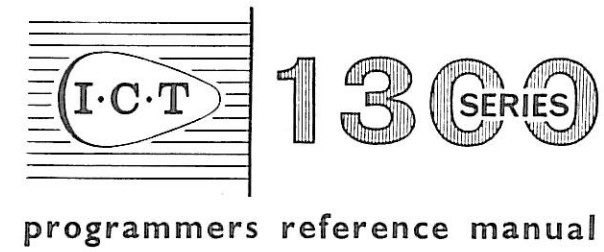1301 Programmers Manual

Section = Part Six

Original PDF by Roger Holmes
Jan 2009

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by Rod Brown

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ICT 1301
Resurrection Project

I·C·T 1300 SERIES

programmers reference manual

REFERENCE TABLES AND GLOSSARY

Contents

3165(2.64)

Table I

Summary of Characteristics of the 1300-series Computer System

		INPUT/OUTPUT			
CARD READER	CARD PUNCH	LINE PRINTER	PAPER-TAPE READER	PAPER-TAPE PUNCH	INTERROGATING TYPEWRITER
80 Column Cards	80 Column Cards	Line of 80 or 120 Characters	5-, 6-, 7- or 8-Track Tape	5-, 6-, 7- or 8-Track Tape	Line of up to 120 Characters
600 or 300 cards a minute	100 cards a minute	600 or 300 Lines a minute	1,000 Characters a second	300 Characters a second	10 Characters a second

MAGNETIC TAPE

Up to 8 magnetic-tape units can be used. Three alternative systems are available:-

i)   1" tape operating at a rate of 90,000 decimal digits a second. Maximum Reel length 3,600 feet.

ii) $\frac{1}{2}$" tape operating at a rate of 22,500 decimal digits a second. Maximum Reel length 3,600 feet.

iii) $\frac{1}{4}$" tape operating at an average rate of 16,500 decimal digits a second. Maximum Reel length 1,800 feet.

COMPUTER

STORAGE

IMMEDIATE ACCESS STORE (I.A.S.)	MAGNETIC DRUM STORE
Magnetic Core Storage ranging from 400 to 2,000 word capacity is available in units of 400 word capacity. Alternatively may have 4,000 word capacity.	1 to 8 drums are available. Capacity of each drum is 12,000 words held on 60 channels, each channel having a capacity of 200 words. Alternatively, a machine may be fitted with a single drum of 3,000 or 6,000 words. Each drum has an additional 2 channels of reserved storage. Speed 5,240 revolutions a minute. Average access time less than 6 ms. Channel transfer to or from I.A.S. within 12 ms including access.

ARITHMETIC UNIT

Comprises Mill and three Registers. Functions available include: add, subtract and multiply in decimal or sterling with variable £.s.d. positions; transfer between registers and to and from storage; logical operations; shifts; etc.

INDICATORS

Provided to record the result of past events, manual switch setting and states of input/output units. A jump instruction, causing a jump out of sequence in the order of instruction obeyed, is provided by a test of an indicator that is set.

GENERAL

Pulse Rate of 1 Mc/s (Megacycle).
Binary Coded Representation of decimal or sterling quantities.
Digits transferred in series, the binary-codings of that digit being recorded on 4 lines.
Word length - 12 digits including sign.
Core store has 2 parity bits with each word.
Drum store has one check digit of 4 bits with each word.
Instructions affecting arithmetic unit and I.A.S. only, except multiplication, take between 17 and 34 μs to be obeyed.
Instruction length, normally 6 digits.
Transfer of instruction pair to control register takes 12 μs.
Multiplication takes approximately 175 μs per multiplier digit on average.

Table 2

Summary of Functions and Function Timings

Func.	Description of Function	Address	Inds. affected	Register A	Time micro-seconds
00	Do nothing				12
11	Stop			Original	-
21	Set Decimal Point Register	No. Dec.			12
22	Set Sterling Position Register	10/ - pos.			12
30	Set Row Binary Register from I.A.S.				
31	Create Row Binary 1 (1 Stream) in Register B				
32	Create Row Binary 2 (2 Stream) in Register B			I.A.S. Word	
33	Create Row Binary 3 (4 Stream) in Register B	I.A.S.			21
34	Create Row Binary 4 (8 Stream) in Register B				
35	Logical AND I.A.S. to Register B		Mill		
36	Logical OR I.A.S. to Register B and I.A.S.			Result	
37	Transfer from I.A.S. to Register B			I.A.S. Word	
38	Input/Output Control	See Table 4		Original	12, or 24 if double -length instruction
39	Magnetic-tape Control				
40	Write Zero to I.A.S.			0	
41	Transfer Register A to I.A.S.	I.A.S.		Original	21
42	Transfer Register B to I.A.S.			Result	
43	Transfer Register C to I.A.S.				
44	Transfer Register C to Register B			Original	17
45	Block Transfer I.A.S. to I.A.S.	I.A.S.		X X X	See Table 4
54	Circulate Left in Register B			Original	17
55	Left Shift Register B, entering zeros	No.		0	34
56	Right Shift Register B, propagating sign	of posns.		Original	17
57	Right Shift Register B, entering zeros				

Table 2A: SUMMARY OF FUNCTIONS AND TIMINGS

Func.	Description of Function	Address	Inds. affected	Register A	Time micro-seconds
60	Clear Add I.A.S. to Register B				
61	Clear Subtract I.A.S. from Register B			I.A.S. Word	21
62	Add I.A.S. to Register B				
63	Subtract I.A.S. from Register B	Decimal Arithmetic } I.A.S.	Mill and Over-flow		
64	Add Register B to I.A.S.				
65	Subtract Register B from I.A.S.			Result	25
66	Add 1 to I.A.S.				
67	Subtract 1 from I.A.S.				
68	Compare I.A.S. with Register B				26
69	Multiply I.A.S. (decimal) by Register B (decimal) into Register B and Register C			X X X	See Table 2C
70					
71				I.A.S. Word	
72					21
73			Mill and Over-flow		
74	As functions 60-68, with Arithmetic in Sterling	I.A.S.			
75					
76				Result	25
77					
78					26
79	Multiply I.A.S. (Sterling) by Register B (decimal) into Register B and Register C			X X X	See Table 2C
80	Decade transfer to drum				
81	Decade transfer from drum				
82	Channel transfer to drum				See Table 2B
83	Channel transfer from drum	See Table 4			
84	Decade transfer to reserved store			X X X	
85	Decade transfer from reserved store				
86	Channel transfer to reserved store				
87	Channel transfer from reserved store				

```
Decade

        Average : 5.7 + 0.57n ms

        Maximum : 11.4 + 0.57n ms

        Where n = number of decades

        If change of drum or drum section:

        Average : 11.7 + 0.57n ms

        Maximum : 23.4 + 0.57n ms

Channel

        Average : 11.7 ms

        Maximum : 12.0 ms

        If different drum of drum section from last transfer:

        Average : 17.7 ms

        Maximum : 24 ms
```

Table 2B: DRUM TRANSFER TIMES

```
Minimum:   44(n + 1 + m) µs

Maximum:   44(6n + 2 + m) µs

Average:   22(7n + 3 + 2m) µs

Where n = number of digits in multiplier (excluding non-

significant zeros) and m = P - n if positive, and 0 otherwise;

where P is the number entered in the Decimal Point Register.
```
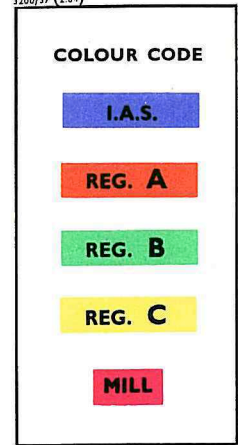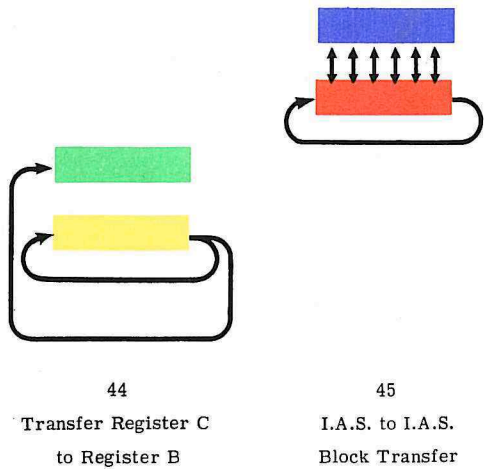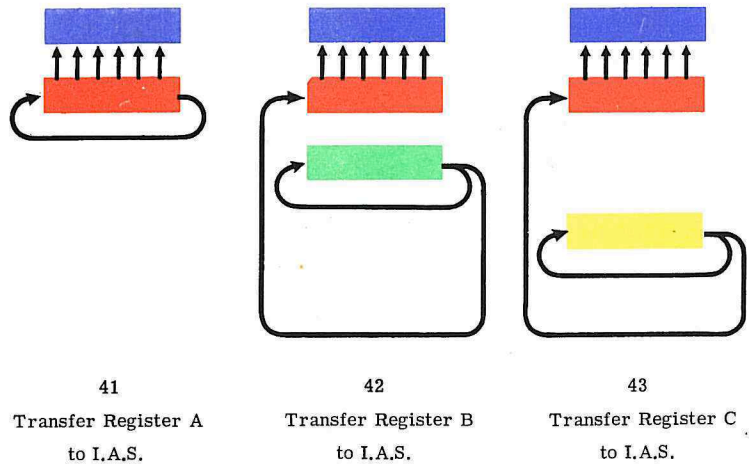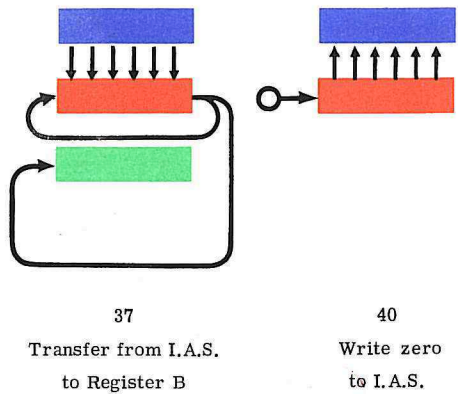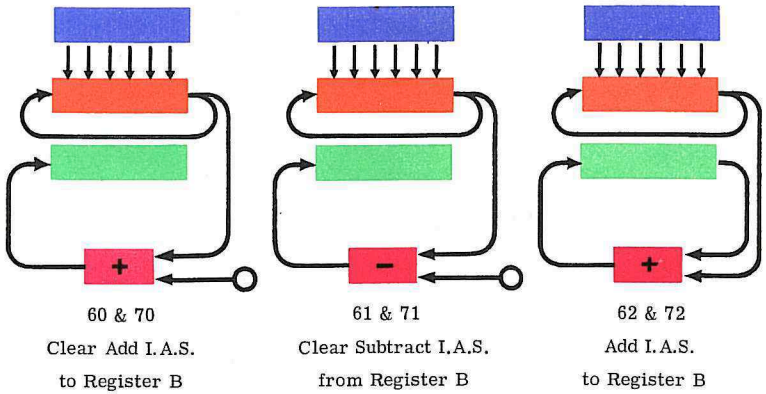
Table 2C: MULTIPLICATION TIMES

Table 3

1300-SERIES COMPUTER FUNCTION CHART

3200/37 (2.64)

COLOUR CODE

- **I.A.S.** (blue)
- **REG. A** (red)
- **REG. B** (green)
- **REG. C** (yellow)
- **MILL** (pink)

TRANSFER FUNCTIONS

37 — Transfer from I.A.S. to Register B

40 — Write zero to I.A.S.

41 — Transfer Register A to I.A.S.

42 — Transfer Register B to I.A.S.

43 — Transfer Register C to I.A.S.

44 — Transfer Register C to Register B

45 — I.A.S. to I.A.S. Block Transfer

ARITHMETIC FUNCTIONS

60 & 70 — Clear Add I.A.S. to Register B
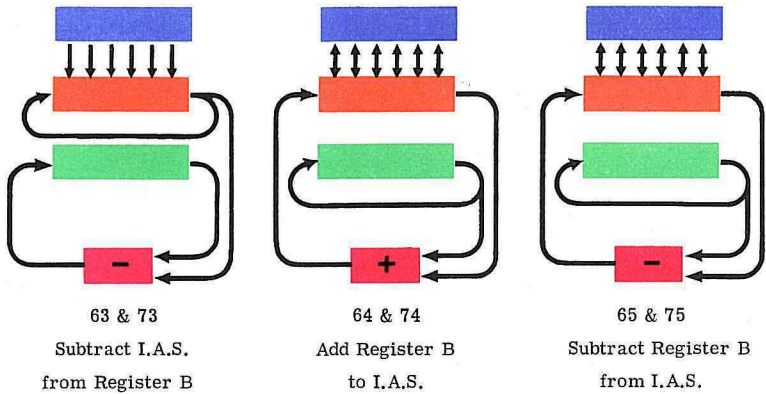
61 & 71 — Clear Subtract I.A.S. from Register B

62 & 72 — Add I.A.S. to Register B
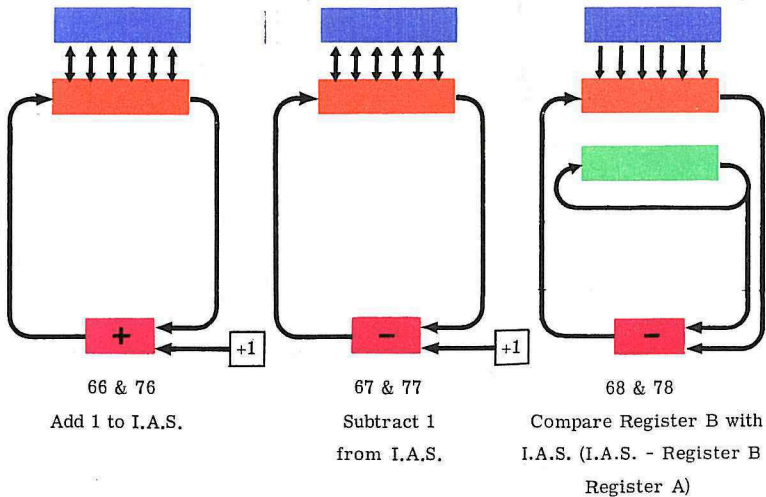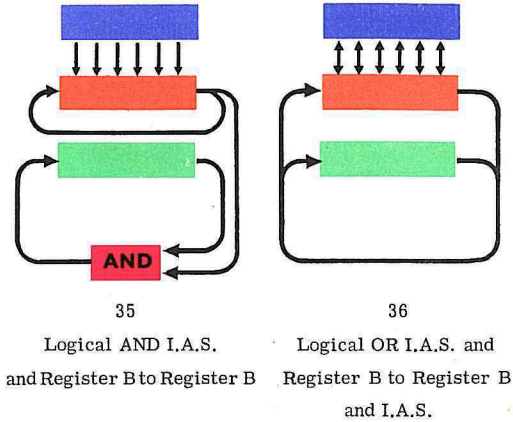
The sixty range of functions is for decimal operations and the seventy range is for sterling operations in conjunction with the setting of the Sterling Position Register.

63 & 73 — Subtract I.A.S. from Register B

64 & 74 — Add Register B to I.A.S.

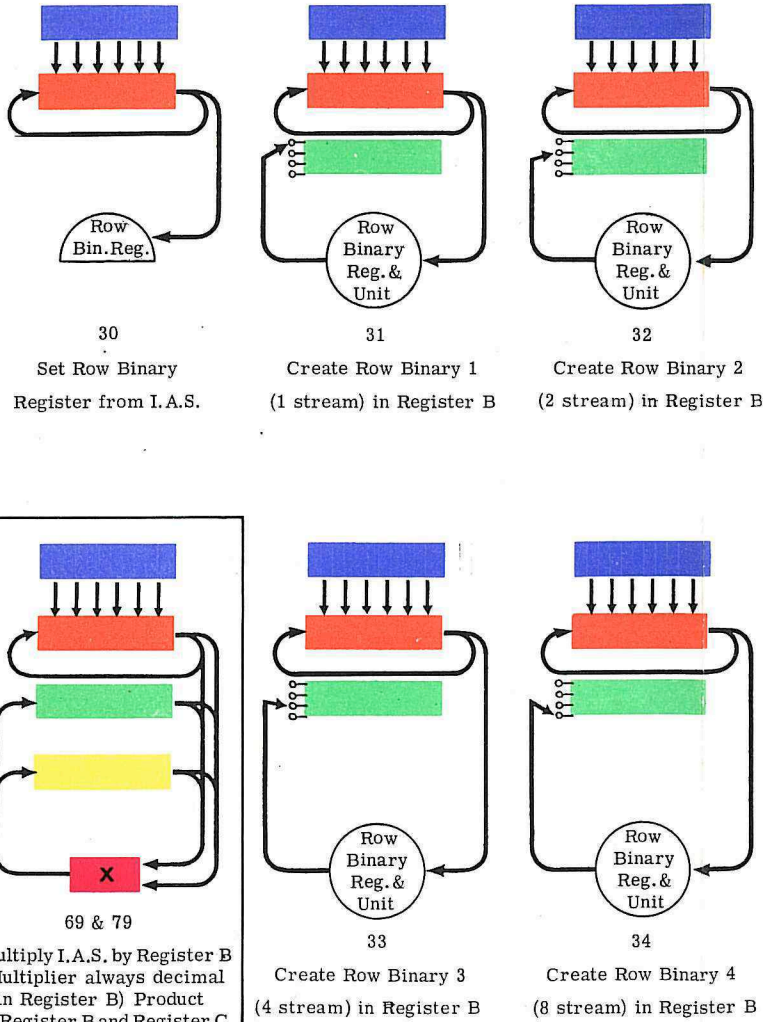**65 & 75** — Subtract Register B from I.A.S.

The appropriate sign indicator is set on all functions where figures pass through the Mill. Similarly the overflow indicator may be set by the same functions with the exception of the 35 Logical AND instruction.
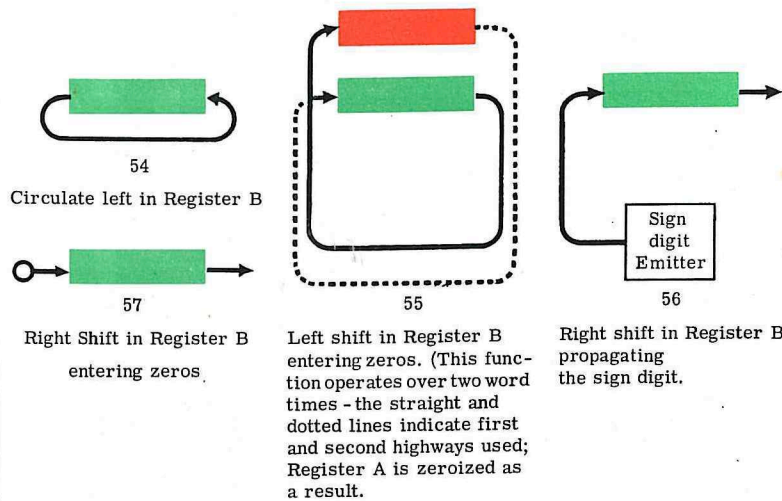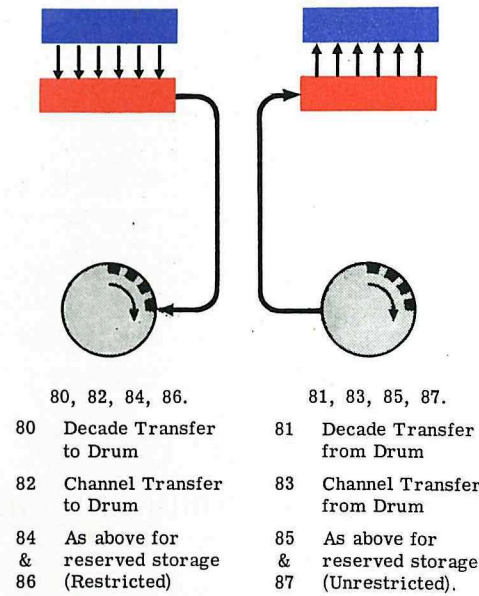
66 & 76 — Add 1 to I.A.S.

67 & 77 — Subtract 1 from I.A.S.

68 & 78 — Compare Register B with I.A.S. (I.A.S. - Register B = Register A)

69 & 79 — Multiply I.A.S. by Register B (Multiplier always decimal - in Register B) Product in Register B and Register C

LOGICAL FUNCTIONS

35 — Logical AND I.A.S. and Register B to Register B

36 — Logical OR I.A.S. and Register B to Register B and I.A.S.

ROW BINARY FUNCTIONS

30 — Set Row Binary Register from I.A.S.

31 — Create Row Binary 1 (1 stream) in Register B

32 — Create Row Binary 2 (2 stream) in Register B

33 — Create Row Binary 3 (4 stream) in Register B

34 — Create Row Binary 4 (8 stream) in Register B

SHIFT FUNCTIONS

54 — Circulate left in Register B

57 — Right Shift in Register B entering zeros

55 — Left shift in Register B entering zeros. (This function operates over two word times - the straight and dotted lines indicate first and second highways used; Register A is zeroized as a result.

56 — Right shift in Register B propagating the sign digit.

Sign digit Emitter

Left shifting is achieved in the 1300-series computers by right shifting

DRUM FUNCTIONS

80, 82, 84, 86.

80	Decade Transfer to Drum
82	Channel Transfer to Drum
84 & 86	As above for reserved storage (Restricted)

81, 83, 85, 87.

81	Decade Transfer from Drum
83	Channel Transfer from Drum
85 & 87	As above for reserved storage (Unrestricted).

OTHER FUNCTIONS

Function No.	Description
00	Do Nothing
11	Stop
21	Set Decimal Point Register
22	Set Sterling Position Register
38	Input Output Control
39	Magnetic Tape Control

Table 4

Peripheral and Magnetic Drum Instructions

F	A	F	A	DESCRIPTIONS	
45	First I.A.S. Address Source	N	First I.A.S. Address Destination	Transfer N words from source to destination Timing = 26N us	BLOCK TRANSFERS
80	First I.A.S. Address	N	First Drum Decade Address	Transfer N decades from I.A.S. to drum	MAGNETIC DRUM N = 1 to 20
81				Transfer N decades from drum to I.A.S.	
82		20		Transfer channel from I.A.S. to drum	
83				Transfer channel from drum to I.A.S.	
84	First I.A.S. Address	N	First Drum Decade Address	Transfer N decades from I.A.S. to reserved store *	MAGNETIC DRUM RESERVED STORAGE N = 1 to 20
85				Transfer N decades from reserved store to I.A.S.	
86		20		Transfer channel from I.A.S. to reserved store *	
87				Transfer channel from reserved store to I.A.S.	

*Available only under engineers' control

Table 4A: MAGNETIC DRUM AND BLOCK TRANSFER INSTRUCTIONS

F	A	DESCRIPTIONS	
38	0002	Call Card Feed	CARD READER
38	0007	Reject Card	
38	0013	Set Row Binary Register from Print Counter	LINE PRINTER (PRINT)
38	0014	Print Left-hand Bank	
38	0015	Print Centre Bank	
38	0016	Print Right-hand Bank	
38	0020	Lift all Sprags	LINE PRINTER (SPACE)
38	0021	Drop Sprag 1, lift all others	
38	0022	Drop Sprag 2, lift all others	
38	0023	Drop Sprag 3, lift all others	
38	0024	Drop Sprag 4, lift all others	
38	0025	Drop Sprag 5, lift all others	
38	0026	Drop Sprag 6, lift all others	
38	0042	Call Punch Feed	CARD PUNCH
38	0043	Punch Left-hand Bank	
38	0044	Punch Right-hand Bank	
38	0045	Check Read Left-hand Bank	
38	0046	Check Read Right-hand Bank	
38	0047	Off-set Card	
38	0050	Read One Code	PAPER-TAPE READER
38	0051	Select Reader No. 1	
38	0052	Select Reader No. 2	
38	0070	Select TYPE IN Mode	INTERROGATING TYPEWRITER
38	0071	Select TYPE OUT Mode	
38	0072	Type one character to or from Register B according to mode	
38	0076	Punch one code, check one code	PAPER-TAPE PUNCH

Table 4B: PERIPHERAL EQUIPMENT INSTRUCTIONS

F	A	F	A	DESCRIPTION	
39	001X	00	First I.A.S. Address	Write one Block	
39	002X			Read one block (read on Track A for $\frac{1}{4}$" tape)	
39	003X			Backspace one block	
39	004X		Single -length instructions	Cancel one block (one section on $\frac{1}{4}$" tape)	X = deck address 1 to 8
39	005X			Rewind to start of tape	
39	006X			Unload - tape completely rewound on spool	
39	007X	00	First I.A.S. Address	Read one block on track B ($\frac{1}{4}$" tape only)	

Table 4C: MAGNETIC-TAPE INSTRUCTIONS

Table 5

Summary of Indicators

TYPE	IND No.	SET BY	UNSET BY
	00	PERMANENTLY SET	
MILL	01	$= 0$	$\neq 0$
	02	Last Number through Mill > 0 – i.e. 4 in sign digit	Last Number through Mill $\not> 0$
	03	< 0 – i.e. 5 to 15 in sign digit	$\not< 0$
OVERFLOW	04	Sign digit $\neq 0$ or 9, or last number through mill = 900000000000	Program when tested
ERROR	06	I.A.S. Parity Error	Program when tested
	07	Drum Parity Error	
PROGRAM	10 to 19	Instruction (Designation 8)	Instruction (Designation 9)
MANUAL	20 to 29	MANUAL CONTROL ON CONSOLE	

Table 5A: CENTRAL PROCESSOR INDICATORS

TYPE	IND No.	SET BY	UNSET BY
CARD READER	35	Card Reader Ready	Instruction 380002 and Card Reader Interlock
	36	6 Columns Read	Program when tested or automatically if not tested
	37	6 Columns Missed	Program when tested
	38	Mischeck	or between card cycles
LINE PRINTER	42	Printer Ready	Printer Interlock
	43	Print Index Point Time	Program when tested or automatically if not tested
	44	Print Character Time	Program when tested
	45	Line Space Time	Program when tested or automatically if not tested
	47	Paper Trolley Empty	New supply of paper inserted
	49	Print Counter Error	Program when tested
INTERR- OGATING TYPE- WRITER	50	Paper Supply Low	New supply of paper inserted
	51	Typewriter Ready	Instruction to Type In or Out given
	52	Request Type-in	Program test
	53	Carriage at End	Carriage leaving left-hand stop
	59	Typewriter Mechanical Failure	Program test
CARD PUNCH	54	Punch Ready	Punch Interlock & Instruction 380042
	55	Punch Index Point Time	Program when tested or automatically if not tested
	56	Check Index Point Time	Program when tested or automatically if not tested
	57	Punch Index Point Time missed	Program when tested
	58	Check Index Point Time missed	
PAPER -TAPE READER	60	Tape Reader Ready	Automatically if Reader not ready
	61	Parity Error	Program test
PAPER -TAPE PUNCH	65	Tape Supply Low	More than 20 feet of tape on spool
	66	Tape Punch Ready	automatically if Punch not ready
	67	Tape Punch Error	Program test

Table 5B: PERIPHERAL EQUIPMENT INDICATORS

INDICATOR No.		TITLE	SET BY	UNSET BY
70		Write Unit Ready	Write Unit not busy	Write or Cancel Instruction
71		Write Master	W74, W76, W77 becoming set	Unsetting of all three Indicators
72		Read Unit Ready	Read unit not busy	Read or Backspace Instruction
73		Read Master	R75, R76, R77 becoming set	Unsetting of all three Indicators
74	W74	Write Any Errors	Any Bit Errors Written	Write or Cancel Instruction
	R74	Read Any Errors	Any Bit Errors Read	Read Instruction
75	W75	Write Multiple Errors	Multiple Bit Errors Written	Write or Cancel Instruction
	R75	Read Multiple Errors	Multiple Bit Errors Read	Read Instruction
76	W76	Write Final End of Tape	Final End of Tape Marker	Program Test
	R76	Read Final End of Tape	Final End of Tape Marker	Program Test
77	W77	Write Early End of Tape	Early End of Tape Marker	Program Test
	R77	Read Short Block	Short Block Read	Program Test
79		Writing Ring Present	Writing Ring present on spool, Tape Unit mechanically ready and Address seized, for the last Deck tested	Writing ring not present on spool or Tape Unit not mechanically ready or address not seized, for last deck tested
80		Tape Order Error	Unacceptable Instruction	Program Test
81 to 88		Deck Address (1 to 8)	Address seized and Tape Unit mechanically ready and not busy	Address not seized or tape unit busy or not mechanically ready
89		Transport mechanically ready and address seized	Tape unit mechanically ready and address seized	Tape unit not mechanically ready or address not seized.

NOTE: R stands for Read, W for Write

Table 5C: ONE-INCH (90kc/s) AND HALF-INCH ($22\frac{1}{2}$kc/s) MAGNETIC-TAPE INDICATORS

INDICATOR No.	TITLE	SET BY	UNSET BY
70	Write Unit Ready	Write Unit not busy	Write or Cancel Instruction
71	Write Master	Indicator 74 or 76 becoming set	Unsetting of both Indicators 74 and 76
72	Read Unit Ready	Read Unit not busy	Read or Back Space Instruction
73	Read Master	Indicators 75 or 77 becoming set	Unsetting of both Indicators 75 and 77
74	Write Errors	Any Errors during Writing	Write or Cancel Instruction
75	Read Errors	Any Errors during Reading	Read Instruction
76	End of Tape	End of Tape Marker During Writing	Program Test
77	Short Block	Short Block Read	Program Test
79	Writing Ring Present	Writing Ring present on spool, Tape Unit mechanically ready and Address seized, for the last Deck tested	Writing ring not present on spool or Tape Unit not mechanically ready or address not seized, for last deck tested
80	Tape Order Error	Unacceptable Instruction	Program Test
81 to 88	Deck Address (1 to 8)	Address seized and Tape Unit mechanically ready and not busy	Address not seized or tape unit busy or not mechanically ready
89	Transport mechanically ready and address seized	Tape unit mechanically ready and address seized	Tape unit not mechanically ready or address not seized.

Table 5D: QUARTER-INCH (16kc/s) MAGNETIC-TAPE INDICATORS

Card Punching	Numeric No Overpunch	Numeric + 10 Overpunch	Numeric + 11 Overpunch	Numeric + 0 Overpunch	Numeric + 1 Overpunch
10	10				
11	11				
0	0				
1	1	A	J	&	
2	2	B	K	S	%
3	3	C	L	T	$\frac{1}{4}$
4	4	D	M	U	-
5	5	E	N	V	/
6	6	F	O	W	$\frac{1}{2}$
7	7	G	P	X	.
8	8	H	Q	Y	@
9	9	I	R	Z	$\frac{3}{4}$
Computer Coded Zone Component	1	2	3	4	5

Table 7

Code for Line Printer

Numeric Component	Zone Component 1	Zone Component 2	Zone Component 3	Zone Component 4	Zone Component 5
0	0	11	10	*	£
1	1	A	J	&	$
2	2	B	K	S	%
3	3	C	L	T	$\frac{1}{4}$
4	4	D	M	U	-
5	5	E	N	V	/
6	6	F	O	W	$\frac{1}{2}$
7	7	G	P	X	.
8	8	H	Q	Y	@
9	9	I	R	Z	$\frac{3}{4}$

Table 8

Recommended Paper - tape Codes

This is the basic code having six data bits with no parity bit.
The main use of this code is as the foundation on which the other codes are based.

Numeric Component	Zone			
	0	1	2	3
0	Space	0		P
1		1	A	Q
2	New Line	2	B	R
3	Paper Throw	3	C	S
4	Tabulate	4	D	T
5	Backspace	5	E	U
6	Shift Out	6	F	V
7	Shift in and run out	7	G	W
8	(	8	H	X
9	)	9	I	Y
10		10	J	Z
11	£	11	K	
12			L	
13	&	+	M	
14	*	−	N	Escape ◊
15	/	.	O	Erase

REPRESENTATION WITHIN THE COMPUTER

Numeric Component	Track No.			
	4	3	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

The Zone is registered in tracks 6 and 5 thus:

Zone	Track No.	
	6	5
0	0	0
1	0	1
2	1	0
3	1	1

REPRESENTATION ON PAPER TAPE

Table 8A: RECOMMENDED PAPER-TAPE 6-TRACK CODE

The only difference from the 6-track Code is the provision for an
ODD parity bit in track 5 and the positioning of the zone punching in tracks 6 and 7.

Numeric Component	Zone			
	0	1	2	3
0	Space	0		P
1		1	A	Q
2	New Line	2	B	R
3	Paper Throw	3	C	S
4	Tabulate	4	D	T
5	Backspace	5	E	U
6	Shift Out	6	F	V
7	Shift in & Run out	7	G	W
8	(	8	H	X
9	)	9	I	Y
10		10	J	Z
11	£	11	K	
12			L	
13	&	+	M	
14	÷	—	N	Escape ◊
15	/	.	O	Erase

REPRESENTATION WITHIN THE COMPUTER

Numeric Component	Track No.			
	4	3	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

The Zone is registered in tracks 6 and 7 thus:

Zone	Track No.	
	7	6
0	0	0
1	0	1
2	1	0
3	1	1

REPRESENTATION ON PAPER TAPE

Table 8B: RECOMMENDED PAPER-TAPE 7-TRACK CODE

This code is an extended version of the 6-track code. It has the same six data bits
with the addition of even parity and an an eighth track, used in this specification to obtain a shift into lower case.

Numeric Component	Zone 0	1	2	3	4	5	6	7
0	Blank Tape	0		P	Space	0		p
1		1	A	Q		1	a	q
2	New Line	2	B	R		2	b	r
3	Paper Throw	3	C	S		3	c	s
4	Tabulate	4	D	T		4	d	t
5	Backspace	5	E	U		5	e	u
6	Shift Out	6	F	V	Shift Out	6	f	v
7	Shift In and Run Out	7	G	W	Shift In and Run Out	7	g	w
8	(	8	H	X		8	h	x
9	)	9	I	Y		9	i	y
10		10	J	Z			j	z
11	£	11	K				k	
12			L				l	
13	&	+	M				m	
14	*	-	N	Escape ◇			n	
15	/	.	O				o	Erase

REPRESENTATION WITHIN THE COMPUTER

Numeric Component	Track No. 4	3	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

The Zone is registered in tracks 6, 7 & 8 thus:

Zone	Track No. 8	7	6
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

REPRESENTATION ON PAPER TAPE

Table 8C: RECOMMENDED PAPER-TAPE 8-TRACK CODE

Table 9

NUMERIC COMPONENT	ZONE							
	0	1	2	3	4	5	6	7
0	Space	0			*	£	,	¢
1	Do nothing	1	A	J	&	$	=	×
2	Tabulate	2	B	K	S	%	<	÷
3	Set Tab	3	C	L	T	$\frac{1}{4}$	>	?
4	Clear Tab	4	D	M	U	-	+	≠
5	Carriage Return/ Line Feed	5	E	N	V	/	↑	□
6		6	F	O	W	$\frac{1}{2}$	(	:
7		7	G	P	X	.	)	;
8		8	H	Q	Y	@	"	!
9		9	I	R	Z	$\frac{3}{4}$	↓	◊
10		10						
11		11						
12		12						
13		13						
14		14						
15		15						

Table 10

Peripheral Equipment Timings

OPERATION	TIME FOR OPERATION	
Card Reading Rate	600 cards a minute Reader (Minimum times)	300 cards a minute Reader (Minimum times)
Complete Card Cycle	100 ms	200 ms
Time after 14th 6 Columns Read in which a Call Card instruction may be given to maintain continuous running of the reader	2.44 ms	7.3 ms
Time between calling a card and the first 6 Columns Read if the card reader has been unlatched. Register C comes into use for card reading before the first 6 Columns Read. Therefore if multiplication is taking place this should be reduced to:	36.1 ms 32.4 ms	70.4 ms 60.75 ms
Time between 14th 6 Columns Read and 1st 6 Columns Read of next card during continuous running. If multiplication is taking place this should be reduced to:	40 ms 35.4 ms	80 ms 70.8 ms
Interval between successive 6 Columns Read. Multiplication cannot be carried out during this time.	3.18 ms	6.36 ms
Time after 14th 6 Columns Read during which a Reject Card instruction can be given.	25.4 ms	50.8 ms
Time after which 6 Columns Read indicator (36) is automatically unset if not previously unset by program.	538 μs	1076 μs

Table 10A: CARD READER TIMINGS

OPERATION	MINIMUM TIME OF OPERATION
Card Punching rate	100 cards a minute
Card Cycle	600 ms
Calling Punch from rest, with motor running, to 1st Punch Index Point Time on.	35.83 ms
Index Point Interval	40.7 ms
Punch Index Point Time indicator (55) duration	6.52 ms
Check Index Point Time indicator (56) duration	14.66 ms
Interval between last setting of indicator 56 to last time to give 380042 instruction for continuous running.	58.22 ms
Interval between last setting of indicator 56 and 1st setting of indicator 55 when feeding continuously	102.2 ms
Time between last setting of indicator 56 and last time to give 380047 instruction	41.94 ms

Table 10B: CARD PUNCH TIMINGS

OPERATION	TIME OF OPERATION	
	600 l.p.m. PRINTER (Minimum times)	300 l.p.m. PRINTER (Minimum times)
Character time interval	1.2 ms	2.6 ms
Line space indication interval at speed	6.9 ms	6.9 ms
Duration of Line Space Time indicator (45) being set if not tested	3.1 ms	3.1 ms
Duration of Print Index Point Time indicator (43) being set if not tested	550 to 800 µs	1150 to 1700 µs
Time to space first line	32 ms	32 ms
Time to space subsequent lines	7.56 ms	7.56 ms

Table 10C: LINE PRINTER TIMINGS

OPERATION	TIME OF OPERATION
Reading Speed	1,000 characters a second
Character Read Interval	1 ms
Time to transfer character to buffer after sensing leading edge of hole	22 µs
Time in which buffer must be unloaded to maintain continuous running	978 ± 50 µs

Table 10D: PAPER-TAPE READER TIMINGS

OPERATION	TIME OF OPERATION
Punching Speed	300 characters a second
Character Time Interval	3.33 ms

Table 10E: PAPER-TAPE PUNCH TIMINGS

OPERATION	TIME OF OPERATION
Printing Speed	10 characters a second

Table 10F: INTERROGATING TYPEWRITER TIMINGS

Table II

Timings and Statistics for One-inch (90kc/s) and Half-inch ($22\frac{1}{2}$kc/s) Magnetic-tape Systems

OPERATION	ONE-INCH	HALF-INCH
Time for a queued tape unit to come under computer control.	800 milliseconds after the unload instruction has been accepted	800 milliseconds after the unload instruction has been accepted
Fixed Delay Period on reading or writing	0.48 ms	2.04 ms
Delay before writing first block	2 seconds	2 seconds
Rewinding or unloading speed	Two speeds available, choice depending on engineers adjustment. (a) 150 inches a second. (b) 300 inches a second, subject to last 600 feet (approx.) of tape being rewound at 150 inches a second; previous 2,400 feet (approx.) or remainder of tape if less than 3,000 feet, is rewound at the full speed of 300 inches a second; remainder up to 600 feet, is rewound at 150 inches a second.	The rewinding speed is not constant but increases as the length of tape on the loading spool decreases. The time to rewind half a reel is therefore more than half the complete rewind time.
Time to rewind a 3,600 foot reel.	At 150 inches a second, 4 minutes 48 seconds At 300 inches a second, 3 minutes 12 seconds	Under 4 minutes
Length of long gap.	1.35 inches	1.24 inches
Length of short gap.	1.12 inches	1.0 inches
Time to create long gap on writing	11.2 ms	18.8 ms
Time to create short gap on writing	7.5 ms	13.4 ms
Time to traverse long gap on reading- with stop/start	11.2 ms	18.8 ms
Time to traverse long gap on reading- without stop/start	9.0 ms	16.6 ms
Time to traverse short gap on reading- with stop/start	9.7 ms	15.6 ms
Time to traverse short gap on reading- without stop/start	7.5 ms	13.4 ms
Time for a word to be transferred from Register G to I.A.S. during reading	15 μs	15 μs
Time for a word to be transferred from I.A.S. to Register F during writing	15 μs	15 μs
Minimum distance between final end of tape marker and actual end of tape	15 inches	15 inches
Minimum distance between early end of tape marker and final end of tape marker	15 feet	15 feet

Table 12

Timings and Statistics for Quarter - inch (16kc/s) Magnetic - tape Systems

Maximum length of tape on spool	1, 800 feet
Minimum distance between end of tape marker and actual end of tape	25 feet
Distance between beginning of tape and beginning of tape marker	7 to 10 feet
Tape Speed	$37\frac{1}{2}$ inches a second
Delay before writing first block	5 seconds
Rewind time for a complete reel	under 3 minutes
Packing density - assuming random distribution of digits	440 digits an inch
Packing density - assuming 25% of digits are zero - otherwise random distribution	480 digits an inch
Digit rate - assuming random distribution	16, 500 digits a second
Digit rate - assuming 25% of digits zero otherwise random distribution	18, 000 digits a second
Digit rate for all zeros	32, 000 digits a second
Digit rate for all fifteens	8, 000 digits a second
Average time for one word to pass the read/write heads - assuming random distribution	727 µs
Length of inter-block gap	approximately 0.8 inches
Time to traverse inter-block gap on writing, and write block start marker - excluding time when tape is awaiting an instruction	20 to 25 ms
Time to traverse inter-block gap and block start marker on reading - excluding time when tape is awaiting an instruction	20 to 25 ms
Break-in time when transferring a word to or from I.A.S.	16 µs

Table 13

Program Flowchart Symbols
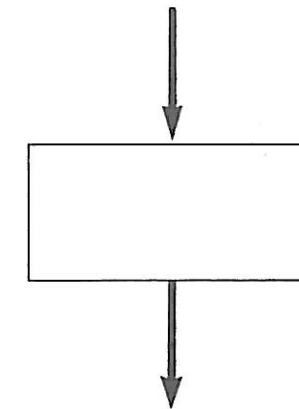
Normal Arithmetic or Transfer Process
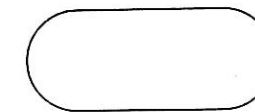
Decision or Test
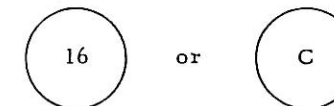
16   or   C   Fixed or Variable Connector (Switch)
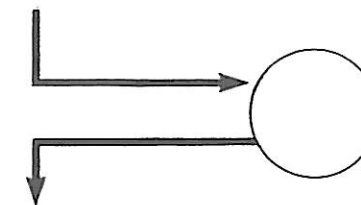
Exit to and return from Subroutine
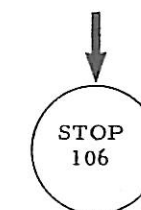
STOP
106   Stop (or Start) point

Table 14

Systems Flowchart Symbols
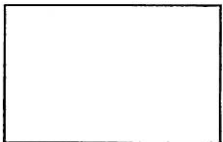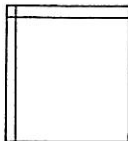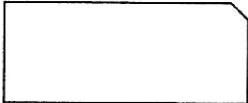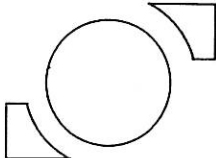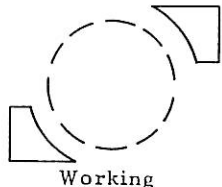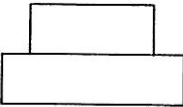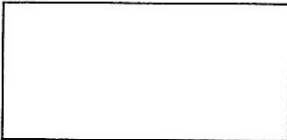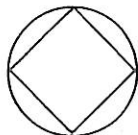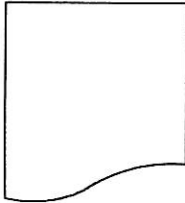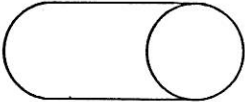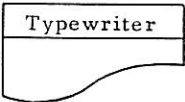
COMPUTER EQUIPMENT

Description	I.C.T. Symbol	Description	I.C.T. Symbol
Source Document		Core Store	
Punched Card		Magnetic Tape	
Paper Tape			Working
Typewriter Input		General Operational Symbol	
Computer		Printed Output	
Magnetic Drum		Typewriter Output	Typewriter
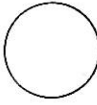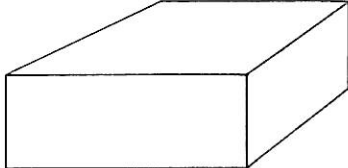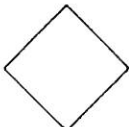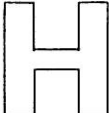
NON-COMPUTER EQUIPMENT

Description	I.C.T. Symbol	Description	I.C.T. Symbol
Punch and Verify		Sort	
File of Punched Cards		Tabulator	
		Calculator	
Interpret, Match, Collate, Interpolate or Reproduce		Manual Operations	

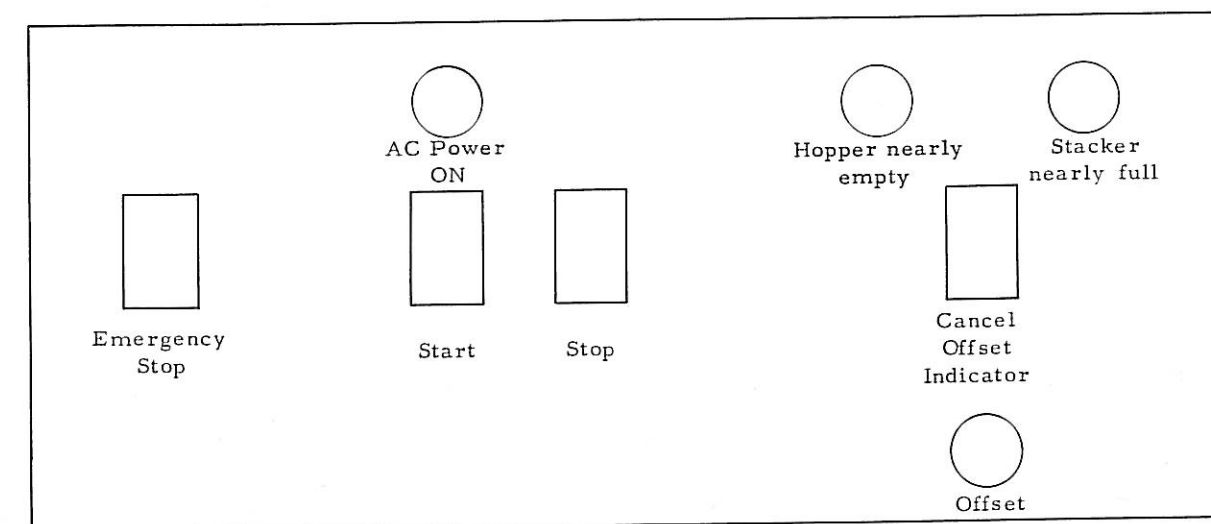Table 15

Operator's and Programmer's Display and Switch Panels

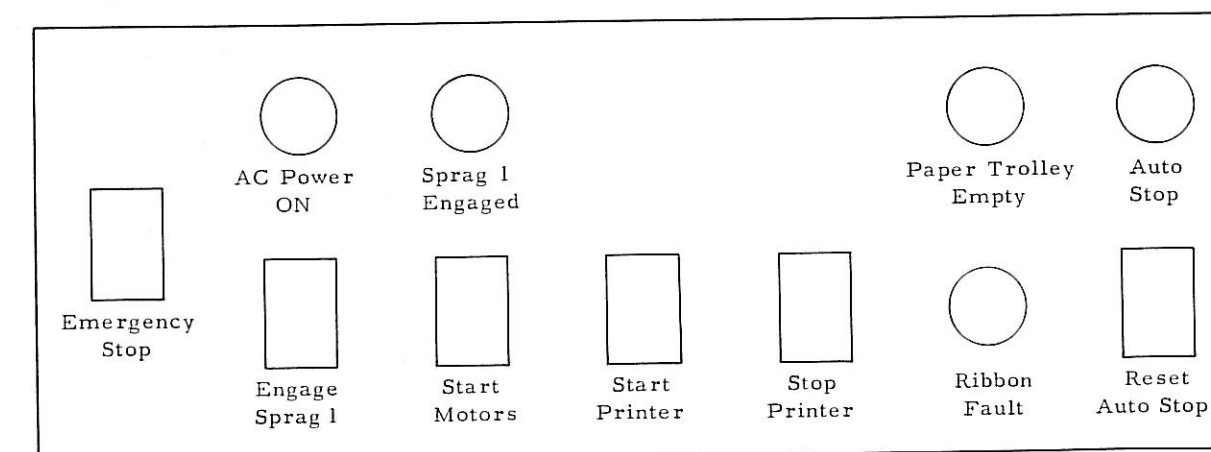Set | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12

A   B   G

——————————— ARITHMETIC REGISTER ———————————

Set | 1 | 2 | 3 | 4 | 5 | 6

| 20 | 21 | 22 | 23 | 24 |

| 25 | 26 | 27 | 28 | 29 |

1   2   3

———————— CONTROL REGISTER ————————   PROGRAMMED INDICATORS   ——————— MANUAL INDICATORS ———————

Computer   1   5

On   Reader   Auto
                                  Micro · · Manual Initial Orders

                2   6
                                  AUTO MANUAL
                     Attention

Printer   3   7   COMPUTER STOPPED

Off   Start

Punch   4   8

—— READY INDICATORS ——

TAPE ADDRESS

COMPULSORY   OPTIONAL

◄ Slip Pulse   I.A.S. ►
◄ Drum count   Drum ►   Stop
◄ I.A.S. ► CR   Tape ►
◄ CR1/3   Transfer error   Engineers   Inhibit
                                                 control   CR Shift   Gain

                                                          Off   Monitor

◄ Mains failure Tape ►
◄ DC failure   Stop   Limit   On   Alarm
                           Order Error   temperature
                                                         LAMP TEST

——————— COMPUTER STOPPED INDICATORS ———————

Table 15A: COMPUTER CONSOLE
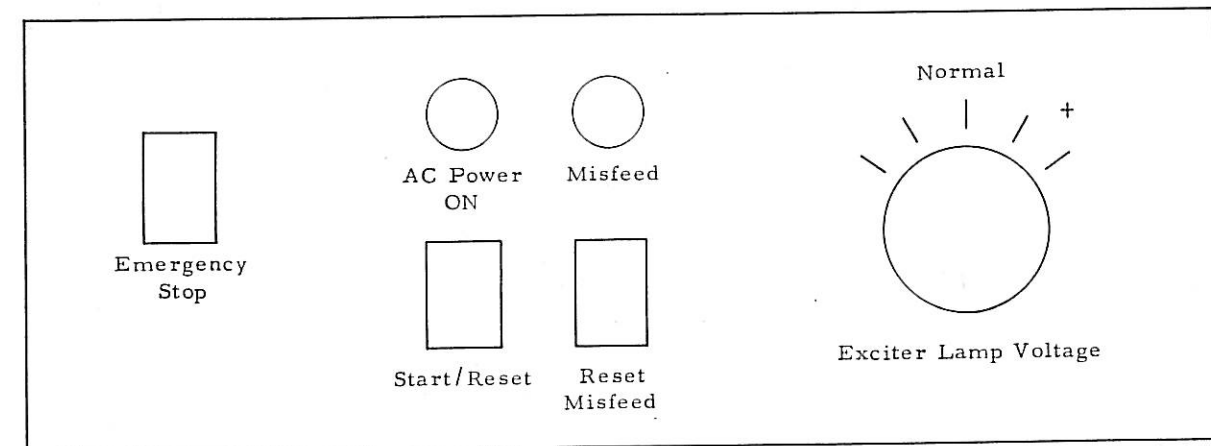
(i) CARD READER

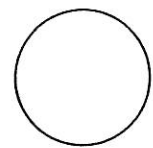(ii) CARD PUNCH

(iii) LINE PRINTER

Table 15B: PERIPHERAL EQUIPMENT

Address allocated in this space.

1

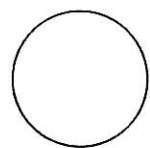| Allocate | Unload | Brake Release | Fault Reset | Secure |

Reverse — Auto — Forward
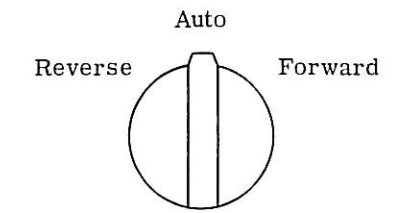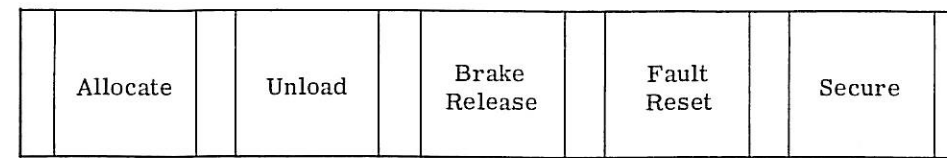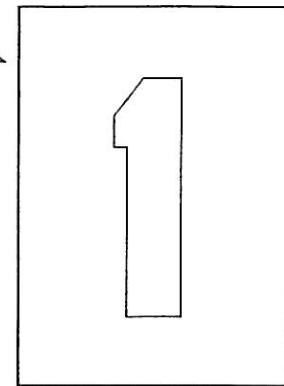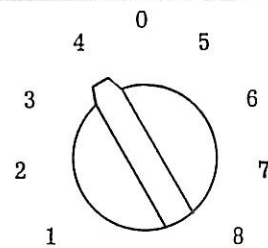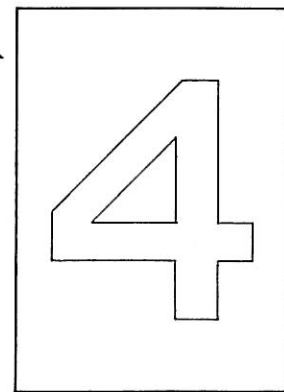
(i)   QUARTER-INCH (16kc/s) MAGNETIC-TAPE UNIT

Address allocated in this space.

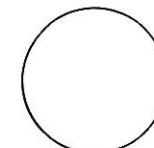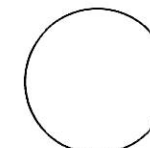AC Power ON   Transport ON
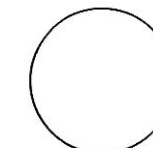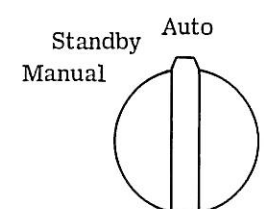
4

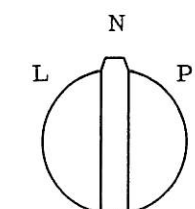Emergency Stop   Start

Selector (0 1 2 3 4 5 6 7 8)

Secure   Overload   Lockout

Allocate   Unload   Reset

Marginal Test (L N P)

Auto/Manual (Standby Auto Manual)

Leader Drive

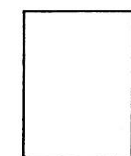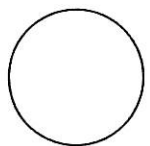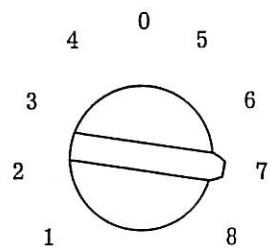Selector (Forward Stop Reverse)
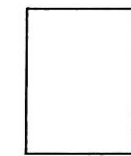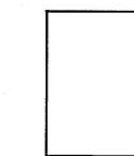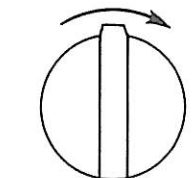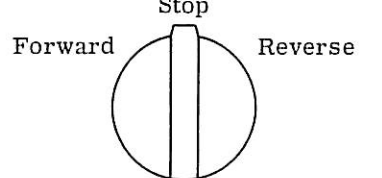
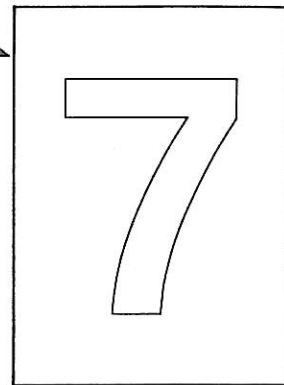(ii)   HALF-INCH (22½kc/s) MAGNETIC-TAPE UNIT

Address allocated in this space.

Emergency Stop   AC Power ON
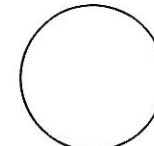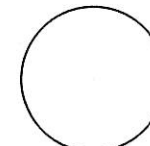
7

Start

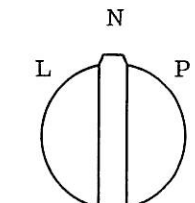Selector (0 1 2 3 4 5 6 7 8)
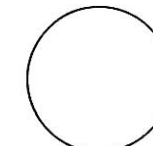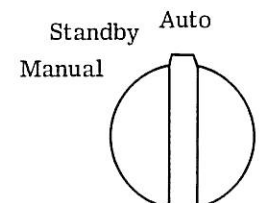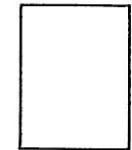
Secure   Overload   Lockout

Allocate   Unload   Loop   Reset

Marginal Test (L N P)

Auto/Manual (Standby Auto Manual)

Leader Drive

Selector (Forward Stop Reverse)
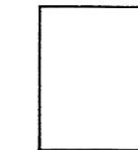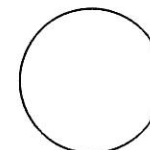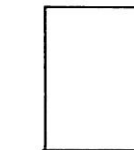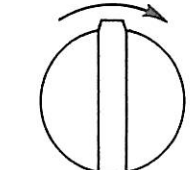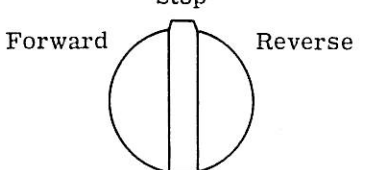
(iii)   ONE-INCH (90kc/s) MAGNETIC-TAPE UNIT

Table 15C: MAGNETIC-TAPE UNITS

Access Time

The time elapsing between giving an instruction which operates on data held in store (e.g. I.A.S. or magnetic drum) and the instant when the data are so positioned that the operation can commence.

Address

The name or number identifying a location either in a store (e.g. I.A.S.) or in some other part of the computing system (e.g. a tape deck).

Absolute Address   The number identifying a *specific* location in a store.

Relative Address   A number identifying a location which is relative to another address, and is therefore, not a specific storage location.

Assembler (Assembly System)

A program which converts autocode instructions into a machine-coded program.

Autocode

A programming language intended to simplify programming by the use of macro-instructions (q.v.) written in an elementary programming code.

Binary Coded Decimal (B.C.D.)

A system of binary notation in which the decimal digits 0 to 15 are represented by four bits which have values of 1, 2, 4 and 8 respectively.

Binary Notation

A system of positional notation in which the digits are coefficients of powers of a base of two.

Bit (Binary Digit)

A digit (0 or 1) in binary notation.

Block

A group of consecutive data or program words considered or transferred as a whole.

Block Relativizer

The relativizer used for the I.A.S. and drum settings given in the block relativizer control words. As each block is read by Initial Orders the block relativizer setting is used to convert addresses specifying relativizer 'B' to absolute form.

Buffer

A storage device (either a special register or an area of I.A.S.) used to compensate for the difference in rates of flow of information or in times of occurrence of events when transferring information from one device to another, as from input unit to I.A.S. or I.A.S. to output unit.

Channel

A recording band on the magnetic drum comprising 200 locations.

Compiler

A program which has the characteristics of an assembler (i.e. converting autocode instruction to machine-coded instructions) but is more comprehensive. It usually produces several machine-coded instructions from one autocode instruction and assembles a complete program by allocation of storage etc.

Decade

The smallest unit of transfer from the magnetic drum; it comprises 10 consecutive storage locations on one channel i.e. there are 20 decades per drum channel.

E - Card

A card bearing the designation E which is the last program card in a pack. An 'entry word' punched in the E-card effects an entry to the program under Initial Orders (q.v.).

E - Word

The 'entry word' which is punched in a program pack after the last program word and which effects an entry under Initial Orders. It is usual to punch the E-word on a separate card, the E-Card.

End of Block Marker

A marker to indicate the end of a data or program block.

Applied to magnetic tape   A word after the last data word which contains 15 in every digit position.

Applied to program cards   A punching with a non-zero numeric component in column 17 of the last card of the block.

Frame

A cross-section of one-inch or half-inch magnetic tape which consists of one bit position for each tape track. According to the number of tape tracks, a frame may be used to record one or more characters.

Hardware

A term for the computer and the mechanical, magnetic, electronic and electrical devices from which it is made. A colloquial term for apparatus as opposed to program.

Housekeeping

Programs or instructions which are included for organizational purposes and do not actually perform calculations. The term is particularly applied to magnetic tape organization.

Initial Orders

An input routine permanently stored on the reserved channels of the magnetic drum which enables programs to be read into the computer and stored on the drum.

Key

(a) A group of characters usually representing an item which is used to identify a record, or

(b) A parameter (q.v.).

Link

An instruction which returns control from a subroutine to the main program. The link is stored by the subroutine in a word allocated for the purpose.

Loop

A group of instructions which may be obeyed more than once. A loop will normally be conditional upon the testing of an indicator. Depending on the state of an indicator (set or unset) a number of instructions will be repeated and the indicator tested again. The loop will continue until the state of the indicator is changed.

Macro - instruction

Usually used in autocode programs where one program instruction, a macro-instruction, corresponds to several machine-coded instructions.

Mask

A constant used with a Logical AND instruction to extract information from part of a word.

Microsecond

One millionth of a second (μs).

Millisecond

One thousandth of a second (ms).

Object Program

A complete program in machine code produced by the action of a compiler or assembly system upon a source program (q.v.).

Off - line

A data processing machine which operates when not directly linked (electronically or mechanically) to the computer is said to be used off-line.

On - line

A data processing machine which operates when directly linked to a computer (e.g. for input /output purposes) is said to be used on-line.

Packing Density

The number of digits that can be accommodated on a given amount of storage.   The term is especially applied to magnetic tape.

Parameter

Information or requirements supplied to a subroutine by the main program, the format and address for the information being set down in the subroutine specification.

Parity Bit

A bit which is automatically generated and appended to an array of bits (usually representing a character) to make the sum of the number of 1-bits in the array either odd or even, as nominated. The parity bit is included for checking purposes only.

P.P.F. (Print Punch Feed)

A utility program allowing input/output units to operate in parallel with maximum time-sharing under a control routine.

Relativizers

A number which can be set to give an I.A.S. and drum setting for the appropriate R.R.N.   The relativizer settings are used by Initial Orders to convert relative addresses to absolute addresses.

Queueing

If, on one-inch (90 kc/s) or half-inch ($22\frac{1}{2}$ kc/s) magnetic-tape systems, a tape deck is allocated an address and that address has been previously seized by another tape deck, then the second tape deck to be allocated the address is said to be 'queued'. The queued tape deck will seize the address when that address becomes available.

R.R.N. (Relativizer Reference Number)

A reference number which is associated with a block of program or data enabling the words in the block to be addressed in relative form.

Search Code

A code is held in I.A.S. which is compared with codes which are input from a paper-tape reader or punch, interrogating typewriter etc., a successful comparison indicating that a specific code has been read on input.

Software

An antonym of 'Hardware' (q.v.).   A colloquial term for programs available (e.g. subroutines and autocode programs) as opposed to facilities provided by the apparatus of the computer.

Source Program

A program written in an autocode programming language which will be converted to machine code by a compiler or assembly system (q.v.).

Subroutine

A self-contained section of program which can be incorporated into a complete program.

Time - sharing

A method of programming used to reduce the running time on the computer. When an instruction has been initiated and the execution of that instruction is time consuming but does not involve Register A or Register B (e.g. an instruction governing a peripheral unit) control can be transferred to another section of program so that the two operations are carried out simultaneously.

Track

A longitudinal section of magnetic or paper tape which consists of a series of recording positions. A cross-section of the tape consists of one recording position for each track and may be used to represent one or more characters.

Writing Ring

A safety device used on magnetic-tape spools to prevent the overwriting of 'Master' information.