WANG
LABORATORIES, INC. 836 NORTH ST., TEWKSBURY, MASS. 01876, TEL. (617) 851-7311

April 5, 1967

LOCI User Application Letter #2

The programs for User Application Letter #2 are enclosed, as you requested. The enclosures are:

L42-67	3 Simultaneous Equations
L43-67	Random Number Generator
L44-67	ARCSIN (X)
L45-67	ARCCOS (X)

If you would like addition copies, please let us know. Please note -- We would like your application also.

Ned Chang
Manager, LOCI Division

NC/bw

WANG LABORATORIES, INC. 836 NORTH ST., TEWKSBURY, MASS. 01876, TEL. (617) 851-7311

March 29, 1967

3 Simultaneous Equations

by

Dr. James Drummond
Boeing Scientific Research Laboratories

One of the first programs developed by Dr. Drummond is this solution of 3-Simultaneous Equations. It is the most compact solution we have seen, consisting of only two cards. The equations are:

$$a_{10} = a_{11} x_1 + a_{12} x_2 + a_{13} x_3$$

$$a_{20} = a_{21} x_1 + a_{22} x_2 + a_{23} x_3$$

$$a_{30} = a_{31} x_1 + a_{32} x_2 + a_{33} x_3$$

Operation of the program is extremely simple. Start with the first card, AUTO DISP down.

1. Prime, Po
2. Key in a_{10}, P1
   Key in a_{20}, P2
   Key in a_{30}, P3
3. Repeat (2) for a_{11}, a_{21}, a_{31}.
4. Repeat (2) for a_{12}, a_{22}, a_{32}.
5. Repeat (2) for a_{13}, a_{23}, 2_{33}.
6. RUN
7. Put in Second Card
8. Po, read X_1.
9. RUN, read X_2.
10. RUN, read X_3.

Incidentally, the second card can be used to solve two simultaneous equations.

Example:

$$2x + .5y + z = 9$$
$$x - y - z = 2$$
$$-x + 3y + 5z = 10$$

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LOCI User Application Letter # 2

1st Card, AUTO DISP Down

1. Prime, Po
2. 9 P1 2 P2 1 0 P3
3. 2 P1 1 P2 1 ± P3
4. . 5 P1 1 ± P2 3 P3
5. 1 P1 1 ± P2 5 P3
6. RUN

2nd Card

7. Po read X1 = 3
8. RUN read X2 = -4
9. RUN read X3 = 5

LOCI Program 3 Simultaneous Equations **Date:** January 5, 1967

$a_{10} = a_{11}X_1 + a_{12}X_2 + a_{13}X_3$
$a_{20} = a_{21}X_1 + a_{27}X_2 + a_{23}X_3$
$a_{30} = a_{31}X_1 + a_{32}X_2 + a_{33}X_3$
$a_{33} \neq 0$

(1) Prime, Auto, Po
(2) a_{10}, P_1
(3) a_{20}, P_2
(4) a_{30}, P_3

Repeat (2)-(4) for a_{11} a_{12} a_{13} / a_{21} a_{22} a_{23} / a_{31} a_{32} a_{33}

(5) "RUN", Then go to second card.

Memory will be left in 3rd stage.

results in 33
results in S_1
results in S_0
results in S_3

0th Stage, a_{30}: $\frac{a_{10}a_{33}}{a_{13}} - a_{30}$, $\frac{a_{20}a_{33}}{a_{23}} - a_{30}$

1st Stage a_{31}: $\frac{a_{11}a_{33}}{a_{13}} - a_{31}$, $\frac{a_{21}a_{33}}{a_{23}} - a_{31}$

2nd Stage a_{32}: $\frac{a_{12}a_{33}}{a_{13}} - a_{32}$, $\frac{a_{22}a_{33}}{a_{23}} - a_{32}$

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	3	23		20	Ln^{-1}	14		40	W--DC	42		60	S_3--W	57	
1	W--DC	42		21	W--A	44		41	Ln^{-1}	14		61	-	15	
2	Stop	37		22	A--W	45		42	W--A	44		62	A--W	45	
3	W--S_1	52	$a_{10}, a_{11}, a_{12}, a_{13}$	23	×	12		43	A--W	45		63	W--S_1	52	
4				24	S_2--W	55		44	X	12		64	S_2--W	55	
05	Stop	37		25	X	12		45	S_1--W	53		65	W--A	44	
6	W--S_2	54	$a_{20}, a_{21}, a_{22}, a_{23}$	26	Ln^{-1}	14		46	X	12		66	S_3--W	57	
7				27	W--S_2	54	$\frac{a_{20}a_{33}}{a_{23}}$ etc.	47	Ln^{-1}	14		67	-	15	
8	Stop	37		28	DEC	66		48	W--S_1	52	$\frac{a_{10}a_{33}}{a_{13}}$ etc.	68	A--S_0	50	
9	W--S_3	56	$a_{30}, a_{31}, a_{32}, a_{33}$	29	SM	10	to 1,2,3	49	DEC	66		69	SM	10	to 1, 2, 3
10				30	TestDC=0	70		50	SM	10	to 1,2,3	70	DEC	66	
11	SM	10	to 1, to 2, to 3, to 0	31	2	22		51	TestDC=0	70		71	TestDC=0	70	
12	Stop	37		32	2	22		52	4	24		72	5	25	
13	X	12		33	W--PC	40		53	3	23		73	8	30	
14	SM	10		34	S_3--W	57		54	W--PC	40		74	W--PC	40	
15	SM	10		35	X	12		55	Prime	36	to 0	75	Stop	37	
16	SM	10	to 3	36	S_1--W	53		56	3	23		76			
17	S_2--W	55		37	+	17		57	W--DC	42		77			
18	+	17		38	CLW	02	to 0	58	S_1--W	53		78			
19	CLW	02	to 0	39	3	23		59	W--A	44		79			

NO. L42-67

$a_{10} = a_{11}X_1 + a_{12}X_2$

$a_{20} = a_{21}X_1 + a_{22}X_2$

results printed X_1, X_2, X_3.

omit if set by previous card →

(1) PRIME, Auto
(2) Index a_{10}, W→S
(3) " a_{20}, W→A, A→S_o, 5M ← repeat for a_{11} a_{12} a_{21} a_{22}
(8) " a_{32}, W→S_3, SM, repeat for a_{33}, a_{30}, a_{31}

(12) Po

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	Prime	36		20	C1W	02	to 0	40	X	12		60	Stop	37	X_2
1	SM	10	to 1	21	A---W	45		41	C1W	02	to 0	61	X	12	
2	S_o---A	51		22	W----S_2	54	$a_{22} - \frac{a_{12}a_{21}}{a_{11}}$	42	S_o---A	51		62	S_3---W	57	
3	A---W	45		23	S_1---W	53		43	Ln^{-1}	14		63	X	12	
4	X	12		24				44	-	15		64	Ln^{-1}	14	
05	S_1---W	53		25	X	12		45	SM	10	to 1	65	+	13	
6	÷	17		26	Ln^{-1}	14		46	A---W	45		66	SM	10	to 3
7	SM	10	to 2	27	S_o---A	51		47	X	12		67	S_3---W	57	
8	Ln^{-1}	14		28	-	15		48	S_o---A	51		68	÷	17	
9	W---A	44		29	S_2---W	55		49	A---W	45		69	C1W	02	to 0
10	X	12		30	÷	17		50	÷	17		70	S_3---W	57	
11	S_1---W	53		31	A---W	45		51	Ln^{-1}	14		71	-	15	
12	X	12		32	X	12		52	Stop	37	X_1	72	A---W	45	
13	Ln^{-1}	14		33	Ln^{-1}	14		53	X	12		73	±	33	
14	W---S_1	52	$\frac{a_{12}\ a_{21}}{a_{11}}$	34	SM	10		54	S_3---W	57		74	X	12	
15	A---W	45		35	SM	10	to 2	55	X	12		75	Ln^{-1}	14	
16	X	12		36	S_o---A	51		56	SM	10	to 2	76	Stop	37	X_3
17	S_o---A	51		37	W---S_2	54	X_2	57	Ln^{-1}	14		77			
18	S_1---W	53		38	X	12		58	W---A	44		78			
19	-	15		39	A---W	45		59	S_2---W	55		79			

No. L42-67

WANG LABORATORIES, INC. 836 NORTH ST., TEWKSBURY, MASS. 01876, TEL. (617) 851-7311

March 29, 1967

LOCI User Application Letter # 2

L43 - 67
p 4

Random Number Generator

by

Dr. Fonda-Bonardi
Litton Industries

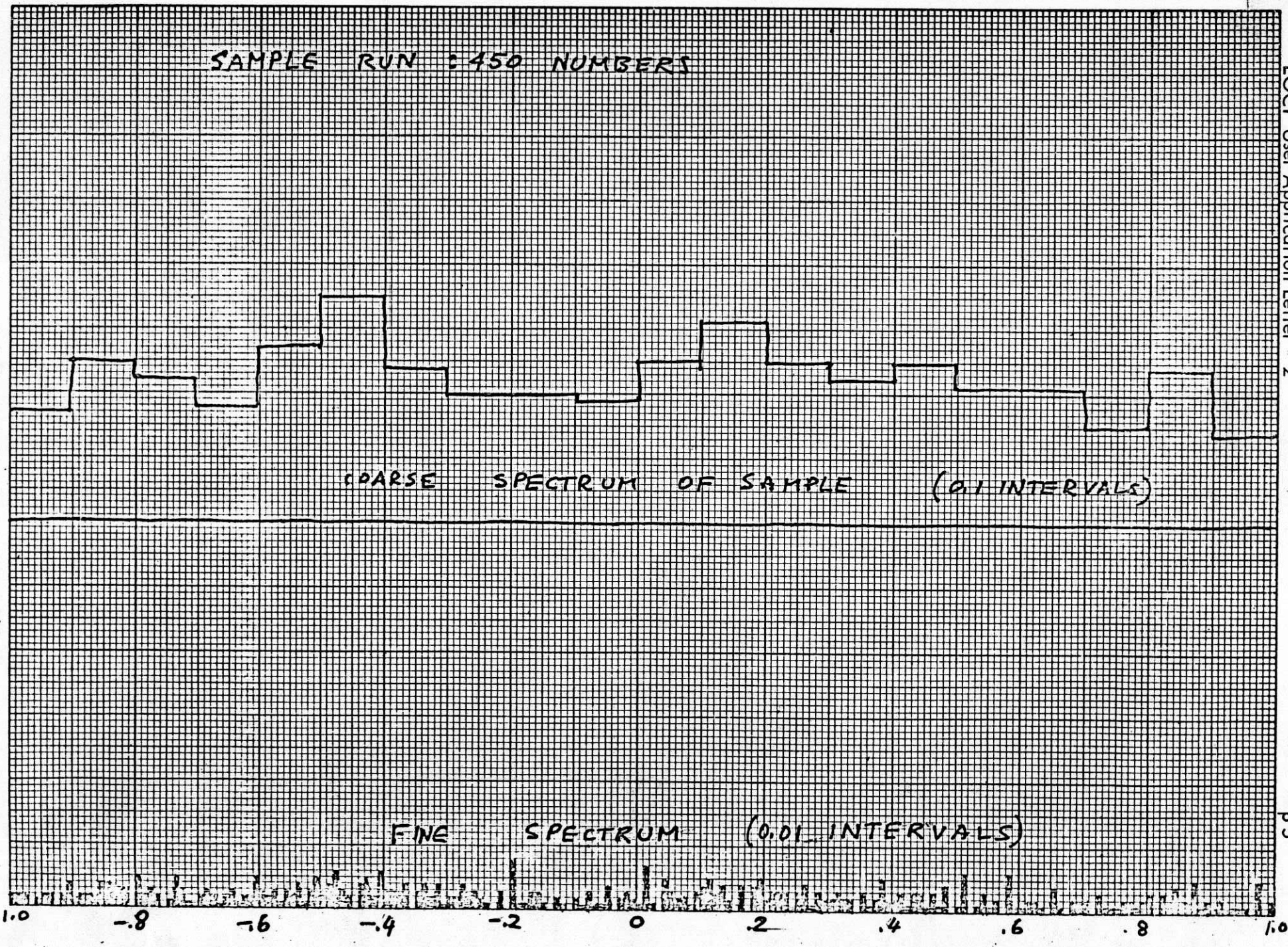
A Random Number Generator is extremely useful in modern computational methods such as Monto Carlo techniques. It is also useful in statistical sampling.

This program is extremely interesting. It was developed by Dr. G. Fonda-Bonardi at Litton Industries. Any Random Number Generator sooner or later begins to repeat a cyclic pattern. While this program itself is very short, the cycle is extremely long. It in fact approaches the numerical capacity of the L register. Dr. Bonardi has discovered the randomness of the truncation errors on the last two digits of the log register. This feature is used to generate the random numbers, giving him this exceptionally long cycle.

The program is written to generate either positive numbers between zero and one, or random numbers between -1 and +1 with random signs.

The program can be initiated by simply keying the number .0000000010 into S2. Then, by keying in any number less than 1 into S3, and pushing P3. The program is written for a printer, so that step 31 has a Write command to print the random number that was generated. However, if you do not have a printer, it is simply necessary to put in a Stop command at that point, permitting a visual readout.

A graph of the spectrum of numbers generated is attached. Note that the program has a flat spectrum.



LOCI PROGRAM

No. L43-67 Date: March 23, 1967

No.	Cmd	Code	Comment
00			
01			
02			
03			
04			
05			
06			
07			
08			
09	S3-→W	57	
10	X	12	
11	L-→W	47	
12	W-→S3	56	
13	X	12	
14	S2-→W	55	
15	X	12	
16	Ln^{-1}	14	
17	X	12	
18	S2-→W	55	
19	÷	17	
20	Ln^{-1}	14	
21	W-→A	44	
22	S3-→W	57	
23	-	15	
24	A-→W	45	
25	X	12	
26	1	21	
27	0	20	
28	X	12	
29	Ln^{-1}	14	
30	W-→S3	56	
31	WRITE	11	
32	P3	63	
33			
34			
35			
36			
37			
38			
39			

No.	Cmd	Code	Comment
40			
41			
42			
43			
44			
45	Alternate for steps #26-36		
46	2	22	
47	0	20	
48	X	12	
49	Ln^{-1}	14	
50	W-→A	44	
51	1	21	
52	-	15	
53	A-→W	45	
54	W-→S3	56	
55	WRITE	11	
56	P3	63	
57			
58			
59			
60			
61			
62			
63			
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73			
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75			
76			
77			
78			
79			

Random Number Generator

Set .000 000 001 0 in S2
Set Any number<1 in S3
START with P3

AUTO DISPLAY ON or OFF

Generates 0<n<1
Alternates generate
-1<n<1 (Random Sign)

Dr. G. Fonda-Bonardi
Director, Applied Physics
Physical Sciences Lab.
Litton Industries
336 North Foothill Road
Beverly Hills, California
90213

List of operations.

00	Not assigned	40	W→PC
01	Clear error	41	W→XPC
02	Clear W	42	W→DC
03	Clear A	43	DC→W
04	$\sqrt{}$	44	W→A
05	$1/\sqrt{}$	45	A→W
06	□	46	W→L
07	1/□	47	L→W
10	Step MSC	50	A→S_0
11	Write	51	S_0→A
12	×	52	W→S_1
13	+	53	S_1→W
14	LN-1	54	(W→S_2)
15	−	55	(S_2→W)
16	·	56	(W→S_3)
17	+	57	(S_3→W)
20	0	60	P_0 (Set PC to 00)
21	1	61	P_1 (" " " 03)
22	2	62	P_2 (" " " 06)
23	3	63	P_3 (" " " 09)
24	4	64	Store PC, DC then W→PC
25	5	65	Recall PC, DC
26	6	66	Decrement DC
27	7	67	Test error
30	8	70	Test DC=0
31	9	71	Test A=0
32	Run	72	Reserved
33	±	73	Test W for — sign
34	Input MX	74	Test L for — exponent
35	Output MX	75	Carriage return
36	Prime	76	Read
37	Stop	77	Not assigned

*Commands 10, 11, 34, 35, 75, and 76 are available only when special options are purchased.

ARCSIN and ARCCOS

by

S. W. Shumilla, Jr.
Mitre Corp.

These two programs provide inverse functions for our SIN and COSIN programs. They were written by Mr. S. W. Shumilla of Mitre Corp. Mr. Shumilla used the following two transformations:

$$\text{ARCSIN}(X) = \text{ARCTAN}\sqrt{\frac{x^2}{1-x^2}}$$

$$\text{ARCCOS}(X) = \text{ARCTAN}\frac{1}{\sqrt{1/x^2 - 1}}$$

These transformations allowed him to than use the Artangent program from our library.

In order to use the programs, simply key in the argument x, than push Po. The AUTO display switch must be in the upper position. Precision of seven digits or more is attained.

LOCI PROGRAM

No. L44-67 Date: March 23, 1967

No.	Cmd	Code	Comment
00	W→S3	56	
01	1	21	
02	W→A	44	
03	3	23	
04	2	22	
05	W→PC	40	
06	2	22	
07	P2	62	
08	Stop	37	
09			
10	2	22	
11	Jump	64	
12	+	17	
13	Ln-1	14	
14	W→A	44	
15	4	24	
16	5	25	
17	+	13	
18	A→W	45	
19	Stop	37	
20	.	16	
21	0	20	
22	1	21	
23	7	27	
24	4	24	
25	5	25	
26	3	23	
27	2	22	
28	9	31	
29	2	22	
30	3	23	
31	Return	65	
32	S3→W	57	
33	1/□	07	
34	Ln-1	14	
35	−	15	
36	A→W	45	
37	±	33	
38	√	04	
39	Ln-1	14	

No.	Cmd	Code	Comment
40	W→A	44	
41	1	21	
42	−	15	
43	A→W	45	
44	X	12	
45	2	22	
46	+	13	
47	A→W	45	
48	÷	17	
49	Ln-1	14	
50	W→S1	52	
51	1	21	
52	0	20	
53	W→DC	42	
54	PRIME	36	
55	DC→W	43	
56	+	13	
57	+	13	
58	□	06	
59	1	21	
60	+	13	
61	S1→W	53	
62		06	
63	A→W	45	
64	÷	17	
65	Ln-1	14	
66	W→A	44	
67	DEC	66	
68	DC=0	70	
69	5	25	
70	5	25	
71	W→PC	40	
72	S1→W	53	
73	X	12	
74	1	21	
75	+	13	
76	A→W	45	
77	÷	17	
78	P3	63	
79			

ARCCOS (X)

1. Put x into W, push Po.

Note: AUTO DISP sw. in the "up" position.

$$\text{ARCCOS}(X)=\text{ARCTAN}\ \frac{\sqrt{1/x^2-1}}{1}$$

S. W. Shumilla, Jr.
Mitre Corp.
Box 208
Bedford, Mass. 01730

List of operations.

00	Not assigned	40	W→PC
01	Clear error	41	W→XPC
02	Clear W	42	W→DC
03	Clear A	43	DC→W
04	√	44	W→A
05	1/√	45	A→W
06	□	46	W→L
07	1/□	47	L→W
10	Step MSC	50	A→S$_o$
11	Write	51	S$_o$→A
12	×	52	W→S$_1$
13	+	53	S$_1$→W
14	LN-1	54	(W→S$_2$)
15	−	55	(S$_2$→W)
16	·	56	(W→S$_3$)
17	+	57	(S$_3$→W)
20	0	60	P$_o$ (Set PC to 00)
21	1	61	P$_1$ (" " " 03)
22	2	62	P$_2$ (" " " 06)
23	3	63	P$_3$ (" " " 09)
24	4	64	Store PC, DC then W→PC
25	5	65	Recall PC, DC
26	6	66	Decrement DC
27	7	67	Test error
30	8	70	Test DC=0
31	9	71	Test A=0
32	Run	72	Reserved
33	±	73	Test W for − sign
34	Input MX	74	Test L for − exponent
35	Output MX	75	Carriage return
36	Prime	76	Read
37	Stop	77	Not assigned

*Commands 10, 11, 34, 35, 75, and 76 are available only when special options are purchased.

LOCI PROGRAM

No. L45-67 Date: March 23, 1967

No.	Cmd	Code	Comment	No.	Cmd	Code	Comment
00	□	06		40	W-→A	44	
01	1	21		41	1	21	
02	W-→A	44		42	-	15	
03	3	23		43	A-→W	45	
04	2	22		44	X	12	
05	W-→PC	40		45	2	22	
06	2	22		46	+	13	
07	P_2	62		47	A-→W	45	
08	STOP	37		48	÷	17	
09				49	LN^{-1}	14	
10	2	22		50	W-→S_1	52	
11	JUMP	64		51	1	21	
12	÷	17		52	0	20	
13	LN^{-1}	14		53	W-→DC	42	
14	W-→A	44		54	PRIME	36	
15	4	24		55	DC-→W	43	
16	5	25		56	+	13	
17	+	13		57	+	13	
18	A-→W	45		58	□	06	
19	STOP	37		59	1	21	
20	.	16		60	+	13	
21	0	20		61	S_1--W	53	
22	1	21		62	□	06	
23	7	27		63	A-→W	45	
24	4	24		64	÷	17	
25	5	25		65	LN^{-1}	14	
26	3	23		66	W-→A	44	
27	2	22		67	DEC	66	
28	9	31		68	DC=0	70	
29	2	22		69	5	25	
30	3	23		70	5	25	
31	RETURN	65		71	W--PC	40	
32	LN^{-1}	14		72	S1-→W	53	
33	W-→S_3	56		73	X	12	
34	-	15		74	1	21	
35	A-→W	45		75	+	13	
36	$1/\sqrt{}$	05		76	A-→W	45	
37	S_3-→W	57		77	÷	17	
38	$\sqrt{}$	04		78	P_3	63	
39	LN^{-1}	14		79			

ARCSIN (X)

1. Put X into W, push Po

NOTE: AUTO DISP. sw. in the "up" position

$$\text{ARCSIN } (X) = \text{ARCTAN } \frac{x^2}{\sqrt{1 - x^2}}$$

S. W. Shumilla Jr.
MITRE Corp.
Box 208
Bedford, Mass. 01730

List of operations.

00	Not assigned	40	W→PC
01	Clear error	41	W→XPC
02	Clear W	42	W→DC
03	Clear A	43	DC→W
04	$\sqrt{}$	44	W→A
05	$1/\sqrt{}$	45	A→W
06	□	46	W→L
07	1/□	47	L→W
10	Step MSC	50	A→S_0
11	Write	51	S_0→A
12	×	52	W→S_1
13	+	53	S_1→W
14	LN-1	54	(W→S_2)
15	−	55	(S_2→W)
16	.	56	(W→S_3)
17	+	57	(S_3→W)
20	0	60	P_0 (Set PC to 00)
21	1	61	P_1 (" " " 03)
22	2	62	P_2 (" " " 06)
23	3	63	P_3 (" " " 09)
24	4	64	Store PC, DC then W→PC
25	5	65	Recall PC, DC
26	6	66	Decrement DC
27	7	67	Test error
30	8	70	Test DC=0
31	9	71	Test A=0
32	Run	72	Reserved
33	±	73	Test W for − sign
34	Input MX	74	Test L for − exponent
35	Output MX	75	Carriage return
36	Prime	76	Read
37	Stop	77	Not assigned

*Commands 10, 11, 34, 35, 75, and 76 are available only when special options are purchased.