ALL ADDRESSES FROM 078 +4
EXCEPT 074,5 076,7 078 084 086

WISCoding for RKS MOD

By JD **Date** 7/28/59 **Page** 5A **of** & 6A

FLOW #	ORDER #	X	TYPE	A	B	C	#	HEX X	HEX T	HEX A	HEX B	HEX C	
				[ ]	[ ]	[ ]							
		45	E	LO [ ] Y	[25,6]	[ ]	073	02d	1	35f	196	~~087~~ 00b	
		100	A	$(8+1)^A$ [ ] $+(N-1)^A$	[ ] →OP	[ ]	4	100	8	088	~~087~~ 08c	35e	
			TN	if Y=0 [ ]	[ ]:	[078]	5	/	e	~~087~~ 00b	001	078	
		100	S	$(8+1)^A$ [ ] -1^A	[ ]	[\ ]	6	100	a	~~08a~~ 088	3fb	800	
		100	A	" [\ ] $+Y^A$	[ ] →OP	[ ]	7	100	8	800	~~087~~ 00b	35e	if Y≠0
		100	A	[ ]	[ ]	[ ]	8	100	8	3fb	3ff	090	
				[ ]	[ ]	[ ]	9	100	8	3fd	3ff	091	
		25	E	OP [ ] Y or N	[13,12] DECON LINK	[ ]	a	019	1	35e	0dc	04c	
				[ ]	[ ] OUT LINK	[ ]	b	019	1	35e	0dc	04d	X
				[ ]	[ ]	[ ]	c	025	1	35f	018	08b	
				[ ]	[ ]	[ ]	d	001	1	035	01c	080	NO CHANGE
				[ ]	[ ]	[ ]	e	001	1	034	19c	080	
				[ ]	[ ]	[ ]	f	001	1	35f	01c	047	
				[ ]	[ ]	[ ]	080	/	8	( )	3ff	( )	
				[ ]	[ ]	[ ]	1	/	e	08c	090	085	
				[ ]	[ ]	[ ]	2	100	8	090	3fb	090	
				[ ]	[ ]	[ ]	3	100	8	080	089	080	
				[ ]	[ ]	[ ]	4	/	5	/	/	080	
				[ ]	[ ]	[ ]	5	100	8	3fb	3ff	090	
				[ ]	[ ]	[ ]	6	100	a	080	08d	080	
				[ ]	[ ]	[ ]	7	/	5	~~(Y)~~ /	/	002	
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							

WISCoding for RKS MOD

By [illegible] **Date** 7/28/59 **Page** 7A **of** ___

FLOW #	ORDER #	X	TYPE	A	B	C	#	X	T	A	B	C
				DUMMY ORDER [ ]	[ ]	[ ]	088	—	8	093	800	093
				1^{AC} [ ]	[ ]	[ ]	9	—	-	001	—	001
				$1/3$ [ ]	[ ]	[ ]	a	101	a	aaa	aaa	aab
			0	P^c [ ]	[ ]	[ ]	b	—	—	—	—	—
			0	$N_i^A (N-1)^A$ [ ]	[ ]	[ ]	c	—	—	—	—	— LOAD ↓
				$(N-1)^{AC}$ [ ]	[ ]	[ ]	d	—				
				h [ ]	[ ]	[ ]	e					
				$h/2$ [ ]	[ ]	[ ]	f					
				i [ ]	[ ]	[ ]	090					
				p^c [ ]	[ ]	[ ]	1					
	δ			x [ ]	[ ]	[ ]	092					
	δ+1			δ_1 [ ]	[ ]	[ ]	093					
	⋮			⋮ [ ] FOR OUT	[ ]	[ ]						
	δ+N			δ_N [ ]	[ ]	[ ]	092+N					
	Y+1			y_{10} [ ]	[ ]	[ ]	093+N					
	⋮			⋮ [ ] FOR KEEPS	[ ]	[ ]						
	Y+N			y_{N0} [ ]	[ ]	[ ]	092+2N					
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						

3.02.01

RKS

RKS

8/4/1959

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1d	100a01208d012,	100a01408d014,	10080203ff35f,	00050000210b9,
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2d	100a02308d023,	100a02408d024,	10080303ff35f,	00050000310b9,
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5	019135f01c021,	019135f19c049,	100a35f3fb35e,	019180019c05b,
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5	100835e3ff006,	100835e3ff012,	100835e3ff024,	100835e3ff034,
9	00110220dc024,	019135e01c035,	10080883ff014,	10080883ff023,
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~~000e00b001078,~~

RKS CWMc 9-14-60 Master Tape lisiting

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d	100a01208d012,	100a01408d014,	10080203ff35f,		00050000210b9,
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9	1008024089024,	0005000000022,	10083ff3fb090,		100a02208c022,
d	100a02308d023,	100a02408d024,	10080303ff35f,		00050000310b9,
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9	100a35e3fb800,	019180019c05c,	00110bfc1208e,		00110be19c08c,
d	000208e3f808f,	100808808c35e,	100835f3fb35d,		019180001c35e,
061	019135d19c005,	019135d19c011,	019135d19c022,		019135d19c031,
5	100835e3ff006,	100835e3ff012,	100835e3ff024,		100835e3ff034,
9	00110220dc024,	019135e01c035,	10080883ff014,		10080883ff023,
d	10080883ff032,	001108801c005,	001108801c036,		100a08c3fb08c,
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9	10083fd3ff091,	019135e0dc04c,	019135e0dc04d,		025135f01808b,
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RKS Master Tape CWMc 10-8-60

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100a35e3fb800,	019180019c05c,	00110e2c1208d,	10110e119c08b,
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101aaaaaaaaab,			

RKS 3-23-59

3.02.01

RKS

WISCoding for FRK

By CB **Date** 2-21-59 **Page** 1 **of** 1

	FLOW #	ORDER #	X	TYPE	A	B	C	#	HEXADECIMAL X	T	A	B	C	
	0,00			I	[ ]	[ ]	[ ]	000	/	0	001	~~08b~~ 08c	3e8	
	0.01			TU	[ ]	[ ] : setup	[6.00]	001	/	5	/	/	04e	
f_{i0}	1.00			A	[1.01] + 0	[ ] →	[35f]	002	✓	8	003	3ff	35f	od1 ?
	1.01			TU	[ ]	[1.02]	[F] 6.00	003	/	5	098 /	004	(/)	
	1.02			A	x_0 [X 6.04] + $\frac{h}{2}$	[ ] → x_1	[X] 6.05	004	/	8	(/)	08f	(/)	
1.13 →	1.03	1.11 1.21		M	f_{i0} [X+i 6.19] × $\frac{h}{2}$	[ ] → δ_{i1}	[δ+i] 6.32	005	/	2	(/)	08f ~~08b~~	093 ~~08f~~	
	~~1.04~~			~~D~~	~~[╲] ÷ $\frac{1}{3}$~~	~~[ ] →~~	~~[╲]~~							
	1.05	6.23 1.12 1.22		A	y_{i0} [Y+i] + $\frac{h f_{i0}}{2}$	[╲] → y_{i1}	[X+i] 6.11	(006	/	8	(/)	800	(/))	
	1.06			TN	$(N-1)^A$ [ ] − i	[ ] : next step	[1.20]	007	/	e	08c ~~088~~	090 ~~08c~~	00c	
	1.10			A	i [ ] + 1^A	[ ] → i+1	[ ]	008	✓	8	090 ~~08c~~	3fb	090 ~~08c~~	
	1.11			A	[1.03] + 1^{AC}	[ ] →	[1.03]	009	✓	8	005	089 ~~085~~	005	
	1.12			A	[1.05] + 1^{AC}	[ ] →	[1.05]	00a	✓	8	006	089 ~~085~~	006	
	1.13			TU	[ ]	[ ]	[1.03]	00b	/	5	(Y) /	/	005	
1.06 →	1.20			A	0 [ ] + 1^A	[ ] → i	[ ]	00c	✓	8	3ff	3fb	090 ~~08c~~	
	1.21			S	[1.03] − $(N-1)^{AC}$	[ ]	[1.03]	00d	✓	a	005	08d ~~089~~	005	
	1.22			S	[1.05] − $(N-1)^{AC}$	[ ]	[1.05]	00e	✓	a	006	08d ~~089~~	006	
f_{i1}	2.00				[ ]	[ ]	[ ]	00f	✓	8	010	3ff	35f	
	2.01				[ ]	[2.02]	[F] 6.01	010	/	5	/	011	(/)	
2.14 →	2.02	2.11 2.21		M	f_{i1} [X+i 6.20] × $\frac{h}{2}$	[ ] →	[35f] for x_{next}	011	/	2	(/)	08f ~~08b~~	35f	
	2.03	6.24 2.12 2.22		A	y_{i0} [Y+i] + $\frac{h f_{i1}}{2}$	[╲] → y_{i2}	[X+i]	(012	/	8	(/)	800	(/))	
	2.04			D	[35f] ÷ $\frac{1}{2}$	[ ] →	[╲]	013	/	3	35f	3f8	800	
	2.05	6.29 2.13 2.23		A	δ_{i1} [δ+i] + $h f_{i1}$	[╲] → δ_{i2}	[δ+i] 6.13	(014	/	8	093 ~~08f~~	800	093 ~~08f~~)	
	2.06			TN	$(N-1)^A$ [ ] − i	[ ] : next step	[2.20]	015	/	e	08c ~~088~~	090 ~~08c~~	01b	
	2.10			A	i [ ] + 1^A	[ ] → i+1	[ ]	016	✓	8	090 ~~08c~~	3fb	090 ~~08c~~	
	2.11			A	[2.02] + 1^A	[ ]	[2.02]	017	✓	8	011	3fb	011	

WISCoding for FRK

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FLOW #	ORDER #	X	TYPE	A	B	C	#	HEX X	T	A	B	C
2.12			A	[2.03] $+1^{AC}$	[ ] →	[2.03]	018	✓	8	012	089 ~~085~~	012
2.13			A	[2.05] $+1^{AC}$	[ ] →	[2.05]	019	✓	8	014	089 ~~085~~	014
2.14			TU	[ ]	[ ]	[2.02]	01a	/	5	/	/	011
(2.06) → 2.20			A	0 [ ] $+1^{A}$	[ ] → i	[ ]	01b	✓	8	3ff	3fb	090 ~~08c~~
2.21			S	[2.02] $-(N-1)^{A}$	[ ]	[2.02]	01c	✓	a	011	08c ~~088~~	011
2.22			S	[2.03] $-(N-1)^{AC}$	[ ]	[2.03]	01d	✓	a	012	08d ~~089~~	012
2.23			S	[2.05] $-(N-1)^{AC}$	[ ]	[2.05]	01e	✓	a	014	08d ~~089~~	014
f_{i2} 3.00				[ ]	[ ]	[ ]	01f	✓	8	020	3ff	35f
3.01				[ ]	[3.02]	[F] 6.02	020	/	5	/	021	(/)
3.02			A	x_2 [X 6.06] + $\frac{h}{2}$	[ ] → x_3	[X 6.07]	021	/	8	~~0c0~~ (/)	08f ~~08b~~	~~0c0~~ (/)
(3.14) → 3.03	3.11 3.21		M	f_{i2} [X+i 6.21] × h	[ ]	[35f]	022	/	2	0c1 (/)	08e ~~08a~~	35f OK
3.04	6.30 3.12 3.22		A	δ_{i2} [δ+i] + ~~hf_{i2}~~	[\ ] → δ_{i3}	[δ+i]	(023	/	8	093 ~~08?~~	800	093 ~~08?~~)
~~3.05~~			~~D~~	~~[35f] ÷ $\frac{1}{3}$~~	~~[ ]~~	~~[\ ]~~	024					
3.06	6.25 3.13 3.23		A	y_{i0} [Y+i] + hf_{i2}	[35f] → y_{i3}	[X+i 6.15]	(024	/	8	091	35f	0c1 (/)) NO!
3.07			TN	$(N-1)^{A}$ [ ] $-i$	[ ] : next step	[3.20]	025	/	e	08c ~~088~~	090 ~~08c~~	02b
3.10			A	i [ ] $+1^{A}$	[ ] → $i+1$	[ ]	026	✓	8	090 ~~08c~~	3fb	090 ~~08c~~
3.11			A	[3.03] $+1^{A}$	[ ]	[3.03]	027	✓	8	022	3fb	022
3.12			A	[3.04] $+1^{AC}$	[ ]	[3.04]	028	✓	8	023	089 ~~085~~	023
3.13			A	[3.06] $+1^{AC}$	[ ]	[3.06]	029	✓	8	024	089 ~~085~~	024
3.14			TU	[ ]	[ ]	[3.03]	02a	/	5	/	/	022
(3.07) → 3.20			A	0 [ ] $+1^{A}$	[ ] → i	[ ]	02b	✓	8	3ff	3fb	090 ~~08c~~
3.21			S	[3.03] $-(N-1)^{A}$	[ ]	[3.03]	02c	✓	a	022	08c ~~088~~	022
3.22			S	[3.04] $-(N-1)^{AC}$	[ ]	[3.04]	02d	✓	a	023	08d ~~089~~	023
3.23			S	[3.06] $-(N-1)^{AC}$	[ ]	[3.06]	02e	✓	a	024	08d ~~089~~	024
f_{i3} 4.00				[ ]	[ ]	[ ]	02f	✓	8	030	3ff	35f
4.01					[4.011]	[F] 6.03	030	/	5	/	031	(/)
4.011	4.15 4.25		M	f_{i3} [X+i 6.22] × $\frac{h}{2}$	[ ] →	[\ ]	031	/	2	(/)	08f ~~08b~~	800

WISCoding for FRK

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	FLOW #	ORDER #	X	TYPE	A	B	C	#	HEX X	HEX T	HEX A	HEX B	HEX C	
(4.16) →	4.02	6.31 4.13 4.23		A	δ_{i3} [δ+i 6.16] +	[\] → δ_{i4}	[δ+i]	(032	/	8	(~~08f~~	800	(~~08f~~))	
	4.03	4.13 4.23		M	[\] × $\frac{1}{3}$	[ ] → Δy	[\]	033	/	2	800	08a ~~084~~	800	
	4.04	6.26 4.11 4.21		A	y_{i0} [Y+i] + Δy	[\] → y_{i4}	[X+i]	(034	/	8	(/)	800	(/))	
	4.05	4.12 4.22		A	[\] + 0	[ ]	[Y+i 6.28]	035	/	8	800	3ff	(/)	
	4.06	4.14 4.24		A	[\] + 0	[ ]	[δ+i 6.33]	036	/	8	800	3ff	093 ~~08f~~	← PATCH TO TRACE
	4.07			TN	$(N-1)^{AC}$ [ ] − i	[ ] : output	[4.20]	037	/	e	08c ~~088~~	090 ~~08c~~	03f	
	4.10			A	i [ ] + 1^{A}	[ ] → i+1	[ ]	038	✓	8	090 ~~08c~~	3fb	090 ~~08c~~	
	4.11			A	[4.04] + 1^{AC}	[ ]	[4.04]	039	✓	8	034	089 ~~085~~	034	
	4.12			A	[4.05] + 2^{C}	[ ]	[4.05]	03a	✓	8	035	3fd	035	
	4.13			A	[4.02] + 1^{AC}	[ ]	[4.02]	03b	✓	8	032	089 ~~085~~	032	
	4.14			A	[4.06] + 1^{C}	[ ]	[4.06]	03c	✓	8	036	3fd	036	← BUGGER 001 7 800 01C 036
	4.15			A	[4.011] + 1^{AC}	[ ]	[4.011]	03d	✓	8	031	3fb	031	
	4.16			TU	[ ]	[ ]	[4.011]	03e	/	5	/	/	031	
(4.07) →	4.20			A	0 [ ] + 1^{A}	[ ] → i	[ ]	03f	✓	8	3ff	3fb	090 ~~08c~~	
	4.21			S	[4.04] − $(N-1)^{AC}$	[ ]	[4.04]	040	✓	a	034	08d ~~089~~	034	
	4.22		25	E	[\] Y+1	[1,12]	[4.05]	041	019	1	800	01c	035	
	4.23			S	[4.02] − $(N-1)^{AC}$	[ ]	[4.02]	042	✓	a	032	08d ~~089~~	032	
	4.24		25	E	[\] δ+1	[1,12]	[4.06]	043	019	1	800	01c	036	
	4.25			S	[4.011] − $(N-1)^{AC}$	[ ]	[4.011]	044	✓	a	031	08c ~~088~~	031	
	5.00			TZ	ρ [ ] − P	[ ] : output	[5.10]	045	/	c	091 ~~08d~~	086 ~~087~~	048	
	5.01			A	ρ [ ] + 1^{AC}	[ ] → ρ+1	[ ]	046	✓	8	091 ~~08d~~	3fd ~~3fb~~	091 ~~08d~~	11T
(5.15) →	5.02			TU	[ ]	[ ]	[β]	047	/	5	/	/	(/)	13f
(5.00) →	5.10			A	0 [ ] + 1^{AC}	[ ] → ρ	[ ]	048	✓	8	3ff	3fd ~~3fb~~	091 ~~08d~~	11T
	5.11		1	A	x [X 6.08] + 0	[ ]	[δ ~~6.33~~]	049	/	8	(/)	3ff	092 ~~08e~~	
DECON	5.12				[ ]	[ ]	[ ]	04a	✓	8	04c	3ff	35f	
	5.13							04b	/	5	/	/	3 ~~260~~	X
	5.14	−			[δ ~~6.36~~]	[δ+N 6.43]	[5.15]	04c	2000	0	092 ~~08e~~	(/)	04d	

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FLOW #	ORDER #	X	TYPE		A	B	C	#	HEXADECIMAL X	T	A	B	C
5,15			O		[δ ~~6.39~~]	[δ+N] 6.43	[5.02]	04d	/	7	~~08c~~ 092	(/)	047
~~6.00~~					[ ]	[ ]	[ ]						
(0.01) → 6.00		13	E		[35f] F	[1,12]	[1.01]	04e	00d	1	35f	01c	003
6.01					[ ]	[ ]	[2.01]	04f	00d	1	35f	01c	010
6.02					[ ]	[ ]	[3.01]	050	00d	1	35f	01c	020
6.03.1					[ ]	[ ]	[4.01]	051	00d	1	35f	01c	030
6.04		25	E		[35f] X	[25,12]	[1.02]	052	019	1	35f	19c	004
6.05					[ ]	[1,12]	[1.02]	053	019	1	35f	01c	004
6.06					[ ]	[25,]	[3.02]	(054	~~019~~ 100	~~1~~ 8	~~35f~~ 004	~~19c~~ 3ff	~~021~~ 021
6.07					[ ]	[1,]	[3.02]	055	~~019~~	~~1~~	~~35f~~	~~01c~~	~~021~~
6.08					[ ]	[25,]	[5.11]	056	019	1	35f	19c	049
6.09			S		[35f] − 1^A	[ ] =	[35e]	057	✓	a	35f	3fb	35e
6.10		25	E		[ ] X−1	[25,12] =]h[	[6.13]	058	019	1	800	19c	05b
6.11			S		[35e] − 1^A	[ ] →	[ ]	059	✓	a	35e	3fb	800
6.12		25	E		[ ] X−2	[25,12] =]N[	[6.14]	05a	019	1	800	19c	05c
6.13		1	E		[X−1] 6.10 h	[1,50] → h	[ ]	05b	001	1	(/)	c12	~~08a~~ 08e
6.14		1	E		[X−2] 6.12 N^A	[25,12] →	]$(N-1)^A$[	05c	001	1	(/)	19c	~~088~~ 08c
6.15			M	h	[ ] X ½	[ ] → h/2	[ ]	05d	/	2	~~08a~~ 08e	3f8	~~08b~~ 08f
6.16			A	dummy word	[ ] + N^A	[ ] → ~~35e~~	[35e]	05e	✓	8	~~086~~ 088	~~048~~ 08c	35e
6.17			A		[35f] + 1^A	[ ] →	[35d]	05f	✓	8	35f	3fb	35d
6.18		25	E		[ ] X+1	[1,12]	[35e]	060	019	1	800	01c	35e
6.19		25	E		[35d] X+1	[25,12]	[1.03]	061	019	1	35d	19c	005
6.20					[ ]	[ ]	[2.02]	062	019	1	35d	19c	011
6.21					[ ]	[ ]	[3.03]	063	019	1	35d	19c	022
6.22					[ ]	[ ]	[4.011]	064	019	1	35d	19c	031

) would save 1 order

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FLOW #	ORDER #	X	TYPE	A	B	C	#	HEXADECIMAL X	T	A	B	C
6,23			A	[35e] +D	[ ]	[1.05]	065	✓	8	35e	3ff	006
6,24				[ ]	[ ]	[2.03]	066	✓	8	35e	3ff	012
6,25				[ ]	[ ]	[3,06]	067	✓	8	35e	3ff	024 ←
6,26				[ ]	[ ]	[4.04]	068	✓	8	35e	3ff	034
6.27		1	E	[3.03]	[13,12]	[3.06]	069	001	1	022	0dc	024 ←
6.28		25	E	[35e] Y+1	[1,12]	[4.05]	06a	019	1	35e	01c	035
6.29			A	dummy word [ ] +D	[ ]	[2.05]	06b	✓	8	~~086~~ 088	3ff	014
6.30				[ ]	[ ]	[3.04]	06c	✓	8	~~086~~ 088	3ff	023
6.31				[ ]	[ ]	[4.02]	06d	✓	8	~~086~~ 088	3ff	032
6.32		1	E	dummy word [ ] δ+1	[1,12]	[1.03]	06e	001	1	~~086~~ 088	01c	005
6.33				[ ]	[ ]	[4.06]	06f	001	1	~~086~~ 088	01c	036
~~6.34~~			~~TU~~	~~[ ] −1^A~~	~~[ ]~~	~~[6.38]~~	~~070~~	~~✓~~	~~5~~			~~014~~
~~6.35~~		~~25~~	~~TU~~	~~[ ]~~	~~[ ]~~	~~[ ]~~	~~071~~		~~0~~			
~~6.36~~				~~[ ]~~	~~[25]~~	~~[5.14]~~	~~072~~		~~0~~			
~~6.37~~				~~[ ]~~	~~[25.]~~	~~[5.15]~~	~~073~~		~~0~~			
6.38			S	N^A [ ] -1^A	[ ] $\to (N-1)^A$	[ ]	070	✓	a	~~088~~ 08c	3fb	~~088~~ 08c
6.39		~~25~~	A	$(N-1)^A$ [ ] +D ~~$(N-1)^A$~~	~~[25,12]~~	[] $(N-1)^{AC}$ []	071	100	8	800	3ff	~~089~~ 08d
6,40		25	E	[ ] $(N-1)^C$	[1,12]	[] $(N-1)^{AC}$ []	072	019	1	~~088~~ 08c	01c	~~089~~ 08d
6.41		100	A	dummy word [ ] $+(N-1)^A$	[ ] → Y+N	[35e]	073	✓	8	086	~~088~~	35e
6.42		25	E	[ ] δ+N	[13,12]	[5,14] 07a	076 ~~074~~	019	1	~~800~~ 35e	01c	04c
6.43		25	E	[35e] δ+N	[13,12]	[5,15] 07b	077 ~~075~~	019	1	35e	0dc	04d
6.44			A	0 [ ] $+1^A$	[ ] → i	[078]	074 ~~076~~	✓	8	3ff	3fb	08c
6.45			A	0 [ ] + ~~1^A~~ 1^C	[ ] → p	[079]	075 ~~077~~	✓	8	3ff	3fb	08d
6.46		37	E	[35f] P	[25,12] → P^C	[ ] 07c	078	025	1	35f	~~1fx~~ 028	087
6.47		1	E	[4.05] Y+1	[1,12]	[6.50] 07d	079	001	1	035	01c	07c

Set up Decon

(Y<N)

5 - - oala

INTER-CHANGE

11T

(Y<N) 11T

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FLOW #	ORDER #	X	TYPE	A	B	C	#	HEXADECIMAL X	T	A	B	C
6.48		1	E	[4.04] X+1	[25,12]	[6.50]	07e 07a	001	1	034	19c	07c
6.49		1	E	[35f] β	[1,12]	[5.02]	07f 07b	001	1	35f	01c	047
6.50	6.54 6.58	1	A	[x+i 6.48] +0	[ ]	[y+i 6.47]	080 07c	/	8	(/)	3ff	(/)
6.51			TN	$(N-1)^A$ [ ] $-i$	[ ]	[6.56]	081 07d	/	e	088	08c	081
6.52			A	i [ ] $+1^A$	[ ] $\to i+1$	[ ]	082 07e	✓	8	08c	3fb	08c
6.53			A	[6.50] $+1^{AC}$	[ ]	[6.50]	083 07f	✓	8	07c	085	07c
6.54			TU	[ ]	[ ]	[6.50]	084 080	/	5	/	/	07c
~~6.55~~			~~TU~~	[ ]	[ ]	~~[6.50]~~	~~085~~	/	0	/	/	/
(6.51) 6.56			A	0 [ ] $+1^A$	[ ] $\to i$	[ ]	085 081	✓	8	3ff	3fb	08c
6.57			S	[6.50] $-(N-1)^{AC}$	[ ]	[6.50]	086 082	✓	a	07c	089	07c
6.58			TU	[ ]	[ ]	[1.00]	087 083	/	5	/	/	002
~~6.59~~			~~TU~~	[ ]	[ ] start	~~[1.00]~~	~~089~~	/	0	/	/	~~08~~
6.60	6.48			[ ]	[ ]	[ ]						
	6.38			[ ]	[ ]	[ ]						
	6.39 6.40			[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
	6.13			[ ]	[ ]	[ ]						
	6.13			[ ]	[ ]	[ ]						
	6.15			[ ]	[ ]	[ ]						
	6.44			[ ]	[ ]	[ ]						
	6.45			[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
				[ ]	[ ]	[ ]						
	Y+1			[ ]	[ ]	[ ]						
6.50	Y+N			[ ]	[ ]	[ ]						

TP (SAT DCA)

3-02-01

WISCoding for FRK

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FLOW #	ORDER #	X	TYPE	A	B	C	#	HEXADECIMAL X	T	A	B	C	
			$\frac{1}{3}$	[ ]	[ ]	08a [086]	~~084~~ 08d	101	a	aaa	aaa	aab	
			1^{AC}	[ ]	[ ]	089 [ ]	085	/	0	001	/	001	
			dummy word		[ ]	08a [084]	086	/	8	~~08f~~ 093	800	~~08f~~ 093	
6,46			P^{C}	[ ]	[ ]	08b [ ]	087	/	0	/	/	/	
6.38	N	A;	$(N-1)^{A}$	[ ]	[ ]	08c [ ]	088	~~/~~	~~0~~	~~/~~	~~/~~	~~/~~	
6.39 6,40			$(N-1)^{AC}$	[ ]	[ ]	08d [ ]	089	~~/~~	~~0~~	~~/~~	~~/~~	~~/~~	
6,13			h	[ ]	[ ]	08e [ ]	08a						
6,15			$\frac{h}{2}$	[ ]	[ ]	08f [ ]	08b						
6.44	07a		i	[ ]	[ ]	090 [ ]	08c						
6.45	07b		p^{C}	[ ]	[ ]	091 [ ]	08d						
	δ		x	[ ]	[ ]	092 [ ]	08e					x	
	$\delta+1$		δ_1	[ ]	[ ]	093 [ ]	08f					y_1	
6.50	⋮		⋮	[ ]	[ ]	[ ]						y_2	090
	$\delta+N$		δ_N	[ ]	[ ]	[ ]	08e+N						091
	$Y+1$		y_{10}	[ ]	[ ]	[ ]	08f+N					y_1	091
	⋮		⋮	[ ]	[ ]	[ ]	⋮					y_2	092
	$Y+N$		y_{N0}	[ ]	[ ]	[ ]	08e+2N						
				[ ]	[ ]	[ ]							
DUMMY WORD			A	X ~~+N~~ Y+1 ( ) +	[\ ] →	X+i (=Yi)	35e						
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							
				[ ]	[ ]	[ ]							

SAMPLE RKS

WISCoding for $\boxed{y'' = y' + 6y}$ LET $y = y_1$, $y' = y_1' = y_2$ } THEN $\boxed{y_1' = y_2 \quad y_2' = y_2 + 6y_1}$

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	FLOW #	ORDER #	X	TYPE	A	B	C	#	HEXADECIMAL X	T	A	B	C	
LOAD				LOAD SET-UP BLOCK	[ ]	[ ]	[ ]	000	000	0	0b1	0b6	0b1	
				LOAD MASTER BLOCK	[ ]	[ ]	[ ]	0b1	—	0	0c1	0c6	0b2	
				LOAD F BLOCK	[ ]	[ ]	[ ]	2	—	0	0d1	0d5	0b3	
				LOAD DATA BLOCK	[ ]	[ ]	[ ]	3	—	0	0e1	0ea 0e7	0e8 0b4	0e8
					[ ]	[ ]	[ ]	4	100	8	0b6	3ff	35f	
		CON			[ ]	[ ]	[ ]	5	—	5	—	—	360	
					[ ]	[ ]	[ ]	6	—	0	0e2	0e7	0c1	
MASTER		TO RKS			[ ]	[ ]	[ ]	0c1	100	8	0c3	3ff	35f	
					[ ]	[ ]	[ ]	2	—	5	—	—	001	
		LINK		P	[X]	[F]	[β]	3	010 000	1	0e3	0d1	0c4	
					[ ]	[ ]	[ ]	4	—	e	0e7	0e3	3e8	
					[ ]	[ ]	[ ]	5	100 —	8 5	0c6 —	3ff 002	[illegible] 002	
F					[ ]	[ ]	[ ]	0d1	019 00d	1	35f	01c	0d5	5 — 098
				M 6	[ ] $\times y_1$	[ ] $\to op_1$	[ ]	2	—	2	0e6	0e4	35f	
				A y_2	[ ] $+0$	[ ] $\to y_1'$	[ ]	3	—	8	0e5	3ff	0e4	
				A y_2	[ ] $+6y_1$	[ ] $\to y_2'$	[ ]	4	—	8	0e5	35f	0e5	
					[ ]	[ ]	[ ]	5	—	5	—	—	( )	09b
DATA				N_{16}^c	[$=2^c$]	[ ]	[ ]	0e1	—	0	—	—	002	
				h	[=.1]	[ ]	[ ]	2	101	1	—	—	—	
X →				0 x	[ ]	[ ]	[ ]	3	—	0	—	—	—	≡ X
				2 y_1	[ ]	[ ]	[ ]	4	—	2	—	—	—	
				1 y_2	[ ]	[ ]	[ ]	5	—	1	—	—	—	
				6	[ ]	[ ]	[ ]	6	—	6	—	—	—	
				x_f	[=1]	[ ]	[ ]	7	—	1	—	—	—	
					[ ]	[ ]	[ ]							

Range & Initial Values

$x = 0\ (.1)\ 1$
$y_0 = 2$
$y_0' = 1$

Introduction

The Runge-Kutta Step routine can be used for the numerical solution, one step at a time, of systems of differential equations by a numerical integration process. Given the starting values of all variables, and the desired increment h of the independent variable (here called x), RKS will calculate the value of each dependent variable corresponding to the new value of x ; x + h . If an appropriate Master Control program is provided, this process can be continued over any desired range of x .

The actual equations used in this, the Runge-Kutta fourth order process, are given in several standard works on numerical analysis.[1,2,3] To use RKS, however, it is necessary merely to understand how to prepare the equations for numerical solution, what program steps have to be written uniquely for these equations, and how to establish linkage with the subroutine. This programming information is given on the following pages.

RKS will automatically deconvert and punch out, at the end of each integration interval if desired, the current value of x and of all* y 's. However, since such a voluminous output would easily cause the computing time to be inordinately held up by the slower deconversion and punching process, it is possible to specify that the machine punch out answers only every 2nd, or 5th, or P th step. For instance, suppose for accuracy in following a rapidly changing function it seems desirable to let x increase inssteps of .01. When plotting the results, however, values of the dependent variables for setps of x = .1 provide a sufficient number of points for accurate plotting. In such a case, punch every 10th point (i.e., set $P = 10_{10} = a_{16}$).

Although the Runge-Kutta method, like many other formulae for numerical integration, can handle directly only first order differential equations, this is a restriction easy to circumvent. Any Nth order differential equation can be converted into N first order equations, merely by substituting new variables for each of the derivatives (except the highest) where they appear. An example of this is shown on the "Sample" page.

*See ~~patch~~ if less output is desired

CHD

Procedure

Given one or more differential equations

$$\frac{d^{N_k} y}{dx^{N_k}} = f_k(x , y , y' \ldots) ,$$

by appropriate substitutions expand 1,2 each N_k th order equation into a set of N_k first order equations:

$$y_1' = f_1 (x , y_1, y_2 \ldots)$$
$$y_2' = f_2 (x , y_1, y_2 \ldots)$$
$$\ldots$$
$$y_{N_k}' = f_k (x , y_1, y_2 \ldots)$$

If there are ℓ such original equations, there will be $N = \sum_{k=1}^{\ell} N_k$ first order simultaneous equations to solve.

Three blocks of instructions and one set of constants and initial values must be prepared:

1. SET-UP
   a. Loading
   b. Conversion of decimal values
   c. Adaption of subroutines, if required

2. RK MASTER, which controls the decision as to whether to integrate another step, whether to change step size, etc.

3. F, which generates the set of (y')s according to the f's listed above.

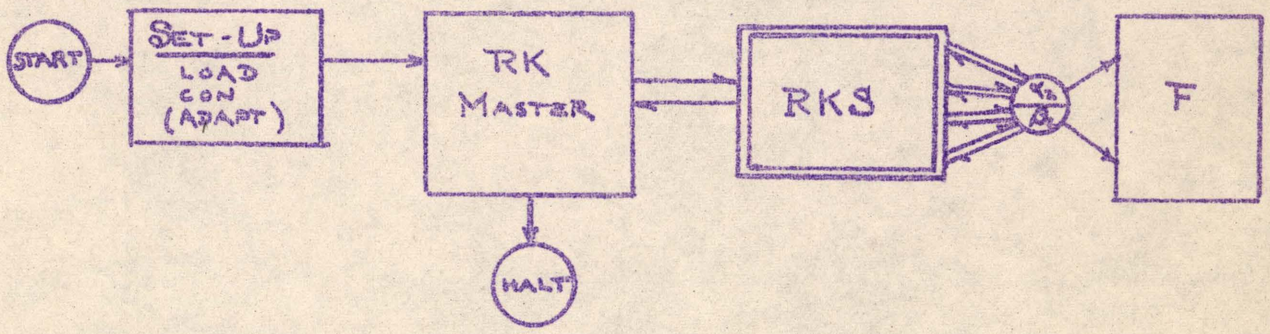
4. DATA

Location	Contents	Remarks	
X - 2:	N	which must be in the form N^C_{16}	
X - 1:	h	= Δx	
X :	x_o	x	initial values must be loaded with rest of Data block.
X + 1:	y_{1_o}	y_1	
X + 2:	y_{2_o}	y_2	
. . .	. . .		
X + N:	y_{n_o}	y_n	

Space Required

In addition to the space required by RKS itself (001-0~~8~~c), a block of storage locations immediately following it must also be reserved, containing 6 + 2N locations. RKS will then require from 001 to 0ec + 2N . Note: like all relocatable subroutines, RKS may be loaded anywhere in standard memory that a block of this size is available, provided it is subsequently ADAPTED to its new location.

Overall Flow Diagram



RK Master

The link word to RKS must supply the following information:

L+2: o P X F β

x. 4°
Y P | X | F | β
6 8
64 256

where P = number of points per punch

X = address of x in the data block

F = address of first word of the F block

β = return

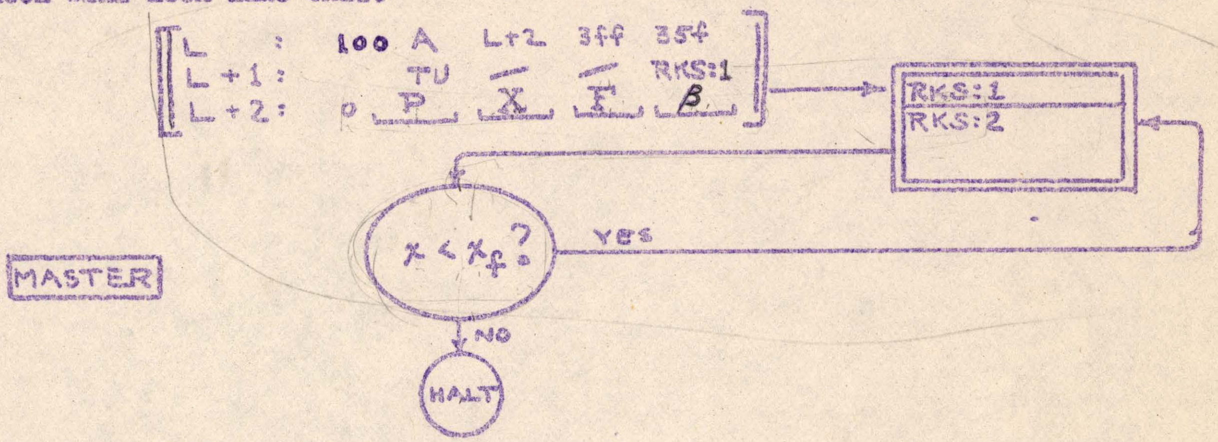
. Y = how many y's to punch
x & Y y's
(if Y = 0, punch N y's)

Whenever entry to RKS is made (as it must be the first time) via RKS:1 (TU - - RKS:1), the set up block contained in RKS will extract the P , X , F , and β information, calculate all necessary constants such as h/2, **N-1**, etc., copy the data twice into two duplicate storage blocks, and make up and insert all necessary orders and addresses. However, since it will often be the case that no change in these quantities is wanted between steps, RKS may alternatively be entered at RKS:2, which bypasses the RKS set-up block and proceeds immediately with the integration routine. In this case h , x , y ,

o PP Y X F β as of 10-10-60

etc., for the new calculation are taken to be the same as at the end of the preceding calculation. (Note: x_i is stepped to $x_i+h = x_{i+1}$ internally by RKS).

In the simple case where no change of increment is contemplated, the MASTER block will look like this:



F BLOCK

F will contain orders to perform the following operations:

$\boxed{F}$

F:1	Set β_2 **from 35f into F:n**
F:2 to F:n-1	Given the y_i in locations X + i, calculate all y_i' and store in X + i, using $y_i' = f_i(x, y_1, y_2 \ldots)$
F:n	TU - - (β_2)

RKS makes four passes through F for each integration step, and hence must make provision for **modifying** its return address accordingly. The linkage used by RKS to transfer to F and return is:

```
L   :  100 A   L + 1   3ff   35f
L + 1:     TU  ———     β2    (F)
```

so that F:1 must be:

F:1: 00d E 35f 01c F:n

---

1. Hildebrand, F. B., Introduction to Numerical Analysis, McGraw-Hill, New York, 1956, p. 214.

2. Levy, H., and E. A. Baggott, Numerical Solutions of Differential Equations, New York, Dover, 1950, pp. 143-4.

3. Crandall, S. H., Engineering Analysis, McGraw-Hill, N.Y., 1956.