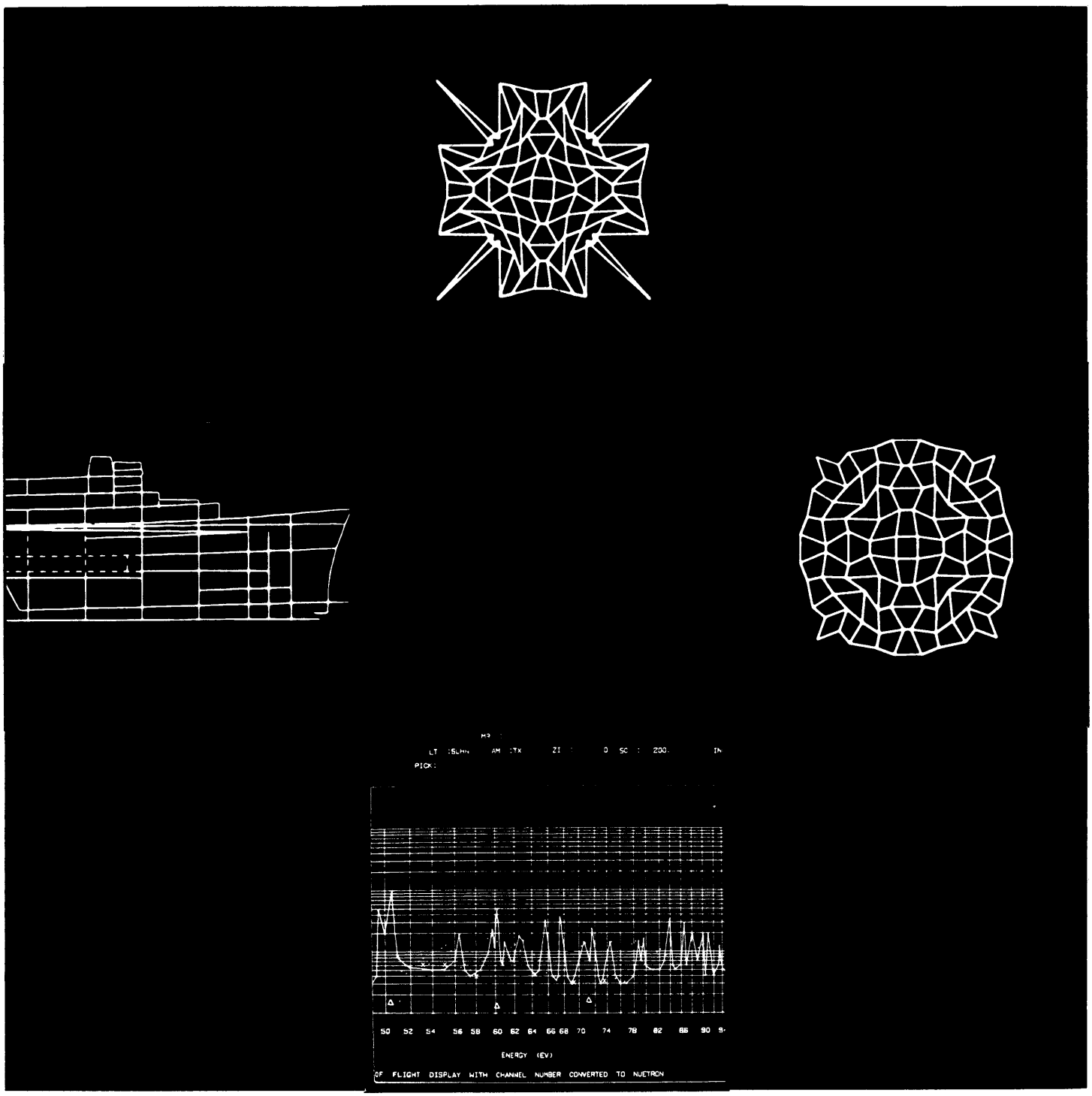
240 SERIES
GRAPHICS SUBSYSTEM

CONTROL DATA
CORPORATION

EXTERNAL SPECIFICATION



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GRAPHICS SUBSYSTEM

EXTERNAL SPECIFICATION

Control Data Corporation
Terminal Equipment Division
2401 North Fairview Avenue
St. Paul, Minnesota 55113

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INTRODUCING–
THE CONTROL DATA 240 SERIES GRAPHICS SUBSYSTEM

The computer with its associated data processing equipment has become an indispensable tool for everyone in industry, government, science, and education. Peripheral devices can extend the computer's capabilities while they provide simple, low cost access to the complex central system.

But, to release the always busy computer for complex processing and system control, the peripheral subsystem must process and store, display and record independent of the main computer and yet respond to demands made by other elements of the system. The peripheral devices must interact directly with the computer and must process data at speeds commensurate with those of the computer or data source.

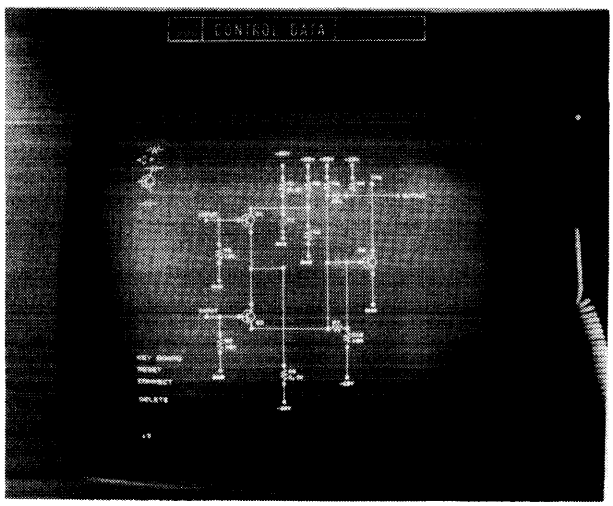
The CONTROL DATA 240 Series Graphics Subsystem can be adapted to the full spectrum of data and display processing applications. During development of the subsystem concept, emphasis was placed upon achieving a high degree of reliability and built-in flexibility in processing methods to ensure complete compatibility with the wide variety of contemporary computers.

The CONTROL DATA 240 Series Graphics Subsystem

The CONTROL DATA 240 Series Graphics Subsystem is a completely versatile integrated circuit, stored program, visual data processing device. In conjunction with a large-scale processing system, the graphics subsystem enables solving complex data processing problems.

The subsystem combines the capability to display symbols, draw lines, and plot points with an internal stored program processor. Processing capabilities include store accessing, logical computations, and fixed point arithmetic. Manual input devices – alphanumeric/function keyboard, light pen, and operator control panel – in conjunction with the visual display and stored program minimize subsystem to computer communications and free the large system for other tasks.

The graphics subsystem can be programmed to be compatible with any existing software developed for a given system or specialized software can be developed to suit the application. The basic instruction repertoire is similar to a CONTROL DATA 160A Computer with a display instruction repertoire added for processing displays and inputs from the manual devices. Program flexibility and complexity is at the discretion of the programmer and his software system.



OPTIONS

In addition, selection of any one or all of several options further increases the subsystem's flexibility. These options are an expanded memory, an expanded symbol repertoire, and a peripheral equipment input/output channel.

The basic memory is 4096 12-bit words. This is optionally expandable to 8192 words or to 12,288 words. Increased storage capacity afforded by the addition of an optional expanded memory provides capacity for a greater number of tasks with fewer interruptions in subsystem operation. Depending upon system applications, the additional storage capacity can result in greater efficiency in the overall data processing arrangement and significantly reduced processing costs. For example, the additional storage capacity could be used to increase the data base to which the controller has immediate access. This means that fewer data transfers are required for communication between the data source and the graphics subsystem. A larger portion of time expended by the data source and the controller could then be directed toward actual processing of data.

The basic symbol set contains 62 symbols composed of the English alphabet in capital letters, numerals 0 through 9, punctuation marks, and other commonly used symbols. The optional extended symbol set adds another 62 symbols for a total of 124. The extended symbol set comprises Greek letters, the lowercase English alphabet, and special symbols used in many scientific and engineering applications.

The optional input/output channel for peripheral equipment communication enables on-site complete data processing. The channel provides for communication with up to five standard CONTROL DATA 8000 Series peripheral units such as paper tape reader and punch, magnetic tape, disk, drum, line printer, and card reader.

FUNCTIONAL DESCRIPTION

Basic components of the graphics subsystem are a controller and a console. The controller functions as the decision-making element of the subsystem. In the on-line status, it can request data from the data source, receive or transmit data, and process all data used within the subsystem. Data obtained by the controller can be processed conventionally (processor mode) or displayed on the console crt (display mode). In display mode, the console presents a visual image in the form of symbols, vectors, and points comprising a graphic display. Data can be dynamically displayed on the crt and objects can be moved about using the light pen to add or delete a particular line segment or symbol and the keyboard to change parameters or add new information. The subsystem operating mode can be selected by any one of three sources: data source, operator, or internal program.

Off-line status provides for maintenance and program debugging. The operator uses the operator control panel to simulate data source operations or monitor internal operations of the subsystem. Except for the interface module, which is locked out while the subsystem is off line, operation within the subsystem is the same in either the on-line or off-line states.

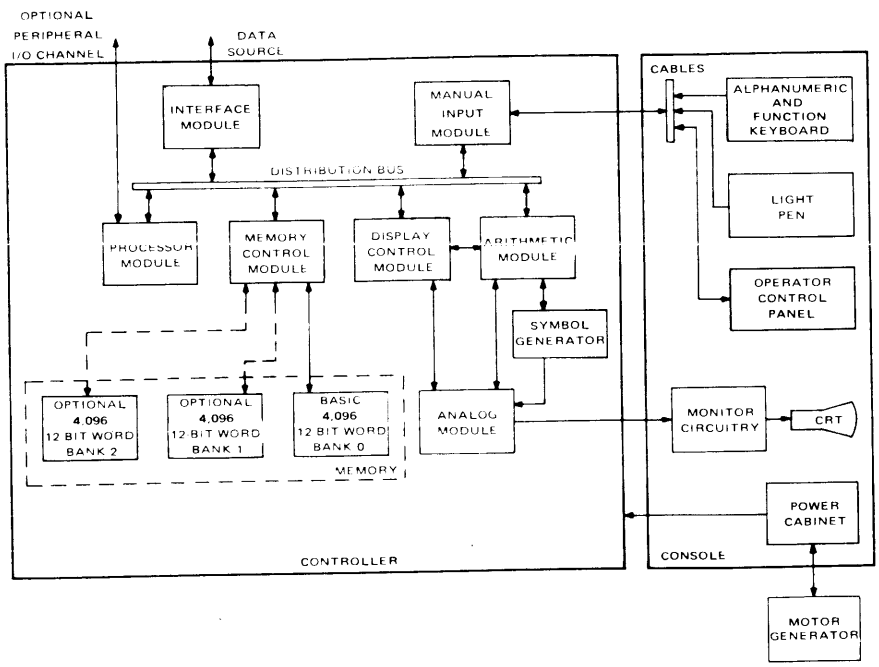
Controller

Seven functional modules in the controller perform all data transfer, processing, and display control operations. Six of the functional modules control all logical operations. Each of the six modules connects to a distribution bus which distributes data and control signals from one module to another. The analog module interfaces to, and operates in conjunction with, the display control and arithmetic modules. The analog module performs digital-to-analog conversions for crt presentations.

Interface Module

In a local (direct interface) configuration, the interface module serves the data source as a path to memory. It provides interrupt selection logic and status information. Function codes, issued by the data source, set up subsystem operating conditions and initiate operations.

In a remote (modem interface) configuration, the interface module functions as a control network between the data source and the remainder of the controller logic. To initiate an interface operation, the processor sets bits in the control register and defines the memory addresses to be referenced by the interface. The processor determines the source of an interrupt or the operational status of the interface by referencing the status register. Once the transmit or receive operation is initiated, the interface operates independently of the processor and accesses memory on a cycle-stealing basis. Data transfers can be in unpacked or packed format.



Processor Module

When in processor mode, the processor module functions as the principal control element governing execution of program instructions. In display mode, the display control module governs execution of program instructions. Since both the display and the processor share the same arithmetic and memory circuitry, they cannot operate simultaneously.

The processor can be activated by the operator control panel, a manual interrupt (keyboard or light pen), a channel interrupt (peripheral i/o channel), an interface interrupt, a display jump to processor instruction, or a data source function code (direct interface). The processor accesses memory to obtain instructions for execution and to obtain operands and data for processing.

The flexible processor instruction repertoire includes both 12- and 24-bit instructions. Seven types of address mode instructions as well as conditional and unconditional jumps in the processor's repertoire facilitate access to any location. These instructions allow programming subroutines and testing conditions which enable solving complex data processing and engineering design problems. (The Technical Brief, included as a part of this specification, lists all instructions.)

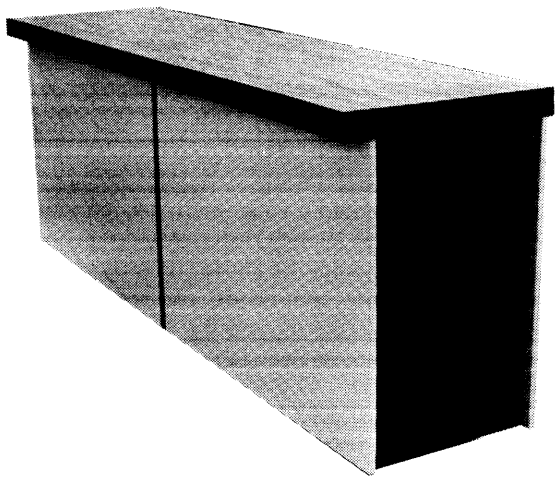
Display Control Module

Display control logic directs actions of the analog, arithmetic, and memory control logic in generating a display. Display mode can be initiated in response to commands by the processor or the manual input logic. In all instances, data for a display is stored in memory prior to initiation of the display mode. Display logic accesses memory for display commands and continues executing commands until termination of the display mode.

Arithmetic Module

The arithmetic module performs computations required to execute processor and display programs. It contains a subtractive adder and X and Y registers.

During processor mode, arithmetic logic adds, subtracts, multiplies, shifts, and performs logical operations required for data manipulation. During display mode, arithmetic logic computes beam positions and vector lengths. The X register controls horizontal beam positioning and the Y register controls vertical beam positioning.



Memory Control Module

Memory control accepts commands from the processor, the interface, manual input, or the display control logic to initiate memory read/write cycles. The memory control logic includes circuitry necessary for random addressing and automatic address incrementing. Data stored in or read from the core memory is transferred into or out of the memory module via the distribution bus.

Each core memory operates in conjunction with the memory control module. When the optional expanded memory is supplied with the subsystem, each group of 4096 12-bit words is assigned a bank number. Within the memory control module, address translation circuits allow the control circuits to recognize the memory bank selected for data storage or retrieval.

Manual Input Module

Manual input logic provides a data transfer path between the controller and operator controls. This transfer path operates during message entry or during operator modification of a graphic display using the light pen or keyboard. Manual input logic also operates in conjunction with controls on the operator panel, permitting off-line subsystem operation.

Analog Module

The analog module converts binary data, in the form of position words and symbol words, into analog signals for the monitor. The analog signals deflect the crt electron beam, generating display images specified by the display control module.

Console

The display monitor, manual input devices, and a power cabinet form the console portion of the graphics subsystem.

Monitor

Displays are presented on a 21-inch magnetic deflection crt in a 12-inch by 12-inch raster area composed of over one million addressable locations. Position words, associated with display commands, control electron beam positioning. The words specify beam deflection to horizontal (X) and vertical (Y) coordinates within the square grid (raster). The raster contains 1024 equally spaced X positions and 1024 equally spaced Y positions.

A point can be plotted in either absolute or relative positioning in 4 to 12 microseconds depending upon the distance from the present beam position to the next specified coordinate.

Vectors, dashed or solid, also can be specified as absolute or relative. Vectors are drawn at a constant rate of beam movement in four categories. Drawing and settling time is 30 microseconds for a full-scale diagonal vector to less than 9 microseconds for a 1/2-inch vector.

Symbols are drawn in 6.4 microseconds maximum plus positioning time which is 2 microseconds for incremental and tabular symbols. Random positioning time is dependent on the distance the crt beam must move. The symbol generator uses stroke techniques to connect points in a 5 by 7 matrix. Nominal size of small symbols is 0.166 inch high and 0.125 inch wide; nominal size of large symbols is 0.210 inch high and 0.160 inch wide. Normal or 90^{o} orientation may be specified for either size.

In addition, any symbol, vector or point may be blinked for emphasis.

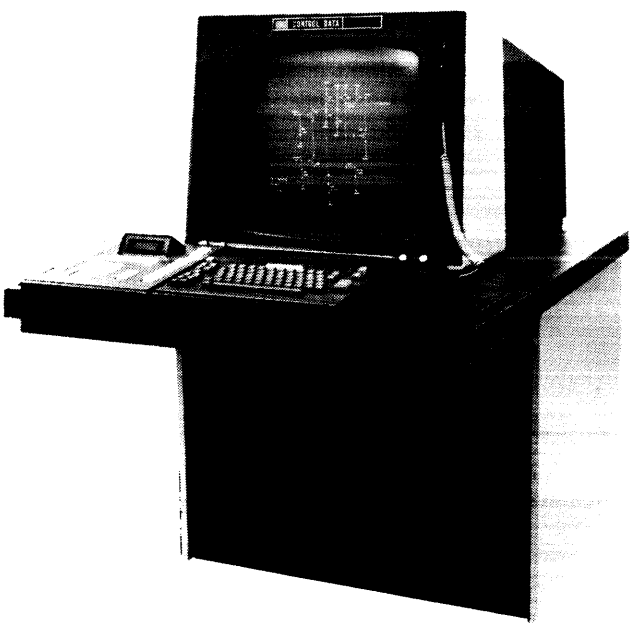
Display refresh is under program control. The rate is internally adjustable and is nominally set at 50 hertz.

Manual Input Devices

Manual input devices provide operator program entry and modification capabilities. The operator panel can be used for off-line program entry, program checkout, and general maintenance. It incorporates operation mode control and register readout. The alphanumeric/function keyboard provides a unique code for each actuated key to the processor. According to program interpretation, the keys can be used for display data entry, edit functions, selection of subroutines, and status indication. Under program control, the light pen allows the operator to compose graphic drawings in the form of charts, graphs, schematics, and 3-dimensional objects. Display entities may be selected or identified and deleted or changed as dictated by the program.

Power Cabinet

The power cabinet contains all the power supplies required by the controller and monitor and a power distribution panel incorporating connectors, circuit breakers, fuses, and a running time meter. Although not an integral part of the power cabinet, a motor generator is the source of 400-hertz power required by the power supplies.



OPERATIONAL CHARACTERISTICS

The inherent operational characteristics of the graphics subsystem can be defined by a description of the specific functions of the monitor front panel controls and the light pen, alphanumeric/function keyboard, and operator control panel.

Monitor Panel

Four main controls adjust the display. These are HORIZONTAL (horizontal) and VERTICAL (vertical) CENTERING for adjusting display positioning and FOCUS and INTENSITY for adjusting display appearance. Other front panel switches and indicators initiate and show various subsystem operating conditions as follows:

POWER ON — Actuation applies subsystem power. Indicator lights while power is on.

POWER OFF — Actuation removes subsystem power.

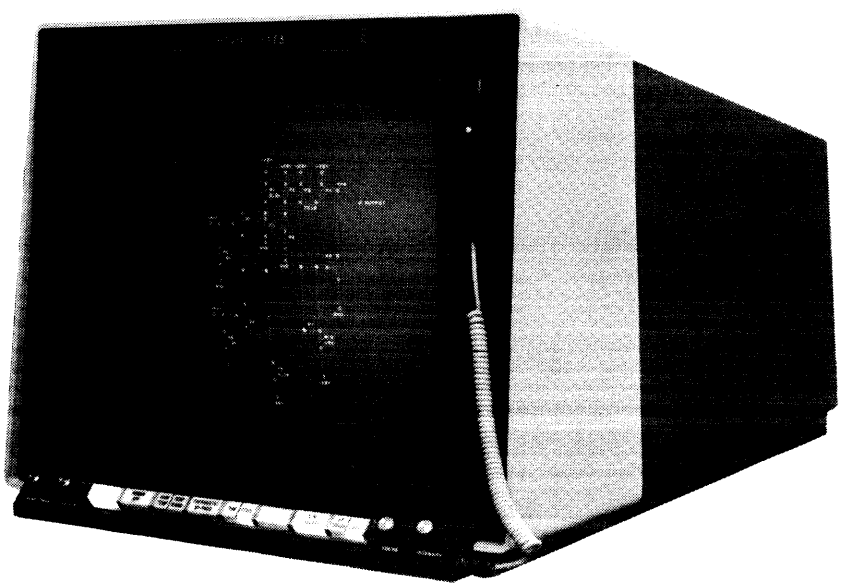
HIGH TEMP/TEMP WARN — HIGH TEMP lights when an interior thermostat determines an unsafe temperature and removes subsystem power. TEMP WARN lights when subsystem interior air rises above a preset temperature.

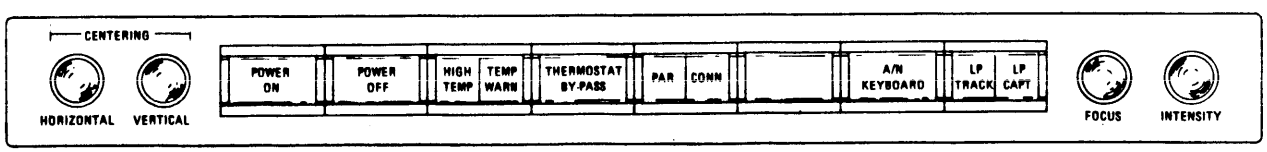
THERMOSTAT BY-PASS — Actuation allows bypassing the high temperature thermostat for continued operation. Indicator lights when the subsystem is in a bypass condition.

PAR/CONN — PAR indicates a parity error in transmission from the data channel to the subsystem. Turned off by master clear or initiating a new modem operation. CONN indicates connection to the data channel for input/output operations.

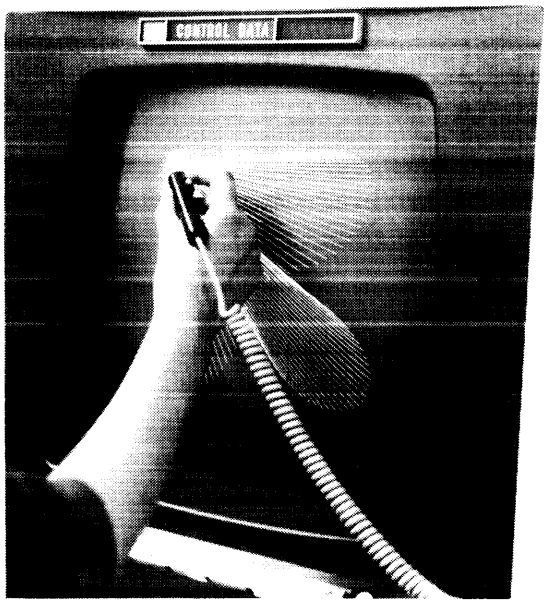
A/N KEYBOARD — Lights after program selection of the alphanumeric/function keyboard.

LP TRACK/LP CAPT — Lights after program selection of the light pen; switch depression selects the desired light pen operating mode. LP TRACK lights for tracking mode; LP CAPT lights for capture mode.





Light Pen



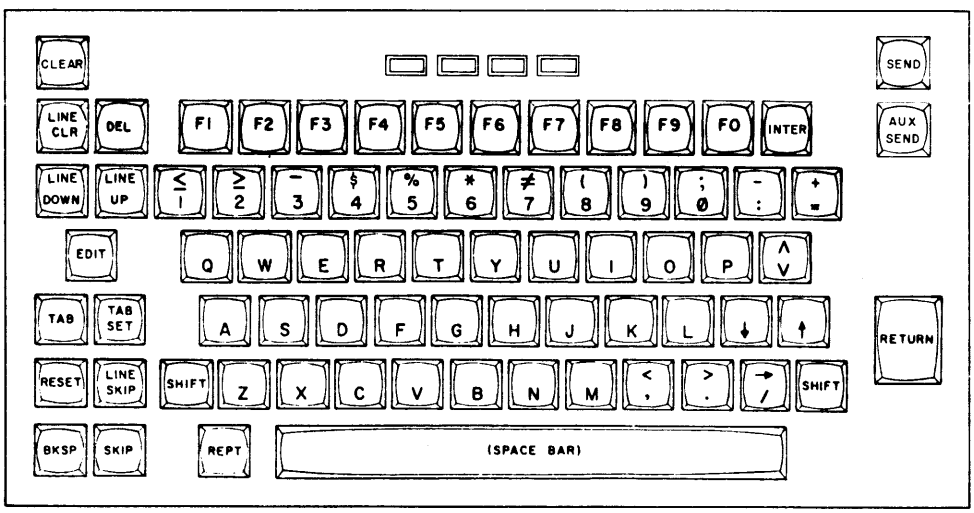
The light pen is a solid-state, high-speed, photosensitive stylus activated by a two-position, momentary switch on the body of the pen. Aiming dots of light, emitted from the light pen tip, enable operator selection of a specific display item by placing the tip of the light pen on the face of the crt and depressing the activate switch.

When the light pen is program enabled, the operator may select capture or track mode by actuation of a switch on the monitor front panel. The selected light pen mode determines operation of the activate switch on the light pen itself. In track mode, all light pen hits are recognized while the switch is depressed. In capture mode, only one light pen hit is recognized for each depression of the switch. The switch must be released and depressed again before another hit is recognized.

Light pen enables and disables may be placed at any number of locations in the program. This allows protection of individual display items from light pen operation.

Alphanumeric/Function Keyboard

The alphanumeric portion of the keyboard may be used for message composition or editing. A number of other keys especially adaptable to editing functions also is a standard keyboard feature. The function portion of the keyboard includes ten function keys, four status switches (offering 16 possible combinations), and an INTER (interrupt) key. All operations involving the keyboard are completely flexible with interpretation of each key determined by the processor program. The keyboard is enabled or disabled by display program control.



Operator Control Panel

The operator control panel incorporates switches to control the mode of operation, switches for internal register selection, an operator keyboard for data entry, and an octal readout indicator for monitoring selected internal registers.

The right bank of interlocking switch indicators designates by illumination the register being monitored. Depressing a switch indicator displays the contents of the respective register in the octal readout indicator as follows:

F — Processor function register containing the processor function (instruction) to be executed or in the process of execution.

S — Storage address register containing the storage address for the next memory reference.

Z — Transfer register holding data read from or written into memory during the last memory reference.

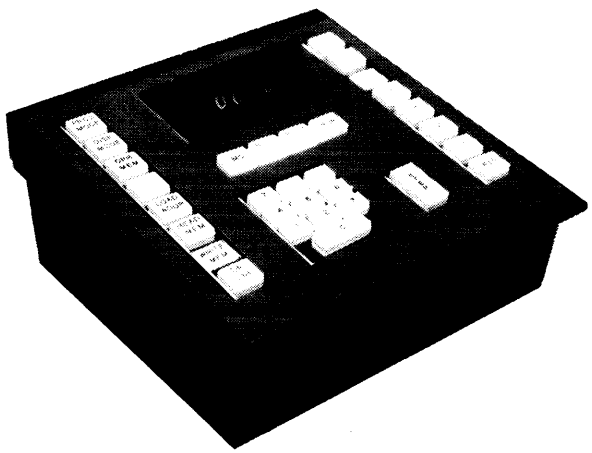
P — Program address register containing the address of the current program instruction.

IR — Interface input register containing the last data word received from the data source (not applicable to remote interfaces).

X — X register contents. In processor mode, contains results of arithmetic, logical, and shifting operations. In display mode, contains the horizontal (X) display position.

Y — Y register containing the vertical (Y) display position.

KBD — Keyboard register containing data loaded by the operator keyboard.



The operator keyboard is a switch-actuated data entry device. Each time a numeric key is depressed, the octal code for that key enters the lowest octal position of the keyboard register. The operator keyboard enables storing data in memory by supplying the initial memory address and data for storage.

The left and top banks of switches, together with the STEP switch, are a combination of interlocking and momentary contact switches. These switches enable operator mode control of the graphics subsystem.

PROC MODE — Selects processor mode and remains illuminated until selection of display mode.

DISP MODE — Selects display mode and remains illuminated until selection of processor mode.

OPR MEM — When operating off line, must be depressed to enable selection of processor or display mode. Lights while depressed.

LOAD ADDR — Enables entering a 12-bit memory address via the operator keyboard. STEP transfers this address to the P and S registers. Lights while depressed.

READ MEM — Enables reading data from memory by depressing STEP or RUN. Aids in checking programs stored in memory. Lights while depressed.

WRITE MEM — Enables storing keyboard data into memory by depressing STEP or RUN. Permits manual entry of program data. Lights while depressed.

ON LINE — Selects the graphics subsystem operating status, on line (illuminated) or off line. On-line status enables communication with the data source. Off-line status enables the operator control panel. Depressing any one of the other interlocking left bank switches places the subsystem off line.

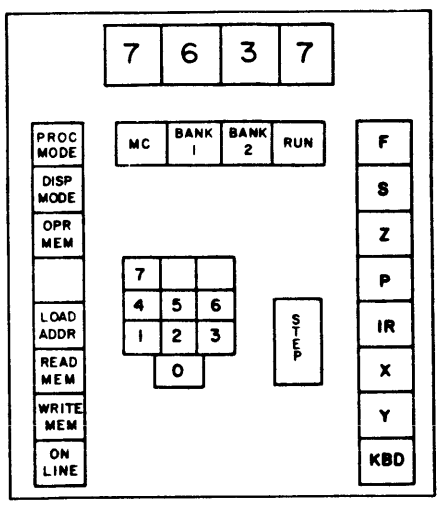
MC — Master clears the graphics subsystem.

BANK 1 — Selects and indicates selection of memory bank 1.

BANK 2 — Selects and indicates selection of memory bank 2.

RUN — Enables (illuminated) and disables high-speed program execution.

STEP — Initiates a complete operational cycle for each depression in off-line mode. This feature aids program debugging.



FEATURES

- Stored program
- Parallel mode of operation
- Flexible processor and display repertoires
- 2.4- to 9.2-microsecond processor execution time
- Binary arithmetic using modulus $2^{12} - 1$ (one's complement)
- Single-address logic
- Magnetic core storage

  Basic, 4096 words
  Expanded, 8192 words or 12,288 words
  12-bit word
  1.2-microsecond cycle time
  0.8-microsecond access time
  Relative, direct, and indirect addressing

- Solid-state logic

  Digital, DTL and TTL integrated circuits
  Analog, integrated, and discrete components
  Easy access pluggable logic boards

- Operation controls

  Alphanumeric/function keyboard
  Light pen
  Operator panel

- Display times

  Random points, 4.0 to 12.0 microseconds
  Incremental points, 4.0 microseconds
  Random symbols, 5.2 to 18.4 microseconds
  Incremental symbols, 5.2 to 8.4 microseconds
  Tabular symbols, 2.8 to 8.4 microseconds
  Full-scale diagonal vectors (approx 16 inches), 30 microseconds
  2-inch vector, less than 12 microseconds
  1/2-inch vector, less than 9 microseconds

FEATURES (CONT)

— Display characteristics

21-inch electromagnetic deflection cathode-ray tube
12-inch by 12-inch display area
0.030 inch (maximum) spot size
Positioning accuracy of ± 2% of full scale in 8-hour period
Position stability of less than ± 0.010 inch variation
Large symbols are 0.210 inch high by 0.160 inch wide (nominal)
Small symbols are 0.166 inch high by 0.125 inch wide (nominal)
Display refresh rate is nominally 50 hertz
Display intensity of 0 to 45 foot-lamberts

— Interfaces

Modem 201A or 201B (2000, 2400, or 4800 baud)
Modem 301B (40,800 baud)
CONTROL DATA 3000 Series Computers

— Optional peripheral input/output channel

96-kHz transfer rate
Services up to 5 peripheral controllers
Maximum cable length of 75 feet

— Interrupt system

— Power requirements

60-hertz, 3-phase, 208-volt, 10-ampere and
60-hertz, single-phase, 120-volt, 7-ampere

— Physical dimensions

52-1/2 inches wide
72 inches deep
48 inches high

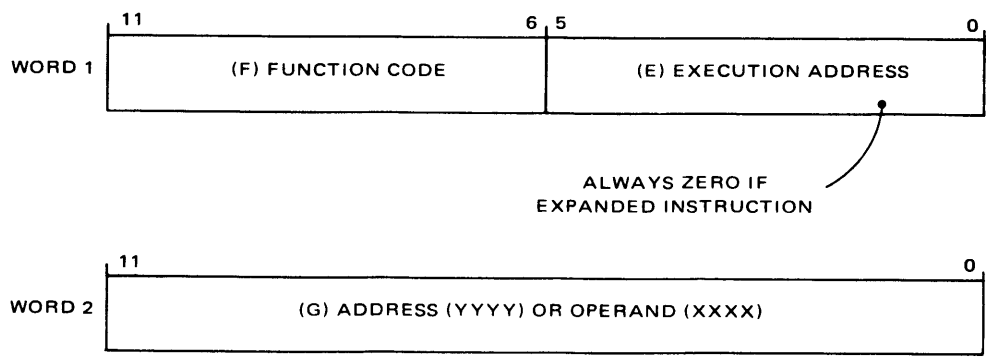
— Operating environment

+40F to +110F temperature
10% to 90% relative humidity
-1000 to +8000 feet altitude

MEMORY ADDRESS MODES

ADDRESS MODE	DESCRIPTION
No Address (N)	When the E portion of a processor instruction is a 6-bit operand, the instruction initiates arithmetic and logical operations using this 6-bit operand as a constant. By combining operand and instruction, this mode conserves memory locations.
Direct Address (D)	Refers to a 12-bit operand address in one of the first 100_8 memory locations in this direct memory bank.
Indirect Address (I)	Provides for operand references and jump addresses. For processor instructions employing indirect addressing, E refers to one of 77_8 of the first 100 memory locations starting at location 0001 of the direct storage bank. The contents of this address become the address of the operand or the jump address.
Relative Address Forward (F)	Generates operand or jump address by adding E to the current contents of P. This specifies one of 77_8 addresses immediately following the address of the current processor instruction.
Relative Address Backward (B)	Generate operand or jump address by subtracting E from the current contents of P. This specifies one of 77_8 addresses immediately preceding the address of the current processor instruction.
Constant Address (C)	The G portion of a 24-bit processor instruction contains the operand.
Memory Address (M)	The G portion of a 24-bit processor instruction contains the address of the operand.

PROCESSOR INSTRUCTION WORD



PROCESSOR INSTRUCTION REPERTOIRE

INSTRUCTION CODE			MNEMONIC	ADDRESS MODE	NAME	EXECUTION TIME (Microseconds)
F	E	G				
00	00		ERR	N	Error Stop	2.4
00	0X		NOP	N	No Operation	2.4
00	1X		SRJ	N	Set Relative Bank Control and Jump	2.4
00	2X		SIC	N	Set Indirect Bank Control	2.4
00	3X		IRJ	N	Set Indirect and Relative Bank Control and Jump	2.4
00	4X		SDC	N	Set Direct Bank Control	2.4
00	5X		DRJ	N	Set Direct and Relative Bank Control and Jump	2.4
00	6X		SID	N	Set Indirect and Direct Bank Control	2.4
00	7X		ACJ	N	Set Direct, Indirect, and Relative Bank Control and Jump	2.4
01	00		STX	N	State Register to X Register	2.4
01	01		PTA	N	P Register to X Register	2.4
01	02		LS1	N	Left Shift One	2.4
01	10		LS3	N	Left Shift Three	2.4
01	11		LS6	N	Left Shift Six	2.4
01	12		MUT	N	Multiply by 10	3.2
01	20		CIL	N	Clear Interrupt Lockout	2.4
01	21		SIL	N	Set Interrupt Lockout	2.4
#01	22		IDS	N	Interrupt Data Source	2.4
01	30		CTA	N	Memory Bank Control to X Register	2.4
01	70		YTX	N	Y Register to X Register	2.4
01	71		RTX	N	R_1 Register to X Register	2.4
01	72		RMX	N	R_2 Register to X Register	2.4
*01	73		RSX	N	Remote Status to X	2.4
01	74		XTY	N	X Register to Y	2.4
*01	75		XTA	N	X Register to A_1	2.4
*01	76		XMA	N	X Register to A_2	2.4
*01	77		XTR	N	X Register to Remote Control Register	2.4
02	XX		LPN	N	Logical Product No Address	2.4
02	XX		SCN	N	Selective Complement No Address	2.4
04	XX		LDN	N	Load No Address	2.4
05	XX		LCN	N	Load Complement No Address	2.4
06	XX		ADN	N	Add No Address	2.4
07	XX		SBN	N	Subtract No Address	2.4
10	YY		LPD	D	Logical Product Direct	4.8
11	00	YYYY	LPM	M	Logical Product Memory	6.8
11	YY		LPI	I	Logical Product Indirect	6.8
12	00	XXXX	LPC	C	Logical Product Constant	4.8
12	XX		LPF	F	Logical Product Forward	5.6
13	XX		LPB	B	Logical Product Backward	5.6
14	YY		SCD	D	Selective Complement Direct	4.8
15	00	YYYY	SCM	M	Selective Complement Memory	6.8
15	YY		SCI	I	Selective Complement Indirect	6.8
16	00	XXXX	SCC	C	Selective Complement Constant	4.8
16	XX		SCF	F	Selective Complement Forward	5.6
17	XX		SCB	B	Selective Complement Backward	5.6
20	YY		LDD	D	Load Direct	4.8
21	00	YYYY	LDM	M	Load Memory	6.8
21	YY		LDI	I	Load Indirect	6.8
22	00	XXXX	LDC	C	Load Constant	4.8
22	XX		LDF	F	Load Forward	5.6
23	XX		LDB	B	Load Backward	5.6
24	YY		LCD	D	Load Complement Direct	4.8
25	00	YYYY	LCM	M	Load Complement Memory	6.8
25	YY		LCI	I	Load Complement Indirect	6.8
26	00	XXXX	LCC	C	Load Complement Constant	4.8
26	XX		LCF	F	Load Complent Forward	5.6
27	XX		LCB	B	Load Complement Backward	5.6

PROCESSOR INSTRUCTION REPERTOIRE (CONT)

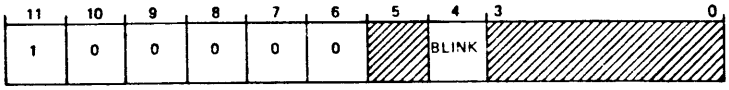
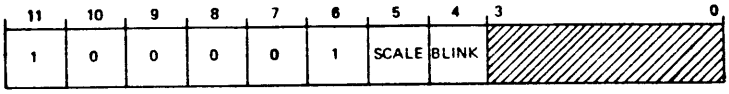
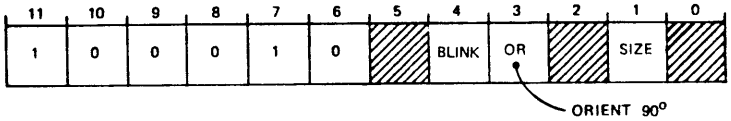
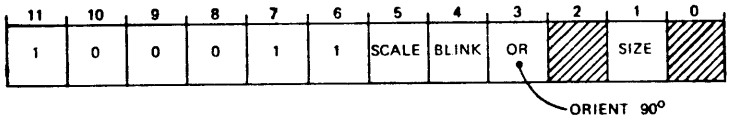
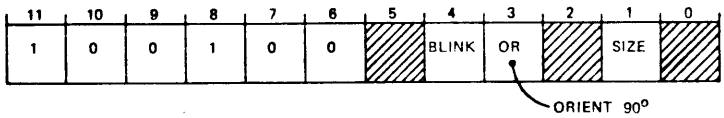
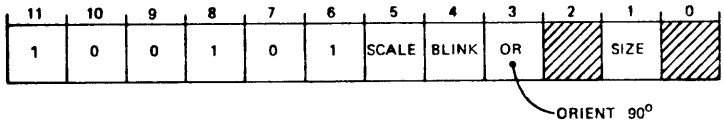
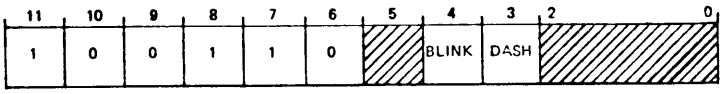
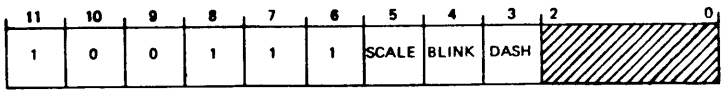
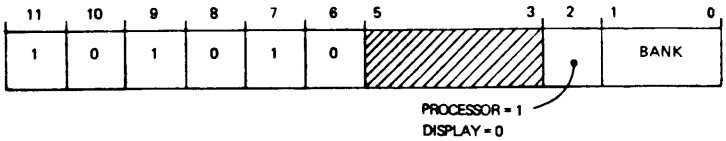
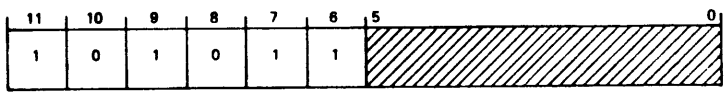
INSTRUCTION CODE			MNEMONIC	ADDRESS MODE	NAME	EXECUTION TIME
F	E	G				(Microseconds)
30	YY		ADD	D	Add Direct	4.8
31	00	YYYY	ADM	M	Add Memory	6.8
31	YY		ADI	I	Add Indirect	6.8
32	00	XXXX	ADC	C	Add Constant	4.8
32	XX		ADF	F	Add Forward	5.6
33	XX		ADB	B	Add Backward	5.6
34	YY		SBD	D	Subtract Direct	4.8
35	00	YYYY	SBM	M	Subtract Memory	6.8
35	YY		SBI	I	Subtract Indirect	6.8
36	00	XXXX	SBC	C	Subtract Constant	4.8
36	XX		SBF	F	Subtract Forward	5.6
37	XX		SBB	B	Subtract Backward	5.6
40	YY		STD	D	Store Direct	4.8
41	00	YYYY	STM	M	Store Memory	6.8
41	YY		STI	I	Store Indirect	6.8
42	00	XXXX	STC	C	Store Constant	4.8
42	XX		STF	F	Store Forward	5.6
43	XX		STB	B	Store Backward	5.6
44	YY		SRD	D	Shift Replace Direct	5.6
45	00	YYYY	SRM	M	Shift Replace Memory	9.2
45	YY		SRI	I	Shift Replace Indirect	9.2
46	00	XXXX	SRC	C	Shift Replace Constant	7.2
46	XX		SRF	F	Shift Replace Forward	8.0
47	XX		SRB	B	Shift Replace Backward	8.0
50	YY		RAD	D	Replace Add Direct	7.2
51	00	YYYY	RAM	M	Replace Add Memory	9.2
51	YY		RAI	I	Replace Add Indirect	9.2
52	00	XXXX	RAC	C	Replace Add Constant	7.2
52	XX		RAF	F	Replace Add Forward	8.0
53	XX		RAB	B	Replace Add Backward	8.0
54	YY		AOD	D	Replace Add One Direct	7.2
55	00	YYYY	AOM	M	Replace Add One Memory	9.2
55	YY		AOI	I	Replace Add One Indirect	9.2
56	00	XXXX	AOC	C	Replace Add One Constant	7.2
56	XX		AOF	F	Replace Add One Forward	8.0
57	XX		AOB	B	Replace Add One Backward	8.0
60	XX		ZJF	F	Zero Jump Forward	3.2
61	XX		NZF	F	Non-Zero Jump Forward	3.2
62	XX		PJF	F	Positive Jump Forward	3.2
63	XX		NJF	F	Negative Jump Forward	3.2
64	XX		ZJB	B	Zero Jump Backward	3.2
65	XX		NZB	B	Non-Zero Jump Backward	3.2
66	XX		PJB	B	Positive Jump Backward	3.2
67	XX		NJB	B	Negative Jump Backward	3.2
70	YY		JPI	D	Jump Indirect	4.4
71	00	YYYY	JPR	M	Return Jump	6.8
71	XX		JFI	FI	Jump Forward Indirect	5.2
+72	XX	YYYY	INP	FI	Normal Input	
+73	XX	YYYY	OUT	FI	Normal Output	
74	XX	YYYY	JPD	M	Jump to Display	4.4
+75	00	XXXX	EXC	M	External Function Constant	
+75	XX		EXF	N	External Function Forward	
+76	00		INA	M	Input to X	
+76			OTA	M	Output From X	
77	XX		HLT	N	Halt	2.4

** 3000 series interface only*

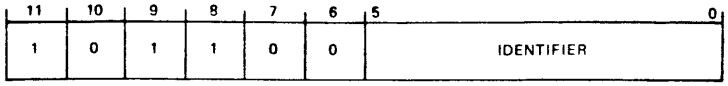
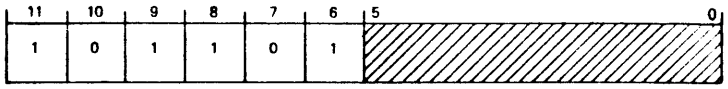
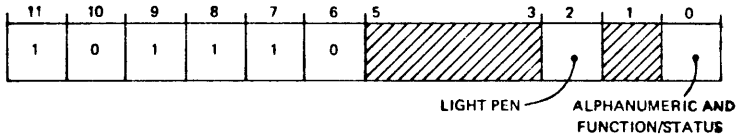
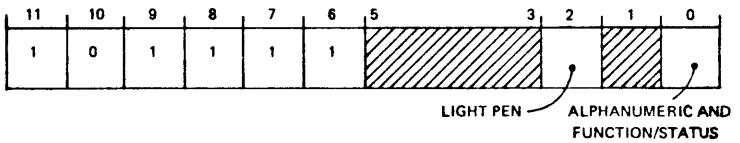
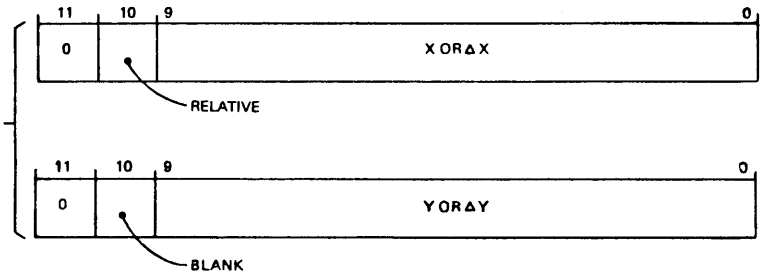
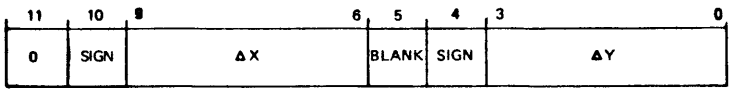
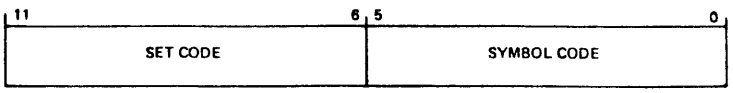
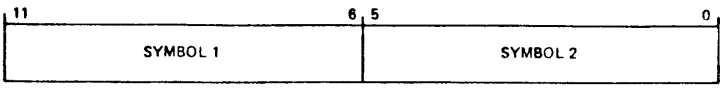
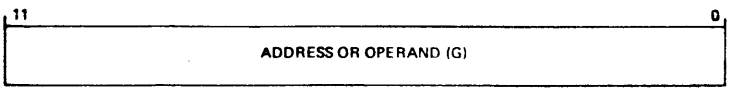
* Remote interfaces only

+ Optional peripheral I/O channel only; execution time determined by peripheral equipment

DISPLAY REPERTOIRE

COMMAND	FORMAT
ENTER PLOT POINT MODE I (40)	
ENTER PLOT POINT MODE II (41)	
ENTER PLOT SYMBOL MODE I (42)	
ENTER PLOT SYMBOL MODE II (43)	
ENTER TABULAR SYMBOL MODE I (44)	
ENTER TABULAR SYMBOL MODE II (45)	
ENTER VECTOR MODE I (46)	
ENTER VECTOR MODE II (47)	
JUMP (52)	
RETURN JUMP (53)	

DISPLAY REPERTOIRE (CONT)

COMMAND	FORMAT
IDENTIFIER (54)	
START REFRESH CYCLE (55)	
ENABLE OPERATOR DEVICE (56)	
DISABLE OPERATOR DEVICE (57)	
"X" AND "Y" MODE I POSITION WORDS	
MODE II POSITION WORD	
SYMBOL CODE WORD FOR PLOT SYMBOL MODE	
SYMBOL CODE WORD FOR TABULAR SYMBOL MODE	
ADDRESS WORD	

BASIC SYMBOLS

OCTAL CODE	SYMBOL	DESCRIPTION	OCTAL CODE	SYMBOL	DESCRIPTION
00	:	Colon	40	-	
01	1		41	J	
02	2		42	K	
03	3		43	L	
04	4		44	M	
05	5		45	N	
06	6		46	O	
07	7		47	P	
10	8		50	Q	
11	9		51	R	
12	0		52	$\vee$	Logical OR
13	=		53	$	
14	≠		54	*	
15	≤		55	↑	Arrow up
16	%		56	↓	Arrow down
17		Set shift	57	>	
20		Space	60	+	
21	/		61	A	
22	S		62	B	
23	T		63	C	
24	U		64	D	
25	V		65	E	
26	W		66	F	
27	X		67	G	
30	Y		70	H	
31	Z		71	I	
32		Tabular escape	72	<	
33	'		73	.	Period
34	(		74	)	
35	→		75	≥	
36	–	Underline	76	>	
37	$\wedge$	Logical AND	77	;	

OPTIONAL EXTENDED SYMBOLS

OCTAL CODE	SYMBOL	DESCRIPTION	OCTAL CODE	SYMBOL	DESCRIPTION
00	β	Small beta	40	$\pm$	Plus or minus
01	1	Subscript 1	41	j	
02	2	Subscript 2	42	k	
03	3	Subscript 3	43	l	
04	ψ	Psi	44	m	
05	ρ	Rho	45	n	
06	γ	Gamma	46	o	
07	ϕ	Small phi	47	p	
10	ω	Small omega	50	q	
11	α	Small alpha	51	r	
12	∇	Del	52	$\int$	Integral sign
13	δ	Small delta	53	∂	Partial sign
14	Σ	Sigma	54	$^{\circ}$	Degree sign
15	σ	Small sigma	55	Δ	Delta
16	μ	Mu	56	π	Pi
17		Set shift	57	$\surd$	Square root
20		Space	60	θ	Theta
21	$\leftarrow$	Left arrow	61	a	
22	s		62	b	
23	t		63	c	
24	u		64	d	
25	v		65	e	
26	w		66	f	
27	x		67	g	
30	y		70	h	
31	z		71	i	
32		Tabular escape	72	2	Superscript 2
33	$\boxdot$		73	3	Superscript 3
34	$\odot$		74	"	Quotation mark
35	$\triangle$		75	'	Prime mark
36	$\diamond$		76	∞	Infinity
37	$\triangledown$		77	?	Question mark

CONTROL DATA
CORPORATION

CORPORATE HEADQUARTERS, 8100 34TH AVE. SO., MINNEAPOLIS, MINN. 55440/SALES OFFICES AND SERVICE CENTERS IN MAJOR CITIES THROUGHOUT THE WORLD