1	0	200	SIN
2	0	201	COS
3	0	202	SQRT
4	0	203	EXP
5	0	204	LOG
6	0	205	TAN^{-1}
7	0	206	TAN
10	0	207	CTN
11	0	211	NUM. INTEGRATION
12	0	212	
13	0	213	ROOT FINDER
14	0	214	SIMULTANEOUS ROOT FINDER
15	0	215	COMPLEX ROOT FINDER
16	0	217	DIAGONALIZATION
17	0	220	MCOPY
20	0	221	MADD
21	0	222	MSUB
22	0	223	MMPY
23	0	224	MINV
24	0	225	MTRAN
25	0	226	SMPY
26	0	227	LINEQ
27	0	230	SIN, COS
30	0	231	SIN^{-1}
31	0	232	SINH, COSH, e^x, e^{-x}
32	0	233	$SINH^{-1}$
33	0	234	$COSH^{-1}$
34	0	235	$TANH^{-1}$
35	0	236	2^x
36	0	237	LOG_2
37	0	240	J_0
40	0	241	J_0, Y_0
41	0	242	J_1
42	0	243	J_1, Y_1
43	0	244	$K(k^2)$
44	0	245	$E(k^2)$
45	0	246	COMPLEX PROD
46	0	247	COMPLEX QUOT
47	0	250	COMPLEX SIN, COS
50	0	251	COMPLEX SINH, COSH
51	0	252	COMPLEX SQRT
52	0	253	COMPLEX EXP
53	0	254	COMPLEX LOG
54	0	255	COMPLEX TANH, CTNH
55	0	256	COMPLEX TAN, CTN
56	0	260	$F(k,\phi)$
57	0	261	$F(k,\phi)$, $E(k,\phi)$
60	0	262	$\Theta(k^2,u)$
61	0	263	$H(k^2,u)$
62	0	264	$H_1(k^2,u)$
63	0	265	$\Theta_1(k^2,u)$
64	0	266	$\Theta'(k^2,u)$
65	0	270	$sn(k^2,u)$
66	0	271	$cn(k^2,u)$
67	0	272	cn after sn
70	0	273	$dn(k^2,u)$
71	0	274	dn after sn
72	0	275	dn after cn
73	0	276	$tn(k^2,u)$
74	0	277	$Zn(k^2,u)$

Elementary Functions

8/16/63

LIBRARYED

31200000000135	EXECUTE		3530	3	13765
31000000000170	EXECUTE		3127	411	13765
72014000000001141	READ	SIN	3614	72	13672
10140000000001142	READ	COS	3707	1	13670
43014000000001143	READ	SQRT	3711	43	13624
50014000000001144	READ	EXP	3755	50	13553
43014000000001145	READ	LOG	4026	43	13507
45014000000001146	READ	ATAN	4072	45	13441
52014000000001147	READ	TAN	4140	52	13366
60014000000001150	READ	CTN	4213	60	13305
40140000000001151	READ	ROW	4274	4	13300
11014000000001152	READ	CLMN	4301	11	13266
35014000000001153	READ	RT*Y	4313	35	13230
105014000000001154	READ	RT*XY	4351	105	13122
75014000000001155	READ	CRT	4457	75	13024
71014000000001156	READ	ORTHG	4555	71	12732
37014000000001157	READ	MCOPY	4647	37	12672
24014000000001160	READ	MADD	4707	24	12645
30140000000001161	READ	MSUB	4734	3	12641
115014000000001162	READ	MMPY	4740	115	12523
151014000000001163	READ	MINV	5056	151	12351
44014000000001164	READ	MTRAN	5230	44	12304
236014000000001165	READ	LINEQ	5275	236	12045
60014000000001166	READ	SNCS	5534	60	11764
63014000000001167	READ	ASIN	5615	63	11700
11014000000001170	READ	SNCSH	5701	11	11666
14014000000001171	READ	ASINH	5713	14	11651
12014000000001172	READ	ACOSH	5730	12	11636
11014000000001173	READ	ATANH	5743	11	11624
46014000000001174	READ	PWR**2	5755	46	11555
36014000000001175	READ	LOG**2	6024	36	11516
107014000000001176	READ	J**0	6063	107	11406
153014000000001177	READ	J,Y**0	6173	153	11232
114014000000001200	READ	J**1	6347	114	11115
163014000000001201	READ	J,Y**1	6464	163	10731
53014000000001202	READ	K	6650	53	10655
67014000000001203	READ	E	6724	67	10565
11014000000001204	READ	CMPY	7014	11	10553
16014000000001205	READ	CDIV	7026	16	10534
14014000000001206	READ	CSIN	7045	14	10517
15014000000001207	READ	CSINH	7062	15	10501
31014000000001210	READ	CSQRT	7100	31	10447
10014000000001211	READ	CEXP	7132	10	10436
30014000000001212	READ	CLOG	7143	30	10405
21014000000001213	READ	CTANH	7174	21	10363
20014000000001214	READ	CTAN	7216	20	10342
134014000000001215	READ	RF	7237	134	10205
154014000000001216	READ	RF,E	7374	154	10030
14014000000001217	READ	RTH	7551	14	10013
16014000000001220	READ	RH	7566	16	7774
21014000000001221	READ	RH**1	7605	21	7752
17014000000001222	READ	RTH**1	7627	17	7732
176014000000001223	READ	RATH	7647	176	7533
13014000000001224	READ	RSN	10046	13	7517
14014000000001225	READ	RCN	10062	14	7502
13014000000001226	READ	RSNCN	10077	13	7476
13014000000001227	READ	RDN	10103	13	7462
6014000000001230	READ	RSNDN	10117	6	7453
7014000000001231	READ	RCNDN	10126	7	7443
20014000000001232	READ	RTN	10136	20	7422
6014000000001233	READ	RZN	10157	6	7413
23014000000001234	READ	SMPY	10166	23	7367
441014000000001235	READ	DIAG	10212	441	6725
17014000000001236	READ	PCOPY	10654	17	6705
54014000000001237	READ	PADD	10674	54	6630

130140000001240	READ	PSUB.	10751	3	6624
430140000001241	READ	PMUL.	10755	43	6560
1360140000001242	READ	PDIV.	11021	136	6421
150140000001243	READ	PEVAL	11160	15	6403
320140000001244	READ	PDIF.	11176	32	6350
260140000001245	READ	PINT.	11231	26	6321
230140000001246	READ	VSPC.	11260	23	6275
440140000001247	READ	MSPC.	11304	44	6230
1030140000001250	READ	MNSRT	11351	103	6124
740140000001251	READ	MINDX	11455	74	6027
550140000001252	READ	MPTCH	11552	55	5751
200140000001253	READ	FIX..	11630	20	5730
50140000001254	READ	FLOAT	11651	5	5722

READ SYMBOLIC TAPE

```
105014000000001255 READ    FXPRN    11657   105   5614
173014000000001256 READ    DCPRN    11765   173   5420
 40014000000001257 READ    ABS      12161    40   5357
163014000000001260 READ    DCTRC    12222   163   5173
 71014000000001261 READ    CMPRS    12406    71   5101
223014000000001262 READ    RPTRC    12500   223   4655
314014000000001263 READ    FGDSP    12724   314   4340
135014000000001264 READ    PPLT     13241   135   4202
  5014000000001265 READ    BSTRT    13377     5   4174
  6014000000001266 READ    BINC     13405     6   4165
  6014000000001267 READ    BDEC     13414     6   4156
 11014000000001270 READ    BJMP     13423    11   4144
 11014000000001271 READ    BPEEK    13435    11   4132
  6014000000001272 READ    BEND     13447     6   4123
 77014000000001155 READ    CRT      13456    77   4121
 40014000000001157 READ    MCOPY     4457    40   4120
 25014000000001246 READ    VSPC      4520    25   4116
 33014000000001247 READ    MSPC      4647    33   4127
164014000000001273 READ    DT=>2    13556   164   3742
 35014000000001274 READ    SMPLZ    11304    35   3704
 24014000000001275 READ    SXREF    13743    24   3657
 60014000000001276 READ    CNTXT    13770    60   3576
READ SYMBOLIC TAPE
```

1	0000SIN.	0	0	2	72000000003614	0
2	0000COS.	0	0	2	10000000003707	0
3	0000SQRT.	0	0	2	43000000003711	0
4	0000EXP.	0	0	2	50000000003755	0
5	0000LOG.	0	0	2	43000000004026	0
6	0000ATAN.	0	0	2	45000000004072	0
7	0000TAN.	0	0	2	52000000004140	0
10	0000CTN.	0	0	2	60000000004213	0
11	0000RUN.	0	0	2	40000000004274	0
12	0000CLMN.	0	0	2	11000000004301	0
13	0000RT.Y.	0	0	2	35000000004313	0
14	0000RT.XY	0	0	2	105000000004351	0
15	0000CRT.	0	0	2	77000000013456	0
16	0000ORTHG	0	0	2	71000000004555	0
17	0000MCOPY	0	0	2	40000000004457	0
20	0000MADD.	0	0	2	24000000004707	0
21	0000MSUB.	0	0	2	3000000004734	0
22	0000MMPY.	0	0	2	115000000004740	0
23	0000MINV.	0	0	2	151000000005056	0
24	0000MTRAN	0	0	2	44000000005230	0
25	0000LINEQ	0	0	2	236000000005275	0
26	0000SNCS.	0	0	2	60000000005534	0
27	0000ASIN.	0	0	2	63000000005615	0
30	0000SNCSH	0	0	2	11000000005701	0
31	0000ASINH	0	0	2	14000000005713	0
32	0000ACOSH	0	0	2	12000000005730	0
33	0000ATANH	0	0	2	11000000005743	0
34	0000PWR**	0	0	2	46000000005755	0
35	0000LOG**	0	0	2	36000000006024	0
36	0000J*0..	0	0	2	107000000006063	0
37	0000J.Y*0	0	0	2	153000000006173	0
40	0000J*1..	0	0	2	114000000006347	0
41	0000J.Y*1	0	0	2	163000000006464	0
42	0000K....	0	0	2	53000000006650	0
43	0000E....	0	0	2	67000000006724	0
44	0000CMPY.	0	0	2	110000000007014	0
45	0000CDIV.	0	0	2	160000000007026	0
46	0000CSIN.	0	0	2	140000000007045	0
47	0000CSINH	0	0	2	150000000007062	0
50	0000CSQRT	0	0	2	31000000007100	0
51	0000CEXP.	0	0	2	100000000007132	0
52	0000CLOG.	0	0	2	30000000007143	0
53	0000CTANH	0	0	2	21000000007174	0
54	0000CTAN.	0	0	2	20000000007216	0
55	0000RF...	0	0	2	134000000007237	0
56	0000RF.E.	0	0	2	154000000007374	0
57	0000RTH..	0	0	2	14000000007551	0
60	0000RH...	0	0	2	16000000007566	0
61	0000RH*1.	0	0	2	21000000007605	0
62	0000RTH*1	0	0	2	17000000007627	0
63	0000RATH.	0	0	2	176000000007647	0
64	0000RSN..	0	0	2	13000000010046	0
65	0000RCN..	0	0	2	14000000010062	0
66	0000RSNCN	0	0	2	3000000010077	0
67	0000RDN..	0	0	2	13000000010103	0
70	0000RSNDN	0	0	2	6000000010117	0
71	0000RCNDN	0	0	2	7000000010126	0
72	0000RTN..	0	0	2	20000000010136	0
73	0000RZN..	0	0	2	6000000010157	0
74	0000SMPY.	0	0	2	23000000010166	0
75	0000DIAG.	0	0	2	44100000010212	0
76	0000PCOPY	0	0	2	17000000010654	0
77	0000PADD.	0	0	2	54000000010674	0
100	0000PSUB.	0	0	2	3000000010751	0
101	0000PMUL.	0	0	2	43000000010755	0
102	0000PDIV.	0	0	2	136000000011021	0

103	0000PEVAL	0	0	2	150000000011160	0
104	0000PDIF.	0	0	2	320000000011176	0
105	0000PINT.	0	0	2	260000000011231	0
106	0000VSPC.	0	0	2	250000000004520	0
107	0000MSPC.	0	0	2	330000000004647	0
110	0000MNSRT	0	0	2	103000000011351	0
111	0000MINDX	0	0	2	74000000011455	0
112	0000MPTCH	0	0	2	55000000011552	0
113	0000FIX..	0	0	2	20000000011630	0
114	0000FLOAT	0	0	2	5000000011651	0
115	0000EXPRN	0	0	2	105000000011657	0
116	0000DCPRN	0	0	2	173000000011765	0
117	0000ABS..	0	0	2	40000000012161	0
120	0000DCTRC	0	0	2	163000000012222	0
121	0000CMPRS	0	0	2	71000000012406	0
122	0000RPTRC	0	0	2	223000000012500	0
123	0000FGOSP	0	0	2	314000000012724	0
124	0000PPLT.	0	0	2	135000000013241	0
125	0000BSTRT	0	0	2	5000000013377	0
126	0000BINC.	0	0	2	6000000013405	0
127	0000BDEC.	0	0	2	6000000013414	0
130	0000BJMP.	0	0	2	11000000013423	0
131	0000BPEEK	0	0	2	11000000013435	0
132	0000BEND.	0	0	2	6000000013447	0
133	0000DTR.2	0	0	2	164000000013556	0
134	0000SM2L7	0	0	2	350000000011304	0
135	0000SXREF	0	0	2	240000000013743	0
136	0000CNTXT	0	0	2	600000000013770	0

10 ≤ C ≤ 76H35 [C for sub-subroutines must equal that for their subroutine]

Subroutines for functions of one real argument

	Subroutine	Argument	Entry	Transition	Space occupied	Registers used	Sub-subroutines
✓	$X^{\frac{1}{2}}$	$X \geq 0$ T_6	C+0	$X \to T_7$ T_6	C+0 → C+37	T_4, T_5, T_6, T_7, B_6	
✓	sinh X +	$\lvert X\rvert < 2^{48} \ln 2$		$e^x \to T_6$ T_5			
✓	cosh X (e^{-x})	T_6	C+70	$e^{-x} \to T_7$ U	C+67 → C+77	T_5, T_6, T_7, B_6	e^x
✓	e^x	$\lvert X\rvert < 2^{48} \ln 2$ T_6	C+100	$e^{\lvert X\rvert} \to T_7$ T_6	C+100 → C+150	T_6, T_7, B_6	
✓	2^x	$\lvert X\rvert < 2^{48}$ T_6	C+101	$2^{-\lvert X\rvert} \to T_7$ T_6	C+101 → C+147	T_6, T_7, B_6	
✓	$\tanh^{-1} X$	$\lvert X\rvert < 1$ T_6	C+151	T_6	C+151 → C+157	T_5, T_6, T_7, B_6	ln X
✓	$\sinh^{-1} X$	T_6	C+160	T_6	C+160 → C+166	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, ln X
✓	$\cosh^{-1} X$	$X \geq 1$ T_6	C+167	T_6	C+167 → C+175	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, ln X
✓	ln X	$X > 0$ T_6	C+200	T_6	C+200 → C+242	T_5, T_6, T_7, B_6	
✓	$\log_2 X$	$X > 0$ T_6	C+204	T_6	C+204 → C+241	T_5, T_6, T_7, B_6	
✓	sin X	T_6	C+300	T_6	C+300 → C+372	T_6, T_7, B_6	
✓	cos X	T_6	C+301	T_6 $(\frac{\pi}{2})^2 - x^2$ accuracy	C+301 → C+372	T_6, T_7, B_6	
✓	tan X	T_6	C+400	T_6	C+400 → C+453	T_5, T_6, T_7, B_6	
✓	ctn X	T_6	C+454	T_6 $-\frac{\pi}{2} \leq \sin^{-1} \leq \frac{\pi}{2}$	C+400 → C+461	T_5, T_6, T_7, B_6	
✓	$\sin^{-1} X$	T_6	C+462	T_6 $-\frac{\pi}{2} \leq \tan^{-1} \leq \frac{\pi}{2}$	C+461 → C+476	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, $\tan^{-1} X$
✓	$\tan^{-1} X$	T_6	C+500	T_6 accuracy: $1-k^2$	C+500 → C+544	T_5, T_6, T_7, B_6	
	$K(k^2)$	$k^2 < 1$ T_6	C+600	T_6	C+600 → C+651	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$
	$E(k^2)$	$k^2 < 1$ T_6	C+700	T_6	C+651 → C+736	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, ln X
✓	$J_0(X)$	T_6	C+1000	T_6 C+1154 T_4	C+1000 → C+1110	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, sin X, cos X
✓	$J_0(X)$ + $Y_0(X)$	$X > 0$ T_6	C+1111	T_6	C+1000 → C+1154	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, ln X, sin X, cos
✓	$J_1(X)$	T_6	C+1170	T_6 C+1154 T_4	C+1155 → C+1267	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, sin X, cos X
✓	$J_1(X)$ + $Y_1(X)$	$X > 0$ T_6	C+1270	T_6	C+1152 → C+1332	T_4, T_5, T_6, T_7, B_6	$X^{\frac{1}{2}}$, ln X, sin X, cos

Registers used: T_4, T_5, T_6, T_7, B_6

$10 \le C \le 73170$ [C for sub-subroutines must equal that for their subroutine]

Subroutines for functions of two real arguments

Subroutine	Arguments	Entry	Function	Space occupied	Sub-subroutines
$F(k,\phi)$	$\lvert\phi\rvert<\frac{\pi}{2}$, $k<1$		T_6		
$E(k,\phi)$	T_4 & T_6, $k<1$, $\lvert\phi\rvert<\frac{\pi}{2}$	C+H000	T_4	C+H000 → C+H152	$x^{\frac{1}{2}}$, $\sin x$, $\cot x$, $\sin^{-1}x$, $\tan^{-1}x$
$F(k,\phi)$	T_4 & T_6, $k<1$	C+H020	T_6	C+H020 → C+H152	$x^{\frac{1}{2}}$, $\sin x$, $\cot x$, $\sin^{-1}x$, $\tan^{-1}x$
$sn(k^2,u)$	T_4 & T_6, $k^2<1$	C+H200	T_6	C+H200 → C+H212	θ, H after θ
$cn(k^2,u)$	T_4 & T_6, $k^2<1$	C+H213	T_6	C+H213 → C+H226	θ, H_1 after θ
cn after sn	not recentered, $k^2<1$	C+H227	T_6	C+H227 → C+H231	H_1 after H, cn (without recomputing H_1 & θ)
$dn(k^2,u)$	T_4 & T_6	C+H232	T_6	C+H232 → C+H2HH	θ, θ_1 after θ
dn after sn	not recentered	C+H245	T_6	C+H245 → C+H252	$x^{\frac{1}{2}}$
dn after cn	not recentered, $k^2<1$	C+H253	T_6	C+H253 → C+H261	$x^{\frac{1}{2}}$
$zn(k^2,u)$	T_4 & T_6, $k^2<1$	C+H262	T_6	C+H262 → C+H301	H, H_1 after H
~~$zn(k^2,u)$~~	T_4 & T_6, $k^2<1$	C+H302	T_6	C+H302 → C+H306	θ, θ' after θ
$\theta(k^2,u)$	T_4 & T_6, $k^2<1$	C+H310	T_6	C+H310 → C+H323 C+HH25 → C+H577 C+H324 → C+H336	$x^{\frac{1}{2}}$, e^x, $\sin x$, $\cot x$, $K(k^2)$
$H(k^2,u)$	T_4 & T_6, $k^2<1$	C+H32H	T_6	C+HH25 → C+H577 C+H337 → C+H341	$x^{\frac{1}{2}}$, e^x, $\sin x$, $\cot x$, $K(k^2)$
H after θ, θ_1, or θ'	not recentered, $k^2<1$	C+H337	T_6	C+HH25 → C+H577 C+H342 → C+H35H	H (without recomputing $q^{(2n-1)^2/4}$)
$H_1(k^2,u)$	T_4 & T_6	C+H3H2	T_6	C+HH25 → C+H577 C+H356 → C+H357	$x^{\frac{1}{2}}$, e^x, $\sin x$, $\cot x$, $K(k^2)$
H_1 after θ, θ_1, or θ'	not recentered	C+H355	T_6	C+HH25 → C+H577 C+H360 → C+H362	H_1 (without recomputing $q^{(2n-1)^2/4}$)
H_1 after H	not recentered, $k^2<1$	C+H360	T_6	C+HH25 → C+H577 C+H363 → C+H376	H_1 (without recomputing $q^{(2n-1)^2/4}$ & $\cot\frac{(2n-1)\pi}{K}$)
$\theta_1(k^2,u)$	T_4 & T_6	C+H363	T_6	C+HH25 → C+H577 C+H377 → C+HH01	$x^{\frac{1}{2}}$, e^x, $\sin x$, $\cot x$, $K(k^2)$
θ_1 after θ or θ'	not recentered, $k^2<1$	C+H377	T_6	C+HH25 → C+H577 C+HH02 → C+HH21	θ_1 (without recomputing q^{n^2} & $\cot\frac{n\pi u}{K}$)
$\theta'(k^2,u)$	T_4 & T_6	C+HH02	T_6	C+HH25 → C+H577	$x^{\frac{1}{2}}$, e^x, $\sin x$, $\cot x$, $K(k^2)$
θ' after θ or θ_1	not recentered	C+HH22	T_6	C+HH22 → C+H577	θ' (without recomputing q^{n^2} & $\cot\frac{n\pi u}{K}$)

$10 \le C \le 74570$ [C for sub-subroutines must equal that for their subroutine]

Subroutines for functions of complex argument

	Subroutine	Argument x y	Entry	Function u v	Space occupied	Registers used	Sub-subroutines
✓	$(x+iy)^{\frac{1}{2}}$	T_4 + T_5	C+3000	$u \ge 0$ T_4 + T_5	C+3000 → C+3031	T_4, T_5, T_6, T_7, B_6	$x^{\frac{1}{2}}$
✓	e^{x+iy}	T_4 + T_5	C+3032	T_4 + T_5	C+3032 → C+3042	T_4, T_5, T_6, T_7, B_6	e^x, sin x, cos x
✓	ln(x+iy)	T_4 + T_5	C+3043	$-\pi \le v \le \pi$ T_4 + T_5	C+3043 → C+3072	T_4, T_5, T_6, T_7, B_6	ln x, $\tan^{-1} x$
	sin(x+iy)+			T_4 + T_5			
✓	cos(x+iy)	T_4 + T_5	C+3100	T_6 + T_7	C+3100 → C+3115	T_4, T_5, T_6, T_7, B_6	sinh x, cosh x, sin x, cos x
	sinh(x+iy)+			T_5 + T_4			
✓	cosh(x+iy)	T_5 + T_4	C+3116	T_6 + T_7	C+3100 → C+3120	T_4, T_5, T_6, T_7, B_6	sinh x, cosh x, sin x, cos x
	tan(x+iy)+			T_4 + T_5			
✓	ctn(x+iy)	T_4 + T_5	C+3121	T_6 + T_7	C+3121 → C+3144	T_4, T_5, T_6, T_7, B_6	sinh x, cosh x, sin x, cos x
	tanh(x+iy)+			T_5 + T_4			
✓	ctnh(x+iy)	T_5 + T_4	C+3145	T_6 + T_7	C+3121 → C+3150	T_4, T_5, T_6, T_7, B_6	sinh x, cosh x, sin x, cos x
✓	$(x_1+iy_1)(x_2+iy_2)$	x_1 y_1 x_2 y_2 T_4, T_5, T_6, T_7	C+3151	T_4 + T_5	C+3151 → C+3161	T_4, T_5, T_6, T_7, B_6	
✓	$\frac{x_1+iy_1}{x_2+iy_2}$	x_1 y_1 x_2 y_2 T_4, T_5, T_6, T_7	C+3162	T_4 + T_5	C+3161 → C+3176	T_4, T_5, T_6, T_7, B_6	

$-1 \leq X \leq 1$ $\qquad |\epsilon|_{max} \simeq .2 \times 10^{-14}$

$$\sin \tfrac{\pi}{4} X \simeq X(\quad .7853\ 9816\ 3397\ 426 \quad - .0807\ 4551\ 2187\ 616\ X^2$$
$$+ .0024\ 9039\ 4565\ 024\ X^4 - .0000\ 3657\ 6186\ 880\ X^6$$
$$+ .0000\ 0031\ 3333\ 248\ X^8 - .0000\ 0000\ 1734\ 656\ X^{10})$$

$-1 \leq X \leq 1$ $\qquad |\epsilon|_{max} \simeq .3 \times 10^{-13}$

$$\cos \tfrac{\pi}{4} X \simeq \quad .9999\ 9999\ 9999\ 94 \quad - .3084\ 2513\ 7530\ 08\ X^2$$
$$+ .0158\ 5434\ 4197\ 39\ X^4 - .0003\ 2599\ 1688\ 26\ X^6$$
$$+ .0000\ 0359\ 0476\ 29\ X^8 - .0000\ 0002\ 4268\ 80\ X^{10}$$

$-1 \le X \le 1$ $\qquad |\epsilon|_{max} \simeq .25 \times 10^{-12}$

$$\tan \frac{\pi}{2} X \simeq \frac{4}{\pi} X \left[\frac{1}{1 - X^2} + .2337\ 0055\ 0136\ 04 + .0146\ 7803\ 1620\ 58\ X^2 + .0014\ 4707\ 6300\ 03\ X^4 + .0001\ 5518\ 1717\ 79\ X^6 + .0000\ 1703\ 0972\ 40\ X^8 + .0000\ 0190\ 7434\ 31\ X^{10} + .0000\ 0018\ 4828\ 01\ X^{12} + .0000\ 0003\ 6990\ 64\ X^{14} \right]$$

$0 \le X \le 1 \qquad C = \frac{\pi}{8} \qquad Y = \frac{X - (\sqrt{2} - 1)}{1 + (\sqrt{2} - 1)X}$ $\qquad |\epsilon|_{max} \simeq .24 \times 10^{-12}$

$1 \le X < \infty \qquad C = \frac{3\pi}{8} \qquad Y = \frac{(\sqrt{2} - 1)X - 1}{X + (\sqrt{2} - 1)}$

$$\tan^{-1} X \simeq C + Y(.9999\ 9999\ 9999\ 27 - .3333\ 3333\ 2783\ 66\ Y^2 + .1999\ 9993\ 1868\ 43\ Y^4 - .1428\ 5391\ 1738\ 18\ Y^6 + .1110\ 3533\ 2091\ 55\ Y^8 - .0899\ 3199\ 7777\ 14\ Y^{10} + .0697\ 6915\ 8729\ 77\ Y^{12} - .0376\ 9993\ 2176\ 53\ Y^{14})$$

$0 \leq X \leq 4$ $\qquad |\epsilon|_{max} \simeq .16 \times 10^{-12}$

$$J_0(X) \simeq .9999\ 9999\ 9999\ 9 - 3.9999\ 9999\ 9974\ 4\left(\frac{X}{4}\right)^2 + 3.9999\ 9999\ 9154\ 5\left(\frac{X}{4}\right)^4 - 1.7777\ 7776\ 6925\ 4\left(\frac{X}{4}\right)^6 + .4444\ 4437\ 3657\ 4\left(\frac{X}{4}\right)^8 - .0711\ 1084\ 5605\ 0\left(\frac{X}{4}\right)^{10} + .0079\ 0062\ 7190\ 3\left(\frac{X}{4}\right)^{12} - .0006\ 4413\ 5989\ 7\left(\frac{X}{4}\right)^{14} + .0000\ 3956\ 7011\ 5\left(\frac{X}{4}\right)^{16} - .0000\ 0162\ 8383\ 1\left(\frac{X}{4}\right)^{18}$$

$|\epsilon|_{max} \simeq .24 \times 10^{-12}$

$$Y_0(X) \simeq \frac{2}{\pi} \ln X\, J_0(X) - .0738\ 0429\ 5108 + 2.8416\ 9626\ 9855\ 8\left(\frac{X}{4}\right)^2 - 4.1149\ 3581\ 3009\ 6\left(\frac{X}{4}\right)^4 + 2.2061\ 1650\ 2534\ 9\left(\frac{X}{4}\right)^6 - .6222\ 6452\ 4590\ 8\left(\frac{X}{4}\right)^8 + .1086\ 1598\ 1454\ 3\left(\frac{X}{4}\right)^{10} - .0129\ 0567\ 4361\ 9\left(\frac{X}{4}\right)^{12} + .0011\ 1061\ 4739\ 5\left(\frac{X}{4}\right)^{14} - .0000\ 7128\ 5992\ 6\left(\frac{X}{4}\right)^{16} + .0000\ 0303\ 1753\ 3\left(\frac{X}{4}\right)^{18}$$

$4 \leq x < \infty$

$$J_0(X) = X^{-1/2}\left[P_0(X)\cos\left(X - \frac{\pi}{4}\right) - Q_0(X)\sin\left(X - \frac{\pi}{4}\right)\right]$$

$$Y_0(X) = X^{-1/2}\left[P_0(X)\sin\left(X - \frac{\pi}{4}\right) + Q_0(X)\cos\left(X - \frac{\pi}{4}\right)\right]$$

$$|\epsilon|_{max} \simeq 1.5 \times 10^{-12}$$

$$\begin{aligned} P_0(X) \simeq\ & .7978\ 8456\ 0801\ 43 - .0035\ 0632\ 8261\ 58\left(\frac{4}{X}\right)^2 \\ & + .0003\ 4953\ 1999\ 29\left(\frac{4}{X}\right)^4 - .0001\ 1122\ 6139\ 86\left(\frac{4}{X}\right)^6 \\ & + .0000\ 7110\ 5669\ 54\left(\frac{4}{X}\right)^8 - .0000\ 6619\ 2910\ 10\left(\frac{4}{X}\right)^{10} \\ & + .0000\ 6577\ 7001\ 81\left(\frac{4}{X}\right)^{12} - .0000\ 5506\ 6781\ 97\left(\frac{4}{X}\right)^{14} \\ & + .0000\ 3299\ 8974\ 11\left(\frac{4}{X}\right)^{16} - .0000\ 1208\ 0878\ 39\left(\frac{4}{X}\right)^{18} \\ & + .0000\ 0199\ 8672\ 80\left(\frac{4}{X}\right)^{20} \end{aligned}$$

$$|\epsilon|_{max} \simeq 1.3 \times 10^{-12}$$

$$\begin{aligned} Q_0(X) \simeq \frac{1}{X}\Bigg[& - .0997\ 3557\ 0085\ 32 + .0036\ 5242\ 2961\ 80\left(\frac{4}{X}\right)^2 \\ & - .0007\ 0772\ 6008\ 67\left(\frac{4}{X}\right)^4 + .0003\ 3464\ 7686\ 79\left(\frac{4}{X}\right)^6 \\ & - .0002\ 7845\ 1198\ 31\left(\frac{4}{X}\right)^8 + .0003\ 0428\ 6096\ 73\left(\frac{4}{X}\right)^{10} \\ & - .0003\ 2947\ 6654\ 51\left(\frac{4}{X}\right)^{12} + .0002\ 8830\ 7294\ 77\left(\frac{4}{X}\right)^{14} \\ & - .0001\ 7689\ 0718\ 81\left(\frac{4}{X}\right)^{16} + .0000\ 6562\ 2317\ 43\left(\frac{4}{X}\right)^{18} \\ & - .0000\ 1094\ 1347\ 36\left(\frac{4}{X}\right)^{20}\Bigg] \end{aligned}$$

$0 \leq X \leq 4$

$$|\epsilon|_{max} \simeq .02 \times 10^{-12}$$

$$\begin{aligned} J_1(X) \simeq X \Bigg[& .5000\ 0000\ 0000\ 00 - .9999\ 9999\ 9998\ 82\left(\frac{X}{4}\right)^2 \\ & + .6666\ 6666\ 6627\ 68\left(\frac{X}{4}\right)^4 - .2222\ 2222\ 1721\ 94\left(\frac{X}{4}\right)^6 \\ & + .0444\ 4444\ 1182\ 23\left(\frac{X}{4}\right)^8 - .0059\ 2591\ 3695\ 01\left(\frac{X}{4}\right)^{10} \\ & + .0005\ 6434\ 5933\ 74\left(\frac{X}{4}\right)^{12} - .0000\ 4027\ 2733\ 34\left(\frac{X}{4}\right)^{14} \\ & + .0000\ 0220\ 5337\ 01\left(\frac{X}{4}\right)^{16} - .0000\ 0008\ 2937\ 44\left(\frac{X}{4}\right)^{18} \Bigg] \end{aligned}$$

$$|\epsilon|_{max} \simeq .5 \times 10^{-12}$$

$$\begin{aligned} Y_1(X) \simeq \frac{2}{\pi} \ln X\, J_1(X) + \frac{1}{X} \Bigg[& - .6366\ 1977\ 2368 - 3.1369\ 1345\ 0329\left(\frac{X}{4}\right)^2 \\ & + 13.9132\ 6416\ 8649\left(\frac{X}{4}\right)^4 - 12.1049\ 3064\ 9685\left(\frac{X}{4}\right)^6 \\ & + 4.6951\ 7511\ 2648\left(\frac{X}{4}\right)^8 - 1.0408\ 9393\ 8030\left(\frac{X}{4}\right)^{10} \\ & + .1498\ 5131\ 6245\left(\frac{X}{4}\right)^{12} - .0151\ 5987\ 6046\left(\frac{X}{4}\right)^{14} \\ & + .0011\ 3621\ 7243\left(\frac{X}{4}\right)^{16} - .0000\ 6460\ 4319\left(\frac{X}{4}\right)^{18} \\ & + .0000\ 0246\ 7250\left(\frac{X}{4}\right)^{20} \Bigg] \end{aligned}$$

$4 \leq x < \infty$

$$J_1(X) = X^{-1/2}\left[P_1(X)\cos\left(X - \frac{3\pi}{4}\right) - Q_1(X)\sin\left(X - \frac{3\pi}{4}\right)\right]$$

$$Y_1(X) = X^{-1/2}\left[P_1(X)\sin\left(X - \frac{3\pi}{4}\right) + Q_1(X)\cos\left(X - \frac{3\pi}{4}\right)\right]$$

$$|\epsilon|_{max} \simeq 1.5 \times 10^{-12}$$

$$\begin{aligned} P_1(X) \simeq\ & .7978\ 8456\ 0804\ 42 \\ & + .0058\ 4388\ 0654\ 71\left(\frac{4}{X}\right)^2 \\ & - .0004\ 4940\ 1651\ 07\left(\frac{4}{X}\right)^4 \\ & + .0001\ 3147\ 8678\ 41\left(\frac{4}{X}\right)^6 \\ & - .0000\ 8073\ 7832\ 94\left(\frac{4}{X}\right)^8 \\ & + .0000\ 7363\ 7009\ 95\left(\frac{4}{X}\right)^{10} \\ & - .0000\ 7244\ 7787\ 77\left(\frac{4}{X}\right)^{12} \\ & + .0000\ 6035\ 3228\ 95\left(\frac{4}{X}\right)^{14} \\ & - .0000\ 3607\ 2199\ 06\left(\frac{4}{X}\right)^{16} \\ & + .0000\ 1318\ 5844\ 85\left(\frac{4}{X}\right)^{18} \\ & - .0000\ 0217\ 9380\ 00\left(\frac{4}{X}\right)^{20} \end{aligned}$$

$$|\epsilon|_{max} \simeq 1.3 \times 10^{-12}$$

$$\begin{aligned} Q_1(X) \simeq \frac{1}{X}\Big[\ & .2992\ 0671\ 0284\ 88 \\ & - .0051\ 1339\ 3015\ 44\left(\frac{4}{X}\right)^2 \\ & + .0008\ 6501\ 4276\ 90\left(\frac{4}{X}\right)^4 \\ & - .0003\ 8627\ 7630\ 96\left(\frac{4}{X}\right)^6 \\ & + .0003\ 1197\ 1654\ 89\left(\frac{4}{X}\right)^8 \\ & - .0003\ 3569\ 2686\ 13\left(\frac{4}{X}\right)^{10} \\ & + .0003\ 6071\ 9474\ 07\left(\frac{4}{X}\right)^{12} \\ & - .0003\ 1442\ 6210\ 90\left(\frac{4}{X}\right)^{14} \\ & + .0001\ 9250\ 6220\ 50\left(\frac{4}{X}\right)^{16} \\ & - .0000\ 7132\ 4371\ 77\left(\frac{4}{X}\right)^{18} \\ & + .0000\ 1188\ 2266\ 96\left(\frac{4}{X}\right)^{20}\Big] \end{aligned}$$

$0 \leq k^2 \leq .9375$ $\qquad\qquad$ $|\epsilon|_{max} \simeq .3 \times 10^{-11}$

$$K(k^2) \simeq (1+m)\,(1.5707\ 9632\ 6797 + .3926\ 9907\ 9994\ m^2 + .2208\ 9341\ 8939\ m^4 + .1533\ 9023\ 9689\ m^6 + .1176\ 1434\ 5062\ m^8 + .0930\ 2369\ 3712\ m^{10} + .0961\ 2977\ 1696\ m^{12} - .0095\ 5988\ 8429\ m^{14} + .2974\ 6574\ 6578\ m^{16} - .3634\ 8748\ 7106\ m^{18} + .4029\ 5006\ 4706\ m^{20})$$

$$m = \frac{1 - \sqrt{1-k^2}}{1 + \sqrt{1-k^2}} = \frac{1-k'}{1+k'}$$

Note: for $.9375 < k^2 < 1$, use Landen's transformation until $k_n^2 \leq .9375$ $(\frac{b_n}{a_n} \geq .25)$, i.e., if $k' = k_o' = \sqrt{1-k_o^2} = \frac{b_o}{a_o} < .25$,

where, $a_o = 1$, compute a set of a_r, b_r as follows:

1) $.5(a_r + b_r) = a_{r+1}$

2) $\sqrt{a_r b_r} = b_{r+1}$

3) $k'_{r+1} = \frac{b_{r+1}}{a_{r+1}}$

4) a) if $\frac{b_{r+1}}{a_{r+1}} < .25$, return to 1)

b) if $\frac{b_{r+1}}{a_{r+1}} = \frac{b_n}{a_n} \geq .25$, compute $\frac{1}{a_n} K(k_n^2) = K(k^2)$

$0 \le k^2 \le .992$ $\qquad |\epsilon|_{max} \simeq .5 \times 10^{-11}$

$$E(k^2) \simeq \frac{1}{1+m}\,(1.5707\ 9632\ 6799 + .3926\ 9907\ 9948\ m^2 + .0245\ 4382\ 7985\ m^4 + .0061\ 3183\ 1023\ m^6 + .0024\ 6069\ 8217\ m^8 + .0005\ 8632\ 6220\ m^{10} + .0040\ 9930\ 3949\ m^{12} - .0128\ 6769\ 3447\ m^{14} + .0346\ 1981\ 2874\ m^{16} - .0589\ 3286\ 2948\ m^{18} + .0653\ 3943\ 3006\ m^{20} - .0418\ 9920\ 0263\ m^{22} + .0122\ 8780\ 4214\ m^{24})$$

$$m = \frac{1-\sqrt{1-k^2}}{1+\sqrt{1-k^2}} = \frac{1-k'}{1+k'}$$

$.992 \le k^2 < 1$ $\qquad |\epsilon|_{max} \simeq .4 \times 10^{-12}$

$$E(k^2) \simeq .9999\ 9999\ 9999\ 63 + .4431\ 4718\ 2037\ 64\ (1-k^2) + .0568\ 0426\ 9148\ 27\ (1-k^2)^2 + .0220\ 1608\ 2786\ 41\ (1-k^2)^3 - (1-k^2)\ln(1-k^2)\ \{.2499\ 9999\ 9998\ 92 + .0937\ 5000\ 4306\ 64\ (1-k^2) + .0585\ 9105\ 8349\ 61\ (1-k^2)^2 + .0432\ 6293\ 9453\ 12\ (1-k^2)^3\}$$

Fast Math Subr. Elem. Func

Function	Prog.	Input	Output	Storage (8)	Registers Used	Argument Range
Sin(x)	200	T6	T6	37	T6, T7, B5; Mov.	Any
Cos(x)	201	T6	T6	1	*200.	Any
Exp(x)	203	T6	T6	30	T6; Mov.	$\|x\| < 170$
Ln(x)	204	T6	T6	32	T6, T7, B5; Mov.	$x > 0$
Tan^{-1}(x)	205	T6	T6	35	T6, T7; Mov.	Any
$\int_0^x \frac{e^{-x^2/2}dx}{\sqrt{2\pi}}$	236	T6	T6	35	T6; B5	$x \geq 0$

Note: Maximum error for *200, 201, 203, and 205 = 0.000001,
" " " *204 = 0.000005, and
" " " *236 = 0.0000001.

Mov. refers to mantissa overflow light.

Gary Sitton,
June 8, 1964.

213 Root Finder

9/8/63

```
00213           ORG
                REM            BACK-TRANSLATION
L1        T7    STO            aL30
          PF    RPA            L12
                CLA            L26
                STO            aL31
                TSR            aPF+Z
          PF    RPA            L24
          T6    STO            aL32
                CLA            L31
                FAD*           L30,IU*T7
L12             TSR            aZ
          T6    FSB            L32,IU*T7
                IF(ZER)TRA     aL33
          -T6   FMP            L31
                FDV            7
                STO            aL31,IU*T5
          T6    STO            aL32
          T5    FAD*           L30,IU*T7
          |T5|  FDV            |7|
                FSB            L27
L24             IF(NNZ)TRA     aZ
                TRA            aL12
L26             OCT            770024365605075341 = .01
L27             OCT            740004000000000000
L30             OCT            000000000000000000
L31             OCT            000000000000000000
L32             OCT            000000000000000000
L33             CLA            L31,IU*T5
                CLA            L30,IU*T7
                TRA            a*L24
                END
```

```
PROGRAM   213
  T7      STO          00026+CC                          1
  PF      RPA          00007+CC                          2
          CLA          00022+CC                          3
          STO          00024+CC                          4
          TSR          00000+PF                          5
  PF      RPA          00015+CC                          6
  T6      STO          00022+CC                          7
          CLA          00020+CC                         10
          10401        00016+CC      ,U T7              11
          TSR          *00000                           12
  T6      10500        00016+CC      ,U T7              13
          IF(ZER)TRA   -00016+CC                        14
 -T6      10600        00013+CC                         15
          10700        00007                            16
          STO          00011+CC      ,U T5              17
  T6      STO          00011+CC                         20
  T5      10401        00006+CC      ,U T7              21
 /T5/     10700        -00007                           22
          10500        00003+CC                         23
          IF(NNZ)TRA   -00000        EXIT               24
          TRA          -77763+CC                        25
          OCT          7700243656050753 41              26
          OCT          7400040000000000                 27
          OCT          0000000000000                    30
          OCT          0000000000000                    31
          OCT          0000000000000                    32
          OCT          -0121700050001777 74             33
          OCT          0121700070001777 72              34
          OCT          0101000004401777 65 = TRA a*cc-10 35
```

213 PRINT 3105 35 12734

1	7200010040010026	4721601000010007	1217000000100022	1200010040010024	1400000042000000
6	4721601000001000 15	6200010040010022	1217000000100020	1104010700010016	1400000040000000
13	6105000700010016	1010100040010016	1610600000001000 13	1107000000000007	1200010540010011
20	6200010040010011	5104010700010006	2510700020000007	1105000000100003	1055500040000000
25	1010000040017763	7700243656035075341	7400040000000000	0	0
32	0	1217000500017774	1217000700017772	1010000044017765	

4130000000213 PRINT 3105 35 12734

1	+3603329944194+16	+8837654044405-59	+1430000000596+02	+1280157471299+02	-2559998703002+02
6	+8837654044405-59	+1407548025075+14	+1430000000596+02	+6801733404400+01	-2559998779296+02
13	+7586818143026+13	+8125125129942-00	+1419768673462+33	+7100000000001+01	+1280169678330+02
20	+1407548025075+14	+2921322253800+11	+1037667054532+50	+6900000005961+01	+4562512207031+01
25	+8000122189498-00	+9999999993998-03	+1164153218269-10	+0	+0
32	+0	+1430012208223+02	+1430017091035+02	+8000137448290-00	

214 Simul. Root Finder

9/8/63 00214

```
                ORG
                REM           BACK-TRANSLATION
L1      T6      STO           aL70
        T7      STO           aL71
        PF      RPA           L17
        PF      RPA           L31
                CLA           L66
                STO           aL72
                STO           aL73
                TSR           aPF+Z
        PF      RPA           L64
        T6      STO           aL74
        T7      STO           aL75
L14             CLA           L72
                FAD*          L70,IU*T6
                CLA           L71,IU*T7
L17             TSR           aZ
        T6      FSB           L74
                STO           aL76
        T7      FSB           L75
                STO           aL77
        T6      STO           aL74
        T7      STO           aL75
                CLA           L73
                FAD*          L71,IU*T7
                CLA           L70,IU*T6
L31             TSR           aZ
        T6      FSB           L74,IU*T4
        T7      FSB           L75,IU*T5
                FMP           L76
                STO           aL100
        -T4     FMP           L77
                FAD*          L100
                IF(ZER)TRA    aL101
        T7      FMP*          4
        -T6     FMP           5
                FAD           4
                FDV           L100
                FMP*          L72,IU*T4
        T6      FMP           L77,IU*T5
        -T7     FMP           L76
                FAD           5
                FDV           L100
                FMP*          L73,IU*T5
        T6      STO           aL74
        T7      STO           aL75
                CLA           L70,IU*T6
                CLA           L71,IU*T7
        |T4|    FDV           |6|
                IF(NNZ)SKP    L67
                TRA           aL14
L62     |T5|    FDV           |7|
                FSB           L67
L64             IF(NNZ)TRA    aZ
                TRA           aL14
L66             OCT           770024365605075341
L67             OCT           740004000000000000
L70             OCT           000000000000000000
L71             OCT           000000000000000000
L72             OCT           000000000000000000
L73             OCT           000000000000000000
L74             OCT           000000000000000000
L75             OCT           000000000000000000
L76             OCT           000000000000000000
L77             OCT           000000000000000000
```

```
L100    OCT     0000000000000000        103
L101    CLA     L72,1U→T4               104
        CLA     L73,1U→T5               105
        CLA     L70,1U→T6               106
        CLA     L71,1U→T7               107
        TRA     a*L64                   110
        END                             111
                                        112
                                        113
```

```
PROGRAM   214
  T6      STO          00066+CC                        1
  T7      STO          00066+CC                        2
  PF      RPA          00013+CC                        3
  PF      RPA          00024+CC                        4
  T7      10600        00060+CC                        5
          STO          00063+CC                        6
          STO          00063+CC                        7
          TSR          00000+PF                       10
  PF      RPA          00052+CC                       11
  T6      STO          00061+CC                       12
  T7      STO          00061+CC                       13
          CLA          00055+CC                       14
          10401        00052+CC     ,U T6             15
          CLA          00052+CC     ,U T7             16
          TSR          00000                          17
  T6      10500        00053+CC                       20
          STO          00054+CC                       21
  T7      10500        00052+CC                       22
          STO          00053+CC                       23
  T6      STO          00047+CC                       24
  T7      STO          00047+CC                       25
          CLA          00044+CC                       26
          10401        00041+CC     ,U T7             27
          CLA          00037+CC     ,U T6             30
          TSR          00000                          31
  T6      10500        00041+CC     ,U T4             32
  T7      10500        00041+CC     ,U T5             33
          10600        00041+CC                       34
          STO          00042+CC                       35
 -T4      10600        00040+CC                       36
          10401        00040+CC                       37
          IF(ZER)TRA   00040+CC                       40
  T7      10601        00004                          41
 -T6      10600        00005                          42
          10400        00004                          43
          10700        00033+CC                       44
```

```
          10601          00024+CC                ,U T4      45
T6        10600          00030+CC                ,U T5      46
-T7       10600          00026+CC                           47
          10400          00005                              50
          10700          00026+CC                           51
          10601          00020+CC                ,U T5      52
T6        STO            00020+CC                           53
T7        STO            00020+CC                           54
          CLA            00012+CC                ,U T6      55
          CLA            00012+CC                ,U T7      56
/T4/      10700          -00006                             57
          IF(NNZ)SKP     00006+CC                           60
          TRA            77731+CC                           61
/T5/      10700          -00007                             62
          10500          00003+CC                           63
          IF(NNZ)TRA     00000                              64
          TRA            77725+CC                           65
          OCT            770024365605075341                 66
          OCT            740004000000000000                 67
          OCT            000000000000                       70
          OCT            000000000000                       71
          OCT            000000000000                       72
          OCT            000000000000                       73
          OCT            000000000000                       74
          OCT            000000000000                       75
          OCT            000000000000                       76
          OCT            000000000000                       77
          OCT            0000000( 00000                     100
          CLA            77767+CC                ,U T4      101
          CLA            77767+CC                ,U T5      102
          CLA            77763+CC                ,U T6      103
          CLA            77763+CC                ,U T7      104
          TRA            • 77755+CC                         105
```

214 PRINT 3142 105 12734

1	6200010040010006 6	7200010040010006 6	4721601000001000 13	4721601000001000 24	1217000000010006 0
6	1200010040010006 3	1200010040010006 3	1400000042000000	4721601000001000 52	6200010040010006 1
13	7200010040010006 1	1217000000010005 5	1104010600010005 2	1217000700010005 2	1400000040000000
20	6105000000010005 3	1200010040010005 4	7105000000010005 2	1200010040010005 3	6200010040010004 7
25	7200010040010004 7	1217000000010004 4	1104010700010004 1	1217000600010003 7	1400000040000000
32	6105000400010004 1	7105000500010004 1	1106000000010004 1	1200010040010004 2	1410600000000100 40
37	1104010000010004 0	1010100040010004 0	7106010000000000 4	1610600000000000 5	1104000000000000 4
44	1107000000010003 3	1106010400010002 4	6106000500010003 0	1710600000000100 26	1104000000000000 5
51	1107000000010002 6	1106010500010002 0	6200010040010002 0	7200010040010002 0	1217000600010001 2
56	1217000700010001 2	2410700002000000 6	1065500000010000 6	1010000040017773 1	2510700002000000 7
63	1105000000010000 3	1055500040000000 0	1010000040017772 5	7700243656050753 41	7400040000000000 0
70	0	0	0	0	0
75	0	0	0	0	1217000400017776 7
102	1217000500017776 7	1217000600017776 3	1217000700017776 3	1010000044017775 5	

4130000000214 PRINT 3142 105 12734

1	+1407548025077+14	+3603322944198+16	+8837654044405-59	+8837654044405-59	+1430000000596+02
6	+1280157471300+02	+1280157471300+02	-2559998703002+02	+8837654044405-59	+1407548025077+14
13	+3603322944198+16	+1430000000596+02	+6801708990343+01	+1430017090440+02	-2559998779296+02
20	+7586630238212+13	+1280157471299+02	+1942177340982+16	+1280157471299+02	+1407548025077+14
25	+3603322944198+16	+1430000000596+02	+6801733404403+01	+1430014649034+02	-2559998779296+02
32	+7586737612393+13	+1942211700720+16	+7000000005966+01	+1280157471299+02	+2163950705930+28
37	+6801562505966+01	+8125122123975-00	+1970764641624+16	+1419768672254+33	+6800000000000+01
44	+7100000005965+01	+7001660163214+01	+7696715618714+13	+3634607804064+35	+6800000000000+01
51	+7100000005964+01	+7001684576275+01	+1407548025075+14	+3603322944194+16	+1430014649033+02
56	+1430017090439+02	+4053386931768+47	+5362500005961+01	+8000122189450-00	+1037667054532+50
63	+6900000005961+01	+4562512207031+01	+8000122189443-00	+9999999999998-03	+1164153218269-10
70	+0	+0	+0	+0	+0
75	+0	+0	+0	+0	+1430009766816+02
102	+1430012208823+02	+1430014648629+02	+1430017091035+02	+8000137448276-00	

215 Complex Root Finder

```
215                 ORG
START       T6      STO             Y1
            T7      STO             Y2
            PF      RPA             LOOP
            T6      FMP             DYI
                    STO             DYI,U→T4
            T7      FMP             DYI
                    STO             DY2,U→T5
                    TSR             PF
            PF      RPA             EXIT
            T4      STO             REFK
            T5      STO             IMFK
                    CLA             DYI,U→T4
                    FAD→            Y1,U→T6
                    CLA             DY2,U→T5
                    FAD→            Y2,U→T7
LOOP                TSR             (PF)
            T4      FSB             REFK
                    STO             REDIF
            T5      FSB             IMFK
                    STO             IMDIF
            T4      STO             REFK
            T5      STO             IMFK
                    CLA             -DY1,U→T6
                    CLA             -DY2,U→T7
                    TSR             *246
                    CLA             REDIF,U→T6
                    CLA             IMDIF,U→T7
            T6      IF(NZE)TRA      CC+1
            T7      IF(ZER)TRA      EXIT1
                    TSR             *247
            T4      STO             DY1
            T5      STO             DY2
            T4      FAD→            Y1,U→T6
            T5      FAD→            Y2,U→T7
            T6      IF(NZE)TRA      CC+1
            T7      IF(ZER)TRA      ERROR
            T6      STO             B6,B6+1
                    TSR             *247
                    LDR+60          B6-1,B6-1
            |T4|    FSB             T
                    IF(PNZ)TRA      LOOP
            |T5|    FSB             T
EXIT                IF(NEG)TRA      (PF)
                    TRA             LOOP
ERROR               CLA             CC+Z,CC+1
                    BCD             ERROR215
                    SB3             1,U→T7
            B3      TSR             *127,U→B1
                    TSR             *127,B1+1
                    HTR             Z
DYI                 DEC             0.01
T                   OCT             740040000000000000
Y1                  OCT             0
Y2                  OCT             0
DY1                 OCT             0
DY2                 OCT             0
REFK                OCT             0
IMFK                OCT             0
REDIF               OCT             0
IMDIF               OCT             0
EXIT1               CLA             Y1,U→T6
                    CLA             Y2,U→T7
            -|T6|   TRA             EXIT
                    END
```

PROGRAM 215

220	START	0	1	0	20000000000000	0
221	Y1	0	65	0	72000000000000	0
222	Y2	0	66	0	74000000000000	0
223	LOOP	0	20	0	21000000000000	0
224	DYI	0	63	0	66000000000000	0
225	DY1	0	67	0	76000000000000	0
226	DY2	0	70	0	100000000000000	0
227	EXIT	0	53	0	54000000000000	0
230	REFK	0	71	0	102000000000000	0
231	IMFK	0	72	0	104000000000000	0
232	REDIF	0	73	0	106000000000000	0
233	IMDIF	0	74	0	110000000000000	0
234	EXIT1	0	75	0	111000000000000	0
235	ERROR	0	55	0	56000000000000	0
236	T	0	64	0	70000000000000	0

2	START	1	620001004001000 63	3	Y1	
3		2	720001004001000 63	2	Y2	
4		3	472160100000100014	2	LOOP	
5		4	610600000001000 56	2	DYI	
6		5	120001044001000 61	2	DY1	
7		6	710600000001000 54	2	DYI	
10		7	120001054001000 60	2	DY2	
11		10	140000004200000 00	0		
12		11	472160100000100041	2	EXIT	
13		12	420001004001000 56	2	REFK	
14		13	520001004001000 56	2	IMFK	
15		14	121700040001000 52	2	DY1	
16		15	110401060001000 47	2	Y1	
17		16	121700050001000 51	2	DY2	
20		17	110401070001000 46	2	Y2	
21	LOOP	20	140000004000000 00	1		
22		21	410500000001000 47	2	REFK	
23		22	120001004001000 50	2	REDIF	
24		23	510500000001000 46	2	IMFK	
25		24	120001004001000 47	2	IMDIF	
26		25	420001004001000 43	2	REFK	
27		26	520001004001000 43	2	IMFK	
30		27	121700061001000 37	2	DY1	
31		30	121700071001000 37	2	DY2	
32		31	140000004400002 46	0		
33		32	121700060001000 40	2	REDIF	
34		33	121700070001000 40	2	IMDIF	
35		34	601050004001000 01	0		
36		35	701010004001000 37	2	EXIT1	
37		36	140000004400002 47	0		
40		37	420001004001000 27	2	DY1	
41		40	520001004001000 27	2	DY2	
42		41	410401060001000 23	2	Y1	
43		42	510401070001000 23	2	Y2	
44		43	601050004001000 01	0		
45		44	701010004001000 10	2	ERROR	
46		45	620001264100000 00	0		
47		46	140000004400002 47	0		
50		47	150460660100777 76	0		
51		50	241050000001000 13	2	T	
52		51	105150004001777 45	2	LOOP	
53		52	251050000001000 11	2	T	
54	EXIT	53	101510004000000 00	1		
55		54	101000004001777 42	2	LOOP	
56	ERROR	55	121700200001000 00	1		
60		56	446161556102010 525	0		
61		57	140003074000000 01	0		
62		60	434000041440000 127	0		
63		61	140000214400001 27	0		

64		62	1000000040000000	0	
66	DYI	63	7700243656050753 41	1	
70	T	64	7400400000000000	1	
72	Y1	65	0	1	
74	Y2	66	0	1	
76	DY1	67	0	1	
100	DY2	70	0	1	
102	REFK	71	0	1	
104	IMFK	72	0	1	
106	REDIF	73	0	1	
110	IMDIF	74	0	1	
111	EXITI	75	1217000600017776 6	3	Y1
112		76	1217000700017776 6	2	Y2
113		77	3601000004001775 52	2	EXIT

$236\ 2^{x}$

```
                                                                    1
236                 ORG                                             2
                    REM             2 TO THE X                      3
          T6        IF(NNZ)SKP      @Z,I-B5                         4
                    ILF             @4000,CC+1                      5
          -U        ILN             @4000,U-T6                      6
                    FAD+60          EXP06                           7
                    DML             @1,U-T5                         10
                    IF(ZER)TRA      @CC+1                           11
          F         @EU             EXP77,U-T6                      12
          T6        IF(NNZ)SKP      @0.5                            13
                    STO             T6,B5-1                         14
          T6        FSB             @0.25,U-T6                      15
                    VDF             C8,U-T7                         16
                    FAD             T6                              17
                    VDF             C7                              20
                    FAD             T7                              21
                    FSB             C6,U-T7                         22
          T6        FMP             C5                              23
                    FAD             T7                              24
                    VDF             C4+B5                           25
                    FAD             C1+B5,U-T7                      26
          T5        IDV+20          @10,U-B5                        27
          Z         CRR             @6                              30
                    ADD+20          @1.0                            31
                    DML             @B5                             32
                    FMP             T7                              33
                    IF(NMO)TRA      @PF,U-T6                        34
                    VDF             @1.0,U-T6                       35
EXP77     77        TRA             @PF                             36
EXP06               OCT             0600000000000000000             37
C8                  OCT             0112732563043057346             40
C7                  OCT             0132613040426156 1              41
C6                  OCT             0103622736664622 6              42
C5                  OCT             0100103 1+631463146             43
C4                  OCT             0114571735342702 2              44
C3                  OCT             0111003547620767 4              45
C2                  OCT             0100153504771453 7              46
C1                  OCT             0100114067740506 6              47
                    END                                             50
                                                                    51
```

```
311     EXP06       0    34    0           41000000000000     0
312     EXP77       0    33    0           37000000000000     0
313             0   0    45    0           63000000000000     0
314             0   0    46    0           64000000000000     0
315     C8          0    35    0           43000000000000     0
316     C7          0    36    0           45000000000000     0
317     C6          0    37    0           47000000000000     0
320     C5          0    40    0           51000000000000     0
321     C3          0    42    0           55000000000000     0
322     C1          0    44    0           61000000000000     0
323             0   0    47    0           65000000000000     0
324     C4          0    41    0           53000000000000     0
325     C2          0    43    0           57000000000000     0
2 TU THE X
                 1    06 06550 75 4000 00000
                 2    01 42005 20 4000 04000
                 3    11 42001 06 4000 04000
                 4    01 10460 00 0001 00027     EXP06
                 5    01 44010 05 4000 00001
                 6    01 01010 00 4001 00001
                 7    02 21000 06 0001 00023     EXP77
                10    06 06550 00 0001 00034         0
                11    01 20001 65 4000 00006
                12    06 10500 06 0001 00033         0
                13    01 16700 07 0001 00021     C8
                14    01 10400 00 0000 00006
                15    01 16700 00 0001 00020     C7
                16    01 10400 00 0000 00007
                17    01 10500 07 0001 00017     C6
                20    06 10600 00 0001 00017     C5
                21    01 10400 00 0000 00007
                22    01 16700 00 0041 00017     C3
                23    01 10400 07 0041 00020     C1
                24    05 13320 45 4000 00010
                25    00 45055 00 4000 00006
                26    01 10020 00 0001 00020         0
                27    01 44010 00 4040 00000
                30    01 10600 00 0000 00007
                31    01 01600 06 4200 00000
                32    01 16700 06 0001 00014         0
      EXP77     33    77 01000 00 4200 00000
      EXP06     34    06 00000 00 0000 00000
      C8        35    01 12732 56 0430 57346
      C7        36    01 32613 04 0426 10661
      C6        37    01 03622 76 6664 62216
      C5        40    01 00103 14 6314 63146
      C4        41    01 14571 73 5342 70212
      C3        42    01 11003 54 7620 76734
      C2        43    01 00153 50 4771 45327
      C1        44    01 00114 06 7740 50616
                45    77 20000 00 0000 00000
                46    77 10000 00 0000 00000
                47    01 00100 00 0000 00000
```

237 Log base 2

```
237                 ORG
                    REM             LOG BASE 2
                T6  IF(NEG)TRA      @PF
                    CRL             @15,R+.5
                B5  DMR             @9,U+R
                    DML             @3,U+B5
                    ILF             @4000
                T6  BEU             @2,CC+1
                    IF(MOV)SKP      -U,B5-1
                    ACC,ERM         @X
                -S  BEU             C7,U+T6
                    FAD             S,U+T7
                T6  FSB             C7,B5+1
                    FDV             T7,U+T7
                    FMP             U,U+T6
                    FMP             C6
                    FAD             C5
                    FMP             T6
                    FAD             C4
                    FMP             T6
                    FAD             C3
                    FMP             T6
                    FAD             C2
                    FMP             T7
                    FSB             @0.5,U+T7
                B5  BEU             C2,U+R
                    DML             @47
                    FAD             T7
                    TRA             @PF,U+T6
C7                  OCT             772650117146376357
C6                  OCT             771276042023345572
C5                  OCT             771512645706501504
C4                  OCT             772235o77135762423
C3                  OCT             773661604703647613
C2                  OCT             010027052435451335
                    END
```

```
237                 ORG
                    REM             LOG BAS  2
            T6      IF(NEG)TRA      @PF
                    CRL             @15,R+ 5
            B5      DMR             @9,U+F
                    DML             @3,U+F
                    ILF             @4000
            T6      BEU             @7,CC+1
                    IF(MOV)SKP      -U,B5-1
                    ACC,ERM         @X
            -S      BEU             C7,U+T6
                    FAD             S,U+T7
            T6      FSB             C7,B5+1
                    FDV             T7,U+T7
                    FMP             U,U+T6
                    FMP             C6
                    FAD             C5
                    FMP             T6
                    FAD             C4
                    FMP             T6
                    FAD             C3
                    FMP             T6
                    FAD             C2
                    FMP             T7
                    FSB             @0.5,U+T7
            B5      BEU             C2,U+R
                    DML             @47
                    FAD             T7
                    TRA             @PF,U+T6
C7                  OCT             7726501171463763 57
C6                  OCT             7712760420233455 72
C5                  OCT             7715126457065015 04
C4                  OCT             7722356771357624 23
C3                  OCT             7736616047036476 13
C2                  OCT             0100270524354513 35
                    END
```

240 J_0

9/8/63

```
    00240                ORG
                         REM              BACK-TRANSLATION
L1            IT61       10510            L43
                         IF(PNZ)TRA       aL12
              T6         10610            6,U→T7
              Z          SB5              a77766
              Z          CLA              L50,U→R
L6            T7         10610            2,B5+1
                         10410            B5+L61,U→R
              B5         IF(NZE)TRA       aL6
              R          TRA              aPF+Z,U→T6
L12           PF         RPA              L42
              IT61       16710            L44,U→T5
              T5         10610            5,U→T7
              Z          SB5              a77765
              Z          CLA              L62,U→R
L17           T7         10610            2,B5+1
                         10410            B5+L74,U→R
              B5         IF(NZE)TRA       aL17
              R          STO              aL46
              Z          SB5              a77765
              Z          CLA              L75,U→R
L25           T7         10610            2,B5+1
                         10410            B5+L107,U→R
              B5         IF(NZE)TRA       aL25
              R          10610            5
                         STO              aL47
              Z          TSR              a*202
              T6         20001            4
              T7         10410            -L45,U→T6
                         TSR              a*230
              T7         10610            L46,U→T5
              -T6        10610            L47
                         10410            5
                         10710            4,U→T6
L42                      TRA              aZ
L43                      OCT              010040000000000000
L44                      OCT              010010000000000000
L45                      OCT              773110375524210264
L46                      OCT              000000000000000000
L47                      OCT              000000000000000000
L50                      OCT              717762256113625110
                         OCT              720024575140516110
                         OCT              737752711141765660
                         OCT              740020134320731471
                         OCT              757766713533756742
                         OCT              751616161550160000
                         OCT              767434343434635776
                         OCT              770037777777777057
                         OCT              777000000000000340
L61                      OCT              773777777777777755
L62                      OCT              030414203577327430
                         OCT              037632521013361704
                         OCT              030021232060357372
                         OCT              037776144103743543
                         OCT              020042370702225354
                         OCT              016724567473255656
                         OCT              010045217220635624
                         OCT              776132757273647722
                         OCT              770267202620140120
                         OCT              777615065445446306
L74                      OCT              773142042463650017
L75                      OCT              047772206750526650
                         OCT              031046365552074630
                         OCT              037643204304564733
```

```
                    OCT     0300113447746337l3      103
                    OCT     0275232046213220l6      104
                    OCT     0200117610455260l0      105
                    OCT     0175560056465542l5      106
                    OCT     0100127563515732l0      107
                    OCT     7772147451760137l4      110
                    OCT     7701675353722601l7      111
                    OCT     7774635735314170l0      112
L107                END                             113
                                                    114
                                                    115
```

```
PROGRAM   240
 /T6/     FSB          00041+CC                      1
          IF(PNZ)TRA   00007+CC                      2
  T6      FMP          00006          ,U T7          3
  Z       SB5          77766                         4
  Z       CLA          00042+CC       ,U R           5
  T7      FMP          00002          ,B5+1          6
          FAD          00051+B5+CC    ,U R           7
  B5      IF(NZE)TRA   77774+CC                      10
  R       TRA          00000+PF       ,U T6          11
  PF      RPA          00027+CC                      12
 /T6/     VDF          00030+CC       ,U T5          13
  T5      FMP          00005          ,U T7          14
  Z       SB5          77765                         15
  Z       CLA          00043+CC       ,U R           16
  T7      FMP          00002          ,B5+1          17
          FAD          00053+B5+CC    ,U R           20
  B5      IF(NZE)TRA   77774+CC                      21
  R       STO          00023+CC                      22
  Z       SB5          77765                         23
  Z       CLA          00050+CC       ,U R           24
  T7      FMP          00002          ,B5+1          25
          FAD          00060+B5+CC    ,U R           26
  B5      IF(NZE)TRA   77774+CC                      27
  R       FMP          00005                         30
          STO          00015+CC                      31
  Z       TSR          *00202                        32
  T6      20001        00004                         33
  T7      FAD          /00010+CC/     ,U T6          34
          TSR          *00230                        35
  T7      FMP          00007+CC       ,U T5          36
 -T6      FMP          00007+CC                      37
          FAD          00005                         40
          FDV          00004          ,U T6          41
          TRA          00000                         42
            400        00000                         43
          OCT          0100100000000000              44
```

OCT	7731103755242102 64	45
OCT	0000000000000 0	46
OCT	0000000000000	47
OCT	717762256113625110	50
OCT	720024575140516110	51
OCT	737752711141765660	52
OCT	740020134320731471	53
OCT	757766713533756742	54
OCT	7516161615501600 00	55
OCT	767434343434635776	56
OCT	770037777777777057	57
OCT	777000000000000340	60
OCT	773777777777777755	61
OCT	0304142(3577327430	62
OCT	037632521013361704	63
OCT	030021232060357372	64
OCT	037776144103743543	65
OCT	020042370702225354	66
OCT	016724567473255656	67
OCT	010045217220635624	70
OCT	776132757273647722	71
OCT	770267202620140120	72
OCT	777615065445446306	73
OCT	773142042463650017	74
OCT	047772206750526650	75
OCT	031046365552074630	76
OCT	037643204204564733	77
OCT	030011344774633713	100
OCT	027523204621322046	101
OCT	020011761045526060	102
OCT	017556005646554255	103
OCT	010012756351573250	104
OCT	7772147(5176013734	105
OCT	770167535372260157	106
OCT	777463573531417050	107

```
                    240 PRINT            4273     107 12734

  1 2610510000001000041  1051500040010030?  4106106700000606   4000500400077766   2170002000100042
  6  7106102500000000?   1104100200410005   4501050004001777?4  2010000642000000  4721601000001000?7
 13 2616710050001000030  5104100707000003   4000500400077765   2170002000100043   7106102500000002
 20  1104100200410065?  45010500040017777   2200010040100023   4000500400077745   2170002000100050
 25  7106102500000000?   1104100200410036   4501050004001777?4  2106100000000005   1200010040010001?

 32   4000000440000302   6000100000000004   7104100610010001?   1400000044000230   7106100500010000?
 37 1610610000010000?   1104100000000003   1107100600000004   1010000040000000   1004000000000000
 44  1001000000000000   7721103755242102?4                 0                  0 7177622561136251?0
 51 7200285751405151?0  7377527111417656?  7400201342072147?   7577667135337547?2  751416161550160000
 56 7674343434346327?6  7700777777777771?57  77700000000000?40  77777777777777755   3041420357732743?

 63  3763252101236120?   3002123205035737?   3777614410374354?3   20042370702225354   1672456747325565?
 70  1004521722063062?   7741327572736477?2  7702672026201401?0  7776150654454463?6  7731420424636500?7
 75  477722067505246?0   3104676558207463?   3744320420456473?   30011344774633713   2752320462132204?
102  2001174104552606?   1756600563655425?   1001275630157325?   7772147451760137?4  7701675353722601?7
107 7774625735314170?0
```

```
             4120000000240 PRINT            4273     107 12734

  1 +25862732989647+52  +41625122122992+01  +77105131945595+13  +14069447154074?  +78615349854242
  6 +19735875855083+16  +68125890223327+01  +81900472605?85-65  +20484082031?5+03  +98376540444?5-59
 13 +44570410672948+52  +30119160215540+11  -14069447154074?  +7861534985424?  +19738875850834+16
 20 +63125490?4828+01   +81900432055?8-65  +32772071265?6+04  -14069447154074?  +78615349854248
 25 +19735875850834+16  +68125890234?9+01  +8190047206588?-65  +179520000000?+04  +12801574712?9+02

 32  -14073741285775?   +1807546682243+14  +19175903711?8+15  -25599866267?6+02  +19738776355?8+16
 37 +14223032746?+93    +68125000000000+01  +71126466448375+01  +80001220703?2+00  +4000000000000-00
 44 +10000000000000+00  +78579816337?4-31                 +0                +0  -2369609218767-17
 51 +92124127550?9-15   -2299593553300-12  +47031407717?9-13  -67816567071?6-08  +67916829476?4-06
 56 +43407777512?2-04   +1868409997649-02  -24999999999?84+01  +39999999999?98-01  +21975639819?5+06

 63 +83015164148?5+05   +14172951461?2+05  -14781276727?5+04  +11035649672?4+03  -69408296900?1+01
 70 +46898111?294-00    -4555822683565-31  +89490151819?0-02  -56101252185?2-02  +79788456080?4-01
 75 +12030138442?8+07   +45095213162?0+06  -75972985?2381+05  +77391900140?6+04  -55277009997?8+03
102 +31906709816?0+02   -19248577732?7+01  +13707169250?4-00  -19117785821?8-01  +58439767388?8-02
107 +99735570?8832-02
```

241 J_0,Y_0

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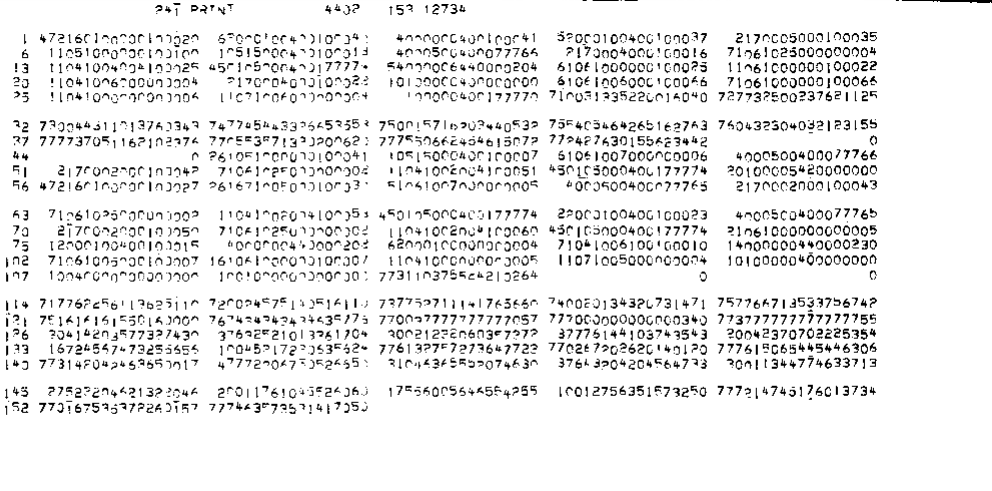
```
00241                 ORG
                      REM            BACK-TRANSLATION
L1           PF       RPA            L22
             T6       STO            aL43
             Z        TSR            aL45
             T5       STO            aL44
             Z        CLA            L43,U→T5
                      10510          L107
                      IF(PNZ)TRA     aL23
             Z        SB5            a77766
             Z        CLA            L30,U→T4
L12          T7       10610          4,B5+1
                      10410          B5+L41,U→T4
             B5       IF(NZE)TRA     aL12
             T5       TSR            a*204,U→T6
             T6       10610          L44
                      10610          L42
                      10410          4,U→T6
L21          Z        CLA            L44,U→T4
L22                   TRA            aZ
L23          T6       10610          L112,U→T6
             T7       10610          L113
                      10410          6
                      10710          4,U→T6
             Z        TRA            aL21
L30                   OCT            710031335220016040
                      OCT            727732500237621125
                      OCT            730044311013760343
                      OCT            747745443326653553
                      OCT            750015716203440532
                      OCT            755405464265162763
                      OCT            760432304032123155
                      OCT            777737051162102376
                      OCT            770553571320200620
L41                   OCT            777550662454615072
L42                   OCT            772427630155623442
L43                   OCT            000000000000000000
L44                   OCT            000000000000000000
L45          IT6I     10510          L107
                      IF(PNZ)TRA     aL56
             T6       10610          6,U→T7
             Z        SB5            a77766
             Z        CLA            L114,U→R
L52          T7       10610          2,B5+1
                      10410          B5+L125,U→R
             B5       IF(NZE)TRA     aL52
             R        TRA            aPF+Z,U→T5
L56          PF       RPA            L106
             IT6I     16710          L110,U→T5
             T5       10610          5,U→T7
             Z        SB5            a77765
             Z        CLA            L126,U→R
L63          T7       10610          2,B5+1
                      10410          B5+L140,U→R
             B5       IF(NZE)TRA     aL63
             R        STO            aL112
             Z        SB5            a77765
             Z        CLA            L141,U→R
L71          T7       10610          2,B5+1
                      10410          B5+L153,U→R
             B5       IF(NZE)TRA     aL71
             R        10610          5
                      STO            aL113
             Z        TSR            a*202
             T[illegible] 00001       4
```

```
                T7      10410   -L111,U->T6                     103
                        TSR     a*230                           104
                T7      10610   L112,U->T5                      105
                -T6     10610   L113                            106
                        10410   5                               107
                        10710   4,U->T5                         110
        L106            TRA     aZ                              111
        L107            OCT     0100400000000000                112
        L110            OCT     0100100000000000                113
        L111            OCT     7731103755242102 64             114
        L112            OCT     0000000000000000                115
        L113            OCT     0000000000000000                116
        L114            OCT     7177622561136251 10             117
                        OCT     7200245751405161 10             120
                        OCT     7377527111417656 60             121
                        OCT     7400201343207314 71             122
                        OCT     7577667135337567 42             123
                        OCT     7516161615501600 00             124
                        OCT     7674343434346357 76             125
                        OCT     7700377777777770 57             126
                        OCT     7770000000000003 40             127
        L125            OCT     7737777777777757 55             130
        L126            OCT     0304142035773274 30             131
                        OCT     0376325210133617 04             132
                        OCT     0300212320603573 72             133
                        OCT     0377761441037435 43             134
                        OCT     0200423707022253 54             135
                        OCT     0167245674732556 56             136
                        OCT     0100452172206356 24             137
                        OCT     7761327572736477 22             140
                        OCT     7702672026201401 20             141
                        OCT     7776150654454463 06             142
        L140            OCT     7731420424636500 17             143
        L141            OCT     0477722067505266 50             144
                        OCT     0310463655520746 30             145
                        OCT     0376432042045647 33             146
                        OCT     0300113447746337 13             147
                        OCT     0275232046213220 46             150
                        OCT     0200117610455260 60             151
                        OCT     0175560056465542 55             152
                        OCT     0100127563515732 50             153
                        OCT     7772147451760137 34             154
                        OCT     7701675353722601 57             155
        L153            OCT     7774635735314170 50             156
                        END                                     157
                                                                160
                                                                161
```

```
PROGRAM   241
  PF      RPA      00020+CC                          1
          STO      00040+CC                          2
  T6      STO      00041+CC                          3
  Z       TSR      00037+CC                          4
  T5      CLA      00035+CC          ,U T5           5
  Z       FSB      00100+CC                          6
          IF(PNZ)TRA 00013+CC                        7
          SBS      77766                             10
  Z       CLA      00016+CC          ,U T4           11
  Z       FMP      00004             ,B5+1           12
  T7      FAD      00025+B5+CC       ,U T4           13
          IF(NZE)TRA 77774+CC                        14
  B5      TSR      *00204            ,U T6           15
  T5      FMP      00025+CC                          16
  T6      FMP      00022+CC                          17
          FAD      00004             ,U T6           20
          CLA      00022+CC          ,U T4           21
  Z       TRA      00000                             22
          FMP      00066+CC          ,U T6           23
  T6      FMP      00066+CC                          24
  T7      FAD      00006                             25
          FDV      00004             ,U T6           26
          TRA      77770+CC                          27
  Z       OCT      7100313352200160 40               30
          OCT      7277325002376211 25               31
          OCT      7300443110137603 43               32
          OCT      7477454733266535 53               33
          OCT      7500157162034405 32               34
          OCT      7554054642651627 63               35
          OCT      7604323040321231 55               36
          OCT      7777370511621023 76               37
          OCT      7705535713202006 20               40
          OCT      7775506624546150 72               41
          OCT      7724276301556234 42               42
          OCT      0000000000000                     43
          OCT      0000000000000                     44
```

```
/T6/    FSB          00041+CC                    45
        IF(PNZ)TRA   00007+CC                    46
 T6     FMP          00006          ,U T7        47
 Z      SB5          77766                       50
 Z      CLA          00042+CC       ,U R         51
 T7     FMP          00002          ,B5+1        52
        FAD          00051+B5+CC    ,U R         53
 B5     IF(NZE)TRA   77774+CC                    54
 R      TRA          00000+PF       ,U T5        55
 PF     RPA          00027+CC                    56
/T6/    VDF          00030+CC       ,U T5        57
 T5     FMP          00005          ,U T7        60
 Z      SB5          77765                       61
 Z      CLA          00043+CC       ,U R         62
 T7     FMP          00002          ,B5+1        63
        FAD          00053+B5+CC    ,U R         64
 B5     IF(NZE)TRA   77774+CC                    65
 R      STO          00023+CC                    66
 Z      SB5          77765                       67
 Z      CLA          00050+CC       ,U R         70
 T7     FMP          00002          ,B5+1        71
        FAD          00060+B5+CC    ,U R         72
 B5     IF(NZE)TRA   77774+CC                    73
 R      FMP          00005                       74
        STO          00015+CC                    75
 Z      TSR          *00202                      76
 T6     20001        00004                       77
 T7     FAD          /00010+CC/     ,U T6        100
        TSR          *00230                      101
 T7     FMP          00007+CC       ,U T5        102
-T6     FMP          00007+CC                    103
        FAD          00005                       104
        FDV          00004          ,U T5        105
        TRA          00000                       106
        OCT          0100400000000000000         107
        OCT          0100100000000000000         110
        OCT          7731103755242102 64         111
```

```
OCT  0000000000000                112
OCT  0000000000000                113
OCT  717762256113625110           114
OCT  720024575140516110           115
OCT  737752711141765660           116
OCT  740020134320731471           117
OCT  757766713533756742           120
OCT  751616161550160000           121
OCT  767434343434635776           122
OCT  770037777777777057           123
OCT  777000000000000340           124
OCT  773777777777777755           125
OCT  030414203577327430           126
OCT  037632521013361704           127
OCT  030021232060357372           130
OCT  037776144103743543           131
OCT  020042370702225354           132
OCT  01672456 7473255656          133
OCT  010045217220635624           134
OCT  776132757273647722           135
OCT  770267202620140120           136
OCT  777615065445446306           137
OCT  773142042463650017           140
OCT  047772206750526650           141
OCT  031046365552074630           142
OCT  037643204204564733           143
OCT  030011344774633713           144
OCT  027523204621322046           145
OCT  020011761045526060           146
OCT  017556056646554255           147
OCT  010012756351573250           150
OCT  777214745176013734           151
OCT  770167535372260157           152
OCT  777463573531417050           153
```


24T PRINT
4402
153 12734


413000000241 PRINT
4402
153 12734

242 J_1

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```
00242                  ORG
                       REM              BACK-TRANSLATION
L1        |T6|         10510            L45
                       IF(PNZ)TRA       aL13
          T6           10610            6,U+T7
          Z            SB5              a77766
          Z            CLA              L50,U+R
L6        T7           10610            2,B5+1
                       10410            B5+L61,U+R
          B5           IF(NZE)TRA       aL6
          R            10610            6,U+T6
                       TRA              aPF+Z
L113      T6           IF(NNZ)TRA       aPF+L112
          PF           RPA              L44
          |T6|         16710            L46,U+T5
          T5           10610            5,U+T7
          Z            SB5              a77765
          Z            CLA              L62,U+R
L21       T7           10610            2,B5+1
                       10410            B5+L74,U+R
          B5           IF(NZE)TRA       aL21
          R            STO              aL110
          Z            SB5              a77765
          Z            CLA              L75,U+R
L27       T7           10610            2,B5+1
                       10410            B5+L107,U+R
          B5           IF(NZE)TRA       aL27
          R            10610            5
                       STO              aL111
          Z            TSR              a*202
          T6           20001            4
          T7           10410            -L47,U+T6
                       TSR              a*230
          T7           10610            L110,U+T5
          -T6          10610            L111
                       10410            5
                       10710            4,U+T6
L44                    TRA              aZ
L45                    OCT              010040000000000000
L46                    OCT              010010000000000000
L47                    OCT              010022662761771462
L50                    OCT              707515711241625175
                       OCT              710447775466046564
                       OCT              737776534253665522
                       OCT              730447702352416653
                       OCT              747475643524754445
                       OCT              750133013277527357
                       OCT              767743434343445024
                       OCT              770005252525252477
                       OCT              777600000000000012
L61                    OCT              771777777777777777
L62                    OCT              037333372113251436
                       OCT              030156470613354566
                       OCT              037755054742554606
                       OCT              030001764436224007
                       OCT              027732010343673777
                       OCT              011151554431263116
                       OCT              017725527064570514
                       OCT              772116730477336414
                       OCT              777424304523306604
                       OCT              770277374030454605
L74                    OCT              773142042463650663
L75                    OCT              040006165476254107
                       OCT              036651540117627171
                       OCT              030144733375366546
```

```
                      OCT       0377655446333324113
                      OCT       0202750757130065557
                      OCT       0277650000056520752
                      OCT       0102434402016053433
L104                  77632     |*B1+B5+B6+L247571|,R-PF
            -|PF|     07054     aB1+B2+L51174,R-Z
            -|PF|     75303     aB1+L50521,U-B3
L107        -|PF|     11446     -|a*PF+B1+B3+B4+L326611|,R-T4
L110        Z         00000     Z
L111                  OCT       0000000000000000000
L112        PF        RPA       L114
            Z         TSR       aL104
L114        -T6       TRA       aZ,U-T6
                      END
```

```
PROGRAM   242
 /T6/     FSB          00043+CC                        1
          IF(PNZ)TRA   00010+CC                        2
  T6      FMP          00006          ,U T7            3
  Z       SB5          77766                           4
  Z       CLA          00042+CC       ,U R             5
  T7      FMP          00002          ,B5+1            6
          FAD          00051+B5+CC    ,U R             7
  B5      IF(NZE)TRA   77774+CC                        10
  R       FMP          00006          ,U T6            11
          TRA          00000+PF                        12
  T6      IF(NNZ)TRA   00076+PF+CC                     13
  PF      RPA          00027+CC                        14
 /T6/     VDF          00030+CC       ,U T5            15
  T5      FMP          00005          ,U T7            16
  Z       SB5          77765                           17
  Z       CLA          00041+CC       ,U R             20
  T7      FMP          00002          ,B5+1            21
          FAD          00051+B5+CC    ,U R             22
  B5      IF(NZE)TRA   77774+CC                        23
  R       STO          00063+CC                        24
  Z       SB5          77765                           25
  Z       CLA          00046+CC       ,U R             26
  T7      FMP          00002          ,B5+1            27
          FAD          00056+BF+CC    ,U R             30
  B5      IF(NZE)TRA   77774+CC                        31
  R       FMP          00005                           32
          STO          00055+CC                        33
  Z       TSR          *00202                          34
  T6      20001        00004                           35
  T7      FAD          /00010+CC/     ,U T6            36
          TSR          *00230                          37
  T7      FMP          00047+CC       ,U T5            40
 -T6      FMP          00047+CC                        41
          FAD          00005                           42
          FDV          00004          ,U T6            43
          TRA          00000                           44
```

```
OCT  0100400000000000000  45
OCT  0100100000000000000  46
OCT  0100226627617714620  47
OCT  7075157112416251750  50
OCT  7104477754660465640  51
OCT  7377765342536695220  52
OCT  7304477023524166530  53
OCT  7474756735247544450  54
OCT  7501330132775273570  55
OCT  7677434343434450240  56
OCT  7700052525252524770  57
OCT  7776000000000000120  60
OCT  7717777777777777770  61
OCT  0373333721132514360  62
OCT  0301564706133545660  63
OCT  0377550547425546060  64
OCT  0300017644362240070  65
OCT  0277320103436737770  66
OCT  0111515544312631160  67
OCT  0177255270645705140  70
OCT  7721167304773364140  71
OCT  7774243045233066040  72
OCT  7702773740304546050  73
OCT  7731420424636506630  74
OCT  0400061654762541070  75
OCT  0366515401176271710  76
OCT  0301447333753665460  77
OCT  0377655446333241130  100
OCT  0202750757130065570  101
OCT  0277650000056207520  102
OCT  0102434402016053430  103
OCT  0177632572543246520  104
OCT  7707054104007510660  105
OCT  7775303434003504120  106
OCT  7711446147633325510  107
OCT  0000000000000        110
OCT  0000000000000        111
```

```
PF      RPA     00001+CC                        112
Z       TSR     77767+CC                        113
-T6     TRA     00000           ,U T6           114
```

242 PRINT 4855 114 12734

1	2610510000010042	1051500040010001	6106100700000006	4000500400077756	2170002000100042
6	7106102500000002	1104100020041000051	4501050004001777774	2106100600000006	1010000042000000
13	6055500042010076	4721601000001000027	2616710050001000030	5106100700000005	4000500400077765
20	2170002000100041	7106102500000004	1104100600410005 1	4501050000400177774	2200010040010006 3
23	4000500400077765	2170002000100042	7106102500000002	1104100200410005 6	4501050004001777774
32	2106100000000005	1200010040010005 3	4000000440000202	6200010000000004	7104100610010001 0
37	1400000044000023 0	7106100500100047	1610610000001000047	1104100000000005	1107100600000004
44	1010000040000000	1004000000000000 3	1001000000000000	1002246276177 1462	7075157112416251 75
51	7104477754660465 64	7377765342236655 22	7304477023524166 53	7474756435247544 45	7501330132775273 57
56	7677434243434445 24	7700052525 25252477	7776000000000000 12	7717777777777777 77	3733337211325143 6
63	3015647041235496 4	3775505474255460 0	3000176443622400 7	2773201034367377 7	1115155443126311 6
70	1772552706457051 4	7721167304772364 1+	7774243045233066 04	7702773740304546 05	7731420424636506 63
75	4000616547628410 7	3465154011742717 1	3014472337536654 6	3776554963332411 3	2027507571300655 7
102	2776500020562075 2	1024344022160534 3	1776325725432465 2	7707054104007510 66	7775303434003504 12
107	7711446147633325 51	0	0	4721601000001000 01	4000000400177767

114 1401000640000000

417000000000+2 PRINT 4885 114 12734

1	+2526779299647+52	+4168512212993+01	+7710512134598+13	+1406944715 40745	+7861534985 4242
6	+1973587598063+16	+6812549023327+01	+8190043206588-65	+1795237500000+04	+8000129699707-00
13	+5016534068925+13	-8837654044405-59	+4457041037348+52	+3011919216640+11	-1406944715 40746
20	+7861534985 4241	+1972987585083+16	+6812549024827+01	+8190043206588-65	+3277203126528+04
25	-1406944715 40746	-7861534235 4246	+1972987535082+16	+6812549024828+01	+8190043206588-65
32	+1795200000000+04	+1280157471289+02	-1407374128577 25	+1407546682243+14	+1917590371198+16
37	+2559898626706+02	+1972827633600+16	+1422303974664+33	+6812500000000+01	+7112646484375+01
44	+8000142070312-00	+4000000000000-00	+1000000000000-00	+2356194490192-00	-1206898653616-18
51	+5134700344021-16	-1500276227864-13	+3363762891081-11	-3651391692147-09	+6781683530001-07
56	-5425247210000-06	+2604166665007-03	-6249999999992-02	+4999999999909-01	-2396253645900+06
63	+9061243581988+05	-1546289153365+05	+1620094653407+04	-1215472184181+03	+7721400134559+01
70	-5291834619309-00	+5285366667706-01	-1150468226741-01	+9350209047537+02	+7978845608044-01
75	+1306469068964+07	-4901373505394+06	+8260792130 73+05	-8440314330148+04	+6051868531874+03
102	-3519992940523+02	+2044537437469+01	-1582193176416-00	+2214436548860-01	-8181428824710-02
107	+2392067102848-01	+0	+0	+8837654044405-59	-1407374211809 36

114 +1622914672700+32

J_1,Y_1

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```
00243                     ORG
                          REM            BACK-TRANSLATION
L1          PF            RPA            L23
            T6            STO            aL46
            Z             TSR            aL50
            T5            STO            aL47
            Z             CLA            L46,U→T5
                          10510          L45
                          IF(PNZ)TRA     aL24
            Z             SB5            a77765
            Z             CLA            L31,U→T4
L12         T7            10610          4,B5+1
                          10410          B5+L43,U→T4
            B5            IF(NZE)TRA     aL12
            T4            12710          5,U→T4
            T5            TSR            a*204,U→T6
            T6            10610          L47
                          10610          L44
                          10410          4,U→T6
L22         Z             CLA            L47,U→T4
L23                       TRA            aZ
L24         T6            10610          L157,U→T6
            T7            10610          L160
                          10410          6
                          10710          4,U→T6
            Z             TRA            aL22
L31                       OCT            700513114105050330
                          OCT            716742036440333315
                          OCT            730002247321771437
                          OCT            737017173370260401
                          OCT            740462712374642221
                          OCT            757572607763106162
                          OCT            760045437337701350
                          OCT            777771745106417232
                          OCT            770157234565616172
                          OCT            777156363172741644
L43                       OCT            775350147622154344
L44                       OCT            772427630155623442
L45                       OCT            010040000000000000
L46                       OCT            000000000000000000
L47                       OCT            000000000000000000
L50         |T6|          10510          L114
                          IF(PNZ)TRA     aL62
            T6            10610          6,U→T7
            Z             SB5            a77766
            Z             CLA            L117,U→R
L55         T7            10610          2,B5+1
                          10410          B5+L130,U→R
            B5            IF(NZE)TRA     aL55
            R             10610          6,U→T5
                          TRA            aPF+Z
L62         T6            IF(NNZ)TRA     aPF+L161
            PF            RPA            L113
            |T6|          16710          L115,U→T5
            T5            10610          5,U→T7
            Z             SB5            a77765
            Z             CLA            L131,U→R
L70         T7            10610          2,B5+1
                          10410          B5+L143,U→R
            B5            IF(NZE)TRA     aL70
            R             STO            aL157
            Z             SB5            a77765
            Z             CLA            L144,U→R
L76         T7            10610          2,B5+1
                          10410          B5+L156,U→R
```

```
                B5      IF(NZE)TRA      aL76                    103
                R       10610           5                       104
                        STO             aL160                   105
                Z       TSR             a*202                   106
                T6      20001           4                       107
                T7      10410           -L116,U→T6              110
                        TSR             a*230                   111
                T7      10610           L157,U→T5               112
                -T6     10610           L160                    113
                        10410           5                       114
                        10710           4,U→T5                  115
L113                    TRA             aZ                      116
L114                    OCT             0100400000000000        117
L115                    OCT             0100100000000000        120
L116                    OCT             0100226627617 1462      121
L117                    OCT             7075157112416 25175     122
                        OCT             7104477754660 46564     123
                        OCT             7377765342536 65522     124
                        OCT             7304477023524 16653     125
                        OCT             7474756435247 54445     126
                        OCT             7501330132775 27357     127
                        OCT             7677434343438 45024     130
                        OCT             7700052525252 52477     131
                        OCT             7776000000000 00012     132
L130                    OCT             7717777777777 77777     133
L131                    OCT             0373333721132 51436     134
                        OCT             0301564706133 54566     135
                        OCT             0377550547425 54606     136
                        OCT             0300017644362 24007     137
                        OCT             0277320103436 73777     140
                        OCT             0111515544312 63116     141
                        OCT             0177255270645 70514     142
                        OCT             7721167304773 36414     143
                        OCT             7774243045233 06604     144
                        OCT             7702773740304 54605     145
L143                    OCT             7731420424636 50663     146
L144                    OCT             0400061654762 54107     147
                        OCT             0366515401176 27171     150
                        OCT             0301447333753 66546     151
                        OCT             0377655446333 24113     152
                        OCT             0202750757130 06557     153
                        OCT             0277650000056 20752     154
                        OCT             0102434402016 05343     155
                        OCT             0177632572543 24652     156
                        OCT             7707054104007 51066     157
                        OCT             7775303434003 50412     160
L156                    OCT             7711446147633 32551     161
L157                    OCT             0000000000000 00000     162
L160                    OCT             0000000000000 00000     163
L161    PF      RPA     L163                                    164
        Z       40000   B1+B2+B3+B4+B5+B6+L5235,U→CC             165
L163                    OCT             0100006400000 00004     166
                        END                                     167
                                                                170
                                                                171
```

```
PROGRAM   243
  PF      RPA              00021+CC                      1
  T6      STO              00043+CC                      2
  Z       TSR              00044+CC                      3
  T5      STO              00042+CC                      4
  Z       CLA              00040+CC          ,U T5       5
          FSB              00036+CC                      6
          IF(PNZ)TRA       00014+CC                      7
  Z       SB5              77765                        10
  Z       CLA              00017+CC          ,U T4      11
  T7      FMP              00004             ,B5+1      12
          FAD              00027+B5+CC       ,U T4      13
  B5      IF(NZE)TRA       77774+CC                     14
  T4      12710            00005             ,U T4      15
  T5      TSR              *00204            ,U T6      16
  T6      FMP              00027+CC                     17
          FMP              00023+CC                     20
          FAD              00004             ,U T6      21
  Z       CLA              00024+CC          ,U T4      22
          TRA              00000                        23
  T6      FMP              00132+CC          ,U T6      24
  T7      FMP              00132+CC                     25
          FAD              00006                        26
          FDV              00004             ,U T6      27
  Z       TRA              77770+CC                     30
          OCT              7005131141050503 30          31
          OCT              7167420364403333 15          32
          OCT              7300022473217714 37          33
          OCT              7370171733702604 01          34
          OCT              7404627123746422 21          35
          OCT              7575726077631061 62          36
          OCT              7600454373377013 50          37
          OCT              7777717451064172 32          40
          OCT              7701572345656161 72          41
          OCT              7771563631727416 44          42
          OCT              7753501476221543 44          43
          OCT              7724276501556234 42          44
```

```
        OCT     0100400000000000000                     45
        OCT     0000000000000000                        46
        OCT     00000000000000                          47
/T6/    FSB     00043+CC                                50
        IF(PNZ)TRA 00010+CC                             51
 T6     FMP     00006           ,U T7                   52
 Z      SB5     77766                                   53
 Z      CLA     00042+CC        ,U R                    54
 T7     FMP     00002           ,B5+1                   55
        FAD     00051+B5+CC     ,U R                    56
 B5     IF(NZE)TRA 77774+CC                             57
 R      FMP     00006           ,U T5                   60
        TRA     00000+PF                                61
 T6     IF(NNZ)TRA 00076+PF+CC                          62
 PF     RPA     00027+CC                                63
/T6/    VDF     00030+CC        ,U T5                   64
 T5     FMP     00005           ,U T7                   65
 Z      SB5     77765                                   66
 Z      CLA     00041+CC        ,U R                    67
 T7     FMP     00002           ,B5+1                   70
        FAD     00051+B5+CC     ,U R                    71
 B5     IF(NZE)TRA 77774+CC                             72
 R      STO     00063+CC                                73
 Z      SB5     77765                                   74
 Z      CLA     00046+CC        ,U R                    75
 T7     FMP     00002           ,B5+1                   76
        FAD     00056+B5+CC     ,U R                    77
 B5     IF(NZE)TRA 77774+CC                             100
 R      FMP     00005                                   101
        STO     00055+CC                                102
 Z      TSR     *00202                                  103
 T6     20001   00004                                   104
 T7     FAD     /00010+CC/      ,U T6                   105
        TSR     *00230                                  106
 T7     FMP     00047+CC        ,U T5                   107
-T6     FMP     00047+CC                                110
        FAD     00005                                   111
```

```
FDV     00004                   ,U T5       112
TRA     00000                               113
OCT     0100400000000000                    114
OCT     0100100000000000                    115
OCT     0100226627617714 62                 116
OCT     7075157112416251 75                 117
OCT     7104477754660465 64                 120
OCT     7377765342536655 22                 121
OCT     7304477023524166 53                 122
OCT     7474756435247544 45                 123
OCT     7501330132775273 57                 124
OCT     7677434343434450 24                 125
OCT     7700052525252524 77                 126
OCT     7776000000000000 12                 127
OCT     7717777;7777777777                  130
OCT     0373333721132514 36                 131
OCT     0301564706133545 66                 132
OCT     0377550547425546 06                 133
OCT     0300017644362240 07                 134
OCT     0277320103436737 77                 135
OCT     0111515544312631 16                 136
OCT     0177255270645705 14                 137
OCT     7721167304773364 14                 140
OCT     7774243045233066 04                 141
OCT     7702773740304546 05                 142
OCT     7731420424636506 63                 143
OCT     0400061654762541 07                 144
OCT     0366515401176271 71                 145
OCT     0301447333753665 46                 146
OCT     0377655446333241 13                 147
OCT     0202750757130065 57                 150
OCT     0277650000056207 52                 151
OCT     0102434402016053 43                 152
OCT     0177632!7254324652                  153
OCT     7707054104007510 66                 154
OCT     7775303434003504 12                 155
OCT     7711446147633325 51                 156
```

```
OCT  0000000000000000  157
OCT  0000000C00000     160
OCT  4721601000000100001  161
OCT  0040000400177050 52  162
OCT  0100006400000000004  163
```

243 PRINT 4671 163 12734

1	472160100000100021	620001004001000043	400000040010000044	520001004001000042	217000500100040
6	110510000000100036	105150004010001	400050040007776	217000400100017	710610250000004
13	110410040041000027	450105000401777	412710040000005	540000064400020	610610000010002
20	110610000001000023	110410060000004	217000400100024	101000004000000	610610060001013
25	710510000001000132	110410000000005	110710060000004	10300040017777	700513114105050
32	716742026440333315	730002047321771437	737017173370260401	740462712374442221	757572607763106162
37	760045427737701350	777771745176417234	770157234565616172	777156363172741644	775350147622154344
44	772427630159562442	100400000000000000	0	0	261051000000100043
51	105150004001000010	610410070000000005	400050040007776	217000200100042	710610250000002
56	110410020041000051	430105000401777	210610050000005	101000042000000	605550004201000076
63	472160100000100027	261671005001000030	510610070000005	400050040007776	217000200100041
70	710610250000000002	110410020041000051	450105000400177774	220001004001000063	400050040007776
75	217000200100046	710610250000000004	110410020041000056	450105000400177774	210610000000005
102	120001004001000055	400000044000020	620001000000004	710410061001000010	140000004400002
107	710610050001000047	161061000001000047	110410000000005	110710050000004	101000004000000
114	100400000000000000	100100000010000000	100226627617714	707516711241425175	710447775466046564
121	737776524253665522	730447702352416653	747425643524754445	750133013277527357	767743434343445024
126	770005252525252477	777600000000000013	771777777777777777	373333721113251436	301564706133545660
133	377550547425546066	300017644362240070	277320103436737770	111515554431263116	177255270645705140
140	772116730477356414	777424704523304604	770277374030454605	772142042463450663	400061654762541070
145	366515401176277171	301447337376366545	377655444333241130	202750757130065570	277650000056207520
152	102424402016053430	177432672344324652	770705410400751066	777530343400350412	771144614763332551
157	0	0	472160100000100001	400004001770505	100006400000000004

4170000000U243 PRINT 4671 163 12734

1	+8337654044405-59	+1407548025077+14	-1407374212136	+5498234472962+11	+78615752507424
6	+6912500005965+01	+4162512212993+01	-14069447154074	+7861561828967	+1973987585083+16
13	+6812597852949+01	+8190043206588-65	+1461731328000+09	-1099504746494+12	+7710325296333+13
20	+7012500005963+01	+6812646484375+01	+7861561628968	+8000122070312+00	+7710486357620+13
25	+1973843275864+16	+6812500000001+01	+7112646484375+01	+4396113685496	+2243950881602-18
32	+9401165713459-16	+2645461913337-13	-5647493515887-11	+3931834473918-09	-9926738148022-07
37	+7164269665531+05	-2955306234388-03	+6434868816878+02	-1960570906455+01	-6346197723675+01
44	+6366197723675-01	+4000000000000-00	+0	+0	+2586273299647+52
51	+4162512212993+01	+7710513194595+13	-14069447154074	+7861534985424	+1973987585083+16
56	+6812549024827+01	+8190043206588-65	+1795231250000+04	+8000129699707-00	+5016536068925+13
63	+8337654044405-59	+4457041067348+52	+3011919216440+11	-14069447154074	+78615349854241
70	+1973987585083+16	+6812549024827+01	+8190043206588-65	+3277203126528+04	-14069447154074
75	+7861534985424	+1973987585083+16	+6812549024828+01	+8190043206588-65	+1795200000000+04
102	+1280157471299+02	-14077741235772	+1407546682243+14	+1917590371198+16	-2559998626706+02
107	+1973877635600+16	+1422303974564+33	+6812500000000+01	+7112622070313+01	+8000122070312+00
114	+4000000000000-00	+1000000000000-00	+2356194490192+00	-1206898653616-18	+5134700364021-16
121	+1600276227864-13	+3762763891081-11	-5651391692167-09	+6781683530001-07	+5425347210000-05
126	+2604166666507-03	-6249999991392-02	+4999999999999-01	-2396253645900+04	+9061243581988+05
133	+1549263152365+05	+1420094653403+04	-1215472134181+03	+7721400134559+01	-5291234619309+00
140	+5385266647706-01	-1150468224741-01	+9350209047537-02	+7978845608044-01	+1346469068966+07
145	-4301273506294+06	+8769079813073+05	-8440314330148+04	+6051868531674+03	-3519992940523+02
152	+2044537437469+01	-1582103175416-00	+2214436548860-01	-8181428824710-02	+2992067102848-01
157	+0	+0	+8837654044405-59	-14073318922389	+1015625000072-01

244 K(k^2)

9/8/63 00244

```
                ORG
                REM             BACK-TRANSLATION
L1      PF      RPA             L24
        Z       CLA             L53,U→T4
                STO             aL52
        T4      10410           -6,U→T6
        Z       TSR             a*202
L6      T6      10410           L35
                IF(NNZ)TRA      aL25
        T6      10410           L53,U→T5
        -T6     10410           L53
                10710           5,U→T7
        T7      10610           7,U→T5
        T7      10410           L53,U→T7
        Z       SBS             a77765
        Z       CLA             L37,U→T6
L17     T5      10610           6,B5+1
                10410           B5+L51,U→T6
        B5      IF(NZE)TRA      aL17
        T6      10610           7
                10710           L52,U→T6
L24             TRA             aZ
L25     T6      10610           L52,U→T6
        T6      10410           L52
                10610           L36,U→T5
        T6      10610           L52,U→T6
        T5      STO             aL52
                TSR             a*202
        T6      12710           L52,U→T6
                TRA             aL6
L35             OCT             776777777777777777
L36             OCT             772000000000000000
L37             OCT             771471173610565325
                OCT             776427447575227757
                OCT             771141153342516712
                OCT             777754327565765773
                OCT             770304677276146666
                OCT             770276406323217602
                OCT             770360677450545114
                OCT             770472111245677173
                OCT             770704307423217610
                OCT             771444176651157507
L51             OCT             010014441766521042
L52             OCT             000000000000000000
L53             OCT             773777777777777777
                END
```

```
PROGRAM   244
  PF      RPA          00022+CC                      1
  Z       CLA          00050+CC          ,U T4       2
          STO          00046+CC                      3
  T4      FAD          /00006/           ,U T6       4
  Z       TSR          ▪00202                        5
  T6      FAD          00026+CC                      6
          IF(NNZ)TRA   00015+CC                      7
  T6      FAD          00042+CC          ,U T5       10
 -T6      FAD          00041+CC                      11
          FDV          00005             ,U T7       12
  T7      FMP          00007             ,U T5       13
  T7      FAD          00036+CC          ,U T7       14
  Z       SB5          77765                         15
  Z       CLA          00020+CC          ,U T6       16
  T5      FMP          00006             ,B5+1       17
          FAD          00030+B5+CC       ,U T6       20
  B5      IF(NZE)TRA   77774+CC                      21
  T6      FMP          00007                         22
          FDV          00026+CC          ,U T6       23
          TRA          00000                         24
  T6      FMP          00024+CC          ,U T6       25
  T6      FAD          00023+CC                      26
          FMP          00006+CC          ,U T5       27
  T6      FMP          00021+CC          ,U T6       30
  T5      STO          00020+CC                      31
          TSR          ▪00202                        32
  T6      12710        00016+CC          ,U T6       33
          TRA          77750+CC                      34
          OCT          7767777777777777              35
          OCT          7720000000000000              36
          OCT          7714711736105653 25           37
          OCT          7764274475752277 57           40
          OCT          7711411533425167 12           41
          OCT          7777543275657657 73           42
          OCT          7703046772761466 66           43
          OCT          7702764063232176 02           44
```

OCT	7703606774505451l4	45
OCT	770472111245677173	46
OCT	770704307423217610	47
OCT	771444176651157507	50
OCT	0100144417665210 42	51
OCT	000000000000000	52
OCT	7737777777777777	53

245 E(K^2)

```
PROGRAM    245
  PF       RPA              00017+CC                            1
 -T6       FAD              00035+CC            ,U T6           2
 -T6       FAD              00016+CC                            3
           IF(PNZ)TRA       00035+CC                            4
  Z        TSR              *00202                              5
  T6       FAD              00031+CC            ,U T7           6
 -T6       FAD              00030+CC                            7
           10711            00007                              10
  T7       FMP              00007               ,U T6          11
  T7       FAD              00025+CC            ,U T7          12
  Z        SB5              77763                              13
  Z        CLA              00006+CC            ,U T5          14
  T6       FMP              00005               ,B5+1          15
           FAD              00020+B5+CC         ,U T5          16
  B5       IF(NZE)TRA       77774+CC                           17
  T5       12710            00007               ,U T6          20
           TRA              00000                              21
           OCT              770020304467227432                 22
           OCT              770031124544517146                 23
           OCT              777652141102111050                 24
           OCT              770205641270771552                 25
           OCT              777607234324076523                 26
           OCT              770106715402405552                 27
           OCT              777745513175536004                 30
           OCT              770010312335031333                 31
           OCT              770001146676157310                 32
           OCT              770005024165227405                 33
           OCT              770014435541555254                 34
           OCT              770062210043240722                 35
           OCT              771444176651142741                 36
           OCT              010014441766521043                 37
           OCT              773777777777777777                 40
           OCT              0000000L00000 0                    41
  Z        SB5              77774                              42
  Z        CLA              00014+CC            ,U T4          43
  Z        CLA              00017+CC            ,U T5          44
```

```
T6      FMP     00004                   ,B5+1       45
        FAD     00014+B5+CC             ,U T4       46
T6      FMP     00005                               47
        FAD     00016+B5+CC             ,U T5       50
B5      IF(NZE)TRA  77772+CC                        51
T5      FMP     00006                               52
        STO     77764+CC                            53
Z       TSR     *00204                              54
        FMP     77762+CC                            55
        FAD     00004                   ,U T6       56
        TRA     77740+CC                            57
        OCT     7700550554223433 36                 60
        OCT     770164253457620753                  61
        OCT     771613441377612506                  62
        OCT     773777777777777713                  63
        OCT     777647313412172703                  64
        OCT     777610002645043163                  65
        OCT     777477777775540146                  66
        OCT     777000000000000227                  67
```

260 F(k,0)

9/18/63

```
00260               ORG
                    REM         BACK-TRANSLATION
L1          Z       CLA         a77732
                    RPA         L71
            PF      RPA         L114
            T6      TSR         a*230
            T6      STO         aL116,CC+1
L6                  OCT         0100100000000000000
L7          T7      STO         aL117
            Z       STO         aL133
            T4      STO         aL122
            T4      10610       4,U+T5
                    DMR         a1
                    STO         aL123
            -T5     10410       L6,U+T6
            T7      10610       L116
                    STO         aL120
                    TSR         a*202
                    STO         aL125,CC+1
L22                 OCT         0100144417665210 41
L23         T6      16710       L6
                    STO         aL126
L25         Z       CLA         L116
                    10610       1,U+T4
                    STO         aL121
            Z       CLA         L125
                    10610       1
                    10610       4,U+T6
            Z       CLA         L117
                    10610       1
                    10410       6,U+T6
                    TSR         a*202
            Z       CLA         L6,U+T7
                    10410       L125,U+T5
                    10610       L121
            -U      10410       7
                    10710       6,U+T4
                    STO         aL117
            T5      10610       L120
                    10711       6
                    STO         aL116
            T6      10611       4
                    STO         aL120
            Z       CLA         L133,U+T6
            T4      IF(POS)SKP  aZ
            T6      10410       L22,U+T6
L55         T6      10411       L133
            T7      10410       -L125
                    10710       5
                    STO         aL124
                    10610       1
            -U      10410       7,U+T6
                    TSR         a*202
                    DMR         a2
                    10611       L126
            T6      10510       L115
                    IF(POS)TRA  aL104
            T6      STO         aL125
L71                 TRA         aL72
L72         Z       CLA         L124,U+T6
                    DMR         a1
                    10611       L127
                    10411       L131
                    TSR         a*202
                    DMR         a1
```

```
                        10611       L130                    103
                        10610       L116                    104
                        10411       L132                    105
                        TRA         aL25                    106
L104                Z   CLA         L116,U→T6               107
                        TSR         a*231                   110
                    Z   IF(POS)SKP  -L120                   111
                    -|T6| 10410     L22,U→T6                112
L110                |T6| 10411     L133                    113
                    Z   CLA         L126,U→T6               114
                        TSR         a*202                   115
                    T6  10610       L133,U→T6               116
L114                    TRA         aZ                      117
L115                    OCT         777377777777777576      120
L116                    OCT         000000000000000000      121
L117                    OCT         000000000000000000      122
L120                    OCT         000000000000000000      123
L121                    OCT         000000000000000000      124
L122                    OCT         000000000000000000      125
L123                    OCT         000000000000000000      126
L124                    OCT         000000000000000000      127
L125                    OCT         000000000000000000      130
L126                    OCT         000000000000000000      131
L127                    OCT         000000000000000000      132
L130                    OCT         000000000000000000      133
L131                    OCT         000000000000000000      134
L132                    OCT         000000000000000000      135
L133                    OCT         000000000000000000      136
                        OCT         000000000000000000      137
                        END                                 140
                                                            141
                                                            142
```

```
PROGRAM   260
     Z    CLA    $77732                          1
          RPA    00066+CC                        2
     PF   RPA    00110+CC                        3
     T6   TSR    * 00230                         4
     T6   STO    00110+CC          ,CC+1         5
          OCT    0100100000000000000             6
     T7   STO    00107+CC                        7
     Z    STO    00122+CC                       10
     T4   STO    00110+CC                       11
     T4   FMP    00004             ,U T5        12
          DMR    00001                          13
          STO    00106+CC                       14
    -T5   FAD    77767+CC          ,U T6        15
     T7   FMP    00077+CC                       16
          STO    00100+CC                       17
          TSR    * 00202                        20
          STO    00103+CC          ,CC+1        21
          OCT    0100144417665210 41            22
     T6   VDF    77761+CC                       23
          STO    00101+CC                       24
     Z    CLA    00070+CC                       25
          FMP    00001             ,U T4        26
          STO    00071+CC                       27
     Z    CLA    00074+CC                       30
          FMP    00001                          31
          FMP    00004             ,U T6        32
     Z    CLA    00063+CC                       33
          FMP    00001                          34
          FAD    00006             ,U T6        35
          TSR    * 00202                        36
     Z    CLA    77745+CC          ,U T7        37
          FAD    00064+CC          ,U T5        40
          FMP    00057+CC                       41
    -U    FAD    00007                          42
          FDV    00006             ,U T4        43
          STO    00052+CC                       44
```

```
T5      FMP         00052+CC                    45
        10711       00006                       46
        STO         00046+CC                    47
T6      10611       00004                       50
        STO         00046+CC                    51
Z       CLA         00060+CC        ,U T6       52
T4      IF(POS)SKP  $00000                      53
T6      FAD         77744+CC        ,U T6       54
T6      10411       00055+CC                    55
T7      FAD         /00046+CC/                  56
        FDV         00005                       57
        STO         00043+CC                    60
        FMP         00001                       61
-U      FAD         00007           ,U T6       62
        TSR         *00202                      63
        DMR         00002                       64
        10611       00040+CC                    65
T6      FSB         00026+CC                    66
        IF(POS)TRA  00014+CC                    67
T6      STO         00034+CC                    70
        TRA         00000+CC                    71
Z       CLA         00031+CC        ,U T6       72
        DMR         00001                       73
        10611       00032+CC                    74
        10411       00033+CC                    75
        TSR         *00202                      76
        DMR         00001                       77
        10611       00027+CC                    100
        FMP         00014+CC                    101
        10411       00027+CC                    102
        TRA         77720+CC                    103
Z       CLA         00011+CC        ,U T6       104
        TSR         *00231                      105
Z       IF(POS)SKP  /00011+CC/                  106
-/T6/   FAD         77711+CC        ,U T6       107
/T6/    10411       00022+CC                    110
Z       CLA         00014+CC        ,U T6       111
```

```
                TSR     * 00202                          112
T6              FMP     00017+CC            ,U T6        113
                TRA     00000                            114
                OCT     773777777777777576               115
                OCT     0000000000000                    116
                OCT     0000000000000                    117
                OCT     0000000000000                    120
                OCT     0000000000000                    121
                OCT     000000000000000                  122
                OCT     000000000000000                  123
                OCT     000000000000000                  124
                OCT     0000000000000                    125
                OCT     000000000000000                  126
                OCT     000000000000000                  127
                OCT     0000000000000                    130
                OCT     0000000000000                    131
                OCT     0000000000000                    132
                OCT     000000000000000                  133
                OCT     000000000000000                  134
```

240 PRINT 13122 134 3620

1	2170000400077732	1214010000010006	4721401000001001 10	5400000044000230	6200012040010011 0
6	1001000000000000	7700010042010010 7	2000100430100123	4200010040010011 0	4106100500000004
13	1440000040000001	1200010042010010 5	1510410060017776 7	7106100000010007 7	1200010040010010 0
20	1400000044000020 2	1200012042010010 1	1001444176652104 1	6167100000177761	1200010040010010 1
25	2170000000100070	1106100400200000 1	1200010040010007 1	2170000000100074	1106100000000001
32	1106100600001004	2170000001100061	1106100000000001	1108100600000006	1400000044000020 2
37	2170000700177745	1104100500010006	1106100000010005 7	1110810000000000 7	1167100400000006
44	1200010040010005 2	5106100000010005	1107110000000000 6	1200010040010004 6	6106110000000000 4
51	1200010040010004 6	2170006000100061	4021100040000000	5104100600177744	6104110000010005 5
56	7104100010010004 6	1107100000000000 1	1200010040010004 3	1106100000000001	1110410060000000 7
63	1400000044000020 2	1440000042000000 4	1106110000100004 0	6105100000010002 6	1011100040010001 4
70	6200012004001003 4	1010000042010000 1	2170006000100031	1440000040000000 1	1106110000010003 2
75	1104110000010003 2	1400000044000020 3	1440000040000000 1	1106110000010002 7	1106100000010001 4
102	1104110000010002 7	1010000042017772 1	2170006000100011	1400000044000023 1	2110001001000 11
107	3610410060017771 1	2610411060001000 2	2170006000100014	1400000044000020 2	6106100600010001 7
114	1010000040000000	7777777777777737	0	0	0
121	0	0	0	0	0
126	0	0	0	0	0
133	0	0			

+12000000020 PRINT 13122 134 3620

1	+7861514852757 8	+1420156257697+02	+8837654044912-59	-2814746257151+14	+1407590974749+14
6	+1000000000000+00	+3409322944198+16	+7037740125397 0	+2147747841002+09	+1176522752000+09
13	-2239998779296+02	+1280157471300+02	+5397534637600+30	+1973843275663+16	+1280157471300+02
20	-2559998626706+02	+1280196633800+02	+1570796326794-00	+1309793227897+14	+1280157471300+02
25	+7861508141880 8	+7012597656250+01	+1280157471300+02	+7861508141881 2	+7012500000000+01
32	+7012646484375+01	+7861508141880 3	+7012500000000+01	+6812646484376+01	-2559998626706+02
37	+7861160997858 9	+6812672076282+01	+7012500005969+01	+1256684440021+21	+7112597656251+01
44	+1280157471299+02	+3011845813383+11	+7114062500001+01	+1280157471299+02	+7712043276694+13
51	+1280157471299+02	+7861588567251 68	+2874118720000+08	+7490584038595+13	+7492140957701+13
56	+1917549139513+14	+7112500000000+01	+1280157471299+02	+7012500000000+01	+1256711461618+21
63	-2559998626706+02	-2239998779296+02	+7014062505966+01	+7600374133555+13	+9125122129938-00
70	+1407549825677+14	+8000122123317-00	+7361588672514 5	-2239998779296+02	+7014062505965+01
75	+6814062505965+01	-2559998626706+02	-2239998779296+02	+7014062505964+01	+7012500005962+01
102	+6814062505964+01	+8000122183434-00	+7361588672512 9	-2559998626706+02	+9414585122825
107	+4701915326756+71	+2849443453386+52	+7361589672513 2	-2559998626706+02	+7710486357605+13
114	+8000122070312-00	+9099999993990-01	+0	+0	+0
121	+0	+0	+0	+0	+0
126	+0	+0	+0	+0	+0
133	+0	+0			

261 F(k,0),E(k,0)

9/8/63

```
00261                   ORG
                        REM         BACK-TRANSLATION
L1          PF          RPA         L20
            Z           RPA         L111
            Z           CLA         L26
                        STO         aL147
                        STO         aL150
                        STO         aL151
            Z           STO         aL152
                        TSR         aL23
            Z           CLA         L143
                        10610       L151
            -U          10410       L26
                        10610       6,U+T5
            Z           CLA         L142
                        10610       L152
                        10410       5,U+T4
L20                     TRA         aZ
                        OCT         002170000400077732
                        OCT         012160100000100066
L23         PF          RPA         L134
            T6          TSR         a*230
            T6          STO         aL136,CC+1
L26                     OCT         010010000000000000
L27         T7          STO         aL137
            Z           STO         aL153
            T4          STO         aL142
            T4          10610       4,U+T5
                        DMR         a1
                        STO         aL143
            -T5         10410       L26,U+T6
            T7          10610       L136
                        STO         aL140
                        TSR         a*202
                        STO         aL145,CC+1
L42                     OCT         010014441766521041
L43         T6          16710       L26
                        STO         aL146
L45         Z           CLA         L136
                        10610       1,U+T4
                        STO         aL141
            Z           CLA         L145
                        10610       1
                        10610       4,U+T6
            Z           CLA         L137
                        10610       1
                        10410       6,U+T6
                        TSR         a*202
            Z           CLA         L26,U+T7
                        10410       L145,U+T5
                        10610       L141
            -U          10410       7
                        10710       6,U+T4
                        STO         aL137
            T5          10610       L140
                        10711       6
                        STO         aL136
            T6          10611       4
                        STO         aL140
            Z           CLA         L153,U+T6
            T4          IF(POS)SKP  aZ
            T6          10410       L42,U+T6
L75         T6          10411       L153
            T7          10410       -L145
                        10710       5
```

```
                        STO             aL144
                        10610           1
            -U          10410           7,U→T6
                        TSR             a*202
                        DMR             a2
                        10611           L146
            T6          10510           L135
                        IF(POS)TRA      aL124
            T6          STO             aL145
L111                    TRA             aL112
L112        Z           CLA             L144,U→T6
                        DMR             a1
                        10611           L147
                        10411           L151
                        TSR             a*202
                        DMR             a1
                        10611           L150
                        10610           L136
                        10411           L152
                        TRA             aL45
L124        Z           CLA             L136,U→T6
                        TSR             a*231
            Z           IF(POS)SKP      -L140
            -|T6|       10410           L42,U→T6
L130        |T6|        10411           L153
            Z           CLA             L146,U→T6
                        TSR             a*202
            T6          10610           L153,U→T6
L134                    TRA             aZ
L135                    OCT             773777777777777576
L136                    OCT             000000000000000000
L137                    OCT             000000000000000000
L140                    OCT             000000000000000000
L141                    OCT             000000000000000000
L142                    OCT             000000000000000000
L143                    OCT             000000000000000000
L144                    OCT             000000000000000000
L145                    OCT             000000000000000000
L146                    OCT             000000000000000000
L147                    OCT             000000000000000000
L150                    OCT             000000000000000000
L151                    OCT             000000000000000000
L152                    OCT             000000000000000000
L153                    OCT             000000000000000000
                        OCT             000000000000000000
                        END
```

```
PROGRAM   261
  PF      RPA     00016+CC                          1
  Z       RPA     00106+CC                          2
  Z       CLA     00022+CC                          3
          STO     00142+CC                          4
          STO     00142+CC                          5
          STO     00142+CC                          6
  Z       STO     00142+CC                          7
          TSR     00012+CC                         10
  Z       CLA     00131+CC                         11
          FMP     00136+CC                         12
 -U       FAD     00012+CC                         13
          FMP     00006           ,U T5            14
  Z       CLA     00124+CC                         15
          FMP     00133+CC                         16
          FAD     00005           ,U T4            17
          TRA     00000                            20
  Z       CLA     $77732                           21
          RPA     00066+CC                         22
  PF      RPA     00110+CC                         23
  T6      TSR     *00230                           24
  T6      STO     00110+CC        ,CC+1            25
          OCT     0100100000000000                 26
  T7      STO     00107+CC                         27
  Z       STO     00122+CC                         30
  T4      STO     00110+CC                         31
  T4      FMP     00004           ,U T5            32
          DMR     00001                            33
          STO     00106+CC                         34
 -T5      FAD     77767+CC        ,U T6            35
  T7      FMP     00077+CC                         36
          STO     00100+CC                         37
          TSR     *00202                           40
          STO     00103+CC        ,CC+1            41
          OCT     0100144417665210 41              42
  T6      VDF     77761+CC                         43
          STO     00101+CC                         44
```

```
Z       CLA     00070+CC                        45
        FMP     00001           ,U T4           46
        STO     00071+CC                        47
Z       CLA     00074+CC                        50
        FMP     00001                           51
        FMP     00004           ,U T6           52
Z       CLA     00063+CC                        53
        FMP     00001                           54
        FAD     00006           ,U T6           55
        TSR     *00202                          56
Z       CLA     77745+CC        ,U T7           57
        FAD     00064+CC        ,U T5           60
        FMP     00057+CC                        61
-U      FAD     00007                           62
        FDV     00006           ,U T4           63
        STO     00052+CC                        64
T5      FMP     00052+CC                        65
        10711   00006                           66
        STO     00046+CC                        67
T6      10611   00004                           70
        STO     00046+CC                        71
Z       CLA     00060+CC        ,U T6           72
T4      IF(POS)SKP      $00000                  73
T6      FAD     77744+CC        ,U T6           74
T6      10411   00055+CC                        75
T7      FAD     /00046+CC/                      76
        FDV     00005                           77
        STO     00043+CC                        100
        FMP     00001                           101
-U      FAD     00007           ,U T6           102
        TSR     *00202                          103
        DMR     00002                           104
        10611   00040+CC                        105
T6      FSB     00026+CC                        106
        IF(POS)TRA      00014+CC                107
T6      STO     00034+CC                        110
        TRA     00000+CC                        111
```

```
Z       CLA     00031+CC        ,U T6   112
        DMR     00001           ,       113
        10611   00032+CC        ,       114
        10411   00033+CC        ,       115
        TSR     * 00202         ,       116
        DMR     00001           ,       117
        10611   00027+CC        ,       120
        FMP     00014+CC        ,       121
        10411   00027+CC        ,       122
        TRA     77720+CC        ,       123
Z       CLA     00011+CC        ,U T6   124
        TSR     * 00231         ,       125
Z       IF(POS)SKP  /00011+CC/  ,       126
-/T6/   FAD     77711+CC        ,U T6   127
 /T6/   10411   00022+CC        ,       130
Z       CLA     00014+CC        ,U T6   131
        TSR     * 00202         ,       132
T6      FMP     00017+CC        ,U T6   133
        TRA     00000           ,       134
        OCT     773777777777777576      135
        OCT     0000000000000 0         136
        OCT     000000000000000         137
        OCT     0000000000000 0         140
        OCT     0000000000000 0         141
        OCT     000000000000000         142
        OCT     000000000000000         143
        OCT     000000000000000         144
        OCT     000000000000000         145
        OCT     0000000000000           146
        OCT     0000000000000           147
        OCT     0000000000000 0         150
        OCT     0000000000000 0         151
        OCT     000000000000000         152
        OCT     000000000000000         153
        OCT     000000000000000         154
```

241 PRINT 13256 154 3620

1	4721601000001011016	2140100007010010	2170000000100022	1200010040010142	1200010040010142
6	1200010040010142	2000100400100142	1400000040010012	2170000000100131	1106100000100136
13	1110410700001010012	1104100507000000	2170000000100124	1106100000100133	1104100400000005
20	1010000040000000	2170000400077736	1216010000100066	4721601000000100110	6400000044000230
25	6200012040010110	1001000000000001	7200010040010107	2000100400100122	4200010040010011
32	4106107600000004	1440000040000001	1200010040010106	13104100600177767	7106100000100077
37	1200010040010100	1400000044000202	1200012040010103	10014441766521041	6167100000177761
44	1200010040010101	2170000000100073	1106100400000001	1200010040010071	2170000000100074
51	1106100000000001	1106100600000004	2170000000100063	1106100000000001	1104100600000006
56	1400000044000202	2170000700177743	1104100500100064	1106100000100057	1110410000000000007
63	1107107400000006	1200010040010054	5106100000100052	1107110000000006	1200010040010046
70	6106110700000004	1200010040010043	2170006000100060	4021100040000000	6104100600017774
75	6104110000010055	7104100170100044	1107100000000005	1200010040010043	1106100000000001
102	1110410760000007	1400000044000202	1440000040000002	1106110000100040	6105100000100026
107	1011100040010014	6200010040010034	1011000040010000	2170006000100031	1440000040000001
114	1106110000010002	1104110000100035	1400000044000202	1440000040000001	1106110000100027
121	1106100000100014	1104110000100027	1011000040017772	2170006000100011	1400000044000231
126	2110010010000011	36104100600177771	2610411000000100022	2170006000100014	1400000044000202
133	6106107600100077	1010000040000000	7737777777777776	0	0
140	0	:	0	0	0
145	0	:	0	0	0
152	0	:	0		

4120000000026T PRINT 13256 154 3620

1	+8837654044405+39	+7807391539526	+7861508141870	+1280157471300+02	+1280157471300+02
6	+1280157471300+02	+7037740125303	-2559998776700+02	+7861508141884	+7012500006977+01
13	+1286684441126+01	+7012622070313+01	+7861508141836	+7012500005977+01	+6812597656250+01
20	+8000120703120-00	+7861514332757	+1420154250597+02	+3837654044413-59	-2814748257151+14
25	+1407590974749+14	+1000000000000-00	+3603322944198+16	+7037740125397	+2147747841002+09
32	+1176522752000+09	-2239998779296+02	+1280157471300+02	+5397534637600+30	+1973843275863+16
37	+1280157471300+02	-2559998626706+02	+1280196534800+02	+1570796326794-00	+1309793227897+14
44	+1280157471300+02	+7861508141880	+7012597656250+01	+1280157471300+02	+7861508141881
51	+7012500000000+01	+7012646484375+01	+7861508141880	+7012500000000+01	+6812646484376+01
56	-2559998626706+02	+7861602707558	+4812622076282+01	+7012500005949+01	+1256684440021+21
63	+7112597686251+01	+1280157471299+02	+3011845818882+11	+7114062500001+01	+1280157471299+02
70	+7712043276694+13	+1280157471299+02	+7861588672516	+2873118720000+08	+7490584038595+13
75	+7492140357701+13	+1817549133513+16	+7112500000000+01	+1280157471299+02	+7012500000000+01
102	+1256711461618+21	-2559998626706+02	-2239998779296+02	+7014062505966+01	+7600374133555+13
107	+9126122129938-00	+1407548025077+14	+8000122129917-00	+7861588672514	-2239998779296+02
114	+7014062505965+01	+6814062505365+01	-2559998626706+02	-2239998779296+02	+7014062505964+01
121	+7012500005962+01	+6814062505364+01	+8000122189434-00	+7861588672512	-2559998626706+02
126	+9414385122325	+7019158054756+71	+2540443455386+52	+7861588672513	-2559998626706+02
133	+7710484357405+13	+8000122072312-00	+9993999993990-01	+0	+0
140	+0	+0	+0	+0	+0
145	+0	+0	+0	+0	+0
152	+0	+0	+0		

213 Fourier Waveform Synthesis

FWS (*213)

Fourier Waveform Syntheses

Purpose. To synthesize a given function from its Fourier series coefficients.

Output. Upon exit, vector *251 will contain the desired function. The following senselight options may also be used.

SLN 1 - Vector *251 will be punched hexad with checksum as a B1-modified vector.
SLN 2 - Vector *251 will be plotted on the printer using FLOVP (* 222).

Calling Sequence. The input parameters include the time interval between points, the total time length of the desired waveform, and for each coefficient, frequency (cps), amplitude, and phase shift (seconds), The program may be entered manually (SLF3) or under program control (SLN3). All numbers must be floating point.

Manually (SLF3): Input is from paper tape with the following format:

(CR)
Time interval between points in seconds. (CR)
Time at last point in seconds. (CR)
(TAB) Frequency (TAB) Amplitude (TAB) Phase Shift (CR)
(TAB) Frequency (TAB) Amplitude (TAB) Phase Shift (CR)
etc.

Programmed (SLN3): Parameters are stored on the B6-list as follows (for b coefficients):

Time Interval		B6-3b-4
Total Time		B6-3b-3
Null Word		B6-3b-2
Null Word		B6-3b-1
Frequency	(1)	B6-3b
Amplitude	(1)	B6-3b+1
Phase	(1)	B6-3b+2
---		----
Frequency	(b)	B6-3
Amplitude	(b)	B6-2
Phase	(b)	B6-1

In addition, B1 must contain b.

Registers Used. B1,2,3,4,5,6,PF,T4,5,6,7,X,TT, and FT.

Supporting Routines.

XCWD with STEX activated (*126).
STEX (*135)
MRDDC (*153) if parameters are read from tape.
FLOVP (*222) if plotting is done.
SINCOS (*230)

In addition, matrix *260 is setup, used, and inactivated.

Length. 137 octal

Pat Groves
10 August 1963

```
2 |3                ORG
                    REM          FOURIER WAVEFORM SYNTHESIS
                    REM          PAT GROVES

                    REM          USES SINCOS (*230)
                    REM          USES FLOVP (*222) (SL 2)
                    REM          SETS UP, USES, AND INACTIVATES
                                 MATRIX *260
                    REM          OUTPUT IS VECTOR *251
                    REM          ASSUMES THAT STEX IS ACTIVATED

                    REM          SL1 - PUNCH OUT VECTOR *251
                    REM          SL2 - PLOT OUT ON PRINTER
                                 USING FLOVP (*222)
                    REM          SL3 - INPUT STORED ON ENTRY
                                 ON B6 LIST WITH NP IN B1

                    REM          B4-1      T
                    REM          B4-2      NP
                    REM          B4-3      TMAX
                    REM          B4-4      DELTAT

FWS       PF        STO          TT
                    STX          2
          1Z1       IF(SLF)SKP   10000,U+B2
                    TRA          TAKOUT,R+Z
                    SB1          B6,B6+X
                    TSR          *153,B2+1

          Z         STO          B4+1,B6+X
                    SFT          B4
                    STX          3

READ      Z         SB1          B4,U+B2
                    CLA          SPILL,B2+X
                    RHX+40       a%
                    IF(MOV)TRA   TAKEOT
                    TSR          *153,B6+X
                    TRA          READ

TAKOUT    B1        MPY          a3
          B6        SUB          R,U+B3
                    TRA          FORM

TAKEOT              BAU          FT,U+B3
          B6        SUB          a@3
                    IDV          a3,U+B1

FORM      B1        STO          B3-2
                    LUL          d15
                    21500        MATSET,U+T7
                    SLN          00002
          B1        TSR          *126,U+B5
                    BAU          260,U+B4
                    BAU          B4+1,U+B1
                    RPA          RPAA
                    BAU          B4+2,U+B2
                    RPA          RPAB
                    BAU          B4+3,U+PF
                    RPA          RPAC

XCHANG    B6        IF(PNZ)SKP   a@3
                    TRA          COMPLP
                    CLA          B4-1
                    STO          B3+PF
```

```
                        CLA     B4-2                                    103
                        STO     B2+B5                                   104
                        CLA     B6-3,I+B6                               105
                        STO     B1+B5,B5-1                              106
                        TRA     XCHANG                                  107
                                                                        110
COMPLP                  SB2     1                                       111
                        CLA     B4-3                                    112
                        FDV     B4-4                                    113
                        FAD     PTFIVE                                  114
                        FAD+60  ZERO47                                  115
                        DML     1,U+B1                                  116
                B1      LDR     a7                                      117
                        LRS     di5                                     120
                R       ORU     VECSET,U+T7                             121
                        TSR     *126                                    122
                Z       BAU     251,U+B1                                123
                        CLA     B4-1                                    124
                        LT6     B6-4                                    125
                                                                        126
OUTLP           -U      FAD     B6-3,U+T5                               127
                T6      DMR     1                                       130
                        IF(NEG)SKP T5                                   131
                        TRA     OUTPUT                                  132
                Z       SB3     *B6-2,U+T4                              133
                                                                        134
INLOOP                  CLA     B6-1                                    135
RPAC                    FAD     B3                                      136
RPAA                    FMP     B3                                      137
                        FMP     TWOPI,U+T6                              140
                        TSR     *230                                    141
RPAB            T6      FMP     B3,B3-1                                 142
                        FAD+    T4                                      143
                B3      IF(PNZ)TRA INLOOP                               144
                                                                        145
                T4      STO     B1+B2,B2+1                              146
                        CLA     B6-4,U+T6                               147
                        FAD+    B6-1                                    150
                        TRA     OUTLP                                   151
                                                                        152
OUTPUT          Z       RPA     RPAA                                    153
                Z       RPA     RPAB                                    154
                Z       RPA     RPAC                                    155
                                                                        156
INACT                   LT7     INACWD,B6-1                             157
                        TSR     *126,B6-1                               160
                        SLF     00002,B6-1                              161
                                                                        162
PUNCH                   IF(SLN)SKP 40000,B6-1                           163
                        TRA     PLOT,CC-1                               164
                        LT7     PNCHWD                                  165
                        TSR     *126                                    166
                                                                        167
                        SPF     *TT                                     170
                                                                        171
PLOT                    IF(SLN)SKP 20000                                172
                        TRA     PF                                      173
                        SB1     251                                     174
                        TRA     *222                                    175
                                                                        176
INACWD                  OCT     0000011700000000260                     177
MATSET                  OCT     0000304200000000260                     200
PNCHWD                  OCT     0000052400000000251                     201
PTFIVE                  DEC     0.5                                     202
SPILL                   OCT     4000000000000000000                     203
TWOPI                   DEC     6.283185307178                          204
```

```
VECSET      OCT        000000220000000251
ZERO47      OCT        040000000000000000

            REM        INPUT FORMAT (MRDDC *153)
            REM        (CR)
            REM        DELTAT    (CR)
            REM        TMAX      (CR)
            REM        (TAB)    FREQ    (TAB)    AMP    (TAB)    PH
            REM        (TAB)    FREQ    (TAB)    AMP    (TAB)    PH
            REM        ETC.

            END
```

:275	FWS	0	1	0	7400000000000000	0
:276	TAKOUT	0	20	0	1130000000000000	0
:277	READ	0	12	0	1050000000000000	0
:300	SPILL	0	134	0	:2340000000000000	0
:301	TAKEOT	0	23	0	1160000000000000	0
:302	FORM	0	26	0	1210000000000000	0
:303	MATSET	0	131	0	:2260000000000000	0
:304	RPAA	0	77	0	1720000000000000	0
:305	RPAB	0	102	0	1750000000000000	0
:306	RPAC	0	76	0	1710000000000000	0
:307	XCHANG	0	42	0	1350000000000000	0
:310	COMPLP	0	53	0	1460000000000000	0
:311	PTFIVE	0	133	0	:2320000000000000	0
:312	ZERO47	0	137	0	:2420000000000000	0
:313	VECSET	0	136	0	:2400000000000000	0
:314	OUTLP	0	70	0	1630000000000000	0
:315	OUTPUT	0	111	0	:2040000000000000	0
:316	INLOOP	0	75	0	1700000000000000	0
:317	TWOPI	0	135	0	:2360000000000000	0
:320	INACT	0	114	0	:2070000000000000	0
:321	INACWD	0	130	0	:2240000000000000	0
:322	PUNCH	0	117	0	:2120000000000000	0
:323	PLOT	0	124	0	:2170000000000000	0
:324	PNCHWD	0	132	0	:2300000000000000	0

FOURIER WAVEFORM SYNTHESIS
PAT GROVES

USES SINCOS (*230)
USES FLOVP (*222) (SL 2)
SETS UP, USES, AND INACTIVATES MATRIX *260
OUTPUT IS VECTOR *251
ASSUMES THAT STEX IS ACTIVATED
SL1 = PUNCH OUT VECTOR *251
SL2 = PLOT OUT ON PRINTER USING FLOVP (*222)
SL3 = INPUT STORED ON ENTRY ON B6 LIST WITH INP IN B1

B6-1 T
B6-2 NP
B6-3 TMAX
B6-4 DELTAT

74	FWS	1	4720001004000077776	
75		2	1430050040000002	
76		3	2002070424000010000	
77		4	1010001040010013	TAKOUT
100		5	1400013641000000	
101		6	1400002244000153	
102		7	2000136410000001	
103		10	1430070041000000	
104		11	1430050040000003	
105	READ	12	4000142410000000	
106		13	1217003200010120	SPILL
107		14	1601400040000000	
110		15	1012000040010005	TAKEOT
111		16	1400036440000153	
112		17	1010000040017771	READ
113	TAKOUT	20	4110200004000000003	
114		21	4610100430000000002	
115		22	1010000040010003	FORM
116	TAKEOT	23	1201004300077777	
117		24	4610100004010000000	
120		25	1133004140000003	
121	FORM	26	4120001004010777775	
122		27	1450200040000017	
123		30	1215000700010010	MATSET
124		31	1420000400000002	

```
125              32    4140004544000126
126              33    1201004400000260
127              34    1201004100200001
130              35    1216010000100041    RPAA
131              36    1201004200200002
132              37    1216010000100042    RPAB
133              40    1201004700200003
134              41    1216010000100034    RPAC
135   XCHANG     42    4606150000401000000
136              43    1010000040010007    COMPLP
137              44    1217000001007776
140              45    1200010042400000
141              46    1217000001007775
142              47    1200010040440000
143              50    1217007601007774
144              51    1200016540420000
145              52    1010000040017766    XCHANG
146   COMPLP     53    1400020040000001
147              54    1217000001007774
150              55    1107000001007773
151              56    1104000000100054    PTFIVE
152              57    1104400000100057    ZERO47
153              60    1440104140000001
154              61    4150400004000000
155              62    1450150040000017
156              63    2500100700100052    VECSET
157              64    1400000044000126
160              65    1201004100000251
161              66    1217000001007776
162              67    1504800001007773
163   OUTLP      70    1110400050107774
164              71    5440000040000001
165              72    1025100000000005
166              73    1010000040010015    OUTPUT
167              74    400030445007775
170   INLOOP     75    1217000001007776
171   RPAC       76    1104000000100000
172   RPAA       77    1106000000100000
173              100   1106000600100034    TWOPI
174              101   1400000044000230
175   RPAB       102   5106006300100000
176              103   1104010000000004
177              104   4305150004001777 67 INLOOP
200              105   4200012240060000
201              106   1217000601007773
202              107   1104010001007776
203              110   1010000040017756    OUTLP
204   OUTPUT     111   2160100000177764    RPAA
205              112   2160100000177766    RPAB
206              113   2160100000177761    RPAC
207   INACT      114   1504706600100013    INACWD
210              115   1400066440000126
211              116   1420046640000002
212   PUNCH      117   1020306640004000 0
213              120   1010006040010003    PLOT
214              121   1504700000100010    PNCHWD
215              122   1400000044000126
216              123   1400070044007776
217   PLOT       124   1020300040002000 0
220              125   1010000042000000
221              126   1400010040000251
222              127   1010000044000222
224   INACWD     130   1170000000260
226   MATSET     131   3042000000260
230   PNCHWD     132   524000000251
232   PTFIVE     133   7720000000000000
```

```
 234   SPILL    134        4000000000000000000
 236   TWOPI    135        10062207732504204
 240   VECSET   136              220000000251
 242   ZERO47   137        6000000000000000000
INPUT FORMAT (MPDDC *153)
(CR)
DELTAT    (CR)
TMAX      (CR)
(TAB)   FREQ   (TAB)   AMP   (TAB)   PHASE   (CR)
(TAB)   FREQ   (TAB)   AMP   (TAB)   PHASE   (CR)
ETC.
```

Least Squares

LEAST SQUARES SUBROUTINE PACKAGE

FUNCTION PFIT(XDATA,YDATA,WGHTS,COEFS,YCALC,RESID,SQSUM,SIGMA)

FUNCTION PFIT(XDATA,YDATA,COEFS,YCALC,RESID,SQSUM,SIGMA)

FUNCTION GFIT(XDATA,YDATA,WGHTS,COEFS,YCALC,RESID,SQSUM,SIGMA)

FUNCTION GFIT(XDATA,YDATA,COEFS,YCALC,RESID,SQSUM,SIGMA)

This set of four programs determines the "best" coefficients for a functional approximation to a given set of data according to the principle of least squares. For the PFIT programs, the approximating function is a polynomial which is constructed by the program; for the GFIT programs, any linear combination of functions of any number of variables whose terms can be evaluated at each of the n data points may be chosen. The programs are designed for use as functions, with STEX activated, within a Genie language program; they are independent of each other and differ primarily on the basis of the input data required.

PFIT: Two programs exist, one for use with weighting factors applied to the data points and one for use without such factors. Each program computes the best least squares coefficients for a polynomial of given order approximating the data specified. The parameters of the programs are as follows:

XDATA: A one- or two-rowed matrix of n columns, where n is the number of data points. If the constant term of the polynomial is to be zero, then XDATA has one row consisting of the floating point abscissas of the n data points. If the constant term need not be zero, then XDATA has two rows: each element of the first row is a floating point one, and the second row contains the n abscissas as before. XDATA is unaltered by PFIT.

YDATA: A vector of n elements giving the floating point ordinates of the n data points; unaltered by PFIT.

WGHTS: A vector of n elements giving the weighting factors to be applied to each of the n data points in determining the coefficients of the polynomial, and to the squares of the residuals in forming their sum. If no weights are desired, this vector may be omitted, but the correct version of PFIT must be used in each case. WGHTS is unaltered by PFIT.

COEFS: A vector of zeros whose length, m, determines the degree of the polynomial to be found. If the curve is to have a zero constant term, the polynomial will be of order m; if not, the polynomial will be of order m-1. On output, COEFS contains the coefficients of the polynomial beginning with the coefficient of the lowest power of the independent variable, or the constant term.

Any of the following four names may or may not refer to an existing array on input. If so, such an array will be inactivated by STEX before the output data described below is assigned to that name.

YCALC: A vector of n elements found by evaluating the resulting polynomial at each of the n points given by XDATA.

RESID: A vector of n elements giving the differences between the given ordinates of YDATA and the calculated ordinates of YCALC.

SQSUM: A floating point constant giving the sum of the squares of the elements of RESID; each squared element is multiplied by its corresponding weighting factor, if weights are given, before the sum is formed.

SIGMA: A matrix of m rows and m columns which is the covariance matrix of the least squares coefficients.

GFIT: Two programs exist, one with weights and one without as for PFIT. Each program computes the best least squares coefficients for a linear combination of functions whose terms are chosen and evaluated by the user. Output from the GFIT programs is identical with that from PFIT; input differs as described below. (See examples on next page.)

XDATA: A matrix of m rows and n columns, where m is the number of coefficients required by the approximating function and n is the number of data points. Each successive row of XDATA is formed by evaluating another term of the approximating function at each of the n data points specified. The array is unaltered by GFIT.

YDATA: A vector of n elements giving the "right-hand-side" of the approximating equation; this includes all terms of the approximating function for which coefficients are not required. YDATA is unaltered by GFIT.

WGHTS: An n-element vector identical with that for PFIT; unaltered by GFIT.

COEFS: A name which on input may or may not refer to an existing array. If it does, the array will be inactivated by STEX. On output, COEFS is a vector of m elements giving the coefficients of the approximating function beginning with the one corresponding to the first row of XDATA and continuing in that order.

YCALC, RESID, SQSUM, SIGMA: Identical with that from PFIT; any existing arrays will be inactivated by STEX before output data is assigned.

Jo K. Mann
August, 1964

GFIT examples:

Example 1: To fit a plane of the form

$$Ax + By + Cz + D = 0$$ to a

set of n data points $x_1 y_1 z_1, x_2 y_2 z_2, \ldots, x_n y_n z_n$:

solving for one of the variables (say z), we have

$A'x + B'y + D' = z$, where $A' = \frac{-A}{C}$, $B' = \frac{-B}{C}$, $D' = \frac{-D}{C}$.

Then on input, XDATA = $\begin{vmatrix} x_1 & x_2 & \cdots & x_n \\ y_1 & y_2 & \cdots & y_n \\ 1.0 & 1.0 & \cdots & 1.0 \end{vmatrix}$ and

YDATA = $|z_1, z_2 \cdots z_n|$. On output, COEFS gives the "best" values for the coefficients A', B', and D' in that order.

Example 2: To fit a curve to the equation

$A_i = Be^{-Cr_i} r_i^{-D}$; taking logarithms, we have

$\ln A_i = \ln B - D \ln r_i - C r_i$. Transposing,

$$D \ln r_i + C r_i = \ln B - \ln A_i.$$

Then on input, XDATA = $\begin{vmatrix} \ln r_1 & \ln r_2 & \cdots & \ln r_n \\ r_1 & r_2 & \cdots & r_n \end{vmatrix}$

and YDATA = $|(\ln B - \ln A_1) \; (\ln B - \ln A_2) \cdots (\ln B - \ln A_n)|$.

On output, COEFS = $|D \quad C|$ giving the "best" fit for the logarithmic equation.

```
                                                                        1
        DEFINE                                                          2
        MATRIX XDATA, SIGMA                                             3
        VECTOR YDATA, COEFS, YCALC, RESID                               4
        PFIT(XDATA, YDATA, COEFS, YCALC, RESID, SQSUM, SIGMA), =SEQ
        INTEGER                    .N, .M, .H, .J, .I                   6
        .N = LENGTH(YDATA)                                              7
        .M = LENGTH(COEFS)                                              10
        .H = ROW(XDATA)                                                 11
        .J = .M - .H                                                    12
EXPND   CC = ← WORK .If .J = 0                                          13
Z       BAU             XDATA, U→B1                                     14
        LRS             27                                              15
        CLA             ←+1150                                          16
        LRS             12                                              17
        CLA             .J, U→B2                                        20
        LRS             15, R→T7                                        21
        TSR             *+126                                           22
        SPF             *END+1                                          23
        CLA             B1, U→B4                                        24
        CRL             15, R→B3                                        25
-B2     ADD             ←B4+B3+1, U→B3                                  26
B3      BNA             B4+1, U→R                                       27
        CRL             15                                              30
        LRL             12                                              31
        CLA             ←+0120                                          32
        LRS             12                                              33
R       CRR             15, U→T6                                        34
LOOP    B3      RPA     T6, B2-1                                        35
T6      TSR             *+126, U→T7                                     36
        SPF             *END+1                                          37
B2      IF(NZE)TRA      ←LOOP, B3+1                                     40
        FOR     .J = 1, 1, .N                                           41
        FOR     .I = .H+1, 1, .M                                        42
        XDATA .I, .J = XDATA .I-1, .J × XDATA .H, .J                    43
        REPEAT                                                          44
        REPEAT                                                          45
WORK    COEFS = XDATA × YDATA                                           46
        SIGMA = XDATA × TRAN(XDATA)                                     47
        SIGMA = INV(SIGMA)                                              50
        COEFS = SIGMA × COEFS                                           51
        YCALC = TRAN(XDATA) × COEFS                                     52
        RESID = YDATA - YCALC                                           53
        SQSUM = RESID × RESID                                           54
        SIGMA = SIGMA × (SQSUM / (.N-.M))                               55
END                                                                     56
        DEFINE                                                          57
LEAVE                                                                   60
                                                                        61
```

no weights

```
PFIT     START NEW PROGRAM.                          1/11/66 15.06

←BGIN    PROGRAM SEQUENCE.
EXPND    PROGRAM SEQUENCE.
LOOP     PROGRAM SEQUENCE.
←FOR1    PROGRAM SEQUENCE.
←FOR2    PROGRAM SEQUENCE.
←RPT2    PROGRAM SEQUENCE.
←RPT1    PROGRAM SEQUENCE.
WORK     PROGRAM SEQUENCE.
END      PROGRAM SEQUENCE.
```

```
PFIT  .=
          ←BGIN    1    10 01000 02 4400 00136
                   2    01 40007 00 4100 77756
                   3    47 21641 00 0001 00232    END    +    1
                   4    01 21700 07 0200 00001    YDATA
                   5    01 40000 00 4401 77771    LENGT
                   6    01 40007 00 4401 00227    END    +    1
                   7    01 20001 00 4001 00230    .N
                  10    01 21700 07 0200 00002    COEFS
                  11    01 40000 00 4401 77765    LENGT
                  12    01 40007 00 4401 00223    END    +    1
                  13    01 20001 00 4001 00225    .M
                  14    01 21700 07 0200 00000    XDATA
                  15    01 40000 00 4401 77761    LENGT
                  16    01 40007 00 4401 00217    END    +    1
                  17    01 20001 00 4001 00222    .H
                  20    01 21740 00 0001 00220    .M
                  21    01 10100 00 0001 00220    .H
                  22    01 20001 00 4001 00220    .J
          EXPND   23    01 21740 00 0001 00217    .J
                  24    01 02010 00 4000 00000
                  25    01 01000 00 4001 00002
                  26    01 21700 00 4001 00060    WORK
                  27    01 30000 40 0000 00000
                  30    00 20100 41 0200 00000    XDATA
                  31    01 45015 00 4000 00033
                  32    01 21700 00 4000 01150
                  33    01 45015 00 4000 00014
                  34    01 21700 42 0001 00206    .J
                  35    01 45015 17 4000 00017
                  36    01 40000 00 4400 00126
                  37    01 40007 00 4401 00176    END    +    1
                  40    01 21700 44 0002 00000
                  41    01 45066 53 4000 00017
                  42    52 10000 43 4030 00001
                  43    43 00166 02 0020 00001
                  44    01 45066 00 4000 00017
                  45    01 45002 00 4000 00014
                  46    01 21700 00 4000 00120
                  47    01 45015 00 4000 00014
                  50    02 45055 06 4000 00017
          LOOP    51    43 21601 62 0000 00006
                  52    06 40000 07 4400 00126
                  53    01 40007 00 4401 00162    END    +    1
```

```
             54     42 01050 23 4001 77773    LOOP
←FOR1        55     20 20001 00 4001 00165    ,J
             56     01 21700 00 0001 00161    ,N
             57     01 02110 00 0001 00163    ,J
             60     01 01000 00 4001 00026    ←RPT1  +      2
←FOR2        61     20 10000 00 0001 00160    ,H
             62     01 20001 00 4001 00161    ,I
             63     01 21700 00 0001 00155    ,M
             64     01 02110 00 0001 00157    ,I
             65     01 01000 00 4001 00017    ←RPT2  +      2
             66     01 21700 06 0001 00154    ,J
             67     20 14102 26 0001 00154    ,I
             70     06 30000 42 0000 00000
             71     01 21740 41 0100 77776
             72     01 21740 66 0600 00000    XDATA
             73     01 30000 04 0000 00000
             74     06 30000 42 0000 00000
             75     01 21740 41 0001 00144    ,H
             76     01 21740 00 0600 00000    XDATA
             77     01 10620 02 0000 00004    T4
            100     06 30000 42 0000 00000
            101     01 21700 41 0001 00142    ,I
            102     02 20001 00 4600 00000    XDATA
←RPT2       103     20 10401 00 0001 00140    ,I
            104     01 01000 00 4001 77755    ←FOR2  +      2
←RPT1       105     20 10401 00 0001 00135    ,J
            106     01 01000 00 4001 77746    ←FOR1  +      1
WORK        107     01 21700 41 0200 00000    XDATA
            110     01 21700 42 0200 00001    YDATA
            111     01 40000 00 4401 77664    MMPY
            112     01 40007 00 4401 00123    END    +      1
            113     01 21700 41 0200 00002    COEFS
            114     00 40000 42 4400 00135
            115     01 40007 00 4401 00120    END    +      1
            116     00 50401 52 0000 00010
            117     02 20001 00 4002 00000
            120     41 21641 00 0004 00000
            121     01 21700 07 0200 00000    XDATA
            122     01 40000 00 4401 77652    TRAN
            123     01 40007 00 4401 00112    END    +      1
            124     01 21700 41 0200 00000    XDATA
            125     00 40000 42 4401 77650    MMPY
            126     01 40007 00 4401 00107    END    +      1
            127     01 21700 41 0200 00006    SIGMA
            130     00 40000 42 4400 00135
            131     01 40007 00 4401 00104    END    +      1
            132     00 50401 52 0000 00010
            133     02 20001 00 4002 00000
            134     41 21641 00 0004 00000
            135     01 21700 07 0200 00006    SIGMA
            136     01 40000 00 4401 77635    INV
            137     01 40007 00 4401 00076    END    +      1
            140     01 21700 41 0200 00006    SIGMA
            141     00 40000 42 4400 00135
            142     01 40007 00 4401 00073    END    +      1
            143     00 50401 52 0000 00010
            144     02 20001 00 4002 00000
            145     41 21641 00 0004 00000
            146     01 21700 41 0200 00006    SIGMA
            147     01 21700 42 0200 00002    COEFS
            150     01 40000 00 4401 77625    MMPY
            151     01 40007 00 4401 00064    END    +      1
            152     01 21700 41 0200 00002    COEFS
            153     00 40000 42 4400 00135
            154     01 40007 00 4401 00061    END    +      1
            155     00 50401 52 0000 00010
```

```
                    156    02 20001 00 4002 00000
                    157    41 21641 00 0004 00000
                    160    01 21700 07 0200 00000    XDATA
                    161    01 40000 00 4401 77613    TRAN
                    162    01 40007 00 4401 00053    END    +    1
                    163    01 21700 42 0200 00002    COEFS
                    164    00 40000 41 4401 77611    MMPY
                    165    01 40007 00 4401 00050    END    +    1
                    166    01 21700 41 0200 00003    YCALC
                    167    00 40000 42 4400 00135
                    170    01 40007 00 4401 00045    END    +    1
                    171    00 50401 52 0000 00010
                    172    02 20001 00 4002 00000
                    173    41 21641 00 0004 00000
                    174    01 21700 41 0200 00001    YDATA
                    175    01 21700 42 0200 00003    YCALC
                    176    01 40000 00 4401 77574    MSUB
                    177    01 40007 00 4401 00036    END    +    1
                    200    01 21700 41 0200 00004    RESID
                    201    00 40000 42 4400 00135
                    202    01 40007 00 4401 00033    END    +    1
                    203    00 50401 52 0000 00010
                    204    02 20001 00 4002 00000
                    205    41 21641 00 0004 00000
                    206    01 21700 41 0200 00004    RESID
                    207    01 21700 42 0200 00004    RESID
                    210    01 40000 00 4401 77565    MMPY
                    211    01 40007 00 4401 00024    END    +    1
                    212    01 20001 00 4600 00005    SQSUM
                    213    01 21740 00 0001 00024    .N
                    214    01 10100 00 0001 00024    .M
                    215    01 53100 00 1000 00001
                    216    01 10600 00 0001 00026    +TW47
                    217    01 16700 00 0600 00005    SQSUM
                    220    01 20001 26 4100 00000
                    221    01 21700 42 0200 00006    SIGMA
                    222    00 40000 41 4401 77547    MCOPY
                    223    01 40007 00 4401 00012    END    +    1
                    224    01 50400 66 0100 77776
                    225    02 40000 00 4401 77543    SMMPY
                    226    01 40007 00 4401 00007    END    +    1
                    227    01 21700 41 0200 00006    SIGMA
                    230    00 40000 42 4400 00135
                    231    01 40007 00 4401 00004    END    +    1
                    232    00 50401 52 0000 00010
                    233    02 20001 00 4002 00000
                    234    41 21641 00 0004 00000
          END       235    01 01000 00 4400 00137
                    236    01 40006 00 4000 00000
                    237    07 01000 00 4200 00000

REFERENCE WORDS,,,

          SMMPY 77771    6254545770400000000
          MCOPY 77772    5442565770400000000
          MSUB  77773    5462644125400000000
          INV   77774    5055652525400000000
          TRAN  77775    6361405525400000000
          MMPY  77776    5454577025400000000
          LENGT 77777    5344554663400000000

INTERNAL STORAGE,,

          .N        240                    0
          .M        241                    0
          .H        242                    0
          .J        243                    0
          .I        244                    0
          +TW47     245    6200000000000000
```

PARAMETERS AT PF +

XDATA	0
YDATA	1
COEFS	2
YCALC	3
RESID	4
SQSUM	5
SIGMA	6

PFIT SYMBOL TABLE.

155	SQSUM	102	5	0	0	0
156	←BGIN	0	1	3	0	0
157	,N	200	240	3	0	0
160	,M	200	241	3	0	0
161	,H	200	242	3	0	0
162	,J	200	243	3	0	0
163	,I	200	244	3	0	0
164	EXPND	0	23	3	0	0
165	WORK	100	107	3	0	0
166	BNA	0	166	2	0	0
167	LOOP	0	51	3	0	0
170	←FOR1	0	55	3	0	0
171	←RPT1	0	105	3	0	0
172	←FOR2	0	61	3	0	0
173	←RPT2	0	103	3	0	0

SUBROUTINES REFERENCED

		137
GENIE,,,	SMMPY	
GENIE,,,	MCOPY	
GENIE,,,	MSUB	
GENIE,,,	INV	
GENIE,,,	TRAN	
		135
GENIE,,,	MMPY	
		126
GENIE,,,	LENGT	
		136

END OF DEFINITION SET. EXTERNAL SYMBOLS.

146	XDATA	140	0	0	0	0
147	SIGMA	140	0	0	0	0
150	YDATA	120	0	0	0	0
151	COEFS	120	0	0	0	0
152	YCALC	120	0	0	0	0
153	RESID	120	0	0	0	0
154	PFIT	10	0	0	0	0

```
                DEFINE                                                          2
                MATRIX XDATA, SIGMA                                             3
                VECTOR YDATA, COEFS, YCALC, RESID, WGHTS                        4
                PFIT(XDATA, YDATA, WGHTS, COEFS, YCALC, RESID, SQSUM, SIGMA
                INTEGER                 .N, .M, .H, .J, .I                      6
                .N = LENGTH(YDATA)                                              7
                .M = LENGTH(COEFS)                                              10
                .H = ROW (XDATA)                                                11
                .J = .M - .H                                                    12
                CC = - WATE .IF .J = 0                                          13
                Z       BAU             XDATA, U→B1                             14
                        LRS             27                                      15
                        CLA             -+1150                                  16
                        LRS             12                                      17
                        CLA             .J, U→B2                                20
                        LRS             15, R→T7                                21
                        TSR             *+126                                   22
                        SPF             *END+1                                  23
                        CLA             B1, U→B4                                24
                        CRL             15, R→B3                                25
                -B2     ADD             -B4+B3+1, U→B3                          26
                B3      BNA             B4+1, U→R                               27
                        CRL             15                                      30
                        LRL             12                                      31
                        CLA             -+0120                                  32
                        LRS             12                                      33
                R       CRR             15, U→T6                                34
LOOP            B3      RPA             T6, B2-1                                35
                T6      TSR             *+126, U→T7                             36
                        SPF             *END+1                                  37
                B2      IF(NZE)TRA      -LOOP, B3+1                             40
                FOR     .J = 1, 1, .N                                           41
                FOR     .I = .H+1, 1, .M                                        42
                XDATA .I,.J = XDATA .I-1,.J × XDATA .H,.J                       43
                REPEAT                                                          44
                REPEAT                                                          45
WATE            EXECUTE                 VSPACE(RESID, .N)                       46
                SIGMA = TRAN(XDATA)                                             47
                FOR .I = 1, 1, .N                                               50
                RESID .I = WGHTS .I × YDATA .I                                  51
                FOR .J = 1, 1, .M                                               52
                SIGMA .I,.J = SIGMA .I,.J × WGHTS .I                            53
                REPEAT                                                          54
                REPEAT                                                          55
WORK            COEFS = XDATA × RESID                                           56
                SIGMA = XDATA × SIGMA                                           57
                SIGMA = INV(SIGMA)                                              60
```

```
            COEFS = SIGMA × COEFS                                    61
            YCALC = TRAN(XDATA) × COEFS                              62
            RESID = YDATA - YCALC                                    63
SUMM        SQSUM = 0.0                                              64
            FOR     .I = 1, 1, .N                                    65
            SQSUM = SQSUM + WGHTS.I + RESID.I^2                      66
            REPEAT                                                   67
            SIGMA = SIGMA × (SQSUM / (.N-.M))                        70
END                                                                  71
            DEFINE                                                   72
LEAVE                                                                73
                                                                     74
```

```
PFIT     START NEW PROGRAM.                                  1/11/66 15.03

←BGIN    PROGRAM SEQUENCE,
LOOP     PROGRAM SEQUENCE,
←FOR1    PROGRAM SEQUENCE,
←FOR2    PROGRAM SEQUENCE,
←RPT2    PROGRAM SEQUENCE,
←RPT1    PROGRAM SEQUENCE,
WATE     PROGRAM SEQUENCE,
←FOR3    PROGRAM SEQUENCE,
←FOR4    PROGRAM SEQUENCE,
←RPT4    PROGRAM SEQUENCE,
←RPT3    PROGRAM SEQUENCE,
WORK     PROGRAM SEQUENCE,
SUMM     PROGRAM SEQUENCE,
←FOR5    PROGRAM SEQUENCE,
←RPT5    PROGRAM SEQUENCE,
END      PROGRAM SEQUENCE,


PFIT  .=

         ←BGIN      1    10 01000 02 4400 00136
                    2    01 40007 00 4100 77755
                    3    47 21641 00 0001 00314    END    +    1
                    4    01 21700 07 0200 00001    YDATA
                    5    01 40000 00 4401 77771    LENGT
                    6    01 40007 00 4401 00311    END    +    1
                    7    01 20001 00 4001 00312    ,N
                   10    01 21700 07 0200 00003    COEFS
                   11    01 40000 00 4401 77765    LENGT
                   12    01 40007 00 4401 00305    END    +    1
                   13    01 20001 00 4001 00307    ,M
                   14    01 21700 07 0200 00000    XDATA
                   15    01 40000 00 4401 77761    LENGT
                   16    01 40007 00 4401 00301    END    +    1
                   17    01 20001 00 4001 00304    ,H
                   20    01 21740 00 0001 00302    ,M
                   21    01 10100 00 0001 00302    ,H
                   22    01 20001 00 4001 00302    ,J
                   23    01 21740 00 0001 00301    ,J
                   24    01 02010 00 4000 00000
                   25    01 01000 00 4001 00002
                   26    01 21700 00 4001 00060    WATE
                   27    01 30000 40 0000 00000
                   30    00 20100 41 0200 00000    XDATA
                   31    01 45015 00 4000 00033
                   32    01 21700 00 4000 01150
                   33    01 45015 00 4000 00014
                   34    01 21700 42 0001 00270    ,J
                   35    01 45015 17 4000 00017
                   36    01 40000 00 4400 00126
                   37    01 40007 00 4401 00260    END    +    1
                   40    01 21700 44 0002 00000
                   41    01 45066 53 4000 00017
                   42    52 10000 43 4030 00001
                   43    43 21603 02 0020 00001
                   44    01 45066 00 4000 00017
                   45    01 45002 00 4000 00014
                   46    01 21700 00 4000 00120
                   47    01 45015 00 4000 00014
                   50    02 45055 06 4000 00017
         LOOP      51    43 21601 62 0000 00006
                   52    06 40000 07 4400 00126
                   53    01 40007 00 4401 00244    END    +    1
```

```
                54  42 01050 23 4001 77773     LOOP
+FOR1           55  20 20001 00 4001 00247     ,J
                56  01 21700 00 0001 00243     ,N
                57  01 02110 00 0001 00245     ,J
                60  01 01000 00 4001 00026     +RPT1 +     2
+FOR2           61  20 10000 00 0001 00242     ,H
                62  01 20001 00 4001 00243     ,I
                63  01 21700 00 0001 00237     ,M
                64  01 02110 00 0001 00241     ,I
                65  01 01000 00 4001 00017     +RPT2 +     2
                66  01 21700 06 0001 00236     ,J
                67  20 14102 26 0001 00236     ,I
                70  06 30000 42 0000 00000
                71  01 21740 41 0100 77776
                72  01 21740 66 0600 00000     XDATA
                73  01 30000 04 0000 00000
                74  06 30000 42 0000 00000
                75  01 21740 41 0001 00226     ,H
                76  01 21740 00 0600 00000     XDATA
                77  01 10620 02 0000 00004     T4
                100 06 30000 42 0000 00000
                101 01 21700 41 0001 00224     ,I
                102 02 20001 00 4600 00000     XDATA
+RPT2           103 20 10401 00 0001 00222     ,I
                104 01 01000 00 4001 77755     +FOR2 +     2
+RPT1           105 20 10401 00 0001 00217     ,J
                106 01 01000 00 4001 77746     +FOR1 +     1
WATE            107 01 21702 26 0200 00005     RESID
                110 00 20102 26 4001 00211     ,N
                111 01 40000 00 4401 77664     VSPAC
                112 01 40007 00 4401 00205     END   +     1
                113 01 21700 07 0200 00000     XDATA
                114 01 40000 00 4401 77660     TRAN
                115 01 40007 00 4401 00202     END   +     1
                116 01 21700 41 0200 00007     SIGMA
                117 00 40000 42 4400 00135
                120 01 40007 00 4401 00177     END   +     1
                121 00 50401 52 0000 00010
                122 02 20001 00 4002 00000
                123 41 21641 00 0004 00000
+FOR3           124 20 20001 00 4001 00201     ,I
                125 01 21700 00 0001 00174     ,N
                126 01 02110 00 0001 00177     ,I
                127 01 01000 00 4001 00031     +RPT3 +     2
                130 01 21740 41 0001 00175     ,I
                131 01 21740 04 0600 00002     WGHTS
                132 01 21740 41 0001 00173     ,I
                133 01 21740 00 0600 00001     YDATA
                134 01 10620 02 0000 00004     T4
                135 01 21700 41 0001 00170     ,I
                136 02 20001 00 4600 00005     RESID
+FOR4           137 20 20001 00 4001 00165     ,J
                140 01 21700 00 0001 00162     ,M
                141 01 02110 00 0001 00163     ,J
                142 01 01000 00 4001 00014     +RPT4 +     2
                143 01 21700 06 0001 00162     ,I
                144 01 21700 42 0001 00160     ,J
                145 01 21740 41 0000 00006     T6
                146 01 21740 04 0600 00007     SIGMA
                147 01 21740 41 0000 00006     T6
                150 01 21740 00 0600 00002     WGHTS
                151 01 10620 02 0000 00004     T4
                152 01 21700 42 0001 00152     ,J
                153 06 30000 41 0000 00000
                154 02 20001 00 4600 00007     SIGMA
+RPT4           155 20 10401 00 0001 00147     ,J
```

```
        156   01 01000 00 4001 77760   ←FOR4 +     1
←RPT3   157   20 10401 00 0001 00146   .I
        160   01 01000 00 4001 77743   ←FOR3 +     1
WORK    161   01 21700 41 0200 00000   XDATA
        162   01 21700 42 0200 00005   RESID
        163   01 40000 00 4401 77610   MMPY
        164   01 40007 00 4401 00133   END   +     1
        165   01 21700 41 0200 00003   COEFS
        166   00 40000 42 4400 00135
        167   01 40007 00 4401 00130   END   +     1
        170   00 50401 52 0000 00010
        171   02 20001 00 4002 00000
        172   41 21641 00 0004 00000
        173   01 21700 41 0200 00000   XDATA
        174   01 21700 42 0200 00007   SIGMA
        175   01 40000 00 4401 77576   MMPY
        176   01 40007 00 4401 00121   END   +     1
        177   01 21700 41 0200 00007   SIGMA
        200   00 40000 42 4400 00135
        201   01 40007 00 4401 00116   END   +     1
        202   00 50401 52 0000 00010
        203   02 20001 00 4002 00000
        204   41 21641 00 0004 00000
        205   01 21700 07 0200 00007   SIGMA
        206   01 40000 00 4401 77564   INV
        207   01 40007 00 4401 00110   END   +     1
        210   01 21700 41 0200 00007   SIGMA
        211   00 40000 42 4400 00135
        212   01 40007 00 4401 00105   END   +     1
        213   00 50401 52 0000 00010
        214   02 20001 00 4002 00000
        215   41 21641 00 0004 00000
        216   01 21700 41 0200 00007   SIGMA
        217   01 21700 42 0200 00003   COEFS
        220   01 40000 00 4401 77553   MMPY
        221   01 40007 00 4401 00076   END   +     1
        222   01 21700 41 0200 00003   COEFS
        223   00 40000 42 4400 00135
        224   01 40007 00 4401 00073   END   +     1
        225   00 50401 52 0000 00010
        226   02 20001 00 4002 00000
        227   41 21641 00 0004 00000
        230   01 21700 07 0200 00000   XDATA
        231   01 40000 00 4401 77543   TRAN
        232   01 40007 00 4401 00065   END   +     1
        233   01 21700 42 0200 00003   COEFS
        234   00 40000 41 4401 77537   MMPY
        235   01 40007 00 4401 00062   END   +     1
        236   01 21700 41 0200 00004   YCALC
        237   00 40000 42 4400 00135
        240   01 40007 00 4401 00057   END   +     1
        241   00 50401 52 0000 00010
        242   02 20001 00 4002 00000
        243   41 21641 00 0004 00000
        244   01 21700 41 0200 00001   YDATA
        245   01 21700 42 0200 00004   YCALC
        246   01 40000 00 4401 77523   MSUB
        247   01 40007 00 4401 00050   END   +     1
        250   01 21700 41 0200 00005   RESID
        251   00 40000 42 4400 00135
        252   01 40007 00 4401 00045   END   +     1
        253   00 50401 52 0000 00010
        254   02 20001 00 4002 00000
        255   41 21641 00 0004 00000
SUMM    256   00 20001 00 4600 00006   SQSUM
←FOR5   257   20 20001 00 4001 00046   .I
```

```
                    260    01 21700 00 0001 00041    .N
                    261    01 02110 00 0001 00044    .I
                    262    01 01000 00 4001 00012    ←RPT5 +     2
                    263    01 21700 06 0001 00042    .I
                    264    01 21740 41 0000 00006    T6
                    265    01 21740 00 0600 00005    RESID
                    266    01 10600 04 0000 00001
                    267    01 21740 41 0000 00006    T6
                    270    01 21740 00 0600 00002    WGHTS
                    271    01 10400 00 0000 00004    T4
                    272    01 10401 00 0600 00006    SQSUM
          ←RPT5     273    20 10401 00 0001 00032    .I
                    274    01 01000 00 4001 77762    ←FOR5 +     1
                    275    01 21740 00 0001 00024    .N
                    276    01 10100 00 0001 00024    .M
                    277    01 53100 00 1000 00001
                    300    01 10600 00 0001 00026    ←TW47
                    301    01 16700 00 0600 00006    SQSUM
                    302    01 20001 26 4100 00000
                    303    01 21700 42 0200 00007    SIGMA
                    304    00 40000 41 4401 77464    MCOPY
                    305    01 40007 00 4401 00012    END   +     1
                    306    01 50400 66 0100 77776
                    307    02 40000 00 4401 77460    SMMPY
                    310    01 40007 00 4401 00007    END   +     1
                    311    01 21700 41 0200 00007    SIGMA
                    312    00 40000 42 4400 00135
                    313    01 40007 00 4401 00004    END   +     1
                    314    00 50401 52 0000 00010
                    315    02 20001 00 4002 00000
                    316    41 21641 00 0004 00000
          END       317    01 01000 00 4400 00137
                    320    01 40005 00 4000 00000
                    321    07 01000 00 4200 00000

REFERENCE WORDS,,,

          SMMPY  77770    6254545770400000000
          MCOPY  77771    5442565770400000000
          MSUB   77772    5462644125400000000
          INV    77773    5055652525400000000
          MMPY   77774    5454577025400000000
          TRAN   77775    6361405525400000000
          VSPAC  77776    6562574042400000000
          LENGT  77777    5344554663400000000

INTERNAL STORAGE,,
          .N        322                    0
          .M        323                    0
          .H        324                    0
          .J        325                    0
          .I        326                    0
          ←TW47     327    6200000000000000

     PARAMETERS AT PF +
          XDATA          0
          YDATA          1
          WGHTS          2
          COEFS          3
          YCALC          4
          RESID          5
          SQSUM          6
          SIGMA          7
```

PFIT SYMBOL TABLE.

156	SQSUM	102	6	0		0	0
157	←BGIN	0	1	3		0	0
160	.N	200	322	3		0	0
161	.M	200	323	3		0	0
162	.H	200	324	3		0	0
163	.J	200	325	3		0	0
164	.I	200	326	3		0	0
165	WATE	100	107	3		0	0
166	BNA	0	166	2		0	0
167	LOOP	0	51	3		0	0
170	←FOR1	0	55	3		0	0
171	←RPT1	0	105	3		0	0
172	←FOR2	0	61	3		0	0
173	←RPT2	0	103	3		0	0
174	←FOR3	0	124	3		0	0
175	←RPT3	0	157	3		0	0
176	←FOR4	0	137	3		0	0
177	←RPT4	0	155	3		0	0
200	WORK	0	161	3		0	0
201	SUMM	0	256	3		0	0
202	←FOR5	0	257	3		0	0
203	←RPT5	0	273	3		0	0

SUBROUTINES REFERENCED

		137
GENIE...	SMMPY	
GENIE...	MCOPY	
GENIE...	MSUB	
GENIE...	INV	
GENIE...	MMPY	
		135
GENIE...	TRAN	
GENIE...	VSPAC	
		126
GENIE...	LENGT	
		136

END OF DEFINITION SET. EXTERNAL SYMBOLS.

146	XDATA	140	0	0		0	0
147	SIGMA	140	0	0		0	0
150	YDATA	120	0	0		0	0
151	COEFS	120	0	0		0	0
152	YCALC	120	0	0		0	0
153	RESID	120	0	0		0	0
154	WGHTS	120	0	0		0	0
155	PFIT	10	0	0		0	0

```
                                                                    1
        DEFINE                                                      2
        MATRIX XDATA, SIGMA                                         3
        VECTOR YDATA, COEFS, YCALC, RESID                           4
        GFIT(XDATA, YDATA, COEFS, YCALC, RESID, SQSUM, SIGMA),=SEQ
        INTEGER                  ,N, ,M                             6
        ,N = LENGTH(YDATA)                                          7
        ,M = ROW(XDATA)                                            10
WORK    COEFS = XDATA × YDATA                                      11
        SIGMA = XDATA × TRAN(XDATA)                                12
        SIGMA = INV(SIGMA)                                         13
        COEFS = SIGMA × COEFS                                      14
        YCALC = TRAN(XDATA) × COEFS                                15
        RESID = YDATA - YCALC                                      16
        SQSUM = RESID × RESID                                      17
        SIGMA = SIGMA × (SQSUM / (,N-,M))                          20
                                                                   21
END
        DEFINE                                                     22
                                                                   23
LEAVE                                                              24
```

```
GFIT     START NEW PROGRAM.                                  1/11/66 15.09

←BGIN    PROGRAM SEQUENCE.
WATE     PROGRAM SEQUENCE.
←FOR1    PROGRAM SEQUENCE.
←FOR2    PROGRAM SEQUENCE.
←RPT2    PROGRAM SEQUENCE.
←RPT1    PROGRAM SEQUENCE.
WORK     PROGRAM SEQUENCE.
←FOR3    PROGRAM SEQUENCE.
←RPT3    PROGRAM SEQUENCE.
END      PROGRAM SEQUENCE.
```

no weights.

```
GFIT  .=

          ←BGIN     1    10 01000 02 4400 00136
                    2    01 40007 00 4100 77755
                    3    47 21641 00 0001 00221    END    +    1
                    4    01 21700 07 0200 00001    YDATA
                    5    01 40000 00 4401 77771    LENGT
                    6    01 40007 00 4401 00216    END    +    1
                    7    01 20001 00 4001 00217    .N
                   10    01 21700 07 0200 00000    XDATA
                   11    01 40000 00 4401 77765    LENGT
                   12    01 40007 00 4401 00212    END    +    1
                   13    01 20001 00 4001 00214    .M
          WATE     14    01 21702 26 0200 00005    RESID
                   15    00 20102 26 4001 00211    .N
                   16    01 40000 00 4401 77757    VSPAC
                   17    01 40007 00 4401 00205    END    +    1
                   20    01 21700 07 0200 00000    XDATA
                   21    01 40000 00 4401 77753    TRAN
                   22    01 40007 00 4401 00202    END    +    1
                   23    01 21700 41 0200 00007    SIGMA
                   24    00 40000 42 4400 00135
                   25    01 40007 00 4401 00177    END    +    1
                   26    00 50401 52 0000 00010
                   27    02 20001 00 4002 00000
                   30    41 21641 00 0004 00000
          ←FOR1    31    20 20001 00 4001 00177    .I
                   32    01 21700 00 0001 00174    .N
                   33    01 02110 00 0001 00175    .I
                   34    01 01000 00 4001 00031    ←RPT1  +    2
                   35    01 21740 41 0001 00173    .I
                   36    01 21740 04 0600 00002    WGHTS
                   37    01 21740 41 0001 00171    .I
                   40    01 21740 00 0600 00001    YDATA
                   41    01 10620 02 0000 00004    T4
                   42    01 21700 41 0001 00166    .I
                   43    02 20001 00 4600 00005    RESID
          ←FOR2    44    20 20001 00 4001 00165    .J
                   45    01 21700 00 0001 00162    .M
                   46    01 02110 00 0001 00163    .J
                   47    01 01000 00 4001 00014    ←RPT2  +    2
                   50    01 21700 06 0001 00160    .I
                   51    01 21700 42 0001 00160    .J
                   52    01 21740 41 0000 00006    T6
                   53    01 21740 04 0600 00007    SIGMA
```

```
                54  01 21740 41 0000 00006     T6
                55  01 21740 00 0600 00002     WGHTS
                56  01 10620 02 0000 00004     T4
                57  01 21700 42 0001 00152     ,J
                60  06 30000 41 0000 00000
                61  02 20001 00 4600 00007     SIGMA
 ←RPT2          62  20 10401 00 0001 00147     ,J
                63  01 01000 00 4001 77760     ←FOR2 +     1
 ←RPT1          64  20 10401 00 0001 00144     ,I
                65  01 01000 00 4001 77743     ←FOR1 +     1
 WORK           66  01 21700 41 0200 00000     XDATA
                67  01 21700 42 0200 00005     RESID
                70  01 40000 00 4401 77703     MMPY
                71  01 40007 00 4401 00133     END   +     1
                72  01 21700 41 0200 00003     COEFS
                73  00 40000 42 4400 00135
                74  01 40007 00 4401 00130     END   +     1
                75  00 50401 52 0000 00010
                76  02 20001 00 4002 00000
                77  41 21641 00 0004 00000
               100  01 21700 41 0200 00000     XDATA
               101  01 21700 42 0200 00007     SIGMA
               102  01 40000 00 4401 77671     MMPY
               103  01 40007 00 4401 00121     END   +     1
               104  01 21700 41 0200 00007     SIGMA
               105  00 40000 42 4400 00135
               106  01 40007 00 4401 00116     END   +     1
               107  00 50401 52 0000 00010
               110  02 20001 00 4002 00000
               111  41 21641 00 0004 00000
               112  01 21700 07 0200 00007     SIGMA
               113  01 40000 00 4401 77657     INV
               114  01 40007 00 4401 00110     END   +     1
               115  01 21700 41 0200 00007     SIGMA
               116  00 40000 42 4400 00135
               117  01 40007 00 4401 00105     END   +     1
               120  00 50401 52 0000 00010
               121  02 20001 00 4002 00000
               122  41 21641 00 0004 00000
               123  01 21700 41 0200 00007     SIGMA
               124  01 21700 42 0200 00003     COEFS
               125  01 40000 00 4401 77646     MMPY
               126  01 40007 00 4401 00076     END   +     1
               127  01 21700 41 0200 00003     COEFS
               130  00 40000 42 4400 00135
               131  01 40007 00 4401 00073     END   +     1
               132  00 50401 52 0000 00010
               133  02 20001 00 4002 00000
               134  41 21641 00 0004 00000
               135  01 21700 07 0200 00000     XDATA
               136  01 40000 00 4401 77636     TRAN
               137  01 40007 00 4401 00065     END   +     1
               140  01 21700 42 0200 00003     COEFS
               141  00 40000 41 4401 77632     MMPY
               142  01 40007 00 4401 00062     END   +     1
               143  01 21700 41 0200 00004     YCALC
               144  00 40000 42 4400 00135
               145  01 40007 00 4401 00057     END   +     1
               146  00 50401 52 0000 00010
               147  02 20001 00 4002 00000
               150  41 21641 00 0004 00000
               151  01 21700 41 0200 00001     YDATA
               152  01 21700 42 0200 00004     YCALC
               153  01 40000 00 4401 77616     MSUB
               154  01 40007 00 4401 00050     END   +     1
               155  01 21700 41 0200 00005     RESID
```

```
                        156     00 40000 42 4400 00135
                        157     01 40007 00 4401 00045      END    +     1
                        160     00 50401 52 0000 00010
                        161     02 20001 00 4002 00000
                        162     41 21641 00 0004 00000
                        163     00 20001 00 4600 00006      SQSUM
              ←FOR3     164     20 20001 00 4001 00044      ,I
                        165     01 21700 00 0001 00041      ,N
                        166     01 02110 00 0001 00042      ,I
                        167     01 01000 00 4001 00012      ←RPT3  +     2
                        170     01 21700 06 0001 00040      ,I
                        171     01 21740 41 0000 00006      T6
                        172     01 21740 00 0600 00005      RESID
                        173     01 10600 04 0000 00001
                        174     01 21740 41 0000 00006      T6
                        175     01 21740 00 0600 00002      WGHTS
                        176     01 10620 00 0000 00004      T4
                        177     01 10401 00 0600 00006      SQSUM
              ←RPT3     200     20 10401 00 0001 00030      ,I
                        201     01 01000 00 4001 77762      ←FOR3  +     1
                        202     01 21740 00 0001 00024      ,N
                        203     01 10100 00 0001 00024      ,M
                        204     01 53100 00 1000 00001
                        205     01 10600 00 0001 00025      ←TW47
                        206     01 16700 00 0600 00006      SQSUM
                        207     01 20001 26 4100 00000
                        210     01 21700 42 0200 00007      SIGMA
                        211     00 40000 41 4401 77557      MCOPY
                        212     01 40007 00 4401 00012      END    +     1
                        213     01 50400 66 0100 77776
                        214     02 40000 00 4401 77553      SMMPY
                        215     01 40007 00 4401 00007      END    +     1
                        216     01 21700 41 0200 00007      SIGMA
                        217     00 40000 42 4400 00135
                        220     01 40007 00 4401 00004      END    +     1
                        221     00 50401 52 0000 00010
                        222     02 20001 00 4002 00000
                        223     41 21641 00 0004 00000
              END       224     01 01000 00 4400 00137
                        225     01 40006 00 4000 00000
                        226     07 01000 00 4200 00000

REFERENCE WORDS,,,

              SMMPY  77770    6254545770400000000
              MCOPY  77771    5442565770400000000
              MSUB   77772    5462644125400000000
              INV    77773    5055652525400000000
              MMPY   77774    5454577025400000000
              TRAN   77775    6361405525400000000
              VSPAC  77776    6562574042400000000
```

```
                                                                    1
        DEFINE                                                      2
        MATRIX XDATA, SIGMA                                         3
        VECTOR YDATA, COEFS, YCALC, RESID, WGHTS                    4
        GFIT(XDATA, YDATA, WGHTS, COEFS, YCALC, RESID, SQSUM, SIGMA),=
        INTEGER                  ,I, ,N, ,M                         6
        ,N = LENGTH(YDATA)                                          7
        ,M = ROW(XDATA)                                            10
WATE    EXECUTE                  VSPACE(RESID, ,N)                 11
        SIGMA = TRAN(XDATA)                                        12
        FOR ,I = 1, 1, ,N                                          13
        RESID  ,,I = WGHTS  ,,I × YDATA  ,,I                       14
        FOR ,J = 1, 1, ,M                                          15
        SIGMA  ,,I,,J = SIGMA  ,,I,,J × WGHTS  ,,I                 16
        REPEAT                                                     17
        REPEAT                                                     20
WORK    COEFS = XDATA × RESID                                      21
        SIGMA = XDATA × SIGMA                                      22
        SIGMA = INV(SIGMA)                                         23
        COEFS = SIGMA × COEFS                                      24
        YCALC = TRAN(XDATA) × COEFS                                25
        RESID = YDATA - YCALC                                      26
        SQSUM = 0.0                                                27
        FOR    ,I = 1, 1, ,N                                       30
        SQSUM = SQSUM + WGHTS  ,,I × RESID  ,,I ^2                 31
        REPEAT                                                     32
        SIGMA = SIGMA × (SQSUM / (,N-,M))                          33
END                                                                34
        DEFINE                                                     35
LEAVE                                                              36
                                                                   37
```

```
GFIT     START NEW PROGRAM.                                  1/11/66 15.11

←BGIN    PROGRAM SEQUENCE.
WATE     PROGRAM SEQUENCE.
←FOR1    PROGRAM SEQUENCE.
←FOR2    PROGRAM SEQUENCE.
←RPT2    PROGRAM SEQUENCE.
←RPT1    PROGRAM SEQUENCE.
WORK     PROGRAM SEQUENCE.
←FOR3    PROGRAM SEQUENCE.
←RPT3    PROGRAM SEQUENCE.
END      PROGRAM SEQUENCE.
```

Weights.

```
GFIT  .=

          ←BGIN    1    10 01000 02 4400 00136
                   2    01 40007 00 4100 77755
                   3    47 21641 00 0001 00221    END    +    1
                   4    01 21700 07 0200 00001    YDATA
                   5    01 40000 00 4401 77771    LENGT
                   6    01 40007 00 4401 00216    END    +    1
                   7    01 20001 00 4001 00217    .N
                  10    01 21700 07 0200 00000    XDATA
                  11    01 40000 00 4401 77765    LENGT
                  12    01 40007 00 4401 00212    END    +    1
                  13    01 20001 00 4001 00214    .M
          WATE    14    01 21702 26 0200 00005    RESID
                  15    00 20102 26 4001 00211    .N
                  16    01 40000 00 4401 77757    VSPAC
                  17    01 40007 00 4401 00205    END    +    1
                  20    01 21700 07 0200 00000    XDATA
                  21    01 40000 00 4401 77753    TRAN
                  22    01 40007 00 4401 00202    END    +    1
                  23    01 21700 41 0200 00007    SIGMA
                  24    00 40000 42 4400 00135
                  25    01 40007 00 4401 00177    END    +    1
                  26    00 50401 52 0000 00010
                  27    02 20001 00 4002 00000
                  30    41 21641 00 0004 00000
          ←FOR1   31    20 20001 00 4001 00177    .I
                  32    01 21700 00 0001 00174    .N
                  33    01 02110 00 0001 00175    .I
                  34    01 01000 00 4001 00031    ←RPT1  +    2
                  35    01 21740 41 0001 00173    .I
                  36    01 21740 04 0600 00002    WGHTS
                  37    01 21740 41 0001 00171    .I
                  40    01 21740 00 0600 00001    YDATA
                  41    01 10620 02 0000 00004    T4
                  42    01 21700 41 0001 00166    .I
                  43    02 20001 00 4600 00005    RESID
          ←FOR2   44    20 20001 00 4001 00165    .J
                  45    01 21700 00 0001 00162    .M
                  46    01 02110 00 0001 00163    .J
                  47    01 01000 00 4001 00014    ←RPT2  +    2
                  50    01 21700 06 0001 00160    .I
                  51    01 21700 42 0001 00160    .J
                  52    01 21740 41 0000 00006    T6
                  53    01 21740 04 0600 00007    SIGMA
```

```
                54  01 21740 41 0000 00006   T6
                55  01 21740 00 0600 00002   WGHTS
                56  01 10620 02 0000 00004   T4
                57  01 21700 42 0001 00152   .J
                60  06 30000 41 0000 00000
                61  02 20001 00 4600 00007   SIGMA
 ←RPT2          62  20 10401 00 0001 00147   .J
                63  01 01000 00 4001 77760   ←FOR2 +     1
 ←RPT1          64  20 10401 00 0001 00144   .I
                65  01 01000 00 4001 77743   ←FOR1 +     1
 WORK           66  01 21700 41 0200 00000   XDATA
                67  01 21700 42 0200 00005   RESID
                70  01 40000 00 4401 77703   MMPY
                71  01 40007 00 4401 00133   END   +     1
                72  01 21700 41 0200 00003   COEFS
                73  00 40000 42 4400 00135
                74  01 40007 00 4401 00130   END   +     1
                75  00 50401 52 0000 00010
                76  02 20001 00 4002 00000
                77  41 21641 00 0004 00000
               100  01 21700 41 0200 00000   XDATA
               101  01 21700 42 0200 00007   SIGMA
               102  01 40000 00 4401 77671   MMPY
               103  01 40007 00 4401 00121   END   +     1
               104  01 21700 41 0200 00007   SIGMA
               105  00 40000 42 4400 00135
               106  01 40007 00 4401 00116   END   +     1
               107  00 50401 52 0000 00010
               110  02 20001 00 4002 00000
               111  41 21641 00 0004 00000
               112  01 21700 07 0200 00007   SIGMA
               113  01 40000 00 4401 77657   INV
               114  01 40007 00 4401 00110   END   +     1
               115  01 21700 41 0200 00007   SIGMA
               116  00 40000 42 4400 00135
               117  01 40007 00 4401 00105   END   +     1
               120  00 50401 52 0000 00010
               121  02 20001 00 4002 00000
               122  41 21641 00 0004 00000
               123  01 21700 41 0200 00007   SIGMA
               124  01 21700 42 0200 00003   COEFS
               125  01 40000 00 4401 77646   MMPY
               126  01 40007 00 4401 00076   END   +     1
               127  01 21700 41 0200 00003   COEFS
               130  00 40000 42 4400 00135
               131  01 40007 00 4401 00073   END   +     1
               132  00 50401 52 0000 00010
               133  02 20001 00 4002 00000
               134  41 21641 00 0004 00000
               135  01 21700 07 0200 00000   XDATA
               136  01 40000 00 4401 77636   TRAN
               137  01 40007 00 4401 00065   END   +     1
               140  01 21700 42 0200 00003   COEFS
               141  00 40000 41 4401 77632   MMPY
               142  01 40007 00 4401 00062   END   +     1
               143  01 21700 41 0200 00004   YCALC
               144  00 40000 42 4400 00135
               145  01 40007 00 4401 00057   END   +     1
               146  00 50401 52 0000 00010
               147  02 20001 00 4002 00000
               150  41 21641 00 0004 00000
               151  01 21700 41 0200 00001   YDATA
               152  01 21700 42 0200 00004   YCALC
               153  01 40000 00 4401 77616   MSUB
               154  01 40007 00 4401 00050   END   +     1
               155  01 21700 41 0200 00005   RESID
```

```
                        156    00 40000 42 4400 00135
                        157    01 40007 00 4401 00045     END    +     1
                        160    00 50401 52 0000 00010
                        161    02 20001 00 4002 00000
                        162    41 21641 00 0004 00000
                        163    00 20001 00 4600 00006     SQSUM
              ←FOR3     164    20 20001 00 4001 00044     ,I
                        165    01 21700 00 0001 00041     ,N
                        166    01 02110 00 0001 00042     ,I
                        167    01 01000 00 4001 00012     ←RPT3  +     2
                        170    01 21700 06 0001 00040     ,I
                        171    01 21740 41 0000 00006     T6
                        172    01 21740 00 0600 00005     RESID
                        173    01 10600 04 0000 00001
                        174    01 21740 41 0000 00006     T6
                        175    01 21740 00 0600 00002     WGHTS
                        176    01 10620 00 0000 00004     T4
                        177    01 10401 00 0600 00006     SQSUM
              ←RPT3     200    20 10401 00 0001 00030     ,I
                        201    01 01000 00 4001 77762     ←FOR3  +     1
                        202    01 21740 00 0001 00024     ,N
                        203    01 10100 00 0001 00024     ,M
                        204    01 53100 00 1000 00001
                        205    01 10600 00 0001 00025     ←TW47
                        206    01 16700 00 0600 00006     SQSUM
                        207    01 20001 26 4100 00000
                        210    01 21700 42 0200 00007     SIGMA
                        211    00 40000 41 4401 77557     MCOPY
                        212    01 40007 00 4401 00012     END    +     1
                        213    01 50400 66 0100 77776
                        214    02 40000 00 4401 77553     SMMPY
                        215    01 40007 00 4401 00007     END    +     1
                        216    01 21700 41 0200 00007     SIGMA
                        217    00 40000 42 4400 00135
                        220    01 40007 00 4401 00004     END    +     1
                        221    00 50401 52 0000 00010
                        222    02 20001 00 4002 00000
                        223    41 21641 00 0004 00000
                END     224    01 01000 00 4400 00137
                        225    01 40006 00 4000 00000
                        226    07 01000 00 4200 00000
REFERENCE WORDS,,,

                SMMPY  77770    6254545770400000000
                MCOPY  77771    5442565770400000000
                MSUB   77772    5462644125400000000
                INV    77773    5055652525400000000
                MMPY   77774    5454577025400000000
                TRAN   77775    6361405525400000000
                VSPAC  77776    6562574042400000000
                LENGT  77777    5344554663400000000
INTERNAL STORAGE,,
                 ,N      227                       0
                 ,M      230                       0
                 .I      231                       0
                 ,J      232                       0
                ←TW47    233     6200000000000000000

        PARAMETERS AT PF +
                XDATA       0
                YDATA       1
                WGHTS       2
                COEFS       3
                YCALC       4
                RESID       5
                SQSUM       6
```

GFIT SYMBOL TABLE.

156	SQSUM	102	6	0		0	0
157	←BGIN	0	1	3		0	0
160	,I	200	231	3		0	0
161	,N	200	227	3		0	0
162	,M	200	230	3		0	0
163	WATE	0	14	3		0	0
164	←FOR1	0	31	3		0	0
165	←RPT1	0	64	3		0	0
166	←FOR2	0	44	3		0	0
167	,J	200	232	3		0	0
170	←RPT2	0	62	3		0	0
171	WORK	0	66	3		0	0
172	←FOR3	0	164	3		0	0
173	←RPT3	0	200	3		0	0

SUBROUTINES REFERENCED

137

GENIE,,, SMMPY
GENIE,,, MCOPY
GENIE,,, MSUB
GENIE,,, INV
GENIE,,, MMPY

135

GENIE,,, TRAN
GENIE,,, VSPAC
GENIE,,, LENGT

136

END OF DEFINITION SET. EXTERNAL SYMBOLS.

146	XDATA	140	0	0		0	0
147	SIGMA	140	0	0		0	0
150	YDATA	120	0	0		0	0
151	COEFS	120	0	0		0	0
152	YCALC	120	0	0		0	0
153	RESID	120	0	0		0	0
154	WGHTS	120	0	0		0	0
155	GFIT	10	0	0		0	0

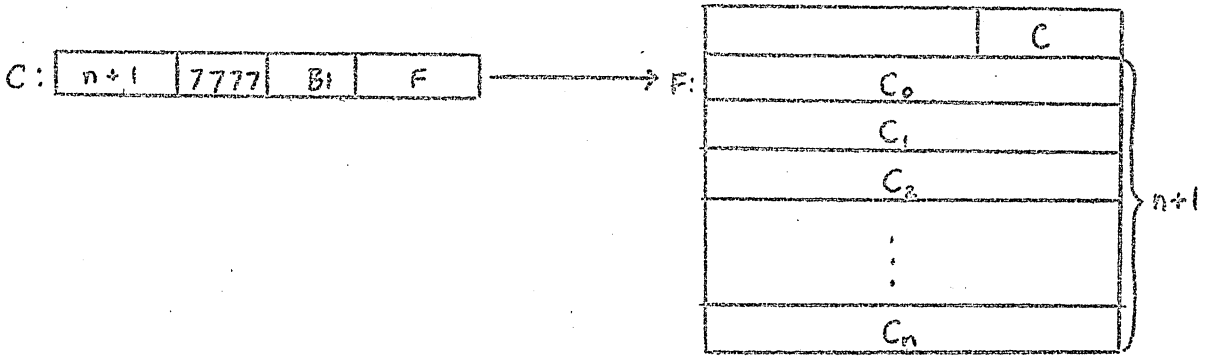
Polynomials

POLYNOMIAL ROUTINES

These routines operate on linear arrays interpreted as polynomials. The polynomial

$$C_0 + C_1 x + C_2 x^2 + \cdots + C_n x^n$$

is represented in the machine by the 77777 base vector of coefficients with codeword at location C as shown below.



The specific format requirements for the polynomials are:

(1) STEX must be activated before loading the polynomials.

(2) The polynomials must be indexed with B1.

(3) The base index of the polynomials must be corrected to 77777.

(4) The constant term must be located in the initial word of the array (indexed (B1) = 0); the succeeding coefficients are to be arranged in order of ascending subscripts. Thus, the coefficient of x^n is reached by setting (B1) = n and addressing *C.

(5) All routines except PADD must be entered with the high order coefficient of each polynomial non-zero. The programmer may obtain this form before beginning calculations by adding the constant zero (as a one-element array) to his polynomial through PADD.

All routines (except as noted below) are entered with B1 containing the codeword address of the first operand and B2 the codeword address of the second operand, if any. Upon exit, the B1 polynomial has been destroyed and the codeword of the result polynomial is left at the original B1 address; B1, B2, and the B2 polynomial are undisturbed.

There are no restrictions on the relative sizes of the polynomials operated on by any of these routines.

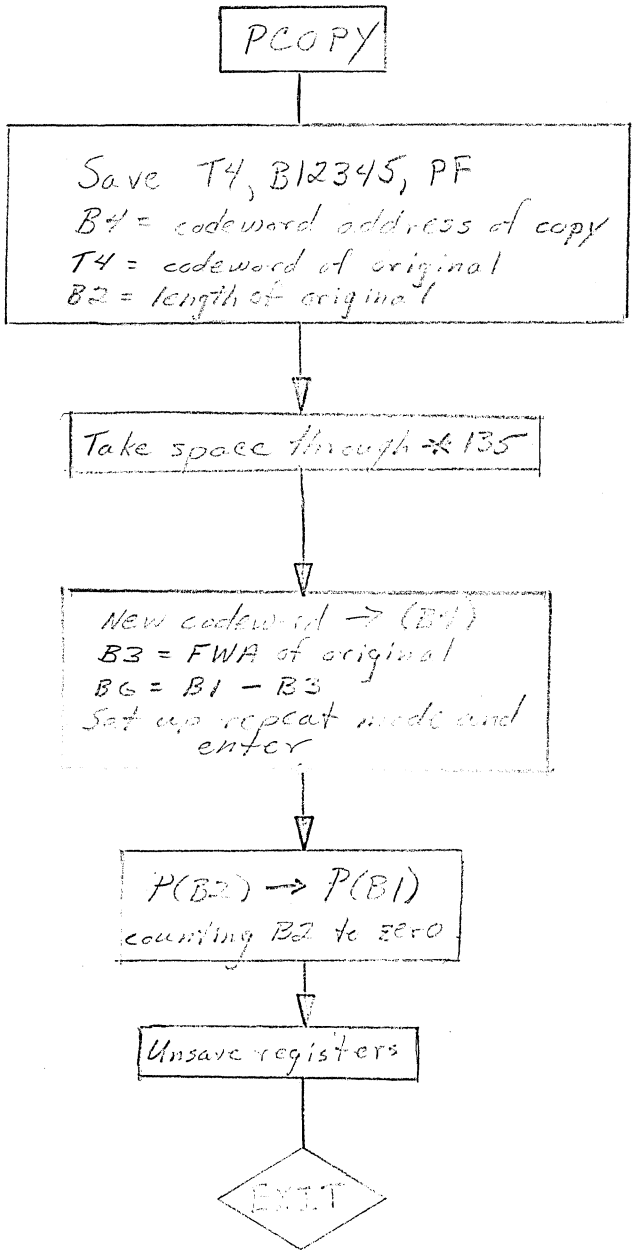
All fast registers used are saved and restored via *136 and *137 (except as noted below), exit is to PF, and no error conditions are considered.

NAME	PROGRAM NUMBER	INPUT	OUTPUT	STORAGE$_8$	REGISTERS, SUBROUTINES USED	NOTES
PCOPY	220	(B1)=codeword address for copy of P(B2), (B2)=codeword address of polynomial P(B2)	(B1), (B2), P(B2) unchanged; P(B1)'= P(B2)	17	*135, *136, *137	
PADD	221	(B1)=codeword address of polynomial P(B1), (B2)=codeword address of polynomial P(B2)	(B1), (B2), P(B2) unchanged; P(B1)'= P(B1)+P(B2)	54	*135, *136, *137	
PSUB	222	Same as for *221, PADD	(B1), (B2), P(B2) unchanged; P(B1)'= P(B1)-P(B2)	3	*221 (PADD)	
PMUL	225	(B1)=codeword address of polynomial P(B1), (B2)=codeword address of polynomial P(B2)	(B1), (B2), P(B2) unchanged; P(B1)'= P(B1)xP(B2)	43	*135, *136, *137	
PDIV	224	(B1)=codeword address of polynomial P(B1), (B2)=codeword address of polynomial P(B2), (B3)=address of location to be used for codeword of remainder P(B3)	(B1), (B2), (B3), P(B2) unchanged; $\frac{P(B1)}{P(B2)} = P(B1)' + \frac{P(B3)}{P(B2)}$	136	*135, *136, *137	(B3)=0 suppresses remainder

NAME	PROGRAM NUMBER	INPUT	OUTPUT	STORAGE$_8$	REGISTERS, SUBROUTINES USED	NOTES
PEVAL	225	(B1)=codeword address of polynomial P(B1), (T7)=argument for which P(B1) is to be evaluated	(B1), P(B1) unchanged; (T7)'=value of P(B1) at (T7)	15	None	
PDIF	226	(B1)=codeword address of polynomial P(B1) to be differentiated	(B1) unchanged; $P(B1)' = \frac{d}{dx} P(B1)$	32	*135, *136, *137	
PINT	227	(B1)=codeword address of polynomial P(B1) to be integrated	(B1) unchanged; $P(B1)' = \int P(B1)dx$	26	*135, *136, *137	Constant term of P(B1)'=0. A value determined by boundary conditions may be stored in this location.

220 PCOPY

*220, PCOPY


PCOPY
Save T4, B12345, PF
B4 = codeword address of copy
T4 = codeword of original
B2 = length of original
Take space through *135
New codeword → (B1)
B3 = FWA of original
B6 = B1 − B3
Set up repeat mode and enter
P(B2) → P(B1)
counting B2 to zero
Unsave registers
EXIT

```
220                     ORG
PCOPY                   CLA             a477,U→R
                        TRA             *136
             B1         LDR+40          B2,U→B4
             T4         CRL             d13,R→B2
             B6         TSR             *135,U→B5
             T4         BAU             aB1,U→R
             T4         XUR→            aB4,R→B3
             B1         SUB             aB3,U→B6
             B3         SUB             a1,I→B1
                        RPA             CC→1
                        MLN             a24000
                        21743           (Z)+B1,B2-1
             B5         MLF             a04000,U→B6
                        TRA             *137
                        TRA             PF
                        END
```

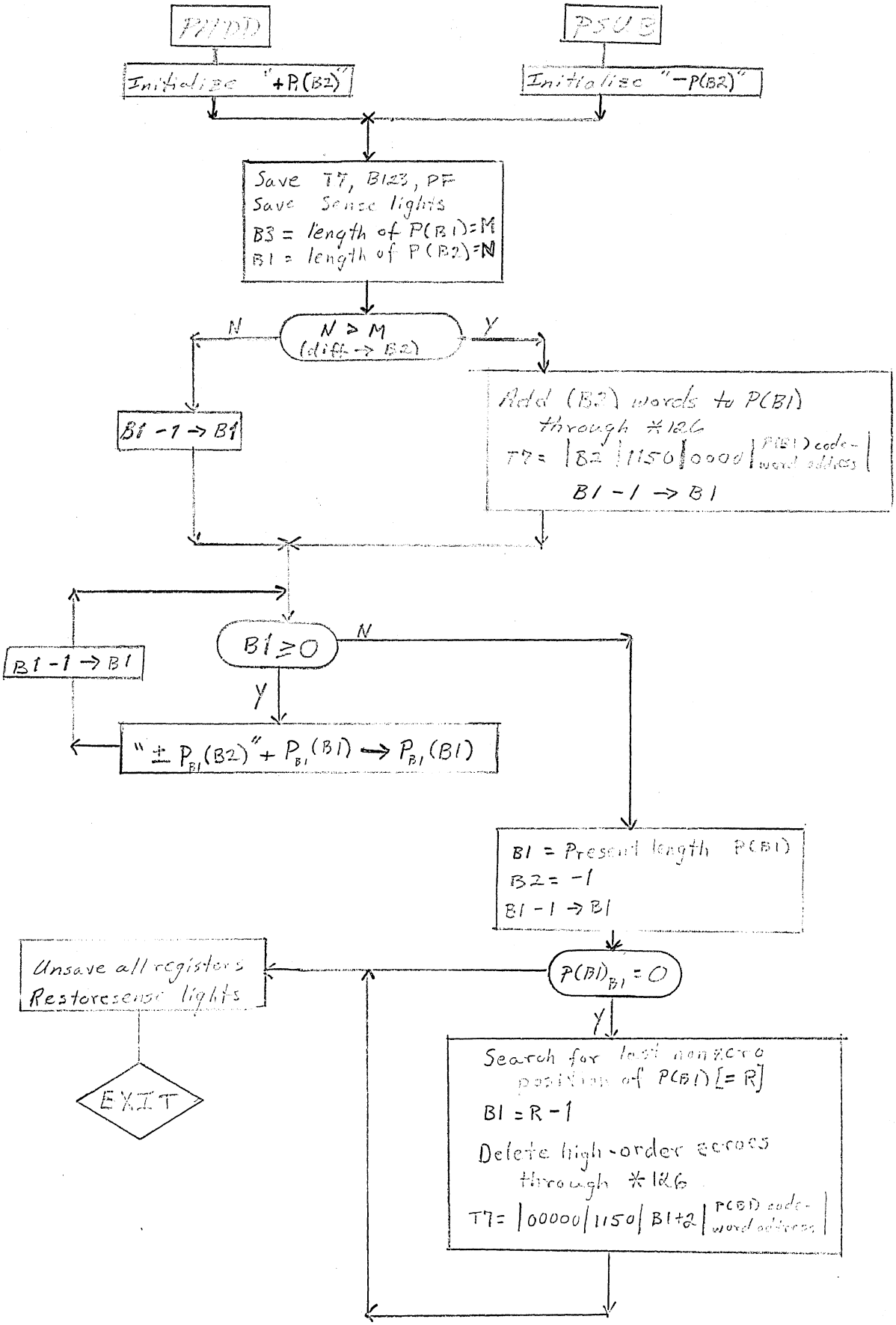
PROGRAM 220

220	PCOPY	0	1	0	20000000000000	0
2	PCOPY	1		12170 02400000477		1
3		2		10100 00440000136		0
4		3		41504 44000400000		0
5		4		44506 52400000017		0
6		5		44400 45440000135		0
7		6		42010 02400200000		0
10		7		45400 53402000000		0
11		10		41101 46401000000		0
12		11		43101 71400000001		0
13		12		12160 00000100001		0
14		13		14200 00400024000		0
15		14		12174 62000200000		0
16		15		45420 46400004000		0
17		16		10100 00440000137		0
20		17		10100 00420000000		0

221 PADD / 222 PSUB

*221, PADD

*222, PSUB



```
221                 ORG
PADD        -Z      LUL             1
            U       RPE             OPND
                    CLA             a071,U→R
                    TRA             *136
            T7      STO             B6,B6+1
                    CLA             77770
                    RPA             RSSL
                    SLN             2
            B1      RPA             MORE
                    RPA             OPND
                    CLA             B1
                    CRL             d15,R→B3
            B2      RPA             OPND-1
                    CLA             B2
                    CRL             d15,R→B1
            B1      IF(PNZ)SKP      aB3,U→B2
                    TRA             ALPHA,B1-1
            IB2I    LUL             d39
                    ORU             MORE,U→T7
                    TSR             *126,B1-1
ALPHA       B1      IF(NNZ)TRA      BETA
                    CLA             *(Z)
OPND        U       FAD→            *(Z),B1-1
                    TRA             ALPHA
BETA                CLA             *MORE
                    CRL             d15,R→B1
                    SB2             77776,B1-1
            B1      IF(ZER)TRA      GAMMA
            Z       IF(ZER)SKP      *OPND,I→B3
                    TRA             GAMMA
            B3      RPA             CC+1
                    MLN             20000
            Z       IF(NZE)SKP      B2-Z,B1-1
                    SB1             1,CC+1
                    AB1             a1
            B1      LUL             d15
                    ORU             MORE,U→T7
                    TSR             *126
GAMMA               CLA             B6-1,B6-1
                    SLF             77777
RSSL                SLN             Z
                    TRA             *137,U→T7
                    TRA             PF
MORE                OCT             000001150000000000
                    END
```

PROGRAM 221

220	PADD	0	1	0	200000000000000	0
221	OPND	0	27	0	300000000000000	0
222	RSSL	0	51	0	520000000000000	0
223	MORE	0	54	0	560000000000000	0
224	ALPHA	0	25	0	260000000000000	0
225	BETA	0	31	0	320000000000000	0
226	GAMMA	0	47	0	500000000000000	0

2	PADD	1	1045020004000000001	1	
3		2	120701000000100024	2	OPND
4		3	121700024000000071	0	
5		4	101000004400000136	0	
6		5	720001264100000000	0	
7		6	121700000000077770	0	
10		7	121601000000100041	2	RSSL
11		10	142000004000000002	0	
12		11	412160100000100042	2	MORE
13		12	121601000000100014	2	OPND
14		13	121700000000200000	0	
15		14	145066534000000017	0	
16		15	422160100000100010	2	OPND
17		16	121700000000400000	0	
20		17	145066514000000017	0	
21		20	410615042401000000	0	
22		21	101000614001000003	2	ALPHA
23		22	624502000400000047	0	
24		23	150010070001000030	2	MORE
25		24	140000614400000126	0	
26	ALPHA	25	410555000400100003	3	BETA
27		26	121700000400000000	0	
30	OPND	27	110401610400000000	1	
31		30	101000004001777773	2	ALPHA
32	BETA	31	121700000400100022	3	MORE
33		32	145066514000000017	0	
34		33	140002614000077776	0	
35		34	410101000400100012	2	GAMMA
36		35	201073040177770	2	OPND
37		36	101000004001000010	2	GAMMA
40		37	432160100000100001	0	
41		40	142002004000200000	0	
42		41	205061000477777	0	
43		42	140001204000000001	0	
44		43	141001004000000001	0	
45		44	414502000400000017	0	
46		45	150010070001000006	2	MORE
47		46	140000004400000126	0	
50	GAMMA	47	121700660100077776	1	
51		50	142004004000077777	0	
52	RSSL	51	142000004000000000	1	
53		52	101000074400000137	0	
54		53	101000004200000000	0	
56	MORE	54	115000000000000	1	

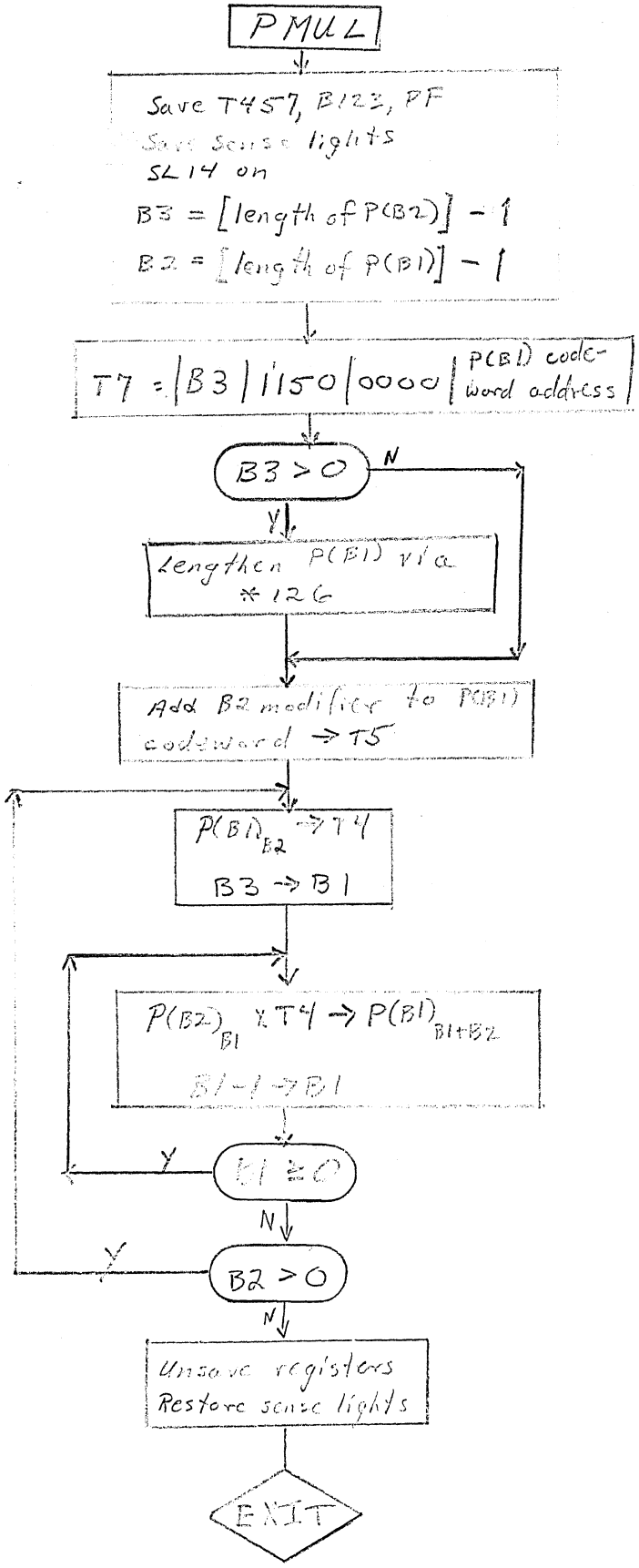
```
222
PSUB    ORG
        CLA     CC,CC+1
        OCT     11,000000000000000
        TRA     *2217CC+1
        END
```

PROGRAM 222

220	PSUB	0	1	0	20000000000000	0
2	PSUB	1		121700020000100000	1	
4		2		1100000000000000000	0	
5		3		1010000204400000221	0	

223 PMUL

* 223, PMUL


PMUL
Save T457, B123, PF
Save sense lights
SL 14 on
B3 = [length of P(B2)] - 1
B2 = [length of P(B1)] - 1
T7 = |B3|1150|0000| P(B1) code-word address
B3 > 0
N
Y
Lengthen P(B1) via *126
Add B2 modifier to P(B1) codeword → T5
P(B1)B2 → T4
B3 → B1
P(B2)B1 XT4 → P(B1)B1+B2
B1 - 1 → B1
B1 ≥ 0
Y
N
B2 > 0
Y
N
Unsave registers
Restore sense lights
EXIT

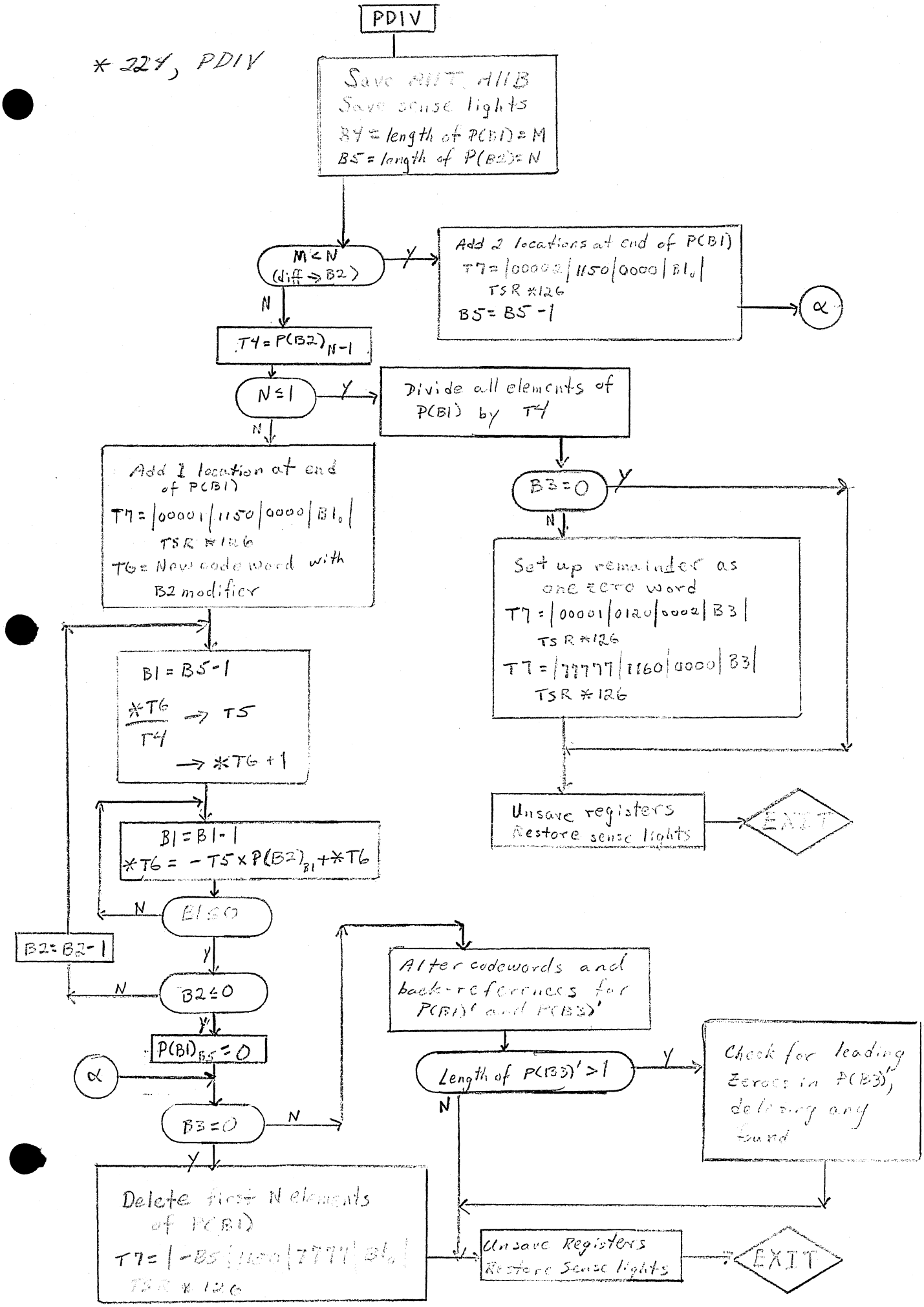
```
0
223                 ORG
PMUL                CLA             a671,U→R
                    TRA             *136
          T7        STO             B6,B6+1
                    CLA             77770
                    RPA             RSSL
                    SLN             2
          B1        RPA             MORE
                    RPA             OPNDA
          B2        RPA             OPNDB
                    CLA             B2
                    LUR             d39
                    SUB             a1,U→B3
                    LUL             d39
                    ORU             MORE,U→T7
                    CLA             B1
                    CRL             d15,R→B2
          B3        IF(NEG)SKP      Z,B2-1
                    TSR             *126
                    CLA             *MORE
                    ORU             BTWO,U→T5
                    SB1             a32
OPNDA               CLA             *(Z),U→T4
          Z         STO             *OPNDA
                    SB1             a33
OPNDB     T4        FMP             *(Z)
                    FAD             *T5,B1-1
          B1        IF(POS)TRA      OPNDB
          B2        IF(PNZ)TRA      OPNDA-1,B2-1
                    SLF             77777
RSSL                SLN             Z
                    CLA             B6-1,B6-1
                    TRA             *137,U→T7
                    TRA             PF
MORE                OCT             000001150000000000
BTWO                OCT             000000000000400000
                    END
```

PROGRAM 223

220	PMUL	0	1	0	2000000000000	0
221	RSSL	0	26	0	3700000000000	0
222	MORE	0	42	0	4400000000000	0
223	OPNDA	0	26	0	2700000000000	0
224	OPNDB	0	31	0	3200000000000	0
225	BTWO	0	43	0	4600000000000	0

2	PMUL	1	1217000240000671	1	
3		2	1010000044000136	0	
4		3	7200012641000000	0	
5		4	1217000000077770	0	
6		5	1216010000100030	2	RSSL
7		6	1420000400000002	0	
10		7	4121601000100032	2	MORE
11		10	1216010000100015	2	OPNDA
12		11	4221601000001000017	2	OPNDB
13		12	1217000000400000	0	
14		13	1450100040000047	0	
15		14	1101004340000001	0	
16		15	1450200040000047	0	
17		16	1500100700001000023	2	MORE
20		17	1217000000200000	0	
21		20	1450456240000017	0	
22		21	4302510620000000000	0	
23		22	1400000044000126	0	
24		23	1217000004010016	2	MORE
25		24	1500100500001000016	2	BTWO
26		25	1400010040040000000	0	
27	OPNDA	26	1217000400400000000	1	
30		27	2000100440177775	2	OPNDA
31		30	1400010040100000000	0	
32	OPNDB	31	4106000004000000000	1	
33		32	1104001610400000005	0	
34		33	4101111004001777774	2	OPNDB
35		34	4220515624001777767	2	OPNDA
36		35	1420040040077777	0	
37	RSSL	36	1420000400000000	1	
40		37	1217006601077776	0	
41		40	1010000744000137	0	
42		41	1010000042000000	0	
44	MORE	42	1150000000000	1	
46	BTWO	43	400000	1	

224 PDIV


* 224, PDIV
PDIV
Save AIIT, AIIB
Save sense lights
B4 = length of P(B1) = M
B5 = length of P(B2) = N
M < N (diff ⇒ B2)
Y
Add 2 locations at end of P(B1)
T7 = |00002|1150|0000|B1₀|
TSR *126
B5 = B5 - 1
α
N
T4 = P(B2)N-1
N ≤ 1
Y
Divide all elements of P(B1) by T4
N
Add 1 location at end of P(B1)
T7 = |00001|1150|0000|B1₀|
TSR *126
T6 = New code word with B2 modifier
B3 = 0
Y
N
Set up remainder as one zero word
T7 = |00001|0120|0002|B3|
TSR *126
T7 = |77777|1160|0000|B3|
TSR *126
B1 = B5 - 1
*T6 / T4 → T5
→ *T6 + 1
Unsave registers
Restore sense lights
EXIT
B1 = B1 - 1
*T6 = -T5 × P(B2)B1 + *T6
N
B1 ≤ 0
Y
B2 = B2 - 1
N
B2 ≤ 0
Y
P(B1)B5 = 0
α
B3 = 0
N
Y
Alter codewords and back-references for P(B1)' and P(B3)'
Length of P(B3)' > 1
Y
N
Check for leading zeroes in P(B3)', deleting any found
Delete first N elements of P(B1)
T7 = |-B5|1160|7777|B1₀|
TSR * 126
Unsave Registers
Restore Sense lights
EXIT

```
                                                                    1
224                 ORG                                             2
PDIV                CLA             77770                           3
                    RPA             RSGL                            4
                -Z  SLN             2,U→R                           5
                    TRA             *136                            6
                T7  STO             B6,B6+1                         7
                B1  RPA             MORE                           10
                    RPA             ALPHA                          11
                B2  RPA             BETA                           12
                    CLA             B1                             13
                    CRL             d15,R→B4                       14
                    CLA             B2                             15
                    CRL             d15,R→B5                       16
                B4  IF(POS)SKP      aB5,U→B2                       17
                    TRA             NORMU0                         20
                    SB1             aB5=1,B4=1                     21
BETA                CLA             *(Z),U→T4                      22
                B5  IF(PNZ)SKP      a1                             23
                B4  TRA             CONST,U→B1                     24
                    CLA             BTNO,B4+1                      25
                    LUL             d22                            26
                    ORU             MORE,U→T7                      27
                    TSR             *126                           30
                    CLA             *MORE                          31
                    ORU             BTNO,U→T6                      32
LOOPA               SB1             aB5=1                          33
                T4  VDF             *T6,I→PF                       34
                    STO             PF+1,U→T5                      35
LOOPB               NOP             Z,B1=1                         36
                T5  FMP             *BETA                          37
                -U  FAD→            *T6                            40
                B1  IF(PNZ)TRA      LOOPB                          41
                B2  IF(PNZ)TRA      LOOPA,B2=1                     42
                    SB1             aB5=1                          43
ALPHA           Z   STO             *(Z)                           44
BASCH           B3  IF(ZER)TRA      NOREM                          45
                    CLA             *MORE,B5=1                     46
                    CRR             d39,U→PF                       47
                B5  CRL             d39,U→B2                       50
                    STO             B3,B2-1                        51
                PF  SUB             aB5+1,U→PF                     52
                    CLA             *MORE                          53
                    CRR             d39                            54
                PF  CRL             d39                            55
                    STO             *MORE                          56
                B2  ADD             aB5+2                          57
                    RPA             *MORE,I→PF                     60
                PF  RPA             B2+B5+1                        61
                B3  RPA             B2                             62
                    CLA             B3                             63
                    CRL             d15,R→B1                       64
                    SB2             77776,B1=1                     65
                B1  IF(ZER)TRA      RETURN                         66
                Z   IF(ZER)SKP      *B3,I→B5                       67
                    TRA             RETURN                         70
                B5  RPA             CC+1                           71
                    MLN             20000                          72
                Z   IF(NZE)SKP      B2→Z,B1=1                      73
                    SB1             a1,CC+1                        74
                    AB1             a1                             75
                B1  LUL             a15                            76
                    ORU             MORE                           77
                    BAU             aB3,U→T7                      100
                    TSR             *126                          101
RETURN              CLA             B5=1,B6=1                     102
```

```
                    SLF     77777,U→T7                  103
RSSL                SLN     Z                           104
                    TRA     *137                        105
                    TRA     PF                          106
BTWO                OCT     0000000000000400000         107
MORE                OCT     0000011500000000000         110
NOQUO               CLA     BTWO                        111
                    LUL     d23,B5-1                    112
                    ORU     MORE,U→T7                   113
                    TSR     *126                        114
                    TRA     BASCH                       115
CONST               CLA     *ALPHA,I→PF                 116
                PF  ADD     a1                          117
                    RPA     CC+1,B4+1                   120
                B4  SB2,ERM 77776,U→B1                  121
                T4  VDF→    (7)+B2,B1-1                 122
                B3  IF(ZER)TRA  RETURN                  123
                B3  ORU     CNRMA,U→T7                  124
                    TSR     *126                        125
                B3  ORU     CNRMB,U→T7                  126
                    TSR     *126                        127
                    TRA     RETURN                      130
CNRMA               OCT     0000101200000200000         131
CNRMB               OCT     7777711600000000000         132
NOREM           -B5 LUL     d24                         133
                    ORU     a7777                       134
                    LUL     d16                         135
                    ORU     MORE,U→T7                   136
                    TSR     *126                        137
                    TRA     RETURN                      140
                    END                                 141
                                                        142
```

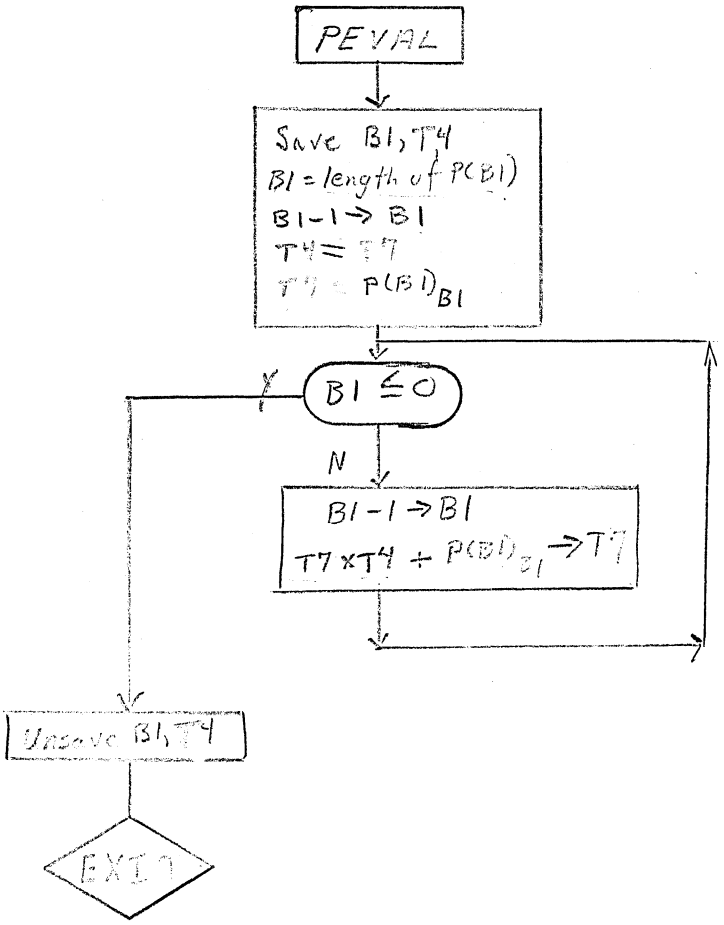
220	PDIV	0	1	0	200000000000000	0
221	RSSL	0	102	0	103000000000000	0
222	MORE	0	106	0	111000000000000	0
223	ALPHA	0	42	0	43000000000000	0
224	BETA	0	20	0	21000000000000	0
225	NOQUO	0	107	0	112000000000000	0
226	CONST	0	114	0	117000000000000	0
227	BTWO	0	105	0	107000000000000	0
230	LOOPA	0	31	0	32000000000000	0
231	LOOPB	0	34	0	35000000000000	0
232	BASCH	0	43	0	44000000000000	0
233	NOREM	0	131	0	136000000000000	0
234	RETURN	0	100	0	101000000000000	0
235	CNRMA	0	127	0	133000000000000	0
236	CNRMB	0	130	0	135000000000000	0

2	PDIV	1	121700000000077770	1		
3		2	12160100000100077	2	RSSL	
4		3	10420000240000002	0		
5		4	10100000440000136	0		
6		5	72000126410000000	0		
7		6	41216010000000100077	2	MORE	
10		7	12160100000100032	2	ALPHA	
11		10	42216010000000100007	2	BETA	
12		11	12170000000200000	0		
13		12	14506654400000017	0		
14		13	12170000000400000	0		
15		14	14506655400000017	0		
16		15	44021104240400000000	0		
17		16	10100000400100070	2	NOQUO	
20		17	14000164404077776	0		
21	BETA	20	12170004040000000	1		
22		21	45061500400000001	0		
23		22	44010004140010071	2	CONST	
24		23	12170024000100061	2	BTWO	
25		24	14502000400000026	0		
26		25	15001007000100060	2	MORE	
27		26	14000000440000126	0		
30		27	12170000040100056	2	MORE	
31		30	15001006000100054	2	BTWO	
32	LOOPA	31	14000100404077776	1		
33		32	41670077040000006	0		
34		33	12000105420000001	0		
35	LOOPB	34	12004061000000000	1		
36		35	51060000040177761	2	BETA	
37		36	11104010004000006	0		
40		37	41051500040177773	2	LOOPB	
41		40	42051506240177767	2	LOOPA	
42		41	14000100404077776	0		
43	ALPHA	42	2000100440000000	1		
44	BASCH	43	42010100040010065	3	NOREM	
45		44	12170065040100041	2	MORE	
46		45	14505547400000047	0		
47		46	45450654240000047	0		
50		47	12000162401000000	0		
51		50	47101004740400001	0		
52		51	12170000040100034	2	MORE	
53		52	14506500400000047	0		
54		53	47450650040000047	0		
55		54	12000100440100031	2	MORE	
56		55	42100000040400002	0		
57		56	12160177040100027	2	MORE	
60		57	47216010000440001	0		
61		60	43216010000040000	0		
62		61	12170000001000000	0		

63		62	14506651400000017	0	
64		63	14000261400077776	0	
65		64	41010100040010013	2	RETURN
66		65	201075041000000	0	
67		66	1010000400100011	2	RETURN
70		67	45216010000100001	0	
71		70	14200200400020000	0	
72		71	205061000477777	0	
73		72	14000120400000001	0	
74		73	14100100400000001	0	
75		74	41450200400000017	0	
76		75	15001000000100010	2	MORE
77		76	12010007401000000	0	
100		77	14000000440000126	0	
101	RETURN	100	12170066010077776	1	
102		101	14200407400077777	0	
103	RSSL	102	14200000400000000	1	
104		103	10100000440000137	0	
105		104	10100000420000000	0	
107	BTWO	105	400000	1	
111	MORE	106	1150000000000	1	
112	NOQUO	107	12170000000177774	3	BTWO
113		110	14502065400000027	0	
114		111	15001007000177773	2	MORE
115		112	14000000440000126	0	
116		113	1010000400177726	2	BASCH
117	CONST	114	12170077040177724	3	ALPHA
120		115	47100000400000001	0	
121		116	12160124000100001	0	
122		117	44400224140077776	0	
123		120	41670161000400000	0	
124		121	43010100040017755	2	RETURN
125		122	43500100700100004	2	CNRMA
126		123	14000000440000126	0	
127		124	43500100700100003	2	CNRMB
130		125	14000000440000126	0	
131		126	1010000400177750	2	RETURN
133	CNRMA	127	10120000200000	1	
135	CNRMB	130	77777116000000000	1	
136	NOREM	131	55450200400000030	1	
137		132	15001000400007777	0	
140		133	14502000400000017	0	
141		134	15001007000177750	2	MORE
142		135	14000000440000126	0	
143		136	1010000400177740	2	RETURN

225 PEVAL

*225, PEVAL


PEVAL
Save B1, T4
B1 = length of P(B1)
B1-1 → B1
T4 = T7
T7 = P(B1)B1
B1 ≤ 0
Y
N
B1-1 → B1
T7 x T4 + P(B1)B1 → T7
Unsave B1, T4
EXIT

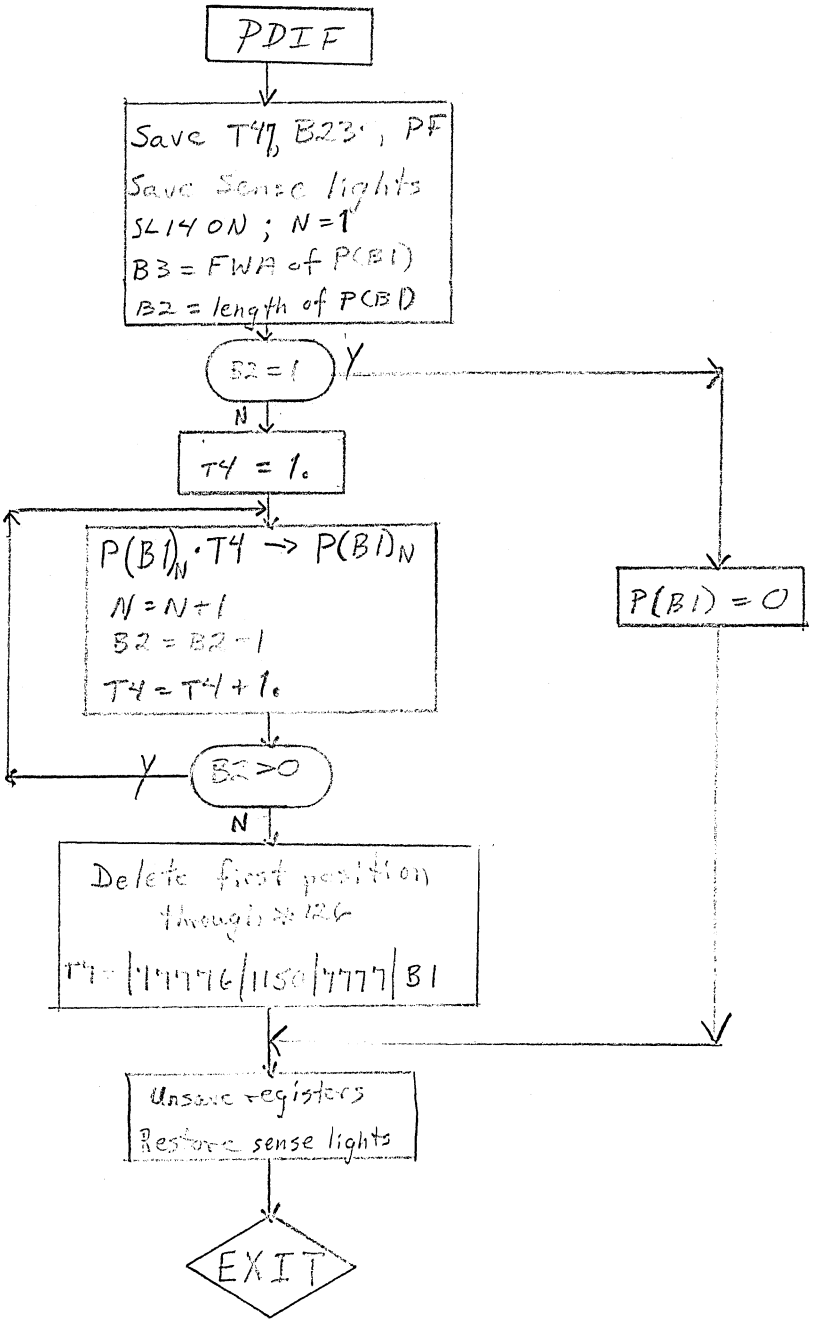
```
225
PEVAL       T4      ORG
                    STO         B6,B6+1
            B1      RPA         OPND
                    CLA         B1
                    CRL         d15,R+B1
            T7      STO         T4,B1-1
                    CLA         *OPND,U+T7
        →   B1      IF(NEG)TRA  CC+3,B1-1
        ⇒   T7      FMP         T4
OPND                FAD         *(Z),U+T7
                    TRA         CC-4
        →           CLA         OPND,U+B1
                    CLA         B6-1,B6-1
                    TRA         PF,U,T4
                    END
```

PROGRAM 22

220		PEVAL	0	1	0	2000000000000	0	
221		OPND	0	11	0	1200000000000	0	
	2	PEVAL	1		4200012641000000	1		
	3		2		4121601000001000006	2	OPND	
	4		3		1217000000200000	0		
	5		4		1450665140000017	0		
	6		5		7200016140000004	0		
	7		6		1217000704001000002	2	OPND	
	10		7		4101510614001000003	0		
	11		10		7106000000000000004	0		
	12	OPND	11		1104000704000000	1		
	13		12		1010000040017777 3	0		
	14		13		1217004100017777 4	2	OPND	
	15		14		1217006601007777 6	0		
	16		15		1010000442000000	0		

226 PDIF

*226, PDIF


PDIF
Save T4, B23, PF
Save Sense lights
SL14 ON ; N=1
B3 = FWA of P(B1)
B2 = length of P(B1)
B2 = 1
Y
N
T4 = 1.
P(B1)N · T4 → P(B1)N
N = N+1
B2 = B2 - 1
T4 = T4 + 1.
B2 > 0
Y
N
P(B1) = 0
Delete first position through #126
T4 = 177776 1150 7777 B1
Unsave registers
Restore sense lights
EXIT

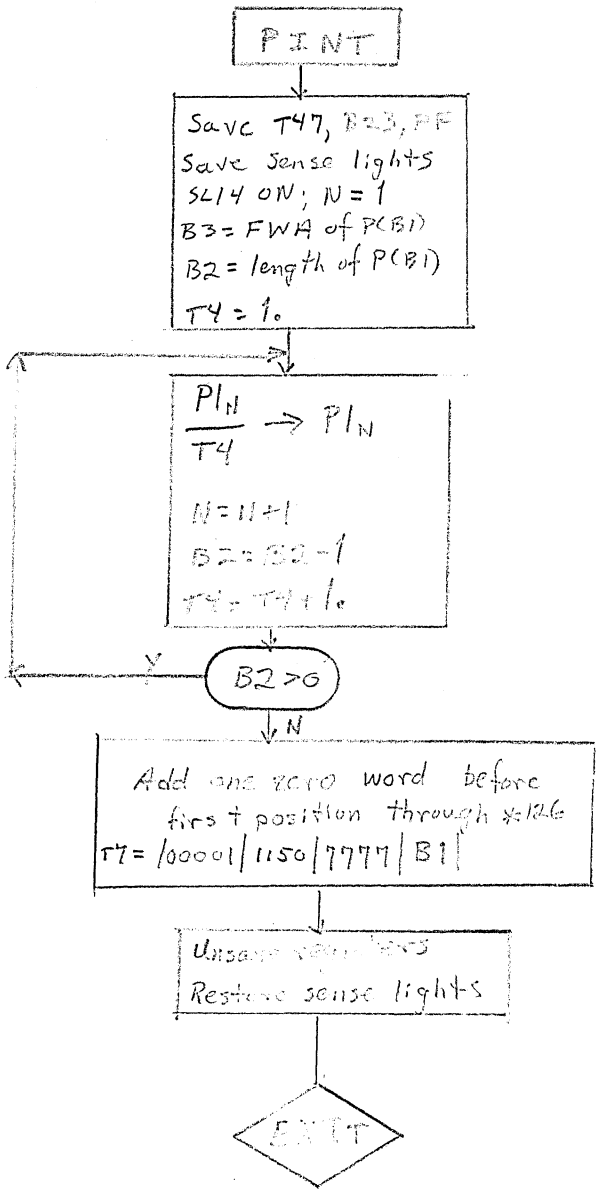
```
226                 ORG
PDIF                CLA             a435, U→R
                    TRA             *136
           T7       STO             B6,B6+1
                    CLA             77770
                    RPA             RSSL
                    SLN             2
                    CLA             B1,U→B3
                    CRL             d15,R→B2
           B2       IF(PNZ)SKP      a1,U→B2
                    TRA             CONST
           B1       RPA             MORE,B3+1
                    CLA             ONE,U→T4
LOOP       T4       FMP→            B3,B2-1
           T4       FAD             ONE,U→T4
           B2       IF(PNZ)TRA      LOOP,B3+1
                    CLA             MORE,U→T7
                    TSR             *136
                    SLF             77777
RSSL                SLN             (Z)
                    CLA             B6-1,B6-1
                    TRA             *137,U→T7
                    TRA             PF
CONST      Z        STO             B3
                    TRA             RSSL-1
MORE                OCT             777761150777700000
ONE                 DEC             1.
                    END
```

PROGRAM 226

220	PDIF	0	1	0	20000000000000		0
221	RSSL	0	23	0	24000000000000		0
222	CONST	0	27	0	30000000000000		0
223	MORE	0	31	0	33000000000000		0
224	ONE	0	32	0	35000000000000		0
225	LOOP	0	15	0	16000000000000		0
2	PDIF	1		12170002400000435		1	
3		2		10100000440000136		0	
4		3		72000126410000000		0	
5		4		12170000000077770		0	
6		5		12160100000100015		2	RSSL
7		6		14200000400000002		0	
10		7		12170043000200000		0	
11		10		14506652400000017		0	
12		11		42061504240000001		0	
13		12		10100000400010014		2	CONST
14		13		41216012300010015		2	MORE
15		14		12170004000100015		2	ONE
16	LOOP	15		41060162001000000		1	
17		16		41040504000100013		2	ONE
20		17		42051502340001777774		2	LOOP
21		20		12170007000100010		2	MORE
22		21		14000000440000126		0	
23		22		14200400400077777		0	
24	RSSL	23		14200000400000000		1	
25		24		12170036010077776		0	
26		25		10100007440000137		0	
27		26		10100000420000000		0	
30	CONST	27		20001004010000000		1	
31		30		10100000400177770		2	RSSL
33	MORE	31		77776115077770000		1	
35	ONE	32		10010000000000000		1	

227 PINT

*227, PINT


PINT
Save T47, B3, PF
Save sense lights
SL14 ON; N = 1
B3 = FWA of P(B1)
B2 = length of P(B1)
T4 = 1.
P1N / T4 → P1N
N = N+1
B2 = B2-1
T4 = T4+1.
B2 > 0
Y
N
Add one zero word before first position through *126
T7 = 100001|1150|7777|B1
Restore sense lights
EXIT

```
227                  ORG
PINT                 CLA            a431,U→R
                     TRA            *136
           T7        STO            B5,B6+1
                     CLA            77770
                     RPA            RSSL
                     SLN            2
                     CLA            B1,U→B3
                     CRL            d15,R→B2
           B1        RPA            MORE
                     CLA            ONE,U→T4
LOOP       T4        VDF→           B3,B2-1
           T4        FAD            ONE,U→T4
           B2        IF(PNZ)TRA     LOOP,B3+1
                     CLA            MORE,U→T7
                     TSR            *126
                     SLF            77777
RSSL                 SLN            (Z)
                     CLA            B5-1,B6-1
                     TRA            *137,U→T7
                     TRA            PF
MORE                 OCT            000011150777700000
ONE                  DEC            1.
                     END
```

PROGRAM 227

220	PINT	0	1	0	200000000000000	0	
221	RSSL	0	21	0	220000000000000	0	
222	MORE	0	25	0	270000000000000	0	
223	ONE	0	26	0	310000000000000	0	
224	LOOP	0	13	0	140000000000000	0	
2	PINT	1		121700024000000431	1		
3		2		101000004400001 36	0		
4		3		720001264100000000	0		
5		4		121700000000077770	0		
6		5		121601000001000013	2	RSSL	
7		6		142000004000000002	0		
10		7		121700430002000000	0		
11		10		145066524000000017	0		
12		11		412160100000100013	2	MORE	
13		12		121700004000100013	2	ONE	
14	LOOP	13		416701620001000000	1		
15		14		410400040000100011	2	ONE	
16		15		420513023400177774	2	LOOP	
17		16		121700007000100006	2	MORE	
20		17		140001004400000126	0		
21		20		142004004000077777	0		
22	RSSL	21		142000004000000000	1		
23		22		121700660100077776	0		
24		23		101000074400000137	0		
25		24		101000004200000000	0		
27	MORE	25		111507777700000	1		
31	ONE	26		100100000000000000	1		

263 PRF (Polynomial Root Finder)

(*263) PRF, Polynomial Root Finder

Purpose: To find all real, imaginary, or complex roots of a polynomial of real coefficients.

Input: The coefficients, in order of decending powers, may be stored in any Spirel vector.

Output: The real and imaginary parts of the roots will be stored in a two row matrix set up internally.

Calling Seq: B1 and B2 are set respectively to the codeword addresses of the coefficient vector and the output matrix. T7 is set to the maximum error desired in root computation. If T7 is zero, the maximum error criterion is automatically set to 1×10^{-10}. *263 is now executed and will exit when all roots have been found.

Method: This program uses Bairstow's method, 3^{rd} order Newtonian interpolation, and interval halving to find zeros. T7 should be large enough so as not to challenge the machine accuracy for higher order polynomials. A minimum error criterion may be best found by trying several values for T7. A maximum of 100 interpolations is performed to find each pair of roots.

Subroutines & Registers: Square root *202 must be loaded with *263. If multiple roots or near multiple roots are suspected, PRF *270 must also be included. All of these programs are in the library. Sense lights 9 thru 15 are used internally. These lights and all registers except T7 are saved by Spirel routines *136 and *137.

Gary Sitton
Pat Groves
June 1965

```
                                                                    1
263             ORG                                                 2
                REM             POLYNOMIAL ROOT FINDER              3
                REM             PAT GROVES, GARY SITTON             4
                REM             B1 = COEFF. VECTOR                  5
                REM             B2 = OUTPUT MATRIX                  6
                REM             T7 = MAX. ERROR                     7
                                                                    10
        Z       BAU+2           SL,B6+1                             11
                BAU+2           X,B6+1                              12
       -Z       TRA             a*136,U→R                           13
                SLN             a2                                  14
        T7      IF(PNZ)TRA      aSETE                               15
                CLA             ERROR                               16
SETE            STO             aE                                  17
                LDR             B1,R→B5                             20
                LLS             ad15,U→B1                           21
                LLS             ad15,U→PF                           22
        FF      LUR             a3,U→PF                             23
                AB5             aPF-1                               24
                SLF             a175,B1-1                           25
        B1      STO             aN,B1+1                             26
                                                                    27
                REM             SET UP WRKPAD                       30
                                                                    31
        B1      LUL             ad15                                32
                BLU             STWKPD                              33
                BAU             aWRKPAD,U→T7                        34
                TSR             *XCWD                               35
                                                                    36
                REM             SET UP OUTMAT (B4,B5)               37
                                                                    40
        B2      RPA             STWDB2,U→T7                         41
                RPA             FIX                                 42
                TSR             *XCWD                               43
                CLA             B2,U→B1                             44
                STO             aOUTMAT                             45
                CLA             N,R→Z                               46
                LRS             a15,B1+1                            47
        R       ORU             VECWD,U→T6                          50
                BAU             aB1,U→T7                            51
                TSR             *XCWD,B1+1                          52
        T6      BAU             aB1,U→T7                            53
                TSR             *XCWD                               54
                                                                    55
                REM             SET B123 TO WRKPAD                  56
                                VECTOR ADDRESSES                    57
                                                                    60
                CLA             WRKPAD,U→B4                         61
                CLA             B4+1,U→B1                           62
                CLA             B4+2,U→B2                           63
                CLA             B4+3,U→B3                           64
                                                                    65
                REM             TEST FOR LEADING                    66
                                ZERO COEFFICIENTS                   67
                                                                    70
        I       STX             a77774,U→B4                         71
                CLA             B5+B4                               72
                IF(NZE)TRA      CKEND                               73
```

```
                B4      IF(NNZ)JMP      N,B4+1                          74
                        TRA             aEXIT                           75
                                                                        76
                        REM             TEST FOR ENDING                 77
                                        ZERO COEFFICIENTS               100
                                                                        101
CKEND                   LT4             aB5+B4,B5+1                     102
                B5      ADD             N,U+B5                          103
THERE           Z       IF(ZER)SKP      B5                              104
                        TRA             STINVC,B4-1                     105
                B5      IF(PNZ)SKP      T4,B5-1                         106
                        TRA             aEXIT                           107
                        TRA             THERE,B4+1                      110
                                                                        111
                        REM             STORE *B1 IN a                  112
                                                                        113
STINVC          -B4     ADD+            N,B1+1                          114
                        IF(NEG)TRA      EXIT,B2+1                       115
                T4      SB5             aB4,U+PF                        116
                        SB4             aZ,B3+1                         117
                        CLA             PF+B4                           120
                        STO             aB1+B4                          121
                B4      IF(NNZ)JMP      N,B4+1                          122
                        CLA             aB1=1                           123
                        RPA             NORM1,B4-1                      124
                                                                        125
                        REM             IDENTITY TEST                   126
                                                                        127
TEST            I       IF(POS)SKP      aB4                             130
                        TRA             aRETST                          131
                        CLA             -B1+1,B5+1                      132
                        IF(SLF)SKP      a4                              133
                        VDF             B1,CC+1                         134
                        FDV             B1                              135
                        STO             a*OUTMAT                        136
                        TRA             aEXIT                           137
                                                                        140
                        REM             REVERSE TEST                    141
                                                                        142
RETST                   IF(SLF)SKP      a4                              143
                        TRA             aREVERS                         144
                        IF(SLN)SKP      a?                              145
                        TRA             aCOMP                           146
                        SLF             a?                              147
                        TRA             aNORMAL                         150
                                                                        151
                        REM             REVERSE COEFFICIENTS            152
                                                                        153
REVERS                  IF(SLF)SKP      a4                              154
                        SLF             a4,CC+1                         155
                        SLN             a4                              156
                B6      RPA             SAVE                            157
                B1      ADD             N,U+B6                          160
                B1      LDR             B6,U+PF                         161
                P       20001           PF,PF+1                         162
                S       LDR+2           B6-1,B6-1                       163
                B6      IF(PNZ)JMP      aPF                             164
SAVE                    SB6             a(Z)                            165
                                                                        166
```

```
                    REM     NORMALIZE COEFFICIENTS                  167
                                                                    170
NORMAL      I       LT4     B1,U→B1                                 171
                    SB4     a*N                                     172
                    SPF,ERM aB4+1                                   173
NORM1       T4      VDF→    B1+(Z),PF-1                             174
                    SB1     a*NORM1                                 175
                                                                    176
                    REM     DETERMINE P AND Q                       177
                    REM     P AND Q WILL CONTAIN                    200
                            NEGATIVE OF →ACTUAL← VALUE              201
                                                                    202
                    REM     (B4) = N                                203
                                                                    204
COMP        B4      LT6     aB1+B4-2,U→T7                           205
LOOPY       Z       IF(NZE)SKP -*T6,U→T4                            206
            T6      SUB     a1,CC+1                                 207
            T4      VDF     B1+B4-1,CC+1                            210
                    TRA     aLOOPY,U→T6                             211
            -U      STO     aP,U→T5                                 212
            T4      VDF     B1+B4                                   213
            -U      STO     aQ,U→T6                                 214
NEXT        I       SFT     aZ,U→B4                                 215
                                                                    216
                    REM     QUADRATIC TEST                          217
                                                                    220
            T7      IF(PNZ)SKP a2                                   221
                    TRA     aQUAD                                   222
                                                                    223
                    REM     CALCULATE b, c VECTORS                  224
                    REM     a(0) → b(0) → c(0)                      225
                                                                    226
CALBC               CLA     B1                                      227
                    STO     B2                                      230
                    STO     B3                                      231
                                                                    232
                    REM     a(1) - P → b(1)                         233
                                                                    234
            T5      FAD     B1+1                                    235
                    STO     B2+1                                    236
                                                                    237
                    REM     b(1) - P → c(1)                         240
                                                                    241
                    FAD     T5                                      242
                    STO     B3+1,B4+1                               243
                                                                    244
                    REM     CHECK FOR CUBIC                         245
                                                                    246
                    CLA     N                                       247
                    IF(PNZ)SKP a3                                   250
                    TRA     LASTLP                                  251
                                                                    252
                    REM     (B4) = 2                                253
                                                                    254
                    REM     a(I)-P*b(I-1)-Q*b(I-2) → b(I)
                    REM     b(I)-P*c(I-1)-Q*c(I-2) → c(I)
                                                                    257
LOOP        T6      FMP     B2+B4-2,U→T4                            260
            T6      FMP     B3+B4-2,U→T7                            261
```

```
                T5      FMP     B2+B4-1                         262
                        FAD     T4                              263
                        FAD     B1+B4,U→T4                      264
                        STO     B2+B4                           265
                T5      FMP     B3+B4-1                         266
                        FAD     T7                              267
                        FAD     T4                              270
                        STO     B3+B4                           271
                                                                272
                        REM     CHECK FOR LAST TWO LOOPS        273
                                                                274
                -B4     ADD     N,B4+1                          275
                        IF(ZER)SKP  a2                          276
                        TRA     LOOP                            277
                                                                300
                        REM     a(N-1)=P*b(N-2)-Q*b(N-3)        301
                                * b(N-1)                        302
                        REM     -P*c(N-2)-Q*c(N-3) → c(N-1)     303
                        REM     B4 NOW EQUALS N-1               304
                                                                305
LASTLP          T6      FMP     B2+B4-2,U→T4                    306
                T6      FMP     B3+B4-2,U→T7                    307
                T5      FMP     B2+B4-1                         310
                        FAD     T4                              311
                        FAD     B1+B4,U→T4                      312
                        STO     B2+B4                           313
                T5      FMP     B3+B4-1                         314
                        FAD     T7                              315
                        STO     B3+B4,B4+1                      316
                                                                317
                        REM     a(N)-P*b(N-1)-Q*b(N-2) → b(N)
                        REM     B4 NOW EQUALS N                 321
                                                                322
                T6      FMP     B2+B4-2,U→T7                    323
                T5      FMP     B2+B4-1                         324
                        FAD     T7                              325
                        FAD     B1+B4                           326
                        STO     B2+B4,U→T7                      327
                Z       STO     B3+B4                           330
                        IF(SLN)SKP  a100                        331
                        TRA     aCHECK                          332
                        SLF     a100                            333
                        TRA     aQUAD                           334
                                                                335
                        REM     CHECK ACCURACY OF RESULTS       336
                                                                337
CHECK           |T7|  FSB     E                               340
                        IF(PNZ)TRA  NEWPQ                       341
                |T4|  IF(PNZ)SKP  E                            342
                        TRA     QUAD                            343
                                                                344
                        REM     CALCULATE NEW P AND Q           345
                                                                346
                        REM                 |c(N-2)  c(N-3)|   347
                        REM     D = |                       |   350
                        REM                 |c(N-1)  c(N-2)|   351
                                                                352
NEWPQ                   LT4     B3+B4-2                         353
                T4      FMP     U,U→T7                          354
```

```
                        CLA     B3+B4-1                          355
                        FMP     B3+B4-3                          356
                -U      FAD+    T7                               357
                                                                 360
                        REM     MULTIPLE ROOT TEST               361
                                                                 362
                |U|     IF(POS)SKP E                              363
                        TRA     MLTPLE                           364
                                                                 365
                        REM                |b(N-1)  c(N-3)|     366
                        REM     DP = |                    |     367
                        REM                |b(N)    c(N-2)|     370
                                                                 371
                        CLA     B2+B4,U+T5                       372
                        FMP     B3+B4-3,U+T6                     373
                T4      FMP     B2+B4-1                          374
                        FSB     T6                               375
                                                                 376
                        REM     P + (DP/D) + P                   377
                                                                 400
                        FDV     -T7                              401
                        FAD+    P                                402
                                                                 403
                        REM                |c(N-2)  b(N-1)|     404
                        REM     DQ = |                    |     405
                        REM                |c(N-1)  b(N)   |     406
                                                                 407
                        CLA     B3+B4-1                          410
                        FMP     B2+B4-1,U+T6                     411
                T4      FMP     T5                               412
                        FSB     T6                               413
                                                                 414
                        REM     Q + (DQ/D) + Q                   415
                                                                 416
                        FDV     -T7                              417
                        FAD+    Q,U+T6                           420
                                                                 421
                        REM     COUNT AND GO BACK                422
                                                                 423
                I       LT5     P,U+B4                           424
                        ADD+    FT                               425
                        IF(PNZ)SKP ad100                         426
                        TRA     aCALBC                           427
                                                                 430
                        REM     FAILURE TEST                     431
                                                                 432
                        IF(SLF)SKP a1                            433
                        TRA     aFAILTR                          434
                        IF(SLF)SKP a10                           435
                        TRA     aLASTRY                          436
                        SLN     a1                               437
                                                                 440
ZPQ             Z       STO     aP,U+T5                          441
                        STO     aQ,U+T6                          442
                I       SFT     aZ,U+B4                          443
                        TRA     aCALBC                           444
                                                                 445
FAILTR                  IF(SLN)SKP a10                           446
                        SLN     a10,CC+1                         447
```

```
                 SLF            ā1,CC+1
                 TRA            āREVERS
                 TRA            āZPQ

                 REM            QUADRATIC SOLVER

QUAD             SLF            ā31
                 IF(SLN)SKP     ā4
                 TRA            āREGULR
                 CLA            ONE
                 FDV→           Q
                 FMP→           -P

REGULR           CLA            FOUR
                 FMP            Q,U→T7
                 CLA            P
                 FMP            U
                 FAD            T7,U→T6
                 IF(POS)TRA     āCC+1
         -U      SLN            ā40,U→T6
         B5      STO            āB6,B6+1
                 TSR            *SQRT
                 SB5            ā*B6-1,B6-1
                 IF(SLF)SKP     ā40
         -T6     SLF            ā40,U→T6
         T6      DMR            ā1,I→B4
                 FAD            āZ,U→T7
                 IF(POS)TRA     REAL,B5+1

                 REM            STORE IMAGINARY PARTS

         T7      AB4            ā1
                 STO            ā*OUTMAT,B5+1
         -U      STO            ā*OUTMAT,B5-1
                 LT7            āZ,B4-1

                 REM            STORE REAL PARTS

REAL             CLA            P
                 DMR            ā1,U→T6
                 FAD            T7
                 STO            ā*OUTMAT,B5+1
         T6      FSB            T7
                 STO            ā*OUTMAT
                 CLA            -ā2,B4-1
                 ADD→           N,U→T4
                 IF(NEG)TRA     āEXIT

                 REM            STORE B IN A

EXCHNG           CLA            B2+B4
                 STO            B1+B4
         T4      IF(PNZ)JMP     āB4,B4+1
                 TRA            TEST,B4-1

EXIT             SLN            ā2
                 CLA            INACWD
                 BAU            āWRKPAD,U→T7
                 TSR            ā*XCWD
```

```
                        LT4     INFLC1                          543
                        LT5     INFLC2                          544
FIX             T4      RPI     (Z),U→B1                        545
                T5      RPI     B1+1                            546
                T5      RPI     B1+2                            547
                        TRA     a*137                           550
                        STX     a*B6-1,B6-1                     551
                        SLF     a177,B6-1                       552
                PF      SLN     a*B6,U→CC                       553
                                                                554
                        REM     MULTIPLE ROOTS                  555
                                                                556
MLTPLE          B1      STO     aB6,B6+1                        557
                I       ADD     WRKPAD,U→B1                     560
                I       ADD     N,U→B4                          561
                        CLA+2   B1,U→R                          562
                        LRL     ad15,B6+1                       563
                B4      LRS     ad15,B4-1                       564
                R       STO     aB1                             565
                        CLA     P                               566
                        DMR     a1                              567
                        FAD     aZ,U→T6                         570
                Z       SLN     a100,U→T7                       571
                        TSR     a*270                           572
                T7      FAD     U                               573
                        STO     aP,U→T5                         574
                T7      FMP     U                               575
                -U      STO     aQ,U→T6                         576
                        CLA     B6-1,B6-1                       577
                        STO     aB1                             600
                        SBI     a*B6-1,B6-1                     601
                B4      TRA     aNEXT,U→T7                      602
                                                                603
LASTRY                  IF(SLN)SKP  a20                         604
                        SLN     a20,CC+1                        605
                        TRA     aMLTPLE                         606
                        SLF     a10                             607
                        CLA     FOUR                            610
                        FMP→    E                               611
                        TRA     aREVERS                         612
                                                                613
INACWD                  OCT     000001170000000000              614
STWKPD                  OCT     000030420000000000              615
STWUB2                  OCT     000020120442000000              616
VECWD                   OCT     000000120004000000              617
INFLC1                  OCT     000000000440200000              620
INFLC2                  OCT     000000000000400000              621
ERROR                   DEC     0.000000000001                  622
FOUR                    DEC     4.0                             623
ONE                     DEC     1.0                             624
E                       OCT     Z                               625
N                       OCT     Z                               626
P                       OCT     Z                               627
Q                       OCT     Z                               630
WRKPAD                  OCT     Z                               631
OUTMAT                  OCT     Z                               632
SQR1                    EQU     202                             633
XCWD                    EQU     126                             634
                                                                635
```

311	SETE	0	7	0	3100000000000000	0
312	ERROR	0	407	0	7250000000000000	0
313	E	0	412	0	7330000000000000	0
314	N	0	413	0	7350000000000000	0
315	STWKPD	0	402	0	7130000000000000	0
316	WRKPAD	0	416	0	7430000000000000	0
317	XCWD	0	126	0	7470000000000000	2
320	STWD82	0	403	0	7150000000000000	0
321	FIX	0	337	0	6430000000000000	0
322	OUTMAT	0	417	0	7450000000000000	0
323	VECWD	0	404	0	7170000000000000	0
324	CKEND	0	50	0	1200000000000000	0
325	EXIT	0	331	0	6350000000000000	0
326	THERE	0	52	0	1220000000000000	0
327	STINVC	0	57	0	1320000000000000	0
330	NORM1	0	123	0	2140000000000000	0
331	TEST	0	70	0	1460000000000000	0
332	RETST	0	100	0	1610000000000000	0
333	REVERS	0	106	0	1730000000000000	0
334	COMP	0	125	0	2320000000000000	0
335	NORMAL	0	120	0	2110000000000000	0
336	SAVE	0	117	0	2040000000000000	0
337	LOOPY	0	126	0	2330000000000000	0
340	P	0	414	0	7370000000000000	0
341	Q	0	415	0	7410000000000000	0
342	NEXT	0	135	0	2420000000000000	0
343	QUAD	0	263	0	5550000000000000	0
344	CALBC	0	140	0	2570000000000000	0
345	LASTLP	0	167	0	3530000000000000	0
346	LOOP	0	152	0	3160000000000000	0
347	CHECK	0	212	0	4120000000000000	0
350	NEWPQ	0	216	0	4360000000000000	0
351	MLTPLE	0	346	0	6550000000000000	0
352	FAILTR	0	256	0	5450000000000000	0
353	LASTRY	0	372	0	7010000000000000	0
354	ZPQ	0	252	0	5410000000000000	0
355	REGULR	0	271	0	5630000000000000	0
356	ONE	0	411	0	7310000000000000	0
357	FOUR	0	410	0	7270000000000000	0
360	SQRT	0	202	0	7460000000000000	2
361	REAL	0	314	0	6150000000000000	0
362	EXCHNG	0	325	0	6310000000000000	0
363	INACWD	0	401	0	7110000000000000	0
364	INFLC1	0	405	0	7210000000000000	0
365	INFLC2	0	406	0	7230000000000000	0

POLYNOMIAL ROOT FINDER
PAT GROVES, GARY SITTON
B1 = COEFF. VECTOR

B2 = OUTPUT MATRIX
T7 = MAX. ERROR

```
                    1      00 20102 26 0000 77770
                    2      01 20102 26 0000 77775
                    3      10 01000 02 4400 00136
                    4      01 42000 00 4000 00002
                    5      07 05150 00 4001 00001      SETE
                    6      01 21700 00 0001 00400      ERROR
          SETE      7      01 20001 00 4001 00402      E
                   10      01 50400 55 0002 00000
                   11      01 45062 41 4000 00017
                   12      01 45062 47 4000 00017
                   13      47 45010 47 4000 00003
                   14      01 41005 00 4200 77776
                   15      01 42004 61 4000 00175
```

```
                            16      41 20001 21 4001 00374       N
SET UP WRKPAD
                            17      41 45020 00 4000 00017
                            20      01 21400 00 0001 00361       STWKPD
                            21      01 20100 07 4001 00374       WRKPAD
                            22      01 40000 00 4400 00126       XCWD
SET UP OUTMAT (B4,B5)
                            23      42 21601 07 0001 00357       STWDB2
                            24      01 21601 00 0001 00312       FIX
                            25      01 40000 00 4400 00126       XCWD
                            26      01 21700 41 0004 00000
                            27      01 20001 00 4001 00367       OUTMAT
                            30      01 21700 10 0001 00362       N
                            31      01 45015 21 4000 00017
                            32      02 50010 06 0001 00351       VECWD
                            33      01 20100 07 4002 00000
                            34      01 40000 21 4400 00126       XCWD
                            35      06 20100 07 4002 00000
                            36      01 40000 00 4400 00126       XCWD
SET B123 TO WRKPAD VECTOR ADDRESSES
                            37      01 21700 44 0001 00356       WRKPAD
                            40      01 21700 41 0020 00001
                            41      01 21700 42 0020 00002
                            42      01 21700 43 0020 00003
TEST FOR LEADING ZERO COEFFICIENTS
                            43      20 43005 44 4000 77774
                            44      01 21700 00 0060 00000
                            45      01 01050 00 4001 00002       CKEND
                            46      44 07550 24 0001 00344       N
                            47      01 01000 00 4001 00261       EXIT
TES! FOR ENDING ZERO COEFFICIENTS
              CKEND         50      01 50440 25 4060 00000
                            51      45 10000 45 0001 00341       N
              THERE         52      00 02010 00 0040 00000
                            53      01 01000 64 4001 00003       STINVC
                            54      45 06150 65 0000 00004
                            55      01 01000 00 4001 00253       EXIT
                            56      01 01000 24 4001 77772       THERE

STORE *B1 IN a
              STINVC        57      54 10001 21 0001 00333       N
                            60      01 01510 22 4001 00250       EXIT
                            61      04 40005 47 4020 00000
                            62      01 40004 23 4000 00000
                            63      01 21700 00 0220 00000
                            64      01 20001 00 4022 00000
                            65      44 07550 24 0001 00325       N
                            66      01 21700 00 4002 77776
                            67      01 21601 64 0001 00033       NORM1
IDENTITY TEST
              TEST          70      20 02110 00 4020 00000
                            71      01 01000 00 4001 00006       RETST
                            72      01 21700 25 1002 00001
                            73      01 02070 00 4000 00004
                            74      01 16700 20 0002 00000
                            75      01 10700 00 0002 00000
                            76      01 20001 00 4401 00320       OUTMAT
                            77      01 01000 00 4001 00231       EXIT
REVERSE TEST

              RETST        100      01 02070 00 4000 00004
                           101      01 01000 00 4001 00004       REVERS
                           102      01 02030 00 4000 00002
                           103      01 01000 00 4001 00021       COMP
                           104      01 42004 00 4000 00002
                           105      01 01000 00 4001 00012       NORMAL
```

```
REVERSE COEFFICIENTS
        REVERS  106     01 02070 00 4000 00004
                107     01 42004 20 4000 00004
                110     01 42000 00 4000 00004
                111     46 21601 00 0001 00005      SAVE
                112     41 10000 46 0001 00300      N
                113     41 50400 47 0100 00000
                114     02 20001 27 0200 00000
                115     03 50402 66 0100 77776
                116     46 07150 00 4200 00000
        SAVE    117     01 40006 00 4000 00000
NORMALIZE COEFFICIENTS
        NORMAL  120     20 50440 41 0002 00000
                121     01 40004 00 4401 00271      N
                122     01 40027 00 4020 00001
        NORM1   123     04 16701 67 0002 00000
                124     01 40001 00 4401 77775      NORM1
DETERMINE P AND Q
P AND Q WILL CONTAIN NEGATIVE OF -ACTUAL- VALUE
(B4) = N
        COMP    125     44 50460 07 4022 77775
        LOOPY   126     00 02050 04 1400 00006
                127     06 10100 20 4000 00001
                130     04 16700 20 0022 77776
                131     01 01000 06 4001 77773      LOOPY
                132     11 20001 05 4001 00261      P
                133     04 16700 00 0022 00000
                134     11 20001 06 4001 00260      Q
        NEXT    135     20 43007 44 4000 00000
QUADRATIC TEST
                136     07 06150 00 4000 00002
                137     01 01000 00 4001 00123      QUAD
CALCULATE b, c VECTORS
a(0) → b( ) → c(0)
        CALBC   140     01 21700 00 0002 00000
                141     01 20001 00 4004 00000
                142     01 20001 00 4010 00000
a(1) - P → b(1)
                143     05 10400 00 0002 00001
                144     01 20001 00 4004 00001
b(1) - P → c(1)
                145     01 10400 00 0000 00005
                146     01 20001 24 4010 00001
CHECK FOR CUBIC
                147     01 21700 00 0001 00243      N
                150     01 06150 00 4000 00003
                151     01 01000 00 4001 00015      LASTLP
(B4) = 2
a(I)-P*b(I-1)-Q*b(I-2) → b(I)
b(I)-P*c(I-1)-Q*c(I-2) → c(I)
        LOOP    152     06 10600 04 0024 77775
                153     06 10600 07 0030 77775
                154     05 10600 00 0024 77776
                155     01 10400 00 0000 00004
                156     01 10400 04 0022 00000
                157     01 20001 00 4024 00000
                160     05 10600 00 0030 77776
                161     01 10400 00 0000 00007
                162     01 10400 00 0000 00004
                163     01 20001 00 4030 00000
CHECK FOR LAST TWO LOOPS
                164     54 10000 24 0001 00226      N
                165     01 02010 00 4000 00002
                166     01 01000 00 4001 77762      LOOP
a(N-1)-P*b(N-2)-Q*b(N-3) → b(N-1)
-P*c(N-2)-Q*c(N-3) → c(N-1)
```

```
B4 NOW EQUALS N-1
        LASTLP  167     06 10600 04 0024 77775
                170     06 10600 07 0030 77775
                171     05 10600 00 0024 77776
                172     01 10400 00 0000 00004
                173     01 10400 04 0022 00000
                174     01 20001 00 4024 00000
                175     05 10600 00 0030 77776
                176     01 10400 00 0000 00007
                177     01 20001 24 4030 00000
a(N)-P*b(N-1)-Q*b(N-2) → b(N)
B4 NOW EQUALS N
                200     06 10600 07 0024 77775
                201     05 10600 00 0024 77776
                202     01 10400 00 0000 00007
                203     01 10400 00 0022 00000
                204     01 20001 07 4024 00000
                205     00 20001 00 4030 00000
                206     01 02030 00 4000 00100
                207     01 01000 00 4001 00002      CHECK
                210     01 42004 00 4000 00100
                211     01 01000 00 4001 00051      QUAD

CHECK ACCURACY OF RESULTS
          CHECK 212     27 10500 00 0001 00177      E
                213     01 05150 00 4001 00002      NEWPQ
                214     24 06150 00 0001 00175      E
                215     01 01000 00 4001 00045      QUAD
CALCULATE NEW P AND Q
     |c(N-2)  c(N-3)|
D =  |                |
     |c(N-1)  c(N-2)|
          NEWPQ 216     01 50440 00 0030 77775
                217     04 10600 07 0000 00001
                220     01 21700 00 0030 77776
                221     01 10600 00 0030 77774
                222     11 10401 00 0000 00007
MULTIPLE ROOT TEST
                223     21 02110 00 0001 00166      E
                224     01 01000 00 4001 00121      MLTPLE
      |b(N-1)  c(N-3)|
DP =  |                |
      |b(N)    c(N-2)|
                225     01 21700 05 0024 00000
                226     01 10600 06 0030 77774
                227     04 10600 00 0024 77776
                230     01 10500 00 0000 00006

P + (DP/D) → P
                231     01 10700 00 1000 00007
                232     01 10401 00 0001 00161      P
      |c(N-2)  b(N-1)|
DQ =  |                |
      |c(N-1)  b(N)   |
                233     01 21700 00 0030 77776
                234     01 10600 06 0024 77776
                235     04 10600 00 0000 00005
                236     01 10500 00 0000 00006
Q + (DQ/D) → Q
                237     01 10700 00 1000 00007
                240     01 10401 06 0001 00154      Q
COUNT AND GO BACK
                241     20 50450 44 0001 00152      P
                242     01 10001 00 0000 77777
                243     01 06150 00 4000 00144
                244     01 01000 00 4001 77672      CALBC
```

```
FAILURE TEST
                  245     01 02070 00 4000 00001
                  246     01 01000 00 4001 00007      FAILTR
                  247     01 02070 00 4000 00010
                  250     01 01000 00 4001 00121      LASTRY
                  251     01 42000 00 4000 00001
          ZPQ     252     00 20001 05 4001 00141      P
                  253     01 20001 06 4001 00141      Q
                  254     20 43007 44 4000 00000
                  255     01 01000 00 4001 77661      CALBC
          FAILTR  256     01 02030 00 4000 00010
                  257     01 42000 20 4000 00010
                  260     01 42004 20 4000 00001
                  261     01 01000 00 4001 77623      REVERS
                  262     01 01000 00 4001 77766      ZPQ

QUADRATIC SOLVER
          QUAD    263     01 42004 00 4000 00031
                  264     01 02030 00 4000 00004
                  265     01 01000 00 4001 00003      REGULR
                  266     01 21700 00 0001 00122      ONE
                  267     01 10701 00 0001 00125      Q
                  270     01 10601 00 1001 00123      P
          REGULR  271     01 21700 00 0001 00116      FOUR
                  272     01 10600 07 0001 00122      Q
                  273     01 21700 00 0001 00120      P
                  274     01 10600 00 0000 00001
                  275     01 10400 06 0000 00007
                  276     01 01110 00 4001 00001
                  277     11 42000 06 4000 00040
                  300     45 20001 26 4100 00000
                  301     01 40000 00 4400 00202      SQRT
                  302     01 40005 66 4500 77776
                  303     01 02070 00 4000 00040
                  304     16 42004 06 4000 00040
                  305     06 44000 74 4000 00001
                  306     01 10400 07 4000 00000
                  307     01 01110 25 4001 00004      REAL
STORE IMAGINARY PARTS
                  310     07 41004 00 4000 00001
                  311     01 20001 25 4401 00105      OUTMAT
                  312     11 20001 65 4401 00104      OUTMAT
                  313     01 50470 64 4000 00000
STORE REAL PARTS
          REAL    314     01 21700 00 0001 00077      P
                  315     01 44000 06 4000 00001
                  316     01 10400 00 0000 00007
                  317     01 20001 25 4401 00077      OUTMAT
                  320     06 10500 00 0000 00007
                  321     01 20001 00 4401 00075      OUTMAT
                  322     01 21700 64 5000 00002
                  323     01 10001 04 0001 00067      N
                  324     01 01510 00 4001 00004      EXIT
STORE B IN A
          EXCHNG  325     01 21700 00 0024 00000
                  326     01 20001 00 4022 00000
                  327     04 07150 24 4020 00000
                  330     01 01000 64 4001 77536      TEST
          EXIT    331     01 42000 00 4000 00002
                  332     01 21700 00 0001 00046      INACWD
                  333     01 20100 07 4001 00062      WRKPAD
                  334     01 40000 00 4400 00126      XCWD
                  335     01 50440 00 0001 00047      INFLC1
                  336     01 50450 00 0001 00047      INFLC2
          FIX     337     04 21501 41 0000 00000
                  340     05 21501 00 0002 00001
```

```
                    341     05 21501 00 0002 00002
                    342     01 01000 00 4400 00137
                    343     01 43005 66 4500 77776
                    344     01 42004 66 4000 00177
                    345     47 42000 40 4500 00000
MULTIPLE ROOTS
          MLTPLE    346     41 20001 26 4100 00000
                    347     20 10000 41 0001 00046      WRKPAD
                    350     20 10000 44 0001 00042      N
                    351     01 21702 02 0002 00000
                    352     01 45002 26 4000 00017
                    353     44 45015 64 4000 00017
                    354     02 20001 00 4002 00000
                    355     01 21700 00 0001 00036      P
                    356     01 44000 00 4000 00001
                    357     01 10400 06 4000 00000
                    360     00 42000 07 4000 00100
                    361     01 40000 00 4400 00270
                    362     07 10400 00 0000 00001
                    363     01 20001 05 4001 00030      P.
                    364     07 10600 00 0000 00001
                    365     11 20001 06 4001 00027      Q
                    366     01 21700 66 0100 77776
                    367     01 20001 00 4002 00000
                    370     01 40001 66 4500 77776
                    371     44 01000 07 4001 77542      NEXT
          LASTRY    372     01 02030 00 4000 00020
                    373     01 42000 20 4000 00020
                    374     01 01000 00 4001 77750      MLTPLE
                    375     01 42004 00 4000 00010
                    376     01 21700 00 0001 00011      FOUR
                    377     01 10601 00 0001 00012      E
                    400     01 01000 00 4001 77504      REVERS
          INACWD    401     00 00011 70 0000 00000
          STWKPD    402     00 00304 20 0000 00000
          STWDB2    403     00 00201 20 4420 00000
          VECWD     404     00 00001 20 0040 00000
          INFLC1    405     00 00000 00 4402 00000
          INFLC2    406     00 00000 00 0004 00000
          ERROR     407     73 15574 67 7547 27573
          FOUR      410     01 00400 00 0000 00000
          ONE       411     01 00100 00 0000 00000
          E         412     00 00000 00 0000 00000
          N         413     00 00000 00 0000 00000
          P         414     00 00000 00 0000 00000
          Q         415     00 00000 00 0000 00000
          WRKPAD    416     00 00000 00 0000 00000
          OUTMAT    417     00 00000 00 0000 00000
```

264 PCHK (Polynomial Check)

(*264) PCHK, Polynomial Check

Purpose: To check from the console the accuracy of and to control program *263, polynomial root finder.

Input: Same as *263.

Output: The coefficients, specified error, roots, restored coefficients, and coefficient differences are printed out in three column decimal format.

Calling Seq: B1 and B2 are set as in *263. After execution, a HTR CC will occur and the error criterion may be typed into U. After pushing continue the program will transfer to *263 and print the results.

Subroutines & Registers: Same as *263. , and * 263

Gary Sitton
Pat Groves
June 1965

```
264                 ORG
                    REM         PRF (*263) CONTROL
                    REM         PAT AND GARY

          Z         BAU+2       X,B6+1
                    BAU+2       SL,B6+1
          -Z        TRA         a*136,U→R
          Z         ATR         aCC,U→T7
                    STO         a36,B6+1
                    TSR         a*PRF
                    SLN         a2

                    BAU         aWRKPAD
                    RPA         INACT
                    RPA         SETPAD
                    RPA         PRN6
          B2        RPA         OUTMAT
                    RPA         PRN4
          B1        RPA         FIX
                    RPA         PRN2
                    LDR         B1
          Z         LLS         ad15,U→B3
                    LUL         ad15,B3-1
                    BLJ,BAU     SETPAD,U→T7
                    TSR         a*XCWD

                    CLA         OUTMAT,U→PF
                    BIU+2       PF,B6+1
          PF        LDR+2       BFOR,B6+1
          R         RPI         PF,U→PF
                    LT4         BFIV
                    BIU+2       PF+1,B6+1
          T4        RPI         PF+1
                    BIU+2       PF+2,B6+1
          T4        RPI         PF+2
          I         SB2         a2,U→P1
                    SB4         a1,U→P5

                    CLA         -*OUTMAT,B4+1
                    STO         a*WRKPAD,B1+1
                    CLA         -*OUTMAT,B4-1
                    STO         a*WRKPAD,B1-1
                    CLA         ONE,B2-1
                    STO         a*WRKPAD,B5+1

LOOP2               LT4         *WRKPAD,B1+1
                    LT5         *WRKPAD,B2+1
LOOP1               LT7         *WRKPAD,B1-1
                    LT6         *WRKPAD
          T4        FMP+2       -*OUTMAT,B4+1
          T5        FMP         -*OUTMAT
          -U        FAD         B6
                    FAD         T6
                    STO         a*WRKPAD
          T4        FMP+2       -*OUTMAT,B4-1
          T5        FMP         -*OUTMAT
                    FAD         B6
                    FAD         T7,B1+1
```

```
                    STO         a*WRKPAD
            T7      LT4         T6,U→T5

            B2      IF(PNZ)SKP  aB5,B2+1
                    TRA         aLOOP1

            B5      IF(POS)SKP  aB3,B1-1
                    SB2         a1,CC+1
                    TRA         aCC+1
                    TRA         aLOOP2,B5+1
                    CLA         B6-1,B6-1
                    RPI         PF+2
                    CLA         B6-1,B6-1
                    RPI         PF+1
                    CLA         B6-1,U→PF
                    CLA         B6-2,B6-1
                    RPI         PF,B6-1
                    SP2         PRN0
            S       TSR         a*126,U→T7

                    SP2         PRN1
            S       BAU         aM1,U→T7
                    TSR         a*126

                    LT7         PRN2
                    TSR         a*126

                    SP2         PRN1
            S       BAU         aM5,U→T7
                    TSR         a*XCWD

                    CLA         PRN7
                    BAU         aB6-1,U→T7
                    TSR         a*XCWD

                    SP2         PRN3,B6-1
            S       BAU         aM2,U→T7
                    TSR         a*126

                    LT7         PRN4
                    TSR         a*126

FIX                 CLA         (Z),U→34
            I       STX         aX,U→P2
                    CLA         B4+B2
                    FDV→        *WRKPAD,U→T4
            B2      IF(PNZ)SKP  aB3,B2+1
            T4      FMP→        *WRKPAD,CC→X

                    SP2         PRN5
            S       BAU         aM3,U→T7
                    TSR         a*126

                    LT7         PRN6
                    TSR         a*126


LOOP3               CLA         B4+B2-1,B2-1
                    FSB→        *WRKPAD
```

```
          B2      IF(NEG)SKP      a1                              167
                  TRA             aLOOP?                          170
                                                                  171
                  SP2             PRN3                            172
          S       BAU             aM4,U-T7                        173
                  TSR             a*126                           174
                                                                  175
                  LT7             PRN6                            176
                  TSR             a*126                           177
                  LT7             INACT                           200
                  TSR             a*126                           201
                  PAG             a*137,I-CC                      202
                  SLF             a2,B6-1                         203
                  SLN             a*B6,B6-1                       204
          PF      STX             a*B6,L-CC                       205
                                                                  206
PRN0              OCT             000004310000000131              207
PRN1              OCT             000024010000000000              210
M1                BCD             INPUT COEFFICIENTS              211
PRN2              OCT             000004470000000000              212
PRN3              OCT             000014010000000000              213
M2                BCD             ROOTS                           214
PRN4              OCT             000004470000000000              215
PRN5              OCT             000034010000000000              216
M3                BCD             RESTORED COEFFICIENTS           217
PRN6              OCT             000004470000000000              220
M4                BCD             ERRORS                          221
M5                BCD             SPECIFIED ERROR                 222
PRN7              OCT             000014030000000000              223
BFOR              OCT             000000000442000000              224
BFIV              OCT             000000000004000000              225
SETRAD            OCT             000020420000000000              226
INACT             OCT             000001170000000000              227
ONE               DEC             1.0                             230
WRKRAD            OCT             Z                               231
OUTMAT            NOP             *(Z)                            232
PRF               EQU             263                             233
XCWD              EQU             126                             234
                                                                  235
                  END                                             236
                                                                  237
```

311	PRF	0	263	0	2400000000000000	2
312	WRKPAD	0	204	0	2360000000000000	0
313	INACT	0	202	0	2320000000000000	0
314	SETPAD	0	201	0	2300000000000000	0
315	PRN6	0	172	0	2130000000000000	0
316	OUTMAT	0	205	0	2370000000000000	0
317	PRN4	0	165	0	2030000000000000	0
320	FIX	0	124	0	1330000000000000	0
321	PRN2	0	162	0	1750000000000000	0
322	XCWD	0	126	0	2410000000000000	2
323	BFOR	0	177	0	2240000000000000	0
324	BFIV	0	200	0	2260000000000000	0
325	ONE	0	203	0	2340000000000000	0
326	LOOP2	0	46	0	5500000000000000	0
327	LOOP1	0	50	0	5700000000000000	0
330	PRN0	0	156	0	1660000000000000	0
331	PRN1	0	157	0	1700000000000000	0
332	M1	0	160	0	1720000000000000	0
333	M5	0	174	0	2170000000000000	0
334	PRN7	0	176	0	2220000000000000	0
335	PRN3	0	163	0	1770000000000000	0
336	M2	0	164	0	2010000000000000	0
337	PRN5	0	166	0	2050000000000000	0
340	M3	0	167	0	2070000000000000	0
341	LOOP3	0	137	0	1460000000000000	0
342	M4	0	173	0	2150000000000000	0

PRF (*263) CONTROL
PAT AND GARY

```
    1    00 20102 26 0000 77775
    2    01 20102 26 0000 77770
    3    10 01000 02 4400 00136
    4    00 00000 07 4001 00000
    5    01 20001 26 4100 00000
    6    01 40000 00 4400 00263     PRF
    7    01 42000 00 4000 00002
   10    01 20100 00 4001 00173     WRKPAD
   11    01 21601 00 0001 00170     INACT
   12    01 21601 00 0001 00166     SETPAD
   13    01 21601 00 0001 00156     PRN6
   14    42 21601 00 0001 00170     OUTMAT
   15    01 21601 00 0001 00147     PRN4
   16    41 21601 00 0001 00105     FIX
   17    01 21601 00 0001 00142     PRN2
   20    01 50400 00 0002 00000
   21    00 45062 43 4000 00017
   22    01 45020 63 4000 00017
   23    01 21500 07 0001 00155     SETPAD
   24    01 40000 00 4400 00126     XCWD
   25    01 21700 47 0001 00157     OUTMAT
   26    01 20202 26 0200 00000
   27    47 50402 26 0001 00147     BFOR
   30    02 21501 47 0200 00000
   31    01 50440 00 0001 00146     BFIV
   32    01 20202 26 0200 00001
   33    04 21501 00 0200 00001
   34    01 20202 26 0200 00002
   35    04 21501 00 0200 00002
   36    20 40002 41 4000 00002
   37    01 40004 45 4000 00001
   40    01 21700 24 1401 00144     OUTMAT
   41    01 20001 21 4401 00142     WRKPAD
   42    01 21700 64 1401 00142     OUTMAT
   43    01 20001 61 4401 00140     WRKPAD
   44    01 21700 62 0001 00136     ONE
```

```
                    45    01 20001 25 4401 00136      WRKPAD
LOOP2               46    01 50440 21 0401 00135      WRKPAD
                    47    01 50450 22 0401 00134      WRKPAD
LOOP1               50    01 50470 61 0401 00133      WRKPAD
                    51    01 50460 00 0401 00132      WRKPAD
                    52    04 10602 24 1401 00132      OUTMAT
                    53    05 10600 00 1401 00131      OUTMAT
                    54    11 10400 00 0100 00000
                    55    01 10400 00 0000 00006
                    56    01 20001 00 4401 00125      WRKPAD
                    57    04 10602 64 1401 00125      OUTMAT
                    60    05 10600 00 1401 00124      OUTMAT
                    61    01 10400 00 0100 00000
                    62    01 10400 21 0000 00007
                    63    01 20001 00 4401 00120      WRKPAD
                    64    07 50440 05 0000 00006
                    65    42 06150 22 4040 00000
                    66    01 01000 00 4001 77760      LOOP1
                    67    45 02110 61 4010 00000
                    70    01 40002 20 4000 00001
                    71    01 01000 00 4001 00001
                    72    01 01000 25 4001 77752      LOOP2
                    73    01 21700 66 0100 77776
                    74    01 21501 00 0200 00002
                    75    01 21700 66 0100 77776
                    76    01 21501 00 0200 00001
                    77    01 21700 47 0100 77776
                   100    01 21700 66 0100 77775
                   101    01 21501 66 0200 00000
                   102    01 61020 00 0001 00053      PRN0
                   103    03 40000 07 4400 00126
                   104    01 61020 00 0001 00052      PRN1
                   105    03 20100 07 4001 00052      M1
                   106    01 40000 00 4400 00126
                   107    01 50470 00 0001 00052      PRN2
                   110    01 40000 00 4400 00126
                   111    01 61020 00 0001 00045      PRN1
                   112    03 20100 07 4001 00061      M5
                   113    01 40000 00 4400 00126      XCWD
                   114    01 21700 00 0001 00061      PRN7
                   115    01 20100 07 4100 77776
                   116    01 40000 00 4400 00126      XCWD
                   117    01 61020 66 0001 00043      PRN3
                   120    03 20100 07 4001 00043      M2
                   121    01 40000 00 4400 00126
                   122    01 50470 00 0001 00042      PRN4
                   123    01 40000 00 4400 00126
FIX                124    01 21700 44 0000 00000
                   125    20 43005 42 4000 77775
                   126    01 21700 00 0024 00000
                   127    01 10701 04 0401 00054      WRKPAD
                   130    42 06150 22 4010 00000
                   131    04 10601 30 0401 00052      WRKPAD
                   132    01 61020 00 0001 00033      PRN5
                   133    03 20100 07 4001 00033      M3
                   134    01 40000 00 4400 00126
                   135    01 50470 00 0001 00034      PRN6
                   136    01 40000 00 4400 00126
LOOP3              137    01 21700 62 0024 77776
                   140    01 10501 00 0401 00043      WRKPAD
                   141    42 02510 00 4000 00001
                   142    01 01000 00 4001 77773      LOOP3
                   143    01 61020 00 0001 00017      PRN3
                   144    03 20100 07 4001 00026      M4
                   145    01 40000 00 4400 00126
                   146    01 50470 00 0001 00023      PRN6
```

```
                147     01  40000  00  4400  00126
                150     01  50470  00  0001  00031      INACT
                151     01  40000  00  4400  00126
                152     01  61070  70  4400  00137
                153     01  42004  66  4000  00002
                154     01  42000  66  4500  00000
                155     47  43005  40  4500  00000
PRN0            156     00  00043  10  0000  00131
PRN1            157     00  00240  10  0000  00000
M1              160     50  55576  46  3254  25644
                161     45  45504  25  0445  56362
PRN2            162     00  00044  70  0000  00000
PRN3            163     00  00140  10  0000  00000
M2              164     61  56566  36  2252  52525
PRN4            165     00  00044  70  0000  00000
PRN5            166     00  00340  10  0000  00000
M3              167     61  44626  35  6614  44325
                170     42  56444  54  5504  25044
                171     55  63622  52  5252  52525
PRN6            172     00  00044  70  0000  00000
M4              173     44  61615  66  1622  52525
M5              174     62  57444  25  0455  04443
                175     25  44616  15  6612  52525
PRN7            176     00  00140  30  0000  00000
BFOR            177     00  00000  00  4420  00000
BFIV            200     00  00000  00  0040  00000
SETPAD          201     00  00204  20  0000  00000
INACT           202     00  00011  70  0000  00000
ONE             203     01  00100  00  0000  00000
WRKPAD          204     00  00000  00  0000  00000
OUTMAT          205     01  20000  00  0400  00000
```

270 PRF

PRF (*270)

Purpose: To find the nearest real root of a real polynomial.

Input: The coefficients must be stored in decending order in a Spirel vector.

Output: The root may be found in T7 after exiting *270.

Calling Sequence: B1 is set to the codeword address of the coefficient vector, T6 is set to the first guess for the location of the root, and T7 is set to the maximum error in evaluation. If T7 is zero, the maximum error is assumed to be 1×10^{-12}.

Restrictions: Since this routine uses third order interpolation, one should avoid a first guess in the region of Ω maxima or minima unless the root is repeated. T7 should be sufficiently large as not to challenge the accuracy of the machine during the evaluation of higher degree polynomials and their derivatives.

Running Time: Approximately 0.1 second unless T7 is to small on entry. (A maximum of 100 interpolations will be done.)

Registers Used: All fast registers are used and are saved and unsaved by *136 and *137.

Length: 164 words octal.

Gary Sitton,

May 26, 1964.

```
                                                                    1
270             ORG                                                 2
                REM             THIRD ORDER INTERPOLATION           3
                REM             ROOT FINDER PLUS CORRECTIONS
                REM             FOR MAXIMA OR MINIMA. COEF-         5
                REM             FICIENTS IN *B1, T6 = FIRST         6
                REM             GUESS, T7 = MAXIMUM ERROR.          7
        -Z      TRA             *136,U→R                            10
                LDR             B1,R→B2                             11
                LLS             ad15,U→B3                           12
                LLS             ad15,U→PF                           13
        PF      LUR             a3,U→PF                             14
        I       AB2             aPF-1,U→B1                          15
        T7      IF(NZE)TRA      aCC+1                               16
                CLA             EPSLON                              17
                STO             ERROR                               20
                53100           -aB3-1                              21
                FMP             TWO47                               22
                STO             aDEGREE,I→B5                        23
        I       SB4             ad100,U→PF                          24
                LT5             d1.0,PF+1                           25
NEXT            LT7             B2+B1,B4-1                          26
LOOP0   T6      FMP             T7,B1+1                             27
                FAD             B2+B1,U→T7                          30
        B1      IF(POS)SKP      aB3                                 31
                TRA             aLOOP0                              32
        |T7|    IF(PNZ)SKP      ERROR                               33
                TRA             aEXIT                               34
        T7      LDR→            YZERO                               35
        R       STO             aYZER1                              36
        B5      IF(ZER)TRA      aNOMULT                             37
        I       LT4             DEGREE,U→B5                         40
        T4      FMP             B2+B5,U→T7                          41
LOOP1   T6      FMP→            T7,B5+1                             42
        -T5     FAD             T4,U→T4                             43
                FMP             B2+B5                               44
                FAD             T7,U→T7                             45
        B5      IF(POS)SKP      aB3-1                               46
                TRA             aLOOP1                              47
        T7      LDR→            YONE                                50
        P       LT4→            YONE1                               51
        B4      IF(NEG)SKP      ad90                                52
                TRA             aNOHAF                              53
        R       IF(ZER)TRA      aEXIT                               54
                SYD             T7,U→T7                             55
        PF      IF(ZER)TRA      aNOFIX                              56
                CLA             YZERO                               57
                SYD             YZER1                               60
                ORU             T7,R→Z                              61
                IF(NSN)TRA      aNOFIX,R→PF                         62
        I       LDR             X1,U→B1                             63
        P       FSB             X2,PF+1                             64
                FAD             T6,U→R                              65
                TRA             aNOTEST+1                           66
NOFIX           IF(MOV)TRA      aMULTP                              67
                CLA             YONE                                70
                SYD             T4                                  71
                ORU             T7,R→Z                              72
                IF(PSN)TRA      aNOMULT,R→B5                        73
```

```
MULTP              ILN           @4000
          T7       IF(NSN)TRA    @HALVE,B5+1
                   TRA           @HALVE+1
NOMULT             CLA           YZERO
                   SYD           YZER1
                   IF(PSN)TRA    @CC+1
HALVE              CLA           X1,CC+1
                   CLA           X2
                   FAD+20        T6
                   DMR           @1,I→B1
                   FAD+20        @Z,U→R
                   TRA           @NOTEST+1
NOHAF     |T7|     IF(NEG)SKP    DTEST
                   TRA           @MORE
                   LT4           YZERO
                   TRA           @CREP
MORE      I        LT4           DEGREE,U→B5
          T4       FMP           B2+B5,U→T7
          -T5      FAD           T4,U→T4
                   FMP           T7,U→T7
LOOP2     B5       IF(NNZ)SKP    @B3=2
                   TRA           @EVAL,R→Z
          T6       FMP→          T7,B5+1
          T4       FMP+2         B2+B5
          -T5      FAD           T4,U→T4
                   FMP           B6
                   FAD           T7,U→T7
                   TRA           @LOOP2
EVAL               CLA           YZERO,U→T4
                   FDV           YONE
                   FMP           U,I→B1
                   FMP           T7
                   DMR           @1
                   FAD+20        @Z
                   FAD+20        T4
                   FDV           -YONE,U→T7
          PF       IF(NEG)TRA    @NOTEST,PF-1
          T5       IF(PNZ)SKP    |YONE|
                   TRA           @NOTEST
CREP      T4       FMP           -YONE
                   FDV           |U|
                   FMP           |T4|
                   DMR           @3,U→T7
NOTEST    T7       FAD           T6,U→R
          T6       LT4→          X1,R→T6
          T4       FSB           T6,U→T7
          T6       FSB           X2
          |U|      IF(NNZ)SKP    |T7|
          T4       STO           @X2
          B4       IF(PNZ)TRA    @NEXT
EXIT      T6       TRA           *137,U→T7
          PF       ILF           @6000,U→CC
EPSLON             DEC           0.00000000001
DTEST              DEC           0.000001
TWO47              OCT           0620000000000000000
ERROR              OCT           Z
DEGREE             OCT           Z
YZERO              OCT           Z
YZER1              OCT           Z
```

```
YONE        OCT     Z                   167
YONE1       OCT     Z                   170
X1          OCT     Z                   171
X2          OCT     Z                   172
            END                         173
                                        174
```

```
311   EPSLON    0  151  0   200000000000000   0
312   ERROR     0  154  0   206000000000000   0
313   TWO47     0  153  0   204000000000000   0
314   DEGREE    0  155  0   210000000000000   0
315         0   0  164  0   226000000000000   0
316   NEXT      0   17  0    45000000000000   0
317   LOOPO     0   20  0    46000000000000   0
320   EXIT      0  147  0   175000000000000   0
321   YZERO     0  156  0   212000000000000   0
322   YZER1     0  157  0   214000000000000   0
323   NOMULT    0   70  0   116000000000000   0
324   LOOP1     0   33  0    61000000000000   0
325   YONE      0  160  0   216000000000000   0
326   YONE1     0  161  0   220000000000000   0
327   NOHAF     0  101  0   127000000000000   0
330   NOFIX     0   60  0   106000000000000   0
331   X1        0  162  0   222000000000000   0
332   X2        0  163  0   224000000000000   0
333   NOTEST    0  140  0   166000000000000   0
334   MULTP     0   65  0   113000000000000   0
335   HALVE     0   73  0   121000000000000   0
336   DTEST     0  152  0   202000000000000   0
337   MORE      0  105  0   133000000000000   0
340   CREP      0  134  0   162000000000000   0
341   LOOP2     0  111  0   137000000000000   0
342   EVAL      0  121  0   147000000000000   0

THIRD ORDER INTERPOLATION
ROOT FINDER PLUS CORRECTIONS
FOR MAXIMA OR MINIMA, COEF-
FICIENTS IN *B1. T6 = FIRST
GUESS, T7 = MAXIMUM ERROR,
 27            1   10 01000 02 4400 00136
 30            2   01 50400 52 0002 00000
 31            3   01 45062 43 4000 00017
 32            4   01 45062 47 4000 00017
 33            5   47 45010 47 4000 00003
 34            6   20 41002 41 4200 77776
 35            7   07 01050 00 4001 00001
 36           10   01 21700 00 0001 00140   EPSLON
 37           11   01 20001 00 4001 00142   ERROR
 40           12   01 53100 00 5010 77776
 41           13   01 10600 00 0001 00137   TWO47
 42           14   01 20001 75 4001 00140   DEGREE
 43           15   20 40004 47 4000 00144
 44           16   01 50450 27 0001 00145        0
 45   NEXT    17   01 50470 64 0006 00000
 46   LOOPO   20   06 10600 21 0000 00007
 47           21   01 10400 07 0006 00000
 50           22   41 02110 00 4010 00000
 51           23   01 01000 00 4001 77773   LOOPO
 52           24   27 06150 00 0001 00127   ERROR
 53           25   01 01000 00 4001 00121   EXIT
 54           26   07 50401 00 0001 00127   YZERO
 55           27   02 20001 00 4001 00127   YZER1
 56           30   45 01010 00 4001 00037   NOMULT
 57           31   20 50440 45 0001 00123   DEGREE
 60           32   04 10600 07 0044 00000
 61   LOOP1   33   06 10601 25 0000 00007
 62           34   15 10400 04 0000 00004
 63           35   01 10600 00 0044 00000
 64           36   01 10400 07 0000 00007
 65           37   45 02110 00 4010 77776
 66           40   01 01000 00 4001 77771   LOOP1
```

```
              41   07 50401 00 0001 00116     YONE
              42   02 50441 00 0001 00116     YONE1
              43   44 02510 00 4000 00132
              44   01 01000 00 4001 00034     NOHAF
              45   02 01010 00 4001 00101     EXIT
              46   01 53220 07 0000 00007
              47   47 01010 00 4001 00010     NOFIX
              50   01 21700 00 0001 00105     YZERO
              51   01 53220 00 0001 00105     YZER1
              52   01 50010 10 0000 00007
              53   01 01500 57 4001 00004     NOFIX
              54   20 50400 41 0001 00105     X1
              55   02 10500 27 0001 00105     X2
              56   01 10400 02 0000 00006
              57   01 01000 00 4001 00061     NOTEST+   1
NOFIX         60   01 01200 00 4001 00004     MULTP
              61   01 21700 00 0001 00076     YONE
              62   01 53220 00 0000 00004
              63   01 50010 10 0000 00007
              64   01 01100 55 4001 00003     NOMULT
MULTP         65   01 42001 00 4000 04000
              66   07 01500 25 4001 00004     HALVE
              67   01 01000 00 4001 00004     HALVE +   1
NOMULT        70   01 21700 00 0001 00065     YZERO
              71   01 53220 00 0001 00065     YZER1
              72   01 01100 00 4001 00001
HALVE         73   01 21700 20 0001 00066     X1
              74   01 21700 00 0001 00066     X2
              75   01 10420 00 0000 00006
              76   01 44000 71 4000 00001
              77   01 10420 02 4000 00000
             100   01 01000 00 4001 00040     NOTEST+   1
NOHAF        101   27 02510 00 0001 00050     DTEST
             102   01 01000 00 4001 00002     MORE
             103   01 50440 00 0001 00052     YZERO
             104   01 01000 00 4001 00027     CREP
MORE         105   20 50440 45 0001 00047     DEGREE
             106   04 10600 07 0044 00000
             107   15 10400 04 0000 00004
             110   01 10600 07 0000 00007
LOOP2        111   45 06550 00 4010 77775
             112   01 01000 10 4001 00006     EVAL
             113   06 10601 25 0000 00007
             114   04 10602 00 0044 00000
             115   15 10400 04 0000 00004
             116   01 10600 00 0100 00000
             117   01 10400 07 0000 00007
             120   01 01000 00 4001 77767     LOOP2
EVAL         121   01 21700 04 0001 00034     YZERO
             122   01 10700 00 0001 00035     YONE
             123   01 10600 71 0000 00001
             124   01 10600 00 0000 00007
             125   01 44000 00 4000 00001
             126   01 10420 00 4000 00000
             127   01 10420 00 0000 00004
             130   01 10700 07 1001 00027     YONE
             131   47 01510 67 4001 00006     NOTEST
             132   05 06150 00 2001 00025     YONE
             133   01 01000 00 4001 00004     NOTEST
CREP         134   04 10600 00 1001 00023     YONE
             135   01 10700 00 2000 00001
             136   01 10600 00 2000 00004
             137   01 44000 07 4000 00003
NOTEST       140   07 10400 02 0000 00006
             141   06 50441 16 0001 00020     X1
             142   04 10500 07 0000 00006
```

```
1/1                 143     06 10500 00 0001 00017      X2
1/2                 144     21 06550 00 2000 00007
1/3                 145     04 20001 00 4001 00015      X2
1/4                 146     44 05150 00 4001 77647      NEXT
1/5   EXIT           147     06 01000 07 4400 00137
1/6                 150     47 42005 40 4000 06000
200   EPSLON        151     73 00106 27 4630 04557
202   DTEST         152     75 02061 57 3640 55366
204   TWO47         153     06 20000 00 0000 00000
206   ERROR         154     00 00000 00 0000 00000
210   DEGREE        155     00 00000 00 0000 00000
212   YZERO         156     00 00000 00 0000 00000
214   YZER1         157     00 00000 00 0000 00000
216   YONE          160     00 00000 00 0000 00000
220   YONE1         161     00 00000 00 0000 00000
222   X1            162     00 00000 00 0000 00000
224   X2            163     00 00000 00 0000 00000
226                 164     01 00100 00 0000 00000
```