REPORT THE THE PROPERTY OF THE

903
computer
FACTS

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GENERAL INFORMATION

The Elliott 903 is a desk-sized computer designed to meet the exacting requirements of science, industry and education. Developed from the successful Elliott 920, a second generation military computer, the 903 inherits a rugged reliability and is equally suitable for on or off-line applications Typical applications include:

Engineering Design

Medical Research

Structural Analysis and Design

Research and Teaching in all Educational Institutions

Process Control

Plant and System Simulation Studies

Computer Typesetting

Real Time Collection of Experimental Data etc.

The basic 903 system comprises a central processor, 8,192 word core store, paper tape input and output equipment and control panel, all housed in a single desk-type cabinet.

Input/output facilities consist of a tape reader, tape punch, teleprinter and an 18-bit parallel data highway, to which up to 2,048 peripheral

devices may be attached.

With its large, high-speed immediate access store, effective instruction code and full hardware arithmetic and input/output facilities, the 903 has a versatility and performance previously associated with larger and more costly systems. It is backed by a wide range of peripherals and effective software which are described elsewhere in this booklet.

Weight: (complete with tape reader and punch) 470 lb. Power Requirements: 250 volts a.c. 50 c/s, 120 W.

Dimensions: (desk version, excluding paper tape equipment):

Height: 3ft. 1 in., Depth 2ft. 2 in., Width 3ft. 7 in

903 TELECODE

The standard 903 telecode is the International Standards Organisation 8-track code which is also used by the NCR-Elliott 4100 system. The paper tape station can however read and punch 5, 6, 7 and 8 track paper tape, a facility of great value in the reduction of 'captive data'.

FACTS FOR PROGRAMMERS

The 903 is a binary machine with an 18-bit word length and an internal memory of 8.192 words. The store may be extended to a maximum of 65,536 words by the external addition of store blocks of 8,192 words.

Positive integers are represented directly. Negative integers are represented using the "two's complement" notation. The range of integers allowed by single length working is -131072 to +131071. Greater range and accuracy are obtained by multi-length working.

For floating point working, two words are used to hold one number An instruction is stored and interpreted in the following manner:

F	N
Function	Address
bits 17–14	bits 13–1
	F Function bits 17–14

Bits 13 to 1 ('N') Address bits which specify any of 8,192 store locations.

Bits 17 to 14 ('F')

Function bits which specify the operation to be carried out.

Bit 18 ("B")

The modifier bit. If it is a 0, the instruction is obeyed as stored; if it is a 1, the address bits are modified before the instruction is obeyed by the addition of the contents of the B Register. The function bits remain unaltered and the version of the instruction held in store remains unchanged.

The Control Unit provides either manual or automatic control over the computer. It can also be used to test operation of the computer independently of its peripheral system.

In the "AUTO" mode, only the power ON/OFF, RESET and TRACE controls are operative. When switched ON in this mode, the computer jumps to the program trigger location 8177 and commences operation.

The number generator keys are operative for setting up starting addresses when the Mode Switch is either in the OPERATE or TEST position. The Control Unit provides the following: Power ON/OFF, COMPUTER STOP, COMPUTER RESTART, COMPUTER RESET, JUMP.

With the Mode Switch in the TEST position additional number generator keys are operative, allowing complete instructions to be set up and the following special test controls are provided: ORDER

STOP/CYCLE STOP, CYCLE REPEAT, ENTER, OBEY.

A loudspeaker with volume control is provided as an audible means of identifying individual program operation. Manual priority level control is effected by three buttons while associated lights indicate the level at which the computer is currently operating.

903 PAPER TAPE AND INTERNAL CODES

ISO Code				ISO Code	Value Telecode	0/	SIR Internal Code				
Value	Parity	Character	Pattern	Octal	Decimal	Value	Parity	Character	Binary Pattern	Octal	Decimal
0	1 0	blank	00000-000			64	192	(grave)	11000-000	40	1 22
1	129	Marik	10000-001			65.		·(grave)			32
2	130		100000001		1 1		65	-	01000-001	41	33
3	3	1	10000-010			66	66	В	01000-010	42	34
4			00000-011			67	195	C	11000-011	43	35
1 2	132	aic aic	10000-100			68	68	D	01000-100	44	36
5	0		00000-101		100	69	197	E	11000-101	45	37
6	6		00000-110			70	198	F	11000-110	46	38
7	135	Bell ^{3,4}	10000-111		- 3	71	71	G	01000-111	47	39
8	136		10001-000			72	72	Н	01001-000	50	40
9	9	Hor. Tab1	00001-001	1		73	201		11001-001	51	41
10	10	Line Feed ²	00001-010	01	1	74	202	l i	11001-010	52	42
11	139		10001-011			75	75	K	01001-011	53	43
12	12		00001-100			76	204	l î	11001-100	54	44
13	141	Car. Ret.3,4	10001-101			77	77	M			
14	142	Car. net.	10001-110		100		70		01001-101	55	45
15						78	78	N	01001-110	56	46
	15		00001-111	12		79	207	0	11001-111	57	47
16	144		10010-000			80	80	P	01010-000	60	48
17	17		00010-001			81	209	Q	11010-001	61	49
18	18	(=)	00010-010			82	210	R	11010-010	62	50
19	147		10010-011			83	83	S	01010-011	63	51
20	20	Halt1,4	00010-100		100	84	212	S	11010-100	64	52
21	149		10010-101			85	85	Ü	01010-101	65	53
22	150		10010-110			86	86	v	01010-110	66	54
23	23		00100-111			87		VA.			
24	24					88	215	ŵ	11010-111	67	55
26	153		00011-000				216	X	11011-000	70	56
20		La transfer	10011-001			89	89	Y	01011-001	71	57
20	154		10011-010			90	90	Z [£	01011-010	72	58
21	27		00011-011			91	219	[11011-011	73	59
28	156		10011-100			92	92	£	01011-100	74	60
29	29		00011-101			93	221	1	11011-101	75	61
30	30		00011-110			94	222	Ť	11011-110	76	62
21 22 23 24 25 26 27 28 29 30 31	159 160	Space	10011-111	00	0	95	95	-3,4	01011-111	77	63
31 32	159	Space		00	0			@1			
31 32	159	Space	10011-111	00	0	95	95	-3,4	01011-111		
31 32	159	Space	10011-111	00	0	95	95	-3,4	01011-111		
2	159	Space	10011-111	00 		95	95	-3,4	01011-111		
2]	159 160	n n	10011-111	00 H	•	95 96	95 96		01011-111	77	63
33 34	159	Spans	10011-111	00	0	95	95	-3,4	01011-111		
33 34 35	159 160	1	10011-111 10100-000 00100-001 00100-010	02	2	95 96 97 98	95 96 225 226	e''	01011-111 01100-000 11100-001 11100-010	77 41 42	63 33 34
33 34 35	159 160 33 34 163		10011-111 10100-000 00100-001 00100-010 10100-011	02	2 3	95 96 97 98 99	95 96 225 226 99	e ·	01011-111 01100-000 11100-001 11100-001 01100-011	77 41 42 43	33 34 35
33 34 35	159 160 33 34 163 36		00100-001 00100-001 00100-010 0100-010 0100-010	02 03 04	2 3 4	95 96 97 98 99 100	95 96 225 226 99 228	+ ®	01011-111 01100-000 11100-001 11100-010 01100-010 11100-100	77 41 42 43 44	33 34 35 36
33 34 35 36 37	159 160 33 34 163 36 165	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0011-111 10100-000 00100-001 00100-010 10100-010 10100-100	02 03 04 05	2 3 4 5	95 96 97 98 99 100 101	95 96 225 226 99 228 101	a b c d e	01011-111 01100-000 11100-001 11100-011 11100-010 01100-101 01100-101	41 42 43 44 45	33 34 35 36 37
33 34 35 36 37 38	33 34 163 36 165 166	p.564+ 1-2	0010-001 00100-001 00100-011 00100-011 00100-101 10100-101 10100-101	02 03 04 05 06	2 3 4 5 6	95 96 97 98 99 100 101 102	95 96 225 226 99 228 101 102	a b c d e f	01011-111 01100-000 11100-001 11100-010 01100-011 11100-100 01100-101 01100-101	41 42 43 44 45 46	33 34 35 36 37 38
33 34 35 36 37 38 39	33 34 163 36 165 166 39	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0011-111 10100-000 00100-001 00100-010 10100-101 10100-101 10100-110 00100-101	02 03 04 05 06 07	2 3 4 5 6 7	95 96 97 98 99 100 101 102 103	95 96 225 226 99 228 101 102 231	e b c d e f	01011-111 01100-000 11100-001 11100-011 11100-010 01100-101 01100-101 01100-101 01100-101	41 42 43 44 45 46 47	33 34 35 36 37 38 39
33 34 35 36 37 38 39 40	33 34 163 36 165 166 39 40	p.564+ 1-2	0010-001 00100-001 00100-010 10100-011 00100-101 10100-111 00100-110 00100-111 00101-000	02 03 04 05 06 07 10	2 3 4 5 6 7 8	95 96 97 98 99 100 101 102 103 104	95 96 225 226 99 228 101 102 231 232	e b c d e f g h	01011-111 01100-000 11100-011 11100-010 01100-011 11100-110 11100-111 11100-101 11100-111 11101-000	41 42 43 44 45 46 47 50	33 34 35 36 37 38 39 40
33 34 35 36 37 38 39 40 41	33 34 163 36 165 166 39 40 169	p.564+ 1-2	0010-001 00100-001 00100-001 00100-010 10100-101 10100-101 10100-101 10100-101 10100-101 10101-000	02 03 04 05 06 07 10	2 3 4 5 6 7 8 9	95 96 97 98 99 100 101 102 103 104 105	95 96 225 226 99 228 101 102 231 232 105	e b c d e f	01011-111 01100-000 11100-000 11100-010 01100-011 11100-110 11100-110 11100-111 11101-000 01101-001	41 42 43 44 45 46 47 50 51	33 34 35 36 37 38 39 40 41
33 34 35 36 37 38 39 40 41 42	33 34 163 36 165 166 39 40 169 170	p.564+ 1-2	00100-001 00100-001 00100-010 10100-011 10100-110 10100-111 00100-111 00100-111 00100-111 00100-101 10101-001	02 03 04 05 06 07 10 11 12	2 3 4 5 6 7 8 9	95 96 97 98 99 100 101 102 103 104 105 106	95 96 225 226 99 228 101 102 231 232 105 106		11100-001 11100-001 11100-011 11100-010 01100-011 11100-101 01100-110 11100-111 11101-000 01101-001 01101-010	41 42 43 44 45 46 47 50 51 52	33 34 35 36 37 38 39 40 41 42
33 34 35 36 37 38 39 40 41 42 43	33 34 163 36 165 166 39 40 169 170 43	p.564+ 1-2	0010-001 00100-001 00100-001 00100-010 10100-101 10100-101 10100-101 10100-101 10100-101 10101-000	02 03 04 05 06 07 10	2 3 4 5 6 7 8 9	95 96 97 98 99 100 101 102 103 104 105	95 96 225 226 99 228 101 102 231 232 105	e b c d e f g h	01011-111 01100-000 11100-000 11100-010 01100-011 11100-110 11100-110 11100-111 11101-000 01101-001	41 42 43 44 45 46 47 50 51	33 34 35 36 37 38 39 40 41
33 34 35 36 37 38 39 40 41 42 43 44	33 34 163 36 165 166 39 40 169 170	p.564+ 1-2	00100-001 00100-001 00100-010 10100-011 10100-110 10100-111 00100-111 00100-111 00100-111 00100-101 10101-001	02 03 04 05 06 07 10 11 12	2 3 4 5 6 7 8 9	95 96 97 98 99 100 101 102 103 104 105 106	95 96 225 226 99 228 101 102 231 232 105 106		11100-001 11100-001 11100-011 11100-010 01100-011 11100-101 01100-110 11100-111 11101-000 01101-001 01101-010	41 42 43 44 45 46 47 50 51 52	33 34 35 36 37 38 39 40 41 42
33 34 35 36 37 38 39 40 41 42 43	33 34 163 36 165 166 39 40 169 170 43 172	12 -4 -4 -5 -8 (acute) (0011-111 10100-000 00100-001 00100-010 10100-101 10100-101 10100-101 10100-101 10101-001 10101-010 00101-011 10101-010 00101-011	02 03 04 05 06 07 10 11 12 13	2 3 4 5 6 7 8 9 10 11 11 12	95 96 97 98 99 100 101 102 103 104 105 106 107 108	95 96 225 226 99 228 101 102 231 105 106 235 108	+ @ abcdef shink	01011-111 01100-000 11100-000 11100-010 01100-011 11100-110 11100-110 11100-110 11100-110 11101-010 01101-011 01101-011 01101-011 01101-011	41 42 43 44 45 46 47 50 51 52 53 54	33 34 35 36 37 38 39 40 41 42 43 44
33 34 35 36 37 38 39 40 41 42 43 44	33 34 163 36 165 166 39 40 169 170 43	12 -4 -4 -5 -8 (acute) (00100-001 00100-001 00100-010 10100-010 10100-010 10100-110 10100-110 10100-110 10101-001 10101-010 10101-010 10101-010 10101-010 10101-101 00101-111	02 03 04 05 06 07 10 11 12 13 14 15	2 3 4 5 6 7 8 9 10 11 12 13	97 98 99 100 101 102 103 104 105 106 107 108 109	95 96 225 226 99 228 101 102 231 232 106 235 108 237		0101-111 01100-000 11100-001 11100-010 01100-011 11100-101 01100-110 11100-110 11100-110 11101-010 11101-011 01101-011 01101-011 01101-011 01101-010	77 41 42 43 44 45 46 47 50 51 52 53 54 55	33 34 35 36 37 38 39 40 41 42 43 44 45
33 34 35 36 37 38 39 40 41 42 43 44 45 46	33 34 163 36 165 166 39 40 169 170 43 172 45 46	12	0010-001 00100-001 00100-001 00100-010 10100-010 10100-101 10100-101 10100-101 10101-010 00101-011 10101-101 00101-011 10101-101 00101-101 00101-101	02 03 04 05 06 07 10 11 12 13 14 15 16	2 3 4 5 6 7 8 9 10 11 12 13 14	95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110	95 96 225 226 99 228 101 102 231 232 106 106 235 108 237 238	abcdef Shink _ En	0101-111 01100-000 11100-000 11100-010 01100-011 11100-100 01100-110 11100-110 11101-010 01101-011 01101-110 01101-100 11101-101 11101-100 11101-101	41 42 43 44 45 46 47 50 51 52 53 54 55 56	33 34 35 36 37 38 39 40 41 42 43 44 45
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33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50	33 34 163 36 165 166 39 40 170 43 172 45 46 175 48 177 178	(acute) (comma)	00100-001 00100-001 00100-001 00100-010 10100-010 10100-010 10100-101 10100-110 00101-011 10101-010 00101-111 10101-101 00101-111 00101-001 10101-010 10101-101 00101-111	02 03 04 05 06 07 110 111 12 13 14 15 16 16 17 20 21 22	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	97 98 99 99 100 101 103 104 105 106 107 108 109 110 111 112 113 114	95 96 225 226 99 228 101 102 231 105 235 106 235 106 237 238 111 240 113	abodet Shijik _ Enopgr	11100-001 11100-000 11100-010 11100-010 01100-011 11100-101 01100-110 11100-110 11101-100 11101-101 11101-101 11101-101 11101-101 11101-111 11101-100 011101-111 11101-000 011101-010	41 42 43 44 45 46 47 50 51 52 53 54 56 56 60 61 62	33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
33 34 35 36 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51	33 34 163 36 166 39 170 43 172 45 46 177 178 51	12 3 4 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	00100-001 00100-001 00100-001 00100-100 10100-101 10100-101 10100-101 10101-101 00101-001 10101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-001	02 03 04 06 07 07 11 12 13 14 15 16 17 20 21 22 23	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	97 98 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 111 112 113 114 115	95 96 225 226 99 228 101 102 231 105 106 235 108 237 238 111 240 113 114 243	abcdefghijk_Enopgrs	11100-001 11100-000 11100-000 11100-010 01100-011 11100-100 01100-110 11101-010 01101-011 01101-101 01101-110 01101-111	41 42 43 44 45 46 47 50 51 52 53 54 56 57 60 61 62 63	33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52	33 34 163 36 165 166 39 40 170 43 172 45 48 175 48 177 178 51 180	3" -4" -4" -4" -4" -4" -4" -4" -4	00100-001 00100-001 00100-010 10100-010 10100-011 10100-111 10100-110 00100-111 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10101-101 10110-010 10110-011	02 03 04 05 06 07 10 11 12 13 14 15 16 17 20 21 22 23 24	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 19 20	95 96 97 98 99 100 101 102 103 104 105 107 108 109 110 111 112 113 114 115	95 96 225 226 99 228 101 102 231 232 106 235 108 237 238 111 240 1113 114 243 116	⊕ abcdef Shijk, mopqrst	11100-001 11100-000 11100-001 11100-010 01100-011 11100-100 01100-101 01100-101 01101-001 01101-001 01101-101 11101-100 11101-110 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-001 01110-001 01110-001	41 42 43 44 45 46 47 50 51 52 53 54 55 60 61 62 63 64	33 34 35 36 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 51 52
33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53	33 34 36 165 166 39 170 43 172 46 177 48 177 178 51 180 53	1	00100-001 00100-001 00100-001 00100-010 10100-010 10100-101 10100-101 10100-101 10101-001 10101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 00101-101 10110-001 10110-001 10110-001 10110-010 10110-010 10110-101 00110-101	02 03 04 06 07 10 11 12 13 14 15 16 17 20 21 22 23 24 25	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21	97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 111 113 114 115 116	95 96 225 226 99 228 101 102 231 105 106 235 108 237 238 111 240 113 114 243 116 245	abcdefghijk_Enopgrs	0101-111 01100-000 11100-000 11100-010 01100-011 01100-110 01100-110 01100-110 01101-001 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01110-010 01110-010	41 42 43 44 45 46 47 50 51 52 53 54 56 67 60 61 62 63 64 65	63 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53
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33 34 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 55 56 56 57 58 56 60	159 160 33 34 163 36 165 166 39 170 43 172 45 46 178 51 180 53 54 183 184 183 184 57 58 187 60	1	00100-001 00100-001 00100-010 10100-010 10100-010 10100-010 10100-101 10100-101 10100-101 10101-010 00101-011 10101-101 00101-101 00101-101 00101-101 10101-001 10101-010 10101-011 10110-010 10110-011 10110-010 10110-011 10110-111 10110-110 10110-111 10110-110 10110-111 10110-110 10110-110 10110-110 10110-110 10110-110 10110-110 10111-110 10111-110 10111-111	02 03 04 05 06 07 10 11 12 13 14 15 16 17 20 21 22 23 32 24 25 27 30 31 32 33 34	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 22 23 24 25 27 28 29 29 29 20 20 20 20 20 20 20 20 20 20 20 20 20	95 96 97 98 99 100 101 102 103 104 105 107 108 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 121 122 123 124	95 96 96 225 226 99 228 101 102 231 232 105 106 235 108 237 238 111 240 1114 243 245 246 245 246 119 129 229 129 229 228 237 238 249 249 249 249 249 249 249 249 249 249	⊕ abudef Shijk _ Enopgrstuv Wxy	11100-001 11100-000 11100-000 11100-010 01100-011 11100-100 01100-110 01100-110 11100-110 01101-001 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01101-101 01110-101 01110-101 01110-101 01110-101 01110-101 01110-101 01111-101 01111-100 01111-101 01111-101 01111-101 01111-101 01111-101 01111-101	77 41 42 43 44 45 46 47 50 51 52 53 54 55 66 61 62 63 64 66 67 70 71	33 34 35 36 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 66 67

¹Ignored by Teleprinter ³Ignored by Flexowriter ⁴Space on Lineprinter ⁵Upper case on Teleprinter

BASIC INSTRUCTION CODE TIMES

Function		Effect	Time μs ⁵
1	¹ B-modification		6.5
ON	² B:=Q ₁₈₋₁ :=m	Set B-register	30-0
1 N	A:=A+m	Add	23.5
2 N	$\left\{ \begin{matrix} A:=m-A; \\ O_{18-1}:=m \end{matrix} \right\}$	Negate and Add	26.5
3 N	${m_{1s}:=0 \atop m_{17-1}:=\Omega_{1s-2}}$	Store Q-register	25-0
4 N	A:=m	LOAD	23.5
5 N	m:=A	STORE	25-0
6 N	A:=A and m	Collate	23.5
7 N	{if A=0 then S:=M } and Q:=undefined }	Jump if zero	21-04
8 N '	S:=M	Jump	24.0
9 N	\left\{\text{if A<0 then S:=M}\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	Jump if negative	21.04
10 N	m=m+1 (m ₁₃₋₁ :=(S+1) ₁₃₋₁)	Count in store	24-0
11 N	Q16-14:=(S+1)16-14	Store S-register	31-6
12 N	$\{Q_{13-1} := 0 \\ (A, Q) := A*m \}$	Multiply	76-5
1	A:= (A, Q) ±2-17		
13 N	Q:=A±2-17 A:=1;Q:=0	Divide	79.5
14 N	$\begin{cases} (A, Q) + Q_1 := ((A, Q) + Q_2) \\ (A, Q) + Q_2 := ((A, Q) + Q_3) \end{cases}$	Q,)*2Z-8192	Up to 48 places
Maria La	0040 47 .0444	Right shift	J 22+3Z
15 N	2048≤Z<6144 (Z=7168)	Block Transfer ³ Program terminate, i.e. return to lower level	20·5 (minimum)

- 1. In the first stage of B-modification the Q register is affected in an undefined manner, consequently the effect of a modified 3 instruction is undefined.
- Interrupt cannot occur after this instruction.
- Functions 14 and 15 are used with other addresses for input/output, and block transfer. Details are given against the relevant devices.
- Add 6-5µs if jump occurs.
- 5. All times are quoted to a tolerance of $\pm 10\%$.

A is contents of Accumulator (18 bits).

B is contents of B register for the current level (18 bits).

S is content of the sequence control register (containing the address of the current instruction). The S register is incremented before the instruction is obeyed.

Q is content of bits 18 to 2 of the Q register (extension Accumulator).

 $M = (S_{16-14}+N)_{16-1}$ or $(S_{16-14}+N+B)_{16-1}$ m is the contents of location M

 $Z = N \text{ or } (N+B)_{13-1}$

INSTRUCTIONS REFERRING TO THE BASIC PAPER TAPE STATION

Instruction	Effect	Time ¹	Status bits4
15 2048	Input one character from the paper tape reader to A ² , ³	20 - 5μs	1
15 2052	Input one character from the on-line teleprinter to A ² , ³	20·5μs	3
15 6144	Output one character (A ₁₋₈) to the paper tape punch ²	20-5µs	2
15 6148	Output one character (A ₁₋₈) to the on-line teleprinter ²	20-5μs	4

ADDITIONAL PAPER TAPE STATION FACILITIES

Instruction	Effect	Time	Status bits4
15 2050	Input one character from tape		1
15 2054	Input one character from tele- printer 2 to A ² , ³	20-5μs¹	3
15 6146	Output one character (A ₁₋₈) to punch 2 ²	20-5μs ¹	2
15 6150	Output one character (A ₁₋₈) to teleprinter 2 ²	20-5μs ¹	4
15 2049	Read status word ⁴	20-5µs	
15 6145	Output control word ⁴	20-5µs	
15 2051	Read status word of second paper tape station ⁴	20-5μs	
15 6147	Output control word to second paper tape station ⁴	20-5µs	7.5

- 1. If the device is busy, the computer will be held up and the instruction will only be obeyed when the device becomes free.
- 2. The select input and select output switches may be used to override the choice of source and destination respectively.
- 3. The exact effect of these instructions, if C1-8 is the character input, is defined as:

A₁₈₋₉:=A₁₁₋₂ (shift 7 places left) A₈:=A₁ or C₈

A₇₋₁:=C₇₋₁

If 7 track or 5 track tape is used C₈ or C₈-6 respectively are undefined

 Status and control functions are only available if the appropriate on-line adaptor is fitted. If the indicated bit of the status word is one the appropriate device is available and the given instruction will be completed in the time shown.

If the device is not available the output or input instruction will be held up, unless the paper tape station is in on-line mode, set by output, control with A=1. Return to off-line mode by output control with A=0 or RESET.

INSTRUCTIONS REFERRING TO THE DIGITAL PLOTTER

Instruction	Effect	Time ¹
15 4864	Output one character to the plotter.	20-5μs
14 4864	Output Q characters (1 \leq Q \leq 4095) to the plotter. Characters are held one to a word. A contains the address of the first character.	sum of busy times for each character

Bit of word output	Effect	Time ²
1	Move one step East.	h
3	Move one step West.	00
3	Move one step North.	> 3.3ms
4	Move one step South.	
5	Raise pen.	Ĭ.
6	Lower pen.	∫ 20ms

If the device is busy, there will be a delay and the instruction will only be obeyed when the device becomes free.

9 KCS MAGNETIC TAPE FACILITIES

Programs are available for reading and writing blocks and records of data, and opening and closing magnetic tape files. The 903 9kcs Magnetic Tapes should normally be used via these routines. Details of the instruction code will be found in the Technical Manual. The status word read from the controller is usually printed when a non-recoverable error occurs. This may be interpreted by the table given below.

Bit	Meaning when set to 1 in status word
and the second second	Handler busy (rewinding)
2	Handler in manual, or not available. All other bits undefined
3	Missed data transfer
4	Parity error
5	Short block
6	Long block
7	Write permit ring fitted
8	Tape on load point
9	End of tape detected
10	False end of block
11	An instruction has been rejected as 'Do Nothing'

Tape speed: 45 inches/sec.

Rewind speed: 180 inches/sec. (approx.)

Density: 200 characters/inch (3 characters per word)

Inter block gap: 0-75 inches

Block length: Between 5 and 2047 words

Start/stop time: 18 millisec. (approx.)

Maximum tape length: 2400 feet

² Time for which the plotter is busy and cannot accept another instruc-

PRIORITY LEVEL PROGRAM ORGANISATION

Each priority level has its own sequence control register (SCR) and B register. These registers are locations in the store and can be referred to by program in the normal way.

A program may not address its own SCR location. It may address the SCR location of other priority levels.

Priority Level	B. Reg. Location	S.C.R. Location
1 highest level	1	0
2	3	2
3	5	4
4 base level	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. 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 ENTRY.

15 7168 (Terminate)

ENTRY 5 A1 (A1 and Q1 must be distinct)

3 Q1 (for each interrupt program)
(INTERRUPT LEVEL PROGRAM)

8 L A1 +0 Q1 +0

Note that this program does not preserve bit 1 of Q.

Programs entered by the JUMP button are obeyed from level 1. The Initial program should set up locations 2, 4 and 6 to appropriate addresses, then terminate to level 4, which is regarded as the base level.

INITIAL INSTRUCTIONS

Locations 8180 to 8191 inclusive are used for the initial instructions, used to input an initial program loader punched in 'binary' form. These instructions are entered on level 1 at location 8181. On 903 processors fitted with more than 8192 words of core store the locations 8180 to 8191 may be used as normal core store when the initial instructions are 'disabled'. The instructions are disabled whenever a 15 7168 is obeyed. They are enabled whenever the JUMP button is pressed. The contents of 8180 to 8191 will be preserved unless program is obeyed from those locations. The effect of reading these locations on a basic machine or while the instructions are enabled should be regarded as undefined.

The instructions are as follows:

39	8180	/15	8189	(-3)	
	ENTRY			(-0)	
		4	8189		
	8183	15	2048		
		9	8186		
	8185	8	8183		
		15	2048		
	8187	/5	8180		
		10	1		
	8189	4	1		
		9	8182		
	8191	8	8177	(Trigger to	program)

STORE ADDRESSING

The basic 8192 words of store can be addressed directly by the 13 bit instruction address (N). Larger stores are considered to be divided into modules of 8192 words (Module numbers from 0 to 7). Within each module, program and data are addressed relative to the first location (location 0) of that module. B-modification is used to access program and data outside the current module. The address actually accessed is (S_{1e-14}+N+B)_{1e-1} therefore the address used for modification must be relative to the current module. Attempts to address store modules not fitted cause the processor to hold up.

SYMBOLIC INPUT ROUTINE

Symbolic Input Routine (SIR) enables programs to be written in modified machine code form. Essential details of SIR are given below. Full details of the routine can be obtained from the SIR Handbook.

S.I.R. Symbols used for the Major Facilities

- (i) IDENTIFIER Group of up to six letters or numbers commencing with a letter.
- (ii) GLOBAL IDENTIFIER LIST [] e.g. [CAT "DOG RAT] (CAT and RAT are Global, DOG is Sub-Global.)
- (iii) CONSTANTS

(a) Integer or fraction	± e.g71032
(b) Octal groups	& e.g. & 770123
(c) Alphanumeric groups	£ e.g. £ A23

(iv) ADDRESSES

(a) Absolute	an unsigned integer
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- (b) Block relative address N; (c) S.I.R. relative ;±N
- (d) Identified address Identifier ± Integer (if required)
- (e) Literal address

 Any constant as in (ii) above or = followed by a quasi instruction (absolute address only)
- (v) SKIP >+N
- (vi) COMMENT (THIS IS A COMMENT)
- (vii) PATCH † A (viii) RESTORE \$
- (ix) OBEYED INSTRUCTION (* e.g. ' 8 A * (x) END OF TAPE (HALT CODE)
- (xi) END OF PROGRAM 9

(Locate literals, cancel Sub-Global identifiers, list undeclared Global Identifiers and display a FIRST LAST NEXT message.)

Note

N is an unsigned integer.

A is any currently located address.

(xii) OPTION

*N where N is the sum of the following:

		Availability		
Value	Effect	Load GO	Non- Load GO	Check
1	Display labels.	0 or 1	0 or 1t	1
2	Load and go operation (otherwise punch relocatable binary tape).	1	0	0
4	Clear the store up to the assembler.	0 or 1	0	0
8	Punch a binary loader tape.	0	0 or 1	0
16	Continue assembly at location 32.	0 or 1	0	0
32	Set dictionary below the program.	0 or 1	0	0
64	Check without assembly.	0	0	1

† 903C only.

N is an unsigned integer.

The presumed option is * + 3

ERROR INDICATIONS

Assembling

FO	E-1E	or quasi-instruction not absolute	
	P > 10	or duasi-instruction not absolute	

E1 Contextual error.

E2 Error in Octal or Alphanumeric Group.

E3 Label declared twice.
E4 Global identifier list error.
E5 Store full or patch error.

E6 Number overflow.

E7 Buffer overflow (over 120 characters in a line).

E8 Illegal character.

E9 Step code not first on line.

EG Global label error.

EL Literal error.

EP Patch or Obeyed instruction error.

EU Unlocated identifier.

Loading

FA	M	ieroad	or m	isnunc	had	tane

FC Label used twice.

FD Misread or mispunched tape.

FE Store full.

FF Check sum failure.

FP Patch or Obeyed instruction error.

FU Unlocated identifier.

903 ALGOL HARDWARE REPRESENTATION

Algol Symbol	903 hardware representation	Recommended mode of writing the symbol
8-Z	A-Z	8-Z
×		•
•	"DIV"	div
<	"LE"	le
>	"GE"	ge
د)،	"NE"	ne
٨	"AND"	and
٧	"OR"	or
5	"IMPL"	impl
	"EQUIV"	equiv
	"NOT"	not
begin end etc.	"BEGIN" "END" etc. "CODE" "ALGOL"	begin endetc.

SUMMARY OF STANDARD PROCEDURES

H is a handler number
N is a block number
P is number of words in a block
E is integer variable :=
last block or error
STAT is integer variable := status
T is an integer indicating
operation required

Real	Boolean	Input
abs (X)	checkb (Q)	read Z, M,
exp (X)		reader (I)
In (X)	Output	instring (A, M)
sqrt (X)	print X, I, S,	
sin (X)	digits (I)	Control
cos (X)	scaled (I)	wait
arctan (X)	freepoint (I)	stop
checkr (X)	aligned (I, J)	
Integer	sameline	Magnetic Tape
	prefix (S)	MTCHECK (H, E, STAT, L)
	CHOCKS (O)	
Integer entier (X) sign (X) range (B, I) lowbound (B, I) checki (I)	sameline prefix (S) punch (I) outstring (A, M) checks (S)	Magnetic Tape MTCHECK (H, E, STAT, L) MTOPEN (H, A, T, S) MTWRITE (H, A, P) MTREAD (H, A, N) MTCLOSE (H, T)

serion properties of the serion of the serio 903 ALGOL TRANSLATOR ERROR MESSAGES

1	read misplaced.
2	print misplaced.
3	Constant or expression in read list.
4	Wrong delimiter in switch declaration.
5	Illegal actual parameter.
6	Too many parameters to a procedure.
7	Illegal number.
8	Integer constant too big.
9	Two statements in the same block are prefixed by the same label.
10	Identifier or constant not as expected.
11	Letter, digit, "." or "10" misused.
12	true or false follows an identifier or constant.
13	comment does not follow ";" or begin
14	<reserved></reserved>
15	Unrecognised basic symbol.
16	No assignment to the procedure identifier occurred within the body of a type procedure.
17	An identifier in the value or specification part of a procedure is not a formal parameter.
18	Use of undeclared identifier.
19	Illegal symbol.
20	Non procedure identifier used as a statement.
21	": =" omitted from for clause.
22	Illegal use of label name.
23	Inadmissible array declaration.
24	<switch name=""> not an actual parameter nor preceded by goto.</switch>
25	Non type procedure as function designator.
26	switch misplaced.
27	Declaration without identifier.
28	":=" preceded by a constant or used inside an expression.
29	":" in type or switch declaration or misused.
30	Adjacent delimiters inadmissible.

a string in a read list.

31

Constant before ":=" or "[", or constant or name of

32	Item other than a non-type procedure used as a
32	statement.
33	Identifier or constant follows a closing round or square bracket.
34	Relation on each side of a simple arithmetic expression.
35	Illegal statement, delimiter misused.
36	Declaration starts incorrectly.
37	Error between for and ":=".
38	Missing array or switch name or "[" misplaced.
39	":" misused in array declaration.
40	end misused.
41	Local identifier used in array bound.
42	goto follows an identifier or a constant.
43	Wrong for clause preceding do
44	for misused.
45	Misused Boolean constant:
46	Assignment to procedure identifier outside procedure body.
47	real integer or boolean misplaced.
48	Identifier declared twice in same block-head.
49	Blank parameter.
50	No begin at start of program.
51	Wrong number of subscripts or parameters.
52	":=" appears in an actual parameter list.
53	Statement ends incorrectly.
54	Declaration follows statement.
55	':', goto or for used in expression.
56	Illegal parameter comment or) precedes identifier.
57	Wrong use of delimiter.
58	Relational or logical operator used as an arithmetic operator.
59	Illegal use of logical operator.
60	Omission or error precedes begin or begin follows ":=".
61	"(" misplaced or missing procedure name.
62	Function designator as designational expression.

63	Misplaced declarator.
64	Subscripted variable as statement.
65	Illegal specifier.
66	Misused comma or colon in an expression.
67	if misused.
68	If used in type declaration.
69	Corresponding if has been omitted, or conditional expression without an else.
70	Corresponding then missing.
71	Illegal character in inner string or missng close quote in previous string.
72	array misplaced.
73	Left square bracket not preceded by an identifier.
74	Unmatched closing square brackets.
75	Upper bound missing in array declaration.
76	Illegal type declaration.
77	Illegal array list.
78 79	Corresponding for missing. A jump is made to a label declared, but not placed in the block that ends here.
80	step, until or while misused in for list element.
81	Misused ")" other than in expression.
	")" misplaced or unmatched.
82 83 84 85	Program too complex, i.e. some statement is too complicated.
84	Wrong delimiter after procedure statement.
85	labels, constants or switches.
. 86	
87	Repeated formal parameter.
88	
89	<re><reserved></reserved></re>
80	Wrong delimiter in value or specification part.
91	in a line.
92	specification part.
93	Declaration terminated by end or containing begin.

94	A formal parameter which is a switch, string or procedure is called by value.
95	Switch designator has more than one subscript.
96	Wrong for clause.
97	then misused.
98	Illegal character or parity error. The character is replaced by ← in the displayed line, but ↑ is not printed beneath it.
99	Current use of identifier inconsistent with previous uses.
00	Conditional expression needs parentheses.
01	Wrong delimiter after procedure identifier in procedure declaration.
02	No ";" between formal parameter part and value or specification part.
03	Commas or colons wrong in array bounds.
04	div used with a real argument.
05	Illegal parameter deliminter after a string.
06	Integer labels not allowed.
07	Recursive function calls not allowed.
08	An actual parameter which is a procedure has one of its parameters called by value.
09	Constant should not be used in procedure heading.
10	Wrong specification part.
11	Different number of parameters from previous use of formal procedure or wrong number of subscripts.
12	Mixed types in multiple assignment.

The following errors will cause an Algol program tape Note: to shoot through and unload the reader, instead of stopping at the end:

- (1) No halt code at the end of a tape which is not the last tape of the program.
- (2) Insufficient end's to match all the begin's in the program.
- (3) Missing 'at the end of a string.

The following errors will cause the end of an Algol program to be found prematurely:

- (1) Missing begin.
- (2) end or the comment following end not followed by end, else or a semicolon causing a begin to be treated as comment. These errors lead to a breakdown of the block structure of Algol and will usually cause many error messages to be displayed.

Any one error, particularly in a declaration, may cause many spurious errors to follow.

WARNING messages are output if identifiers are not used or the comment following end contains a delimeter.

903 ALGOL LOADER ERRORS

[A]	misread or mispunched tape.
FC	Two procedures (at least one of which is a library procedure) have the same name.
FE	Program too large to load.
FU	Missing library procedure.

903 ALGOL ENTRY POINTS

Translator

- Normal translation. 8
- Continue after halt.
- Report mode.
- Include check functions.

- Library mode (for large programs).
- Library mode plus check functions.
- Normal plus reports (903C only).

Interpreter

- Normal, load translated program.
- Continue after halt.
- Run program.
- Load R.L.B. machine code.
- Reload library.
- Load large program overwriting library.

ALGOL RUN TIME ERRORS

Error Number	Meaning	Value substituted or Effect on continuation at 9 continuation not possible continuation not possible			
1 2	Parameter mismatch Space overflow, e.g. too much claim on store for an array				
3	Integer overflow	continuation not possible			
3 4	Jump error, i.e. switch subscript outside its per- mitted range	continuation not possible			
5	Subscript error, i.e. address outside the store area allotted to the array referred	continuation not possible			
6	to Illegal symbol inside inner string quotes (only discovered when the string	newline is substituted			
7	is output) Attempt to output an unstandardised floating point number. (Probably the result of an error in a code procedure.)	*** is substituted			
8	illegal character or ' found when attempting to read a number	The read routine is re- entered			
9	Real overflow	P is substituted			
10	Invalid argument for sin(E) or cos(E), i.e. exponent greater than or equal to 18	0-0 is substituted			
11	Negative argument for sqrt(E)	sqrt(abs(E)) is substituted			
12	Argument > 40 for exp(E)	P is substituted			
13	Argument ≤ 0 for log(E)	0-0 is substituted			
14	Illegal character on data tape	space is substituted			

Error Number	Meaning	Value substituted or Effect on continuation at 9
15	Parity error on data tape	space is substituted
(16	Overflow of input buffer in 920 Algol	The entire line of text is ignored
17	Numeric character found before ' when attempting to read a string	The instring operation is ignored
18	illegal form of number	Ignore existing number,
777	e.g. 2 decimal points	re-enter read routine
19	A B with A and B real and	0.0 is substituted
20	Program corrupted, probably due to an error in a code procedure	Continuation not possible
21	An attempt has been made to assign a value to a formal parameter which is a constant	Continuation not possible
22	Range of array subscript bounds is negative	Continuation not possible
23	Instring or outstring error, i.e. Array not a one- dimensional integer array, subscript value is outside range or instring overfills the array	Continuation not possible
24	Attempt to jump to a label in an inner block or into a for loop	Continuation not possible
25	Translator used is incompatible with this version of the interpreter	Continuation not possible

Nates

- 1. $P = (1-2^{-27}) \times 2^{63}$ except for overflow of a negative real number where $P = -1-0 \times 2^{63}$
- 2. When continuation is not possible entry at 9 results in a dynamic stop.

903 FORTRAN

General

A 903 FORTRAN program is translated into SIR and then run as a SIR program in conjunction with the 903 FORTRAN run-time routines (tape 2). Input is free-format, and mixed type working is allowed, with automatic type conversion. When a real number is converted to an integer it is rounded towards zero.

Summary of FORTRAN Statements

Control	Specification	Real functions
IF (E) n ₁ , n ₂ , n ₃	GLOBAL, P1, P2, PN]	ALOG (X)
GOTO n	DIMENSION A(10), K(20,20)	SIN (X)
GOTO (n ₁ , n ₂ , n _X)M	COMMON A, K, M,, R	COS (X)
DO n M=L, L, L,	FUNCTION	ATAN (X)
DO n M=L, L,	SUBROUTINE	ABS (X)
CONTINUE	FORMAT	SQRT (X) EXP (X)
		The state of the s

CALL	Input-output	Integer function
RETURN	READ (L, n) M, R, A, K,	IABS (I)
PAUSE	READ (L) M, R, A, K,	SIR code
STOP	WRITE (L, n) Z1, Z2, A, K,	CODE
END	WRITE (L) Z ₁ , Z ₂ , A, K,	FORTRAN

X represents a real expression

R represents a real variable

E represents any expression

I represents an integer expression

M represents a simple integer variable

L represents an integer constant or variable

n represents a statement númber

A is a real array

K is an integer array

Z represents any expression not containing a Function

Field descriptors (r=repeat count)

Floating point	rF w.d or F w.d	(d characters after point)
	-F I F I	/F

rE w.d or E w.d (Exponent printed)

Integer rl w or l w (w=total print positions)

Alphanumeric nHh₁h₂h₃...h_n (n characters)
Spaces nX (n spaces)

FORTRAN TRANSLATOR ERROR MESSAGES

- 1 Unacceptable form to left of = sign in an arithmetic
- 3 Two operators in succession in an arithmetic expression.
- 5 Parentheses do not match.
- 6 Subscripted variable has not been declared in a DIMENSION statement or Function not in GLOBAL.
- 7 Unacceptable subscript form.
- 8 An unsubscripted array name has appeared in an arithmetic statement.
 - In statements of type DO n M = L_1 , L_2 , L_3 errors:
- 9 n is omitted, or is not an acceptable statement number.
- 10 i is not an unsubscripted integer variable, or is omitted.
- 11 There is an impermissible number of Li's.
- 12 One of the Li's is of impermissible form.
- 13 DO statement has no = sign.
- 14 DO statements have intersecting loops.
- 15 A DO loop terminates with a GOTO or IF statement.
- 16 There is at least one unterminated DO loop when END is reached.
- 18 A number found where a variable expected.
- 19 No variable where one expected.
- 20 A statement number has more than 5 digits.
- 21 An integer or real constant is out of range.
- 22 A CALL statement has an unacceptable format.
- 23 A FUNCTION or SUBROUTINE statement has an unacceptable format.
- 24 The word FORTRAN has not been preceded by a CODE statement.
- 25 An error in GOTO or an IF statement.
- 26 A mis-spelt or otherwise corrupt or unrecognisable statement.
- 27 Statement too long or too complex to compile.
- 28 Program too long or too complex to compile.
- 29 Error in FORMAT statement.

31 Error in DIMENSION statement. 32 Error in COMMON statement. 33 A variable has been declared twice in a COMMON list. in a DIMENSION statement, a bound exceeds 8192. 38 A variable has been declared twice in a DIMENSION list. 39 A sub-program has more than 18 parameters. 40 A continuation line has been used other than after a 41 GLOBAL or FORMAT statement. Too many sub-programs declared in a GLOBAL statement. 42 Error in a READ or WRITE statement. 43 A FUNCTION or SUBROUTINE statement has appeared 44 in a sub-program. 45 Error in a GLOBAL statement. Too many variables have been used in a program or 46 sub-program. A sub-program does not contain a RETURN statement. 47 (i) RETURN has occurred outside a sub-program. A number appears against a statement that should not be 48 labelled. The channel number in a READ or WRITE statement is not 49 an integer. Halt code not preceded by new line, therefore last statement 50 not translated. **FORTRAN TRANSLATOR QUERIES** 101 Variable name has more than 6 characters (first 6 are significant). CONTINUE statement not numbered. 105 Statement following GOTO or IF is not numbered. 106 Un-numbered FORMAT statement. 108 109 EQUIVALENCE statement used (statement ignored). An executable statement has occurred before a COMMON 110

FORTRAN LOADING ERRORS

E1		Paper tape mispunched.
B	Cn ,	(n is an integer). Two statements numbered n.
B	<identifier></identifier>	Two different entities with this name.
E		Program too large to load by batch mode.
EU	o	statement number n referred to in GOTO, IF, READ, WRITE statements, but does not occur in program.
EU	<sub-program name=""></sub-program>	This sub program has not been loaded.
EU	<identifier></identifier>	This identifier has been used, but has not been assigned any value (possibly mis-spelt).

903 FORTRAN ENTRY POINTS

Translator (tape 1) for basic system only.

- 8 Translate to SIR code.
- 9 Continue after halt.
- 10 Report mode.

Tape 2

- 8 Load SIR code for batch mode.
- 9 Continue after wait.
- 10 Indicate program complete.
- 11 Run the program.
- 12 Load for batch mode, display store map.
- 13 Load SIR code for relocatable mode.
- 14 Load relocatable program tape.
- 15 Load an extra relocatable binary (user's library) tape.

compiled).

113

or DIMENSION statement. (Statement may be wrongly

More than one GLOBAL statement in a program unit.

FORTRAN RUN TIME ERRORS

(Continuation is only possible where specified. A=address in object code.)

E1 A P1 P2

Number of parameters in sub-program not compatible with

P1=Number in definition, P2=Number in call.

E2 A Q1 Q2

Types of parameters in sub-program not compatible with the call.

Q1 represents types in definition, Q2 those in call.

E3 A 1 S1 S2

Array subscript out of range. S1 = actual value of subscript. On continuation S1=1 or S2.

E4 A 1 S1 S2

Computed GOTO variable out of range. S1 = actual value. On continuation S1=1 or S2.

E6 A C

Parity error on input. C=Decimal value of character. On continuation, character ignored.

E7 A C

Illegal character in number. C=Decimal value of character. On continuation, character treated as terminator.

E10 A L3

Increment in DO statement, L3<0 On continuation L3 is taken as +1.

E 11 A N

Attempt to output non-standardised real number on channel N. On continuation, number is ignored.

E12 0

Compiler overwritten.

E13 0

Program incorrectly compiled (N.B. entry at 10).

E14 0

Translated program and systems incompatible.

E15 X A

Real number overflow. (Ignore X). On continuation number=largest possible signed value.

E16 X A

Illegal QF instruction (corrupt code).

E17 A

Overflow on real to integer conversion.

E18 A Z

Z=78 In ALOG (X), X≤0. On continuation, result=0.

Z=81 In SQRT (X), X<0.

On continuation, result=SQRT (ABS(X)).

Z=88 In EXP (X), X>216

Note A**B is calculated EXP (B*ALOG(A)). On continuation, result of EXP(X) is X.

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PERIPHERALS AND INTERFACES

The following facilities can be added to the basic 903 at any time, enabling the system to be adapted to changing requirements:

This unit enables more than one peripheral to be fitted to the system. It consists of 8 channels which may be

extended to take an NPL interface.

Care Store: Units of 8,192 words may be used to increase the directly addressable core memory to a maximum of

65,536 words.

Digital Plotter: Available with 14-inch or 30-inch paper width, and operating at 300 increments per second, this unit enables the computer output to be presented in the

> form of permanently recorded graphs, charts and diagrams.

N.P.L. Interface: The computer can be fitted with the standard N.P.L. electrical interface which makes available the in-

creasingly wide range of peripherals conforming to this

standard.

Store Access Permits the transfer of data out of or into the extra Control Unit: store units, as the computer is carrying out other tasks.

Unit:

Magnetic Tape A 9.000 character per second unit, consisting of electronic controller and mechanism compatible with the European Computer Manufacturers' Association

standards.

4100 Interface: This allows standard 4100 peripherals such as card

readers and punches to be attached to the 903.

A 300-line per minute, 120 character per line line-

printer is available.

TABLES OF BINARY

The purpose of these tables is to assist in the

- 1. Select the highest multiple of 64 less than (or equal
- 2. Set the first (left-hand) 7 buttons to the binary
- 3. Set the last (right-hand) 6 buttons to the binary

TABLE A

Multiple	Binary	Multiple	Binary	Multiple	Binary
of 64	equivalent	of 64	equivalent	of 64	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
				4000	4004000
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
			1		
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

EQUIVALENTS

setting of binary addresses on the word generator.

to) the required address, and work out the difference (if any).

requirement of the multiple, working from Table A.

Table B.

TABLE B

Multiple Binary of 64 equivalent	Difference	Binary equivalent	Difference	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
6582 1100111	7	000111	39	100111
1101000	8	001000	40	101000
6720 1101001	9	001001	41	101001
6794 1101010	10	001010	42	101010
COCS 1101011	- 11	001011	43	101011
6912 1101100	12	001100	44	101100
6576 1101101	13	001101	45	101101
7000 1101110	14	001110	46	101110
7104 1101111	15	001111	47	101111
7166 1110000	16	010000	48	110000
7232 1110001	17	010001	49	110001
7296 1110010	18	010010	50	110010
7300 1110011	19	010011	51	110011
7424 1110100	20	010100	52	110100
7008 1110101	21	010101	53	110101
7552 1110110	22	010110	54	110110
7616 1110111	23	010111	55	110111
7000 1111000	24	011000	56	111000
7744 1111001	25	011001	57	111001
7808 1111010	26	011010	58	111010
7672 1111011	27	011011	59	111011
7936 11111100	28	011100	60	111100
2000 11111101	29	011101	61	111101
MEG 1111110	30	011110	62	111110
8128 1111111	31	011111	63	111111

POWERS OF 2 IN DECIMAL

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

Useful Constants

	log 100 log 102		3·141 0·434 0·301 1·414 57·295	294 029 213	481 995 562	903 664 373	loge10	=	0·318 2·302 2·718 1·732 0·017	585 281	092 828	994 459
1	radian	-	57-295	779	513	082°	1°	-	0-017	453		520 dian

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