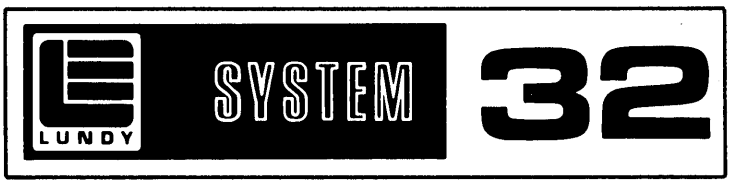
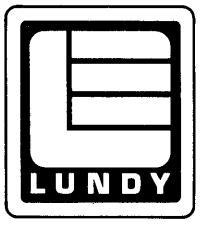


High Performance Interactive Graphics



LUNDY ELECTRONICS & SYSTEMS, INC.
COMPUTER GRAPHICS OPERATION

28 PARK PLACE, PARAMUS, NEW JERSEY 07652 • PHONE (201) 262-5400

LUNDY SYSTEM 32

High Performance Interactive Graphics

May 1971

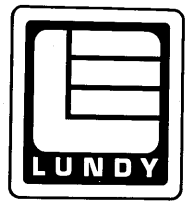


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TABLE OF CONTENTS

		Page Number
I	**INTRODUCTION**	
1.1	General	1
1.2	Performance	1
1.3	System Hardware	1
II	**FEATURES AND SPECIFICATIONS**	
2.1	Features	2
2.2	Specifications	2
III	**EQUIPMENT FUNCTIONAL DESCRIPTION**	
3.1	General	4
3.2	CRT Display and Deflection Subsystem	4
3.3	Vector Generator	4
3.4	Character Generator	4
3.5	Display Processor	4
3.6	Rotation and Reflection	7
3.7	3-Dimensional Display	7
3.8	Scissoring and Field Selection	7
3.9	Input Devices	7
3.9.1	Light Pen Pointer	7
3.9.2	Light Pen Tracking	7
3.9.3	Trackball	7
3.9.4	Function Keyboard	7
3.9.5	Alphanumeric Keyboard	7
3.10	Display Interface	7
3.11	Refresher Memory	7
3.12	Interrupt Control	7
IV	**SOFTWARE COMMAND SET**	
4.1	Display Command Set	9
4.2	Vector Commands	9
4.3	Rectangle (REC)	9
4.4	Point Commands	9
4.5	Circle (CIR)	9
4.6	Ellipse (ELP)	9
4.7	Character Mode	9
4.8	Set Modes (SMD)	9
4.9	Vector Absolute (VAB)	9
4.10	Jump (JUP)	9
4.11	Jump and Save (JUS)	11
4.12	Jump Back (JUB)	11
4.13	No Operation (NOP)	11
4.14	3-Dimensional Commands	11
V	**HARDWARE DESCRIPTION**	
5.1	CRT Display Console	11
5.2	Display Processor	11
VI	**DOCUMENTATION, TRAINING AND MAINTENANCE**	
6.1	Documentation	11
6.2	Training	11
VII	**ACCEPTANCE TESTS AND WARRANTY**	
7.1	Factory Tests	13
7.2	Installation Tests	13
7.3	Warranty	13
VIII	**PURCHASE OR LEASE PLAN**	
8.1	Purchase or Lease Plan	13
IX	**MAINTENANCE**	
9.1	Maintenance Plan	13

LIST OF ILLUSTRATIONS

Figure		Page
1	System 32	ii
2	Block Diagram of System 32 and DEC PDP-9 Interface	5
3	Block Diagram of System 32 and IBM 1130 Interface	6
4	Display Map	8
5	Computer Display Command Set	10
6	System 32 Outline	12

FIGURE 1. SYSTEM 32

Section I

INTRODUCTION

1.1 GENERAL

The Lundy System 32, a High Performance Interactive Graphic Display combines state-of-the-art technology in digital and analog systems. The system utilizes the latest medium scale integrated (MSI) circuits to reduce digital package size, and to achieve higher performance and greater reliability. Lundy has designed System 32 to yield the highest performance for writing speed, display resolution, and high brightness for operator convenience and comfort in viewing.

System 32, with the combined capability of line drawing and alphanumeric display, provides modular flexibility permitting a wide choice in computer interfaces, and auxiliary hardware selection. Items that appear repeatedly in the Display may be "display subroutined" to conserve space in the display core memory.

By combining digital and analog technology, the display generators have the capability of drawing individual or multiple vectors, long, short or point size, with a single operation command word at maximum speeds of 1.0 inches per microsecond. Circle, ellipse and rectangle generators similarly enhance the Display Processor performance capability. A programmed character generator provides the user with a 96 character font alterable or expandable to 192 with minimal hardware modifications and a capability of displaying 6000 characters on the CRT screen.

1.2 PERFORMANCE HIGHLIGHTS

HIGHEST LINE DRAWING SPEED CAPABILITY – allows display of more data per frame.

FAST CHARACTER GENERATOR – allows display of more data per frame.

EFFICIENT COMMAND SET – increase processing speed and cuts waste of core storage. Saves programming time.

HIGH DATA RESOLUTION – enhances system application for high, precise current and future requirements.

HIGH VISUAL RESOLUTION – improves operator interpretation of displayed data.

DISPLAY SUBROUTINES – conserves buffer core, and reduces programming.

HIGH SPEED PROCESSOR – increases display capability per frame.

1.3 SYSTEM HARDWARE

MODULAR CONCEPT – selective choice of hardware tailored to customer application and total need.

LARGE AREA DISPLAY – increases amount of data displayable, visual resolution, operator convenience.

DISPLAY FORMAT, COMMAND VARIABLE – increases flexibility for many applications, enhances display appearance, and improves interpretation.

PROGRAMMED CHARACTER GENERATOR – offers 96 individually stylized character symbols, for specific task, changeable in style, size or content with minimal hardware. Lower case and expanded 192 character set is an additional option.

LATEST MEDIUM SCALE INTEGRATED CIRCUITS – offers next generation system design, increased speed, greater reliability and reduced package size.

Section II

FEATURES AND SPECIFICATIONS

2.1 FEATURES

The Lundy System 32 is specifically designed as a high performance system for use with modern computers. Distinctive system features include:

MODULAR CONCEPT

Allows customer selection of specific capability and performance at maximum economy.

DIGITAL TECHNOLOGY

Latest MSI and Integrated Circuit technology is used in the hardware design. Greater performance, reliability and economy with reduced equipment size are the results.

LARGE DISPLAY AREA

System 32 provides the full 314 square inch CRT viewing surface as a working area. Large amounts of data at high resolutions of 1 part in 2047 are displayed.

LINE DRAWING

High performance vector generators combine digital and analogy integrated circuit technology, and are capable of displaying 12,000 inches of 2-inch lines or 23,000 inches of 8-inch lines per 30 Hz frame. Solid, dot, dash or dot/dash line construction and four brightness levels can be selected.

CIRCLE, ELLIPSE AND RECTANGLE DISPLAY

Single command words permit complete or partial display of circles and rectangles developed with special generators. Complete ellipses may also be drawn with one display word.

CHARACTER AND SYMBOL DISPLAY

A programmed character generator with the capability to display a font of 96 or 192 characters and symbols. Style or choice of character font may be altered with minimal hardware changes. The system can display up to 6,000 characters per frame at 30 Hz refresher rate.

VERSATILE COMMAND SET

The operation command set provides for a highly efficient software system for displaying individual or multiple vectors, circles or symbols with each 32 bit word. Internal subroutine operational commands permit conditional jumps and returns to display repetitive items with less computer core space; or display reference data, occasionally interlaced with working data. Mode commands also permit changes in individual display mode variables without changing others. Some variables may be activiated for individual command words as desired.

COMPUTER INTERFACE

Computer interfaces are available or can be provided for most computers.

REFRESHER MEMORY

An optional 16,384 x 16 or 8192 x 16 field Core Refresher Memory field expandable to 16,384 x 16 with a cycle time of one microsecond.

MANUAL INPUT DEVICES

Manual input devices include:

AN Keyboard	64 Keys
Function Keyboard	16 or 32 Keys
Light Pen Pointer	
Trackball	
Tablet	

2.2 SPECIFICATIONS

PHYSICAL CHARACTERISTICS	
Power Input	208 ± 10 VAC, 4 wire, 3 phase, 60 ± 3 Hz, 2.5 KVA
Enviornment	60° to 85°F at 95% maximum relative humidity
Size	Approx. 56" high x 60" wide x 48" deep (46" width optional)
Writing Surface	12" depth (U-shaped desk optional)

CATHODE RAY TUBE	
Tube Size	22" O.D.
Tube Shape	Round
Radius of Tube Face Curvature	215 ± 7"
Phosphor Type	P31*
Colors	White, yellow-green
Display Size	20" dia.
Display Area	314 sq. inches
Spot Size (within 14" x 14" non-menu area)	.015
Brightness	40 ft. lamberts
Contrast	5 to 1
Implosion Panel	Bonded, with etched outer surface
Face Plate and Implosion Panel Combined Transmission	40%

* Other phosphor types available

DEFLECTION SYSTEM	
Raster Count	2048 x 2048 (20 x 20 inches)
Raster Interval	.010 inches
Focus Method	Electromagnetic
Deflection Type	Random Scan
Drift	±0.5%
Deflection Method	Electromagnetic

PROCESSOR DESIGN

Op Command Set, words	14 standard
Word Length[1]	32 Bits
X and Y Accumulator Registers	2048 x 2048
Menu Area Blanking	14" x 14"
3-Dimensional Rotation	± ½ LSB
Reflection and Rotation of Subset	8
Line Vector Generator	
Vector Absolute Generator	
Alternate Vector Generator	
Point Vector Generator	
Rectangle Generator	
Circle Generator	
Ellipse Generator	
Character Generator	96 or 192 Characters
Frame Timer	10 to 100 ms. adjustable
Conditional/Unconditional Jump Commands	3

NOTE 1. 48 bits for 3-dimensional data.

COMPUTER INTERFACES

Computer	IBM—System 360 IBM-1130 PDP-9, 11 and 15 Varian 620/i or 620/f MAC-16
Other interfaces available	

REFRESH MEMORY

Type	Core
Word Size	16 Bits
Number of Words	8192 (Field expandable to 16,384) or 16,384
Cycle Time	1 μsec

LINE VECTOR GENERATOR

Line Definition	Analog
Display Method	Stroke
Max. Component Length	2047 raster units
Line Types	Solid, dash, dot and dot/dash
Mode	Delta or Absolute
Intensity Levels	4
Long Vectors per Word	1
Short Vectors per Word	2

POINT VECTOR GENERATOR

Used with number of Command Words	5

ALTERNATE VECTOR GENERATOR

Number vectors per word	2 (Orthogonal, horizontal or vertical)

RECTANGLE GENERATOR

Rectangle Location	Counterclockwise from lower left hand corner for positive values of X and Y at the last coordinate.
Line Types	Same as vector
Vectors per Word	4

CIRCLE/ELLIPSE GENERATOR

Circle Center Locations	Last coordinates
Segment Start and Stop Display	Each programmable in 5° increments CCW from 0° reference axis.
Radius	Programmable to 511 raster units
Circle or Segments per Word	1
Ellipse Center Locations	Last coordinates
X and Y Ordinates	Programmable to 511 raster units
Complete Ellipses per Word	1

CHARACTER GENERATOR

Character Definition	Analog
Display Method	Stroke (5 average)
Character Code	ASCII – or EBCDIC
Number of Strokes per Character	Variable – max. of 16 components of vectors
Number of Characters in Font	96 upper case and symbols or 192 with lower case and symbols.
Character Aspect Ratio	$\frac{\text{height}}{\text{width}} = \frac{5}{3}$
Character Height	.125, .250 and .500 inches standard (.375 additional option)
Bold and/or italic Characters	Optional
Characters per Word	4

STORED INTERRUPT DATA

Function Keyboard Key Number
Current Program Address
Last Saved Program Address
Interrupt Type
Level of Saved Program Addresses
Current Rot. and Ref. Status
Last Saved Rot. and Ref. Status
X Accumulator Position
Y Accumulator Position
Event of Multiple Vector or Character Commands
Character Code of Alphanumeric Keyboard Key

DISPLAY TIMING

Vector Drawing, inches per μsec max	1"
Overhead time per vector	3.4 to 4.5 μsec
Overhead time per vector (3-dimensional)	5.8 μsec max. and overlapped

Section III

EQUIPMENT FUNCTIONAL DESCRIPTION

3.1 GENERAL

The Lundy System 32 is packaged in an attractive console and color matched to the system being employed.

System 32 major hardware groupings:

- CRT Display system with deflection, focus, linearity correction, blanking circuits, and analog generators.
- Processor electronics file consisting of the display control, registers, CPU interface, timing and function generators.
- Input devices which include function keys and light pen pointer. Other input devices are also available, such as the "Trackball" and "Tablet."
- Refresher memory.
- Power supplies

Functional descriptions of the hardware subsystems are discussed in the subsequent paragraphs, and refer to Display System Block Diagram, *Figure 2 and Figure 3.*

3.2 CRT DISPLAY AND DEFLECTION SUBSYSTEM

A 22-inch CRT display tube provides 314 square inches of active display working area with high visual resolution. Uniquely developed circuitry with responsive magnetic deflection yokes provide ultrahigh writing capability, fundamental to the display of large amounts of data, per flicker-free frame. This, combined with CRT designed for small spot size, provides a Display with excellent visual resolution and brightness levels for comfortable operator viewing. Critical design of input digital and analog electronics provides the system with high resolution, linearity and frame repeatability.

The display area will be a 20" circle with a 20" x 20" circumscribed or 14" x 14" inscribed x and y coordinate area, subdivided into 2048 x 2048 increments of addressable points. Programmable CRT bias levels are available to produce four display intensity levels.

A Blanking Amplifier will bias the CRT on and off to produce dotted and/or dashed lines and blank out all unwanted positioning lines.

3.3 VECTOR GENERATOR

The Vector Generator receives digital delta coordinate input data, and generates analog horizontal and vertical deflection voltages to produce linear lines of uniform intensity. A digital accumulator updates the absolute coordinate position of the last displacement command, and as analog comparators signal the completion of the vector, the generator provides a blanking signal to prevent CRT screen damage by a stationary beam. Vector brightness is held uniform by a precision ramp generator that maintains a constant velocity of the CRT beam during the vector drawing.

Anolog comparators monitor the beam position for edge violation and blank the beam when the trace proceeds beyond the Display area. The X and Y accumulator storage is larger in size than the displayable area, and thus overflow is not encountered as frequently with normal operation. However, an overflow/underflow signal interrupts the CPU and requests service. When menu area blanking is desired, comparators will blank out vectors or characters exceeding the adjustable 14" x 14 " window. However, light boxes or instruction in the menu area will be displayed. This is controlled by setting a bit in Set Mode Command.

3.4 CHARACTER GENERATOR

A programmed character generator has the capability of displaying any of 192 characters or symbols, including lower case characters with lower extenders. The displayed character is formed in an addressable matrix with the analog outputs proportioned to a 3 x 5 aspect ratio and scaled for the various character sizes.

The character code from the CPU or keyboard input is used as an address to a dedicated read only memory. Stored in the memory, at the character coded address, is a sequence of delta X and Y coordinates defining the strokes of the character to be drawn. The stored contents of these address locations are changeable to create new characters or symbols, or even change the style of the displayed character.

The writing speed per character will vary from character to character depending upon the number of strokes required to produce the symbol. Optionally available equipment will display either italic characters or increase brightness of selected character by setting the first bit of the character code to "1".

3.5 DISPLAY PROCESSOR

The heart of the System 32 is the Processor. It is designed with latest in computer packaging technology using MSI's for speed, reliability, and packaging efficiency. The Processor controls the data flow between the Memory and the CRT Display. It functions to decode the command sets and properly order and display the data. It must interpret operator interrupts and request CPU service.

The Display Processor contains several registers, counters and accumulators, functions of which are varying, including packing of word size from 16 to 32 or 48 bits, maintaining of program and jump addresses, set modes, and character unpacking. It also includes the Frame Timer which assures uniform display brightness and prevents screen damage from excessive refreshing.

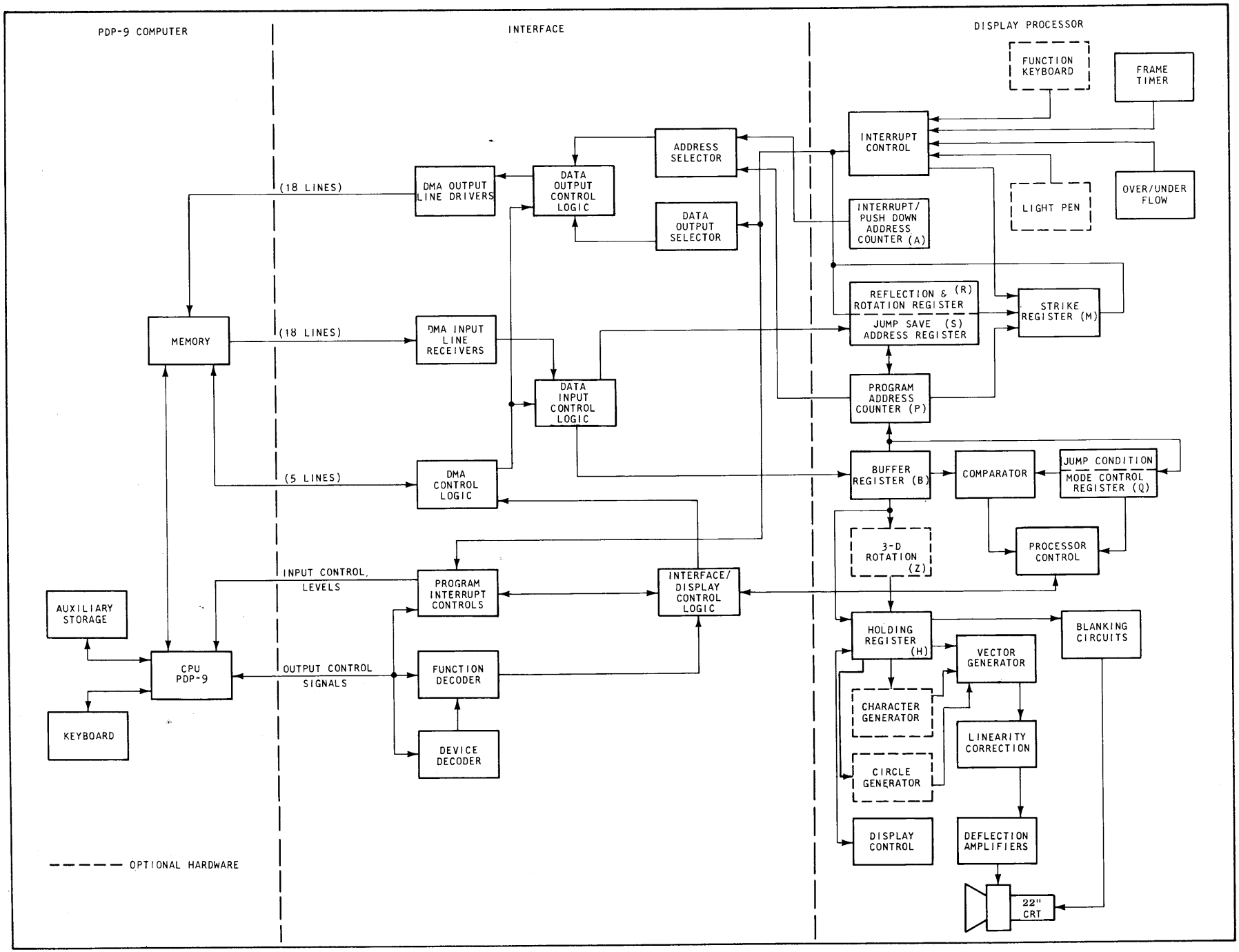


FIGURE 2. BLOCK DIAGRAM OF SYSTEM 32 AND DEC PDP-9 INTERFACE

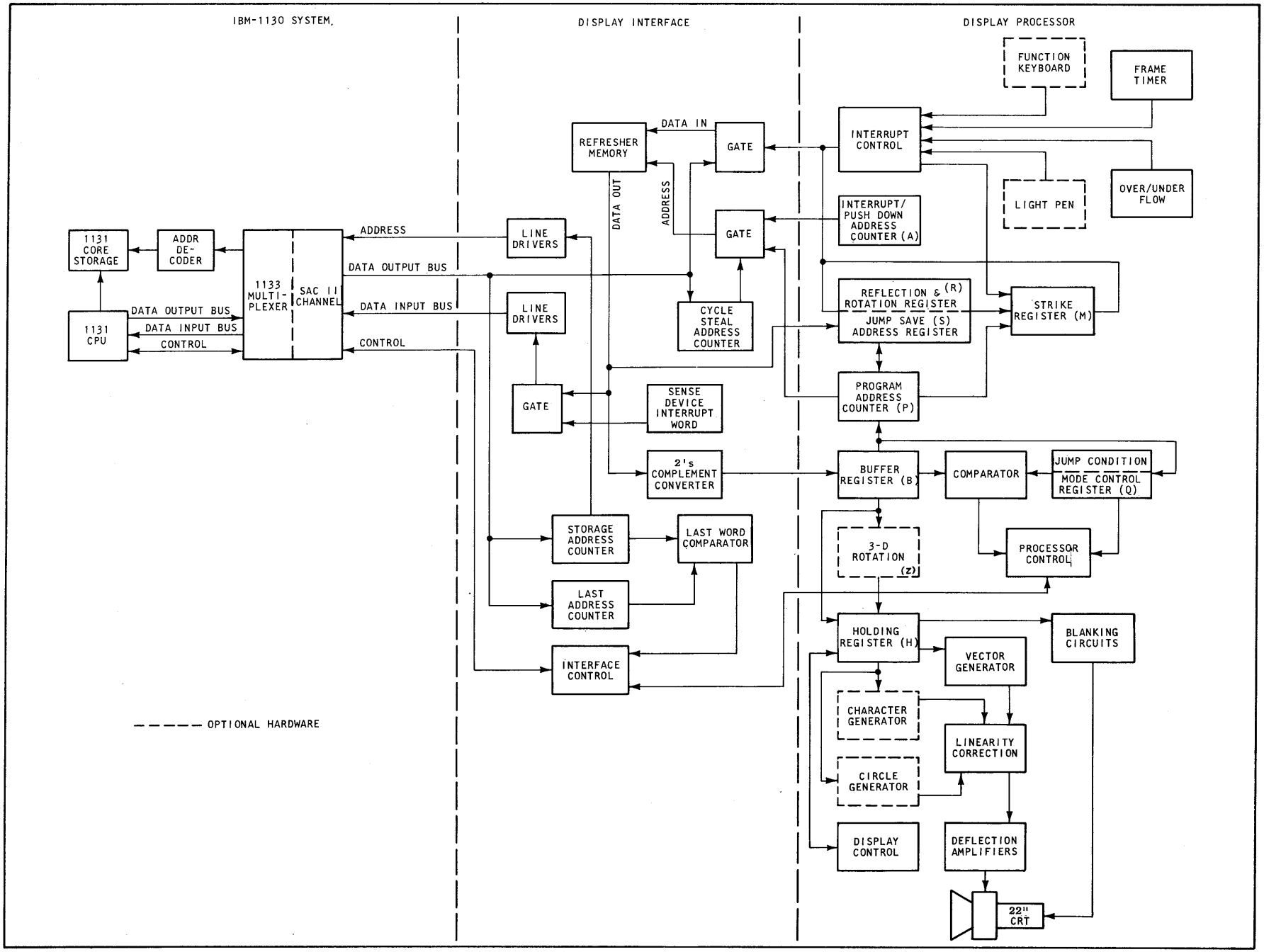


FIGURE 3. BLOCK DIAGRAM OF SYSTEM 32 DISPLAY AND IBM 1130 INTERFACE

The processor is designed within a single computer card file which also contains the optional function generators, and Display/CPU interface modules. This creates a system of maximum compactness without penalty for flexibility and at increased performance.

3.6 ROTATION AND REFLECTION

The Display System provides as a standard feature the ability to rotate or reflect a subset display (JUP or JUS commands) in the X Y dimensional frame. This function will invert the image about the vertical and/or horizontal axes and/or rotate in 90° coordinate steps.

3.7 3-DIMENSIONAL DISPLAY

The Display System may be provided with the capability of accepting X Y Z coordinate data and presenting a two dimension orthologonal projection on the CRT viewing area, rotatable about any of the X, Y or Z axes in small or large discrete steps.

Equations (1) and (2) show the mathematical relationship of the CRT h and v display coordinates for input data presented in the ΔX, ΔY, ΔZ coordinate forms.

(1) $h = i_h\Delta X + j_h\Delta Y + k_h\Delta Z$

(2) $v = i_v\Delta X + j_v\Delta Y + k_v\Delta Z$

i_h, j_h, etc. are unit vector coefficients and are functions of the rotation angle in space. These coefficients are calculated by the CPU and are transferred to the Display Processor by two SBM commands on operator interrupt. Binary rate multipliers are used to compute three (3) products simultaneously, and these are summed to form "h" coordinate and are repeated with the other coefficients for the "v" coordinate.

The 3-Dimensional rotation hardware consists of two logic cards in the Display Processor Unit card file.

3.8 SCISSORING AND FIELD SELECTION

The Processor accumulators are capable of maintaining a field area of 2048 x 2048, in both X and Y, to allow utilization of the entire CRT screen area. By setting of Vector Absolute Commands to new values any section of the field may be displayed in any position on the CRT screen. Scissoring is accomplished utilizing software techniques. See *Figure 4.*

3.9 INPUT DEVICES

3.9.1 LIGHT PEN POINTER

The Light Pen provides a means of selecting displayed items on CRT screen. The pen senses the light from the CRT and latches, at that specific time, the data word being displayed. This requests a computer interrupt to set or reset the mode bits of the specific display word on or for the next refresh cycle.

3.9.2 LIGHT PEN TRACKING

When a coordinate data point not currently displayed is desired, a light pen movable target may be software generated and displayed by the Processor. The tracking target, a series of short vectors displayed in the form of a cross (+), follows the motion of the light pen on the CRT with desired speed and positional selectivity.

3.9.3 TRACKBALL

A trackball can be supplied in the system that allows positioning of a cursor on the CRT. When the selected function key is depressed, the trackball X and Y coordinate data is read into the dedicated section of memory and is available to the CPU on a program interrupt control.

3.9.3.1 CURSOR CONTROL FOR TRACKBALL

With the "Display Cursor" function button activated, the trackball registers will be displayed on CRT. The initial position will be preset to the center of the screen and operator control of the trackball will move the cursor as desired.

The cursor symbol is program generated by the character generator at the beginning of each refresh cycle.

When a specific function key is depressed, analog comparators will cause a strike to be detected whenever the vector display deflection voltages match the trackball position voltages in both X and Y within band limits.

The strike signal will set or reset the appropriate function modes requested, e.g., Blink, Unblink, Decenter, Erase, etc.

3.9.4 FUNCTION KEYBOARD

The function keyboard provides 16 or 32 keys, programmable to their function by the CPU. The function keys cause interrupts and present device status conditions when an interrupt request is serviced by the processor. The 32 key keyboard may also be optionally provided with a double interrupt for second interrupt on release.

3.9.5 ALPHANUMERIC KEYBOARD

The alphanumeric keyboard is available with 64 keys, coded in either ASCII or EBCDIC. Key depression causes a processor interrupt with subsequent storage of the coded character of the key.

3.10 DISPLAY INTERFACE

The Display Processor is provided with an interface module (single card) to condition all input/output data and control signals between the Display and CPU. The interface will also contain the Device Selector hardware for selection of Display and data from the CPU Input/Output Data Bus.

3.11 REFRESHER MEMORY

A Refresher Memory, 8192 or 16,384 words by 16 bits, will refresh the CRT Display. The memory will be block loaded by the computer. Transfer of data between the CPU memory and the Refresher memory is under the control of Display Interface.

3.12 INTERRUPT CONTROL

The interrupt control module controls the read of data from the strike register, accumulators, keyboards, etc. to dedicate section of either CPU memory or to the optional refresher memory. In the latter case, the control also functions to allow transfer of data from the refresher memory to CPU memory.

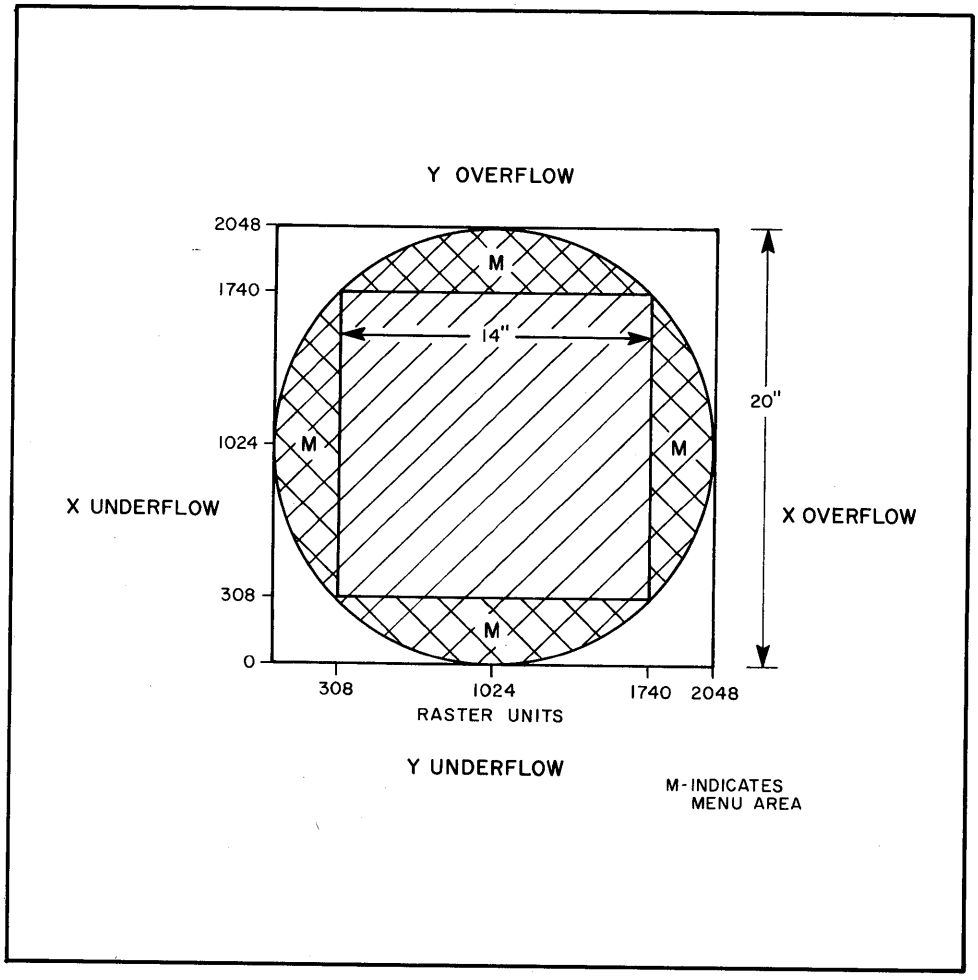


FIGURE 4. DISPLAY MAP

Section IV

SOFTWARE COMMAND SET

4.1 DISPLAY COMMAND SET

The following are descriptions of the Display Processor commands, formats (*Figure 5*), including standard and optional features that may or may not be supplied in the proposed system.

4.2 VECTOR COMMANDS

Three types of vectors are drawn by the Display Vector Long (VLN), Alternate X Y Vector (ALT) and Vector Short (VSH). The VLN delta coordinate commands 12 bits of each, including sign, $\pm\Delta X$ and $\pm\Delta Y$ specify the position to which the beam is to move relative to the absolute position stored in the X and Y registers (12 bits each).

VSH allows the 32-bit word to contain two vector instructions. Each delta X and Y coordinate is specified by 7 bits including sign.

ALT provides for two connecting long vectors to be drawn with one 32-bit word when the alternate X or Y coordinates are zero. Sequence is specified by bit A.

The vectors are intensified when the intensifier bits are "0". If "1", the beam is moved to the next coordinate position without intensification.

4.3 RECTANGLE (REC)

REC orders the display to draw a rectangle with selectivity blanked sides, starting at the present position (X,Y) of the display. The intensifier bits control the unblanking of the sides of the rectangle, in the order of their drawing, clockwise from origin.

4.4 POINT COMMANDS

Points may be displayed by setting the "p" bit in VLN and ALT commands. In the VSH and REC commands, points will be displayed when all I bits are "1".

4.5 CIRCLE (CIR)

CIR orders the display to draw a circle with its center at the current accumulator positions (X, Y) of the display, with radius Rc and starting/stopping points specified by the command.

4.6 ELLIPSE (ELP)

ELP orders the display to draw an ellipse with its center at the current position (X,Y) of the display accumulator, with R_X and R_Y as its ordinates.

4.7 CHARACTER MODE

Set Character Mode (SCM) conditions the Display Processor to receive and display a string of characters in linear format. Once the SCM code has been recognized, all succeeding 32-bit words are interpreted as four 8-bit character codes, until an EOT (End of Text) is detected in the string.

When an SCM command is decoded, the first character is written to the right of the position contained in the X and Y registers. The X position is incremented for each character by one character space until a New Line (NL) character is encountered. The X position is then reset to the beginning of a new line while the Y position is decremented by one line space.

4.8 SET MODES (SMD)

This control word sets the parameters to be stored in the Display Processor, which may apply to several succeeding words in the display program.

An asterisked mode bit, such as C*, I* and others, permits the alteration of that specific Set Mode parameter without effecting other modes set by previous SMD commands.

Eight conditional jump modes may be set by setting any or all of the C_0 through C_7 bits true (1). Blinking and desired brightness may be set with appropriate B and b bits respectively. For selecting type of display line, D bits are set for solid, dot, dash and dot/dash. Bit L will enable light pen for all subsequent displayed lines or characters.

An F* will start the regeneration of next frame conditional upon the frame times. Normally only one F* command should appear in a display program.

J bits will be set for data to be displayed in the menu area (outside inscribed square, 14" x 14"). If these bits are always set to 1, no blanking of data will occur in this area. The redundancy of B and L in the display command word set provides additional flexibility when individual commands are requesting vectors or circles to Blink or allow light pen enabling.

4.9 VECTOR ABSOLUTE (VAB)

The op-code VAB, presets an absolute value, 11 bits unsigned, into the coordinate registers of the Display Processor.

4.10 JUMP (JUP)

The jump commands, except JUB may be conditional or not, depending on bit C. If C. is false, the jump will be conditional on one of the bits of C_0 to C_7 being set, and the corresponding bit in the SMD command being true. If no jump occurs, the next command in memory will be executed.

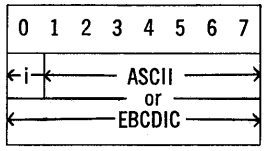
If C is true, the jump will take place unconditionally to the jump address contained in the Jump Command. When a jump takes place, the new address replaces the current address in the program counter and program execution proceeds. No return address is saved by the JUP command.

COMMAND	BIT	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Vector Short	VSH	1 1 ± (i) ± (o) ← △X_I → ← △X_O →	I_I I_O ± (i) ± (o) ← △Y_I → ← △Y_O →	0 0 ± (i) ± (o) ← △Z_I → ← △Z_O →
Vector Long	VLN	0 0 0 1 ± ← △X →	I B L p ± ← △Y →	0 0 K K ± ← △Z →
Rectangle	REC	0 0 1 0 ± ← △X →	I_O I_1 I_2 I_3 ± ← △Y →	
Vector Alternate	ALT	0 0 1 1 ± ← △H →	I_O I_1 A p ± ← △V →	
Circle	CIR	0 1 0 0 N N K ← R_C →	L B ← Arc Start → ← Arc Stop →	
Ellipse	ELP	0 1 0 1 N N K ← R_X →	L B K K K K K K ← R_Y →	
Vector Absolute	VAB	0 1 1 0 0 ← X →	I B L p 0 ← Y →	
Set Binary Multipliers	SBM	0 1 1 0 ± ← i_h or i_v →	0 0 0 0 ± ← j_h or j_v →	T_O T_I E K ± ← k_h or k_v →
Set Mode	SMD	0 1 1 1 C* C_O C_1 C_2 C_3 C_4 C_5 C_6 C_7 b* b_O b_1	L* L B* B J* J D* D_O D_1 M* M_O M_1 $\frac{t^*}{Z^*}$ t Z F*	
Set Character Mode	SCM	1 0 0 0 N S* S_O S_1 ← Char 0 →	← Char 1 → ← Char 2 →	
Set Character Mode	SCM	← Char 3 → ← Char 4 →	← Char 5 → ← Char 6 →	
No Operation	NOP	0 0 0 0 N N K K · · ·	· · · K	
Jump	JUP	1 0 0 1 $\overline{C}$ C_O C_1 C_2 C_3 C_4 C_5 C_6 C_7 R_O R_1 R_2	P_O P_1 · · · · · · P_{15}	
Jump and Save	JUS	1 0 1 0 $\overline{C}$ C_O C_1 C_2 C_3 C_4 C_5 C_6 C_7 R_O R_1 R_2	P_O P_1 · · · · · · P_{15}	
Jump Back	JUB	1 0 1 1 N N K K K · · ·	· · · K	
3-Dimensional	Automatic for VSH, VLN and SBM commands following a SMD where Z bit is true. Rotation and orthogonal projection is to the angle for which the SBMs are set.			

CODE LEGEND

A = 0: △H = △X, △Y = 0 1st Vector
△X = 0, △V = △Y 2nd Vector
A = 1: △X = 0, △V = △Y 1st Vector
△Y = 0, △H = △X 2nd Vector
()* = Alter mode
B = Blink
b = Brightness
C = Conditional jump
$\overline{C}$ = Unconditional jump
D = Line type
F* = Frame start
E = Reset 3-dimensional accumulator
I = Blanking
i = Italic character or increased brightness level (bold)
J = Blanking in menu area
K = Not used
L = Enable light pen
M = Magnification
N = Reserved for op code expansions
P = Jump address
p = Point display
R = Subroutine reflection or rotation
R_C = Radius of circle
R_X,R_Y = X and Y ordinates of ellipse
S = Character size
T = Set binary multipliers
t = Tracking enable
Z = 3-dimensional data

CHARACTER FORMAT



NOTE: Command Set shown includes both standard and optional features.

FIGURE 5. COMPUTER DISPLAY COMMAND SET

4.11 JUMP AND SAVE (JUS)

The op-code, Jump and Save command, has the same functions as in the Jump instruction except the current address is saved to which the program may be returned. JUS may also be conditional or unconditional upon the prior SMD commands.

4.12 JUMP BACK (JUB)

To return to the mainline program, a JUB command is executed. The address saved by the JUS is read into the program counter and incremented to the next command.

4.13 NO OPERATION (NOP)

Op-code 0000 indicates that no operation is to be performed for the specific command word in file. Program is advanced to the next command word.

4.14 3-DIMENSIONAL COMMANDS

When the Z bit in the SMD is set to 1, 48-bit words are automatically used for the VSH, VLN and SBM commands. This requires 3 fetches of 16-bit words from the memory for each command. Rotation processing is accomplished as a function of the Set Binary Multiplier Command (SBM). This command is processed whenever the Z bit has been set true (SMD) and the T bits appear true in subsequent SBM commands. Two SBM commands are required to set the 6 unit vector coefficients into the Binary Multiplier for vector rotation.

Section V

HARDWARE DESCRIPTION

5.1 CRT DISPLAY CONSOLE

Figure 6 shows the outline configuration of the Display Console and electrical power requirements.

The CRT tube is front mounted for convenient access and removal from cabinet. All side and cover panels except front are removable and held in place with magnetic rubber latch material and/or captive screws.

The CRT console pivots about a vertical axis for operator convenience. Deflection amplifiers are mounted close as possible to CRT yoke assembly to minimize lead length for compatibility with high performance of the system.

Equipment power supplies are mounted in the lower portion of the console with filtered forced air ventilation to the supplies, amplifiers and processor card file.

Refresher memory package(s) are located also in lower portion of the console for convenient access and minimizing cable lengths in the system.

5.2 DISPLAY PROCESSOR

The Display Processor and all interface logic between the computer and the processor is designed with the latest Integrated Circuits (IC) in the TTL family. The latest Medium Scale Integrated (MSI) devices, also of the TTL family, such as 4-bit shift registers, 1 of 10 decoders, counters, multiplexers, etc. are used.

The TTL family offers the needed speed capability without additional complexity. Combined with MSI, the circuit reliability is further increased. The dual-in-line-packages (DIP) offer the convenience of high density system packaging where as many as 198 individual DIP's may be mounted on a single two-sided PC board with plated through holes.

Research has developed this high density modular packaging technique. The system provides a means for handling 400 connections in and out of each board with access to local interboard busing and I/O system busing. The system allows for expansion capability at the designers convenience. All the logic circuit boards will be tested by special testers for the system or board functions.

Printed circuit mother boards are used in the Processor File eliminating need for wire wrap back planes.

Section VI

DOCUMENTATION, TRAINING AND MAINTENANCE

6.1 DOCUMENTATION

Lundy will provide Operation and Maintenance Manuals complying with best commercial practice with sufficient information to allow operation and service of the CRT display equipment.

Maintenance manuals will contain functional description with block diagram, schematics, wire lists and periodic calibration and preventive maintenance procedures.

6.2 TRAINING

Lundy will provide a two-week orientation and training course at its facility to train customer personnel in the operation of the equipment. Additional time, if desired, may be arranged at the site or at Lundy.

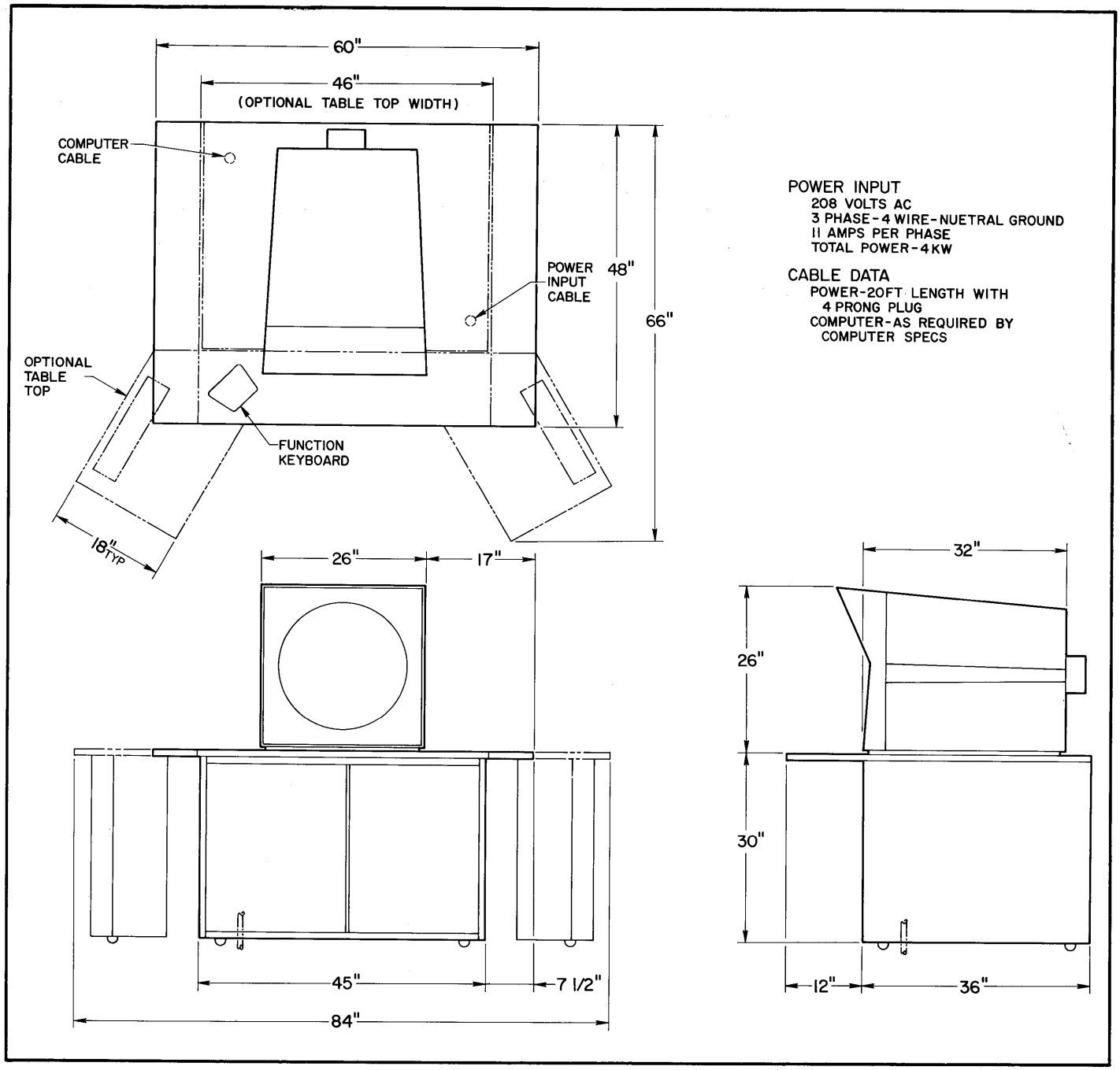


FIGURE 6. SYSTEM 32 OUTLINE

Section VII

ACCEPTANCE TESTS AND WARRANTY

7.1 FACTORY TESTS

Lundy will operationally demonstrate the complete hardware system at its facility to meet the requirements stipulated under the performance specification within this proposal.

7.2 INSTALLATION TESTS

At the completion of the installation at the Customer's site, Lundy will demonstrate the same performance tests as in the Factory Acceptance Test Plan for final acceptance of equipment.

7.3 WARRANTY

Lundy warrants that each new System 32 and supplementary display equipment is free from defects in material or workmanship under normal use and service for a period of ninety (90) days from the date of its installation at the site.

Section VIII

PURCHASE OR LEASE PLAN

8.1 PURCHASE OR LEASE PLAN

The equipment is available either by direct purchase or Lease Plan. 1, 2 or 3 year Lease Plans are offered.

Section IX

MAINTENANCE

9.1 MAINTENANCE PLAN

Three types of Maintenance Plans are offered:

Plan A – includes periodic preventative maintenance to assure highest equipment performance, and corrective on-call maintenance including replacement of any defective parts, except CRT.

Plan B – provides six (6) periodic preventative maintenance calls per year. Cost of replacement parts is additional.

Plan C – will offer service on an on-call basis.