IBM

Reference Summary

IBM 1620 Data Processing System

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The information contained in this summary is intended as an aid for the more experienced programmer and operator. It is condensed from the *IBM Reference Manual, 1620 Data Processing System* (Form A26-4500). Reference to that manual should be made when more complete information is required.

Address comments regarding this publication to:
IBM, Product Publications Dept., San Jose, Calif.

Contents

* Throughout this summary, an asterisk is used to indicate a special feature.

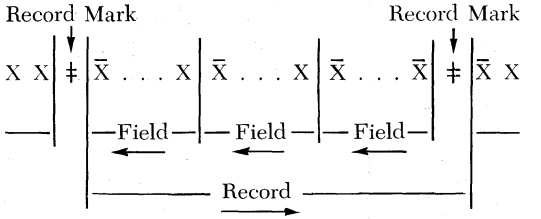
BCD Bit Array

Check Bit	Flag Bit	Numerical Bits			
C	F	8	4	2	1

Bit Configuration of Decimal Digits

Digit	Bit Configuration					
	C	F	8	4	2	1
0	1	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	1	0	0	0	1	1
4	0	0	0	1	0	0
5	1	0	0	1	0	1
6	1	0	0	1	1	0
7	0	0	0	1	1	1
8	0	0	1	0	0	0
9	1	0	1	0	0	1

Data Field and Record Definition



Arrows Indicate Direction of Processing

Character Coding

Alphameric Character	Input			Core Storage	
	Type-writer	Tape	Card	Alpha	Num
(Blank)	(Space)	C	(Blank)	C	C
. (Period)	.	X0821	12, 3, 8	C	3
)	)	X0C84	12, 4, 8	C	4
+	+	X0C	12	1	C
$	$	XC821	11, 3, 8	1	3
*	*	X84	11, 8, 4	1	4
-(Hyphen)	-	X	11	2	C
/	/	0C1	0, 1	2	1
, (Comma)	,	0C821	0, 3, 8	2	3
(	(	084	0, 4, 8	2	4
=	=	821	3, 8	3	3
@	@	C84	4, 8	3	4
A-I	A-I	X0, 1-9	12, 1-9	4	1-9
0 (−)	(None)	(None)	11, 0	5	C
J-R	J-R	X, 1-9	11, 1-9	5	1-9
1-9 (−)	J-R	X, 1-9	11, 1-9	5	1-9
S-Z	S-Z	0, 2-9	0, 2-9	6	2-9
0 (+)	0	0	0 or 12, 0	7	C
1-9 (+)	1-9	1-9	1-9	7	1-9
‡	‡	082	0, 2, 8	C	C28
Numerical Character					
(Blank)	(Space)	C	(Blank)		C
0 (+)	0	0	0		C
0 (−)	$\bar{0}$	X, X0C	11, 0		F
1-9 (+)	1-9	1-9	1-9		1-9
1-9(−)	$\bar{1}$-$\bar{9}$	X, 1-9	11, 1-9		1-9
‡	‡	082	0, 2, 8		C82
Num Blank †	@	C84	4, 8		C84

† For Card Format Use Only

Character Coding (Contd.)

Alphameric Character	Output		
	Typewriter	Tape	Card
(Blank)	(Space)	C	(Blank)
. (Period)	.	X0821	12, 3, 8
)	)	X0C84	12, 4, 8
+	+	X0C	12
$	$	XC821	11, 3, 8
*	*	X84	11, 4, 8
- (Hyphen)	-	X	11
/	/	0C1	0, 1
, (Comma)	,	0C821	0, 3, 8
(	(	084	0, 4, 8
=	=	821	3, 8
@	@	C84	4, 8
A-I	A-I	X0, 1-9	12, 1-9
0 (−)	- (Hyphen)	X	11, 0
J-R	J-R	X, 1-9	11, 1-9
1-9 (−)	J-R	X, 1-9	11, 1-9
S-Z	S-Z	0, 2-9	0, 2-9
0 (+)	0	0	0
1-9 (+)	1-9	1-9	1-9
‡	(Stop)	EOL	0, 2, 8
Numerical Character			
(Blank)	0	0	0
0 (+)	0	0	0
0 (−)	$\overline{0}$	X	11, 0
1-9 (+)	1-9	1-9	1-9
1-9 (−)	$\overline{1}$-$\overline{9}$	X, 1-9	11, 1-9
‡	(Stop, WN) ‡ (DN)	EOL (WN) 082 (DN)	0, 2, 8
Num Blank †	@	C84	(Blank)

† For Card Format Use Only

Operation

Instruction Format

OP Code		P					Q				
O_0	O_1	P_2	P_3	P_4	P_5	P_6	Q_7	Q_8	Q_9	Q_{10}	Q_{11}

Instruction Codes and Execution Times

Mnemonic	Code	Instruction	Operation	Time
A	21	Add	F_P+F_Q replaces F_P	160+80 D_P basic time. 80 D_P recomp. time†
AM	11	Add (I)	F_P+Q replaces F_P	160+80 D_P basic time. 80 D_P recomp. time†
B	49	Branch	Do I_P	200
BB	42	Branch Back	Do I_S	200
BD	43	Branch on Digit	If d_Q not zero, do I_P	200 no branch. 240 branch.
BI	46	Branch Indicator	If i_Q on, do I_P	160 no branch. 200 branch.
BNF	44	Branch No Flag	If no f_Q, do I_P	200 no branch. 240 branch.
BNI	47	Branch No Indicator	If i_Q off, do I_P	160 no branch. 200 branch.
BNR	45	Branch No Record Mark	If no r_Q, do I_P	200 no branch. 240 branch.
BT	27	Branch & Transmit	Save A_S, F_Q to L_P-1, do I_P	200+40D_Q

Instruction Codes and Execution Times (Contd.)

Mnemonic	Code	Instruction	Operation	Time
BTM	17	Branch & Transmit (I)	Save A_S, Q to L_P-1, do I_P	$200+40D_Q$
BTFL	07	Branch & Transmit Floating*	Save A_S, F_Q to L_P-1, do I_P	$280+40L$
C	24	Compare	F_P compared with F_Q	$200+80D_Z$ unlike signs. $160+80D_P$ like signs.
CF	33	Clear Flag	Remove f from L_P	200
CM	14	Compare (I)	F_P compared with Q	$200+80D_Z$ unlike signs. $160+80D_P$ like signs.
D	29	Divide*	Product Area (00080-00099) $\div F_Q$	$160+520D_VQ_T+740Q_T$ Average quotient digit 4.5
DM	19	Divide (I)*	Product Area (00080-00099) $\div Q$	$160+520D_VQ_T+740Q_T$ Average quotient digit 4.5
DN	35	Dump Numerically	I/O_Q writes from L_P to 19999, 39999, or 59999	§
FADD	01	Floating Add*	Mp + Mq replaces Mp	$400+100L$ basic time. 80L recomp. time†

Instruction Codes and Execution Times (Contd.)

Mnemonic	Code	Instruction	Operation	Time
FDIV	09	Floating Divide*	Mp ÷ Mq replaces Mp Ep −Eq replaces Ep	880+940L +520L² Average quotient digit 4.5
FMUL	03	Floating Multiply*	Mp × Mq replaces Mp Ep + Eq replaces Ep	1120+80L +168L²
FSL	05	Floating Shift Left*	Mq shifted left so that high-order position is in Lp	200+40L +40L′
FSR	08	Floating Shift Right*	Fq shifted right to Lp	200+40L
FSUB	02	Floating Subtract*	Mp − Mq replaces Mp	400+100L basic time. 80L recomp. time†
H	48	Halt	Stop	160
K	34	Control	Do Q_{11} on I/O_Q	¶
LD	28	Load Dividend*	F_Q to L_P	400+40D_N
LDM	18	Load Dividend (I)*	Q to L_P	400+40D_N
M	23	Multiply	F_Q x F_P (result at 00099)	560+40D_Q +168$D_P D_Q$
MF	71	Move Flag*	f_Q to L_P	240
MM	13	Multiply (I)	Q x F_P (result at 00099)	560+40$D_{Q'}$ +168$D_P D_{Q'}$
NOP	41	No Operation	Go to A_S	160

Instruction Codes and Execution Times (Contd.)

Mnemonic	Code	Instruction	Operation	Time
RA	37	Read Alphamerically	I/O_Q reads at L_P-1	§ Except Card I/O (3.4ms)
RN	36	Read Numerically	I/O_Q reads at L_P	§ Except Card I/O (3.4ms)
S	22	Subtract	F_P-F_Q replaces F_P	$160+80D_P$ basic time. 80 D_P recomp. time‡
SF	32	Set Flag	Place f at L_P	200
SM	12	Subtract (I)	F_P-Q replaces F_P	$160+80D_P$ basic time. 80 D_P recomp. time‡
TD	25	Transmit Digit	d_Q to L_P	200
TDM	15	Transmit Digit (I)	Q_{11} to L_P	200
TF	26	Transmit Field	F_Q to L_P	$160+40D_Q$
TFM	16	Transmit Field (I)	Q to L_P	$160+40D_Q$
TFL	06	Transmit Floating*	F_Q to F_P	240+40L
TNF	73	Transfer Numerical Fill*	F_Q to F_P	$160+40D_P$
TNS	72	Transfer Numerical Strip*	F_P to F_Q	$160+40D_P$
TR	31	Transmit Record	R_Q to L_P	$160+40D_Q$
WA	39	Write Alphamerically	I/O_Q writes from L_P-1	§ Except Card I/O (3.4 ms)
WN	38	Write Numerically	I/O_Q writes from L_P	§ Except Card I/O (3.4 ms)

Instruction Codes and Execution Times (Contd.)

Symbols and Definitions for "Operation" Column

P	P part of instruction	I/O_Q	I/O defined by Q_8Q_9
Q	Q part of instruction	d_Q	Digit at L_Q
F_P	Field defined by P	f_Q	Flag bit at L_Q
F_Q	Field defined by Q	f	Flag bit
I_P	Instruction defined by P	R_Q	Record defined by Q
I_S	Saved instruction	r_Q	Record mark at L_Q
L_P	Location defined by P	i_Q	Indicator defined by Q_8Q_9
L_Q	Location defined by Q	A_S	Address of next seq. instr.
Mp	Mantissa of field at P address	Ep	Exponent of field at P address
Mq	Mantissa of field at Q address	Eq	Exponent of field at Q address

Symbols and Definitions for "Time" Column

D_P	Number of digits, including high-order zeros, in the field at P.
D_Q	Number of digits, including high-order zeros, in the field at Q.
$D_{Q'}$	Number of digits, including high-order zeros, in the Q part of the instruction.
D_N	Number of digits, including high-order zeros, in the dividend.
Q_T	Number of digits, including high-order zeros, in the quotient.
D_V	Number of digits, including high-order zeros, in the divisor.
D_Z	Number of positions compared until a digit other than zero is detected in either field.
L	Number of digits in mantissa.
L′	No. of digits mantissa is increased by shift left.

All times are in microseconds
(1 microsecond = 1/1,000,000 second).

Instruction Codes and Execution Times (Contd.)

NOTES

(I)	Immediate.
†	If signs initially unlike and numerical value of Q data greater than P data.
‡	If signs initially alike and numerical value of Q data greater than P data.
§	Depends on speed of I/O device and number of characters involved.
¶	Depends on control function and speed of I/O device.

Significance of P and Q Addresses

OP Code	Instruction	P Address	Q Address
01	Floating Add*	Location of units position of Exponent of Augend and Result.	Location of units position of Exponent of Addend.
02	Floating Subtract*	Location of units position of Exponent of Minuend and Result.	Location of units position of Exponent of Subtrahend.
03	Floating Multiply*	Location of units position of Exponent of Multiplicand and Product.	Location of units position of Exponent of Multiplier.
05	Floating Shift Left*	Location of high-order position of resulting field.	Location of units position of field shifted.
06	Transmit Floating*	Location of units position of Exponent of resulting field.	Location of units position of Exponent of field transmitted.

Significance of P and Q Addresses (Contd.)

OP Code	Instruction	P Address	Q Address
07	Branch and Transmit Floating*	P-1: location of units position of field to which Q field is transmitted. P: location of next instruction executed.	Location of units position of Exponent of field transmitted.
08	Floating Shift Right*	Location of units position of field shifted.	Location of units position of resulting field.
09	Floating Divide*	Location of units position of Exponent of Dividend and Quotient.	Location of units position of Exponent of Divisor.
11	Add (I)	Location of units position of Augend and Result.	Q_{11} is units position of Addend.
21	Add	Same as Code 11	Location of units position of Addend.
12	Subtract (I)	Location of units position of Minuend and Result.	Q_{11} is units position of Subtrahend.
22	Subtract	Same as Code 12.	Location of units position of Subtrahend.
13	Multiply (I)	Location of units position of Multiplicand.	Q_{11} is units position of Multiplier.
23	Multiply	Same as Code 13.	Location of units position of Multiplier.

(I) Immediate

Significance of P and Q Addresses (Contd.)

OP Code	Instruction	P Address	Q Address
14	Compare (I)	Location of units position of field compared with Q field.	Q_{11} is units position of field compared with P field.
24	Compare	Same as Code 14.	Location of units position of field compared with P field.
15	Transmit Digit (I)	Location to which digit is transmitted.	Q_{11} is digit transmitted.
25	Transmit Digit	Same as Code 15.	Location of digit transmitted.
16	Transmit Field (I)	Location to which units position of field is transmitted.	Q_{11} is units position of field transmitted.
26	Transmit Field	Same as Code 16.	Location of units position of field transmitted.
17	Branch and Transmit (I)	Same as Code 07.	Q_{11} is units position of field transmitted.
27	Branch and Transmit	Same as Code 07.	Same as Code 26.
18	Load Dividend (I)*	Location in Product Area to which units position of Dividend is transmitted.	Q_{11} is units position of Dividend.

Significance of P and Q Addresses (Contd.)

OP Code	Instruction	P Address	Q Address
28	Load Dividend*	Same as Code 18.	Location of units position of Dividend.
19	Divide (1)*	Location in Product Area of units position of Divisor for first subtraction.	Q_{11} is units position of Divisor.
29	Divide*	Same as Code 19.	Location of units position of Divisor.
31	Transmit Record	Location to which high-order position of record is transmitted.	Location of high-order position of record transmitted.
32	Set Flag	Location at which flag is set.	Not used.
33	Clear Flag	Location at which flag is cleared.	Not used.
34	Control	Not used	Q_8 and Q_9 specify I/O device. Q_{11} specifies control function performed.
35	Dump Numerically	Location of first character written.	Q_8 and Q_9 specify output device.
36	Read Numerically	Location where first character is stored.	Q_8 and Q_9 specify input device.

Significance of P and Q Addresses (Contd.)

OP Code	Instruction	P Address	Q Address
37	Read Alpha-merically	P-1: location where zone digit of first character is stored. P: location where numerical digit of first character is stored.	Same as Code 36.
38	Write Numerically	Location of first character written.	Same as Code 35.
39	Write Alpha-merically	P-1: location of zone digit of first character written. P: location of numerical digit of first character written.	Same as Code 35.
41	No OP	Not used.	Not used.
42	Branch Back	Not used.	Not used.
43	Branch on Digit	Branch: location of next instruction executed. No Branch: not used.	Location tested for digit other than zero.
44	Branch No Flag	Same as Code 43.	Location tested for flag bit.
45	Branch No Record Mark	Same as Code 43.	Location tested for Record Mark character.

Significance of P and Q Addresses (Contd.)

OP Code	Instruction	P Address	Q Address
46	Branch on Indicator	Same as Code 43.	Q_8 and Q_9 specify program switch or indicator tested.
47	Branch No Indicator	Same as Code 43.	Same as Code 46.
48	Halt	Not used.	Not used.
49	Branch	Location of next instruction executed.	Not used.
71	Move Flag*	Location to which flag is moved.	Location of flag to be moved.
72	Transfer Numerical Strip*	Location of units position of alphameric field.	Location of units position of numerical field.
73	Transfer Numerical Fill*	Same as Code 72.	Same as Code 72.

Addition Table

High-Order Positions of Address	Units Position of Address									
	0	1	2	3	4	5	6	7	8	9
0030	0	1	2	3	4	5	6	7	8	9
0031	1	2	3	4	5	6	7	8	9	$\overline{0}$
0032	2	3	4	5	6	7	8	9	$\overline{0}$	$\overline{1}$
0033	3	4	5	6	7	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$
0034	4	5	6	7	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$
0035	5	6	7	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$
0036	6	7	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$
0037	7	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$	$\overline{6}$
0038	8	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$	$\overline{6}$	$\overline{7}$
0039	9	$\overline{0}$	$\overline{1}$	$\overline{2}$	$\overline{3}$	$\overline{4}$	$\overline{5}$	$\overline{6}$	$\overline{7}$	$\overline{8}$

Multiplication Table

High-Order Positions of Address	Units Position of Address									
	0	1	2	3	4	5	6	7	8	9
0010	0	0	0	0	0	0	0	0	0	0
0011	0	0	1	0	2	0	3	0	4	0
0012	0	0	2	0	4	0	6	0	8	0
0013	0	0	3	0	6	0	9	0	2	1
0014	0	0	4	0	8	0	2	1	6	1
0015	0	0	5	0	0	1	5	1	0	2
0016	0	0	6	0	2	1	8	1	4	2
0017	0	0	7	0	4	1	1	2	8	2
0018	0	0	8	0	6	1	4	2	2	3
0019	0	0	9	0	8	1	7	2	6	3
0020	0	0	0	0	0	0	0	0	0	0
0021	5	0	6	0	7	0	8	0	9	0
0022	0	1	2	1	4	1	6	1	8	1
0023	5	1	8	1	1	2	4	2	7	2
0024	0	2	4	2	8	2	2	3	6	3
0025	5	2	0	3	5	3	0	4	5	4
0026	0	3	6	3	2	4	8	4	4	5
0027	5	3	2	4	9	4	6	5	3	6
0028	0	4	8	4	6	5	4	6	2	7
0029	5	4	4	5	3	6	2	7	1	8

Sign Control Chart

Addition

Sign of P Field	+	+	−	−
Sign of Q Field	+	−	+	−
Stored P Field Sign	+	+	−	−
True or Complement Add Q Field	True	Comp	Comp	True
Recomplement Answer if Q Field Value is Greater Than P Field Value		X	X	
Resulting Sign of P Field (Change on Recomplement)	+	−	+	−

Sign Control Chart (Contd.)

Subtraction

Sign of P Field	+	+	−	−
Sign of Q Field	+	−	+	−
Stored P Field Sign	+	+	−	−
True or Complement Add Q Field	Comp	True	True	Comp
Recomplement Answer if Q Field Value is Greater Than P Field Value	X			X
Resulting Sign of P Field (Change on Recomplement)	−	+	−	+

Summary of Automatic Division* Rules

1. Load Dividend (LD-28 or LDM-18)
   a. P address = 00099 minus the number of zeros desired to the right of the units position of the dividend.
   b. Q address = core storage address of the dividend.
2. Divide (D-29 or DM-19)
   a. P address = 00100 minus the length of the quotient. The quotient length must be at least two digits.
   b. Q address = core storage address of the divisor.
3. Quotient address = 00099 minus the length of the divisor.
4. Remainder address = 00099.
5. Sign of quotient: determined by the algebraic signs of the dividend and divisor.
6. Sign of remainder: same as that of the dividend.

Summary of Automatic Floating Point* Operations Rules

1. Field format: $\bar{M}$ . . . . M$\bar{E}\bar{E}$
2. Limits

	Minimum	Maximum
Mantissa digits	2	100
Mantissa quantity	−99 . . . 9	+99 . . . 9
Exponent digits	2	2
Exponent quantity	−99	+99

3. High-order digit of mantissa must *not* be zero, unless all zeros.
4. Negative mantissa and exponent represented by flags over units positions.

5. P and Q addresses are low-order positions of exponents *except* in Floating Shift Right and Floating Shift Left.
6. Zeros entered as data must be in floating point zero form ($\bar{0}$ . . . . $0\bar{9}\bar{9}$) for assured results.
7. Exponent overflow, resulting field: $\bar{9}$ . . . . $9\bar{9}\bar{9}$
   Exponent underflow, resulting field: $\bar{0}$ . . . . $0\bar{9}\bar{9}$

Compare Collating Sequences

1. Numerical Sequence:
   0 1 2 3 4 5 6 7 8 9
2. Alphameric Sequence:
   b (Blank) .) + $ * − / , (= @ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 0 1 2 3 4 5 6 7 8 9

The record mark (‡) and numerical blank are not usable as digits in an instruction or as data for an arithmetic or compare operation. Flag bits have no effect on the collating sequence.

Compare Results

Condition (Algebraic)	Indicator	
	High/Positive	Equal/Zero
P greater than Q	ON	OFF
P less than Q	OFF	OFF
P equal to Q	OFF	ON

P = Data in field at P Address.
Q = Data in field at Q address.

Allowable Indirect Addressing*

Instructions	Mnemonic	Code	P&Q	P
ARITHMETIC				
Add	A	21	X	
Add (I)	AM	11		X
Subtract	S	22	X	
Subtract (I)	SM	12		X
Multiply	M	23	X	
Multiply (I)	MM	13		X
Load Dividend*	LD	28	X	
Load Dividend(I)	LDM	18		X
Divide*	D	29	X	
Divide (I)	DM	19		X

Allowable Indirect Addressing* (Contd.)

Instructions	Mnemonic	Code	P&Q	P
INTERNAL DATA TRANSMISSION				
Transmit Digit	TD	25	X	
Transmit Digit (I)	TDM	15		X
Transmit Field	TF	26	X	
Transmit Field (I)	TFM	16		X
Transmit Record	TR	31	X	
Transfer Numerical Strip*	TNS	72	X	
Transfer Numerical Fill*	TNF	73	X	
LOGIC (COMPARE AND BRANCH)				
Compare	C	24	X	
Compare (I)	CM	14		X
Branch	B	49		X
Branch No Flag	BNF	44	X	
Branch No Record Mark	BNR	45	X	
Branch on Digit	BD	43	X	
Branch Indicator	BI	46		X
Branch No Indicator	BNI	47		X
Branch and Transmit	BT	27	X	
Branch and Transmit (I)	BTM	17		X
Branch Back	BB	42		
INPUT/OUTPUT				
Read Numerically	RN	36		X
Write Numerically	WN	38		X
Dump Numerically	DN	35		X

Allowable Indirect Addressing* (Contd.)

Instructions	Mnemonic	Code	P&Q	P
INPUT/OUTPUT				
Read Alphamerically	RA	37		X
Write Alphamerically	WA	39		X
Control	K	34		
PROGRAM CONTROL				
Set Flag	SF	32		X
Clear Flag	CF	33		X
Move Flag*	MF	71	X	
Halt	H	48		
No Operation	NOP	41		

Switch and Indicator Codes

Code Q_8 Q_9	Switch or Indicator
0 1	Program Switch 1
0 2	Program Switch 2
0 3	Program Switch 3
0 4	Program Switch 4
0 6	Read Check Indicator†
0 7	Write Check Indicator†
0 9	Last Card Indicator
1 1	High/Positive Indicator
1 2	Equal/Zero Indicator
1 3	High/Positive or Equal/Zero Indicator
1 4	Overflow Check Indicator
1 5	Exponent Check Indicator†
1 6	MBR-even Check Indicator†
1 7	MBR-odd Check Indicator†
1 9	Any Data Check

† Will cause 19 to be ON.

Storage Register Functions

Register	Function
IR-1	Contains address of next instruction if machine is stopped with stop key or halt instruction.
IR-2	Saves return address when BT and BTM instructions are executed.
OR-1	Contains Q addresses after I-cycle of an instruction.
OR-2	Contains P address after I-cycle of an instruction.
OR-3	Retains address of low-order multiplier digit during multiplication.
PR-1	Saves return address when a save key operation occurs. Decremented for each new multiply digit during multiply.
PR-2	Decremented for each new multiplicand digit during multiply.
PR-3	Used to add partial product to each multiply cycle result.
MAR	Addresses core storage.
MBR	Receives digits entering or leaving core storage.
MDR	Receives addressed digit entering or leaving core storage.
Digit	Stores partial product during multiplication.
OP	Contains OP code of instruction just executed if machine is stopped with stop key or halt instruction.
Multiplier	Contains multiplier digits during multiply operation.
Sense and Branch	Contains I/O device code during input/output operations. Units position used to develop each quotient digit during divide operation.
Digit and Branch	On some machines, combines functions of both Digit, and Sense & Branch Registers.

Input/Output Device Codes

Code $Q_8 Q_9$	Device
0 1	Typewriter—10 char/sec
0 2	Tape Punch—15 char/sec
0 3	Paper Tape Reader—150 char/sec
0 4	Card Punch—125 cpm
0 5	Card Reader—250 cpm

Table Areas in Core Storage

Address	Area
00000-00099	Console Area
00080-00099	Product Area
00100-00299	Multiplication Table
00300-00399	Addition Table

Typewriter

Typewriter Control Codes

Q_{11}	Control Function
1	Space
2	Return Carriage
8	Tabulate

Manual Adjustments to Typewriter

Impression Indicator. The lever under this window can be positioned in settings from 0 to 10 to determine the force with which the type bars strike the paper. The higher the indicator setting, the harder the type bars strike. To test for the correct setting, move the indicator up until the comma and period print distinctly but not heavily. Use a higher setting for multiple copies, but be sure that the multiple copy lever is also correctly set before finally adjusting the impression.

Tab Clear Lever. To clear tab stops, tabulate to the point to be cleared and depress the clear lever. To clear all stops at once, position the carriage at the right margin, hold down the clear lever, and return the carriage to the left margin stop.

Tab Set Lever. To set tabular stops, move the carriage to the desired position and depress the set lever. Set tab stops only when the indicator pointer is in line with a white marking on the front paper scale below it.

Carriage Release Lever. Depress the lever on either side to free the carriage and manually move the carriage to the right or left.

Paper Release Lever. To free the paper for positioning or quick removal, move this lever forward.

Line Space Lever. Moved to position 1, 2, or 3, the line space lever provides for single, double, or triple line spacing, respectively.

Multiple Copy Control. This lever moves the platen backward to compensate for the greater thickness of additional copies. As a general rule, the lever should be set at "A" for one to three copies and moved back one

position for each additional three to five copies. Heavy print at the top of characters shows that the platen is too far back; heavy print at the bottom of characters shows that the platen is too far forward. The shilling mark (/) is a good character to use in checking multiple copy settings.

Left-Hand Margin Set. The left margin stop is set as follows:

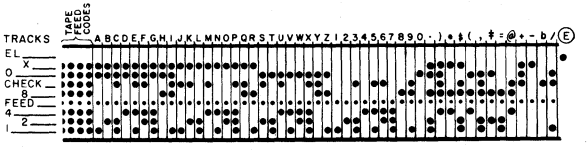
1. Return the carriage to the present left margin stop.
2. Depress the margin set key.
3. Manually move the carriage as near as possible to the position desired. The back space key and space bar are convenient to use to obtain the exact position desired, with the margin set key depressed.
4. Release the margin set key.

Right-Hand Margin Set. The right margin stop is set as follows:

1. Move the carriage to the left until stopped by the right margin stop.
2. Depress the margin set key.
3. Move the carriage right or left to the desired position.
4. Release the margin set key.

IBM 1621 Paper Tape Reader and IBM 1624 Tape Punch

Paper Tape Tracks and Codes



Loading the Paper Tape Reader

Paper tape can be handled in three forms; the procedure for loading each one varies slightly.

STRIP FORM

Small strips of tape may be loaded directly onto the read head with the following procedure:

1. Position the reel switch to STRIP.
2. Open the tape guides, form an inverted U (Ω) with the leading 12 inches of paper tape, and install the tape around the read head with sufficient tension to keep the runout and tape tension contacts closed. Start on the takeup reel side of the read head. Run a finger up over the tape on top of the read head, smoothing the tape down with a firm, moderate pressure so that the tape tension bar is slightly depressed and the right side of the feed pinwheel engages the tape feed holes. Be careful not to tear the feed holes. The tape feed holes must mesh with both sides of the pinwheel.
3. Close the tape guides.

CENTER ROLL FEED

The center roll feed eliminates the necessity for rewinding paper tape rolls to expose the starting end of the tape on the outside of the tape roll. Tape is supplied from the inside of the center roll feed, to the supply reel, around the read head, and onto the takeup reel.

The procedure for loading paper tape from the center roll feed is as follows:

1. Position the reel strip switch to REEL.
2. Place the reel buffer arms in the upper latched positions.

3. Open the tape guides and form an inverted U (Ω) with the center section of the first eight feet of paper tape. Wrap the paper tape around the read head with sufficient tension to keep the runout and tape tension contacts closed. Start on the takeup reel side of the read head. Run a finger up over the tape on top of the read head, smoothing the tape down with a firm, moderate pressure so that the tape tension bar is slightly depressed and the right side of the feed pinwheel engages the tape feed holes. Be careful not to tear the feed holes. The tape feed holes must mesh with both sides of the pinwheel.
4. Close the tape guides.
5. Thread the leading section of paper tape under the guide roller, between the stationary buffer rollers and buffer arm rollers, and onto the takeup reel.
6. Thread the paper tape from the right side of the read head, under the guide roller, between the stationary buffer rollers and buffer arm rollers, over the supply reel (the rubber drive hub must be installed), around the tape guide stand, and around the tape reel nylon roll.
7. Lower the idler roller onto the supply reel.
8. Lower the buffer arms gently.
9. Depress the reel power key. The buffer arms should swing down to a neutral position, applying tension to the paper tape.

NOTE: The roll of paper tape must be positioned centrally, or evenly, around the center rollers to prevent excessive vibration during reading.

REEL

A reel of paper tape may be read on the 1621 by removing the rubber drive hub from the supply reel and mounting the reel of tape in its place. The tape is threaded from the right-hand side of the reel, directly to the stationary buffer rollers, and to the takeup reel as described under CENTER ROLL FEED.

Loading the Tape Punch

Place the roll of unpunched tape on the turntable. The tape retainer must be rotated to the left by pushing back on its extended left edge. This also moves the tape lever

forward to facilitate threading. An unwound section of tape is then threaded as follows:

1. Through first tape guide.
2. Inside second tape guide.
3. In front of tape tension guide.
4. In back of tape lever.
5. Between the punching mechanism and the punch guide block, which can be seen in front of the tape.
6. Between the guides on the tape retainer. With the end of the tape held to the left, the tape retainer is returned to normal position, which causes the pins on the feed roll to pierce through the blank tape. The tape lever simultaneously returns to normal position with the top guide above the tape.

The tape feed key is used to repetitively punch automatic feed punches and to provide a leader section of paper tape. The approximately 60" of leader needed for threading paper tape on the 1621 can be obtained from the 1624 in 40 seconds. The leader is threaded into the 1624 takeup reel so that the top edge of the tape is at the outside of the reel.

Correction of Incorrect Tape Punch

If a character with incorrect parity is transmitted from core storage and punched, or a valid character is incorrectly punched, the tape feed does not advance. The computer stops in both the automatic and manual modes, and the automatic and manual lights and punch no feed and write check lights on the 1620 console are turned on. Functions of these lights are described under IBM 1620 CONSOLE. Program processing can be resumed with the following procedure:

1. Position the 1624 tape feed switch ON.
   a. The feed code (all punches) is punched over the incorrect character.
   b. The punch no feed and write check lights are turned off.
   c. The machine is returned to manual mode only.
2. Depress the start key on the 1620 console.
   a. The original character from storage is again punched. If an incorrect character still persists, the record may be corrected, if desired, before processing continues.
   b. The computer continues processing.

If the 1624 runs out of paper tape, the machine stops in automatic mode and the punch no feed light turns on. The "character correction procedure" outlined is used to restore operation.

When this procedure is used to correct the incorrect punching of a valid character and the character is re-punched incorrectly, the SIE key (described under STOP/SIE KEY) can be used as follows to determine the cause of the incorrect punching:

Use the SIE key to execute one instruction at a time.

When the write check light is turned on, observe the MBR display (described under REGISTER DISPLAY INDICATORS) to determine if the character is valid. If it is, notify an IBM Customer Engineer.

A transient condition may cause the write check light (but not the punch no feed light) to come on even though a valid character has been correctly punched. Should this occur, briefly turn on the tape feed switch to turn off the write check light, then depress the console start key and proceed with the program.

The punch registration (proper hole spacing) can be verified by the use of a standard paper tape gage. Off-line punching equipment can be checked in the same manner.

Paper Tape Splicing Procedure

A splice should only be made in non-data portions of paper tape because correct reading cannot be assured at the point of splice. Some methods of splicing chad tape in the data portions are possible, but the reading accuracy is not reliable. The reading mechanism feeds and guides the tape by means of the feed holes; therefore they should not be restricted in any way by splices. Splice specifications are:

1. The total thickness of the tape must not exceed 0.010 inch (nominal paper tape thickness is 0.004 inch).
2. The tape overlap at the splice should be no more than one tape code long (0.100 inch).
3. The splice must be as strong as the tape.
4. The splice must be no wider than the tape.
5. The splice must be free of staples and gummy substances.

The following procedure may be used to splice two lengths of paper tape together.

1. Punch tape feed code into the two ends of the tape to be spliced together.
2. Cut the tapes on approximately a 45° angle.

3. Holding the ends of the tape with the tape feed holes toward you, overlap the tape end in the left hand over the tape end in the right hand by approximately 1/16 inch.
4. Glue in this position with holes aligned, using a quick-setting glue such as IBM tape mucilage, P/N 221030.

Operating Switches and Lights

Power Switch. With this switch on, all necessary power for operation of the 1621 is supplied by the 1620.

Reel Strip Switch. In reel mode, tape is fed from the supply reel and to the left, onto the takeup reel. In strip mode, short pieces of tape may be read without reel operation.

Reel Power Key. Operates the supply and takeup reels to position the paper tape for reading and to place the machine in ready status.

Nonprocess Runout Key. Causes paper tape to feed. Ready status is terminated and all data transfer is blocked until all paper tape has passed. Paper tape must be reloaded and the reel power key depressed before the machine can be returned to ready status.

Power On Light. Light on indicates that power is supplied from the 1620.

Operator Keys and Lights

CARD READER

Reader On/Off Switch. Used to supply power to the reader and to turn on the power ready light. The 1620 power on/off switch must be on to make the 1622 reader on/off switch active.

Load Key. Causes data from the first card to be checked, read into buffer storage, and automatically transferred in numerical mode to core storage positions 00000-00079. Upon completion of this data transfer, another card feed cycle occurs which loads buffer storage with data from the second card. The 1620 then simulates release and program start at 00000. The instructions from the first card, now in 00000-00079, can be used to continue loading the program or to begin processing. The 1620 must be reset and in manual mode to make the load key operate correctly.

Start Key. Used (1) to run in cards, which are then placed under program control (data from the first card is checked and loaded in input buffer storage); (2) to set up a runout condition, which permits programmed reading of the cards remaining in the feed when the hopper has become empty; and (3) to restore ready status after the reader has been stopped by a depressed stop key, an empty hopper, an error, a misfeed. or a transport jam.

Stop Key. Used to stop the read feed at the end of the card cycle in progress and/or to remove the reader from ready status. Data entered into buffer storage during the read cycle in progress is transferred to core storage. The computer continues processing until the next read card command causes a reader no feed stop.

Nonprocess Runout Key. Used to run cards out of the read feed after a reader check error, or after the stop key has been used to stop the reader. The cards are run out into the read select stacker without a buffer-storage to core-storage transfer. The reader check light and check circuits are turned off. Cards must be removed from the hopper to make the nonprocess runout key active.

Reader Ready Light. Turns on to indicate that the first card has been loaded into buffer storage with the start key, without a reader check error. It is turned off by a depressed stop key, a reader check error, a transport jam, a misfeed, or an empty hopper.

Reader Check Light. Turned on by an unequal comparison between the read and check stations and by incorrect parity detected in buffer storage during card read. When there is an unequal comparison, the reader is stopped, ready status is terminated, and the buffer storage data just read cannot be transferred to core storage on the next read command.

1620 Console Read Check Light. The 1620 read check (06) indicator and console read check light are turned on by a 1620 parity error during a buffer-storage to core-storage transfer.

1620 Console Reader No Feed Light. Turns on each time the reader is selected by a read command.. The light remains on if the reader is not in ready status and the read command cannot be executed.

CARD PUNCH

Punch On/Off Switch. Used to supply power to the punch and to turn on the power ready light. The 1620 power on/off switch must be on to make the 1622 punch on/off switch active.

Start Key. Used to feed cards to the punch station initially or after an error and nonprocess runout, and to re-establish ready status after an empty hopper, a misfeed, a transport jam, or a depressed stop key.

Stop Key. Used to stop the punch feed at the end of the card cycle in progress and/or to remove the punch from ready status.

Check Reset. Used to reset error circuits and turn off the punch check light. A start key or nonprocess runout key depression follows, as described under ERROR RESTART PROCEDURES.

Select N-Stop — Select Stop Switch. Used to control the stopping of the punch when error cards are selected into the punch error select stacker. With the switch set to STOP, the punch feed stops with the error card in the select stacker.

Nonprocess Runout Key. Following a punch check error, depression of the nonprocess runout key resets the error circuits and causes the punched card that is between the punch station and the punch check station to feed into the stacker. If this card is in error also, it follows the first error card into the select stacker and causes the punch check light to turn on again. The next two (blank) cards go into the nonselect pocket. These cards should be removed before further processing.

This key is also used to run out and check the last punched card of a job. Cards must be removed from the hopper to make the nonprocess runout key operative.

Punch Ready Light. Indicates that the 1622 has a card in punch position and will respond to a write command from the 1620. The ready light is turned off by a punch check error, an empty hopper, a full chip box, a depressed stop key, a transport jam, or a misfeed.

Punch Check Light. Turns on when there is an unequal comparison between the data punched and the data read (one card feed cycle later, at the check station), or when a 1622 parity errors occurs during punching (select stop switch set to STOP). The machine stops, and ready status is terminated.

Chip Light. Indicates that the chip box should be emptied.

1620 Console Write Check Light. Turned on by a parity error during a core-storage to buffer-storage transfer.

1620 Console Punch No Feed Light. Turns on each time the punch is selected by a write command. The light remains on until the punch unit is ready to execute the command.

READ PUNCH COMMON LIGHTS

Stacker Light. Turns on when a stacker is full. Both feeds are stopped temporarily and removed from ready status; the ready light remains on. Operation is resumed automatically after the stacker is emptied.

Transport Light. Turns on when a card jam has occurred in either the read or punch feed or above any stacker. When this occurs, both feeds are stopped and removed from ready status. Both start keys must be depressed to resume operation after the condition is corrected.

Fuse Light. Indicates a blown fuse.

Thermal Light. Turns on if the internal temperature of the 1622 becomes excessive. After several minutes delay, the 1620 console reset key may be depressed to turn off the thermal light. If depression of the reset key turns off the thermal light, the 1620 power switch must be turned off and then on again. Operation may be resumed after the power ready light is turned on.

Error Restart Procedures

READER CHECK ERROR

Cause: Unequal comparison between the read and check stations, or a buffer storage parity error. The reader stops with the error card (last card) in the select stacker.

Indicators: 1622 reader check light ON.
1622 ready light OFF.

Restart Procedure:

1. Remove cards from the read hopper.
2. Depress the nonprocess runout key.
3. Remove the last three cards from the select stacker.
4. Place these three cards in front of the cards removed from the hopper and replace the deck in the hopper.
5. Depress the start key. The card that caused the error is read into buffer storage again, and if an equal comparison is obtained, the interlocked read instruction is executed and processing continues.

1620 READ CHECK ERROR

Cause: Parity error in the 1620 during data transfer from 1622 buffer storage to 1620 core storage. Reader stops with the "error" card (last card) in the nonselect stacker.

Indicators: 1620 read check light ON.
1622 reader ready light ON.
06 read check indicator ON.

Restart Procedure:

1. Remove cards from the read hopper.
2. Depress the nonprocess runout key.
3. Remove the last card from the nonselect stacker and the last two cards from the select stacker.
4. Place these three cards in front of the cards removed from the hopper. The "error" card from the nonselect stacker is to be read in first.

5. Insert a branch to the address of the instruction that transfers the error card data from input buffer storage to core storage.
6. Depress the start key.

PUNCH CHECK ERROR

Cause: Unequal comparison between the data punched and the data read (one card feed cycle later, at check station), or a 1622 parity error while punching data from buffer storage. If the select stop switch is set to STOP, the punch stops with the error card in the select stacker.

Indicators: 1622 punch check light ON.
1622 punch ready light OFF.

Restart Procedure: To restart without (1) immediate manual correction of the error card or (2) reprocessing of the error card:

1. Depress the check reset key.
2. Depress the start key. Processing continues from the point at which the program stopped.

For manual correction of the error card:

1. Remove the last (error) card from the punch select stacker and correct the error card. Place the corrected card behind those in the punch nonselect stacker.
2. Depress the check reset key.
3. Depress the start key. The interlocked write command for the second card following the error card can now be executed.

For reprocessing of the error card, *when one card is punched out for each card read:*

1. Remove cards from both hoppers.
2. Depress both nonprocess runout keys.
3. Remove the last two cards from the punch error select stacker and the last two (blank) cards from the punch nonselect stacker. Also, remove the last two cards from the read nonselect and the last two cards from the read select stacker.
4. Mark or destroy the two punched cards removed from the punch select stacker. Place four cards from the read stackers (nonselect in front of select) ahead of those removed from the read hopper. Place blank cards in the punch hopper.

5. Insert a branch to the address of the instruction that begins the reprocessing of the error card.
6. Depress both start keys.

1620 WRITE CHECK ERROR

Cause: 1620 parity error. The error has not been punched into a card.

Indicators: 1620 write check light ON.
07 write check indicator ON.

Restart Procedure: A typeout of the core storage positions that were transferred indicates whether the data in core storage is correct. If the data in core storage is incorrect, reread the card or cards from which this data originated.

Double Punch Detection

Double punches are detected only if there is a duplication of BCD bits. For example, a nine (8, 1) punch and an eight (8) punch in the same column is detected as a reader check because of 8-bit duplication; a six (4, 2) punch and a one (1) punch in the same column is read without error as a seven (4, 2, 1) because there is no bit duplication; etc.

Indicator Displays and Switches

MBR-E (Memory Buffer Register, Even). This light and indicator are turned on when the digit in the even address portion of the MBR has a parity error. An error stops the machine immediately if the parity check switch is set to STOP.

MBR-O (Memory Buffer Register, Odd). This light and indicator are turned on when the digit in the odd address portion of the MBR has a parity error. An error halts the machine immediately if the parity check switch is set to STOP.

MARS (Memory Address Register Storage). This light turns on when a digit in MARS has a parity error. This is an unconditional machine stop, and is not affected by the position of the parity check switch.

Rd Chk (Read Check). This light and indicator are turned on when an input character with a parity error is detected, prior to conversion of input data to BCD code. An error halts the machine after the input operation is complete, if the I/O check switch is set to STOP.

Wr Chk (Write Check). This light and indicator are turned on when an output character with an even number of bits is detected during conversion of output data from BCD to output code. The effect on machine operation as a result of detection of this parity error varies, depending on the output device selected, as follows:

Typewriter: Error detection halts the 1620 after the output operation is complete, if the I/O check switch is set to STOP.

Card Punch: The card is not punched; error detection halts the 1620 at the end of an 80-character transfer to output buffer storage, if the I/O check switch is set to STOP.

Tape Punch: Error detection halts the 1620 as soon as the character is punched and prevents the tape feed from advancing, regardless of the check switch setting.

O'Flow Arith Chk (Arithmetic Check). An overflow that occurs as a result of an add, subtract, divide, or compare operation turns on the overflow check indicator and light.

When the overflow check switch is set to STOP, and the overflow check indicator is turned on, the computer halts at the end of the instruction being executed. If the start key is depressed, the overflow check indicator remains on, and the computer continues to execute instructions in the automatic mode, until another overflow occurs.

When the overflow check switch is set to PROGRAM, and the overflow check indicator is turned on, the machine continues to operate in the automatic mode. The indicator can be interrogated and turned off by the program.

Exponent Check. This light and indicator are turned on by an exponent overflow or underflow during Automatic Floating Point* operations.

Console Program Switches. There are four modifier switches in this group. They are labeled PROGRAM SWITCHES on the console and are numbered 1 through 4. A branch occurs when a switch specified by a Branch Indicator (BI-46) instruction is set to ON.

When the switch specified is set to OFF, no branch occurs from the BI instruction, and the next instruction in sequence is executed.

When a Branch No Indicator (BNI-47) instruction is used to interrogate one of these switches, the branch occurs when the switch is set to OFF.

Register Display Indicators

Memory Buffer Register (MBR). The two stored digits affected by a core storage address are displayed in the MBR. When the core storage location addressed for display is an even-numbered address, the digit at this location is placed in the MBR display in the E (even line); the O (odd) line contains the digit in the next *higher*-numbered location. If the core storage location addressed for display is an odd-numbered address, the digit at this location is placed in the MBR display on the O line; the E line contains the digit in the next *lower*-numbered location. When the machine is in alphabetic mode, the complete two-digit representation of an alphameric character may be viewed at one time.

Memory Data Register (MDR). Displays the bit configuration of each digit in core storage as it is read out. These digits can be seen on single cycle operation,

using the SCE key. The digit displayed in the MDR display is duplicated in the MBR-E or MBR-O display, depending on whether the digit read out is located at an even- or an odd-numbered core storage position.

Operation (OP) Register. Displays the bit configuration of the two digits representing the operation code of the instruction last executed. Flag bits of these two digits are not displayed.

Sense and Branch (S-B). Displays Q_8 and Q_9 of the Branch Indicator, Branch No Indicator, and Input/Output instructions from the Sense and Branch Register. Input/output device codes (digits 01-05) are displayed for Input/Output and Control instructions.

Digit Register. Used primarily for diagnostic testing by IBM Customer Engineers. Displays the digits affecting MARS during all I cycles. As the multiplication progresses, displays the two product digits "looked up" in the multiply table. The Digit Register stores the partial product during multiplication.

NOTE: On some machines the *Sense and Branch Register* and the *Digit Register* are combined into a *Digit and Branch Register.* The functions of the combined register are the same as those of the individual registers.

Multiplier. Shows each multiplier digit as it is used during a multiply operation.

Memory Address Register (MAR). Displays the bit configuration of the five-digit address in any one of the eight MARS registers selected by the MAR display selector switch and the display MAR key. There is no flag bit notation.

Memory Address Register Storage (MARS) Display Selector. The 8-position rotary switch permits selection of any of the eight MARS registers for display in MAR by depressing the display MAR key. The position of the switch can be changed without altering the display. However, the rotary switch should not be turned while the display MAR key is depressed.

Control Gate Indicators

H/P (High/Positive). Shows the condition of the internal high/positive indicator as a result of the last arithmetic or compare operation.

E/Z (Equal/Zero). Shows the condition of the internal equal/zero indicator as a result of the last arithmetic or compare operation.

Bypass. Shows that the MAR address was neither decreased nor increased. Either the increment or decrement light is also on.

Decr (Decrement). Shows that the address routed from MAR to MARS was decreased by 1, unless the bypass light is also on. Both lights on indicate that no decrease occurred.

Incr (Increment). Shows that the address routed from MAR to MARS was increased by 1, unless the bypass light is also on. Both lights on indicate that no increase occurred.

Plus 2. Shows that the address routed from MAR to MARS was increased by 2. The increment light must also be on.

Rec Mark (Record Mark). Shows that a record mark was sensed in core storage. The record mark is displayed in MDR.

Branch. Comes on during the I cycle of Branch Indicator and Branch No Indicator instructions if the branch is to occur during the E cycle.

Recomp (Recomplement). Shows that an add or subtract result will be recomplemented upon completion of the computation.

Carry Out. Shows that the result from the add table has a carry (flag bit) or that a carry went into a position containing a nine, which causes the carry out light to come on one to three storage cycles later.

Carry In. Turned on by a carry out and shows that a one will be added on the next machine cycle.

IA (Indirect Addressing) Shows that an indirect addressing operation is in progress. It is turned on when a flag bit is present in the units position of the indirect address.

Field Mk 1 (Field Mark 1). Comes on when the flag bit in the high-order position of the Q field is detected in the MDR.

Field Mk 2 (Field Mark 2). Comes on when the flag bit in the high-order position of the P field is detected in the MDR.

T/C 1 (True/Complement 1). Shows that the Q address data is complemented during arithmetic operations.

Instruction and Execute Cycle Lights

The instruction and execute cycle lights are a visual aid for the console operator in stepping an instruction through I and E cycles with the INSTANT STOP/SCE key. The I and E lights progress through each cycle with repeated depressions of this key.

Input/Output Lights

The input/output lights are used primarily for diagnostic testing by IBM Customer Engineers. The Last Card light has significance for the operator and programmer.

LC (Last Card). This light turns on when data from the last card has been transferred from 1622 input buffer storage to 1620 core storage, without a parity error.

Control Keys and Signal Lights

Power On/Off Switch – Power On Light. When set to the ON position, applies electrical power to the computer and turns on the power on light.

Power Ready Light. Comes on when internal machine temperature and voltages reach proper operating values. There is a delay from the time the power on/off switch is positioned ON until operating temperature and voltages are obtained. This delay varies with room temperature and the time lapse since power was turned off.

Start Key. Used to start program processing and to put the computer in automatic mode. It is operative only when the computer is in manual mode.

Automatic and Manual Lights. The manual light ON indicates that the computer is in the manual mode. In manual mode, the computer has terminated all operation and is prepared to accept operator intervention. Manual mode is initiated and the manual light is turned on by the execution of a Halt Instruction or by depression of the release key (on an I/O operation only), instant stop key, or stop key. Depression of the start key, insert key, or display MAR key initiates automatic mode and turns the manual light off. The save light and/or no feed light can be on when the manual light is on.

The automatic light ON indicates that the computer is in the automatic mode (e.g., while executing a stored program or while entering data into core storage from the typewriter keyboard).

Both the manual and automatic lights are on when an instruction is single-cycled with the SCE key.

Reset Key. Used to restore all machine status indicators, machine check indicators, and signal lights to their initial or reset condition. The reset key functions only when the computer is in the manual mode (manual light on). Parity errors can occur if the reset key is used while the computer is in the automatic mode. When the computer is in the automatic mode, the instant stop key should be depressed to put the computer in the manual mode and permit use of the reset key.

Insert Key and Insert Light. Depression of the insert key places the 1620 in automatic mode, turns on the insert light, and activates the typewriter keyboard so that direct entry of instructions may be made in numerical mode, starting at 00000 and continuing into higher-numbered storage positions. As many as 100 digits may be keyed in. After the 100th digit is entered, an automatic release is initiated and the 1620 returns to manual mode.

When less than 100 characters are entered, entry of the last character should be followed by depression of the console release and start keys, or by depression of the R-S key on the typewriter keyboard. The R-S key combines the release and start functions of the console keys. The R-S symbol is typed as a permanent record that the R-S key has been used.

The insert key is operative only when the computer is in the manual mode.

Save Key and Save Light. Turns on the save light and saves the address of the next sequential instruction to be executed. This address is saved in Product Address Register 1 (PR-1). If a multiply operation is performed before the saved address is used, the saved address is lost because the contents of PR-1 are decremented for each new multiply digit during a multiply operation.

Release Key. Used to terminate any input/output operation, including console keyboard entry of data into core storage. When this key is depressed, manual mode is

initiated, the manual light is turned on, and the insert light is turned off.

The release key is operative only when the computer is in automatic mode and performing an I/O operation.

Stop SIE (Single Instruction Execute) Key. Stops the computer in manual mode at the end of the instruction being executed when the key is depressed.

The STOP/SIE key also serves as a single instruction execute key. Successive depressions of the key cause one instruction to be executed for each depression. The manual light remains on.

Instant Stop/SCE (Single Cycle Execute) Key. Causes the machine to stop at the end of the 20-microsecond machine cycle in progress when the key is depressed. Successive depressions of the key cause single machine cycles. Both the manual and automatic lights remain on.

Check Stop Light. Turned on when the machine stops because of a parity check. One or more of the parity or I/O check indicators that caused the stop is also on. The check stop light is turned off when the check indicators are reset or the parity or I/O switch is set to PROGRAM.

Display Mar Key. Operative only when the manual light is on and the automatic light is off. Depression of the display MAR key causes display of the MARS register to which the MARS display selector switch is set.

The rotary switch should not be turned while the display MAR key is depressed.

Reader No Feed Light. Turned on when the computer attempts a paper tape read or card read operation and the reader is not in the ready status. This not-ready status is often temporary in a card read operation because the buffer is interlocked while the read cycle is in process.

Punch No Feed Light. The punch no feed light is turned on if one of the following conditions exists:

1. The computer executes a write instruction using the tape punch and there is no paper tape on the feed reel.
2. A parity check occurs while punching paper tape.
3. The paper tape supply is exhausted.

4. The card punch is not ready. This not-ready status is often temporary on a card punch operation because the buffer is interlocked while the punch cycle is in process.

Any of these conditions stops the computer in automatic mode with both the automatic and punch no feed lights turned on. When a parity error occurs, the I/O write check light is also turned on. Depression of the release key disconnects the punch and puts the computer in manual mode. Depression of the reset key, while in manual mode, turns off the punch no feed and I/O write check lights. Manual correction and restart procedures can begin after depression of the release and reset keys.

Thermal Light. Turned on if the internal temperatures of the 1620, 1622, or 1623 become too high. Power is turned off, and the power ready light goes off. The thermal light may be turned off by depression of the reset key, after the internal machine temperatures return to normal. The power switch must be turned off and on again before power can be applied to the machine.

Emergency Off Switch. For emergency use only. If positioned OFF, all power is turned off in the machine and the blowers that cool the electronic circuits are stopped. Damage to the machine may therefore result.

Program Entry from Typewriter

Operation Action	Explanation
1. Depress insert key.	Typewriter is conditioned to enter data into core storage, beginning at location 00000.
2. Type: 36 xxxxx 00100 49 xxxxx (No Q address)	Enter instructions to read numerically from typewriter, beginning at the first position of program storage (xxxxx), and branch to first program instruction.
3. Depress release key.	Releases typewriter.
4. Depress start key.	The Read Numerically instruction, entered in step 2, is executed.
5. Type program steps and data.	As each character is typed, it is stored at location xxxxx and succeedingly higher core storage positions.
6. Depress release key.	Terminates read instruction.
7. Depress start key.	The next sequential instruction, which is the branch to the first program instruction at xxxxx, is executed.

Program Entry from Paper Tape Reader

Operator Action	Explanation
1. Depress insert key.	Typewriter is conditioned to enter data into core storage, beginning at location 00000.
2. Type: 36 xxxxx 00300 49 xxxxx (No Q address)	Enter instruction to read numerically from paper tape reader, beginning at the first position of program storage (xxxxx), and branch to first program instruction.
3. Depress release key.	Releases typewriter.

4. Depress start key.	The Read Numerically instruction, entered in step 2, is executed. The EL character punched in the tape causes a termination of the read instruction and execution of the next sequential instruction (branch to first program instruction, which was entered in step 2).

Program Alteration and Data Entry

Operator Action	Explanation
1. Depress stop key.	Halts processing and initiates manual mode.
2. Depress save key.	The address of the next instruction in sequence is saved in Product Address Register 1 (PR-1).
3. Depress insert key.	Typewriter is conditioned to enter data into core storage, beginning at location 00000.
4. Type: 36 xxxxx 00100 42 (No P or Q address)	Enter instructions to read numerically from typewriter, beginning at the first position of data entry (xxxxx), and branch to address saved in PR-1 (step 2).
5. Depress release key.	Releases typewriter.
6. Depress start key.	The Read Numerically instruction, entered in step 4, is executed.
7. Type instructions and data.	As each character is typed, it is stored at location xxxxx and succeedingly higher core storage positions.
8. Depress release key.	Terminates read instruction.
9. Depress start key.	The next sequential instruction, which is Branch Back (step 4) to the address saved in PR-1 (step 2), is executed, and processing is resumed.

Print Core Storage Data on Typewriter

Operator Action	Explanation
1. Depress insert key.	Typewriter is conditioned to enter data into core storage, beginning at location 00000.
2. Type one of the following:	Enter instruction to:
39 xxxxx 00100	Write alphamerically, beginning at xxxxx and continuing until a record mark is sensed, or,
38 xxxxx 00100	Write numerically, beginning at xxxxx and continuing until a record mark is sensed, or,
35 xxxxx 00100	Write (Dump) numerically, beginning at xxxxx and continuing until location 19999 is printed or the release key is depressed.
3. Depress release key.	Releases typewriter.
4. Depress start key.	Instruction entered in step 2 is executed.

Check Program Step Sequence and Operation

Operator Action	Explanation
1. Depress stop key.	Halts processing and initiates manual mode.
2. Depress SIE key.	Each depression causes the execution of one instruction.
3. Depress SCE key.	The OP code and the address of the next instruction to be executed are displayed in the OP register and MAR.
4. Depress SIE key.	The instruction displayed in step 3 is executed. Steps 3 and 4 can be alternated to display succeeding instructions.

Display P and Q Addresses

Operator Action	Explanation
1. Depress stop key.	Halts processing and initiates manual mode.
2. Depress SIE key until the instruction that contains the desired address is next.	One instruction is executed with each depression of the SIE key.
3. Depress the SCE key eight times.	This steps through the eight I cycles.
4. *Note the on/off conditions of the machine status and check indicators and of the signal lights to be reset by Reset (step 5), so that proper restart can be initiated after the display has been completed.* At this time a branch to the original instruction also must be inserted if it is desired to execute this instruction and proceed with the normal program. (If reset and the subsequent necessity for branching and proper restart are undesirable, step 5 can be omitted and the P and Q addresses can be viewed, two digits at a time, during SCE.)	
5. Depress reset key.	Initiates manual mode.
6. Turn MARS switch to OR-1 (Operand Address Register 1) and depress the display MAR key.	The Q address, which is in OR-1, is displayed in MAR.

7. Turn MARS switch to OR-2 (Operand Address Register 2) and depress the display MAR key.	The P address, which is in OR-2, is displayed in MAR.

Reset Core Storage to Zeros

Operator Action	Explanation
1. Depress stop key.	Halts processing and initiates manual mode.
2. Depress insert key.	Typewriter is conditioned to enter data into core storage, beginning at location 00000.
3. Type: 26 00008 00009	Enter instruction to transmit field from location 00009 to 00008.
4. Depress release key.	Releases typewriter.
5. Depress start key.	The instruction entered in step 3 is executed. The zero at 00009 is transmitted to 00008. Since the next location read is always the zero previously transmitted, there is no flag bit to halt the operation. Approximately 0.8 seconds is required to clear the entire 20,000 positions of core storage.
6. Depress instant stop key.	The operation is stopped with the machine in manual mode.

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