A STATISTICAL INTERPRETIVE SYSTEM FOR THE IBM 650 MAGNETIC DRUM CALCULATOR

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in collaboration with the Statistical Laboratory

Case Institute of Technology

March 1957

STATISTICAL INTERPRETIVE SYSTEM

INTRODUCTION

The following pages contain a description of the operation of the Statistical System along with a brief description of the remaining Bell Interpretive System programs as described completely in IBM Technical Newsletter No. 11 (by Dr. V. M. Wolontis of the Bell Telephone Laboratories). It may be noted that the Statistical System is an extension of the Bell System to include statistical operations while sacrificing the SIN D, SIN R, COS D, COS R, ART D, and ART R commands along with 500 additional storage locations. It is absolutely essential that one becomes familiar with the "Bell System" by studying IBM Technical Newsletter No. 11 before attempting to use the Statistical System.

In brief, the interpretive system under study converts the IBM 650 MDDPM from a one plus one address system, fixed point, 2000 ten digit word machine into a three address, fixed or floating point, 500 ten digit word machine (using locations 000 through 499). The advantages of this interpretive system for problems of a statistical nature are numerous and should become evident when the system is used.

STATISTICAL INTERPRETIVE SYSTEM

I. FLOATING DECIMAL REPRESENTATION

Write the number to be used as an eight decimal digit figure with a non-zero first digit. Assume the decimal point to be to the right of the most significant digit. Determine the proper power of ten to multiply the number by and add this exponent ($\pm$) to 50. Put the sum in the two right hand positions (following the least significant digit).

Examples.

1. +256.3 is written as $+2.563 \times 10^{2}$ and then as +2 563 000 052.
2. -256347.02 is written as -2.5634702×10^{5} and then as -2 563 470 255.
3. +0.000374 is written as $+3.74 \times 10^{-4}$ and then as +3 740 000 046.
4. -0.0000000009275436 is written as $-9.275436 \times 10^{-10}$ and then as -9 275 436 040.
5. Zero is written as + 0 000 000 000.

II. OPERATION CODES

O_1 Operations

0	Go to O_2	
1	ADD	(A) + (B) = (C)
2	SUB	(A) - (B) = (C)
3	MPY	(A) x (B) = (C)
4	DIV	(A) $\div$ (B) = (C)
5	FLOAT	Float A. When B is 000_9 the fixed point number located at A is assumed to have its decimal point at the extreme right of the word position. B designates the number of places to the left of the right hand end that the decimal point is located. If the decimal point is located further to the right, then the number of places is subtracted from 1000. The result in floating point form is stored in C.

6	TR A	A address of (A) compared with B, transfer to C for unequal
7	TR B	B " " " " " " " " " " " "
8	TR C	C " " " " " " " " " " " "
9	MOVE	Moves block of A words starting at B to locations starting at C. (000) is not changed if A $\neq$ 0. If A = 0, then one word is moved from B to C and also into (000) for use by the transfer commands.

0_2 Operations

000	UNC STOP	9999 on address lights, (B) in upper accumulator.
200	COND STOP	1120 on address lights, (B) in upper accumulator, control transferred to C when PROG START is depressed.
201	TR SGN	Transfer on sign. Control is transferred to C if (000) is negative, and to B if (000) is positive.
202	TR EXP	Transfer on exponent. The exponent in (000) is compared with B. If Exp $\geq$ B control is transferred to C. If Exp $<$ B control goes to next instruction.
203	TR	Transfer unconditionally to C. The B address is ignored but must be punched, e.g. 000.
204	TR SUBR	Transfer subroutine. The C address of the instruction located at C is set equal to B. The sign of the instruction at C is made positive. Control is transferred to the instruction at C.
205	TR OUT	Transfer out. Control is transferred to C and the instruction there is executed in machine language. When it is desired to return to the Statistical System from machine language, an I address of 1095 is given and the instruction following the 205 instruction is executed next in Statistical language.
100	LOOP A	Loop on A. Increase the contents of the A segment of the loop box by unity. After the increase, the contents of the segment are compared with the B address of the loop instruction. If A segment $<$ B, control is transferred to C. If A segment $\geq$ B, the entire loop box is reset to zero and control proceeds to the next instruction.
010	LOOP B	Loop on B. Analogous to Loop A with B segment now being increased and used for comparison.

001	LOOP C	Loop on C. Analogous to Loop A with C segment being increased etc.
110	LOOP AB	Loop on AB. A and B segments both increased but A segment used for comparison.
101	LOOP AC	Analogous. A segment used for comparison.
011	LOOP BC	Analogous. B segment used for comparison.
111	LOOP ABC	Analogous. A segment used for comparison.
500	SET A	Set the A address. The A address of the instruction at B is set equal to C.
050	SET B	Set the B address. The B address of the instruction at B is set equal to C.
005	SET C	Set the C address. The C address of the instruction at B is set equal to C.
600	ADD A	Add to the A address. The A address of the instruction at B is increased by C.
060	ADD B	Analogous.
006	ADD C	Analogous.
700	SUB A	Subtract from the A address. The A address of the instruction at B is decreased by C.
070	SUB B	Analogous.
007	SUB C	Analogous.
800	COUNT	The number standing in the counter is increased by 1. Its new value is compared to B. If B is greater, control is transferred to C. Otherwise, the counter is reset to zero and control proceeds to the next instruction. The counter is also reset in loading.
300	SQRT	$\sqrt{(B)} = (C)$

301 EXP E $e^{(B)} = (C)$

302 LOG E $\log_e (B) = (C)$

303 MEAN The mean of X_i, i.e.,

$$\bar{X}_i = \frac{1}{N} \sum_{k=1}^{N} X_{ik}$$

is stored in Location C. B of the command specifies the i^{th} variable (numbered from 000 thru 009) corresponding to the word positions on the data cards. This command should always be preceded by a Statistical Read 1 or 2 command. The result is in fixed point form with four more decimal places than the data. See Statistical Read 2 for use with this command.

304 COVAR The covariance or variance specified by B is stored in floating point form in location C as follows:

$$s_{ij} = \frac{\sum_{k=1}^{N} (X_{ik} - \bar{X}_i)(X_{jk} - \bar{X}_j)}{N - 1}$$

The hundreds digit of B specifies the number of places the decimal point is from the right hand end of the data words. The tens digit specifies the first variable from 0 thru 9 according to the data location on the input cards. The units digit specifies the second variable from 0 thru 9. This command should always be preceded by a Statistical Read 1 or 2 command. See Statistical Read 2 for use with this command. (Note: $s_{ii} = s_i^2$ = variance estimate of X_i).

305 α_3^2 The square of the third standard moment. The result is stored in location C in floating point form. This instruction must be preceded by a Statistical Read 2 command.

306 α_4 The fourth standard moment is stored in floating point form in Location C. This command must be preceded by a Statistical Read 2 command.

307 RN A random number is stored in location C in fixed point form. The first two high order digits are the most random while the tens and units digits are essentially constant.

308 NEG The negative of the number located at B is stored in Location C.

309 Γ The Gamma function of 1 plus the number located at B is stored in location C. Note: the maximum value for the argument will be 40 before an error stop occurs.

350 ABS $|(B)| = (C)$-

351 EXP 10 $10^{(B)} = (C)$

352 LOG 10 $\log_{10}(B) = (C)$

353 $\int_0^{(B)} \phi(t)dt$ The area under the standard normal curve from 0 to the number located at B ($B > 0$). The result is stored in location C.

354 P(n;m) The cumulative Poisson distribution function given by

$$P(n;m) = \sum_{i=0}^{n} \frac{e^{-m} m^i}{i!}$$

where n is located at B and m at C, is stored in location 000 and 981. The Poisson probability function

$$p(n,m) = \frac{e^{-m} m^n}{n!}$$

is stored in location 980.

355 $B(x;n,p)$ The cumulative binomial distribution function given by

$$B(x;n,p) = \sum_{i=0}^{x} \binom{n}{i} p^i(1-p)^{n-i}$$

where p must be located in 000, n in B, and x in C, is stored in location 000 and 981. The binomial probability function

$$b(x;n,p) = \binom{n}{x} p^x(1-p)^{n-x}$$

is simultaneously stored in location 980.

356 χ^2 The Chi Square test for testing sample variance vs. population variance is given by the formula

$$\chi^2 = (N-1)\frac{s^2}{\sigma^2}$$

where s^2 is located at B, σ^2 is located at C, and N is stored in 621 as the result of a Statistical Read command. The result is stored in 000.

357 t_1 The Student's t test for testing sample mean vs. population mean is given by the formula

$$t = \frac{\bar{X} - \mu}{s\sqrt{N}}$$

where $\bar{X}$ is located in 000, μ is located at B, s^2 is located at C, and N is located in 621. The result is stored in 000.

358 F The F test for testing sample variances is given by the following formula. The calculation is performed so that $F \geq 1$, and

the result is stored in 000.

$$F = s_1^2/s_2^2$$

where s_1^2 is located at B and s_2^2 is located at C.

359 t_2 The Student's t test for testing sample means is given by the formula

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(N_1-1)\ s_1^2 + (N_2-1)\ s_2^2}{N_1 + N_2 - 2}}\ \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

where the quantities must be located as follows: (e.g., by means of a move command). Note: N_1 and N_2 should be expressed in floating point forms.

N_1 ——> 996 $\bar{X}_1$ ——> B

s_1^2 ——> 997 $\bar{X}_2$ ——> C

N_2 ——> 998

s_2^2 ——> 999

The result is stored in 000.

706 STR LP The contents of the loop box are stored at Location C, and the loop box is reset to zero. The B address is not referred to but should be filled.

707 RSR LP The number located at B is stored in the loop box, and control is transferred to C.

900 GXP General Exponentiation. The number located at B is raised to the integral power which is equal to the largest integer contained in the absolute value of the number located at C. The result is stored in 000.

$$B^{[C]} \longrightarrow 000.$$

400 READ Read cards. Reads cards into locations B through C inclusive.

Two Statistical Read commands have been incorporated in the system. The first one is used for one to ten variables while the second is used for only one variable.

401 ST R 1 The Statistical Read 1 command will read and accumulate all possible cross products, the sums of squares and the sums of the variables for a set of cards. All cards must contain the same number of variables, otherwise the machine may stop. All variables not present on the card will have sums equal to zero. N, the number of cards read, will be stored fixed point in 621 and n, the number of variables on the card minus 1, will be stored in 620 (Fixed Point). The data cards must be followed by a transfer card to signify the end of the read. The transfer card consists of a card with a 12 punch in column 7 and no other punches. The results of this operation are stored in fixed point multiple precision form in the following locations: (In the summations below a second subscript, k, is understood and the summation is over k).

Quantity	Location	Quantity	Location
ΣX_0	500	ΣX_8	508
ΣX_1	501	ΣX_9	509
ΣX_2	502	ΣX_0^2	510, 511
ΣX_3	503	$\Sigma X_1 X_0$	512, 513
ΣX_4	504	ΣX_1^2	514, 515
ΣX_5	505	$\Sigma X_2 X_0$	516, 517
ΣX_6	506	$\Sigma X_2 X_1$	518, 519
ΣX_7	507	ΣX_2^2	520, 521

Quantity	Location	Quantity	Location
ΣX_3X_0	522, 523	ΣX_7X_4	574, 575
ΣX_3X_1	524, 525	ΣX_7X_5	576, 577
ΣX_3X_2	526, 527	ΣX_7X_6	578, 579
ΣX_3^2	528, 529	ΣX_7^2	580, 581
ΣX_4X_0	530, 531	ΣX_8X_0	582, 583
ΣX_4X_1	532, 533	ΣX_8X_1	584, 585
ΣX_4X_2	534, 535	ΣX_8X_2	586, 587
ΣX_4X_3	536, 537	ΣX_8X_3	588, 589
ΣX_4^2	538, 539	ΣX_8X_4	590, 591
ΣX_5X_0	540, 541	ΣX_8X_5	592, 593
ΣX_5X_1	542, 543	ΣX_8X_6	594, 595
ΣX_5X_2	544, 545	ΣX_8X_7	596, 597
ΣX_5X_3	546, 547	ΣX_8^2	598, 599
ΣX_5X_4	548, 549	ΣX_9X_0	600, 601
ΣX_5^2	550, 551	ΣX_9X_1	602, 603
ΣX_6X_0	552, 553	ΣX_9X_2	604, 605
ΣX_6X_1	554, 555	ΣX_9X_3	606, 607
ΣX_6X_2	556, 557	ΣX_9X_4	608, 609
ΣX_6X_3	558, 559	ΣX_9X_5	610, 611
ΣX_6X_4	560, 561	ΣX_9X_6	612, 613
ΣX_6X_5	562, 563	ΣX_9X_7	614, 615
ΣX_6^2	564, 565	ΣX_9X_8	616, 617
ΣX_7X_0	566, 567	ΣX_9^2	618, 619
ΣX_7X_1	568, 569	n	620
ΣX_7X_2	570, 571	N	621
ΣX_7X_3	572, 573		

Note: N should not exceed 10,000 for this operation.

402 ST R 2 Statistical Read 2 reads one variable per card as specified by B and accumulates the first, second, third and fourth powers of this variable for any number of cards up to 10,000. N, the number of cards read is stored in location 621. Location 620 contains i which corresponds to X_i, the variable read and B of the command. The data cards have the same format as in Statistical Read 1 and must be followed by the same transfer card, to signify the end of the read operation. The results of this command are stored in fixed point multiple precision form in the following locations:

Quantity	Location	Quantity	Location
$\sum_{k=1}^{N} X_{ik}$	500	$\sum_{k=1}^{N} X_{ik}^4$	515,516,517
$\sum_{k=1}^{N} X_{ik}^2$	510, 511	i	620
$\sum_{k=1}^{N} X_{ik}^3$	512,513,514	N	621

If the mean or variance is desired after a Statistical Read 2 command, the command specifying mean or variance must have its B address equal to 000. The result then corresponds to that for variable X_i.

403 CONS Read console. The machine stops with zero on the display lights and 1131 on the address lights. When PROGRAM START is depressed, the number in the storage entry switches is stored in location C and in 000.

410 PCH Punch Cards. Punches the block of consecutive words starting at B and ending at C (inclusive) into cards.

411	ST PCH	Statistical Punch-out. All statistical results stored in location 500 through 621 are punched out on cards in normal punch out format; however, the results themselves are fixed point multiple precision as indicated under the statistical read commands.
450	START TR	Start tracing. (Becomes a no-op when in normal punch mode).
451	STOP TR	Stop tracing. (A no-op for normal punching).
452	ST TR ERAS	Start trace; erase. This instruction replaces itself with a no-op after it has been executed once.
453	CLEAR	The locations on the drum from B through C are reset to plus zero.
454	NO OP	No operation.

III. OPERATOR'S INSTRUCTIONS:

1. Insert the "Statistical System Board" into the 533 unit.

2. Set the 650 console as follows:

Storage Entry Switches	70 1951 1333 +
Program	STOP
Half Cycle	RUN
Address Selection Switches	1338
Control	RUN
Display	UPPER ACCUMULATOR
Overflow	STOP
Error	STOP

3. Insert the cards in the 533 unit (face down, 12 edge first) as follows:

   a. Statistical System Deck

   b. Statistical System drum zero; 1 card

   c. Either Punch or Trace deck; 9 cards

   d. Your program deck

   e. Transfer card

   f. Statistical data cards

4. Depress the following keys in order:

   a. COMPUTER RESET (on console)

   b. PROGRAM START (on console)

   c. START (both keys on the card reader)

5. When the last card is halfway through the hopper, depress the END of FILE key on the card reader.

IV. CARD FORMAT

1. Input cards.

All program and data cards must be punched as follows:

Columns	Contents
1 - 4	card number
5 - 6	deck number
7 - 9	location of word 1
10	word count
11	sign of word 1
12 - 21	word 1
22	sign of word 2
23 - 32	word 2
33	sign of word 3
34 - 43	word 3
44	sign of word 4
45 - 54	word 4
55	sign of word 5
56 - 65	word 5
66	sign of word 6
67 - 76	word 6
77 - 79	problem number

2. Transfer card

The transfer card contains the following information:

Columns	Contents
1 - 4	card number
5 - 6	deck number

(continued)

Columns	Contents
7 - 9	location of first instruction
10	ZERO
77 - 79	problem number

3. Output cards.

In general output cards will have the same format as the input cards.

4. Statistical Input Cards.

The card format for the Statistical Read commands is different than that used to load commands and other data, since 10 six digit fixed point words can be punched on one card. The locations of the data are as follows:

Columns	Information
1 - 4	card number
5 - 9	problem number or numbers
7	12 punch to designate the Statistical Read cards
10	number of words on the card less one (n)
11	sign of first variable X_0
12 - 17	first variable X_0
18	sign of second variable X_1
19 - 24	second variable X_1
25	sign of X_2
26 - 31	X_2
32	sign of X_3
33 - 38	X_3
39	sign of X_4
40 - 45	X_4

(continued)

Columns	Contents
46	sign of X_5
47 - 52	X_5
53	sign of X_6
54 - 59	X_6
60	sign of X_7
61 - 66	X_7
67	sign of X_8
68 - 73	X_8
74	sign of X_9
75 - 80	X_9

V. STOPS

During the first running of a program of any length, unexpected stops may occur. Some clues as to the reasons may be obtained by looking at the address lights.

Address Lights	Reason for Stop
1120	programmed COND STOP
1131	CONS
1835	loss of two or more digits of accuracy in LOG
2222	move with $(C + A - 1) \geq 1000$
2222	PCH with $B \geq (C + 1)$
2222	READ with incorrect location or word count.
3333	DIV with (B) = 0
4444	SQRT with (B) < 0
5555	MPY with result out of range
5555	DIV with result out of range

(continued)

Address Lights	Reason for Stop
6666	EXP with result out of range
6666	LOG with B $\leq$ 0
7777	cards missing or out of order in system deck
9999	programmed UNC STOP

In any case, the location of the interpretive instruction being executed at any time will be found in 1098. Location 1098 will contain 60 0 xxx 1107 + . The xxx is the location of the Statistical System instruction being used. Location 1017 will contain 0 AAA BBB CCC where the letters indicate the contents of the respective loop boxes.

VI. NUMERICAL METHODS

A brief description of the numerical methods employed in the subroutines is listed below. Some of the subroutine programs use interpretive commands in their internal structure; however, the standard tracing mode will not trace these internal commands.

A. Square Root - See IBM Technical Newsletter No. 11.

B. Exponential - " " " " " "

C. Logarithm - " " " " " "

D. Mean - The mean is computed from the definition:

$$\bar{X} = \sum_{k=1}^{N} \frac{X_{ik}}{N}$$

E. Variance, Covariance - This computation is preferred using the standard computational formula:

$$s_{ij} = \frac{N \sum_{k=1}^{N} X_{ik} X_{jk} - \sum_{k=1}^{N} X_{ik} \sum_{k=1}^{n} X_{jk}}{N (N - 1)}$$

F. Third and Fourth Standard Moments - These are calculated in three steps. First the moments about the origin are calculated by:

1) $$X_1 = \frac{\sum_{k=1}^{N} X_k}{N}$$

2) $$X_2 = \frac{\sum_{k=1}^{N} X_k^2}{N}$$

3) $$X_3 = \frac{\sum_{k=1}^{N} X_k^3}{N}$$

4) $$X_4 = \frac{\sum_{k=1}^{N} X_k^4}{N}$$

Then these moments are reduced to moments about the mean by:

5) $$X_2' = X_2 - X_1$$

6) $$X_3' = X_3 - 3X_2X_1 + 2X_1^2$$

7) $$X_4' = X_4 - 4X_3X_1 + 6X_2X_1^2 - 3X_1^3$$

From these results α_3^2 and α_4 are calculated by:

8) $$\alpha_3^2 = \frac{(X_3')^2}{(X_2')^3}$$

9) $$\alpha_4 = \frac{X_4'}{(X_2')^2}$$

G. Random Numbers - See "Random Number Generation on the IBM 650" by M. Conway.

H. Gamma Function - The calculation is performed in two steps. First the argument is reduced to the principle range by using the recursion formula:

$$\Gamma(X+1) = X\,\Gamma(X)$$

when X is in the range $0 \leq X \leq 1$ the Hasting's Approximation is used for $\Gamma(X+1)$

$$\Gamma^*(X+1) = 1 + a_1X + a_2X^2 + \ldots + a_8X^8$$

* (See C. Hastings; Approximations for Digital Computers, page 158)

I. Cumulative Normal - The area under the standard normal curve is computed by:

1) $$\int_0^X \Phi(X) = \frac{1}{2} \Phi\left(\frac{X}{\sqrt{2}}\right)$$

2) $$\Phi(y) = \frac{2}{\sqrt{\pi}} \int_0^y e^{-t^2} dt$$

3) $$\Phi^*(y) = 1 - (a_1\eta + a_2\eta^2 + \ldots + a_5\eta^5)\, \Phi'(y)$$

where $\eta = \frac{1}{1+py}$

*(See Hastings page 169)

J. Cumulative Poisson - This is computed by using the recursion formula.

1) $$p(x+1, m) = \frac{m}{x+1}\, p(x, m)$$

2) $$p(o, m) = e^{-m}$$

K. Cumulative Binomial - This is computed by using the recursion formula

1) $$b(x+1; n, p) = \frac{n-x}{x+1} \cdot \frac{p}{1-p}\, b(x; n, p)$$

2) $$b(o; n, p) = (1-p)^n$$

VII. CONTROL PANEL WIRING FOR THE READ-PUNCH UNIT

The control panel for the 533 Read-Punch Unit associated with the 650 is wired as follows:

A. For standard "Bell System"

Col. 1, 1st Reading, to LOAD

R + Sign, jackplugged.

P + Sign, jackplugged.

Col. 5, 1st Reading, to Pilot Sel. 1 X PU.

Rd. Hold to PS 1 Hold.

Read Card C, Col. 6, to PS 1 T.

Read Impulse 0 to PS 1 N.

PS 1 C to Storage Entry C, Word 1, pos. 3 (from the left)

Read Card C	to	Storage Entry C
7 - 9		word 1, position 4-6
10		word 2, position 6
11		word 3, sign
12 - 21		word 3, position 1-10
22		word 4, sign
67 - 76		word 8, position 10
77 - 79		word 9, position 4-6
Read Impulse 12		words 1, 2, 9, 10, sign
Read Impulse 0		word 1, position 7-10
		word 2, position 7-10
		word 9, position 7-10

Word Size Emitter	to	Word Size Entry C
10		words 3-8, 10
8		word 1
7		word 9
5		word 2

Storage Exit C	to	Punch Card C, Col.
Word 10, position 3-6		1 - 4
word 1, position 3-6		6 - 9
word 2, position 6		10
word 3, sign		11
word 3, position 1-10		12 - 21
word 4, sign		22
word 8, position 1-10		67 - 76
word 9, position 4-6		77 - 79
word 2, position 10		80

B. Additional wiring for "Statistical System"

Column 7, 1st Reading, to Pilot Selector 2 X PU.

Read Hold to PS 2 Hold.

Read Hold to PS 2 C.

PS 2 T to Entry A.

Column 10, 1st Reading, to Pilot Selector 3 D PU

Read Hold to PS 3 Hold

PS 3 Coupling Exit to Co-Selector 1 and 2 PU.

Read Hold to Co-Selector 1 and 2 Hold.

Read Card A, Column 10, to CS 1 position 1 T

CS 1 position 1 N to Read Impulse "0".

CS 1 position 1 C to Storage Entry A, Word 1, position 1.

CS 1 position 2-4 T to Read Impulse "9".

CS 1 position 2-4 N to Read Impulse "8".

CS 1 position 2-5 C to Storage Entry A, Word 1, position 2-5.

CS 2 position 1-5 C to Storage Entry A, Word 1, position 6-10.

CS 1 position 5 T to Read Card A, Column 12.

CS 1 position 5 N to Read Impulse "0".

CS 2 position 1-5 N to Read Impulse "0".

CS 2 position 1-5 T to Read Card A, columns 13-17.

PS 3 C to Storage Entry A, sign position.

PS 3 N to Read Impulse "12".

PS 3 T to Read Card A, column 11.

Read Card A, Col.	to	Storage Entry A.
18		word 2, sign
19 - 24		word 2, position 5-10
25		word 3, sign
26 - 31		word 3, position 5-10
32		word 4, sign
33 - 38		word 4, position 5-10
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75 - 80		word 10, position 5-10

Word Size Emitter	to	Word Size Entry A
10		word 1
6		words 2-10

Double Punch and Blank Column Detection as available and desired.

VIII. SUMMARY OF OPERATION CODES

Numeric	Mnenomic
0	GO TO O_2
1	ADD
2	SUB
3	MPY
4	DIV
5	FLOAT
6	TR A
7	TR B
8	TR C
9	MOVE
000	UNC STOP
200	COND STOP
201	TR SGN
202	TR EXP
203	TR
204	TR SUBR
205	TR OUT
100	LOOP A
010	LOOP B
001	LOOP C
110	LOOP AB
101	LOOP AC
011	LOOP BC
111	LOOP ABC

Numeric	Mnemonic
800	COUNT
500	SET A
050	SET B
005	SET C
600	ADD A
060	ADD B
006	ADD C
700	SUB A
070	SUB B
007	SUB C
300	SQRT
301	EXP E
302	LOG E
303	MEAN
304	COVAR
305	α_3^2
306	α_4
307	RN
308	NEG
309	GAMMA
350	ABS
351	EXP 10
352	LOG 10
353	NORMAL
354	POISSON

Numeric	Mnenomic
355	BINOMIAL
356	χ^2
357	t_1
358	F
359	t_2
400	READ
401	ST R 1
402	ST R 2
403	CONS
410	PCH
411	ST PCH
450	START TR
451	STOP TR
452	ST TR ERAS
453	CLEAR
454	NO-OP
706	STR LP
707	RSR LP
900	GXP