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Westinghouse Astronuclear Laboratory

TWO RAYTHEON 250 COMPUTER SUB-ROUTINES

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Westinghouse Astronuclear Laboratory

TWO RAYTHEON 250 COMPUTER SUB-ROUTINES

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Reactor Analysis Department

INFORMATION CATEGORY

Unclassified

B. G. Rankin

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INTRODUCTION

The purpose of this report is to present two subroutines for the Raytheon 250 computer* which were developed at the Westinghouse Astronuclear Experimental Facility (WANEF). WANEF is the critical experiments unit of Westinghouse Astronuclear Laboratory, located at the Waltz Mill Site in Pennsylvania. It is the task of this facility to perform basic research and reactor analysis on the NRX series of nuclear reactors to be used in America's first nuclear rocket engine. A group of programs previously reported by the WANEF group appear in a Raytheon 250 User's Group newsletter of March, 1965 and in a Westinghouse report¹.

The first of these subroutines involves a combination and modification of two Raytheon-supplied subroutines, the Decimal Input-Output IA, and the Floating Point Package. The purpose of the modification is to simplify the writing of programs using these subroutines by providing input and output between fixed point numbers on the typewriter keyboard and floating point numbers in the computer memory. Since keywords are required for these functions, the ease of use is improved.

The second of the subroutines described in this report is designed to replace an existing Raytheon-supplied subroutine which provides control of a Calcomp digital incremental recorder. The purpose of re-writing this subroutine was to provide increased versatility. Whereas the original program could plot only one symbol, the new program can plot any one of seven. Also, the new program can plot a line which more closely approximates a straight line between two given points.

This information is extended to others who may be involved in the Computer/Nuclear field. A continuation of this effort will be provided as development takes place.

* The Raytheon 250 was previously known as the Packard-Bell 250 computer.

¹ WANL-TME-997, Reactor Experiments and the Packard-Bell Computer,
Westinghouse Astronuclear Experimental Facility, October, 1964

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MODIFIED DECIMAL INPUT-OUTPUT AND FLOATING POINT ROUTINES

PURPOSE

To modify existing decimal input-output and floating point routines in order to 1) provide input directly into the floating point format instead of into the fixed point format, and 2) to provide, in addition to the normal output function, a keyboard output obtained directly from the floating point format without the need of specifying an output keyword.

RESTRICTIONS

- 1) The program is designed for lines 04 and 05 and is not line relocatable.
- 2) Other restrictions are described in the Decimal Input-Output 1A and the Single Precision Floating Point Packages which are identified in Appendix A and B.

STORAGE

The following instructions refer to the two long lines 04 and 05. The unused sectors in line 05 are: 000 and 005. The unused sectors in line 04 are: 015, 020, 022, 026, 030, 032, 033, 041, 042, 043, 050, 051, 057, 061, 062, 070, 077, 101, 102, 113, 120, 122, 124, 126, 130, 132, 133, 135, 137, 141, 143, 155, 157, 161, 163, 164, 170, 171, 173, 175, 177, 203, 215, 220, 222, 225, 226, 237, 241, 242, 251, 260, 262, 270, 273, 274, 276, 277, 300, 301, 302, 303, 304, 305, 306, 207, 310, 311, 312, 313, 314, 315, 317, 321, 325, 326, 330, 340, 375, 377. The fast line 00 is used for temporary storage. All sectors except 14 and 16 are used.

PROGRAM FEATURES

- 1) The program is loaded by means of the Octal Utility Package.
- 2) It is not necessary to set the index register in calling any of the routines in this program.
- 3) The Floating-Point-Package part of this program is located in line 04. All of the routines are unchanged with the exception of FLT whose entry point becomes 04004.
- 4) The Decimal-Input-Output part of this program is located in line 05.

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5) The routine for input of numbers now produces a floating point number located in the A and B registers. It is not necessary to specify a keyword for this routine. Entry points are 00105 for keyboard entry and 00605 for tape entry. The calling sequence is as follows:

- a) LDC with return instruction
- b) TRU to entry point

6) There is a new output routine to provide output to keyboard of a floating point number. No keyword is required. The calling sequence is as follows:

- a) LDP with the number to be output
- b) LDC with the return instruction
- c) TRU to 14105

7) The routine will print out the number to six digits, placing the decimal point so as to provide an optimized number of decimal places consistent with the size of the number.

DISCUSSION

This subroutine is basically a patched-up version of the existing Floating Point Package and the Decimal Input-Output 1A. The chief advantage gained in using this subroutine is the ability to either input or output numbers to the typewriter keyboard without the need of specifying keywords. This provides flexibility which greatly simplifies the problem of programming. In particular, this subroutine has been used to provide flexible plotting programs for data input from the keyboard and to provide desk calculator type programs for some specific types of calculation where data are input and results are output on the keyboard. Several programs of this type will be reported at a later date.

Table 1 contains a listing of those commands which differ from those contained in the listings supplied by Raytheon for the Decimal Input-Output and Floating Point Packages.

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TABLE 1. MODIFIED DECIMAL INPUT-OUTPUT AND FLOATING POINT PACKAGES

PROGRAMMER: WILLIAM D. RANKIN

Line	Sector	Command	Op	Address	Location	Remarks
05	107	003 0500;	LDA	K		Modification of the decimal input package to produce floating point numbers.
	110	111S1405;	ADD	a + 1		
	111	146 0505;	LDA			
	112	120 1105;	STA			
	113	002 0500;	LDA	Σ		
	114	115S0405;	LDC	a + 1		
	115	117S3705;	TRU	a + 2		
	116	000S3704;	TRU	FLO		
	117	001 1300;	STD	F01		
	120	153 0505	LDA			
	121	122S0405;	LDC	a + 1		
	122	124S3705;	TRU	a + 2		
	123	000S3704;	TRU	FLO		
	124	125S0405;	LDC	a + 1		
	125	127S3705;	TRU	a + 2		
	126	112S3704;	TRU	FDV		
	127	010 0400;	LDC	F10		
	130	132 3405;	TCN	a + 2		
	131	134S3700;	TRU	EXIT		
	132	133S0405;	LDC	a + 1		
	133	000 0000;				
	134	001 1000;	STC	F01		
	135	002 1000;	STC	F02		

TABLE 1 (CONT'D.)

Line	Sector	Command	Op	Address	Location	Remarks
	136	137S0405;	LDC	$\alpha+1$		Modification of the decimal input package to produce floating point numbers
	137	154S7500;	TOF	EXIT		
	140	200S3704;	TRU	FSB		
05	012	014 1000;	STC		Changes address of return instruction in D10	
04	000	103S1000;	STC			Changed address of return instruction in FLO
04	104	002S3704;	TRU			
04	037	043S3700;	TRU			
05	141	007 1000;	STC	F07		
	142	143S5605;	CAM	-0		
	143	-0000000				
	144	106 7504;	TOF			
	145	360S0300	ROT			
05	362	000 4300;	CLB			
	363	003 2110;	SLT	$\alpha+20$		Routine to select keyword for decimal output of mantissa on basis of characteristics of floating point number
	364	362 3504;	TAN			
	365	366S1505;	SUB	$\alpha+1$		
	366	+0400000			4	
	367	361 3504;	TAN			
	370	371S1505;	SUB	$\alpha+1$		
	371	+0300000			3	
	372	357 3504;	TAN			
	373	371 1505;	SUB		3	
	374	356 3504;	TAN			
	375	342S3704;	TRU	$\alpha+1$		

TABLE 1 (CONT' D.)

Line	Sector	Command	Op	Address	Location	Remarks
04	342	366 1505;	SUB	4		Routine to select keyword for decimal output of mantissa on basis of characteristics of floating point number.
	343	354 3504;	TAN			
	344	371 1505;	SUB	3		
	345	353 3504;	TAN			
	346	371 1505;	SUB	3		
	347	352 3504;	TAN			
	350	351S1404;	ADD	$a+1$		
	351	+0001000				
	352	360 1404;	ADD			
	353	360 1404;	ADD			
	354	355S1404;	ADD	$a+1$		
	355	+0400770				
	356	360 1404;	ADD			
	357	360S1404;	ADD	$a+1$		
	360	+0300770				
	361	370S1404;	ADD			
04	370	+0401050				
	371	000 0100;	IAC			
	372	000 0200;	IBC			
	373	007 0400;	LDC			
	374	155S3705;	TRU			
04	362	001 1100;	STA	F01		
	363	053 0504;	LDA	0		
	364	001 1500;	SUB	F01		
	365	366S1404;	ADD	$a+1$		
	366	-0001060				

TABLE 1 (CONT' D.)

Line	Sector	Command	Op	Address	Location	Remarks
	367	371S3704;	TRU			
04	106	107S1604;	DPA	$\alpha + 1$		
	107	+0000001;				
	110	+4000000;				
	111	145S3705;	TRU			
04	040	043S1000;	STC			
04	044	054S0200;	IBC			New FLT routine
04	055	005S4300;	CLB			
04	016	075S2300;	SAI			Correction to FIX routine
04	075	045S3704;	TRU			
04	205	206S0200;	IBC			
04	207	212S4300;	CLB			
04	213	234 1104;	STA			
	214	216S4500;	CLA			
04	217	234S1504;	SUB			
04	234	000 0000;				Corrections to FSB routine
	235	216S2000;	NAD			
04	216	223S0200;	IBC			
04	332	376S2000;	NAD			
04	376	340S0200;	IBC			
04	215					
04	220	} vacated				
04	222					
05	000					
05	005					

DIGITAL PLOTTER SUBROUTINE

PURPOSE

To provide an improved subroutine for use with the Calcomp Digital Incremental Recorder. The advantages gained by this subroutine are 1) a choice of seven symbols which can be plotted and 2) the ability to draw a straight line in any direction on the graph.

RESTRICTIONS

The program is not line relocatable.

STORAGE

The program occupies 226 sectors of line 07. (Sectors not used: 020, 021, 023, 024, 100, 115, 122, 124, 161, 252, 253, 274, 276, 277, 300, 316, 317, 334, 335, 336, 345, 354, 355, 356, 360, 361, 362, 367, 371, 374.)

In addition, the following temporary storage locations are used: F00-F04, F06-F12, F17.

PROGRAM FEATURES

- 1) Store the number of the symbol desired in 03307 at a Q of 7.

e.g. 000 0000; no symbol
 001 0000;
 002 0000;
 003 0000;
 004 0000;
 005 0000;
 006 0000;
 007 0000;

- 2) LDC with return instructions as follows:

- a) sequence tagged TCN or TAN to draw line to point.
- b) sequence tagged TBN or TRU to move to point with the pen raised

- c) sequence tagged TOF to set the location counter to (0, 0)
- 3) LDA with increments of X in .010 inch
- 4) LDB with increments of Y in .010 inch
- 5) TRU 00007

DISCUSSION

The DR-1 subroutine previously used has two restrictions which limit its usefulness. First, it can only plot one symbol, and it is difficult to modify for plotting any other symbol. The present program provides a choice of seven different symbols. If others are desired, it is a simple matter to provide the required program modification. The second disadvantage to the DR-1 routine is that in drawing a line from one point to another, it does not draw directly to the point but rather traces a dog-leg made up of two line segments. The present program draws a line made of .010 inch incremental steps sequenced in such a way as to trace a staircase line which departs no more than .010 inch from a true straight line between the points. The speeds of the two subroutines are approximately the same.

The flow diagrams for this subroutine are shown on the following six pages. The commands for the Digital Recorder Subroutine are listed in table 2.

Flow Diagram of the Digital Plotter Routine

Flow Diagram of the Digital Plotter Routine

Flow Diagram of the Digital Plotter Routine

Flow Diagram of the Digital Plotter Routine

Flow Diagram of the Digital Plotter Routine

TABLE 2. DIGITAL RECORDER SUBROUTINE

Programmer: William D. Rankin

Sector	Command	Op	Address	Location	Remarks
000	040S1300;	STD	X_0, Y_0	Store	
042	057S0200;	IBC			
060	244 1207;	STB	Return		
061	073S2110;	SLT	$a + 12$	Transfer if TOF return command	
073	076 3607;	TBN	$a + 2$		
074	101S2110;	SLT	$a + 5$		
076	120S4500;	CLA			
121	241S4300;	CLB		Transfer if TBN or TRU return command	
101	103 3607;	TBN	$a + 2$		
102	105S4400;	CLC		Set WOC for "pen up" or "pen down"	
103	104S0507;	LDA	$a + 1$		
104	032S6010;	WOC			
105	144S4400;	CLC			
106	144S0507;	LDA	$a + 1$		
144	032S6000;	WOC			
145	353 1107;	STA	WOC pen	Find magnitude of X increment	
146	160S0700;	LDP	X_0, Y_0		
162	110 1507;	SUB	X_1		
163	172S1100;	STA	$\pm X_2$		
173	175 3507;	TAN			
174	214S0300;	ROT			
175	176S0000;	MAC			
177	200S4500;	CLA

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
201	212S1500;	SUB	$\pm X_2$	}	Find magnitude of Y increment
213	214S0300;	ROT			
216	217S1000;	STC	X_2		
220	221S4400;	CLC			
222	107 1507;	SUB	Y_1		
223	226S1100;	STA	$\pm Y_2$		
227	231 3507;	TAN			
230	247S3707;	TRU			
231	232S0000;	MAC			
233	234S4500;	CLA			
235	246S1500;	SUB	$\pm Y_2$		
247	250S1100;	STA	Y_2		
251	257S1500;	SUB	X_2		Transfer if $X_2 > Y_2$
260	262 3507;	TAN			
261	262S1100;	STA	DIFF		$DIFF = Y_2 - X_2$
263	317S1500;	SUB	X_2		
320	321S0300;	ROT		}	Place sign of Y into both WOC commands
323	346S2210;	SRT	$a + 23$		
346	347S4707;	EXF	$a + 1$		
347	377S77751				
350	355S0300;	ROT			
357	363S1407;	ADD	$a + 1$		
363	072S6020;	WOC			
364	170 1107;	STA	WOC A		
365	160 1107;	STA	WOC B		

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
366	367S0200;	IBC			
370	373S2110;	SLT	$a + 3$		
373	375S4707;	EXF	$a + 1$		
375	377S7767;				
376	377S0300;	ROT			
001	237S0400;	LDC	X_2		
240	273 3607;	TBN			
241	301S0607;	LDB	$a + 1$		
301	000 0004;			Y only	
302	007 1000;	STC	B_0	Δ	
303	160 1407;	ADD	WOC B		
304	160 1107;	STA	WOC B		
305	342S0500;	LDA	DIFF		
343	177S1100;	STA	A_0		
200	222S0300;	ROT			
224	170 1407;	ADD	WOC A		
225	170 1107;	STA	WOC A		
226	236S0407;	LDC	$a + 1$		
236	000S0400;			$\downarrow$	
237	353S7030;	PTU			
353	032860XX;	WOC			Enable recorder WOC pen up or down and transfer to line draw routine.
273	321S0607;	LDB	$a + 1$		
321	000 0004;			Y only	
322	337S1000;	STC	A_0	Γ	
340	170 1407;	ADD	WOC A		

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
341	170 1107;	STA	WOC A		
342	062S0500;	LDA	DIFF		
063	007 1100;	STA	B ₀		
064	065S0300;	ROT			
067	160 1407;	ADD	WOC B		
070	160 1107;	STA	WOC B		
071	236S0407;	LDC	ψ		
262	263S1100;	STA	N		
264	274S4500;	CLA			
275	323S1500;	SUB	N		
324	122S1100;	STA	DIFF		
123	030S1500;	SUB	Y ₂		
031	175S0100;	IAC			
176	217S2210;	SRT	$\alpha + 21$		
217	266S4707;	EXF	$\alpha + 1$		
266	377S7767;				
267	370S0300;	ROT			
372	254S1407;	ADD	$\alpha + 1$		
254	072S6020;	WOC			
255	170 1107;	STA	WOC A		
256	160 1107;	STA	WOC B		
257	264S0200;	IBC			
265	270S2210;	SRT	$\alpha + 3$		
270	332S4707;	EXF	$\alpha + 1$		

Place sign of X into both
WOC commands

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
332	377S7775;				
333	342S0300;	ROT			
344	350S0400;	LDC	Y_2		
351	377 3607;	TBN			
352	012S0607;	LDB	$a + 1$		
012	000 0001;			X only	
013	302S3707;	TRU	Δ		
377	065S0607;	LDB	$a + 1$		
065	000 0001;			X only	
066	322S3707;	TRU	Γ		
032	117S0500;	LDA	A_0	Line Draw	
120	207S1500;	SUB	B_0		
210	212S2210;	SRT	$a + 2$		
212	010S0100;	IAC			
011	047S0500;	LDA	B_0		
050	137S1400;	ADD	A_0		
140	141S5607;	CAM	Zero		
142	022 7507;	TOF	Symbol		Transfer to symbol routine.
143	210S0100;	IAC			Line draw routine.
211	231S0200;	IBC			
232	244S4400;	CLC			
245	250 3507;	TAN			
246	167S1500;	SUB	B_0		

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
170		WOC			
250	157S1400;	ADD	A_O		
160		WOC			
072	073S0300;	ROT			
075	137S1507;	SUB	$a + 1$		Recycle
137	000 0000;				
022	033S0507;	LDA	$a + 1$	Symbol	
033				$S \#$	
034	035S1407;	ADD	$a + 1$		Locate symbol address keyword
035	306 0407;	LDC			
036	043 1107;	STA	L_1		
037	040S0607;	LDB	$a + 1$		
040	000 0407;	LDC			
041	042S4500;	CLA			
043		LDC		L_1	
044	045S4607;	ADC	$a + 1$		
045	377 0000;				Find address of first word in symbol description
046	131 1207;	STB	L_2		Find n_0 and m
047	054S0200;	IBC			
055	056S4707;	EXF	$a + 1$		
056	377S0000;				
057	077S2110;	SLT	$a + 20$		
077	127S1300;	STD	n_0, m		
131		LDC		L_2	Load word of symbol description

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
132	133S0607;	LDB	$a + 1$	}	Form WOC command
133	221S6000;	WOC			
134	135S4607;	AOC	$a + 1$		
135	000 0037;				
136	145S0307;	ROT		}	Test for end of word
147	150S5607;	CAM	$a + 1$		
150	221S6037;	WOC			
151	157 7507;	TOF			
152	111 1107;	STA	W_1	}	WOC pen up or down or WOC pen displacement
153	154S4007;	EBP	$a + 1$		
154	377S7700;				
155	325 3507;	TAN			
156	214S0407;	LDC			
325	127S0500;	LDA	n_0		
130	110S4400;	CLC			
214	000S0400;				
215	110S4500;	CLA			
111		WOC			
221	271S1507;	SUB	$a + 1$	}	If WOC was pen displacement repeat for n_0 times
271	010 0000;				
272	126S5607;	CAM	$a + 1$		
126	370 0000;				
127	337 7507;	TOF

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
337	116S0507;	LDA	$a + 1$		Shift to discard used portion of symbol description word and recycle.
116	000 0047;				
117	125S2210;	SRT	$a + 6$		
125	131S0200;	IBC			
157	170S0500;	LDC	m		Update L_2 and m . If all words in symbol description are used, transfer to exit routine, otherwise recycle.
171	131 0607;	LDB	L_2		
172	202S1607;	DPA	$a + 1$		
202	001 0000;			$+ 1$	
203	377S7777;			$- 1$	
204	164S5607;	CAM	$a + 1$		
164	000 0000;		0		
165	234 7507;	TOF	Exit		
166	131 1207;	STB	L_2		
167	130S1100;	STA	m		
234	240S0700;	LDP	X_0, Y_0	Exit	Exit routine
242	107 1307;	STD	X_1, Y_1		
243	244S7032;	PTU			
244		TRV		Return	Symbol address keywords
306	062 0100;				
307	026 0306;				
310	051 0405;				
311	112 0305;				
312	205 0304;				
313	326 0403;				
314	014 0403;				
315	002 0701;				

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
062	000 0037;				
026	300 2110;				
027	104 2232;				
030	000 3731;				
051	310 2010;				
052	215S2631;				
053	105 2421;				
054	000 3732;				
112	316 6100;				
113	265S2421;				
114	000 3724;				
205	326S2000;				
206	306 2220;				
207	000 3722;				
326	004 6110;				
327	326 7130;				
330	204 6122;				
331	376 7110;				
014	005 2410;				
015	225S2632;				
016	305 2420;				
017	375S2610;				
002	214 6110;				
003	306 2400;				
004	326S3131;				

Symbol descriptions

TABLE 2 (CONT' D.)

Sector	Command	Op	Address	Location	Remarks
005	224S2626;				Symbol descriptions
006	204 2121;				
007	316 5024;				
010	000 3731;				

APPENDIX A

DECIMAL INPUT - OUTPUT LA

IDENTIFICATION:	Single-Precision, Fixed-Point Subroutine
AUTHOR:	F. Valadez, PBCC
ACCEPTED:	June 16, 1961
PURPOSE:	<ol style="list-style-type: none">1. To input a fixed-point decimal number from either the Flexowriter keyboard or paper tape reader, and convert it to a single-precision binary number at a specified scaling.2. To convert a single-precision binary number which is stored in the computer at a specified scaling into decimal, and output the number on punched paper tape or in printed form.
RESTRICTIONS:	<ol style="list-style-type: none">1. <u>Input</u><ol style="list-style-type: none">a. The only characters which should be entered are plus (+), minus (-), space, decimal point (.), carriage return, and tab.b. The magnitude of the number, ignoring decimal point, must be less than 2,097,152.2. <u>Output</u><ol style="list-style-type: none">a. The magnitude of the number, ignoring decimal point, must be less than 2,097,152.b. The output number, ignoring decimal point, can have a maximum of 7 decimal digits.c. If the output number is entirely fractional, the maximum number of decimal digits possible is 6.

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APPENDIX B

SINGLE PRECISION FLOATING POINT PACKAGE

IDENTIFICATION:	Subroutine package
AUTHOR:	R. Johnsen, PBCC -- Revised by J. Johnson
ACCEPTED:	July 3, 1962
PURPOSE:	To perform the basic arithmetic floating point operations.
RESTRICTIONS:	<ol style="list-style-type: none">1. If division by zero is attempted, FDV will exit with no operations performed and no registers changed. No error indication is given.2. FSR makes no distinction between positive and negative numbers. It will attempt to take the square root in either case. No error indication is given.