S-C 4060
STORED PROGRAM RECORDING SYSTEM

DESCRIPTION
AND
SPECIFICATIONS

9500209

Revised 28 April 1967

Stromberg-Carlson A Subsidiary of General Dynamics

1895 HANCOCK ST. P.O. BOX 2449, SAN DIEGO, CALIFORNIA 92112 TELE. (714) 298–8331

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S-C 4060 STORED PROGRAM RECORDING SYSTEM

INTRODUCTION

The use of high speed microfilm plotters for recording scientific data is not new. These high speed microfilm recorders have been used in the past five years in such applications as curve plotting, computer developed drawings, mapping, schedule networks, animated motion pictures and other applications involving combinations of both drawing and character recording. By far, the major portion of microfilm recording in use today has been done by the more than forty users of the Stromberg-Carlson S-C 4020. The major drawback of existing microfilm recorder systems has been the rigid format requirements for inputting to the machine, the use of high cost consumables when on-line hardcopy is desired, and the inability to perform certain jobs which require exceptionally high quality printing or plotting.

The S-C 4060 STORED PROGRAM RECORDING SYSTEM described below and shown in Figure 1, not only solves these problems, but also provides additional flexibility which results in the most powerful recording system available today. It does this by

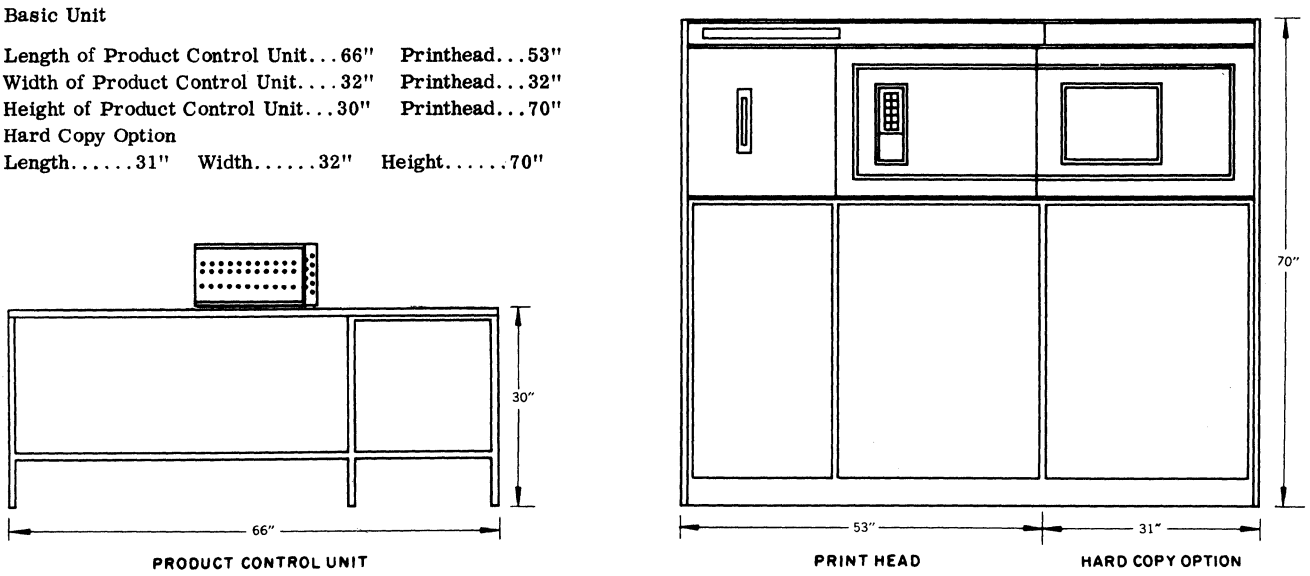

Figure 1. S-C 4060 Stored Program Recording System

combining the latest advances in the art of high speed recording with the flexibility and reliability of a stored program buffer. In addition, the system design uses the "building block" philosophy which results in an expandable, highly flexible recording system. Because of the "building block" philosophy, the recording system can be tailored to the customer's needs at the time of delivery and can be expanded whenever future needs require it. This is especially valuable for existing S-C 4020 users who can replace their present system, utilize their existing software developed for the S-C 4020 and provide for future buildup. The options which provide this flexibility are shown in Figure 2.

SYSTEM DESCRIPTION

The functional organization of the S-C 4060 Stored Program Recording System may be divided into four main sections: The Input/Output Section, the Product Control Unit, the Printhead and the Recording Section. The Input/Output Section controls the flow of information to and from the Product Control Unit. The Product Control Unit serves to control the flow of data between the Input Section and the Printhead. In the process of controlling this data, the Product Control Unit is used to derive control information and produce formatted output data as required by the Printhead. The Printhead responds to information sent by the Product Control Unit by producing a high resolution, accurately positioned visual image of alphanumeric and/or graphic symbols capable of being viewed by the Recording Section. The Recording Section functions to transfer the visual image displayed by the Printhead onto microfilm. The Recording Section also contains that hardware necessary for converting the latent image recorded on microfilm into the desired output form.

INPUT/OUTPUT

The S-C 4060 system can accept inputs from a variety of sources - directly from computers, or from magnetic tape. Input from and output to these sources passes through the

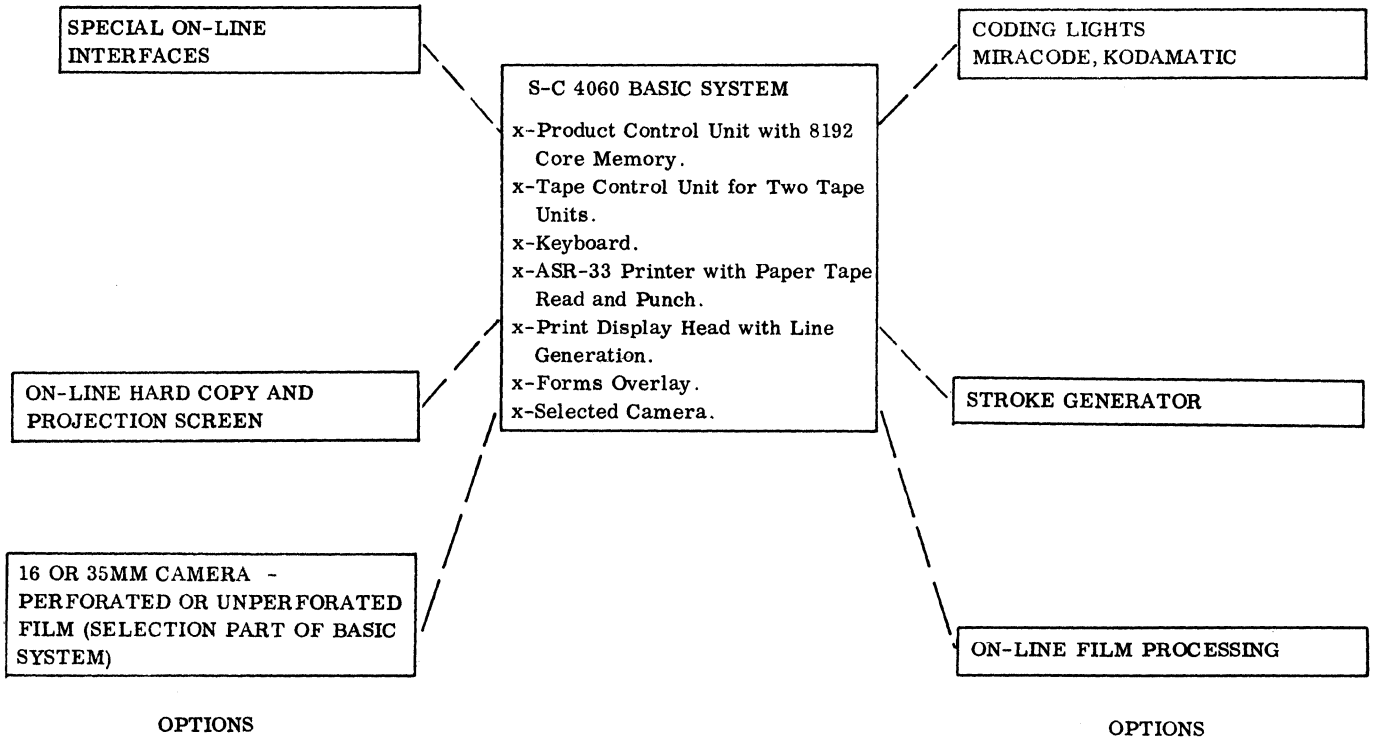

Figure 2. S-C 4060 Basic System with Options

Input/Output Section of the S-C 4060 System. Regardless of the source of input, this section serves to send control signals to the input device and to transfer data to the buffer of the Product Control Unit. The Input/Output Section is designed in modular fashion so that interface hardware can be added for compatibility with most any data source.

The basic S-C 4060 System is equipped with an ASR-33 Teletype Unit which communicates by keyboard and type out and will read and punch paper tape at the rate of 10 characters per second.

A tape control interface is available for compatibility with the IBM 360 nine channel tape format. This latter interface controls the IBM 2401 (Mod I, II, and III) series tape transports.

The basic S-C 4060 system is also equipped with a tape control interface which will accept information from magnetic tape in the form of seven (7) bit characters (six bit character code and redundancy check bit).

When the S-C 4060 system is receiving data from magnetic tape, the input data rates can vary depending on the tape speed and recorded bit density. The tape control interface is capable of reading data from tape at rates of up to 90, 000 characters or bytes per second. Table 1 shows data rates from some typical tape transports.

In addition to the ASR-33 interface and the tape control interface, the S-C 4060 system can be provided with the capability of accepting data from other sources. The maximum data transfer rate is limited to 250,000 16-bit words per second.

SPECIFICATIONS

Type

Parallel binary, solid state, integrated circuit

Word Length

16 Bits

Buffer Size

8192-words

Cycle Time

1 μsec

Standard Peripheral Equipment

ASR-33 Teletype Unit

Standard Input/Output Lines

16-bit input bus
16-bit output bus
External control and sense lines

PRODUCT CONTROL UNIT

GENERAL

The Product Control Unit (PCU) is a solid-state integrated circuit, internally-stored-program device and is organized as a parallel, 16-bit binary machine. The cycle time is one microsecond with storage of 8192-word modules.

INPUT/OUTPUT

Data is read from tape one block at a time upon receipt of a read instruction. Tape record blocks must not exceed the capability of the input buffers allocated by the Input/Output Monitor in the Product Control Unit. At the end of each block, the tape control Interface will send an End of Block Signal to the Product Control Unit. After the End of Block Signal is transmitted, further action is under control of the Input/Output Monitor.

Parity data from tape is sensed. Error sensing and recovery procedures are under control of the Input/Output Monitor.

A tape write feature is also available with the S-C 4060 system. When the feature is provided, the S-C 4060 system is capable of selectively writing blocks of data onto tape from the buffer. The length of the record to be written and the selection of the tape onto which the data is to be written is under control of the Input/Output monitor. Both longitudinal and lateral parity bits are written along with the data. Circuitry for checking the data written (read after write) is provided.

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Standard Peripheral Equipment

ASR-33 Teletype Unit

Standard Input/Output Lines

16-bit input bus
16-bit output bus
External control and sense lines

PRINTHEAD

GENERAL

The Printhead functions to convert digital data received from the Product Control Unit into the analog signals required to drive the display tube. The display tube is an improved version of the CHARACTRON® shaped beam tube used in the S-C 4020. Improvements to this tube include higher quality character generation, rotatable characters, selectable character size, increased character repertoire, higher resolution and improved line generation. In addition to the characters generated by the CHARACTRON shaped beam tube, the Printhead can also be equipped with a "stroke" character generator. This can be used to generate different character fonts and can be changed and/or added to between job runs.

Functions performed by the Printhead and specifications for these functions follow.

CHARACTER GENERATION (Standard)

1. The Character Generator has the capability of generating 116 alphanumeric and graph symbols. Character set is comprised of 26 upper case, 26 lower case, 10 numerics and 54 special symbols. Table 2 lists the standard character set. Other character sets are available on request.
2. Character style (Refer to Table 2) is such that the normal sized character will resemble typewriter copy when produced on 8-1/2" x 11" format.
3. The aspect ratio of characters is such that a normal sized upper case "H" will appear in a 4:3 height to width ratio.
4. The height to line-weight ratio of normal sized characters when recorded on microfilm varies depending on the characters being printed. The height to line-weight of normal size characters will be greater than 10 to 1 for the thinnest line-weight and greater than 7 to 1 for the thickest lines.

TABLE 2. S-C 4060 SYSTEM STANDARD CHARACTER SET

		δ	π	?	#	±	∂			
¬	{	←	@	!	%	'	_	}	-|	
\	→	&	"	(	)	*	/	¬	—	
γ	C	B	A	D	E	F	Y	J	I	O	
∧	c	b	a	d	e	f	y	j	i	o	~
G	L	M	N	H	·	·	P	Q	R	T	S
g	l	m	n	h	•	•	p	q	r	t	s
¤	U	V	W	X	K	Z	;	,	.	:	β
	u	v	w	x	k	z	0	1	2	3	°
	△	4	5	6	7	8	9	+	−	○	
|-	∝	|	>	<	□	[	]	∫	⊥		
			$	¢	=	Σ					

5. Four character sizes are provided as defined below. Additionally, both horizontal and vertical character orientation is provided. Both size and orientation is available under program control.

   a. Normal Height:

Upper Case	32 Raster Units
Lower Case	24 Raster Units

   b. Small Size:

      .75 x Normal

   c. Medium Size:

      1.25 x Normal

   d. Large Size:

      1.5 x Normal

6. The character generator performs, as described above, within the following limitations:

a.	Registration	Less than ±5% of character heights (imperfections undetectable to the unaided eye)
b.	Character tilt	Less than 3.5 degrees
c.	Character Shrinkage	Less than 5% of character height
d.	Character skew	Less than 3 degrees

STROKE GENERATOR (Optional)

Provisions are made in the design of the Printhead circuits for inclusion of the necessary electronics to implement a stroke writing character generator capability. This method of character generation uses the CHARACTRON shaped beam tube to display the generated characters but does not utilize the shaped beam principle. Instead, a spot is deflected to trace the shape of the character desired. The voltages necessary to deflect the spot are generated by sweep generators, one for X deflection and one for Y deflection.

Sweep input instructions for the character are stored in the Product Control Unit, which contains two stroke instructions per word. Since about 16 strokes are used on an average per character, each character typically requires eight words of storage and can be displayed in 32 - 40 μsec.

Refer to Figure 4 for a description of the Stroke Generator.

Point "0" is the starting point for every character to be drawn. The position is one of the 4096 x 3072 raster units of the S-C 4060 system. This point is addressed by the main deflection system (character position).

The stroke lattice, ABCD, forms a boundary, beyond which stroke writing cannot go in a sequence which starts at "0". ABCD and Point "0" are in a fixed relationship to each other, i.e. Point "0" is always 4 half strokes in both X and Y directions from the lower left corner of ABCD.

The distance AB, AC, CD and BD are equal to nine full length strokes. As many strokes as desired may be drawn within ABCD; strokes to the "left" of and "below" the Point "0" are permitted, but it should be pointed out that these areas should generally be used for special character effects or for lower case letters which should fall slightly below the regular character line.

Point "P" represents any point which is a multiple of a half stroke length from "0" in any direction and within ABCD. A half stroke is defined as the distance between point "P" and any ADJACENT point in the 5 x 5 matrix.

The 5 x 5 matrix that is centered on "P" shows the possible end points of any stroke drawn from "P".

Writing of the strokes for a given symbol must be in an unbroken time sequence.

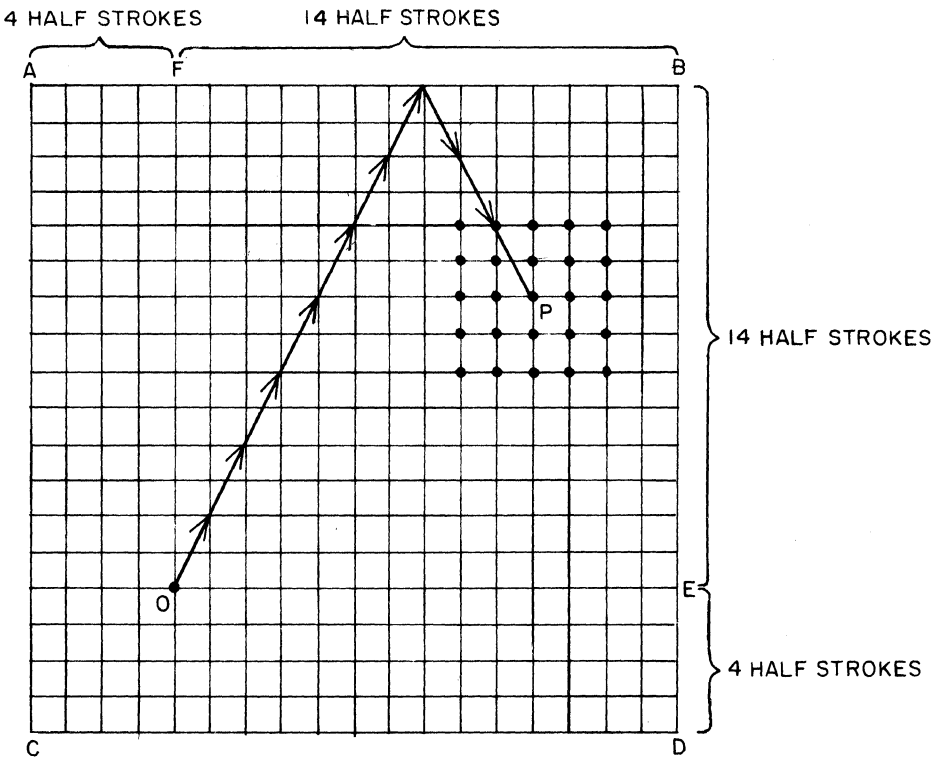


Figure 3. Stroke Generator Description

By use of the blank/unblank bit, the spot may be positioned without printing any stroke in the generation sequence.

The above described arrangement makes possible great flexibility in the design of symbols and will produce smooth even characters lacking the jumps and discontinuities often associated with stroke writing techniques.

Two programmed character heights are provided nominally with a 2:1 height ratio. These heights (BE in Figure 4) are factory set between the limits of 16 raster units and 64 raster units. Selection between the two character heights is under program control.

Maximum excursion of any stroke is one seventh (1/7) of the character height. It should be noted that the maximum excursion, the vertical line of an "E" for example, although made up of seven strokes is drawn as a continuous line.

Linearity - Any stroke will appear straight to the unaided eye within the size limits set forth above.

Accuracy - A stroke length will be accurate to within 3 raster units.

Drift - Drift will be undetected by the unaided eye between normal maintenance periods.

PLOTTING

1. The Printhead has the capability of generating plots over a 4096 x 3072 equal increment, addressable point raster. Four selectable plotting dot sizes are available nominally between 2 and 16 raster units. (Units refer to the average diameter of the spot).
2. The system operates in either a Plot Random or a Plot Sequential mode. In the plot random mode of operation, the time necessary to carry out each plotting instruction is 33 microseconds. For plot sequential, this time is 15 microseconds. In the plot sequential mode of operation, incremental changes of X and Y position shall be limited to 80 raster positions maximum.
3. The overall equipment accuracy is ±.5% of full scale deflection within the requirements outlined in paragraph 4 as follows. This is an absolute measurement against a theoretical grid. Relative accuracy in the plot sequential mode is such that the distance between two points is accurate to ±50% of one raster unit or ±1.0% of the distance between the points, whichever is greater.
4. Equipment stability is as follows:
   a. Short term (1 minute) ±0.15% of full scale.
   b. Long term (8 hours) ±0.3% of full scale, when operating between 50°F and 90°F after 15 min. warmup.

LINE GENERATION

1. The line generator is capable of drawing vectors and axes minimum to full length with four selectable line weights. The minimum line length is equal to four plotting increments. Speed of line generation is such that a maximum length line, at minimum line weight, requires less than one millisecond.

2. Linearity or line straightness is ±0.3% line length or ±3 raster units, whichever is greater.

3. Vector and axis generation accuracy is such that beginning and end of any line will be within ±3 raster units of its intended position.

FORMS OVERLAY

1. A forms overlay feature is provided capable of superimposing predetermined, fixed forms with the generated image. Capability of program controlled flashing is provided. Forms are interchangeable by an operator.

2. Intensity of the overlay form is variable from 50% to 100% of normal character intensity and is uniform to the eye over the entire frame. Variation of intensity between these limits is in discrete steps.

3. Provision is made for image to form alignment such that per sons intending to rule a line between characters must provide at least 20 raster units between the trailing and leading edges of the two adjacent characters.

4. Resolution of the projected form is such that line weights greater than .005 inch may be resolved on 8-1/2" x 11" format.

PRINTHEAD WORD FORMATS

Draw Specified Vector

B = Size
- 01 = minimum line weight
- 00 =
- 10 =
- 11 = maximum line weight

C = 000 Solid Line

C = < 000 Dash Line
Length of equal dashes & spaces is shown below
- 001 = 32 raster units
- 011 = 64 raster units
- 101 = 128 raster units
- 111 = 256 raster units

-X +Y	+X +Y
-X -Y	+X -Y

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	1	0	0	12 Bits X Start Pt											
B		D	F	12 Bits Y Start Pt											
C			E	12 Bits Slope $\frac{\Delta Y}{\Delta X}$ or $\frac{\Delta X}{\Delta Y}$ **											
				12 Bits ΔX or ΔY *											

*The larger of the two, as specified in D bit.

**When ΔX is provided, then slope provided must be

$4096 \times \frac{\Delta Y}{\Delta X}$; when ΔY is provided, then slope provided must be

$4096 \times \frac{\Delta X}{\Delta Y}$.

E = Y Axis Sign
- 0 = plus
- 1 = minus

F = X Axis Sign
- 0 = plus
- 1 = minus

D = Major Axis
- 0 = ΔX
- 1 = ΔY

Stroke Write

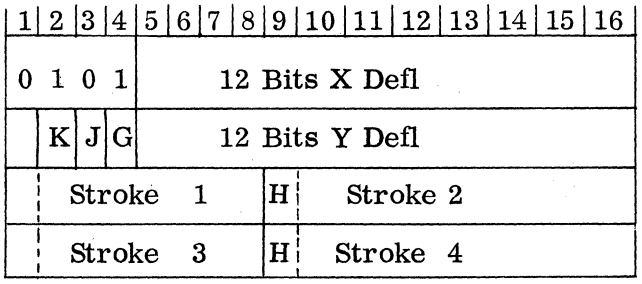
J = Size
- 0 = normal size char.
- 1 = large size char.

H = Stroke Designator
- 0 = continue
- 1 = last stroke

K = Settle time
- 0 = Random Settle
- 1 = Fast Settle

G = Height Adjust
- 0 = Normal
- 1 = Increase

S = Stroke Sign
- 0 = Plus
- 1 = Minus

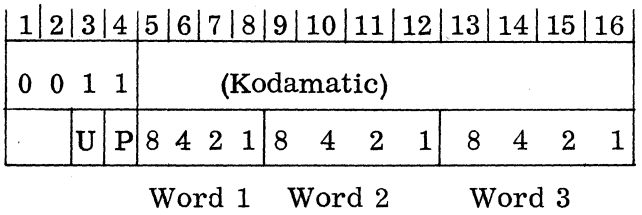


UB S 1 2 S 1 2 UB S 1 2 S 1 2
X_{LSB} Y X_{LSB} Y

UB = Unblank Bit
1 = yes 0 = no

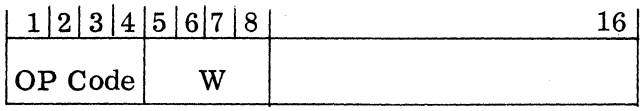
Retrieval Code

U = Utility bit
P = Parity
WORD = Excess 3 retrieval char.
MIRACODE = Format shown



Special Functions

Test Mode	$16)_8$
End of File	$17)_8$
Block Mode	$14)_8$
Expose Hard Copy	$15)_8$

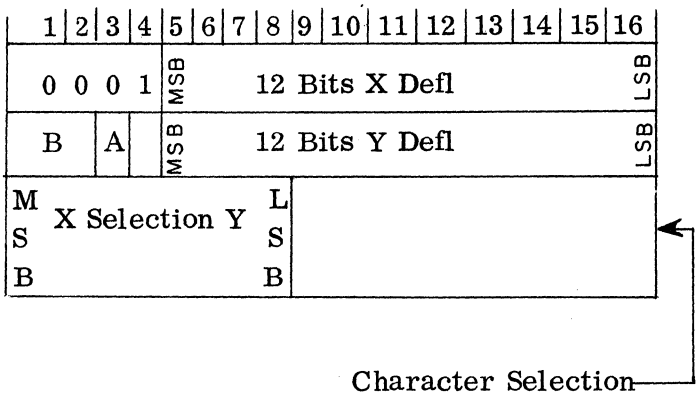


W = Expose Hard Copy Lights

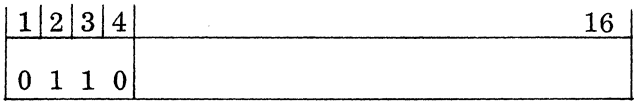
Plot Random Point

A = Orientation
- 1 = Rotated
- 0 = Normal

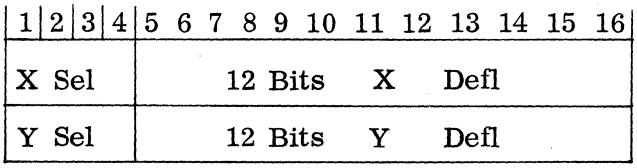
B = Size
- 01 = Small (.75N)
- 00 = Normal (N)
- 10 = Medium (1.25N)
- 11 = Large (1.5N)



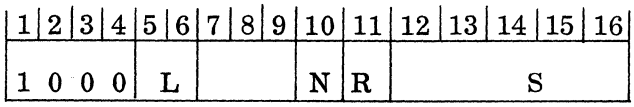
Plot Sequential Mode



X Sel. = 1111 End Mode



Control Functions



L = Form Flash
- 00 = No Change
- 01 = Clear Auto FF
- 10 = Single Form Flash
- 11 = Set Auto FF

N = Void Frame

R = Generate Leader

S = Frame Advance
- 10000 = 2 Pole Adv
- 10001 = 3 "
- 10010 = 4 "
- 10100 = 5 "
- 11000 = 6 "

ROTATABLE TUBE MOUNT

The CHARACTRON shaped beam tube is mounted in a rotatable tube mount which permits rotation and accurate indexing of the tube at zero and 90 degrees clockwise. Tube rotation is accomplished by releasing the indexing knob, tilting the tube mount forward, rotating to the desired position, returning the tube to the upright position and tightening the indexing knob. Precision indexing is automatic.

RECORDING SECTION

The Recording Section serves to convert the displayed image on the CHARACTRON shaped beam tube into a latent image on microfilm. Choice of either 16mm or 35mm, perforated or unperforated microfilm is provided with the basic machine. In addition, on-line processing of the 35mm perforated film is provided as an option. Table 3 shows film advance distances, image size and intended use of the various cameras.

35MM Recording Camera:

The Recording Camera is a 35mm (perforated) camera which views the face of the CHARACTRON shaped beam tube screen of the Printhead. The camera is equipped with a supply and takeup magazine each having a film capacity of 600 feet of 0.0055-inch-thick film. The supply and takeup magazines are independent, light-tight units which may be attached and dismounted from the camera in daylight. The camera and magazines are designed so that exposure and removal of film in less than full reels is possible with minimum (about 2 feet) waste due to cutting. The camera is equipped with a footage indicator which will display the amount of film left in the feed magazine and an interlock will be provided which will prevent operation when the film supply is exhausted.

The film in the camera will be advanced by an electrical pulse from the logic circuits and the advance time will be approximately 100 milliseconds. Film advance is

TABLE 3. Microfilm Cameras And Film Characteristics

Camera Type	Advance Distance	Lens	Typical Use	Image Format Size (Inches)	Smallest Spot Size (Inches)	Maximum Film Resolution
16MM Perf	0.300 Inch	50MM	16MM Movies	0.366 x .275 Min 0.387 x .292 Typ 0.400 x .300 Max	0.0003 4 Addressable Points	125 LP/MM
16MM Unperf	0.117 Inch	--	Coding	Code Bars		
	0.351 Inch	55MM	Cine Oriented Smallest Recording Format	0.435 x 0.326		
	0.470 Inch	55MM	Comic Strip Oriented Smallest Format	0.326 x 0.435		125 LP/MM
	0.470 Inch	63MM	Cine Oriented Largest Recording Format	0.550 x 0.410		
	0.470 Inch	75MM	Typical 8 1/2 x 11 Printed Page	0.340 x 0.468		
	0.470 Inch	75MM	Butted Frame Stripcharts (3072 x 3072 Format)	0.470 x 0.470	0.0003	
	0.470 Inch	55MM	Butted Frame Stripcharts	0.351 x 0.470		
	0.587 Inch	63MM	Butted Frame Stripcharts	0.440 x 0.587		
	0.587 Inch	55MM	General Printing Plotting	0.351 x 0.470		
	0.705 Inch	63MM	General Printing Plotting	0.440 x 0.587		
	0.705 Inch	75MM	Largest 3072 x 4096 Format	0.470 x 0.630		
	0.705 Inch	75MM	Largest Square Format (3072 x 3072)	0.550 x 0.550		
35MM Perf	4 Perf 0.748 Inch	100MM	Smallest Comic Strip Oriented Format	0.735 x 0.555		
	4 Perf 0.748 Inch	100MM	35MM Movies or General Cine Oriented Recording	0.850 x 0.638		
NOTE: All 35MM Perf Film may be rapid on line processed	4 Perf 0.748 Inch	100MM	Butted Frame Stripchart (3072 x 3072 Format)	0.750 x 0.750	0.00053	100 LP/MM
	4 Perf 0.748 Inch	100MM	8 1/2 x 11 Printed Page Hardcopy	0.750 x 0.548		
	6 Perf 1.112 Inch	100MM	General Printing Plotting & 11 x 14 132 character line hardcopy	0.750 x 1.000		
Hardcopy Option Formats	4 Perf 0.748 Inch	100MM	8 1/2 x 11 Printed Page	0.750 x 0.548		
	6 Perf 1.112 Inch	100MM	11 x 14 Printed Page-General Printing Plotting	0.750 x 1.000		
	4 Perf	100MM	Butted Frame Stripchart (3072 x 3072 Format)	0.750 x 0.750		
35MM Unperf	0.500	75MM	1/4 Aperature Card	0.630 x 0.475	0.0005	
	1.00	100MM	1/2 Aperature Card	0.720 x 0.960	0.0005	100 LP/MM
	2.00		Full Aperature Card	1.120 x 1.500	0.0007	

selectable in increments of two perforations up to a maximum of 6 perforations (i.e., 1.122 inches).

The 35mm camera comes equipped with a single lens which will record a single image size on film. This film, when used with the hardcopy option results in printing normal size characters 1/10 inch high (6 lines per inch, 10 characters per inch). Additional lenses are available if applications require other image sizes. Changing lenses is an operator function; no adjustment by a Customer Engineer is necessary after a lens change.

16mm Recording Camera:

A 16mm camera is also available. The camera is directly interchangeable with the 35mm camera. As in the case of the 35mm camera, the 16mm camera will be equipped with a supply and takeup magazine each having 600 feet of film capacity and the same features as the 35mm magazines.

The film in the camera will be advanced by an electrical pulse from the logic circuits and the advance time will be approximately 100 milliseconds. Pulldown is selectable in increments of 0.1175 inches. Advance time of approximately 100 milliseconds is for advance distances of up to 0.075 inches.

The camera comes equipped with either a 55mm, 63mm or 75mm lens. The camera can also be equipped with a data box as an option. Data boxes for Miracode and code line indexing are available.

The Recording Section, in addition, is designed to provide space for the On-Line Processor option. The Viewing Screen/Hard Copy option requires adding an additional cabinet.

ON-LINE PROCESSOR OPTION

Provision is made for on-line processing of 35mm perforated film. The 600-foot take-up magazine can be removed and the film processor slid into place--this change is an operator function which can be accomplished in a few minutes. The processor processes the film as a negative at 27 inches per minute. Film control loop columns are provided at the input and output end of the processor--the input loop to allow the frames to be exposed in rapid sequence until a quantity of frames have been accumulated, the column following the processor to allow the output to be stopped for periods up to 1-1/2 minutes when the Viewing Screen/Hard Copy option is used. The processed film has resolution of at least 80 line pairs per millimeter and is of semi-archival quality. If the film is to be kept for longer than one year, it should be thoroughly washed in conventional washing equipment. The processed film is taken up on a 600 foot spool.

HARD COPY OPTION

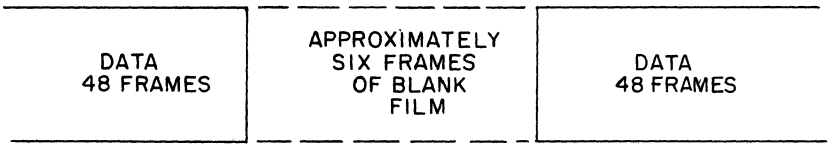
GENERAL

The Hard Copy Option is housed in a cabinet alongside the Printhead. Functions performed by the Hard Copy Option and specifications for these functions follow.

THROUGHPUT	Throughput is one 8 1/2" x 11" page every two seconds.
ACCESS TIME	The first page is available in less than 60 seconds after data is read into the PCU.
PAGE SIZE	There are three selectable page sizes (sheet sizes to be as follows): 1. 8 1/2" x 11" 2. 11" x 14" 3. Strip Chart
MODES	There are three selectable modes of operation. 1. No Hard Copy. 2. Hard Copy for each frame of film. 3. Automatic Mode. In this mode, hard copy will be produced for frames which are marked with special programmable dots.
VIEWING SCREEN	Each frame will be projected and displayed on an 11" x 14" daylight viewing screen while in the Hard Copy Option projection station. Approximately two seconds view time will be available before the frame is advanced into the exposure station. A hold pushbutton will be provided which permits limited extension of viewing time dependent upon the on-line processor output film-loop conditions.

BLOCK MODE

Runs using the block mode instruction will permit viewing of film frames an unlimited amount of time. This will be accomplished by allowing approximately six frames of blank film to accumulate between respective blocks of film frames (48 frames per block of film) as shown in the following illustration. This allows the on-line film processor to stop processing with the blank film over the processing head, thereby, insuring that data will not be overdeveloped. A manual PRINT pushbutton will be provided for selective hard copy.



STRIP CHART RECORDING

Strip chart recording will be available on 35mm microfilm or on hard copy using the on-line hard copy option. When strip charting is required the view hold will be disabled. The view station can be viewed 1.9 seconds per frame.

SOFTWARE

(For S-C 4060 Software Description of Specifications, refer to Stromberg-Carlson Document 9500236.)