

PART III - APPENDIX

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TEST ROUTINES NO. 1 AND NO. 2

Test Routines No. 1 and No. 2 are combined in one master magazine and a Block Selector Routine is incorporated for selection of the desired test. Test No. 1 is a cursory check of a computer, resulting in a bell being rung at regular intervals. Basically, re-circulation, arithmetic circuits, AR and PN registers are tested by this routine. In order to subject the computer to a more comprehensive test, Test Routine No. 2 should be used.

It is assumed that the input circuits (including the pertinent memory lines - L. 19, L. 23 and L. MZ), L. 00, the command and control circuits are in working condition. If one or more of these is making errors, the result will be erratic operation, usually evidenced by the computer getting lost in a loop of commands.

METHOD OF OPERATION

1. Read the Number Track in - p key.
2. Read in the Block Selector Routine by striking p key again.
(Steps 1 and 2 must be executed when machine is ON and are automatically executed during the start cycle.)
3. Set Compute switch to GO - a type-out will occur.
4. Type in 000002 tabⓈ for Test Number One. Test Number One will then begin: The first block of tape (the loader routine for Test No. 1) is read into the computer. If it is properly recorded, the type-out will be: XXXXXXXX. The second block of tape is then automatically read in and terminated when the bell rings twice. (There is no type-out unless an error is encountered.) The second block of tape then forms a closed loop in the computer and is repeated indefinitely until the GO-BP switch is moved to the center position.
5. If Test Number Two is desired, type in 000005 tabⓈ and perform steps 6 and 7.
6. The computer will stop on a Test Ready, at which time manual type-in will have been set. The operator must then type a sexadecimal number which is the number of times each type of test will be executed. For example, if 000010 is typed,

each line of the memory will be tested 16 times before the next type of test is accomplished. The normal method of seven digits, tab, and ⊕ key is the method used to type this number.

7. After the ⊕ key is hit, the computer will proceed to execute each type of test without further manual intervention (unless the computer gets lost). The first test made is a test to determine if the accumulator and its associated circuits work reliably. The test involves adding all the commands in Line 0 into the accumulator and subtracting them out again. If the AR is clear after this, the AR is considered reliable. If it is not clear, a number is typed out which is characteristic of this test. (See the list of indications.)

In accomplishing the above test, Line 23 is considered to be reliable and is used to store numbers for determination of the end of the test. A bell is rung at the end of the test.

8. The second test is the determination of the reliability of the two-word registers. Again, if an error is made, a characteristic number is typed. Certain four-word registers and the AR are used in this test and a bell rung upon its completion.
9. The four-word registers are then tested and characteristic numbers typed if an error is made. The two-word registers and AR are used in this test. A bell is rung at the completion of this test also -- the third and last bell in the first block of commands.
10. The next block of commands are then read in. This block tests all of the long lines from one to nineteen by putting the same information as is in line zero into all of them. It fills each line only once at the beginning of this routine unless a certain line makes an error, at which time the information in that line is renewed. As a result, the successful completion of this test is assurance that all lines have stored information for a considerable period of time, i. e. , equal to the total length of time of the entire test.

This method of indication of errors results in a minimum of type-out. A type-out is not made each time a line makes an error. Instead, the number of errors made by each line is counted and this number typed at the completion of the entire test. At the completion of the test, then, a type-out is made; if no errors have been made, only a series of spaces are typed and nothing will appear on the printed page.

However, if Line 9 has made fifteen errors (this could or could not be the total number of tests made on each line), a number will be typed out as follows:

690000z

Note that the second digit is the line number and the last digit is the number of errors (in sexadecimal). If the number is 7300012, the line would be Line 19 and it would have made 18 errors.

11. The next block of commands is then read in. This tests the inverting gates and the sign circuits of the two-word registers. Two bells are rung, one after each of the above-named tests.

NOTE

If the inverting gates are not working, chances are that the tests made in the preceding blocks did not work and have given false indications. The inverting gate test is used to determine if the error indications were caused by the inverting gates.

12. The next block, after being read in, will test the overflow circuits and all combinations of End-Around-Carry conditions in both the AR and PN registers. One bell is rung upon completion of both tests and characteristic numbers are typed in case of error.
13. The next block of commands has three types of tests in it. The first is a multiplication and division test. It involves the determination of the equality:

$$A = \frac{A \cdot B}{B}$$

If this equality is not met, the computer then determines if the equality $A \cdot B = B \cdot A$ is met. ($A \cdot B$ is the same multiplication made for testing the first equality.) If this equality is not met, the computer types out a number characteristic of a multiplication error, while if it is met, a division error indication is made. A bell is rung upon completion of the designated number of tests.

14. The second test is of the shifting and normalizing circuits. The test normalizes a number and then shifts it back where it was, hence, compares it with the starting number. A bell is rung upon completion of this test.

15. The third test is of the logical commands. The third bell is rung here.
16. The next block of commands results in two types of tests. The first is a type-out of six test numbers in the following sequence:
- | | | |
|----------|----------|--------|
| -1122334 | 445566.7 | 778899 |
| -uuvvwx | xyyz.0 | 2345 |
17. The second test in the last block is a series of computations using two standard subroutines. The blocks of commands for the subroutines are read in by the last test block before the type-out of the above test numbers.

The computations involve the calculation of the sine of an angle θ and the calculation of the arcsine of sine θ to produce an angle ϕ . If the computations are correct, $\phi = \theta$, thereby checking this equality. If the angles are not equal, a characteristic number is typed out. The angle θ is then varied by an incremental amount and the computation repeated the number of times specified by the operator. The test type-out will occur during some of these computations.

18. At the end of computations, the tape automatically reverses to the beginning of the test routine and the operation started at the first test in number 4 above. If the operator wishes to change the number of times each test is performed, he should stop computations when the first block is being read in and then do the operations starting with number 1.

ERROR INDICATIONS FOR TEST ROUTINE NO. 1

Typed Number	Likely Error	Possible, But Not Likely
159539v	Inverting gates (IG), LI	AR
21u139v	LII	LI AR IG
33v339v	PN	AR IG
3xvx75v	ID MQ	PN* IG-
-6466w9y	L4	PN* IG LII
-6466wvy	L5	PN* IG LII
-6466wxy	L6	PN* IG LII
-6466wzy	L7	PN* IG LII
-6466xly	L8	PN* IG LII
-6466x3y	L9	PN* IG LII
-6466x5y	L10	PN* IG LII
-6466x7y	L11	PN* IG LII
-6466x9y	L12	PN* IG LII
-6466xvy	L13	PN* IG LII
-6466xxy	L14	PN* IG LII
-6466xzy	L15	PN* IG LII
-6466yly	L16	PN* IG LII
-6466y3y	L17	PN* IG LII
-6466y5y	L18	PN* IG LII

*See Discussion of PN, Test Routine No. 1: Memory Test Indications

Typed Number	Likely Error	Possible, But Not Likely
5300	Overflow flip-flop didn't sense OF. Test overflow didn't work.	Program or operator's error.**
56000	Overflow FF not turned off by test.	Test circuit not working properly.
6000	Source 30 or w1	LI LII
12000	Source 27, 29	LI LII
1x000	Multiplication Division LIII	PN** or IG
58000	Shift or Normalize	ID, MQ
32000	Input circuits Photo reader LV, L19, LIV	

**See Discussion of Test Routine No. 2: Typed Indications of Errors

ERROR INDICATIONS FOR TEST ROUTINE NO. 2

Various characteristic numbers are typed out whenever the computer makes an error. The following is a list of these numbers, the type of error made, and some possibilities as to computer circuits which may have made the error.

1. Accumulator Register Test

393939v This test does additions and subtractions of the commands in LO in the accumulator. If an error is made, it is usually an indication that the accumulator is not holding information reliably, but other circuits such as the inverting gates may also be operating improperly.

Look for:

1. Accumulator Read head out of tangential adjustment.
2. Bad AR Read amplifier.
3. Weak tube in AR preamplifier.
4. Bad AR record amplifier.
5. Bad component in accumulator adder.
6. Bad component in inverting gates. (Try replacing IS flip-flop)
7. Read or Write head open or shorted.
8. Bad taper pin connection between logic panel and memory.
9. Source or destination selector gates bad.

2. PN Register Test

555539v This test stores data in the PN register and compares it against data stored in Line 23. Therefore, Line 23 may be making the error, but since Line 23 was used for read-in, one suspects PN. The AR is used for this test so it may also be making the error, although it should be okay if it passes its test.

Look for:

1. PN register Read head out of tangential adjustment.
2. Weak Read amplifier.
3. Weak preamplifier tube.
4. Bad record amplifier.
5. Bad component in PN adder and associated circuitry.
6. Read or Write head open or shorted.

7. Bad taper pin connection to or from memory.
8. Source or destination selector gates bad.

3. ID and MQ Register Tests

656839v ID }
y0y39v MQ } See discussion of PN test.

Look for:

1. Read head out of tangential adjustment.
2. Bad Read amplifier.
3. Bad preamplifier tube.
4. Bad record amplifier.
5. Recirculation, source or destination gates bad.
6. Read or Write head open or shorted.
7. Bad taper pin connection.

4. Lines 20, 21, 22, 23

616139v - L20

x1x39v - L21

454639v - L22

595w39v - L23 The AR and two-word registers are used in this test. They could be making the error even though they passed their test, but this is unlikely. If L23 indication is made, careful scrutiny is in order because it worked properly to read the data from tape.

Look for:

Same things as listed for ID and MQ Registers.

5. Long Line Tests

730000n - Line 19

720000n - Line 18

710000n - Line 17

700000n - Line 16

6z0000n - Line 15

6y0000n - Line 14

6x0000n - Line 13

6w0000n - Line 12

6v0000n - Line 11
6u0000n - Line 10
690000n - Line 9
680000n - Line 8
6-----

610000n - Line 1

The number N is the number of times the particular line makes an error. Short lines are used in the test, so it should be remembered that they can make errors even though they have passed their own tests. This is unlikely, however.

Look for:

Same things as listed for ID and MQ Registers.

6. Miscellaneous Test

Continuous Bell Ringing

The Long Lines test requires the storage of test data in Line 23. If this data becomes in error, the computer rings a bell continuously. To stop the bell-ringing, hit the ⊕ key, at which time the computer will try again. However, since Line 23 or some other circuit not connected with a long line failed, the best thing to do is to start the whole routine over to test the other circuits again.

Causes may be:

1. Line 23 unreliable
2. PN register unreliable

7. Inverting Gates

222439v Additions and subtractions of very simple numbers into the AR are not working properly. The numbers are stored in lines 21 and 22, so these lines could have failed.

Look for:

1. Bad IS flip-flop.
2. Bad IC flip-flop.
3. Other bad component in the inverting gates.
4. Bad AR (See AR test).
5. Bad Line 21 or Line 22 (See test number 4).

8. Sign Circuits of Product Registers

- 1y1y2xz Sign did not properly set up to be negative when a negative number when a negative number entered the ID and a positive entered the MQ.
- 2x2x29w Sign was negative when two positive numbers were entered into ID and MQ.
- 3w3w2xz Sign was positive when a positive number was entered into the ID and a negative number into the MQ.
- 484w2xz Sign was negative when two negative numbers were entered into ID and MQ.

9. Reader Test

nnnnnnn

- 5w5w39v When reading in the next block of commands, the computer checks the read-in for errors. It types out the block sum that was obtained (which should have been zero) and the indication number.

Look for:

1. Photo reader out of adjustment.
2. Bad Line 19 or 23.
3. Bad AR register (See AR test).
4. Other bad component in input circuitry.

10. Overflow Test

Two quantities, A and B, are used in this test. A is equal to $1/2$, B is slightly greater than $1/2$.

- 32323vz Overflow did not set when $A + B$ was added in the AR.
- 3u3u3vz Overflow did not set when $-A - B$ was calculated in AR.
- 44443vz Overflow did not set when $-A - A$ was calculated in AR.
- 4y4x3vz Overflow set up when the difference of two positive numbers was taken in AR.
- 5u593vz Overflow set up when the difference of two positive numbers was taken in PN.

- 66663vz Overflow did not set up when A + B was added in PN.
- u0u3vz Overflow did not set up when -A -B was calculated in PN.
- 191u3vz Overflow did not set up when -A -A was calculated in PN.

11. End-Around-Carry Test

This subtracts zero from AR and PN to see if the End-Around-Carry is propagated to correct the sign.

- 25262xz The sign of (-A -0) was positive, indicating no End-Around-Carry when calculated in AR.
- 363v2xz The sign of (B - 0) was negative when calculated in PN.

12. Multiplication - Division Test

Two numbers, A and B, are used in this test. The identity $A \cdot B = C$ is assumed in the discussion.

- z5v294 The equality $A = \frac{C}{B}$ does not check, but $A \cdot B = B \cdot A$ does check. This indicates division failed.

Look for:

1. Bad IS flip-flop.
2. Bad IC flip-flop.
3. Sloppy wave forms on input to IS flip-flop or elsewhere in inverting gates.
4. Bad buffer-inverter driving "division" signal.
5. Bad component in PN adder.
6. A bad two-word register.

- 105v2v5 The equality $A = \frac{C}{B}$ does not check nor does the equality $A \cdot B = B \cdot A$.
Lines 20 and 23 are used to store intermediate data in this test.

Look for:

1. Bad PN flip-flop or gate driving this flip-flop.
2. Bad PN adder.
3. Slow rising or falling signals in adder inputs or output.
4. Bad two-word register.
5. Bad Line 20 or Line 23.

13. Shift and Normalize

A number is put in the even half of MQ and normalized. After normalization, it is put in ID and shifted right, with the number of shifts determined by the number accumulated in the AR when normalization occurred.

The number should end up in the same position of ID that it started in MQ.

65662xw The number left in ID at the end of the shifting operation does not agree with the original number which started in the MQ.

Look for:

1. Bad ID or MQ register.
2. Bad AR register.
3. Circuits used to turn on AR carry for incrementing not working properly.
4. Bad PN flip-flop or associated circuits.
5. Gates controlling control circuits on normalize or on shifting not working properly.

14632zz This is a miscellaneous test. Upon shifting the ID right, the MQ should also be shifted left. Also, the number of shifts should be sufficient to shift all the contents of MQ off the left-hand end, clearing MQ. This number will be typed out if MQ is not clear.

Look for:

1. Bad MQ register.
2. Same things as listed on test above.

14. Logical Commands

x0513vw One or both of the logical commands $20 \cdot 21$ and $\overline{20} \cdot 21$ (Sources 31 and 30) did not work properly.

Look for:

1. Bad Line 20 or 21.
2. Bad gates for logical commands.

u4292xw The command $20 \cdot 21 + \overline{20} \cdot AR$ (Source 27) did not work properly.

Look for:
Same as above.

15. Test Type-Out

A test type-out occurs which operates all possible characters of the typewriter:

-1122334	445566.7	778899
-uuvvwx	xyyxx.0	2345

If this does not type correctly,

Look for:

1. Sticking keys on typewriter.
2. Broken or sticking relays in typewriter base.
3. Bad OB flip-flop.
4. Bad Line 23, 19 or 2.
5. Any other Input/Output circuit.

16. Computation Test

w7483zv This test involves the calculation of the sine of an angle θ and the calculation of the arcsine of this result. If the arcsine agrees with θ , the test is passed. This is the last test of the routine and since practically all circuits are tested before this, should work. If not,

Look for:

1. Bad CD flip-flop (this was not tested before) or circuit driving CD.
2. Something wrong with computation registers (all short tracks).
3. Since type-out occurs during computation, look for arcing contacts in typewriter relays.
4. Any other portion of machine bad.

SUMMARY OF ERROR INDICATIONS

		READ IN LAST CLOCK TEST 1	WHICH FIRST OF TEST 2 EXPECTED	
1000294				
1.	393939v			Accumulator Register
2.	555539v			PN Register
3.	656839v			10 Register
4.	y0y39v			MQ Register
5.	616139v			Line 20
6.	x1x39v			Line 21
7.	454639v			Line 22
8.	595w39v			Line 23
9.	6?0000N			Line ?
10.	7?0000N			Line 16 + ?
11.	Continuous Bells			Line 23, or PN
12.	222439v			Inverting Gates
13.	lyly2xz			Sign Circuits
14.	2x2x29w			Sign Circuits
15.	3w3w2xz			Sign Circuits
16.	484w2xz			Sign Circuits
17.	5w5w39v			Input Error
18.	32323vz			Overflow Circuits
19.	3u3u3vz			Overflow Circuits
20.	44443vz			Overflow Circuits
21.	4y4x3vz			Overflow Circuits
22.	54593vz			Overflow Circuits
23.	u0u3vz			Overflow Circuits
24.	191u3vz			Overflow Circuits
25.	25262xz			End-Around-Carry - AR
26.	363v2xz			End-Around-Carry - PN
27.	z5v294			Division
28.	105v2v5			Multiplication
29.	65662xw			Shift or Normalize
30.	14632zz			Shift or Normalize
31.	x0513vw			Source 30 or 31
32.	u4292xw			Source 27
33.	-1122334	445566.7	778899	} Test Type-Out
	-uuvvwx	xyyz.z.0	2345	
34.	w7483zv			Computational Error

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	00		02	00	0	28	31		Test Ready
8	9	10	11	01		02	03	0	00	28		Clear AR
12	13	14	15	03	u	04	04	1	00	29		Add all L0
16	17	18	19	04	u	09	09	1	28	20		AR → 20-D, 1, 2, 3
20	21	22	23	09		10	11	0	00	28		Clear AR
24	25	26	27	11	u	12	12	1	00	29		Add all L0
28	29	30	31	12	u	17	17	1	28	21		AR → 21-0, 1, 2, 3
32	33	34	35	17		18	19	3	20	29		AR - (20 - 2) → AR
36	37	38	39	19		20	21	0	28	27	-	Test AR Bk. Pt.
40	41	42	43	21	u	26	26	1	20	29		Add all L 20
44	45	46	47	22	-	19	u0	0	00	28		(00 - 19) → AR
48	49	50	51	26	u	31	31	3	21	29		Subt. all L 21
52	53	54	55	31		32	33	0	28	27	-	Test AR Bk. Pt.
56	57	58	59	33		34	35	0	20	28		(20 - 02) → AR
60	61	62	63	34		31	u0	0	00	28		(00 - 31) → AR
64	65	66	67	35	u	38	38	1	28	26		AR → PN (e + o)
68	69	70	71	38	u	41	41	1	28	25		AR → ID (c + o)
72	73	74	75	41	u	44	44	1	28	24		AR → MQ (e + o)
76	77	78	79	44		45	47	1	26	28		PN odd → AR
80	81	82	83	47		48	49	3	26	29		AR - (PN even) → AR
84	85	86	87	49		50	51	0	28	27	-	Test AR Bk. Pt.
88	89	90	91	51		52	54	5	25	26		(ID) → PN
92	93	94	95	52		49	u0	0	00	28		(00 - 49) → AR
96	97	98	99	54		56	58	7	24	30		PN - (MQ) → PN
u0	u1	u2	u3	58	u	61	61	1	26	27		Test PN Bk. Pt.
u4	u5	u6		61	u	62	63	5	00	30		Add all L0 → PN

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	62		58	u0	0	00	28		(00 - 58) → AR
8	9	10	11	63		64	66	5	26	21		PN → 21 - 0, 1
12	13	14	15	66		47	71	0	00	21		Command 2 → 21 - 3
16	17	18	19	71		74	76	0	00	21		Command 1 → 21 - 2
20	21	22	23	76		78	79	0	21	28		(21 - 2) → AR
24	25	26	27	79		80	81	0	00	29		AR + "1d" → AR
28	29	30	31	81		82	83	0	28	21		AR → 21 - 2
32	33	34	35	83		85	85	0	31	31		Obey AR
36	37	38	39	74 ^{(85)u}		86	86	0	00	03		L0 → LX
40	41	42	43	86		88	90	5	21	26		(21 - 0, 1) → PN
44	45	46	47	90		91	92	0	21	28		(21-3) → AR
48	49	50	51	92		93	94	0	00	29		AR + "1g" → AR
52	53	54	55	94		95	96	0	28	21		(AR) → 21 - 3
56	57	58	59	96		98	99	0	31	31		Obey AR
60	61	62	63	(99)	u	u0	u2	7	03	30		Subtract all LX → PN
64	65	66	67	u2		u4	05	5	26	27	-	Test PN Bk. Pt.
68	69	70	71	05		06	08	0	21	28		21 - 2 → AR
72	73	74	75	06		08	06	0	28	31		Test Ready
76	77	78	79	08		13	14	3	00	29		AR - "18d" → AR
80	81	82	83	14		15	75	0	22	31		Test AR sign
84	85	86	87	75		76	77	0	17	31		Ring Bell
88	89	90	91	u0		u2	u0	0	28	31		Test Ready
92	93	94	95	u1		u3	00	0	08	31		Type AR
96	97	98	99	77		79	79	1	21	31		Transfer to L1 com.
u0	u1	u2	u3	07		09	15	0	08	31		Type AR
u4	u5	u6		15		17	15	0	28	31		Test Ready

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	16		17	05	0	28	28		"Do Nothing"
8	9	10	11	80	u	00	00	0	00	01		"1 _d "
12	13	14	15	93	u	00	00	0	01	00		"1 _g "
16	17	18	19	13	u	86	86	0	00	18		"18 _d "
20	21	22	23									
24	25	26	27									
28	29	30	31									
32	33	34	35									
36	37	38	39									
40	41	42	43									
44	45	46	47									
48	49	50	51									
52	53	54	55									
56	57	58	59									
60	61	62	63									
64	65	66	67									
68	69	70	71									
72	73	74	75									
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	Y or L _k	N	C	S	D	BP	NOTES
4	5	6	7	00		02	00	0	28	31		Extra commands for
8	9	10	11	01		02	79	0	28	28		convenience of operator
12	13	14	15	79		81	81	0	15	31		Read photo tape
16	17	18	19	81		83	83	0	29	31		Test overflow
20	21	22	23	83		81	56	0	01	28		01 ₈₁ → AR
24	25	26	27	56		57	58	0	28	21		AR → 21 ₀₁
28	29	30	31	58		61	62	0	01	20		E → 20 ₀₁
32	33	34	35	62		65	66	0	31	28		(20, 21 - 1) → AR
36	37	38	39	66		69	70	0	28	21		AR → 21 ₀₁
40	41	42	43	70	w	01	70	0	28	31		Test ready
44	45	46	47	71		73	72	0	08	31		Type AR
48	49	50	51	72	w	01	72	0	28	31		Test ready
52	53	54	55	73		74	75	0	01	28		01 ₇₄ → AR
56	57	58	59	75		77	80	0	21	29		AR + 21 ₀₁ → AR
60	61	62	63	80		82	82	0	31	31		N. C. from AR
64	65	66	67	84		86	86	0	29	31	-	Test overflow
68	69	70	71	86		91	92	4	01	20		01 ₉₁ → 20 ₀₃
72	73	74	75	92		95	96	0	01	21		01 ₉₅ → 21 ₀₃
76	77	78	79	96		99	u0	0	31	28		20, 21 ₀₃ → AR
80	81	82	83	u0		u3	u4	0	30	29		AR + 20, 21 ₀₃ → AR
84	85	86	87	u4		u7	04	3	21	29		AR - 21 ₀₃ → AR
88	89	90	91	04		05	06	0	28	27	-	Test AR B/P
92	93	94	95	06		07	08	0	21	28		21 ₀₃ → AR
96	97	98	99	08		11	12	0	27	28		AR:0
u0	u1	u2	u3	12		15	16	3	21	29		AR - 21 ₀₃ → AR
u4	u5	u6										

0	1	2	3	L	P	T D L _k	N	C	S	D	BP	NOTES
4	5	6	7	16		17	18	0	28	27	-	Test AR B/P
8	9	10	11	18		21	21	0	23	31		Clear PN, ID, MQ
12	13	14	15	21		22	23	0	01	20		A → 20 ₀₂
16	17	18	19	23		24	25	0	01	20		B → 20 ₀₀
20	21	22	23	25		26	28	6	20	25		A → ID
24	25	26	27	28		32	35	6	20	24		B → MQ
28	29	30	31	35		56	93	0	24	31		Multiply
32	33	34	35	93		94	97	4	26	22		PN → 22 _{02, 03}
36	37	38	39	97		u0	u2	6	20	25		B → ID
40	41	42	43	u2		u6	05	4	22	26		22 _{02, 03} → PN
44	45	46	47	05		v6	14	5	25	31		Divide
48	49	50	51	14		15	17	0	24	22		MQ → 22 ₀₃
52	53	54	55	17		19	20	1	22	28		22 ₀₃ → AR
56	57	58	59	20		22	26	3	20	29		AR - A → AR
60	61	62	63	26		27	29	0	28	27	-	Test AR B/P
64	65	66	67	29		32	32	0	23	31		Clear MQ, PN, ID
68	69	70	71	32		34	37	0	20	24		A → MQ
72	73	74	75	37		(66)	u5	0	27	31		Normalize MQ
76	77	78	79	u5		u6	09	3	28	28		-AR → AR
80	81	82	83	09		11	15	1	24	25		MQ → ID ₁
84	85	86	87	15		(66)	78	0	26	31		Shift
88	89	90	91	78		80	82	0	25	20		(ID even) → 20 ₀₀
92	93	94	95	82		84	85	1	20	28		20 ₀₀ → AR
96	97	98	99	85		86	88	3	20	29		AR - 20 ₀₂ → AR
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	60		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
8	9	10	11	60		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
12	13	14	15	64		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
16	17	18	19	65		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
20	21	22	23	67		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
24	25	26	27	68		u0	u2	6	20	25		20 ₀₀ → ID ₀₁
28	29	30	31	69		19	96	0	00	00	-	Go to Loc 96
32	33	34	35	74	u	84	00	3	28	29		Clear AR
36	37	38	39	u7		54	65	7	20	31	-	
40	41	42	43	02								-zy855z4
44	45	46	47	22								-zyxwv10 "A"
48	49	50	51	24								9876543 "B"
52	53	54	55	91								9999999 Extractor for test
56	57	58	59	95								3w3w3w3 Test number
60	61	62	63	61								0072000 E TN Extractor
64	65	66	67									
68	69	70	71									
72	73	74	75									
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
u0	u1	u2	u3									
u4	u5	u6										

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0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	0		1	002	0	19	00		L19 → L0
8	9	10	11	2	-	6	009	0	21	31		Commands L0
12	13	14	15	9		12	023	0	23	31		Halt
16	17	18	19	23		25	027	0	12	31		Set Type-in
20	21	22	23	27		1	027	0	28	31		Test Ready
24	25	26	27	28	-		010	0	23	28		23 - 000 → AR
28	29	30	31	10		12	016	0	28	27		Test AR
32	33	34	35	16		17	018	0	25	19		Clear L19
36	37	38	39	17	-	42	013	0	28	00		N _t → 00 - 042
40	41	42	43	18	-	20	050	0	00	23		"1" → 23 - 0
44	45	46	47	50		52	052	0	25	28		Clear AR
48	49	50	51	52		53	053	1	00	29		Add L0 → AR
52	53	54	55	53		54	055	3	00	29		Subtract L0 → AR
56	57	58	59	55		57	057	0	28	27		Test AR
60	61	62	63	57	-	60	061	0	23	28		N → AR
64	65	66	67	58	-	55	060	0	00	23		00 - 055 → 23 - 3
68	69	70	71	61	-	20	021	0	00	29		+ "1" → AR
72	73	74	75	21	-	24	031	0	28	23		AR → 23 - 0
76	77	78	79	31	-	42	046	3	00	29		-N _t → AR
80	81	82	83	46		48	049	0	22	31		Test Sign
84	85	86	87	49		50	036	4	17	31		Ring Bell
88	89	90	91	50		52	052	0	25	28		Clear AR
92	93	94	95									
96	97	98	99	13		16	016	0	23	31		Clear (See 16 above)
00	01	02	03	020		216	000	0	00	10		"1"
04	05	06		042		216	000	0	01	00		N _t

0	1	2	3	L	P	T r L _k	N	C	S	D	BP	NOTES
4	5	6	7	36		38	040	0	00	28		x → AR
8	9	10	11	40		42	045	0	28	23		x → 23 - 1
12	13	14	15	45		48	051	1	28	26		x → PN
16	17	18	19	51		53	054	0	28	29		Shift x left
20	21	22	23	54		57	059	1	28	25		2x → ID
24	25	26	27	59		61	062	0	28	29		Shift 2x left
28	29	30	31	62		65	065	1	28	24		4x → MQ
32	33	34	35	65		-68	069	0	23	28		N → AR
36	37	38	39	69		-20	022	3	00	29		-1 → AR
40	41	42	43	22		-24	043	0	28	23		N - 1 → 23 - 0
44	45	46	47	43		45	075	0	28	27		Test AR
48	49	50	51	75		76	077	4	17	31		Ring Bell
52	53	54	55	76		78	078	0	23	28		x → AR
56	57	58	59	78		80	080	0	28	29		2x → AR
60	61	62	63	80		83	083	3	26	29		-PN → AR
64	65	66	67	83		85	085	0	28	27		Test AR
68	69	70	71	85		-89	091	0	23	28		x → AR
72	73	74	75	86		-83	060	0	00	23		00 - 083 → AR
76	77	78	79	91		94	096	0	28	29		4x → AR
80	81	82	83	96		99	099	3	25	29		-ID → AR
84	85	86	87	99		101	104	0	28	27		Test AR
88	89	90	91	104		106	106	0	23	28		x → AR
92	93	94	95	105		-99	060	0	00	23		00 - 099 → AR
96	97	98	99	037		216	00Z	x	v9	70		x
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	T or C _k	N	C	S	D	BP	NOTES
4	5	6	7	106		2	008	0	28	29		8x → AR
8	9	10	11	8		11	011	3	24	29		-MQ → AR
12	13	14	15	11		14	014	0	28	27		Test AR
16	17	18	19	15		-17	019	0	23	28		x → AR
20	21	22	23	19		21	040	0	00	29		+1 → AR
24	25	26	27	40		42	045	0	28	23		
28	29	30	31	45		48	051	1	28	26		
32	33	34	35	51		53	054	0	28	29		
36	37	38	39	54		57	059	1	28	25		
40	41	42	43	59		61	062	0	28	29		
44	45	46	47	59		61	062	0	28	29		
48	49	50	51	62		65	065	1	28	24		See Page 24
52	53	54	55	65		-68	069	0	23	28		
56	57	58	59	69		-20	022	3	00	29		
60	61	62	63	22		-24	043	0	28	23		
64	65	66	67	43		45	075	0	28	27		
68	69	70	71	75		76	077	4	17	31		
72	73	74	75	76		78	078	0	23	28		
76	77	78	79									
80	81	82	83	60		-74	101	0	00	20		"0" → 20 - 2
84	85	86	87	101		1	101	0	28	31		Test Ready
88	89	90	91	102		-2	012	0	00	02-		Format → 02 - 2, 3
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	12		-107	033	0	23	19		23 - 3 → 19 - 107
8	9	10	11	33		35	048	0	91	31		Type 19
12	13	14	15	48		-50	089	0	20	27		Test 20 - 2
16	17	18	19	89		-91	066	0	23	28		23 - 3 → AR
20	21	22	23	90		92	103	0	23	28		23 - 3 → AR
24	25	26	27	66		-82	084	0	00	29		+ Command → AR
28	29	30	31	84		86	105	0	31	31		ObeY AR
32	33	34	35	82			000	3	00	2		This command clears AR
36	37	38	39									when proper number is added to it by command 066
40	41	42	43	77		-20	024	1	00	24		"1" → MQ even
44	45	46	47	24		-34	035	0	00	28		y → AR
48	49	50	51	35		38	039	1	28	25		y → ID
52	53	54	55	39		44	044	1	25	20		ID → 20
56	57	58	59	44		49	056	1	25	21		ID → 21
60	61	62	63	56		61	063	1	25	22		ID → 22
64	65	66	67	63		68	068	1	25	23		ID → 23
68	69	70	71	68		-70	100	1	24	28		N → AR
72	73	74	75	100		-20	032	0	00	29		+1 → AR
76	77	78	79	32		-34	038	1	28	24		N + 1 → MQ even
80	81	82	83	38		-42	047	3	00	29		-N _t → AR
84	85	86	87	47		50	072	0	22	31		Test Sign
88	89	90	91	72		73	025	4	17	31		Ring Bell
92	93	94	95	73		75	079	0	00	28		Clear AR
96	97	98	99	034		216	3Zx	u	97	50		y
00	01	02	03									
04	05	06		103			066	1	25	23		Clear Line 23

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	79		84	088	1	20	29		Add L20
8	9	10	11	88		93	095	3	25	29		-2ID → AR
12	13	14	15	95		97	097	0	28	27		Test AR
16	17	18	19	97		102	001	1	21	29		Add L21
20	21	22	23	98		-95	101	0	00	23		00 - 095 → 23 - 0
24	25	26	27	1		6	007	3	25	29		-2ID → AR
28	29	30	31	7		13	029	0	28	27		Test AR
32	33	34	35	29		34	041	1	22	29		Add L22
36	37	38	39	30		-7	101	0	00	23		00 - 007 → 23 - 3
40	41	42	43	41		46	067	3	25	29		-2ID → AR
44	45	46	47	67		69	070	0	28	27		Test AR
48	49	50	51	70		75	081	1	23	29		Add L23
52	53	54	55	71		-67	101	0	00	23		00 - 067 → 23 - 3
56	57	58	59	81		86	087	3	25	29		-2ID → AR
60	61	62	63	87		89	092	0	28	27		Test AR
64	65	66	67	92		94	094	1	25	29		ID odd → AR
68	69	70	71	93		-87	101	0	00	23		00 - 087 → AR
72	73	74	75	94		-20	035	0	00	29		+ "1" → AR
76	77	78	79	35		38	039	1	28	25		AR → ID
80	81	82	83	39		44	044	1	25	20		
84	85	86	87	44		49	056	1	25	21		See Page 26
88	89	90	91	56		61	063	1	25	22		
92	93	94	95	63		68	068	1	25	23		
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or Lk	N	C	S	D	BP	NOTES
4	5	6	7	25		1	025	0	28	31		Test Ready
8	9	10	11	26		28	004	0	15	31		Read Tape
12	13	14	15	4	-	42	005	0	00	28		00 - 042 → AR
16	17	18	19	5		1	005	0	28	31		Test Ready
20	21	22	23	6		7	007	0	19	00		L19 → L0
24	25	26	27	003		216	800	0	00	40		Format
28	29	30	31									
32	33	34	35									
36	37	38	39									
40	41	42	43									
44	45	46	47									
48	49	50	51									
52	53	54	55									
56	57	58	59									
60	61	62	63									
64	65	66	67									
68	69	70	71									
72	73	74	75									
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	7		30	043	0	28	00		N _t → 00 - 030
8	9	10	11	43		45	045	0	00	28		Command → AR
12	13	14	15	45		47	047	0	28	23		AR → 23 - 2
16	17	18	19	47		49	049	0	31	31		Obey AR
20	21	22	23	44		50	050	0	00	01		L0 → L1, 2, 3, . . . or 19
24	25	26	27	50		52	052	3	00	29		-(D = 19) → AR
28	29	30	31	52		54	055	0	22	31		Test Sign
32	33	34	35	55		58	058	4	23	31		Clear
36	37	38	39	56		58	059	0	23	28		23 - 2 → AR
40	41	42	43	59		61	045	0	00	29		+(D = 1) → AR
44	45	46	47									
48	49	50	51	58		60	061	0	00	22		"1" → 22 - 0
52	53	54	55	61		62	063	1	00	30	-	Add L0 → PN
56	57	58	59	63		68	068	1	26	23	-	PN → 23 - 0, 1, 2, 3
60	61	62	63	68		70	070	0	00	28		Command → AR
64	65	66	67	70		71	072	0	28	22		AR → 22 - 3
68	69	70	71	72		76	078	1	23	26	-	23 - 0, 1 → PN
72	73	74	75	78		80	107	0	31	31		Obey AR
76	77	78	79	69		108	028	3	01	30	-	-(L1, 2, 3, . . . , or 19) → PN
80	81	82	83	8		10	012	1	26	27	-	Test PN
84	85	86	87	12		14	015	0	00	29		+(s = 19) → AR
88	89	90	91	13		17	017	2	22	21		22 - 3 → 21 - 0
92	93	94	95	051		050	050	0	00	19		D = 19
96	97	98	99	060		000	000	0	00	01		D = 1
00	01	02	03	014		216	6w1	w	x3	y0		s = 19
04	05	06		Although the L _n number of 69 is 28, that command is obeyed from AR at 197 time, hence next command is in 8.								

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	15		17	018	0	22	31		Test Sign
8	9	10	11	18		21	021	0	22	28		N → AR
12	13	14	15	19		-23	034	0	22	28		22 - 3 → AR
16	17	18	19	34		36	070	0	00	29		+ (s=1) → AR
20	21	22	23	2								
24	25	26	27	21		-23	024	0	00	29		+1 → AR
28	29	30	31	24		-28	029	0	28	22		N + 1 → 22 - 0
32	33	34	35	29		31	032	3	00	29		-N _t → AR
36	37	38	39	32		35	065	0	22	31		Test Sign
40	41	42	43	65		68	071	4	23	31		Clear
44	45	46	47	66		68	068	0	28	28		Do nothing
48	49	50	51	71		72	087	0	25	19		Clear L19
52	53	54	55	87			000	0	00	19		00 - 088 thru 107 → 19
56	57	58	59			2	074	0	09	31		Type 19
60	61	62	63	74		1	074	0	28	31		Test Ready
64	65	66	67	75		77	083	0	15	31		Read Tape
68	69	70	71	83		-30	084	0	00	28		00 - 030 → AR
72	73	74	75	84		1	084	0	28	31		Test Ready
76	77	78	79	85		86	017	0	19	00		L19 → L00
80	81	82	83	035		000	000	0	01	00		s = 1
84	85	86	87	023		216	000	0	00	10		"1"
88	89	90	91									
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	17		20	020	1	23	26-		23 - 2, 3 → PN
8	9	10	11	20		-24	026	3	23	30-		-(23 - 0, 1) → PN
12	13	14	15	26		29	036	1	26	27		Test PN
16	17	18	19	36		-64	067	0	00	20		See below
20	21	22	23	37		38	039	0	12	31		Gate Type in
24	25	26	27	39		40	041	0	17	31		Ring Bell
28	29	30	31	41		-42	042	0	28	28		Do nothing
32	33	34	35	42		-42	039	0	28	31		Test Ready
36	37	38	39	40		-44	045	0	00	28		Command → AR
40	41	42	43									
44	45	46	47	36		-64	067	0	00	20		Extractor → 20 - 0
48	49	50	51	67		-67	073	2	30	25		20. 21 - 0 → ID even
52	53	54	55	73		10	086	0	26	31		Shift right 5
56	57	58	59	86		-88	001	2	30	28		20. 21 - 0 → AR
60	61	62	63	1		17	022	0	28	29		Shift left 15
64	65	66	67	22		-24	025	0	28	21		AR → 21 - 0
68	69	70	71	25		-27	028	0	00	29		+ Command → AR
72	73	74	75	28		30	030	0	31	31		Obey AR
76	77	78	79	27		118	018	0	00	28-		00 - ? → AR. The timing nos. are altered by comm. 25
80	81	82	83	2		-23	031	0	00	29		+1 → AR
84	85	86	87	31		33	033	2	27	28		20. 21 + 20. AR → AR
88	89	90	91	33		38	038	0	28	20		AR → 20 - 0, 1, 2, 3
92	93	94	95	38		-40	046	0	21	28		21 - 0 → AR
96	97	98	99	064		216	ZZ0	0	00	00		Extractor
00	01	02	03	003		216	800	0	00	40		Format
04	05	06		023		216	000	0	00	10		"1"

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	46	-	53	054	0	00	29		+ Command → AR
8	9	10	11	54		56	056	0	31	31		Obey AR
12	13	14	15	53		118	025	0	20	00	-	20 - ? → 00 - ?
16	17	18	19	9		11	011	0	00	28		Command → AR
20	21	22	23	11		13	016	1	25	29		+ID even → AR
24	25	26	27	16		18	018	0	31	31		Obey AR
28	29	30	31	10		19	056	0	13	00		This comm. is L0 → L ? modified by com 11
32	33	34	35	57	-	59	012	0	22	28		22 - 3 → AR
36	37	38	39									
40	41	42	43									
44	45	46	47									
48	49	50	51									
52	53	54	55									
56	57	58	59									
60	61	62	63									
64	65	66	67									
68	69	70	71									
72	73	74	75									
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	Y or L _k	N	C	S	D	BP	NOTES
4	5	6	7	17		-86	020	0	28	00		$N_1 \rightarrow 00 - 086$
8	9	10	11	20		23	025	0	23	31		Clear
12	13	14	15	25		26	000	0	25	19		Clear L19
16	17	18	19			5	005	0	00	21		Constants \rightarrow 21
20	21	22	23	5		-8	009	0	21	20		"1" \rightarrow 20 - 0
24	25	26	27	9		14	014	0	21	22		21 \rightarrow 22
28	29	30	31	14		16	016	0	25	28		Clear AR
32	33	34	35	16		21	027	1	21	29		Add 21
36	37	38	39	27		32	032	3	22	29		Subtract 22
40	41	42	43	32		34	036	0	28	27		Test AR
44	45	46	47	36		-38	039	0	21	28		$C_2 \rightarrow$ AR
48	49	50	51	37		-32	012	0	00	28		00 - 032 \rightarrow AR
52	53	54	55									
56	57	58	59	39		41	041	0	20	29		+1 \rightarrow AR
60	61	62	63	41		43	043	0	28	21		$C_2 \rightarrow$ 21 - 2
64	65	66	67	43		45	045	0	20	28		$C_3 \rightarrow$ AR
68	69	70	71	45		-47	049	0	21	29		+1 \rightarrow AR
72	73	74	75	49		-51	052	0	28	21		$C_3 \rightarrow$ 21 - 0
76	77	78	79	52		54	054	0	21	28		$C_1 \rightarrow$ AR
80	81	82	83	54		-56	057	0	20	29		+1 \rightarrow AR
84	85	86	87	57		-61	062	0	28	21		$C_1 \rightarrow$ 21 - 0
88	89	90	91	62		-64	065	0	21	28		$C_0 \rightarrow$ AR
92	93	94	95	001		216	000	0	00	20		Constant C_1
96	97	98	99	002		216	000	0	00	40		Constant C_2
00	01	02	03	003		216	000	0	00	30		Constant C_3
04	05	06		004		216	000	0	00	10		Constant C_0

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	65		-68	069	0	20	29		+1 → AR
8	9	10	11	69		-72	073	0	28	21		C ₀ → 21 - 3
12	13	14	15	73		-86	095	3	00	29		-N ₁
16	17	18	19	95		07	008	0	22	31		Test Sign
20	21	22	23	8		9	011	4	17	31		Ring Bell
24	25	26	27	9		14	014	0	21	22		21 → 22
28	29	30	31									
32	33	34	35	11		5	007	0	00	21		00 - 1, 2, 3, 4 → 21
36	37	38	39	7		9	019	0	21	20		"1" → 20 - 0
40	41	42	43	19		-21	022	0	21	25		C ₁ → ID
44	45	46	47	22		-24	026	2	21	24		C ₀ → MQ
48	49	50	51	26		-28	028	0	24	28		-C ₀ → AR
52	53	54	55	28		30	030	0	22	31		Test Sign
56	57	58	59	30		-28	023	0	00	28		00 - 028 → AR
60	61	62	63	31		34	035	2	21	25		C ₀ → ID
64	65	66	67	35		38	038	2	21	24		C ₀ → MQ
68	69	70	71	38		40	042	0	24	28		MQ → AR
72	73	74	75	42		45	046	0	22	31		Test Sign
76	77	78	79	46		-48	050	0	21	25		C ₀ → ID
80	81	82	83	47		-43	023	0	00	28		00 - 043 → AR
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	50		-55	056	0	21	24		C ₃ → MQ
8	9	10	11	56		58	058	0	24	28		MQ → AR
12	13	14	15	58		60	060	0	22	31		Test Sign
16	17	18	19	60		-58	023	0	00	28		00 - 058 → AR
20	21	22	23	61		-65	066	0	21	25		C ₁ → ID
24	25	26	27	66		68	068	0	21	24		C ₃ → MQ
28	29	30	31	68		70	070	0	24	28		MQ → AR
32	33	34	35	70		72	076	0	22	31		Test Sign
36	37	38	39	76		-80	081	0	20	28		N → AR
40	41	42	43	77		-70	023	0	00	28		00 - 070 → AR
44	45	46	47									
48	49	50	51	81		83	083	0	00	29		"1" → AR
52	53	54	55	83		85	085	0	28	20		AR → 20 - 0
56	57	58	59	85		87	087	3	00	29		-N _t → AR
60	61	62	63	87		89	018	0	22	31		Test Sign
64	65	66	67	18		19	071	4	17	31		Ring Bell
68	69	70	71	71		1	071	0	28	31		Test Ready
72	73	74	75	72		74	088	0	15	31		Read Tape
76	77	78	79	88		1	088	0	28	31		Test Ready
80	81	82	83	89		90	090	1	19	29		Add L19
84	85	86	87	90		92	092	0	28	27		Test AR
88	89	90	91	92		-86	099	0	00	28		N _t → AR
92	93	94	95	93		95	096	0	08	31		Type AR
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	96		1	096	0	28	31		Test Ready
8	9	10	11	97		-90	094	0	00	28		00 - 090 → AR
12	13	14	15	94		96	091	0	08	31		Type AR
16	17	18	19	91		1	091	0	28	31		Test Ready
20	21	22	23									
24	25	26	27	99		100	017	0	19	00		L19 → L00
28	29	30	31									
32	33	34	35	12		1	012	0	28	31		Test Ready
36	37	38	39	13		-107	015	0	28	19		AR → 19 - 107
40	41	42	43	15		17	036	0	09	31		Type 19
44	45	46	47									
48	49	50	51	23		1	023	0	28	31		Test Ready
52	53	54	55	24		-107	029	0	28	19		AR → 19 - 107
56	57	58	59	29		31	076	0	09	31		Type 19
60	61	62	63									
64	65	66	67									
68	69	70	71									
72	73	74	75									
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
100	101	102	103									
104	105	106										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	17		-86	022	0	28	00		N ₁ → 00 - 086
8	9	10	11	22		25	025	0	23	31		Clear
12	13	14	15	25		30	030	0	25	20		Clear 20
16	17	18	19	30		-32	034	2	00	21-		"1" → 21 - 1
20	21	22	23	34		36	036	0	29	31		Test Overflow
24	25	26	27	36		-41	042	0	00	20		A → 20 - 1
28	29	30	31	37		-41	042	0	00	20		A → 20 - 1
32	33	34	35	42		44	044	0	00	20		B → 20 - 3
36	37	38	39	44		46	046	1	20	28		A → AR
40	41	42	43	46		48	048	1	20	29		+B → AR
44	45	46	47	48		50	050	0	29	31		Test Overflow
48	49	50	51	50		-48	098	0	00	28		00 - 048 → AR
52	53	54	55	51		-53	054	3	20	28		(-A) → AR
56	57	58	59	54		56	056	3	20	29		-B → AR
60	61	62	63	56		58	058	0	29	31		Test Overflow
64	65	66	67	58		-56	098	0	00	28		00 - 056 → AR
68	69	70	71	59		-61	062	3	20	28		(-A) → AR
72	73	74	75	62		-65	066	3	20	29		-A → AR
76	77	78	79	66		68	068	0	29	31		Test Overflow
80	81	82	83	68		-66	098	0	00	28		00 - 066 → AR
84	85	86	87	69		-73	074	1	00	28		x → AR
88	89	90	91	041		216	800	0	00	00		A
92	93	94	95	043		216	800	0	00	10		B
96	97	98	99	032		216	000	0	00	10		"1"
U0	U1	U2	U3	073		See Page	3					x
U4	U5	U6										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	74		76	076	3	20	29		-B → AR
8	9	10	11	76		78	078	0	29	31		Test Overflow
12	13	14	15	78		-80	082	1	20	26		A → PN
16	17	18	19	79		-76	096	0	00	28		00 - 076 → AR
20	21	22	23									
24	25	26	27	82		-86	088	3	20	30		-B → PN
28	29	30	31	88		90	090	0	29	31		Test Overflow
32	33	34	35	90		-92	094	1	20	26		A → PN
36	37	38	39	91		-88	096	0	00	28		00 - 088 AR
40	41	42	43									
44	45	46	47	94		-98	100	1	20	30		+B → PN
48	49	50	51	100		102	102	0	29	31		Test Overflow
52	53	54	55	102		-100	098	0	00	28		00 - 100 → AR
56	57	58	59	103		106	106	0	23	31		Clear
60	61	62	63	106		-	004	3	20	30		(-A) → PN
64	65	66	67	4		-6	008	3	20	30		-B → PN
68	69	70	71	8		10	010	0	29	31		Test Overflow
72	73	74	75	10		-8	098	0	00	28		00 - 008 → AR
76	77	78	79	11		14	014	0	23	31		Clear
80	81	82	83	14		-16	018	3	20	31		(-A) → PN
84	85	86	87	18		-20	023	3	20	30		-A → PN
88	89	90	91	23		25	026	0	29	31		Test Overflow
92	93	94	95	26		-23	098	0	00	28		00 - 023 → AR
96	97	98	99	27		-31	033	3	20	28		(-A) → AR
00	01	02	03	33		34	035	3	25	29		-0 → AR
04	05	06		35		37	038	0	22	31		Test Sign

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	39		42	045	1	20	26-		B → PN
8	9	10	11	45		48	049	3	25	30-		-0 → PN
12	13	14	15	49		51	052	1	26	28		PN even → AR
16	17	18	19	52		54	060	0	22	31		Test Sign
20	21	22	23	60		-65	067	0	21	28		N → AR
24	25	26	27	61		-52	098	0	00	28		00 - 052 → AR
28	29	30	31									
32	33	34	35	67		-72	073	0	00	29		+1 → AR
36	37	38	39	73		-77	085	0	28	21		N + 1 → 21 - 1
40	41	42	43	85		87	085	3	00	29		-N _t → AR
44	45	46	47	87		89	104	0	22	31		Test Sign
48	49	50	51	104		105	006	4	17	31		Ring Bell
52	53	54	55	105		107	044	0	28	28		Do nothing
56	57	58	59									
60	61	62	63	6		86	092		00	28		N _t → AR
64	65	66	67	92		1	092	0	28	31		Test Ready
68	69	70	71	93		95	070	0	15	31		Read Tape
72	73	74	75	70		1	070	0	28	31		Test Ready
76	77	78	79	71		72	017	0	19	00		L19 → L0
80	81	82	83									
84	85	86	87	38		-35	098	0	00	28		00 - 035 → AR
88	89	90	91									
92	93	94	95									
96	97	98	99									
100	101	102	103									
104	105	106										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	96		98	098	3	00	29		(T _n = 1) → AR
8	9	10	11	98		1	098	0	28	31		Test Ready
12	13	14	15	99		100	101	0	25	19		Clear L19
16	17	18	19	101		-10	005	0	28	19		AR → 19 - 107
20	21	22	23	5			012	0	09	31		Type 19
24	25	26	27	12		-16	019	0	28	21		AR → 21 - 0
28	29	30	31	19		21	021	0	00	20		Extractor → 20 - 0
32	33	34	35	21		-24	028	0	31	28		20, 21 - 0 → AR
36	37	38	39	28		-32	040	0	25	20		Clear 20 - 0
40	41	42	43	40		-47	053	0	00	29		+ Command → AR
44	45	46	47	53		55	055	0	31	31		Obey AR
48	49	50	51	47		58	001	0	23	31		Clear and return
52	53	54	55									to proper place in
56	57	58	59									routine. The T _n
60	61	62	63									number of 047 is
64	65	66	67									altered.
68	69	70	71	020		216	007	Z	00	00		Extractor
72	73	74	75	097		000	001	0	00	00		T _n = 1
76	77	78	79									
80	81	82	83									
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	17		-19	020	0	28	22		N _t → 22 - 3
8	9	10	11	20		-25	026	0	00	28		"1" → AR
12	13	14	15	26		-28	031	0	28	22-		"1" → 22 - 0, 1
16	17	18	19	31		-34	035	0	00	22		Exit 1 → 22 - 2
20	21	22	23	35		38	043	0	00	21		A → 21 - 0; B → 21 - 1
24	25	26	27	43		46	046	2	21	25-		A → ID odd
28	29	30	31	46		-49	051	0	21	24		B → MQ
32	33	34	35	51		56	000	0	24	31		Mult.
36	37	38	39			-4	006	0	26	23		A, B → 23 - 0, 1
40	41	42	43	6		-8	013	2	21	25		A → ID odd
44	45	46	47	13		-16	0 9	0	23	26		A, B → PN
48	49	50	51	19		58	078	1	25	31		Divide
52	53	54	55	78		-81	082	1	21	28		B → AR
56	57	58	59	82		-84	085	0	24	20		A, B → 20 - 0
60	61	62	63	85		-88	089	3	20	29		A, B → AR
64	65	66	67	89		91	091	0	28	27		Test AR
68	69	70	71	91		-93	094	0	22	28		"1" → AR
72	73	74	75	92		95	095	0	23	31		Clear
76	77	78	79	025		216	000	0	00	10		"1"
80	81	82	83	036		216	987		54	30		A
84	85	86	87	037		216	345	6	78	90	-	B
88	89	90	91									
92	93	94	95									
96	97	98	99									
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	94		-96	097	0	22	29		+N → AR
8	9	10	11	97		-100	101	0	28	22		N + 1 → 22 - 0
12	13	14	15	101		-103	104	3	22	29		-N _t → AR
16	17	18	19	104		106	004	0	22	31		Test Sign
20	21	22	23	4		5	022	4	17	31		Ring Bell
24	25	26	27	5		7	008	0	22	28		Command 1 → AR
28	29	30	31	8		10	010	0	31	31		Obey AR
32	33	34	35						EXIT 1			
36	37	38	39	34		-12	014	1	21	28		A → AR
40	41	42	43	14		16	016	1	00	29		+ A → AR
44	45	46	47	16		20	021	1	28	21		A + A → 21 - 0
48	49	50	51	21		25	027	1	21	28		B → AR
52	53	54	55	2		29	029	1	00	29		B → AR
56	57	58	59	29		33	043	1	28	21		B + B → 21 - 1
60	61	62	63									
64	65	66	67	95		97	098	0	21	25		B → ID
68	69	70	71	98		100	103	2	21	24		A → MQ
72	73	74	75	103		58	054	0	24	31		Mult.
76	77	78	79	54		-56	057	0	26	20		B=A → 20 - 0, 1
80	81	82	83	57		-60	062	1	20	26		B, A → PN
84	85	86	87	62		-64	066	3	23	30		- AB → PN
88	89	90	91	66		-68	070	1	26	27		Test PN
92	93	94	95	70		72	074	0	00	28		Exit 2 → AR
96	97	98	99	71		-73	074	0	00	28		Exit 3 → AR
00	01	02	03	015		216	001	2	34	50		A
04	05	06		028		216	000	Z		wx	y0	B

0	1	2	3	L	P	T of L _k	N	C	S	D	BP	NOTES
4	5	6	7	74		1	074	0	28	31		Test Ready
8	9	10	11	75		78	079	0	23	31		Clear
12	13	14	15	79		80	080	0	25	19		Clear L19
16	17	18	19	80		-107	001	0	28	19		AR → 19 - 107
20	21	22	23	1		4	007	0	00	02		Format → 2
24	25	26	27	7		10	011	0	09	31		Type
28	29	30	31	11		13	013	0	31	31		Obey AR
32	33	34	35									
36	37	38	39	72		15	091	0	20	20		Exit 2
40	41	42	43	73		16	091	0	21	21		Exit 3
44	45	46	47									
48	49	50	51	22		25	030	0	22	28		"1" AR
52	53	54	55	30		32	039	0	28	22		"1" → 22 - 0
56	57	58	59	39		42	042	0	23	31		Clear
60	61	62	63	42		-44	045	0	21	24		A → MQ
64	65	66	67	45		48	053	1	25	28		Clear AR
68	69	70	71	53		100	009	0	27	31		Normalize
72	73	74	75	9		12	012	0	24	25		MQ → ID
76	77	78	79	12		14	018	0	24	20		MQ → 20 - 1
80	81	82	83	18		20	023	3	28	28		(-AR) → AR
84	85	86	87	23		100	083	0	26	31		Shift
88	89	90	91	83		85	086	0	24	27		Test MQ
92	93	94	95									
96	97	98	99									
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	T Pr L _k	N	C	S	D	BP	NOTES
4	5	6	7	86		-88	090	0	25	28		ID → AR
8	9	10	11	90		-92	093	3	21	29		-A → AR
12	13	14	15	93		95	099	0	28	27		Test AR
16	17	18	19	99		101	102	0	22	28		N → AR
20	21	22	23	100		-99	074	0	00	28		00 - 099 → AR
24	25	26	27									
28	29	30	31	102		-105	106	0	22	29		+1 → AR
32	33	34	35	106			010	0	28	22		N + 1 → 22 - 0
36	37	38	39	10		12	024	3	22	29		- N _t → AR
40	41	42	43	24		26	038	0	22	31		Test Sign
44	45	46	47	38		39	040	4	17	31		Ring Bell
48	49	50	51	39		42	042	0	23	31		Clear
52	53	54	55									
56	57	58	59	87		89	074	0	00	28		00 - 088 → AR
60	61	62	63									
64	65	66	67	88		20	099	0	23	31		Clear
68	69	70	71									
72	73	74	75	60		1	060	0	28	31		Test Ready
76	77	78	79	61		63	064	0	15	31		Read Tape
80	81	82	83	64		1	064	0	28	31		Test Ready
84	85	86	87	65		-67	068	0	22	28		N _t → AR
88	89	90	91	68		69	017	0	19	00		L19 → L0
92	93	94	95									
96	97	98	99									
u0	u1	u2	u3									
u4	u5	u6										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	40		42	044	0	22	28		"1" → AR
8	9	10	11	44	-	48	049	0	28	22		"1" → 22 - 0
12	13	14	15	49	-	84	055	0	00	20		C → 20 - 0
16	17	18	19	55		57	059	0	00	21		D → 21 - 0
20	21	22	23	59		61	063	0	31	28		C·D → AR
24	25	26	27	63		65	067	0	30	29		+ (C·D) → AR
28	29	30	31	67		69	069	3	21	29		- D → AR
32	33	34	35	69		71	076	0	28	27		Test AR
36	37	38	39	76	-	80	081	0	21	28		D → AR
40	41	42	43	77	-	76	074	0	00	28		00 - 076 → AR
44	45	46	47									
48	49	50	51	81	-	84	096	0	27	28		+ C·D + C (C+D) → AR
52	53	54	55	96	-	100	105	3	21	29		- C → AR
56	57	58	59	105		105	032	0	28	27		Test AR
60	61	62	63	32		36	041	0	22	28		N → AR
64	65	66	67	33		32	074	0	00	28		00 - 032 → AR
68	69	70	71									
72	73	74	75	41	-	45	047	0	22	29		+ 1 → AR
76	77	78	79	47		49	050	0	28	22		N + 1 → 22 - 0
80	81	82	83	50		52	052	3	22	29		-N ₁ → AR
84	85	86	87	52		54	058	0	28	27		Test AR
88	89	90	91	58		59	060	4	17	31		Ring Bell
92	93	94	95	59		61	063	0	31	28		See 059 Above
96	97	98	99	084		216	999	9	99	90		C
00	01	02	03	056		216	3w3	w	3w	30		D
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	17		19	044	0	15	31		Read Tape
8	9	10	11	44		1	044	0	28	31		Test Ready
12	13	14	15	45		46	018	0	19	06		L19 → L6
16	17	18	19	18		21	032	0	23	31		Clear
20	21	22	23	32		34	034	0	15	31		Read Tape
24	25	26	27	34		1	034	0	28	31		Test Ready
28	29	30	31	35		36	043	0	19	04		L19 → L4
32	33	34	35	43		44	046	0	25	19		Clear 19
36	37	38	39	46		-86	087	0	28	00		N _t → 00 - 086
40	41	42	43	87		92	101	0	00	20		Not useful
44	45	46	47	101		106	106	0	00	19		00 - 102, 3, 4, 5 → 19
48	49	50	51	106		4	007	0	00	02		Format → 02
52	53	54	55	7		-54	056	0	00	20-		00 - 054, 5 → 20 - 2, 3
56	57	58	59	56		-106	006	0	20	19-		20 - 2, 3 → 19 - 106, 7
60	61	62	63	6		8	008	0	09	31		Type 19
64	65	66	67	8		12	024	0	00	22		S0 → 22 - 1; "1" → 22 - 2 0 → 22 - 3
68	69	70	71	24		27	027	2	22	20		0 → 20 - 2
72	73	74	75	27		29	029	0	00	28		Exit 1 → AR
76	77	78	79	29		30	085	0	06	01		Line 06 → -L1
80	81	82	83	85		87	093	5	21	31		Commands from L 1
84	85	86	87	003		216	800	0	00	x0		
88	89	90	91	002		216	000	0	0w	60		Format
92	93	94	95	001		216	000	0	0y	80		
96	97	98	99	009		216	345	6	78	90		0 ₀
00	01	02	03	010		216	000	0	00	10		"1"
04	05	06		011		216	002	3	45	60		0

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7			100	100	4	21	31		Exit 1; Comm. from L0
8	9	10	11	100	-	104	004	0	20	22		Sin 0 → 22 - 0
12	13	14	15	4	-	36	037	0	00	28		Exit 2 → AR
16	17	18	19	37	-	057	078	1	21	31		Commands from L1
20	21	22	23			56	057	4	20	31		Exit 2; Comm. from L0
24	25	26	27	57		59	059	1	20	28		∅ = Arcsin (sin 0) → AR
28	29	30	31	59		61	062	3	22	29		-0 → AR
32	33	34	35	62		64	064	1	28	20		∅ - 0 → 20 - 3
36	37	38	39	64	-	67	068	0	00	21		Extractor → 21 - 3
40	41	42	43	68	-	71	072	0	31	27		20-21 - 3 → Test
44	45	46	47	72		74	074	1	22	28		0 → AR
48	49	50	51	73	-	68	080	0	00	28		00 - 068 → AR
52	53	54	55									
56	57	58	59	74		76	077	3	22	29		- 0 → AR
60	61	62	63	77	-	81	082	1	28	22		0 - 0 → 22 - 1
64	65	66	67	82	-	86	088	0	22	28		N → AR
68	69	70	71	88	-	14	015	0	00	29		+1 → AR
72	73	74	75	15	-	18	019	0	28	22		N + 1 → 22 - 2
76	77	78	79	19	-	86	092	3	00	29		-N _t → AR
80	81	82	83	92		94	023	0	22	31		Test Sign
84	85	86	87	23	-	25	030	0	00	28		"7" → AR
88	89	90	91	067		216	ZZZ	Z	ZZ	y0		Extractor
92	93	94	95	014		216	000	0	00	10		"1"
96	97	98	99	025		216	000	0	00	70		"7"
00	01	02	03									
04	05	06										

0	1	2	3	L	P	T or L _k	N	C	S	D	BP	NOTES
4	5	6	7	30		1	030	0	28	31		Test Ready
8	9	10	11	31		33	076	0	06	31		Reverse Tape Search
12	13	14	15	76	-	14	020	3	00	29		"1" → AR
16	17	18	19	20		1	020	0	28	31		Test Ready
20	21	22	23	21		23	038	0	22	31		Test Sign
24	25	26	27	38		40	076	0	06	31		Reverse Tape Search
28	29	30	31	39		35	040	0	15	31		Read Tape
32	33	34	35	40		1	040	0	28	31		Test Ready
36	37	38	39	41		43	047	0	28	28		Do nothing
40	41	42	43	47	-	86	093	0	00	28		N _t → AR
44	45	46	47	93		1	093	0	28	31		Test Ready
48	49	50	51	93		1	093	0	28	31		(This is a repeat)
52	53	54	55	94		95	017	0	19	00		L19 → L0
56	57	58	59									
60	61	62	63	80		1	080	0	28	31		Test Ready
64	65	66	67	81	-	107	052	0	28	19		AR → 19 - 107
68	69	70	71	52		54	072	0	09	31		Type 19
72	73	74	75	055		216	112	2	33	40	-	
76	77	78	79	054		216	445	5	66	70		
80	81	82	83	105		216	778	8	99	00		Test Type Out
84	85	86	87	104		216	uvv	v	ww	x0	-	numbers
88	89	90	91	103		216	xyy	y	ZZ	00		
92	93	94	95	102		216	002	3	45	00		
96	97	98	99									
00	01	02	03									
04	05	06										