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**ELLIOTT**

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**ELLIOTT**

# **MCS 920 FACTS**

## FACTS FOR ENGINEERS

The M.C.S. 920 is a rugged and compact digital computer that is particularly suited to the solution of on-line real time problems. Some typical applications are:

- Mobile systems for Air Traffic Control;
- Navigation;
- Weapon and fire control systems;
- Control of satellite tracking aerials;
- Industrial uses.

The Computer can be supplied in two packs, light alloy casting or a standard cabinet. Generally the former meets the British Military Defence Specification D.E.F.133 (L2) whereas the latter meets D.E.F.133 (L1). Silicon semi-conductors are used throughout giving a working temperature range of 0°C to +52°C.

The arithmetic unit of the computer forms a loop comprising the five basic registers and adding unit, in which the computer carries out its addition, subtraction and shifting operations. Gating conditionals produced by the control module, in response to the micro-program, manipulate the program operands within the loop in accordance with the instruction. The program control unit regulates the allocation of computer time when it has to be shared between programs. It can interrupt one program in order to enter and take action in another of higher priority. Thereafter, the computer will select the next program with the highest priority that is waiting for attention. These features of priority interrupt and instruction modification give an effective increase in speed over other computers without these facilities.

## PHYSICAL CHARACTERISTICS

	Length	Width	Height	Weight
Computer (light alloy casting)	3 ft. (91 cms.)	1 ft. (31 cms.)	1 ft. 2 ins. (35 cms.)	170 lbs. (78 Kg.)
Computer (standard cabinet)	2 ft. 6 ins. (76 cms.)	12 ins. (31 cms.)	3 ft. 6 ins. (107 cms.)	200 lbs. (91 Kg.)
Programmers Control Unit	2 ft. 3 ins. (68 cms.)	10 ins. (25 cms.)	5 ins. (13 cms.)	35 lbs. (16 Kg.)

## POWER SUPPLIES

50 Cycles AC mains  
Voltage 200-240 volts  $\pm$  10%  
Frequency 50  $\pm$  5 c.p.s.  
400 Cycle 3 phase  
Voltage 208 volts  $\pm$  6%  
Frequency 400  $\pm$  20 c.p.s.

## FACTS FOR PROGRAMMERS

The M.C.S. 920 is a parallel machine with an 18 bit word length. It utilizes 8 hole tape and has a memory of 4096 or 8192 words according to application. The fifth digit, from the least significant end of the eight digit tape character, is the parity digit and is ignored on input. There are 16 functions and the operations to execute them are detailed by a built-in micro-program.

The sign of the number is represented by the most significant digit with the binary point placed immediately after this digit. Positive numbers are represented directly and negative numbers by their complement with respect to two. The range of numbers that may be represented in the computer is thus from -1 to +1-2<sup>-17</sup>.

When a word represents an instruction, its digits are grouped as follows:—

B	F	N
Modifier	Function	Address

- Digits 1 to 13    -'N'-    Address digits which specify any one of 8192 store locations.
- Digits 14 to 17    -'F'-    Function digits which specify the operation to be carried out.
- Digit 18    -'B'-    The modifier digit which, if it is a
  - 0 ... the instruction is obeyed as stored, and if it is a
  - 1 ... the address digits are modified, before the instruction is obeyed, by the addition of the contents of the B Register. The function digits remain unaltered, and since the modification takes place in the control section, the version of the instruction held in store remains unchanged.

The Control Console provides:— a set of 13 Address Switches which enable a starting address to be selected; control buttons for the following:— power on; power off; clear— (which gives a jump instruction to the address set up on the Address Switches); computer stop; computer restart. There is also a loudspeaker with volume control which provides an audible identification of individual program operation.



# 920 TELECODE

Character	Numerical Value	Elliott (920) meaning	Character	Numerical Value	Elliott (920) Meaning
Zone 0			Zone 2		
00000.000	0	Blank	01010.000	32	:
00010.001	1	New Line (CRLF)	01000.001	33	A
00010.010	2		01000.010	34	B
00000.011	3		01010.011	35	C
00010.100	4		01000.100	36	D
00000.101	5		01010.101	37	E
00000.110	6		01010.110	38	F
00010.111	7		01000.111	39	G
00011.000	8	(	01001.000	40	H
00001.001	9	)	01011.001	41	I
00001.010	10	,	01011.010	42	J
00011.011	11	&	01001.011	43	K
00001.100	12	:	01011.100	44	L
00011.101	13	&	01001.101	45	M
00011.110	14	*	01001.110	46	N
00001.111	15	/	01011.111	47	O
Zone 1			Zone 3		
00110.000	16	0	01100.000	48	P
00100.001	17	1	01110.001	49	Q
00100.010	18	2	01110.010	50	R
00110.011	19	3	01100.011	51	S
00100.100	20	4	01110.100	52	T
00110.101	21	5	01100.101	53	U
00110.110	22	6	01100.110	54	V
00100.111	23	7	01110.111	55	W
00101.000	24	8	01111.000	56	X
00111.001	25	9	01101.001	57	Y
00111.010	26		01101.010	58	Z
00101.011	27		01111.011	59	
00111.100	28	=	01101.100	60	
00101.101	29	+	01111.101	61	
00101.110	30	-	01111.110	62	
00111.111	31	.	01101.111	63	

# 920 TELECODE

Character	Numerical Value	Elliott (920) Meaning	Character	Numerical Value	Elliott (920) Meaning
Zone 4			Zone 6		
10010.000	64	Space	11000.000	96	?
10000.001	65		11010.001	97	
10000.010	66		11010.010	98	
10010.011	67		11000.011	99	
10000.100	68		11010.100	100	
10010.101	69		11000.101	101	
10010.110	70		11000.110	102	
10000.111	71		11010.111	103	
10001.000	72		11011.000	104	
10011.001	73		11001.001	105	
10011.010	74		11001.010	106	
10001.011	75		11011.011	107	
10011.100	76		11001.100	108	
10001.101	77		11011.101	109	
10001.110	78		11011.110	110	
10011.111	79		11001.111	111	
Zone 5			Zone 7		
10100.000	80		11110.000	112	
10110.001	81		11100.001	113	
10110.010	82		11100.010	114	
10100.011	83		11110.011	115	
10110.100	84		11100.100	116	
10100.101	85		11110.101	117	
10100.110	86		11110.110	118	
10110.111	87		11100.111	119	
10111.000	88	[	11101.000	120	
10101.001	89	]	11111.001	121	
10101.010	90	10 (suffix)	11111.010	122	
10111.011	91	<	11101.011	123	
10101.100	92	>	11111.100	124	
10111.101	93	↑	11101.101	125	
10111.110	94	↓	11101.110	126	
10101.111	95	%	11111.111	127	Erase



## INSTRUCTION EXECUTION TIMES

Quoted below are 4096 and 8192 word stores times in micro-seconds for the total execution of each instruction and include: (a) Accessing and incrementing the Sequence Control Register, 9 and 11; (b) Accessing the instruction, 6 and 8; (c) Executing the instruction (depends on instruction). They do not include: B Modification, 6 and 8, and this must be added where relevant. It should be noted that the Sequence Control Register is incremented before the current instruction is obeyed.

FUNCTION	TITLE	EXECUTION TIME	
		4096 word store	8192 word store
0	Set B Register	27	33
1	Add	21	27
2	Negate and add	27	33
3	Store Auxiliary Register	21	27
4	Read	21	27
5	Write	21	27
6	Collate	27	33
7	Jump if zero	30 Acc. zero 24 Acc. +ve 21 Acc. -ve	36 28 25
8	Jump	21	27
9	Jump if Negative	27 Acc. -ve 21 Acc. +ve 21 Acc. zero	33 25 25
10	Count in store	24	30
11	Store S.C.R.	30	38
12	Multiply	180	186
13	Divide	186	192
14	Shift	24 + 9n	28 + 9n
15	Input/Output	24 (minimum)	28 (minimum)

The Auxiliary Register fulfils various roles. It should be noted that B modification affects its contents, as do instructions 0, 2, 6, 7, 8, 9, 11 and 13. In particular, instructions 0 and 2 place the operand from the store in the Auxiliary Register. Thus the contents of the Auxiliary Register previously stored by instruction 8 can be reset in 60/70 micro-seconds by obeying instructions 0 or 2 followed by a left shift, whereas resetting by multiplication or shifting from the accumulator would take about 200 micro-seconds.

## INPUT AND OUTPUT INSTRUCTIONS

If the most significant digit of N is zero, the instruction is an input instruction; otherwise it is an output instruction.

The instruction is further described by the N digits as follows: 15 N (N ≤ 2047) — 18 digit number input to accumulator from the device specified by N. □ 15 2048 — Input to accumulator from tape reader. The contents of the accumulator are shifted left seven places and the character from the tape reader is placed in the seven least significant digit positions. The fifth digit of the eight digit tape character is the parity and is ignored on input. □ 15 N (4096 ≤ N ≤ 6143) — 18 digit number in accumulator is output to the device specified by N. □ 15 6144 — Output from accumulator via paper tape punch. The eight least significant digits of the accumulator are output as an eight digit character on paper tape. □ 15 7168 — "Program terminate" instruction.

## PRIORITY LEVEL PROGRAM ORGANISATION

Each priority level has its own Sequence Control Register and B Register. These registers are locations in the store and can be referred to by program in the normal way.

PRIORITY LEVEL	B. REG. LOCATION	S.C.R. LOCATION
1	1	0
2	3	2
3	5	4
4	7	6

The Accumulator and the Auxiliary Register are shared between all four levels, so they must be safeguarded by program every time an interrupt occurs. It will also usually be necessary to reset the Sequence Control Register on terminating a level so that the program, when next demanded, will start again at the same location. All these conditions are fulfilled by the following control instructions. They are applicable to any program on levels 1, 2 or 3 which starts at location N.

LOCATION INSTRUCTION		REMARKS
Function	Address	
[N-6]	—	Store for lower level AR.
[N-5]	—	Store for lower level Acc.
[N-4]	0	Reset lower level AR.
[N-3]	14	1
[N-2]	4	N-5
[N-1]	15	7168
ENTRY [N]	5	N-5
[N+1]	3	N-6
[N+]		
		Reset lower level Acc.
		Terminate, Note S.C.R. reset to N.
		Store lower level Acc.
		Store lower level AR.
		Required program (x locations).
[N+2+x]	8	N-4
		Jump to reset for lower level.



If the B Register has to be retained unaltered for each subsequent entry, then the instruction in N-4 must be replaced by 2 N-8. If the contents of the AR on the lower level are not required then instructions N-4, N-3 and N+1 can be omitted and store location N-6 is not required. Rules for the punching of instructions and data in teleprinter code are given in the "920 Translation Input Routine" obtainable on demand.

## INITIAL INSTRUCTIONS

A set of permanently available Initial Instructions facilitate the reading of program tapes into the computer. These are obtained for either 4096 or 8192 word store computers by entering the same starting address which corresponds to the last 12 store locations.

The Initial Instructions and their respective addresses for a 8192 word store are tabulated below.

ADDRESS	INSTRUCTION			EFFECT
'N'digits	'B'	'F'	'N'	
8180	15	8189	(-3)	
8181	00	8180	(Set B-Register to -3)	
8182	04	8189	(Set Accumulator initially)	
8183	15	4084	(Shift and input tape character)	
8184	09	8186	(Jump to 8186 if Accumulator is negative)	
8185	08	8183	(Jump to 8183 if Accumulator is positive)	
8186	15	4094	(Shift and input final tape character of word)	
8187	05	8180	(Store word read in)	
8188	10	0001	(Count in B-Register)	
8189	04	0001	(Read B-Register)	
8190	09	8182	(Jump to 8182 if Accumulator is negative)	
8191	08	8177	(Jump to 8177 if Accumulator is positive)	

## NOTES

Instructions 15 4084 and 15 4094 have the same effect as 15 2048. When entered at 8181 the routine initially reads words into 8177, 8178, and 8179, control is then transferred to location 8177. If these instructions set the B register to -n and then transfer control to 8182, words can then be read into the sequence of n locations ending at 8179. Control is then transferred again to location 8177 so that a transfer instruction read into that location can trigger the program.

## POWERS OF 2 IN DECIMAL

2 <sup>n</sup>	n	2 <sup>n</sup>
2	1	.5
4	2	.25
8	3	.125
16	4	.0625
32	5	.03125
64	6	.015625
128	7	.0078125
256	8	.00390625
512	9	.001953125
1024	10	.0009765625
2048	11	.00048828125
4096	12	.000244140625
8192	13	.0001220703125
16384	14	.00006103515625
32768	15	.000030517578125
65536	16	.0000152587890625
131072	17	.00000762939453125
262144	18	.000003814697265625
524288	19	.0000019073486328125
1048576	20	.00000095367431640625
2097152	21	.000000476837158203125
4194304	22	.0000002384185791015625
8388608	23	.00000011920928955078125
16777216	24	.000000059604644775390625
33554432	25	.000000029802322387695313
67108864	26	.000000014901161193847656
134217728	27	.000000007450580596923828
268435456	28	.000000003725290298461914
536870912	29	.000000001862645149230957
1073741824	30	.000000000931322574615479
2147483648	31	.000000000465661287307739
4294967296	32	.000000000232830643653870
8589934592	33	.000000000116415321826935
17179869184	34	.000000000058207660913467
34359738368	35	.000000000029103830456734
68719476736	36	.000000000014551915228367
137438953472	37	.000000000007275957614183
274877906944	38	.00000000000363797807092
549755813888	39	.000000000001818989403546
1099511627776	40	.000000000000909494701773

## SOME USEFUL CONSTANTS

$\pi$	= 3.141 592 653 590	$1/\pi$	= 0.318 309 886 184
$\log_{10} e$	= 0.434 294 481 903	$\log_{10} 10$	= 2.302 585 092 994
$\log_{10} 2$	= 0.301 029 995 664	$e$	= 2.718 281 828 459
$\sqrt{2}$	= 1.414 213 562 373	$\sqrt{3}$	= 1.732 050 807 569
1 radian	= 57.295 779 513 082°	1°	= 0.017 453 292 520 radian



## TABLES OF BINARY EQUIVALENTS

The purpose of these tables is to assist in the setting of binary addresses on the word generator.

1. Select the highest multiple of 64 less than (or equal to) the required address, and work out the difference (if any).
2. Set the first 7 switches (from the left) to the binary equivalent of the multiple, working from Table A.
3. Set the last 6 switches to the binary equivalent of the difference, working from Table B.

### TABLE A

Multiple of 64	Binary Equivalent	Multiple of 64	Binary Equivalent	Multiple of 64	Binary Equivalent
0	0000000	2048	0100000	4096	1000000
64	0000001	2112	0100001	4160	1000001
128	0000010	2176	0100010	4224	1000010
192	0000011	2240	0100011	4288	1000011
256	0000100	2304	0100100	4352	1000100
320	0000101	2368	0100101	4416	1000101
384	0000110	2432	0100110	4480	1000110
448	0000111	2496	0100111	4544	1000111
512	0001000	2560	0101000	4608	1001000
576	0001001	2624	0101001	4672	1001001
640	0001010	2688	0101010	4736	1001010
704	0001011	2752	0101011	4800	1001011
768	0001100	2816	0101100	4864	1001100
832	0001101	2880	0101101	4928	1001101
896	0001110	2944	0101110	4992	1001110
960	0001111	3008	0101111	5056	1001111
1024	0010000	3072	0110000	5120	1010000
1088	0010001	3136	0110001	5184	1010001
1152	0010010	3200	0110010	5248	1010010
1216	0010011	3264	0110011	5312	1010011
1280	0010100	3328	0110100	5376	1010100
1344	0010101	3392	0110101	5440	1010101
1408	0010110	3456	0110110	5504	1010110
1472	0010111	3520	0110111	5568	1010111
1536	0011000	3584	0111000	5632	1011000
1600	0011001	3648	0111001	5696	1011001
1664	0011010	3712	0111010	5760	1011010
1728	0011011	3776	0111011	5824	1011011
1792	0011100	3840	0111100	5888	1011100
1856	0011101	3904	0111101	5952	1011101
1920	0011110	3968	0111110	6016	1011110
1984	0011111	4032	0111111	6080	1011111

### TABLE B

Multiple of 64	Binary Equivalent	Differ- ence	Binary Equivalent	Differ- ence	Binary Equivalent
6144	1100000	0	000000	32	100000
6208	1100001	1	000001	33	100001
6272	1100010	2	000010	34	100010
6336	1100011	3	000011	35	100011
6400	1100100	4	000100	36	100100
6464	1100101	5	000101	37	100101
6528	1100110	6	000110	38	100110
6592	1100111	7	000111	39	100111
6656	1101000	8	001000	40	101000
6720	1101001	9	001001	41	101001
6784	1101010	10	001010	42	101010
6848	1101011	11	001011	43	101011
6912	1101100	12	001100	44	101100
6976	1101101	13	001101	45	101101
7040	1101110	14	001110	46	101110
7104	1101111	15	001111	47	101111
7168	1110000	16	010000	48	110000
7232	1110001	17	010001	49	110001
7296	1110010	18	010010	50	110010
7360	1110011	19	010011	51	110011
7424	1110100	20	010100	52	110100
7488	1110101	21	010101	53	110101
7552	1110110	22	010110	54	110110
7616	1110111	23	010111	55	110111
7680	1111000	24	011000	56	111000
7744	1111001	25	011001	57	111001
7808	1111010	26	011010	58	111010
7872	1111011	27	011011	59	111011
7936	1111100	28	011100	60	111100
8000	1111101	29	011101	61	111101
8064	1111110	30	011110	62	111110
8128	1111111	31	011111	63	111111