RECOMP II USERS' PROGRAM NO. 1058

PROGRAM TITLE:	EXPANDED RECOMP ALGEBRAIC FORMULA TRANSLATOR (RAFT IV)
PROGRAM CLASSIFICATION:	Executive and Control
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PURPOSE:	This program is a modified version of RECOMP II Program No. 1054, RAFT III
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1. INTRODUCTION

The program interprets a symbolic equation which is written using twenty-seven (27) commands, two-hundred-eighty-six (286) data locations, and an effective accumulator. The commands indicate an operation or a function evaluation which is performed on the contents of the letter location which follows the command. The letter location refers to a two letter sequence, the first of which may be conveniently referred to as the channel and the second letter as the sector. Using this notation the channel may be any letter from B through L, and the sector any letter of the alphabet (A through Z). The accumulator is referred to with AA. Each location is directly addressable with every command.

Each symbolic equation must begin with a command followed by a letter location and this sequence continues through the equation. Both the symbolic equation and the numeric data are entered through the typewriter under the computer control. The program operates in floating point arithmetic with the results output in floating point decimal notation. The number of digits for output is eight (8) unless the user specifies a different number which may vary from two (2) to eleven (11) digits.

2. PROGRAM USAGE

2.1 Entry of Data

All the numeric data is entered from the typewriter and automatically converted to floating binary. Before the number is entered, the location is specified according to the format described in 2.2.

2.1.1 The input numbers may be composed of many parts.

a. The sign of the number.
b. The integral part of the number.
c. A decimal point followed by the fractional part of the number (if no decimal point is typed, it is assumed to be at the end of the number).
d. The sign and (integral) value of the power of ten by which the number is to be multiplied.
e. A carriage return is used as a termination character.

Not all of these parts are required for every input. The following combinations are acceptable: BE, CE, ABE, ACE, ABCE, BDE, CDE, ABDE, ACDE, E (yields plus zero), AE (yields signed zero), ABCDE.

2.1.2 The value of the number must not exceed $2^{39}-1$. The exponent must not exceed 511 in absolute value.

2.1.3 If a character other than 0,1,2,3,4,5,6,7,8,9,+,-,., or carriage return is typed, "ERROR" will be printed and the program reset so that a correct entry may be made.

2.2 Program Options

Start	Sense Switch (ON)	Operations
1	B	Enter data into the specified data location. The letter location (e.g. "BC") is entered through the typewriter. The number is then entered as described in 2.1. The Carriage Return is depressed after each number. Use only letter combinations BA thru LZ.
	C	Same as with B ON.
	D	Type out the contents of the location specified by the letter location. The letter location is entered as in the previous options (B or C ON).
	none	Same as with D ON.
2	B	Enter the number of digits for output if other than eight (8) are desired. Any number from two (2) to eleven (11) may be used. The program halts at L0027. Depress N on the console for number fill and enter the number of digits as + X. (decimal point), enter key. Press start.
	C	Punch an entire channel on tape. The particular channel which is to be punched (e.g. "B") is entered through the typewriter. Start 2 and repeat the procedure for other channels.
	D	This setting is not used.

2.2 Program Options (Cont'd.)

Start	Sense Switch (ON)	Operations
2	none	Enter symbolic equation from the typewriter. A carriage return automatically occurs after 16 commands. The symbolic equation must be terminated with a carriage return. The maximum number of commands is 1024.
3	B	Verify the symbolic equation. The equation is typed out exactly as it is in the machine with 16 commands per line.
	C	Correct a mistake in the symbolic equation. When the program halts at L0033, depress N and enter the number of correct instructions preceding the incorrect entry as N, + X, (decimal point), enter key. Push start and re-enter the incorrect command. Always begin the entry with the command whether the error was in the command or the letter.
	D	Punch the symbolic equation on tape.
	none	Begin the calculation.

2.3 Program Memory Locations

Main Program	0000-1457, 7000-7617
Data Area	1500-2775
Symbolic Equation	3000-6777
Accumulator	7766

3. COMMANDS

In the following definitions of commands, "AA" refers to the contents of the accumulator and "LL" refers to the contents of any other location BA through LZ.

3.1 Arithmetic Commands

The arithmetic commands perform operations on the contents of the accumulator and the results always remain in the accumulator.

ADD	(+)	Add LL to AA	
SUB	(-)	Subtract LL from AA	
MUL	(.)	Multiply LL times AA	
DIV	(/)	Divide AA by LL	
EXP	(')	Raise AA to the power LL	(5)(6)

3.2 Function Commands

The function commands compute the indicated operation or function. The commands operate on the contents of "AA" or "LL" with the results remaining in either "AA" or "LL". For example, ?BR takes the square root of BR and $\sqrt{BR}$ remains in BR. "AA" is unaffected by function commands operating on "LL".

SIN	(1)	Compute the sine of AA or LL. (The angle must be in radians)	
COS	(2)	Compute the cosine of AA or LL. (The angle must be in radians)	
LOG	(4)	Compute the logarithm (base 10) of AA or LL	(3)
LN	(5)	Compute the logarithm (base e) of AA or LL	(4)
10^x	(6)	Raise 10 to the power AA or LL	(1)
e^x	(7)	Raise e to the power AA or LL	(2)
SQR	(?)	Compute the square root of AA or LL	
FAC	(,)	Compute the factorial of the positive floating point integer in AA or LL	
ASN	())	Compute the arc sine of AA or LL, where $\lvert x \rvert \leq 1$ (result in radians)	(7)
ACS	(()	Compute the arc cosine of AA or LL, where $\lvert x \rvert \leq 1$ (result in radians)	

(1) - (7) See Restrictions (Error Stops) on Page 6 and 7

3.3 Entry and Output Commands

Entry commands are for the purpose of entering data into the accumulator. The output commands type floating point decimal numbers with a 2-11 digit mantissa followed by the exponent.

CLA	(Space)	Enter LL into AA
CSU	(8)	Enter the negative value of LL into AA
CPO	(9)	Type AA or LL following a carriage return
SPO	(;)	Type AA or LL following a space
-	(:)	Store AA in LL

3.4 Control Commands

The control commands enable the user to perform logical transfers within the symbolic equation.

RET	($)	Return to the beginning of the symbolic equation the number of times contained (floating point) in LL. Each time a return is made a floating point 1 is subtracted from LL. When LL becomes zero, the program overlooks the command and continues in the symbolic equation.
TPL	(H)	If AA contains a positive number transfer to the r^{th} command, where LL contains the floating point number r. For example, HBL would transfer to the 15th command if AA is positive and BL contains a 15. If AA is not positive, continue in sequence in the symbolic equation.
TMI	(S)	Transfer on minus in a manner similar to the TPL command.
TZO	(O)	Transfer on zero in a manner similar to the TPL command.

3.4 Control Commands (Cont'd.)

INC (&) Increment the channel address one letter in the alphabet (not to proceed past channel "L") of the rth command. The rth command is determined by the positive number in LL. For example, &ER, where ER contains a 19, would instruct the program to find the 19th command and increment its channel address. If the letter location is BA, it becomes CA.

INS (3) Increment the sector address of the rth command one letter in the alphabet. This command is similar to the INC command except the sector address is incremented instead of the channel address. Incrementing sector Z causes the channel to be incremented and the sector becomes an A. For example, if BZ is incremented, it becomes CA.

RPL (!) Replace the letter location of the rth command with the letter location of this command. The rth command is determined from the contents of the accumulator. For example, if the accumulator contains a 10, and the command is !FA, the program would replace the letter location of the 10th command with FA. If the 10th command was originally +BX, it would now be +FA.

4. PROGRAM ERROR STOPS

The program contains certain built in error stops which can be useful in debugging if the specific error which caused the stop is known. The following list indicates the location counter setting on the console at the stop and the probable error.

Location Counter

(1) 0125.1 In the 10^x subroutine, the floating point exponent of x must not be greater than 35_{10}.

4. PROGRAM ERROR STOPS (CONT'D.)

Location Counter (Cont'd.)

(2)	0133.1	In the e^x subroutine, the floating point exponent of x must not be greater than 35_{10}.
(3)	1643.1	In the $\log_{10}x$ subroutine if x is negative, the program halts with x in A and R registers.
(4)	0151.1	In the $\log_e x$ subroutine if x is negative, the program halts with x in A and R registers.
(5)	0164.1	In the EXP command, if y in y^x is negative, the program halts in the $\log_{10}$ subroutine.
(6)	0167.1	In the EXP command, if y in y^x is too large, the program halts in the 10^x subroutine.
(7)	0214.1	In the arc sine subroutine, X must meet the conditions $\|X\| \leq 1$.

5. EXAMPLE

Evaluate X, with T ranging from 0 to 4.5 by increments of 0.5, in the following equation:

$X=e^{-.2T}\ 0.5\ (\cos 0.5T - 7.6 \sin 0.5T)$. Number data was entered into the following locations.

BB.5

CC.2

DD +.5

EE +7.6

JJ .9+1

BT 0

5. EXAMPLE (CONT'D.)

The symbolic equation and results are shown below. Results are shown in floating point format with 8 places accuracy.

RAFT SYMBOLIC EQUATION

```
 BT.DD:FF1AA.EE:GG2FF FF-GG.DD:GG8CC.BT7AA.GG:BX
9BT;BX BT+BB:BT$JJ
```

EXPLANATION OF THE ABOVE SYMBOLIC EQUATION

(sp) BT	BT to accumulator
.DD	Multiply by DD
:FF	Store result in FF
1AA	Take sine of AA
.EE	Multiply by EE
:GG	Store result in GG
2FF	Take cosine of FF
(sp) FF	FF to accumulator
-GG	Subtract GG
.DD	Multiply result by DD
:GG	Store result in GG
8CC	-CC to accumulator
.BT	Multiply by BT
7AA	Raise e to power of number in AA
.GG	Multiply by GG
:BX	Store result in BX
9BT	Carriage return and print BT
;BX	Space and print BX
(sp) BT	BT to accumulator
+BB	Add BB
:BT	Store result in BT
$JJ	Return JJ times

PRINTOUT

```
BT 00000000  0  BX 50000000  0

BT 50000000  0  BX-41231526  0

BT 10000000  1  BX-11323257  1

BT 15000000  1  BX-16478633  1

BT 20000000  1  BX-19623208  1
```

5. EXAMPLE (CONT'D.)

PRINTOUT (CONT'D.)

```
BT 25000000  1  BX-20916091  1
BT 30000000  1  BX-20608494  1
BT 35000000  1  BX-19010624  1
BT 40000000  1  BX-16460734  1
BT 45000000  1  BX-13297938  1
```

6. GENERAL DICTIONARY

6.1 Commands

ADD	(+)
SUB	(-)
MUL	(.)
DIV	(/)
EXP	(')
SIN	(1)
COS	(2)
LOG	(4)
LN	(5)
10^x	(6)
e^x	(7)
SQR	(?)
FAC	(,)
ASN	())
ACS	(()

6. GENERAL DICTIONARY (CONT'D.)

6.1 Commands (Cont'd.)

CLA	(Space)
CSU	(8)
CPO	(9)
SPO	(;)
-	(:)
RET	($)
TPL	(H)
TMI	(S)
TZO	(O)
INC	(&)
INS	(3)
RPL	(!)

6.2 Options

Start	Sense Switch (ON)	Operation
1	B	Enter data
	C	Enter data
	D	Type data
	None	Type data
2	B	Enter number of digits for output
	C	Punch channels on tape
	D	Not used
	None	Enter symbolic equation

6. GENERAL DICTIONARY (CONT'D.)

6.2 Options (Cont'd.)

Start	Sense Switch (ON)	Operation
3	B	Verify symbolic equation
	C	Correct mistake in symbolic equation
	D	Punch symbolic equation on tape
	None	Begin calculation

HOW TO USE RAFT IV

Contents:

Training
(R2 - 12 Dec. 1961)

I. GENERAL COMPUTER CONCEPTS

A. There are two general types of computers.

(1) An Analog computer simulates the problem; all numbers read in (and answers read out) are measured in some way. Therefore, an Analog computer can only be as accurate as the measuring device. An example of a simple Analog computer is the slide rule.

(2) A Digital computer actually calculates the answer, with the numbers read in (and the answers read out) all being true decimal numbers. Digital computers carry numbers and calculate results much as a hand calculator does; each number has a given number of digits. (The RECOMP II Computer is a digital computer.)

B. Many people think of computers as being mysterious machines. Actually, they are capable of performing only very simple operations, such as adding, subtracting, dividing, or multiplying numbers. They can also make simple tests, such as determining if a number is equal to zero or not. Computers are very powerful tools because of their speed and the amount of information that they can store (and operate on) and because of their testing ability.

C. Any digital computer, large or small, is made up of four types of devices. (These devices may be packaged separately or together.)

(1) Input-Output units provide the means for getting information into or out of the computer. Examples of Input-Output units are paper tape reader, paper tape punch, typewriter (for input or output), magnetic tape, punched cards, etc.

(2) Storage units are devices that can store information for the computer. (They are quite often called "Memory" devices.) A computer can store three basic types of information - instructions, numbers, and alphabetic characters. Common types of "Memory" devices are Core, Drum, and Disk Storage. (The RECOMP II uses a Disk Memory device.)

(3) Arithmetic units are registers where the actual computation takes place. The dials of a hand calculator which hold one number could be thought of as being a register.

(4) Control units are devices that control the overall actions of a computer. They coordinate the operations of all the units.

D. The Memory of any computer contains a number of locations where information can be stored. (Every location holds a standard amount of information.) Each location in memory has a unique "address" permanently associated with it. A number put into the computer is always referred to by its "address" - actually the address of the location where the number is stored. (An analogy here is a Post Office with 26 boxes that are labeled A - Z. If the number "12.5" is written on a slip of paper, the number could be stored by placing it into Box C. Likewise the number "4.4" could be written on a slip of paper and placed in Box D. Then the instruction "add the number stored in C to the number stored in D" might be given, followed by "store the result in E". The answer, "16.9", would be left in Box E.)

E. Most computers have a register where the computation takes place and where the results are left. The main register is usually called the Accumulator. It normally holds one number - such as could be stored in one location in memory.

F. Computers actually perform individual "instructions". An instruction must state (1) what operation to perform and (2) what data to operate on. One common form of an instruction is an Operation (or Operation Code) plus an Address. (As an example, the instruction "Add G" might mean to take the number already in the Accumulator, add the number stored in memory location G to it, and leave the result in the Accumulator.)

G. A "Program" is a complete set of instructions to solve a given problem. All modern digital computers are "Internally Stored Program" computers. This simply means that the program that the computer will follow is itself stored in the computer in some of the available locations in memory.

H. In order to have a computer perform a Program, the computer is told the location (in memory) of the first instruction. In a "sequential" computer, the computer then proceeds to perform the instructions in the same sequence as they are stored in memory.

I. All computers have some form of "transfer" instruction. A transfer instruction tells the computer to take its next instruction from a specified location in memory, rather than from the next location as it normally would do.

II. RECOMP ALGEBRAIC FORMULAR TRANSLATOR (RAFT IV)

A. RAFT IV is an "Interpretive Routine" (or a General Purpose Program) that has been written for the RECOMP II computer. The RAFT Interpretive Routine allows the user to write his program in a simpler form. This simpler RAFT Program is then put in the computer along with the RAFT Interpretive Routine, which then translates the simpler RAFT Program into a standard program that the computer can understand and perform.

B. GENERAL

1. An Operation (or "Command") is represented by a symbol. (e.g. Add is "+", Subtract is "-", Divide is "/", etc.) There are 27 Operations available.

2. Each number is stored in a data location and is referred to by an Address. An address consists of some 2 letter combination from BA to LZ. (e.g. BA, BB, BC, ... BZ, CA, CB, ... CZ, DA, ... DZ, EA, ... LZ.) There are a total of 286 data locations available. (The first letter is called the "channel" and the second letter the "sector" portion of the address.)

3. The Accumulator (which holds one number) normally contains the results of an operation and is referred to by the address AA.

4. An Instruction consists of one operation and one address. (e.g. " + BA")

5. A Symbolic Equation (or "Program") consists of the instructions necessary to solve a given problem. There may be up to 1024 instructions in one Program.

6. Instructions are always performed in the same sequence as they occur in the Symbolic Equation unless a transfer command is given. A transfer command causes some other instruction to be performed next - rather than the next instruction in sequence.

II. RECOMP ALGEBRAIC FORMULAR TRANSLATOR (RAFT IV) (cont'd)

C. LIST OF COMMANDS

In the following definitions, AA refers to the Accumulator and (AA) refers to the contents of the Accumulator. LL refers to an address (BA thru IZ) and (LL) refers to the contents of that address.

Operation Abbreviation	Operation Symbol	Definition	
1. Move Data Commands - Move data between the Accumulator and any data location.			
CLA	(Space)	(Clear and Add.) Place (LL) into AA after clearing AA to zero.	
CSU	8	(Clear and Subtract.) Place - (LL) into AA.	
STO	:	Store (AA) into LL.	
2. Arithmetic Commands - Performs an operation and places the result in the Accumulator.			
ADD	+	Add (LL) to (AA)	
SUB	-	Subtract (LL) from (AA)	
MUL	.	Multiply (LL) times (AA)	
DIV	/	Divide (AA) by (LL)	
EXP	'	Raise (AA) to the Power (LL)	(1)
3. Function Commands - May operate on the contents of AA with the result remaining in AA or may operate on the contents of LL with the result remaining in LL. (AA is not affected by function commands operating on LL)			
SIN	1	Compute sine of (AA) or (LL)	(2)
COS	2	Compute cosine of (AA) or (LL)	(2)
ASN	)	Compute the arc sine of (AA) or (LL)	(2) (3)
ACS	(	Compute the arc cosine of (AA) or (LL)	(2) (3)

(1) In y^x, y cannot be negative
(2) All angles are in radians
(3) The sin or cos of any angle ≤ 1

LOG	4	Compute the logarithm (base 10) of (AA) or (LL)	(4)
LN	5	Compute the logarithm (base e) of (AA) or (LL)	(4)
10^x	6	Raise 10 to the power (AA) or (LL)	(5)
e^x	7	Raise e to the power (AA) or (LL)	(5)
SQR	?	Compute the square root of (AA) or (LL)	
FAC	,	Compute the factorial of the positive number (AA) or (LL)	

4. Output Commands - Will output number on typewriter in decimal "floating point" form. A floating point printout is in the following form: "LL XXXXXXXX YY" - where LL is the address of the number, XXXXXXXX is the decimal number (no leading zeros) with the decimal point assumed to be before the first digit, and YY is the power of ten the number is to be multiplied by. The decimal number that is printed out may be from 2-11 digits long.

Example:

Printed out	means
CE 46520000 1	The number stored in address CE = 4.652 (= $.4652 \times 10^1$)
FA 64231509 - 2	The number stored in address FA = 0.0064231509 (= $.64231509 \times 10^{-2}$)
HE -5329 3	The number stored in address HE = -532.9 (= $-.5329 \times 10^3$)

Operation Abbreviation	Operation Symbol	Definition
CPO	9	Carriage Return, then print out (AA) or (LL)
SPO	;	Space, then print out (AA) or (LL)

(The instruction "9 CE" would cause the contents of CE to be printed out - see above.)

(4) The number must be positive
(5) The floating point exponent of X must be ≤ 35

EXAMPLE 1

RAFT IV CODING SHEET

for

RECOMP Automatic Formula Translator IV

LIST OF COMMANDS

ARITHMETIC			FUNCTIONS			FUNCTIONS/OUTPUT		CONTROL	
S/P	CLA	enter L to AA	?	SQRoot	L or AA	6	10^x Raise 10 to AA or L	$	RETurn to beginning
8	CLS	- L to AA	1	SINe	L or AA	7	e^x Raise e to AA or L	H	TPLus
+	ADD	L to AA	2	COSine	L or AA	'	EXP AA to power L	S	TMInus
-	SUBtract	L from AA	)	ASN $\sin^{-1}$	L or AA	,	FACtorial of AA or L	0	TZEro
·	MULtiply	AA by L	(	ACS $\cos^{-1}$	L or AA			&	INChannel by 1
/	DIVide	AA by L	4	LOG_{10}	L or AA	9	CRT CR and type	3	INSector by 1
:	STOre	AA in L	5	LNatural (e)	L or AA	:	SPT Space and type	!	RPlace address

PROBLEM STATEMENT:

Solve: $Z = (X + Y)^2$

Print out value of Z

NOTE: "S/P" = space (actually "space bar")

CH.	SEC	DATA
B	X	X
F	Y	Y
B	Z	Z
C	A	2.0

CODE:

1	2	3	4	5	6	7	8
S/P B X	+ B Y	' C A	: B Z	9 B Z			

Explanation of Example 1

Instruction
1. Put X into AA (Accumulator)
2. Add X to Y; result is in AA
3. Raise (X+Y) to power 2.0; result is in AA
4. Store $(X+Y)^2$ into data location BZ
5. Carriage return, then print out contents of BZ ($= (X+Y)^2$)

Operation Abbreviation	Operation Symbol	Definition

5. Transfer Commands - Permit transfers within the Symbolic Equation.

RET	$	Return to the beginning of the Symbolic Equation the number of times contained in LL. Each time a return is made, a "1" is subtracted from (LL). When (LL) becomes "0", the return command is skipped.

(Example: If (FB) = 9, the instruction "$FB" would cause all instructions from the beginning down to the "RET" command to be performed a total of 10 times.)

TPL	H	If AA contains a positive number, transfer to Instruction number n, where LL contains the number n. If AA does not contain a positive number, skip this instruction.

(Example: If (AA) is positive and (DA) = 16, an instruction "H DA" would cause instruction number 16 to be performed next.)

TMI	S	If AA contains a negative number, transfer as above (in TPL).
TZO	O (letter)	If AA contains a zero (+ or -), transfer as above (in TPL). (NOTE: +100 -100 would = +0; -100+100 would = -0)

6. Modify Address Commands

INC	&	Increment the Channel (1st letter) portion of the address of instruction number n by 1 letter in the alphabet. (Do not proceed past channel "L"). LL contains the number n.

(Example: Instruction "& DF", where data location DF contains the number 19, would cause the channel address of the 19th instruction to be incremented - as say from BA to CA.)

INS	3	Increment the Sector portion (2nd letter) of the Address of instruction number n by one letter in the alphabet. LL contains the number n. (See INC above) (If CA is incremented, it becomes CB; if EZ is incremented, it becomes FA)

RAFT IV CODING SHEET

for

RECOMP Automatic Formula Translator IV

EXAMPLE 2

LIST OF COMMANDS

ARITHMETIC		FUNCTIONS		FUNCTIONS/OUTPUT		CONTROL	
	CLA enter L to AA	?	SQRoot L or AA	6	10^x Raise 10 to AA or L	$	RETurn to beginning
8	CLS - L to AA	1	SINe L or AA	7	e^x Raise e to AA or L	H	TPLus
+	ADD L to AA	2	COSine L or AA	'	EXP AA to power L	S	TMInus
-	SUBtract L from AA	)	ASN $\sin^{-1}$ L or AA	,	FACtorial of AA or L	0	TZEro
.	MULtiply AA by L	(	ACS $\cos^{-1}$ L or AA			&	INChannel by 1
/	DIVide AA by L	4	LOG_{10} L or AA	9	CRT CR and type	3	INSector by 1
:	STOre AA in L	5	LNatural (e) L or AA	:	SPT Space and type	!	RPlace address

PROBLEM STATEMENT:

Solve: $X = \sqrt{B^2 + CD - \sin\theta}$

(Print out value of θ° and X

NOTE: θ radians $= \theta^\circ \left(\frac{\pi}{180}\right)$

C_H	S_{EC}	DATA
B	B	B
B	C	C
B	D	D
B	Q	θ°
B	R	θ radians
B	X	$\sqrt{B^2 + CD - \sin\theta}$
C	A	180
C	B	π
D	A	$\sin\theta$
D	B	B^2

CODE:

S/P	C	B	/	C	A	.	B	Q	1	A	A	:	D	A	S/P	B	B	.	B	B	:	D	B
	1			2			3			4			5			6			7			8	
S/P	B	C	.	B	D	+	D	B	-	D	A	?	A	A	:	B	X	9	B	Q	;	B	X
	9			10			11			12			13			14			15			16	

Explanation of Example 2

Instruction

1. Put π into AA (after clearing AA)
2. Divide π by 180; result is in AA
3. Multiply (π/180) by θ°; result is in AA
4. Find the sin of θ; result in AA
5. Store $\sin\theta$ into data location DA
6. Put B into AA (after clearing AA)
7. Multiply B times B; result in AA
8. Store B^2 into data location DB
9. Put C into AA (after clearing AA)
10. Multiply C times D; result in AA
11. Add CD to B^2; result in AA
12. Subtract $\sin\theta$ from (B^2 + CD); result in AA
13. Find the square root of ($B^2 + CD - \sin\theta$); result in AA
14. Store ($B^2 + CD - \sin\theta$) into data location BX.
15. Carriage Return, then print out θ°
16. Space, then print out X

II. RECOMP ALGEBRAIC FORMULAR TRANSLATOR (RAFT IV) (cont'd)

RPL	!	Replace the Address of Instruction number n with the Address of this instruction. AA contains the number n.

(Example: If AA contains a number 10, and the instruction " ! FA " is given, the Address of the 10th instruction will be placed with "FA".)

II. RECOMP ALGEBRAIC FORMULAR TRANSLATOR (RAFT IV) (cont'd)

RAFT EXAMPLE 3 (Illustrates "Return to Beginning" Command)

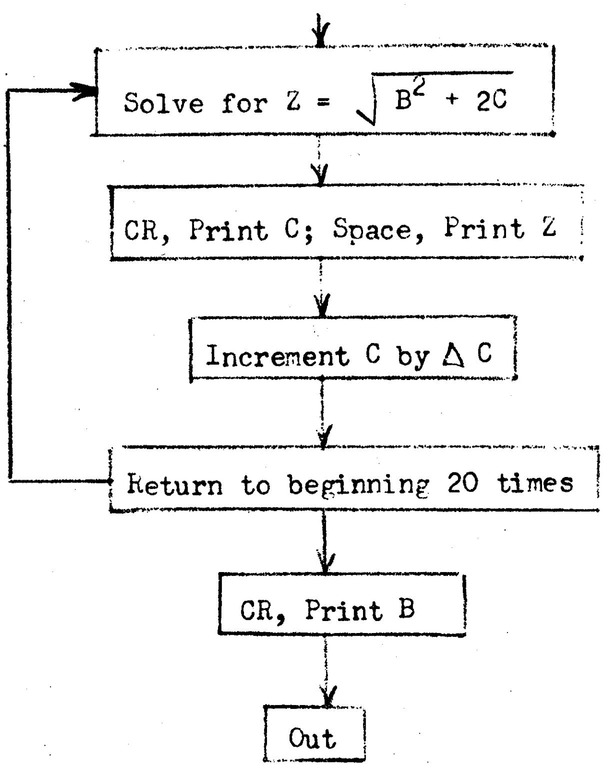
Solve $Z = \sqrt{B^2 + 2C}$

Print each value of C and Z and value of B once

Where: $B = 5$

C goes from 0 to 100 by increments of $\Delta C = 5$

Flow (Logic) Diagram



EXAMPLE 3

RAFT IV CODING SHEET

for

RECOMP Automatic Formula Translator IV

LIST OF COMMANDS

ARITHMETIC			FUNCTIONS			FUNCTIONS/OUTPUT			CONTROL	
	CLA	enter L to AA	?	SQRoot	L or AA	6	10^x Raise 10 to AA or L	$	REТurn to beginning
8	CLS	- L to AA	1	SINe	L or AA	7	e^x Raise e to AA or L	H	TPLus
+	ADD	L to AA	2	COSine	L or AA	'	EXP AA to power L	S	TMInus
-	SUBtract	L from AA	)	ASN $\sin^{-1}$	L or AA	.	FACtorial of AA or L	0	TZEro
·	MULtiply	AA by L	(	ACS $\cos^{-1}$	L or AA			&	INChannel by 1
/	DIVide	AA by L	4	LOG_{10}	L or AA	9	CRT CR and type	3	INSector by 1
:	STOre	AA in L	5	LNatural (e)	L or AA	;	SPT Space and type	!	RPlace address

PROBLEM STATEMENT:

CH.	SEC	DATA
B	B	B (=5)
B	C	C (=0)
B	D	ΔC (=5)
B	Z	Z
C	A	2.0
C	B	B^2
C	C	20.0

CODE:

1	S/P	B	B
2	·	B	B
3	:	C	B
4	S/P	B	C
5	.	C	A
6	+	C	B
7	?	A	A
8	:	B	Z
9	9	B	C
10	;	B	Z
11	S/H	B	C
12	+	B	D
13	:	B	C
14	$	C	C
15	9	B	B
16			

Explanation of Example 3

Instruction

1. Put B (=5) into AA
2. Multiply B by B ; result in AA
3. Store B^2 into data location CB
4. Put value of C (=0 initially) into AA (after clearing AA)
5. Multiply C by 2; result in AA
6. Add B to 2C; result in AA
7. Find <u>square root</u> of (B + 2C); result in AA
8. Store $\sqrt{B + 2C}$ into data location BZ
9. Carriage return, print out value of C
10. Space, print out value of Z
11. Put current value of C into AA
12. Add increment ΔC to C; result in AA
13. Store new value of C into data location BC
14. Return to the beginning of the equation 20 times (for a total of 21 results)
15. Carriage return, print out value of B

D. MACHINE OPERATION

1. Load the RAFT IV Program tape (#1058) into the tape reader and press the tape "FILL" button to read it into the computer.

2. Input the Symbolic Equation into the computer as follows:

   a. Turn all Sense Switches (on console) OFF (UP).

   b. Press the "Start 2" Button.

   c. Using the typewriter, type in the Symbolic Equation. Type exactly the symbols or letters in the Equation. (Do not type Letter Shift, Figure Shift, Tab, etc.; type only the characters in the Equation) Note that "Space" means the Space Bar.

   d. An automatic Carriage Return occurs after every 16 Instructions.

   e. Terminate entry of the Symbolic Equation by pressing the Carriage Return.

3. Input Data and Constants necessary to solve problem.

   a. Turn Sense Switch B ON (others OFF).

   b. Press the "Start 1" button.

   c. Using typewriter, type in each number as follows (Letter or Figure Shifts not necessary):

      (1) Type address of number (e.g. "BC")

      (2) Type in number itself by some combination of the following (see (3) below for examples):

         (a) Sign of number (+ or -)

         (b) Integral part of number

         (c) Decimal point followed by fraction

         (d) The sign and integral value of the power of 10 by which the number is to be multiplied

         (e) A carriage return enters the number

      (3) Examples of (2) (above) are:

         (a) 26.4 may be typed in as

            +26.4 (C/R)

            26.4 (C/R)

(b) 105,000 may be typed as

+105000 (C/R)

105000.0 (C/R)

105 +3 (C/R) (same as 105×10^3)

(c) +105 may be typed as

+105.0 (C/R)

105 (C/R)

(d) 0.65 may be typed as

+0.65 (C/R)

0.65 (C/R)

.65 (C/R)

+65 -2 (C/R) (same as 65×10^{-2})

(4) If a character other than a 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -, ., or carriage return is typed, the typewriter will type out "ERROR" and reset the computer so that the correct number may be entered.

d. After the last number has been entered, press the "FILL" button on the console.

4. After the Symbolic Equation and the Data have been entered, the problem is ready to run. To run,

(1) Turn all Sense Switches OFF

(2) Press "Start 3" button

Your program should now run.

5. The RAFT IV Program allows other very useful machine operations other than those mentioned above. The complete list is as follows:

MACHINE OPERATION	SENSE SWITCH ON	PRESS START
(1) Enter Data into specified locations (use locations BA - LZ only). See D 3 above.	B	1
(2) Type out a number already in the computer. Enter Address (e.g. "EC") of number through typewriter.	D	1
(3) Change the number of digits in each number to be output (if other than 8 is desired). See D 6.	B	2
(4) Punch one entire channel of Data on tape. Enter channel (e.g. "B") through typewriter. Repeat for other channel.	C	2
(5) Enter Symbolic Equation. See D 2.	None	2
(6) Verify the Symbolic Equation by having the typewriter type it out.	B	3
(7) Correct a mistake in the Symbolic Equation. See D7.	C	3
(8) Punch the Symbolic Equation out on tape.	D	3
(9) Run the problem	None	3

NOTE: The above 9 Machine Operations are all independent and may be performed in any sequence desired.

6. Normally 8 decimal digits are typed out for each number (in floating point form). This can be varied from 2 - 11 digits by doing the following (on the console):

(1) Put Sense Switch B ON (others OFF).

(2) Press the "Start 2" button

(3) Press "N" key

(4) Press "+" key

(5) Press "X" where X = the number of digits (2-11)

---

(6) Press the "." (decimal point)

(7) Press "Enter" key

(8) Press the "Start" butttton

7. To correct a mistake in the Symbolic Equation, do the following (on the console):

(1) Put Sense Switch C ON (others OFF).

(2) Press "Start 3" (the computer will halt with "0033.0" in the "location counter" lights on the console).

(3) Press "N" key

(4) Press "+" key

(5) Press "X" where X = the number of <u>correct</u> instructions preceding the incorrect entry.

(6) Press "." (decimal point)

(7) Press "Enter" key

(8) Press "Start" key

(9) Re-enter the correct instruction (put in complete instruction, even if only the address is being changed) through the typewriter.

EXAMPLE IV

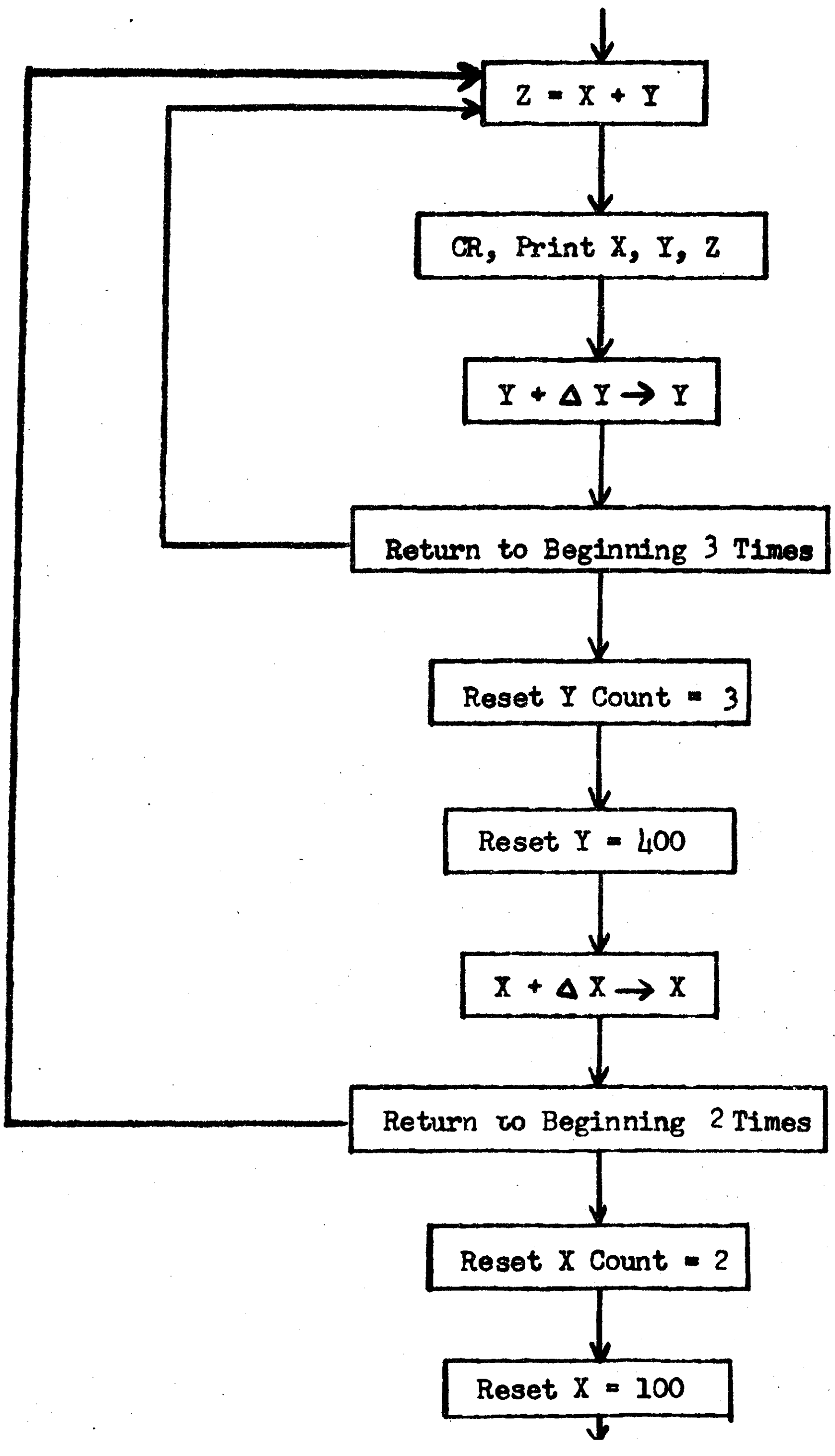
Solve: $Z = X + Y$

Where: X goes from 100 $\rightarrow$ 200 by $\Delta X = 50$

and Y goes from 400 $\rightarrow$ 700 by $\Delta Y = 100$

(let Y go through its range of values for each value of X)

Flow Diagram



RAFT IV CODING SHEET

for

EXAMPLE IV (cont'd) RECOMP Automatic Formula Translator IV

. OF COMMANDS

ARITHMETIC			FUNCTIONS			FUNCTIONS/OUTPUT		CONTROL	
	CLA	enter L to AA	?	SQRoot	L or AA	6	10^x Raise 10 to AA or L	$	RETurn to beginning
8	CLS	- L to AA	1	SINe	L or AA	7	e^x Raise e to AA or L	H	TPLus
+	ADD	L to AA	2	COSine	L or AA	'	EXP AA to power L	S	TMInus
-	SUBtract	L from AA	)	ASN $\sin^{-1}$	L or AA	,	FACtorial of AA or L	O	TZEro
•	MULtiply	AA by L	(	ACS $\cos^{-1}$	L or AA			&	INChannel by 1
/	DIVide	AA by L	4	LOG_{10}	L or AA	9	CRT CR and type	3	INSector by 1
:	STOre	AA in L	5	LNatural (e)	L or AA	;	SPT Space and type	!	RPlace address

PROBLEM STATEMENT:

$Z = X + Y$

Where: X goes from 100 → 200 by $\Delta X = 50$

& Y goes from 400 → 700 by $\Delta Y = 100$

(Let Y go through its range of values for each value of X)

CH.	SEC	DATA
B	X	X
B	Y	Y
B	Z	Z
C	A	ΔX
C	B	ΔY
C	C	Y Count
C	D	3.0
C	E	X Count
C	F	2.0
C	G	50
C	H	100
C	I	400

CODE:

S/P B X	+ B Y	: B Z	9 B X	; B Y	; B Z	S/P B Y	+ C B
1	2	3	4	5	6	7	8
: B Y	$ C C	S/P C D	: C C	S/P C I	: B Y	S/P B X	+ C A
9	10	11	12	13	14	15	16
: B X	$ C E	S/P C F	: C E	S/P C H	: B X		
17	18	19	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

EXAMPLE V

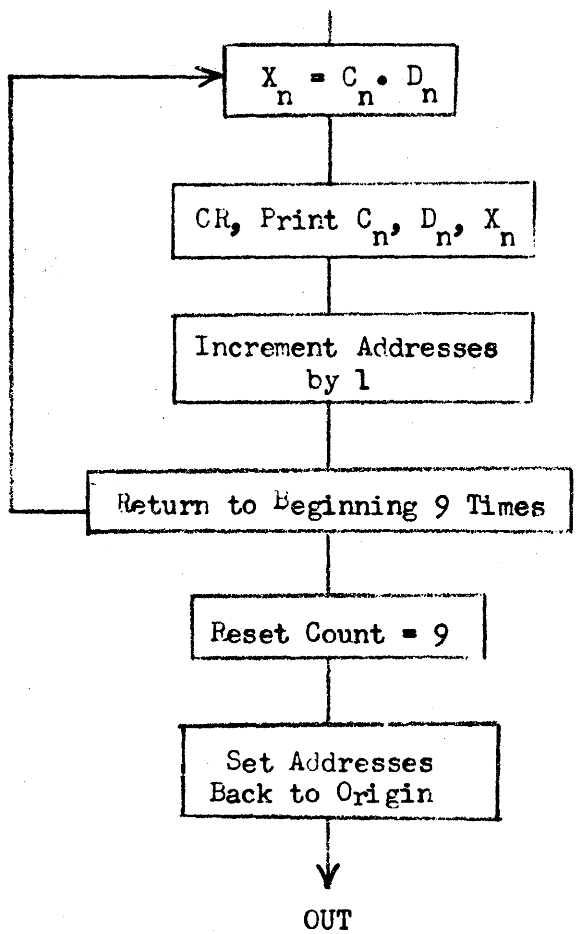
Solve: $X_n = C_n \cdot D_n$ for $n = 1 \rightarrow 10$

There is a table of 10 values of $C(C_1, C_2, \ldots C_{10})$ and also 10 values of D $(D_1, D_2, \ldots D_{10})$. Solve for the 10 corresponding values of X.

e.g.

$$\begin{array}{l} X_1 = C_1 \cdot D_1 \\ X_2 = C_2 \cdot D_2 \\ \vdots \\ X_{10} = C_{10} \cdot D_{10} \end{array}$$

Flow Diagram



EXAMPLE V (cont'd)

RAFT IV CODING SHEET

for

RECOMP Automatic Formula Translator IV

OF COMMANDS

ARITHMETIC			FUNCTIONS			FUNCTIONS/OUTPUT		CONTROL	
	CLA	enter L to AA	?	SQRoot	L or AA	6	10^x Raise 10 to AA or L	$	RETurn to beginning
8	CLS	- L to AA	1	SINe	L or AA	7	e^x Raise e to AA or L	H	TPLus
+	ADD	L to AA	2	COSine	L or AA	'	EXP AA to power L	S	TMInus
-	SUBtract	L from AA	)	ASN $\sin^{-1}$	L or AA	,	FACtorial of AA or L	O	TZEro
·	MULtiply	AA by L	(	ACS $\cos^{-1}$	L or AA			&	INChannel by 1
/	DIVide	AA by L	4	LOG_{10}	L or AA	9	CRT CR and type	3	INSector by 1
:	STOre	AA in L	5	LNatural (e)	L or AA	;	SPT Space and type	!	RPlace address

PROBLEM STATEMENT:

$$Z_n = C_n \cdot D_n$$

$$\text{for } n = 1 \rightarrow 10$$

C_H	S_{EC}	DATA
B	Z	Z
C	A	→ CJ = C_n
D	A	→ DJ = D_n
E	A	1
E	B	2
E	C	4
E	D	5
E	E	Count (9)
E	F	9

CODE:

S/P	C	A	.	D	A	:	B	X	9	C	A	;	D	A	;	B	X	3	E	A	3	E	B
	[1]			[2]			3			[4]			[5]			6			7			8	
3	E	C	3	E	D	$	E	E	S/P	E	F	:	E	E	S/P	E	A	!	C	A	S/P	E	B
	9			10			11			12			13			14			15			16	
!	D	A	S/P	E	C	!	C	A	S/P	E	D	!	D	A									
	17			18			19			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	