deflection coils. This exercise results in the production of a straight line of excitation exposing the recording media. When the beam reaches a predetermined point, the beam is turned OFF and the Major Position updated to the end of the vector just drawn. The vector may progress in any direction from the original absolute X, Y position. This is the Stroke Vector Generator and it operates in the Stroke Vector Mode.

2.5.4 Symbol/Character Mode

The third operational capability is termed the Symbol/Character Mode and is accomplished using the Character Generator within the SVG. The Character Generator has the ability to provide graphic arts quality characters in point sizes from 4 thru 72, and each symbol can be rotated 360° in 1° increments. The Character Generator employs a modified subraster scan to lay down a character or symbol at variable resolutions up to a machine limit of 1023 cuts per scan line, as shown in Figure 14. This produces a high quality Graphic Arts symbol and uses minimum computer time. Rotation of symbols or characters is accomplished by rotation of the entire raster as shown in Figure 15 and 16.

2.5.5 Physical Description

The SVG is contained in a single 5-1/4 inch drawer, designed to mount into a standard 19 inch equipment rack, as shown in Figure 17. The single drawer contains three large wire-wrapped mother boards and a small interface board; it also contains power supplies, cooling fans, plugs and jacks for interconnecting.

The front panel contains indicators only; no operating controls are accessible while the system is operating.

There are several test switches inside the drawer for maintenance purposes and multiple controls for calibration.

Five (5) cables which connect the SVG to the remainder of the system are at the rear of the drawer. The three mother boards may be exposed for repair and calibration by disengaging the fasteners and swinging boards 2 and 3 upright. This permits access for inspection, service and calibration.

Figure 18, is a block diagram of the Symbol/Vector Generator. It consists of three major functional areas: (a) Character/symbol generator, (b) stroke/vector generator, and (c) random position generator which convert the digital input commands from the computer into analog signals drive the CRT.

2.5.6 SVG Performance Characteristics

Table IV is a list of typical performance characteristics of an SVG. These empirically gathered data are for the SVG and does not reflect the limitations in other parts of the CRT Print Head System.

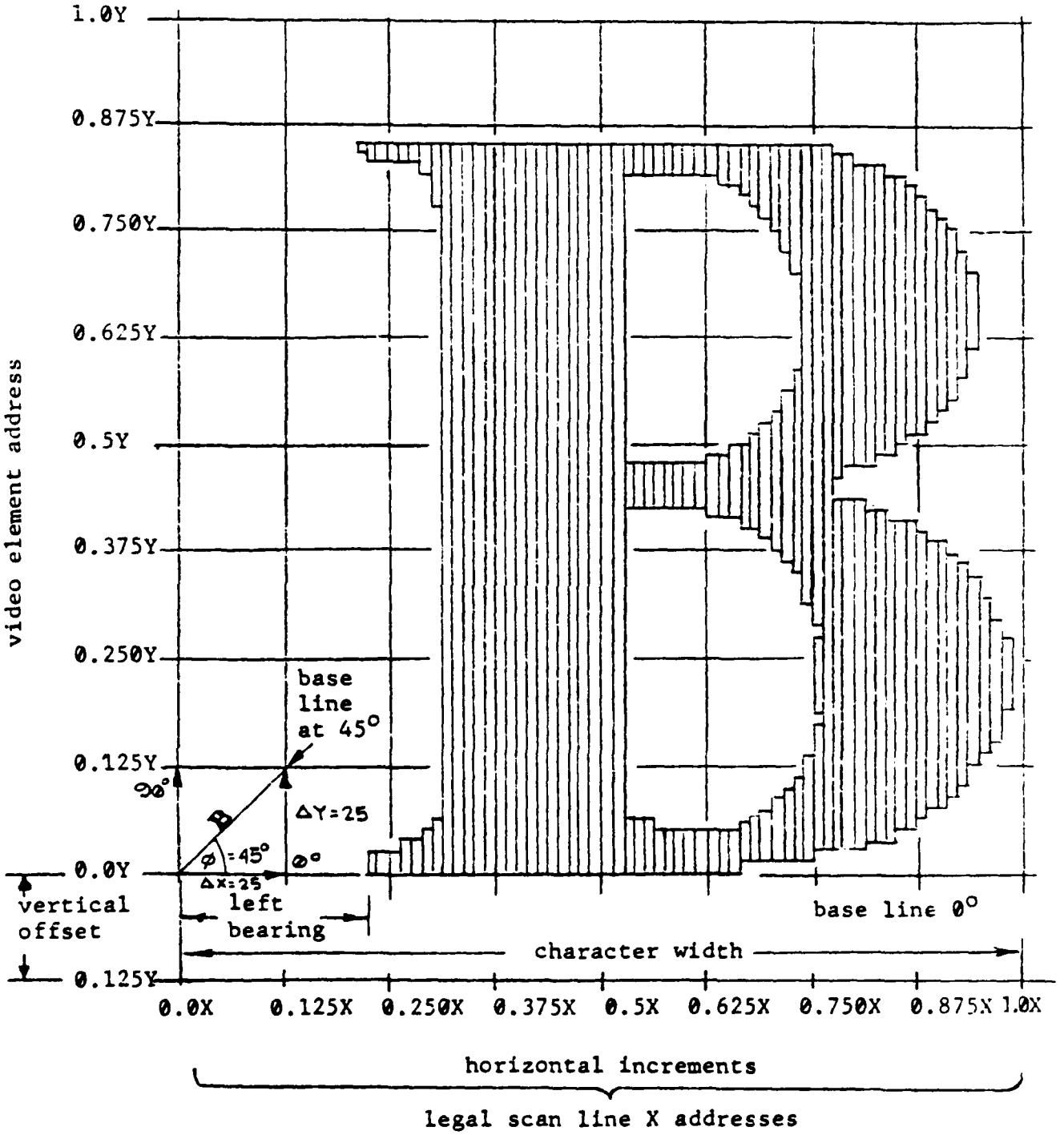


FIGURE 14 - SYMBOL/CHARACTER CONSTRUCTION

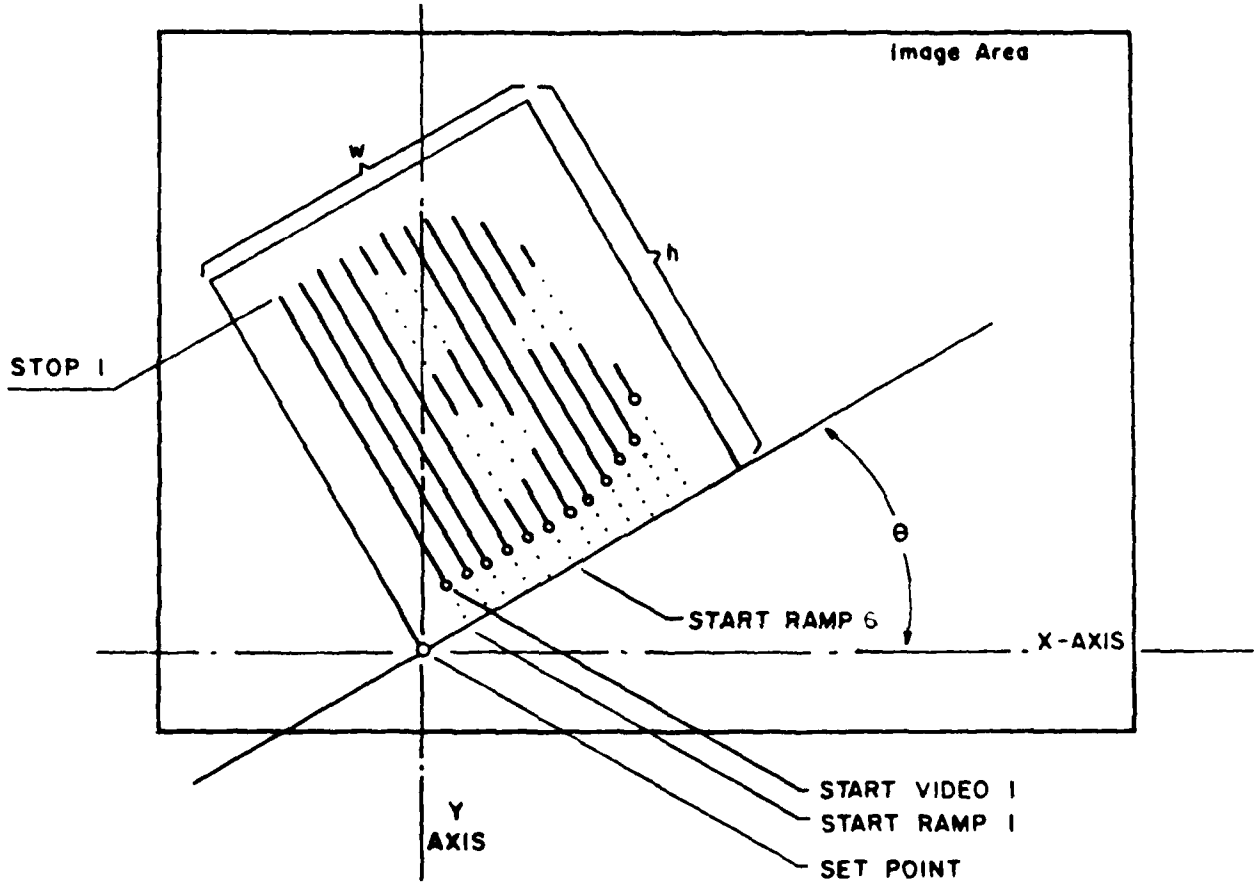


FIGURE 15 - SVG RASTER ROTATION

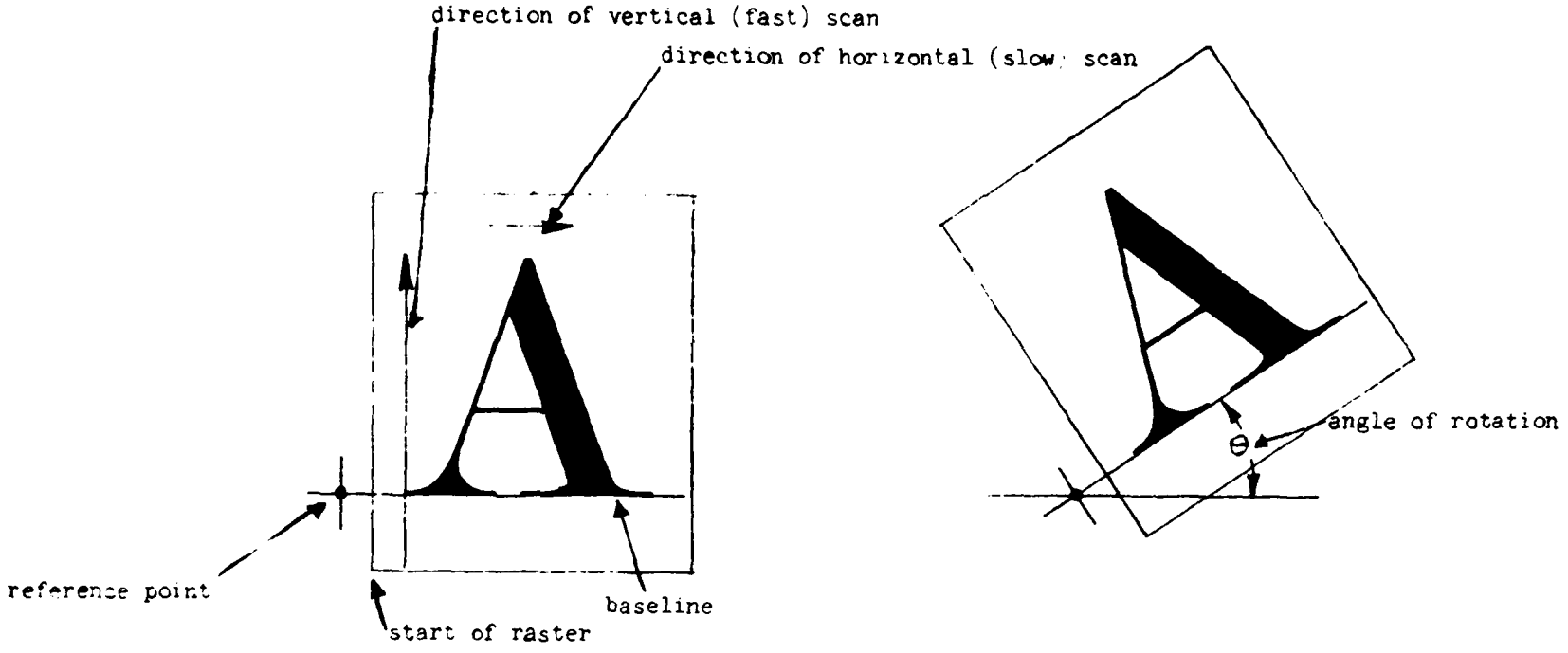


FIGURE 16

CHARACTER ROTATION

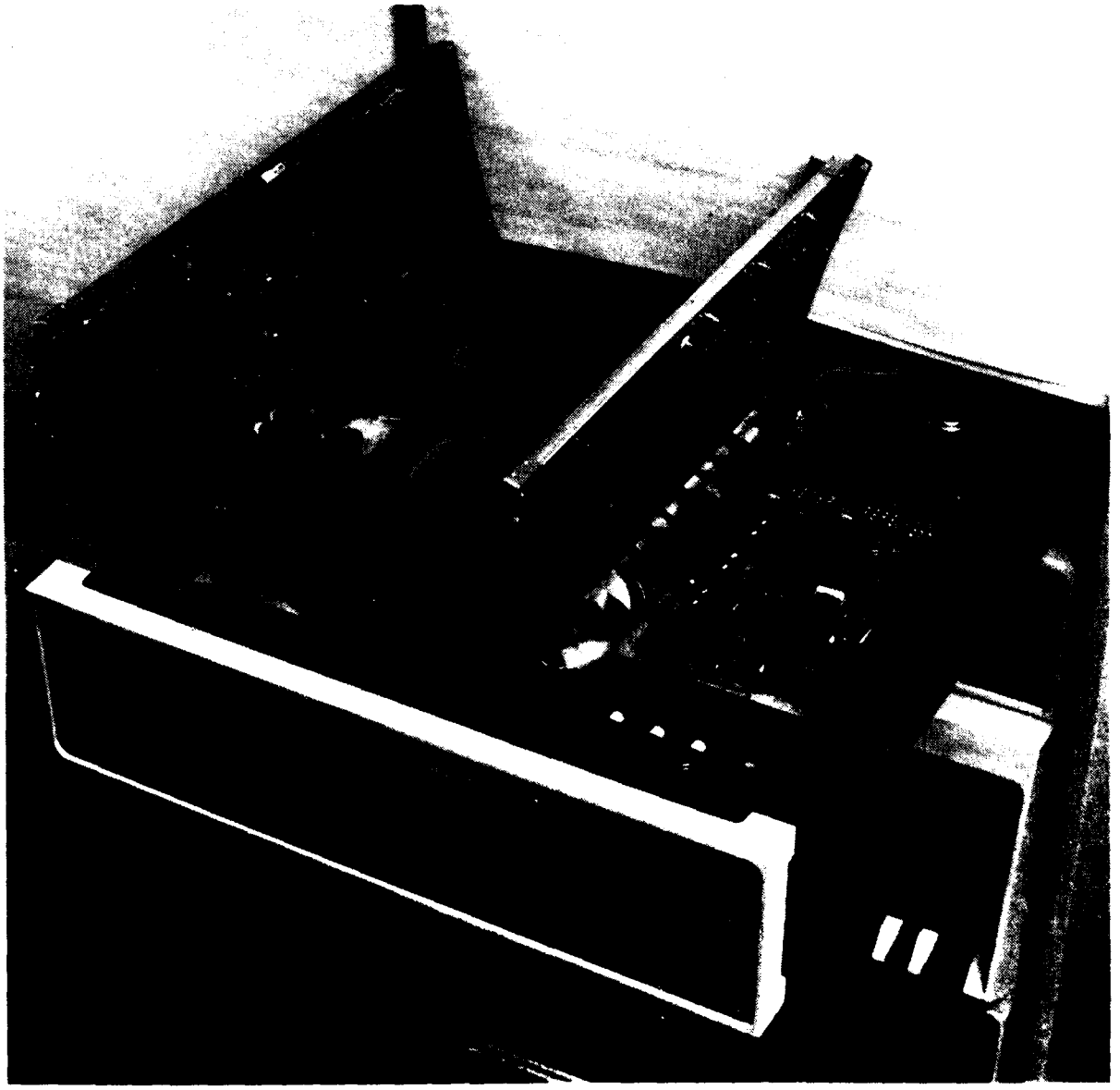


FIGURE 17 - SVG WITH TOP COVER REMOVED

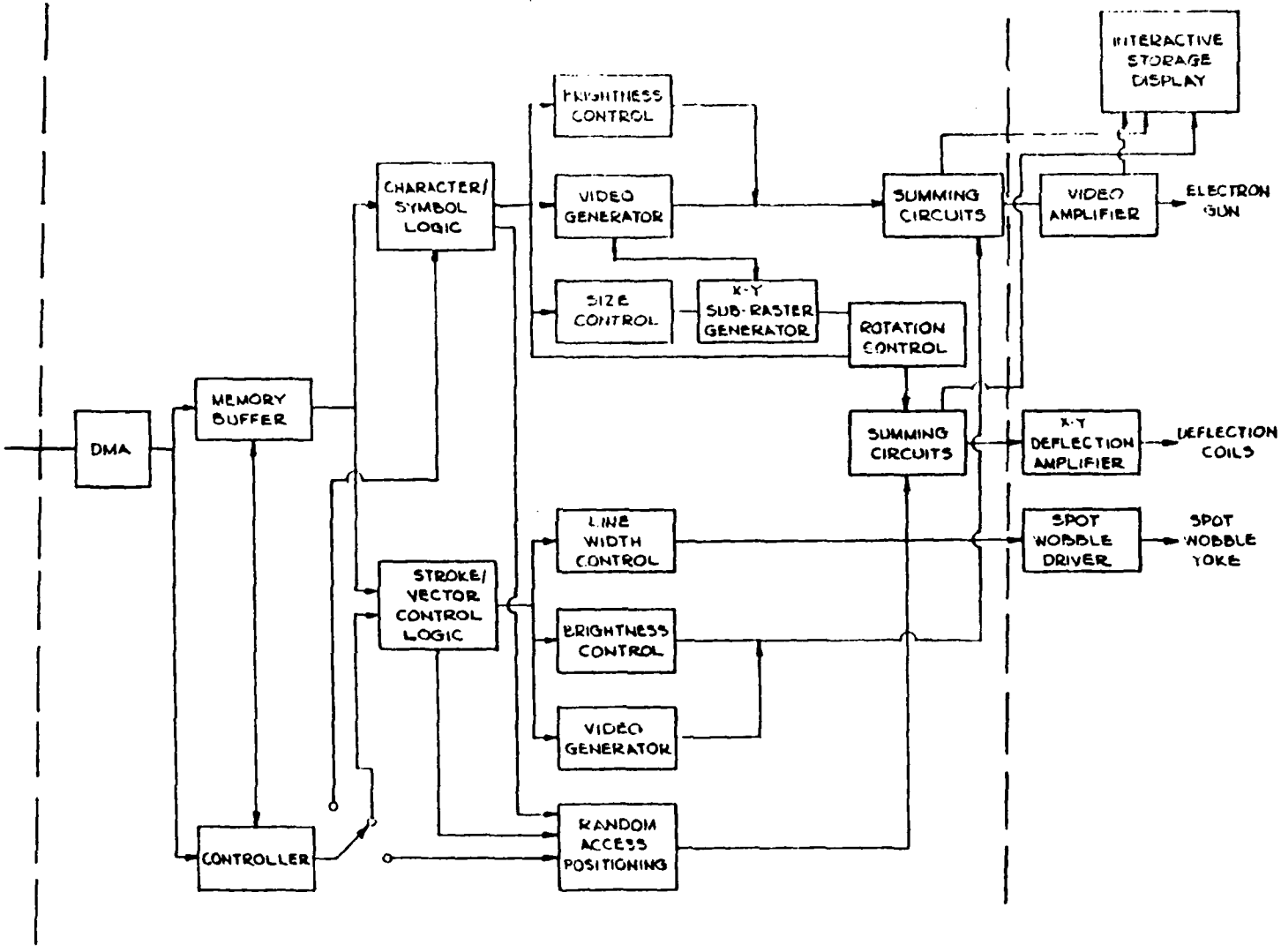


FIGURE 18 - BLOCK DIAGRAM OF SYMBOL/VECTOR GENERATOR

Table IV - Typical Performance of a Symbol/Vector Generator

MODE	
IVP*	125,ØØØ elements/sec
IVP (random points)	45,ØØØ points/sec
Vector (full length)	2,ØØØ,ØØØ elements/sec
Vector (short vectors)	3,ØØØ vectors/sec
Symbol (4 pt I)	0.5 mx/character
Symbol (4 pt W)	4.0 mx/character

*IVP = Incremental point by point plot

System parameters such as software overhead, tape packing density, end-of-record-gaps, etc. reduces these figures for overall system performance. It was found that the change from 16ØØ bpi tape drive to 8ØØ bpi improved the IVP mode but did not improve the other modes.

Tables V and VI give typical performance obtained on film with the CRT Print Head Systems using the Symbol/Vector Generator.

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Table V - Vector Generator Performance

Incremental Plot & Stroke Vectors

Length	.004" to 1.023"
Width	
Spot Wobble	.002" to .036" in 34 Increments
Parallel Vectors	.002" to 1.023" in .001" Increments

Typical Writing Rates for 1" Vectors*

Stroke Vectors	
.002" Width	10,000 inches/second
.036" Width Spot Wobble	400 inches/second
.250" Width Parallel Vectors	30 inches/second
1.023" Width Parallel Vectors	10 inches/second
Incremental Plot Vectors	
.002" Width	1000-1400 inches/second (Velocity is a function of direction)

*Depends upon Computer Controller Configuration, Data Format & Feature Configuration

Table VI - Symbol/Character Generator Performance

Variable Sizes

4-72 points in 1 point increments, or .0056" - 1.000" in .001" increments

Recording Rates **

10-1000 characters/second of Graphic Arts Quality

** Depends upon Character Size, Font Quality, Data Format, Mode of Operation, Computer Controller

2.6 CRT Exposure Head

The CRT Exposure Heads, as shown in Figures 6 and 12 consist of a high resolution, 5" diameter flat face CRT with P11 phosphor, assembled in a magnetic shield with its electromagnetic focus and deflection components as illustrated in the block diagram in Figure 19. The electron beam of the CRT is aligned in the center of a static focus coil which focuses the electron spot in the center of the CRT face to a size of about .0015" in diameter. A dynamic focus coil is used to correct for the change in focus across the flat CRT faceplate. A high precision deflection yoke with low spot distortion and growth is employed to randomly position the electron beam for plotting lines and for generating a subraster for recording characters or symbols over the 2" x 2" area on the face of the CRT. A high frequency circular spot wobble coil is used to vary line width during plotting.

Plot or character data florescing on the CRT faceplate is imaged through a 75 mm focal length 4/4 lens at 1:1 to expose a 2" x 2" area on a large sheet of film attached to the flatbed plotter table.

Geometric distortion of the CRT display and the optical lens are removed using precision geometrical correction circuitry.

All of the CRT control electronics and associated power supplies are assembled in a 12" x 12" x 5" chassis which is located next to the CRT Exposure Head and only requires 120V ac and x, y, and z input signals from the computer controlled Symbol/Vector Generator for operation.

2.7 Recording Media

A cataphoretic P11 phosphor screen was selected for the CRT because of its low grain noise and because its spectral characteristic matches existing blue sensitive high resolution CRT recording films, as shown in Figure 20. A number of filmswere tested during the program and the results are given in Table VII.

2.8 Performance Characteristics

Typical performance characteristics of the CRT Flatbed Photocomposition System are given in Table VIII.

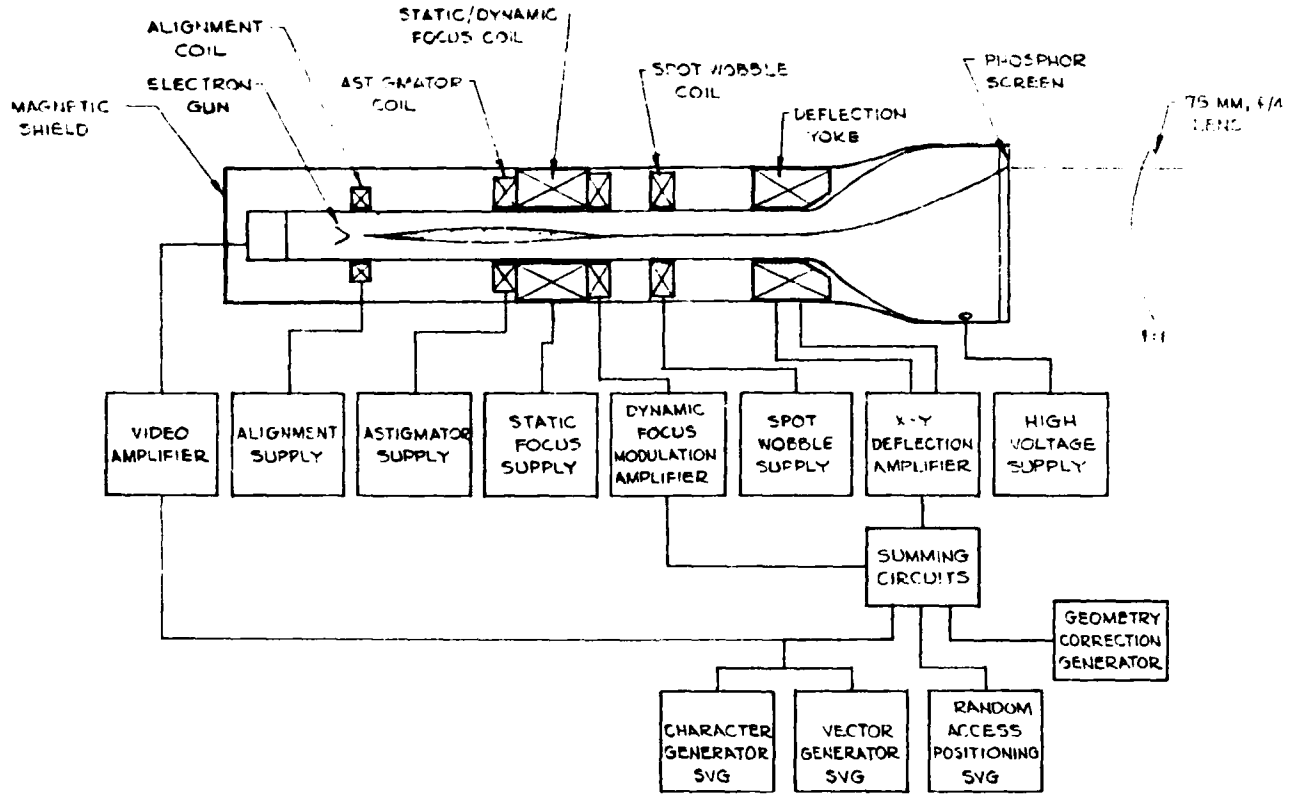

FIGURE 19 - BLOCK DIAGRAM OF CRT EXPOSURE HEAD

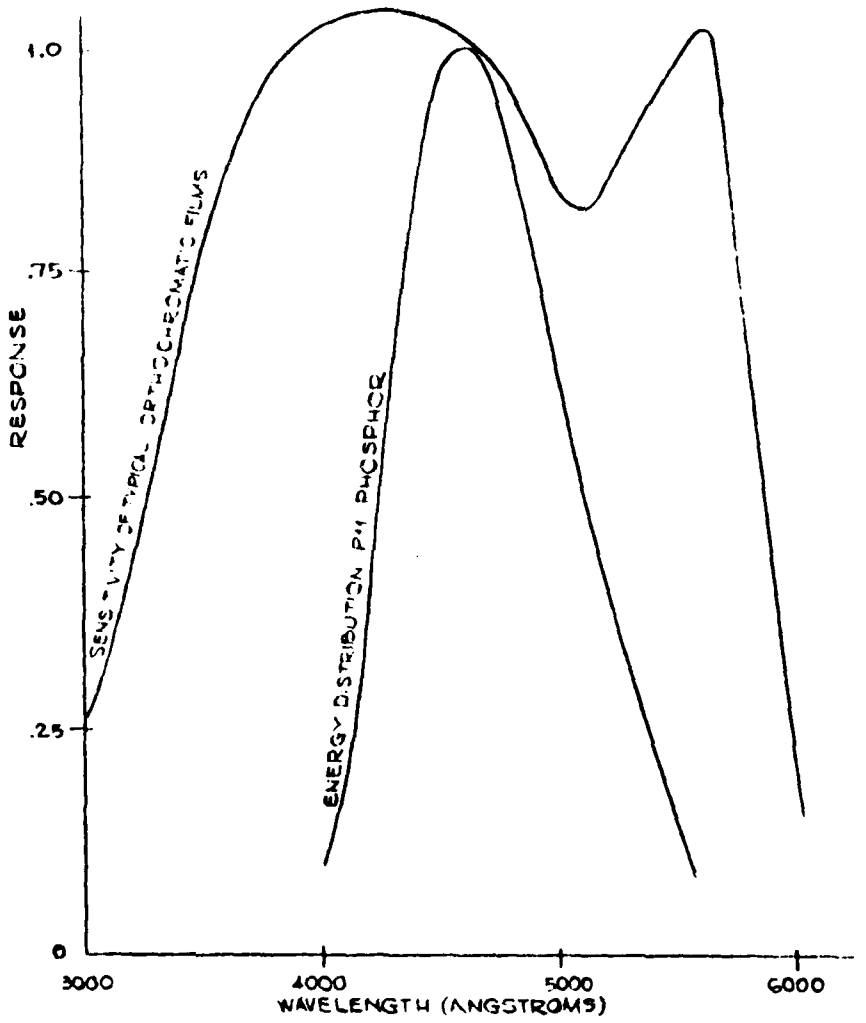

FIGURE 20 - SPECTRAL CHARACTERISTICS OF P11 PHOSPHOR AND CRT RECORDING FILMS

Table VII - Recording Films Tested

		Preferred	
Kodak		High Speed Phototypesetting	Best
Dupont		Phototypesetting	Best
		Acceptable	
Kodak	RAR2497	Recording	Slower, low Dmax
Kodak	2567	Royal Ortho	Still slower, high Dmin
Dupont	1823	Phototypesetting	Slow, too high contrast
		Not Acceptable	
Dupont	HC	Cronalar	Very high Dmin
GAF	EMC	Instrument	Low contrast
		Rejected Without Test*	
Kodak	2556	Kodalith Ortho	Too slow
Kodak	4562	Contact Copy	Too slow
Kodak	4566	Line Production	Too slow
Dupont	COS	Cronar	Too slow
Dupont	CHL	Cronar	Too slow
Dupont	DCL	Cronar	Too slow

*Based upon published data

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Table VIII - System Performance

Film Size	Up to 48" x 60"
Plotting area	2" x 2"
Line Widths	
Spot Wobble	.002" to .036" in 34 increments
Parallel Vectors	.022" to 1.023" in .001" increments
Character/Symbol Sizes	4 to 72 pts. in 1 pt. increments
Character Quality	Graphic Arts - 864 x 864 elements per inch
Line/Character/Symbol Rotation	360^{o} in 1^{o} increments
Plot Time 48" x 60" Chart	30 minutes depending upon information content

3.0 Conclusions and Recommendations

The three CRT Print Head Systems installed at the DMA Centers demonstrate increased versatility and speed for plotting cartographic products. The two systems interfaced to the Gerber plotters were accepted as meeting contract performance specifications. The system interfaced to the Concord plotter met most performance specifications and was conditionally accepted on the basis that it was the best that could be gotten under time and funding limitations imposed. The extent of positioning or geometric plotting errors introduced by the host plotter and the contribution of these errors to line mismatching between plotted pages were not accurately or conclusively determined.

The following recommendations will greatly increase the utilization and improve production at the DMA Centers:

(a) Convert all data bases into the paged SVG format by preparing a software package which operates efficiently on the PDP11 minicomputer controller. The SVG format takes advantage of the optimum hardware capability and the data compression of the system. Plot times are reduced 20-50 times and 5 rolls of magnetic tape of data reduces to 1/4 - 1/2 roll of magnetic tape based upon complexity of data.

(b) A large font library of graphic arts quality characters and symbols must be developed by U.S.A.E.T.L. or outside contractors in order to take advantage of the CRT Print Head Photocomposition capability for names placement and text preparation.

(c) The CRT Exposure Heads should be mounted permanently on the plotter table and used for plotting linework, names and symbols for all cartographic features.

(d) The systems at the Hydrographic Center and the Topographic Center should be expanded to the same configuration of the Aerospace Center.

(e) The plotter computer controllers should be replaced with microprocessors interfaced to the CRT Print Head Computer Controllers, thereby eliminating reliability problems associated with the older plotter computer controllers.

(f) The Vector/Symbol Plot (VSP) software package should be upgraded for all systems to include a new improved version of VSP which will allow (a) greater speed; (b) use less overhead, thereby reduce memory requirement; and (c) increase flexibility.

(g) All new software developed for the CRT Print Head Systems should be processed with the DMA main frame computers into SVG format.

(h) All three DMA Plotter Tables should be carefully measured with accurate instrumentation to determine the physical characteristics of each table which might contribute positioning or geometric errors to a CRT Print Head Plot. The tables should be then upgraded where possible and additional correction software provided to reduce errors caused by: table surface flatness nonuniformity; worn gears or lead screws; non parallelism of carriage to table surface over entire table; and other positional inaccuracies.

(i) The vector position accuracy in the vector plotting mode is about 0.001". This should be improved by developing an all digital vector calculator to replace the sin θ/cos θ analog calculator presently used in the Symbol/Vector Generator.

(j) Organize software development and production to allow the use of the Cartographic EBR for proof plotting of cartographic data before final plotting with the CRT Print Head. This will greatly reduce proofing costs both in labor and film. A typical proof plot in EBR format may be up to 50 times faster than an equivalent plot at full scale with the CRT Print Head.