NCR ELLIOTT

4100

Electronic Data Processing System

FACTS

Contents

1. General Information

The 4100 is a fast, general purpose data processing system designed for a wide range of scientific, technical and commercial applications.

The computer is fully self-contained and transportable, so that installation of a basic system requires only plugging into a suitable mains outlet. To this end the computer is fully transistorised, using silicon components, and capable of tolerating a wide range of environmental conditions. The central processor contains arithmetic and control units, space for up to 32,768 words of magnetic core storage and power supplies for logic and control. An operators desk carries the directly connected control typewriter and the control box on which are mounted the manual controls for the computer.

The minimum storage capacity of the 4120 is 4096 24-bit words, extendable to a maximum of 32,768 words. The store cycle time is 6 microseconds.

A feature of the 4100 is the standard electrical interface, which has been designed to minimise the buffering and control logic needed for any peripheral device, and yet permitting extremely high data transfer rates.

The 4120 is a parallel, binary processor. The word length is 24 bits and this can represent either one long or two short instructions or an integer I. Integers are in the range $-2^{23} \leqslant I \leqslant 2^{23}-1$, and negative integers are held in the two's complement form. For certain purposes words can conveniently be thought of as made up from four six-bit syllables or bytes.

Instructions are of the single address form, and are specified by a simple mnemonic code when using the symbolic assembly language, SAP. Short instructions occupy 12 bits, 6 for specifying the function and 6 the address, which can therefore only refer to the first 64 storage locations. Long instructions may be either of the normal or 'extra-code' form, the latter consisting of subroutine jumps. The address of a long instruction occupies 15 bits, and may be literal, direct, B-modified or indirect, thus providing powerful addressing facilities. To designate what type of instruction or addressing is intended the function mnemonic is followed by a specifying letter, for example:

ADD	direct addressing
ADD:S	short instruction
ADD:L	literal addressing
ADD:M	modified addressing
ADD:I	indirect addressing

There are several special registers in the computer which are accessible by program. These are:

M	Main accumulator	24 bits
R	Reserve accumulator	24 bits
S	Sequence control register	16 bits
K	Count register	12 bits
C	Conditions register	24 bits
Normal interrupt word		12 bits maximum
Attention interrupt word		12 bits maximum

Floating point arithmetic is performed by extracode functions. Numbers are held to double length, with a 9-bit exponent and 39-bit mantissa.

Dimensions, Weights, Power Consumption, Speeds

Model No.	*Description*	*Speed*	*Width, depth and height in inches*	*Weight in pounds*	*Power consumption*
4120	Central processor		56 × 26 × 63	1000	1·3 kVA
4210	Paper tape station		82 × 26 × 48	600	1·3 kVA
4213	Paper tape reader	1000 c.p.s.	6½ × 11 × 10	17	250 W
4216	Paper tape punch	100 c.p.s.	16 × 9½ × 12	25	250 W
4220	Control typewriter	15·5 c.p.s.	36 × 16 × 33	150	200 W
4241	Card reader	400 c.p.m.	42 × 27 × 36	450	½ kVA
4245	Card punch	100 c.p.m.	42 × 27 × 36	500	200 W
4255	Line printer—buffered	300 l.p.m.	56 × 30 × 54	1000	2.0 kVA
4256	Line printer—unbuffered	300 l.p.m.	42 × 24 × 52	1100	2.2 kVA
4257	Line printer—unbuffered	600 l.p.m.	42 × 24 × 52	1100	2·2 kVA
4254	Line printer—buffered	600 l.p.m.	42 × 24 × 52	1200	2.5 kVA
4258	Line printer—buffered	1000 l.p.m.	42 × 24 × 52	1200	2·5 kVA
4260	Disc cartridge file controller	105 kc/s	42 × 27 × 36*	390	½ kVA
4261	Disc cartridge file handler			70	¼ kVA
4268	Magnetic tape master	12 kc/s	24 × 19 × 60	400	1·2 kVA
4269	Magnetic tape slave handler		24 × 19 × 60	325	0·6 kVA
4270	Magnetic tape master	33·3 kc/s	24 × 19 × 60	400	1·2 kVA
4271	Magnetic tape slave handler		24 × 19 × 60	325	0·6 kVA
4286	CRT display unit		42 × 27 × 36	400	250 W
4290	Digital plotter Model 564	300 steps/sec.	40 × 15 × 10	53	125 W
4291	Digital plotter Model 565	300 steps/sec.	18 × 15 × 10	33	125 W
4292	Digital plotter Model 566	300 steps/sec.	18 × 15 × 10	33	125 W
4293	Digital plotter Model 563	200 steps/sec.	40 × 15 × 10	53	125 W
4294	Digital plotter Model 506	300 steps/sec.	40 × 15 × 10	53	125 W
4295	Digital plotter Model 507	300 steps/sec.	18 × 15 × 10	33	125 W

*Controller and 2 handlers housed in one.

2. Powers of 2 in decimal

2^n	n	2^{-n}
2	1	·5
4	2	·25
8	3	·125
16	4	·062 5
32	5	·031 25
64	6	·015 625
128	7	·007 812 5
256	8	·003 906 25
512	9	·001 953 125
1 024	10	·000 976 562 5
2 048	11	·000 488 281 25
4 096	12	·000 244 140 625
8 192	13	·000 122 070 312 5
16 384	14	·000 061 035 156 25
32 768	15	·000 030 517 578 125
65 536	16	·000 015 258 789 062 5
131 072	17	·000 007 629 394 531 25
262 144	18	·000 003 814 697 265 625
524 288	19	·000 001 907 348 632 812 5
1 048 576	20	·000 000 953 674 316 406 25
2 097 152	21	·000 000 476 837 158 203 125
4 194 304	22	·000 000 238 418 579 101 562 5
8 388 608	23	·000 000 119 209 289 550 781 25
16 777 216	24	·000 000 059 604 644 775 390 625
33 554 432	25	·000 000 029 802 322 387 695 313
67 108 864	26	·000 000 014 901 161 193 847 656
134 217 728	27	·000 000 007 450 580 596 923 828
268 435 456	28	·000 000 003 725 290 298 461 914
536 870 912	29	·000 000 001 862 645 149 230 957
1 073 741 824	30	·000 000 000 931 322 574 615 479
2 147 483 648	31	·000 000 000 465 661 287 307 739
4 294 967 296	32	·000 000 000 232 830 643 653 870
8 589 934 592	33	·000 000 000 116 415 321 826 935
17 179 869 184	34	·000 000 000 058 207 660 913 467
34 359 738 368	35	·000 000 000 029 103 830 456 734
68 719 476 736	36	·000 000 000 014 551 915 228 367
137 438 953 472	37	·000 000 000 007 275 957 614 183
274 877 906 944	38	·000 000 000 003 637 978 807 092
549 755 813 888	39	·000 000 000 001 818 989 403 546
1 099 511 627 776	40	·000 000 000 000 909 494 701 773

3. Summary of Symbolic Assembly Program

SAP is the basic mnemonic code for use on the 4100. The table shows operating times in microseconds. If no time is given that instruction or address form does not exist. The following symbols are used:

m = C(M); r = C(R); N = value of address part of instruction; n = number held in location with address N; n^1 = number held in location with address n; $(N+r)^1$ = number held in location with address (N +r); Q = n or n^1 or $(N+r)^1$; c, s = contents of C and S; k = contents of K.

Name	Effect	Times					C_{24} N	C_{23} ST	C_{22} NZ	C_{21} Ca	C_{20} oF
		Short	Literal	Direct	Mod.	Ind.					
LD	m: =Q	12	7·5	12	13·5	18	m	m	m	–	–
ST	Q: =m	13·5		13·5	15	19·5	Q	Q	Q	–	–
ADD	m: =m +Q	12	7·5	12	13·5	18	m	m	m	m	m
SUB	m: =m–Q	12	7·5	12	13·5	18	m	m	m	m	m
NADD	m: =Q–m	12	7·5	12	13·5	18	m	m	m	m	m
AND	m: =m *and* Q	12	7·5	12	13·5	18	m	m	m	–	–
ANDN	m: =m *and not* Q	12	7·5	12	13·5	18	m	m	m	–	–
EXC	m: =Q; Q: =m			15	16·5	21	Q	Q	Q	–	–
LDR	r: =Q	12	7·5	12	13·5	18	r	r	r	–	–
STR	Q: =r	13·5		13·5	15	19·5	Q	Q	Q	–	–
ADDR	r: =r +Q	12	7·5	12	13·5	18	r	r	r	r	r
SUBR	r: =r–Q	12	7·5	12	13·5	18	r	r	r	r	r
NADR	r: =Q–r	12	7·5	12	13·5	18	r	r	r	r	r
EXCR	r: =Q; Q: =r			15	16·5	21	Q	Q	Q	–	–
ADDS	Q: =Q +m	13·5		13·5	15	19·5	Q	Q	Q	Q	Q
SUBS	Q: =Q–m	13·5		13·5	15	19·5	Q	Q	Q	Q	Q
NEGS	Q: =–Q	13·5		13·5	15	19·5	Q	Q	Q	Q	Q
CLS	Q: =0	13·5		13·5	15	19·5	0	0	0	–	–
INCS	Q: =Q +1	13·5		13·5	15	19·5	Q	Q	Q	Q	Q
DECS	Q: =Q–1	13·5		13·5	15	19·5	Q	Q	Q	Q	Q
MVE	r: =r–1; r^1: =m: =Q			19·5	21	25·5	m	m	m	–	r
MVB	Q: =m: =r^1; r: =r +1			21	22·5	27	m	m	m	–	r
GET	Q: =Q (bcda); m: =m(abc) +Q(a)			13·5	15	19·5	Q	Q	Q	–	–
PUT	Q: =Q (bcd) +m(d)			13·5	15	19·5	Q	Q	Q	–	–

Name	Effect	Short	Times				C_{24} N	C_{23} ST	C_{22} NZ	C_{21} Ca	C_{20} oF
			Literal	Direct	Mod.	Ind.					
JIR	s: =n; c(24–18): =n(24–18)	12					–	–	–	–	–
J	s: =Q		7·5	12	13·5	18	–	–	–	–	–
JFL	o[1]: =c(24–18) +s; s: =s +N		15				–	–	–	–	–
JIL	o[1]: =c(24–18) +s; s: =Q	18 (literal)		18	19·5	24	–	–	–	–	–
JF	s: =s +N	7·5	7·5				–	–	–	–	–
JA	s: =s +Q	7·5	7·5	12	13·5	18	–	–	–	–	–
JB	s: =s–N	7·5	7·5				–	–	–	–	–
JS	s: =s–Q	7·5	7·5	12	13·5	18	–	–	–	–	–
JN	s: =s +N if c24 =1	7·5	7·5				–	–	–	–	–
JNN	s: =s +N if c24 =0	7·5	7·5				–	–	–	–	–
JZ	s: =s +N if c22 =0	7·5	7·5				–	–	–	–	–
JNZ	s: =s +N if c22 =1	7·5	7·5				–	–	–	–	–
JST	s: =s +N if c23 =1	7·5	7·5				–	–	–	–	–
JOF	s: =s +N if c20 =1; c20 =0	7·5	7·5				–	–	–	–	–
DKJN	k: =k–1; s: =s +N if k12 =1	7·5	7·5				–	–	–	–	–
LDK	k: =Q	7·5	7·5	12	13·5	18	0	0	k	–	–
COMP	Form m–Q; set C		7·5	12	13·5	18	m–Q	m–Q	m–Q	m–Q	–
DIVM	m: =(r, m)/Q; r: =remainder		84	88·5	90	94·5	m	m	m	–	m
MULM	(r, m) =r +m ×Q		82·5	87	88·5	93	r	r	r	–	–
SBL	Shift both left k places	7·5 +3k					r	r	r	–	r
SBR	Shift both right k places	7·5 +3k					r	r	r	–	–
SBRL	Shift both right logical k places	7·5 +3k					r	r	r	–	–
SML	Shift m left k places	7·5 +1·5k					m	m	m	–	m
SMR	Shift m right k places	7·5 +1·5k					m	m	m	–	–
SMLA	Shift m left around k places	7·5 +1·5k					m	m	m	–	–

Name	Effect	Times: Short	Times: Literal	Times: Direct	Times: Mod.	Times: Ind.	C_{24} N	C_{23} ST	C_{22} NZ	C_{21} Ca	C_{20} oF
SMCL	Shift m k 6-bit characters left	7·5 +1·5k					m	m	m	–	–
SMRL	Shift m right logical k places	7·5 +1·5k					m	m	m	–	–
SRL	Shift r left k places	7·5 +1·5k					r	r	r	–	r
SRR	Shift r right k places	7·5 +1·5k					r	r	r	–	–
SRCL	Shift r k 6-bit characters left	7·5 +1·5k					r	r	r	–	–
SRRL	Shift r right logical k places	7·5 +1·5k					r	r	r	–	–
SBST	Shift both until standardised, or k places, whichever is less	7·5 +3s					r	r	r	–	r
SMST	Shift m until standardised, or k places, whichever is less	7·5 +3s					m	m	m	–	m
SRST	Shift r until standardised, or k places, whichever is less	7·5 +3s					r	r	r	–	r

Name	Effect	Time	C_{24} N	C_{23} ST	C_{22} NZ	C_{21} Ca	C_{20} oF
IDPR	Input data packed repetitive	12 +(15 +4D)k	–	–	–	–	–
OCPR	Output control word packed repetitive	12 +(15 +4D)k	–	–	–	–	–
IDUR	Input data unpacked repetitive	12 +(6 +D)k	–	–	–	–	–
ODUR	Output data unpacked repetitive	12 +(6 +D)k	–	–	–	–	–
ISPR	Input status-word packed repetitive	12 +(15 +4D)k	–	–	–	–	–
OCPR	Output control-word packed repetitive	12 +(15 +4D)k	–	–	–	–	–
ISUR	Input status-word unpacked repetitive	12 +(6 +D)k	–	–	–	–	–
OCUR	Output control-word unpacked repetitive	12 +(6 +D)k	–	–	–	–	–
IDUM	Input data unpacked single to m	12 +D	m	m	m	–	–
ODUM	Output data unpacked single from m	12 +D	m	m	m	–	–
ISUM	Input status-word unpacked single to m	12 +D	m	m	m	–	–
OCUM	Output control-word unpacked single from m	12 +D	m	m	m	–	–

Name	Extracode Functions: Effect	Literal	Direct	Mod.	Ind.	Registers affected
MULS	m: =m ×Q	340	340	342	346	C, M, K
DIV	m: =m/Q; r: =remainder. Results identical to Algol DIV function	230	230	232	236	R, K
BL	(r, m): =(Q, Q +1)		76	78	82	M, R
WB	(Q, Q +1): =(r, m)		90	92	96	
FL	FPA¹: =(Q, Q +1)		136	138	142	M, R
WF	(Q, Q +1): =FPA¹		123	125	129	M, R
FA	FPA¹: =FPA¹ +(Q, Q +1)		340	342	346	M, R, K
FS	FPA¹: =FPA¹—(Q, Q +1)		347	349	353	M, R, K
FM	FPA¹: =FPA¹ ×(Q, Q +1)		678	680	684	M, R, K
FD	FPA¹: =FPA¹/(Q, Q +1)		690	692	696	M, R, K
FCP	Set c(24–22) from FPA¹–(Q, Q +1)		283	285	289	M, R, C
FN	FPA¹: = — FPA¹	100				M
FCF	FPA¹: =integer m in floating point form	156				R, M, K
FMOD	FPA¹: =modulus FPA¹	72 or 128				M
FENT	m: =entier FPA¹	130				R, M, K, C
FSIG	if FPA¹< 0 m: = — 1 if FPA¹ =0 m: =0 if FPA¹ >0 m: =1	90				R, M, C
TR	Nth letter of alphabet displayed (octal)	•				
CH	Q displayed (octal)		•	•	•	
JIRX	Jump indirect and restore link		161	163	169	
JIX	Jump indirect		169	171	175	
JILX	Jump indirect setting link		274	276	280	
INDEX	Array access	175	175	177	181	

4. Summary of EASE

The systems executive (EASE) consists of three routines N.I.C.E., SPAN and T.S.S.

N.I.C.E. (Normal Input and Control Executive)

This enables the operator to communicate with EASE, usually to ask for the input of a program, or entry to a named program. N.I.C.E. also contains an input routine for relocateable binary tapes, and various supplementary routines for listing and deletion of programs.

When the message button is pressed, control is sent to N.I.C.E. which then awaits one of the following messages:

Message	*Effect*
in.	Causes the computer to read in a specially prepared relocateable binary tape.
NAME.	Transfers control to the program called NAME.
list.	The names of the N.I.C.E. supplementary routines, and any other programs in the store are output on the typewriter in chronological order.
cont.	Continues a program from the point at which it was left to obey a manual interrupt.
conter.	Continues a program from the point at which it was left to output an error message.
reset.	Clears the store with the exception of N.I.C.E.
remove, NAME.	Removes the program called NAME from the store.
dump.	Outputs the contents of the store in absolute binary.

Error messages output on the typewriter by N.I.C.E. are:

X	Illegal character encountered during input of message via the typewriter.
NOPROG	Named program not in the computer.
ERRSUM	Sum-check error encountered on input of a program.

Messages output to help the operator to know the state of the computer are:

? Manual interrupt has been accepted, and N.I.C.E. awaits a message.

> Entry to a named program has taken place correctly.

SPAN (Storage Planning and Allocation)

SPAN organises the layout of storage throughout the main and auxiliary store of the computer. It performs all the housekeeping for transfers between various storage levels, and handles the varying demands for space with the minimum of assistance from the programmer.

The following interpreted instructions are the interchapter transfers:

JIX/P:A*B*C Unconditional transfer to label A of block B of chapter C.

JILX/P:A*B*C Subroutine entry to label A of block B of chapter C.

JIRX/LINK Subroutine exit.

The following SPAN routines deal with requests for storage space and the return of storage.

JIL/ALLOC	Asks SPAN to reserve space.
JIL/NOROOM	If ALLOC cannot find sufficient space, this message is output.
JIL/INSERT	This gives a name to an allocated chapter.
JIL/DELETE	This frees the space occupied by a chapter, so that it is available to SPAN again.

Access to array elements is provided by the extracode function:

INDEX/I If this is given with the address of a codeword in R, the address of the i'th element of the chapter to which this codeword points is placed in R.

The following routines may be used by the programmer to help SPAN optimise transfers between different layers of storage:

JIL/BANISH Move a chapter to auxiliary store.

JIL/RETIRE Mark a chapter as retired.

JIL/RECALL Bring a chapter into main store.

It is often convenient to treat one word of an array as a vector. To do this the codeword is moved into fixed workspace by using the following routine.

JIL/DETACH

T.S.S. (Time Sharing Supervisor)

The 4100 data processing system allows three levels of program, the highest at interrupt level, the next at attention level, and the lowest at normal program level. The T.S.S. looks after interrupts and attentions coming in from each standard interface channel, and transfers control to the appropriate device routines at the correct level.

Transfers to routines at a particular level either occur as a result of an interrupt, or because one of the following stepping instructions was given.

ST 12/ Step from interrupt level to attention level.

ST 32/ Step from program level to interrupt level.

RE 23/ Return to level 3, i.e. program level.

The exit instructions from an interrupt or attention routine to a lower level are:

XIT1/ for exiting level 1.

XIT2/ for exiting level2.

Input and output transfers are arranged by the Queue Administrator in T.S.S. which, on being handed a buffer for input or output by a program, attaches the buffer to a queue for a particular device. The following T.S.S. routines provide the appropriate instructions to the Queue Administrator.

JIL/ATTACH Place a buffer in the queue for the device whose channel number is in R.

JIL/RETURN Hand back to the program a named buffer after it has been filled or emptied.

JIL/ADVANCE This can only be given by a level 2 routine, and has the effect of advancing the pointer from the current job to point to the next buffer in the queue.

JIL/REMOVE This can only be given by a level 2 routine, and has the effect of advancing the pointer to the next buffer in the queue, and marking the space occupied by the current buffer as free.

Devices are classified into classes according to their physical nature and their use. Different configurations of the 4100 may use the same channel number to refer to different devices. Therefore programs are written to refer to device classes and serial numbers. The following routine allows the program to discover what channel number is associated with the class of device he wishes to use.

JIL/ASK If this is entered with a class number in R and a serial number in M, exit is made with the channel number in M.

5. 4100 7-bit Character set

0	(Null)	32	Space	64	`	96	@
1		33	!	65	A	97	a
2		34	"	66	B	98	b
3		35	½	67	C	99	c
4		36	$	68	D	100	d
5		37	%	69	E	101	e
6		38	&	70	F	102	f
7		39	'	71	G	103	g
8		40	(	72	H	104	h
9	Hor. Tab.	41	)	73	I	105	i
10	Line Feed	42	*	74	J	106	j
11	(Ver. Tab.)	43	+	75	K	107	k
12	(Form Feed)	44	,	76	L	108	l
13	(Car. Ret.)	45	-	77	M	109	m
14		46	.	78	N	110	n
15		47	/	79	O	111	o
16		48	0	80	P	112	p
17		49	1	81	Q	113	q
18		50	2	82	R	114	r
19		51	3	83	S	115	s
20	(Stop)	52	4	84	T	116	t
21		53	5	85	U	117	u
22		54	6	86	V	118	v
23		55	7	87	W	119	w
24		56	8	88	X	120	x
25		57	9	89	Y	121	y
26		58	:	90	Z	122	z
27		59	;	91	[	123	
28		60	<	92	£	124	
29		61	=	93	]	125	
30		62	>	94	↑	126	
31		63	?	95	←	127	(Delete)

6. Useful Constants

π	= 3·141 592 653 590	$1/\pi$	= 0·318 309 886 184
$\log_{10}e$	= 0·434 294 481 903	$\log_e 10$	= 2·302 585 092 994
$\log_{10}2$	= 0·301 029 995 664	e	= 2·718 281 828 459
$\sqrt{2}$	= 1·414 213 562 373	$\sqrt{3}$	= 1·732 050 807 569
1 radian	= 57·295 779 513 082°	1°	= 0·017 453 292 520 radian

7. 4100 Line Printer Repertoire

0	Space	32	@
1	Tab	33	A
2	" ●	34	B
3	#	35	C
4	$	36	D
5	%	37	E
6	&	38	F
7	' ●	39	G
8	(	40	H
9	)	41	I
10	*	42	J
11	+	43	K
12	,	44	L
13	-	45	M
14	.	46	N
15	/	47	O
16	0	48	P
17	1	49	Q
18	2	50	R
19	3	51	S
20	4	52	T
21	5	53	U
22	6	54	V
23	7	55	W
24	8	56	X
25	9	57	Y
26	:	58	Z
27	;	59	[●
28	<	60	£
29	=	61	] ●
30	>	62	↑ ●
31	¤ ●	63	← ●

Characters marked ● not available on printers model numbers 4256, 4257, 4258.

8. Peripheral Devices

Peripheral devices on the 4100 are controlled by the Time Sharing Supervisor, and include:

Tape Reader

5, 6, 7 or 8 channel tape is read in by the Model 4213 reader at up to 1,000 characters/second by any input instruction.

Tape Punch

5, 6, 7 or 8 channel tape is punched on the Model 4216 punch at up to 100 characters/second by any output instruction.

Typewriter

Messages to and from the central processor may be typed on the control typewriter Model 4220 at up to 15.5 characters/second.

Card Reader

The Model 4241 card reader with a maximum speed of 400 c.p.m. may be attached to the 4100. The input magazine will hold 1,500 cards, and the output stacker 1,800 cards. Cards are read column by column as they move past a single read station consisting of 12 photo transistors.

Card Punch

The Model 4245 is a fully buffered card punch with a maximum speed of 100 cards/minute. Punching occurs row by row, and full check-punching facilities are provided. The input hopper and output magazine can each hold up to 800 cards.

Line Printers

Five models of line printer may be attached to the 4100. The 4256 and 4257 are 300 l.p.m. and 600 l.p.m. unbuffered printers, and the 4258 is a 1,000 l.p.m. buffered line printer. Models 4255 and 4254 are buffered versions of the 300 and 600 l.p.m. printers. All these printers have a character repertoire based on the I.S.O./ECMA code. There are 120 print positions per line, although an option of 160 print positions is available. Vertical format is controlled by program in conjunction with the vertical format loop. Horizontal tabulating facilities are provided.

Random Access Disc File

Up to 8 handlers may be connected to one standard interface socket via a single controller. Digital data is stored on an interchangeable, rotating disc on individually addressable tracks. One disc at a time is held on each handler. Data is held on each side of the disc in 123 tracks, each of which is split into 20 sectors of 64 words. Each side of the disc therefore has a capacity of over six hundred thousand characters, and the transfer rate is 105,000 characters/second.

Magnetic Tape

A maximum of eight handlers may be attached to one standard interface channel via a single controller. Alternative transfer rates of 33,300 and 12,000 characters/second are offered. IBM compatible, variable length records can be written or read, up to a maximum of 2047 alphanumeric characters/record. The inter-record gap is $\frac{3}{4}$ inches. Data parity is checked on reading in two ways—laterally on each character and longitudinally on each block. The parity bits are inserted on writing to the tape. A read after write parity check occurs automatically.

The system uses $\frac{1}{2}$ inch tape with 7 tracks—one for the lateral parity check, and the remaining six for information.

12 kc/s Magnetic Tape Specification

Model 4268 Master Controller, including one handler.
Model 4269 slave handler.
Tape Speed 60 inches per sec.
Packing density 200 characters per inch.
Rewind speed 250 inches per sec.
Inter-record gap $\frac{3}{4}$ inch.
Recording method NRZ.
Tape length 2,400 ft.
Single tape capacity 5,361,664 characters.

33 kc/s Magnetic Tape Specification

Model 4270 master controller, including one handler.
Model 4271 slave handler.
Tape speed 60 inches per second.
Packing density 556 characters per inch.
Rewind speed 250 inches per second.
Inter-record gap $\frac{3}{4}$ inch.
Recording method NRZ.
Tape length 2,400 ft.
Single tape capacity 13,314,252 characters.

CRT Display

The complete CRT system consists of three units:

Model 4286 CRT Display Unit.
Model 4287 Character Generator.
Model 4288 Light Detecting Pen and Switch Panel.

The CRT has an 8½ in. x 8½ in. viewing area on which spot positions can be defined by a pair of co-ordinates to give a resolution of eight thousandths of an inch. A picture must be renewed approximately seven times per second to avoid flickering. A series of simple instructions enable spots, lines, curves and alphanumeric characters to be displayed. The character generator enables a series of characters of 1/10 in., 1/5 in. or 2/5 in. in height to be written in a horizontal line from a given position. The ECMA 64-character repertoire is used. The light pen may be used to draw lines or characters on the display and such information to be retained by the 4100 as additional or revised data Functional times

Display a spot	20 μsecs.
Display a line of characters	20 μsecs/char.
Draw a curve	500 μsecs/inch
Draw a straight line	25 μsecs/inch

Digital Incremental Plotter

The plotter will draw continuous two dimensional plots as a sequence of linear incremental movements of pen over paper. Basic movements of pen relative to paper can be made along three mutually perpendicular axes. Movement of a drum, holding the paper, beneath the pen, and movement of the pen carriage along tracks parallel to the drum axis give the two dimensional plot, while the pen can be raised from or lowered onto the paper to move from one trace to another.

Drum and carriage each give rise to steps by means of geared stepping motors which may be stepped in either direction. The drum and carriage steps may be called for either separately or together, so that from any one point it is possible to move to one of eight others by a single move. The following models are available.

Model No.	*Step size*	*Plotting width*	*Speed steps/sec.*
4290	.005 in.	29.5 in.	300
4291	.01 in.	11 in.	300
4292	.005 in.	11 in.	300
4293	.01 in.	29.5 in.	200
4294	.1 mm.	75 cm.	300
4295	.1 mm.	28 cm.	300

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