

250

graphics display subsystem

EXTERNAL
SPECIFICATION

CONTROL DATA

CORPORATION

250
GRAPHICS DISPLAY
SUBSYSTEM

EXTERNAL SPECIFICATION

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INTRODUCTION

The CONTROL DATA 250 Graphics Display Subsystem meets the demand for new versatility in graphics displays. Incorporating the most desirable features of earlier subsystems and several new design concepts into the CONTROL DATA 250 has produced a state-of-the-art subsystem for viewing, composing, and recording graphic data in off-line or on-line, real-time situations.

The 250 subsystem is one of the few peripherals allowing effective instantaneous communication with a computer. It can be programmed to take full advantage of time-sharing systems. Data presented on the Display Console, Microfilm Recorder, and Hardcopy Recorder are not limited to simple alphanumeric symbols. Rather, data may take the form of complex drawings, graphs, models, etc., which may change dynamically as various program sequences occur.



GRAPHICS DISPLAY SUBSYSTEM

The CONTROL DATA 250 Graphics Display Subsystem is a programmable display and recording complex capable of visual graphic and alphanumeric display, manual data composition, and archival quality data recording.

The subsystem maximum configuration consists of a Display Controller with a CONTROL DATA 6000 Series Computer (via 6681 data channel adapter) or 3000 Series Computer data channel interface, three (maximum) Display Consoles, one (only) Hardcopy Recorder, and one (only) of three available Microfilm Recorders. All configurations must include the 3398-2 Display Controller. Available display subsystem equipments are as follows:

- 3398-2 Display Controller
- 252-2 Display Console
- 253-2 Hardcopy Recorder plus Motor Generator
- 254-2 35mm Microfilm Recorder plus Motor Generator
- 254-2 35mm Butt-Plot Microfilm Recorder plus Motor Generator
- 254-2 16mm Microfilm Recorder

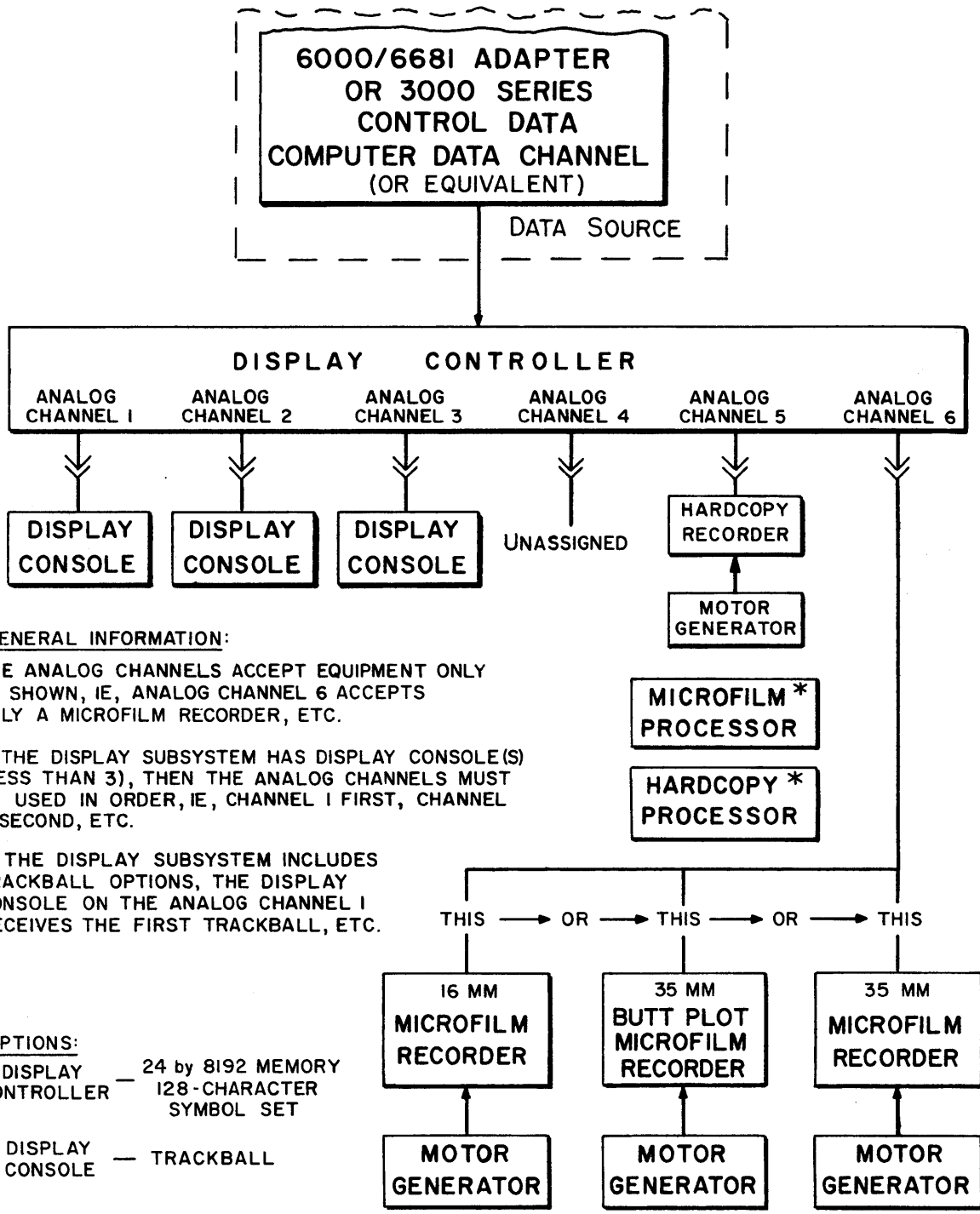
Supplementary Items

- Microfilm Processor
- Hardcopy Processor

Additionally, a Microfilm Processor, which develops 20 feet of film per minute, and an external Hardcopy Processor, which develops archival quality Hardcopy Recorder output, are available.

The Display Controller has six analog channels: three for Display Consoles, one for a Hardcopy Recorder, one for a Microfilm Recorder, and one unassigned. The unassigned analog channel is available for special equipment applications.

The display subsystem is modular. A basic configuration, eg, Display Controller/Display Console or Display Controller/Microfilm Recorder, expands by adding equipment until reaching the maximum configuration.



GENERAL INFORMATION:

THE ANALOG CHANNELS ACCEPT EQUIPMENT ONLY AS SHOWN, IE, ANALOG CHANNEL 6 ACCEPTS ONLY A MICROFILM RECORDER, ETC.

IF THE DISPLAY SUBSYSTEM HAS DISPLAY CONSOLE(S) (LESS THAN 3), THEN THE ANALOG CHANNELS MUST BE USED IN ORDER, IE, CHANNEL 1 FIRST, CHANNEL 2 SECOND, ETC.

IF THE DISPLAY SUBSYSTEM INCLUDES TRACKBALL OPTIONS, THE DISPLAY CONSOLE ON THE ANALOG CHANNEL 1 RECEIVES THE FIRST TRACKBALL, ETC.

OPTIONS:

DISPLAY CONTROLLER — 24 by 8192 MEMORY
 128-CHARACTER SYMBOL SET

DISPLAY CONSOLE — TRACKBALL

* SUPPLEMENTARY ITEM

250 Display Subsystem Block Diagram

TYPICAL APPLICATIONS

The subsystem is operable in on-line, real-time applications which make full use of time-sharing systems. Typically, the display subsystem becomes a communication hub or command center during computer graphic data handling. The Display Consoles allow observation

and control of graphic data. The Hard-copy Recorder presents flash-processed, quick-look quality pictures 4 seconds after exposure. A Microfilm Recorder adds butt-plot, still, or motion-picture production capability. Data can be filmed for later use and analysis.



Programmed Models

Complex mathematical concepts often are difficult to communicate. One of the best methods of communication of such abstract concepts is the visual method — particularly through dynamic or static crt displays.

The computer-generated model can be a three-dimensional outline of a physical object that is currently undergoing computer analysis, eg, an orbital vehicle. The computer can manipulate the model to show effects of calculated gravitational and inertial forces. The interplay of forces — difficult to visualize if printed out as a listing of numbers — becomes clear when seen on the model. A Display Console, programmed as a command center during work with models, gives effective communication with the computer and allows the call-up of subroutines on an as-required basis. A Microfilm Recorder, programmed to produce still or motion pictures, can record highlights or entire sequences of model behavior for later observation and analysis. This type of motion picture, costly with conventional animation, is relatively inexpensive here because the computer generates the pictures as it analyzes the model.

Continuous (Strip) Graphing

The Butt-Plot Microfilm Recorder, in addition to normal still or motion-picture production, can produce continuous strip pictures without frame

separation under program control. Continuous strip (butt plot) film output is oscillography with unexcelled detail. Events sensed or initiated by the computer program can be duly recorded on the graph together with pertinent alphanumeric data.

Design Tool

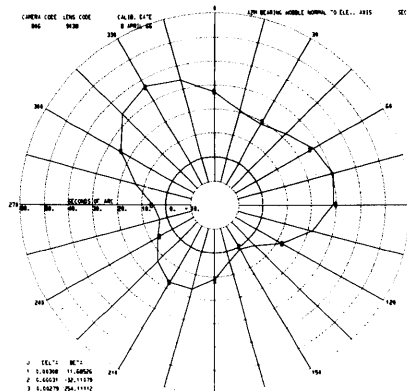
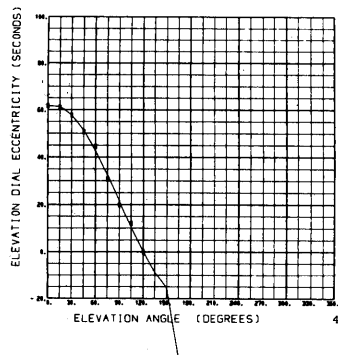
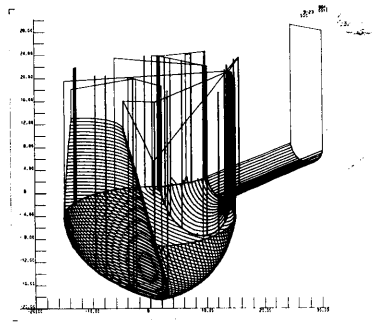
The Display Console may be programmed as a computerized design tool for use in the engineering arts. Many engineering problems are solved by repeating trips to a data center with updated programs and/or new data. With dynamic programming, the Display Console becomes a communication center from which an engineer can work directly with his program. A Display Console allows working with a computer on a time-sharing, real-time basis. Many of the previously necessary output listing analyses and program revisions are bypassed because the program can display program results on the Display Console crt. Using Display Console accessories, the user can manually intervene and direct his program along the most desirable routes.

Graphic Hardcopy

The Hardcopy Recorder outputs pages of positive data records at a one-frame-per-second rate which makes on-the-fly line printers and digital plotters slow by comparison. Display subsystem

alphanumeric and graphic capability allows data output to be consolidated on paper records of quick-look or archival quality. This formerly required combination line printer and plotter usage. The quick-look records are available to the user 4 seconds after exposure.

Archival quality records are obtained by bypassing internal flash processing and using the external Hardcopy Processor. Data recording can be computer initiated or manually initiated by a Display Console operator.



FUNCTIONAL DESCRIPTION

Each of the display subsystem equipments and supplementary items performs separate identifiable operations. This modular approach allows a display subsystem capability consistent with immediate needs. Expansion of capability is accomplished by adding equipments, options, and supplementary items until reaching the maximum configuration. The following descriptions explain the characteristics of the Display Controller, Display Console, Hardcopy Recorder, the three Microfilm Recorders, the Microfilm Processor, the Hardcopy Processor, and the Motor Generator.

Display Controller

The Display Controller is the heart of the display subsystem. It communicates with the computer, exchanges analog and control signals with the monitors, and performs the display subsystem logical operations. The controller contains as a minimum, a symbol generator, vector generator, point plotter, buffer memory, control logic, and digital-to-analog conversion circuits.

The symbol generator uses a stroke technique in a 9 by 9 matrix to produce up to 128 symbols if the expanded symbol set is installed. Automatic matrix shift down allows subscripts and symbols with parts below the line. The vector generator produces eight categories of vectors in two programmable

intensity levels. Through program selection, points may be plotted at a slow or fast rate.

The controller random access, core memory has a 1.67-microsecond cycle time. It provides a storage capacity of 4096 addresses; each address consists of 24 data bits plus 2 parity bits. Adding the expanded memory option doubles the memory storage capacity. Memory control contains two memory address registers which hold the addresses of the next word for display and the next word for an input/output operation. Interlacing of input/output and display sequences, facilitated by the two registers, allows memory access without interruption of the display presentation.



Display Console

The Display Console presents graphic and alphanumeric displays on a 19-inch crt under computer initiation in direct mode or under controller initiation in buffer mode. The alphanumeric and function keyboards, light pen, optional trackball, and front panel controls provide operator intervention, data modification, and mode selection capabilities under program control.

The alphanumeric keyboard contains symbol keys and shift, lock, and clear keys as well as indicators for error and interrupt active conditions. Depression of a symbol key stores the corresponding symbol code in memory from which it may be read by the computer, displayed, or acted upon as determined by the program.

When the function keyboard is enabled, the operator may select conditions for interpretation by the program. Momentary, latching, overlay encoding, and clear switches generate interrupts, store 24-bit words in memory, and clear the keyboard. Latching and overlay encoding switches also can be read directly from the keyboard over the status lines.

The light pen is a high-speed photosensitive stylus with which an operator can selectively modify, change, or compose graphic data. One application is drawing images on the crt with the aid of a programmable tracking cross. A tracking cross is made up of a circular array of dots overlaid with a cross of dots that appears on the crt. Under program control, light pen selection of any tracking cross dots



results in a vector from the tracking cross center to the selected dot. The program repositions the tracking cross center to the end of the vector just drawn. In this manner, the operator draws on the crt. Vector length and the number of tracking cross dots determine line resolution.

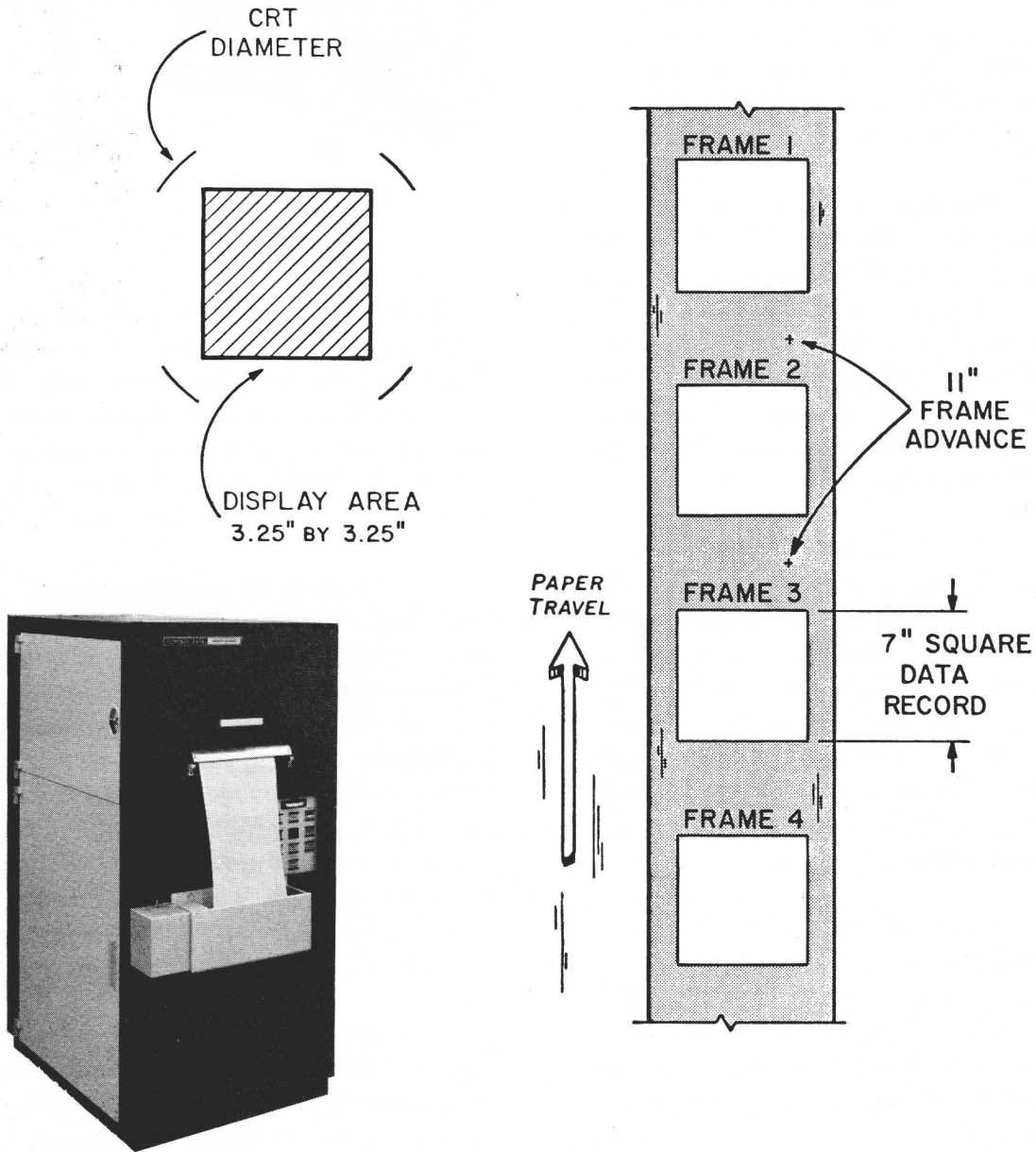
The optional trackball is a phenolic ball mounted in the console desk top. Trackball rotation supplies quantitative information indicating direction and amount of rotation to the Display Controller. During trackball rotation, the controller can move a displayed cursor about the screen. The computer can sample the cursor position at any time and alter relative positions of two or more displayed images, rotate a three-dimensional image, etc.

When program enabled, Display Console front panel controls allow manual interrupts with mode and operation selection of the light pen and trackball. In addition, the operator may choose printout by the Microfilm or Hardcopy Recorder.

Hardcopy Recorder

The Hardcopy Recorder, driven by the Display Controller, provides 7-inch square data records on 9-inch-wide roll-stock photosensitive paper. An 11-inch frame advance, under computer or

operator control, repositions the paper for subsequent recordings. The frame advance takes 1 second which is the time required for internal flash processing.



Hardcopy Recorder Output

Microfilm Recorder

Display subsystem configuration offers a selection, based on desired output, of one of three types of Microfilm Recorders — 35mm, 35mm butt plot, or 16mm. Each Microfilm Recorder incorporates a 5-1/4-inch, high resolu-

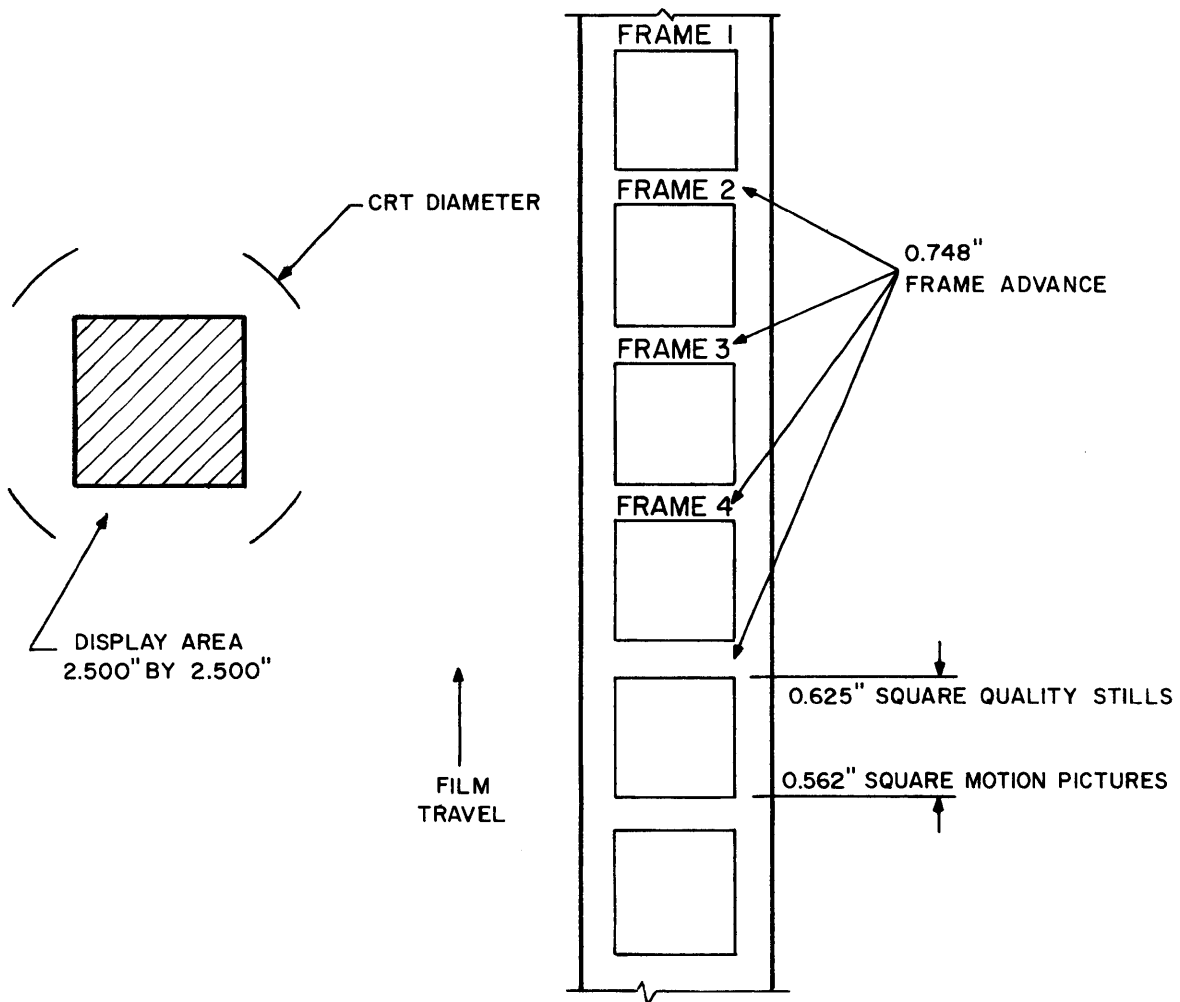
tion crt and a camera with controlling circuitry. When the Microfilm Recorder is program selected, Display Controller clock frequency switches from 6 MHz to 2 MHz to allow recording during a single refresh cycle.



35mm

The 35mm Microfilm Recorder provides data recordings for later observation as still or motion pictures. A Microfilm Recorder, in an application oriented to production of still pictures, presents data within a 0.625-inch square film display area on standard-sized, perforated, 35mm film. Where output is motion-picture oriented, the film display size is

0.562 inch square. A frame advance moves the film 0.748 inch. Physical positioning of the camera and lens achieves a film display size compatible with major applications. The crt display area is the same for both film display sizes. The maximum recording rate is 30 frames per second.

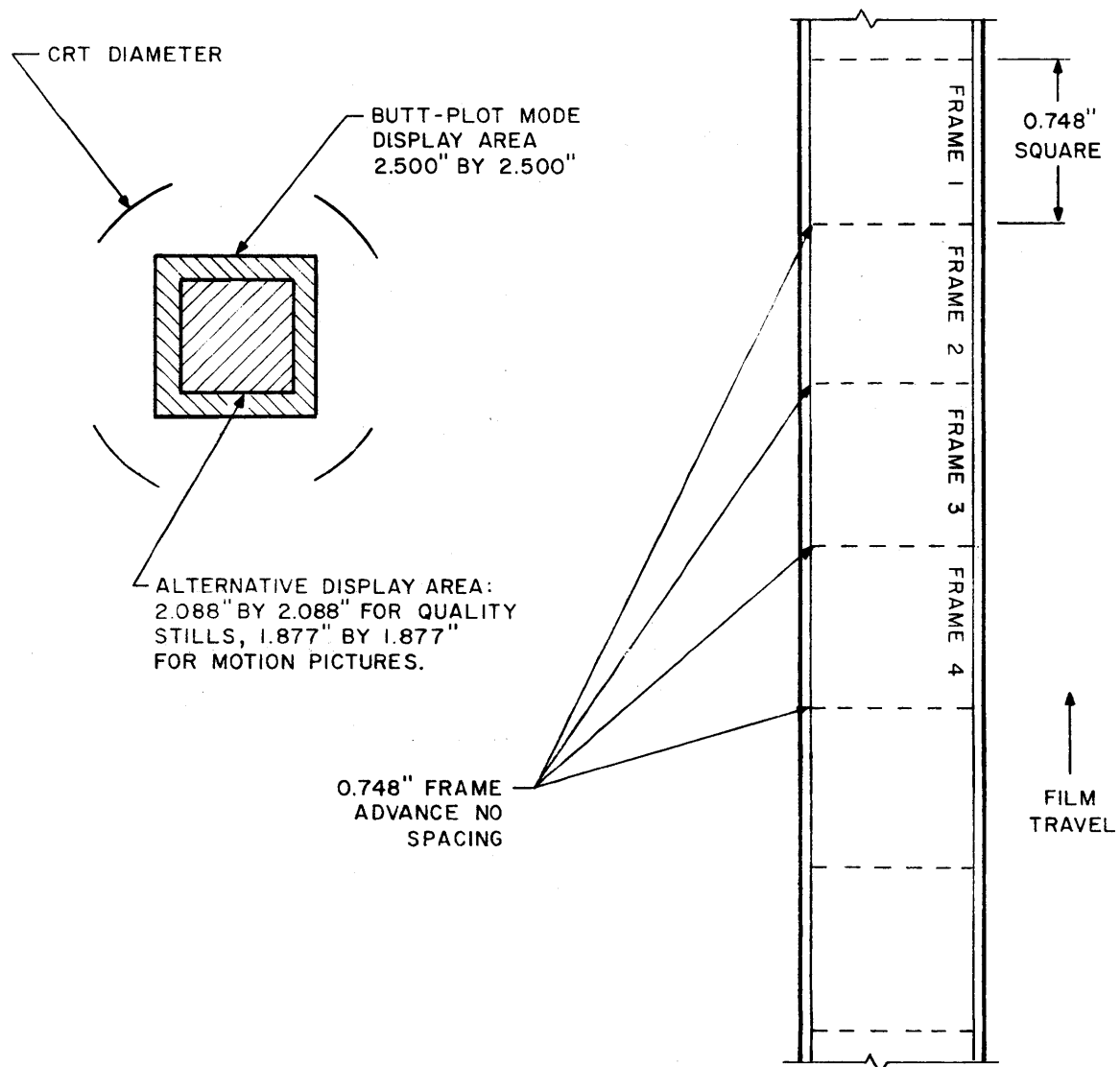


35mm Microfilm Recorder Output

35mm Butt Plot

The 35mm butt-plot Microfilm Recorder has the same output capability as the 35mm Microfilm Recorder. In addition, it plots continuous strip recordings with no film display separation by program selection. In butt-plot mode, the entire crt display image automatically rotates 90° clockwise and the crt display area expands to fill the film frame. Butt-

plot frame size is 0.748 inch square. When used for still pictures, the alternate film display size is 0.625 inch square. For motion pictures, the alternate film display size is 0.562 inch square. Crt display area adjustment provides a film display size compatible with still or motion-picture production when it is not expanded for butt plotting.

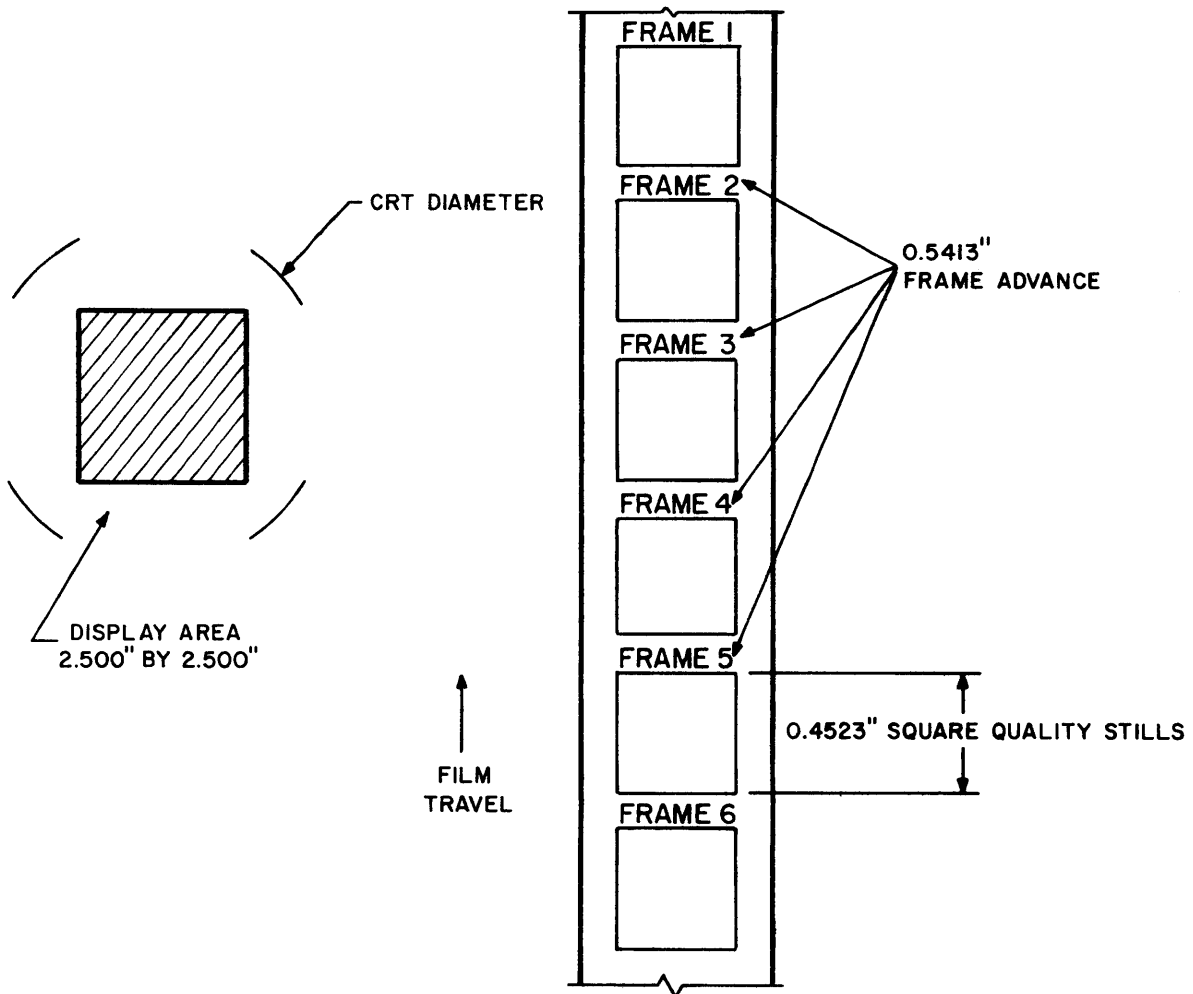


35mm Butt-Plot Microfilm Recorder Output

16mm

The 16mm Microfilm Recorder provides compact data recordings on non-perforated 16mm film. Data recording

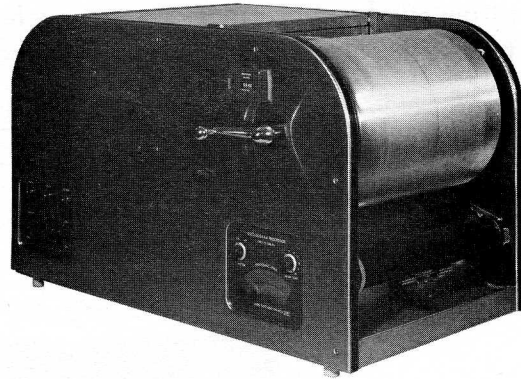
is within a 0.4523-inch square film display area. The maximum recording rate is 15 frames per second.



16mm Microfilm Recorder Output

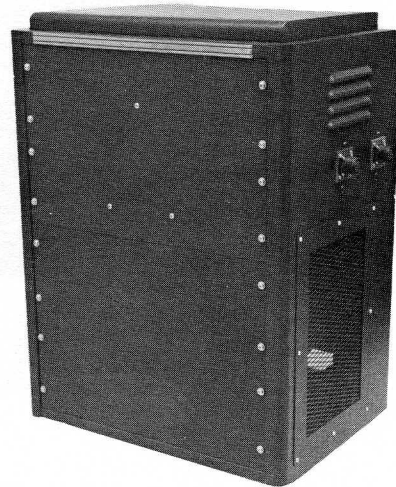
Hardcopy Processor

The external Hardcopy Processor develops Hardcopy Recorder output into archival quality records. A lightproof internal takeup magazine in the Hardcopy Recorder is used when paper is to be developed in the external Hardcopy Processor. Exposed paper is transferred from the internal takeup magazine to the processor magazine by splicing leader to the exposed paper leading edge. Rollers guide the paper into four tanks of processing solution. A heating element dries the fixed paper which is suitable for indefinite storage.



Motor Generator

The Motor Generator is a combination 60-hertz motor and 400-hertz generator. It provides transient-free, primary power for a Hardcopy Recorder or a Microfilm Recorder. In a 50-hertz subsystem configuration, a special 50-hertz Motor Generator is available for use with the Microfilm Recorder only.



OPERATION

The 250 Graphics Display Subsystem operates with a CONTROL DATA 6000 Series Computer via a 6681 data channel adapter or a 3000 Series Computer with a 12-bit data channel. The display subsystem is controlled by the computer which sends digital instructions to the Display Controller. The Display Controller translates those instructions for the crt into analog signals which control movement and unblanking of the monitor crt beam.

The subsystem has two programmable operating modes: direct and buffer. In high-speed direct mode, the Display Controller converts computer-generated instructions directly to analog signals for crt display and recording. In buffer mode, the computer loads a display routine into the Display Controller memory where it remains for observation and possible revision or recording, thus freeing the computer for other operations.

Buffer mode operation handles routines that required direct mode operation in earlier display subsystems. The subsystem repertoire contains instructions required to perform data composition, editing, and manipulation through operator use of the alphanumeric keyboard and light pen without computer intervention. This capability

removes a significant processing burden from the computer.

In both direct and buffer mode, the computer may activate the display subsystem interrupt system so that when certain conditions occur an interrupt signal is sent to the computer. When so interrupted, the computer has two alternatives: it can temporarily ignore the interrupt or it can sample status lines to determine the exact cause of the interrupt. For example, the Display Console keyboard and light pen have the interrupt feature. Depressing a keyboard key or light penning data on the crt generates an interrupt to the computer. The computer can then read the keyboard or light pen information from the display subsystem.

All displays are made up of three basic display elements: symbol, point, and vector. A symbol is a character, letter, or number. A point is simply a dot. A vector is a straight line of programmable length. All displays, from simple statements to complex models or diagrams, are made from combinations of these three basic display elements.

Normal displays of data on the crt are within a square display area. The display area divides into 1024 (1777 octal) increments in both the X

and Y directions. By using 10-bit X and Y coordinates, the computer can direct one of the basic display elements to a specific position. Although the crt are of different diameters — the Display Console, Hardcopy Recorder, and Microfilm Recorder crt are respectively 19 inches, 7-1/2 inches, and 5-1/4 inches in diameter — computer programs consider each display area as 1777 octal increments square.

The Display Controller provides the monitors with precise analog signals which control the crt beam. The analog signals are the results of logical operations in the Display Controller. The digital-to-analog circuitry senses the logical operations and develops corresponding analog signals. Display Controller operation is similar to that of a stored program computer because it has random access memory and an instruction repertoire. The instructions, however, are oriented to data display and recording rather than general problem solving.

Effectively, the Display Consoles provide windows for observation of computer data. The function keyboard, alphanumeric keyboard, light pen, and optional trackball are program-enabled methods of manual data entry and revi-

sion. In a display subsystem with a recording monitor, a Display Console switch initiates a page print of the data currently shown on the Display Console crt.

A Hardcopy or Microfilm Recorder records data pictures under computer and/or operator control. Recording monitor crt presentations are duplications of the Display Console picture. A single unblanking of a recording monitor crt correctly exposes the recording medium. The shutterless Hardcopy Recorder projection system transfers the data image to vacuum-stabilized, photosensitive paper. Similarly, shutterless Microfilm Recorder cameras transfer the data image to either negative or reversal type film.

Quick-look Hardcopy Recorder output, internally flash processed, is operator viewable 4 seconds after exposure. Archival quality hardcopy records are obtained by using a lightproof takeup magazine, which bypasses the internal processor, and developing the exposed paper with the external Hardcopy Processor. The Microfilm Recorder supply and takeup magazines are lightproof and simplify film removal for developing with the external Microfilm Processor.



**TECHNICAL
BRIEF**



FEATURES

3398-2 DISPLAY CONTROLLER

- Solid-state, plug-in logic circuit cards with easily accessible test points.
- Communicates with 6000 (via 6681 adapter) or 3000 Series Computer data channel (or equivalent) in 12-bit parallel mode.
- Internal processing in 24-bit parallel mode.
- Stored program.
- Random access 26 (24 data plus 2 parity) by 4096 core storage optionally expandable to 26 by 8192.
- Memory cycle time of 1.67 microseconds.
- Program error detection (software debugging aid).
- Basic 64 - symbol repertoire, optionally expandable to 128 symbols.
- Programmed 50-hertz refresh rate control.
- Interrupt system.
- Operable in direct or buffer mode.
- Basic clock speed of 6 MHz.
- Recording clock speed to 2 MHz.

- Internal tracking capability with either a light pen or a trackball.
- Internal data (alphanumeric and graphic) entry and editing capability.

252-2 DISPLAY CONSOLE

- Electrostatic 19-inch crt with type P31 phosphor.
- A 3:1 display contrast ratio.
- Dynamic focus and astigmatism correction.
- Spot size of 0.035 inch maximum within the 11.3-inch square display area.
- Positioning accuracy of ± 2 percent of crt display area edge length (11.3 inches).
- Drift tolerance after 30-minute warmup of ± 2 percent in an 8-hour period.
- Full-length vectors.
- Four symbol sizes.
- Program selection of 128 or 136 symbols per line in a 64-line display.
- Random or tabular (automatic) symbol spacing.
- Two intensities.

FEATURES (CONT)

- Italics.
- 90° orientation.
- Blink mode.
- Alphanumeric keyboard for internal data composition.
- Function keyboard allows manual selection of varying operations by storing static and momentary codes and sending an interrupt, when enabled, to the computer.
- Light pen senses discrete display elements on the crt and provides internal tracking for program modification.
- Trackball (optional), used in conjunction with a programmable cursor, allows manual changes of position codes which can be sampled by the computer.
- Drift tolerance after 30-minute warmup of ± 1 percent in an 8-hour period.
- Full-length vectors.
- Four symbol sizes.
- Program selection of 128 or 136 symbols per line with 64 data lines per frame.
- Random or tabular (automatic) symbol spacing.
- Italics.
- 90° orientation.
- Frame advance moves paper 11 inches in 1 second.
- Shutterless projection system.

253-2 HARDCOPY RECORDER

- Electrostatic 7-1/2-inch crt with type P11 phosphor.
- Dynamic focus and astigmatism correction.
- Spot size does not exceed 0.012 inch any place within the 3.25-inch-square display area.
- Positioning accuracy of ± 2 percent of crt display area edge length (3.25 inches).

254-2 MICROFILM RECORDER

- Electrostatic ultra-precision, 5-1/4-inch crt with type P11 phosphor.
- Dynamic focus and astigmatism correction.
- Spot size does not exceed 0.006 inch any place within the 2.5-inch-square display area.
- Positioning accuracy of ± 0.6 percent maximum of crt display area edge length (2.5 inches).

FEATURES (CONT)

- Drift tolerance after 30-minute warmup of ± 1.5 percent in an 8-hour period.
- Full-length vectors.
- Four symbol sizes.
- Two intensities.
- Italics.
- 90° orientation.
- Blink mode.
- Program selection of 128 or 136 symbols per line with 64 data lines per frame.
- Random or tabular (automatic) symbol spacing.
- Frame advance (35mm and 35mm butt plot only) moves film 0.748 inch in 33 milliseconds (40 at 50 hertz).
- Frame advance (16mm only) moves film 0.5413 inch in 66 milliseconds (80 at 50 hertz).
- Shutterless cameras.
- Film magazine capacity of 1000 feet (35mm and 35mm butt plot) or 400 feet (16mm).
- Special f1.2/55mm recording lens, corrected for P11 phosphor, with 1.5 minification.

MOTOR GENERATOR/60 HERTZ

- Output voltage of ± 1 percent nominal in 5 seconds.
- Operating speed of 1760 revolutions per minute.
- Built-in motor starter circuit.
- Thermal overload protection providing automatic shutdown.

HARDCOPY PROCESSOR

- Compact for table top usage.
- Continuous processing at a 10-foot-per-minute rate (maximum).
- Can be placed at a location remote from the display subsystem.
- Archival quality high-contrast fixed stable records.

MICROFILM PROCESSOR

- Processes negative or reversal type film (perforated or unperforated) up to 35mm wide.
- Continuous processing at a 20 foot-per-minute rate.
- Fault sensors and automatic shutoff on failure.
- Operable in normal room lighting.
- Can be placed at a location remote from the display subsystem.

EQUIPMENT SPECIFICATIONS

DIMENSIONS AND WEIGHT

NAME	WIDTH (Inches)	DEPTH (Inches)	HEIGHT (Inches)	WEIGHT (Pounds)
Display Controller	88-3/8	20-1/2	75	2300
Display Console	40-1/2	56	49-1/2	900
Hardcopy Recorder	42-1/2	25	58	850
Microfilm Recorder	64	25-3/4	63-1/2	920
Motor Generator	22-1/4	15-1/4	31	215
<u>Supplementary Items</u>				
Hardcopy Processor	31	19	18-1/4	160 (dry)
Microfilm Processor	105-1/4	19-1/4	67	425 (dry)

INPUT POWER REQUIREMENTS

NAME	VOLTAGE (Volts)	FREQUENCY (Hz)	PHASE	WATTS (Per Unit)
Display Controller	208	400	3	2650
	120	50/60	1	460
Display Console	208	60 *	3	2150
Hardcopy Recorder	208	400	3	500
	120	60	1	1800
Microfilm Recorder	208	400	3	500
	120	50 **/60	1	200
Motor Generator ***	208	60	3	2000
	440			
Hardcopy Processor	120	60	1	1600
Microfilm Processor	120	60	1	1500

* 50 Hz with 50-Hz power conversion kit.

** 50 Hz requires 50-Hz Motor Generator.

*** Power requirements given are for 60 Hz only.

SYMBOL SPACING AND VECTOR LENGTH

TABULAR (AUTOMATIC) SYMBOL SPACING

SIZE	SIZE CODE	RATIO	SYMBOLS PER LINE	LINES PER FRAME	SYMBOL SPACING (OCTAL)	LINE SPACING (OCTAL)
Miniature	00	1.0	128 or 136	64	10 or 7/10	20
Small	01	1.5	94	47	13	26
Medium	10	2.0	64	32	20	40
Large	11	3.0	43	21	30	63

VECTOR LENGTH AND RAMP TIMES

LENGTH (Raster Units)	LENGTH (Inches)	TIME (Microseconds)
0 to 8	0.00 to 0.09	3.30 to 5.00
8 to 16	0.09 to 0.18	5.00 to 6.67
16 to 32	0.18 to 0.35	6.67 to 8.33
32 to 64	0.35 to 0.71	6.67 to 10.00
64 to 128	0.71 to 1.40	8.33 to 13.33
128 to 256	1.40 to 2.80	10.00 to 15.00
256 to 512	2.80 to 5.70	13.33 to 25.00
512 to 1023	5.70 to 11.30	21.67 to 38.33

SYMBOL REPERTOIRE

STANDARD SYMBOL SET

EXT BCD CODE	INT BCD CODE	SYMBOL DISPLAYED	SYM ON A/N KBD	DESCRIPTION	EXT BCD CODE	INT BCD CODE	SYMBOL DISPLAYED	SYM ON A/N KBD	DESCRIPTION
00	12	:	:	Colon	41	41	J	J	
01	01	1	1		42	42	K	K	
02	02	2	2		43	43	L	L	
03	03	3	3		44	44	M	M	
04	04	4	4		45	45	N	N	
05	05	5	5		46	46	O	O	
06	06	6	6		47	47	P	P	
07	07	7	7		50	50	Q	Q	
10	10	8	8		51	51	R	R	
11	11	9	9		52	52	V	V	Logical OR
12	00	0	0		53	53	\$	\$	Dollar sign
13	13	=	=	Equal sign	54	54	*	*	Asterisk
14	14	≠	≠	Not equal sign	55	55	↑	↑	Up arrow
15	15	≤	≤	Less than or equal to sign	56	56	↓	↓	Down arrow
16	16	%	%	Percent sign	57	57	>	>	Greater than
17	17	[	[	Opening bracket	60	20	+	+	Plus sign
20	60			Space (no symbol displayed)	61	21	A	A	
21	61	/	/	Diagonal	62	22	B	B	
22	62	S	S		63	23	C	C	
23	63	T	T		64	24	D	D	
24	64	U	U		65	25	E	E	
25	65	V	V		66	26	F	F	
26	66	W	W		67	27	G	G	
27	67	X	X		70	30	H	H	
30	70	Y	Y		71	31	I	I	
31	71	Z	Z		72	32	<	<	Less than
32	72	]	]	Closing bracket	73	33	.	.	Period
33	73	,	,	Comma	74	34	)	)	Closing parenthesis
34	74	(	(	Opening parenthesis	75	35	≥	≥	Greater than or equal to sign
35	75	→	→	Right arrow	76	36	¬	¬	Logical NOT
36	76	≡	≡	Identical to	77	37	;	;	Semicolon
37	77	∧	∧	Logical AND					
40	40	-	-	Dash or minus sign					

SYMBOL REPERTOIRE (CONT)

EXPANDED SYMBOL SET

EXT BCD CODE	INT BCD CODE	SYMBOL DISPLAYED	DESCRIPTION	EXT BCD CODE	INT BCD CODE	SYMBOL DISPLAYED	DESCRIPTION
00	12	β	Small beta	40	40	\pm	Plus or minus
01	01	1	Subscript 1	41	41	i	
02	02	2	Subscript 2	42	42	k	
03	03	3	Subscript 3	43	43	l	
04	04	ψ	Small psi	44	44	m	
05	05	ρ	Small rho	45	45	n	
06	06	γ	Small gamma	46	46	o	
07	07	ϕ	Small phi	47	47	p	
10	10	ω	Small omega	50	50	q	
11	11	α	Small alpha	51	51	r	
12	00	∇	Del	52	52	\int	Integral sign
13	13	δ	Small delta	53	53	∂	Partial sign
14	14	Σ	Sigma	54	54	$^{\circ}$	Degree sign
15	15	σ	Small sigma	55	55	Δ	Delta
16	16	μ	Small mu	56	56	$_$	Underline
17	17	π	Small pi	57	57	$\sqrt{\quad}$	Square root
20	60	ϵ	Small epsilon	60	20	θ	Small theta
21	61	\leftarrow	Left arrow	61	21	a	
22	62	s		62	22	b	
23	63	t		63	23	c	
24	64	u		64	24	d	
25	65	v		65	25	e	
26	66	w		66	26	f	
27	67	x		67	27	g	
30	70	y		70	30	h	
31	71	z		71	31	i	
32	72	~	Tilde	72	32	λ	Small lambda
33	73	◻		73	33	Ψ	Psi
34	74	⊙		74	34	"	Quotation mark
35	75	▲		75	35	'	Prime mark
36	76	◊		76	36	∞	Infinity
37	77	▽		77	37	?	Question mark

FUNCTION CODES

<u>OCTAL CODE</u>	<u>FUNCTION</u>
0000	Release
0001	Buffered Mode
0002	Stop Buffered Display
0003	Start Buffered Display
0004	Enable Trackball Interrupt
0005	Disable Trackball Interrupt
0006	Enable Alphanumeric Keyboard Interrupt
0007	Disable Alphanumeric Keyboard Interrupt
0010	Enable Light Pen Interrupt
0011	Disable Light Pen Interrupt
0012	Interrupt on Halt Instruction
0013	Release Interrupt on Halt Instruction
0014	Interrupt on Memory Parity or Program Error
0015	Release Interrupt on Memory Parity or Program Error
0016	Enable Function Keyboard Interrupt
0017	Disable Function Keyboard Interrupt
0020	Enable Manual Interrupt
0021	Disable Manual Interrupt
0022	Interrupt on End of Operation
0023	Release Interrupt on End of Operation
0024	Interrupt on Abnormal End of Operation
0025	Release Interrupt on Abnormal End of Operation
0026	Set Interrupt Active
0027	Clear Interrupt Active
0030	Direct Mode
0031	Function Keyboard 1
0032	Function Keyboard 2

FUNCTION CODES (CONT)

<u>OCTAL CODE</u>	<u>FUNCTION</u>
0033	Function Keyboard 3
0034	Select Normal Status
0035	Select Special Status
0036	Enable 01 Decoding
0037	Disable 01 Decoding
0040	Enable Page Print
0041	Record Console 1 on Hardcopy Recorder
0042	Record Console 2 on Hardcopy Recorder
0043	Record Console 3 on Hardcopy Recorder
0044	Record Console 1 on Microfilm Recorder
0045	Record Console 2 on Microfilm Recorder
0046	Record Console 3 on Microfilm Recorder
0047	Disable Page Print
0050	Enable all Interrupts
0051	Clear all Interrupt Causes
0052	Enable Read X, Y Position Register
0053	Continue
0054	Clear
0055	Select External BCD
0056	Select Internal BCD
0057	Select 136 Symbols
0060	Select 128 Symbols
0061	Enable Destructive Readout
0062	Disable Destructive Readout
0063	Enable Butt Plot
0064	Disable Butt Plot

NORMAL STATUS CODES

<u>OCTAL CODE</u>	<u>INDICATES</u>
XXX1	Controller Ready
XXX2	Controller Busy
XXX4	Internal Busy
XX1X	Light Pen Interrupt
XX2X	Function Keyboard Interrupt
XX4X	Alphanumeric Keyboard Interrupt
X1XX	Manual Interrupt
X2XX	Trackball Interrupt
X4XX	Abnormal End of Operation Interrupt
1XXX	End of Operation Interrupt
2XXX	Halt Interrupt or Direct Mode Program Error
4XXX	Program or Memory Parity Error

SPECIAL STATUS CODES

<u>OCTAL CODE</u>	<u>INDICATES</u>
XXX1	Hardcopy Ready
XXX2	Hardcopy Busy
XXX4	Paper Low
XX1X	Microfilm Recorder Ready
XX2X	Microfilm Recorder Busy
XX4X	Film Low
X1XX	Trackball Mode Console 1
X2XX	Trackball Mode Console 2
X4XX	Trackball Mode Console 3
1XXX	Manual Interrupt Console 1
2XXX	Manual Interrupt Console 2
4XXX	Manual Interrupt Console 3

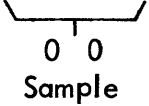
FUNCTION KEYBOARD STATUS CODES

<u>OCTAL CODE</u>	<u>ORIGIN</u>
XXX1	Latching Switch, Bit 12
XXX2	Latching Switch, Bit 13
XXX4	Latching Switch, Bit 14
XX1X	Latching Switch, Bit 15
XX2X	Latching Switch, Bit 16
XX4X	Latching Switch, Bit 17
X1XX	Overlay Switch, Bit 18
X2XX	Overlay Switch, Bit 19
X4XX	Overlay Switch, Bit 20
1XXX	Overlay Switch, Bit 21
2XXX	Overlay Switch, Bit 22
4XXX	Overlay Switch, Bit 23


RESERVED MEMORY ASSIGNMENTS

<u>MEMORY LOCATION</u>	<u>CONTENTS</u>
0	Program error word
1	Store XY, Console 1
2	Store XY, Console 2
3	Store XY, Console 3
4	Light pen word for Console 1
5	Light pen word for Console 2
6	Light pen word for Console 3
7	Trackball word and Manual Interrupt for Console 1
10	Trackball word and Manual Interrupt for Console 2
11	Trackball word and Manual Interrupt for Console 3
12	Alphanumeric keyboard for Console 1
13	Alphanumeric keyboard for Console 2
14	Alphanumeric keyboard for Console 3
15	Function keyboard word for Console 1
16	Function keyboard word for Console 2
17	Function keyboard word for Console 3

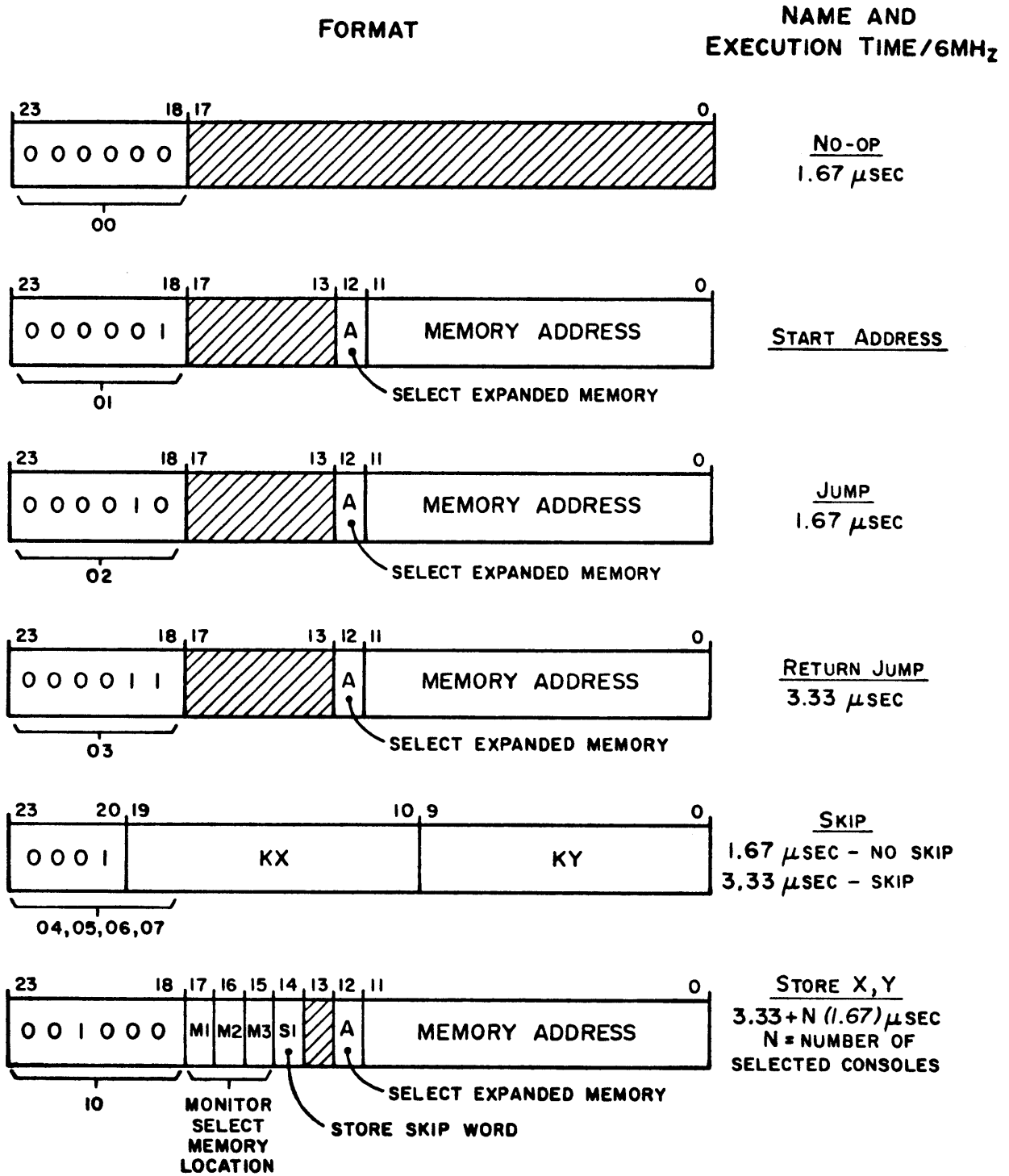
INSTRUCTION FORMAT DESIGNATORS

<u>DESIGNATOR</u>	<u>EXPLANATION</u>
 <p>0 0 Sample</p>	<p>A two-digit octal translation of the upper 6 bits (operation code) of the instruction. The operation code specifies the major function of the instruction. An X in the second octal digit location indicates any digit 0 through 7.</p>
A	Expanded memory select bit.
AC	Address count, difference between memory address and address detected by light pen.
B	Blink control bit.
C	Complement control bit.
G	Reserved memory flag bit.
I	Italic control bit.
K	Interrupt plus status return enable.
KX	An operand to test the current value of X.
KY	An operand to test the current value of Y.
L1, L2, L3	The light pen enables for monitors 1, 2, and 3.
L	Light pen register change enable.
M1, M2, M3, M5, M6	Enable memory store, unblank, or input device flag test for monitors 1, 2, 3 (Display Consoles), 5 (Hardcopy Recorder), and 6 (Microfilm Recorder), respectively. M4 is unassigned.

INSTRUCTION FORMAT DESIGNATORS (CONT)

<u>DESIGNATOR</u>	<u>EXPLANATION</u>
Ø	Orientation control bit.
O/P	Operator/program priority mode enable.
R	Indicates whether the instruction contains X, Y values or ΔX , ΔY values.
S	Expanded symbol set select bit.
SC	Symbol count indicates which symbol of a sequential word was detected.
S/F	Slow or fast point plot mode enable.
SI	Enable bit for storing a skip word.
S1, S2, S3	Expanded symbol set enables for symbols 1, 2, and 3.
T	Transfer memory address to X, Y register.
T/C	Track/capture mode enable.
W	Intensity control bit.
X	A 10-bit horizontal coordinate.
Y	A 10-bit vertical coordinate.
ΔX	Magnitude of horizontal change.
ΔY	Magnitude of vertical change.
	Unused bit positions.

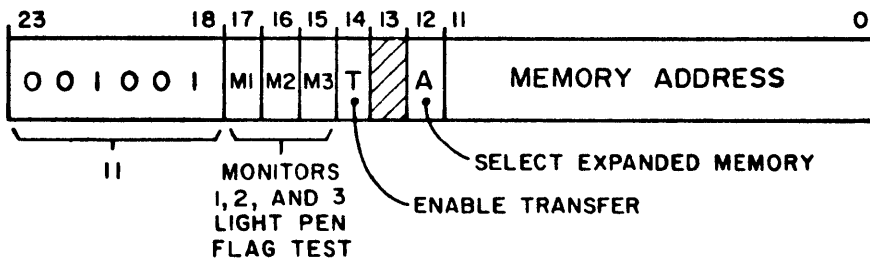
INSTRUCTIONS



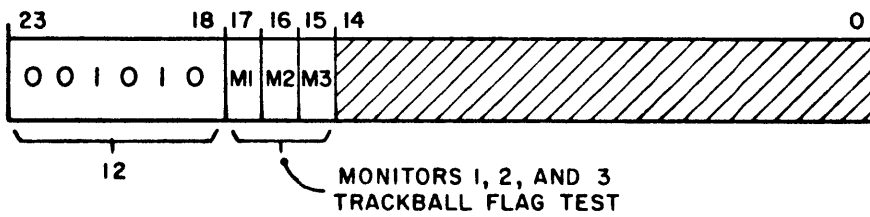
INSTRUCTIONS (CONT)

FORMAT

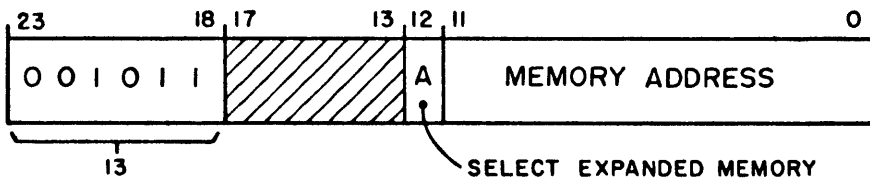
NAME AND EXECUTION TIME/6MH_z



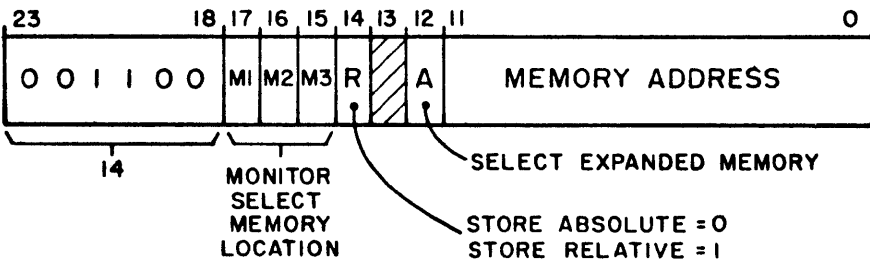
LIGHT PEN SKIP
 6.67 μ SEC - NO SKIP
 8.33 μ SEC - SKIP



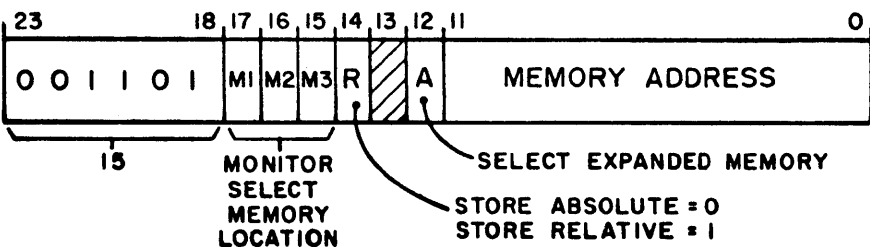
TRACKBALL SKIP
 1.67 μ SEC - NO SKIP
 3.33 μ SEC - SKIP



REPLACE ADD ONE
 5.0 μ SEC

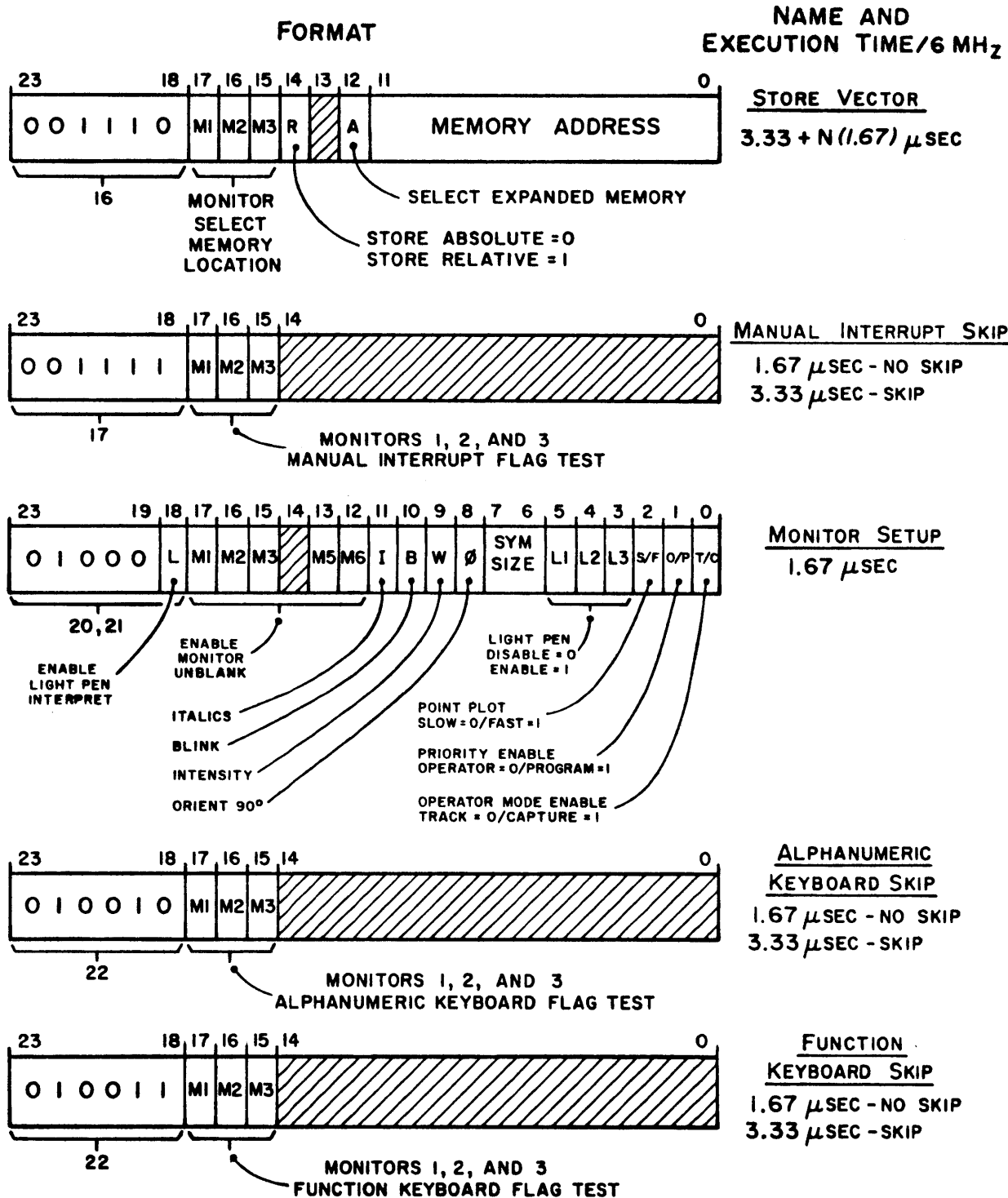


STORE BASE POSITION
 3.33 + N (1.67) μ SEC



STORE PLOT POINT
 3.33 + N (1.67) μ SEC

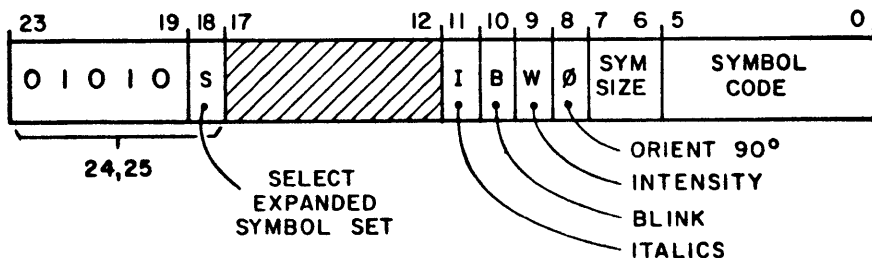
INSTRUCTIONS (CONT)



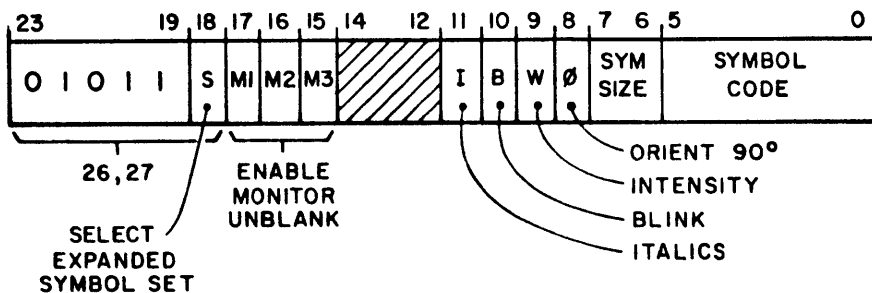
INSTRUCTIONS (CONT)

FORMAT

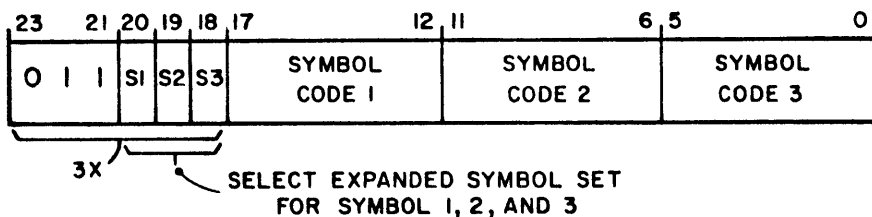
NAME AND
EXECUTION TIME/6 MHz



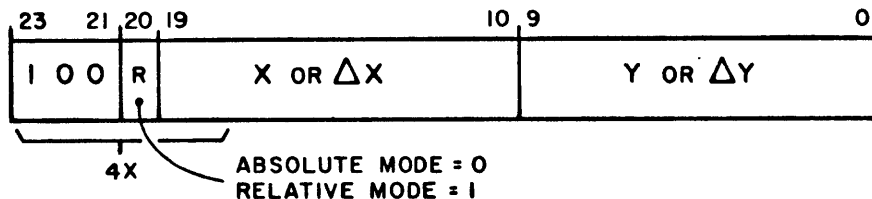
SYMBOL SETUP
3.33 μSEC



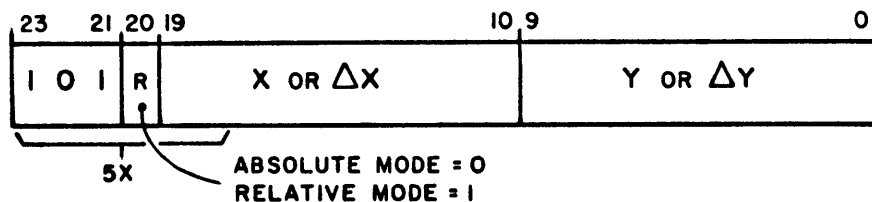
TRACKBALL
5.0 μSEC



SEQUENTIAL SYMBOL
10.0 μSEC

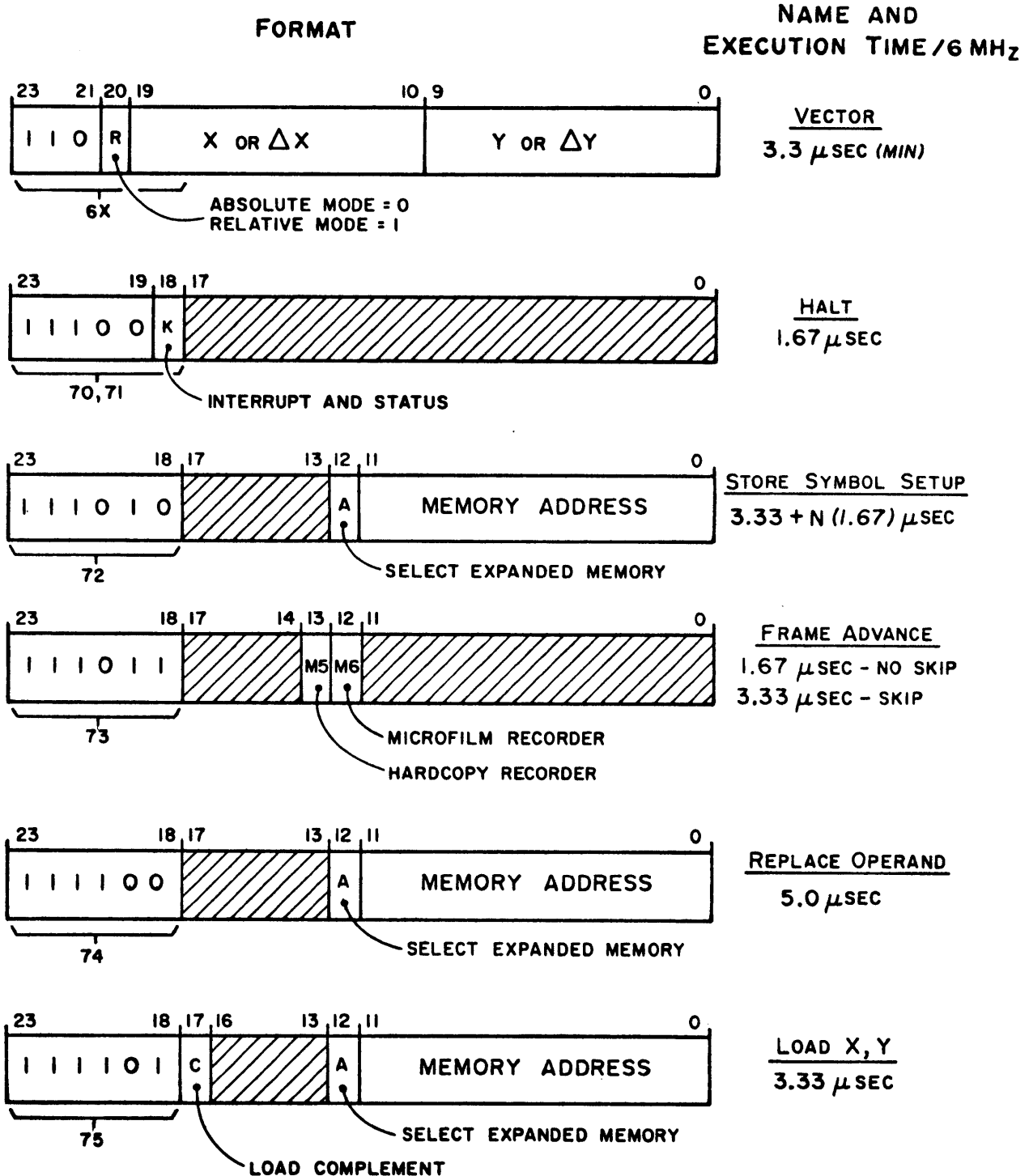


BASE POSITION
3.3 μSEC

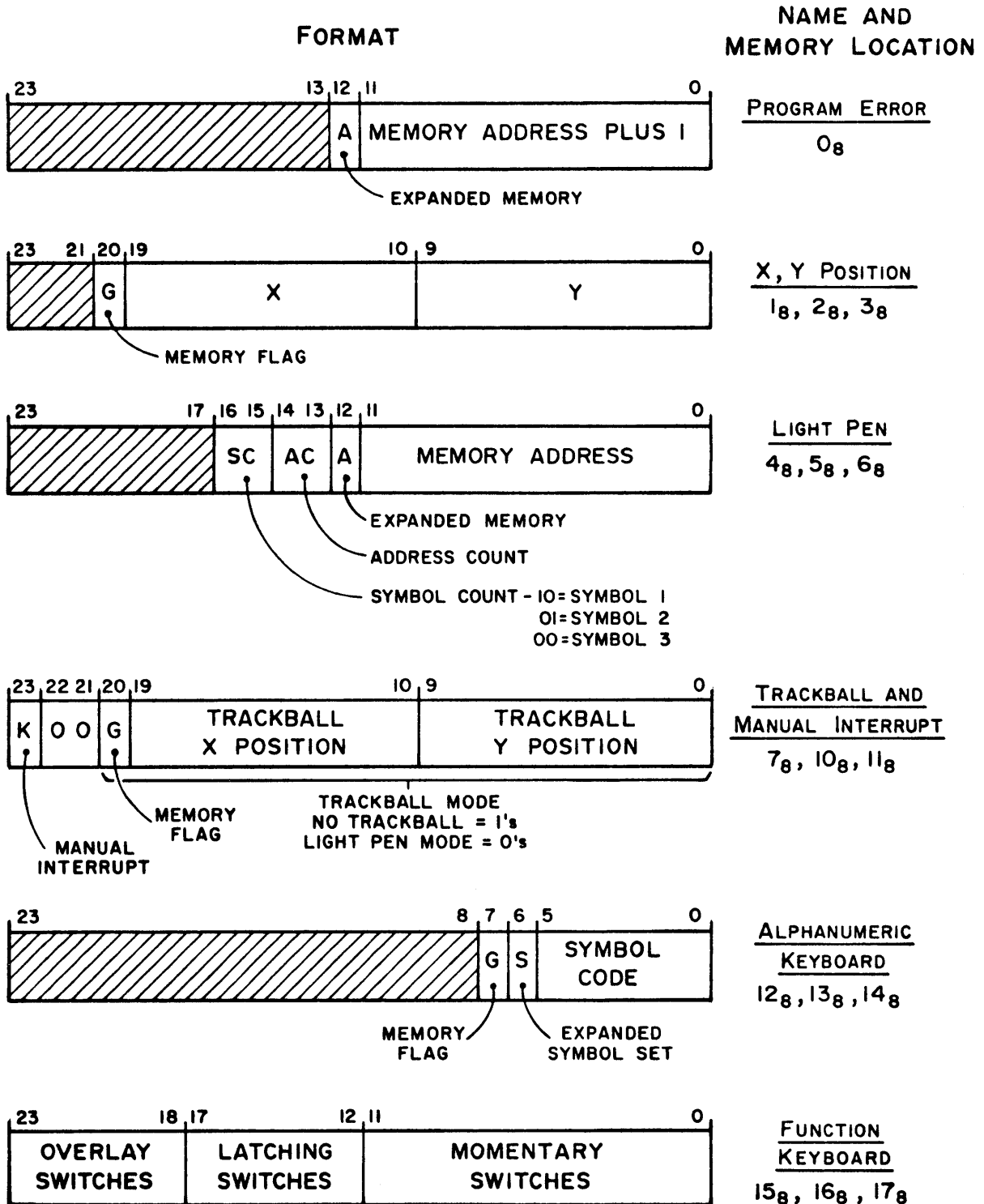


PLOT POINT
5.0 μSEC - SLOW
3.3 μSEC - FAST

INSTRUCTIONS (CONT)



RESERVED MEMORY WORDS



CONTROL DATA
CORPORATION

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