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Simulation of Indexing Registers and Automatic Floating-Decimal Arithmetic for a 4000-Word I.B.M. 650

DONALD BURD

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Simulation of Indexing Registers and Automatic Floating-Decimal Arithmetic for a 4000-Word I.B.M. 650*

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ABSTRACT

This report describes an interpretive program which will allow programs written for a 2000-word I.B.M. 650 with indexing registers and automatic floating-decimal device to be run (possibly with minor changes) on a basic 4000-word 650. Because of the low relative speed of the interpreter (the minimum estimated ratio is about 20/1), its use is recommended only with programs requiring a short time when run as originally intended. Even with this limitation, it is expected that many useful "one-shot" library routines will become available to users of the 4000-word machine without expenditure of additional programming time.

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* This work is supported by the Office of Naval Research.

METHOD

The program has been coded in the SOAP II language and assembled by SOAP IIA-4000 in locations 2000-3011 and 3999. The attempt has been made in the case of each simulated operation to duplicate the numerical result which would have been obtained on the 2000-word machine (see I.B.M. 650 Data Processing Bulletin G24-5003-0 6/59 for a description of these operations). It can therefore be expected that test results given in a program write-up will be duplicated identically by running in the interpretive mode.

RESTRICTIONS

1. The drum should be free of blank cells.

This restriction is necessary since the contents of the address given by the data portion of the instruction are examined regardless of whether this portion has any meaning in the program as an address (i.e., it has none in the case of a shift instruction). One simple way to comply with this restriction is to clear the drum before running, and then to make sure that any blank positions on the input cards are filled with zeros.

2. No illegal address should appear in an instruction being executed in the interpretive mode.

This will apply only to the instruction address portion of a reading instruction intended for operation on load cards, which will usually be set in the console switches.

If it is necessary to violate this restriction, a stop will occur at SI1(01 2138 2138) when the interpreter examines the illegal address. After verifying that the offending instruction is the one in the switches, the program can be restarted at EM1(2100).

3. Load cards cannot be used directly in the interpretive mode, nor can they be used to transfer control to parts of the program which must be executed in the interpretive mode.

This restriction arises because the automatic branch caused by the "load" feature of the 650 interferes with the control of the program by the interpreter. Load cards can be used, however, if revised as follows:

The first location to which control is transferred (given by the data address of the read instruction) must read 65 X_1 2115, where X_1 contains the location of the next program instruction to be executed (00 0000 X_2).

Thus in the case of a conventional "transfer" card which has $\overset{+}{0}0\ 0000\ 123\overset{+}{4}$ as its first word and is read by the instruction 70 1951 9999, the revised card becomes:

word 1: $\overset{+}{6}5\ 1952\ 211\overset{+}{5}$

word 2: $00\ 0000\ 123\overset{+}{4}$

If the load card scheme is more complex than this, some other method must be devised to adhere to the general rules given above.

It should be noted that a failure to observe one of these restrictions is not dangerous in the sense that it can result in a machine stop, but not in erroneous calculations.

It would be advisable, however, to examine the program for possible violations prior to running in order to conserve machine time.

INSTRUCTIONS FOR USE

1. Insert a standard 80-80 input-output panel in the 533 and load the interpreter (70 1951 1950 in the switches; press computer reset, program start, read feed start, ... end of file).

2. Change the console switch settings and the input-output panel if necessary for loading the program. If the loading procedure does not depend on the features being simulated, it can be carried out as under normal running conditions with the exception that any load cards which transfer control to the program must be revised as described above. If the loading procedure uses either the indexing registers or the automatic floating-decimal arithmetic, then loading must be done in the interpretive mode (described in section 3 below). In this case also, load cards which transfer control to the program must be revised.

3. To start computing in the interpretive mode manually (this may be necessary before or after loading as explained in section 2 above, or not at all if the program is normally initiated by a "transfer" card), read the address of the first instruction into BEGIN (3999) in the form 00 0000 XXXX and start the program manually at START (3000). If the first instruction is to be taken from the switches, then 00 0000 8000 must be read into BEGIN.

ACKNOWLEDGEMENT

I would like to express my thanks to Dr. Daniel Tycko, without whose help and encouragement the project would not have been possible.

TABLE OF PSEUDO-REGISTERS

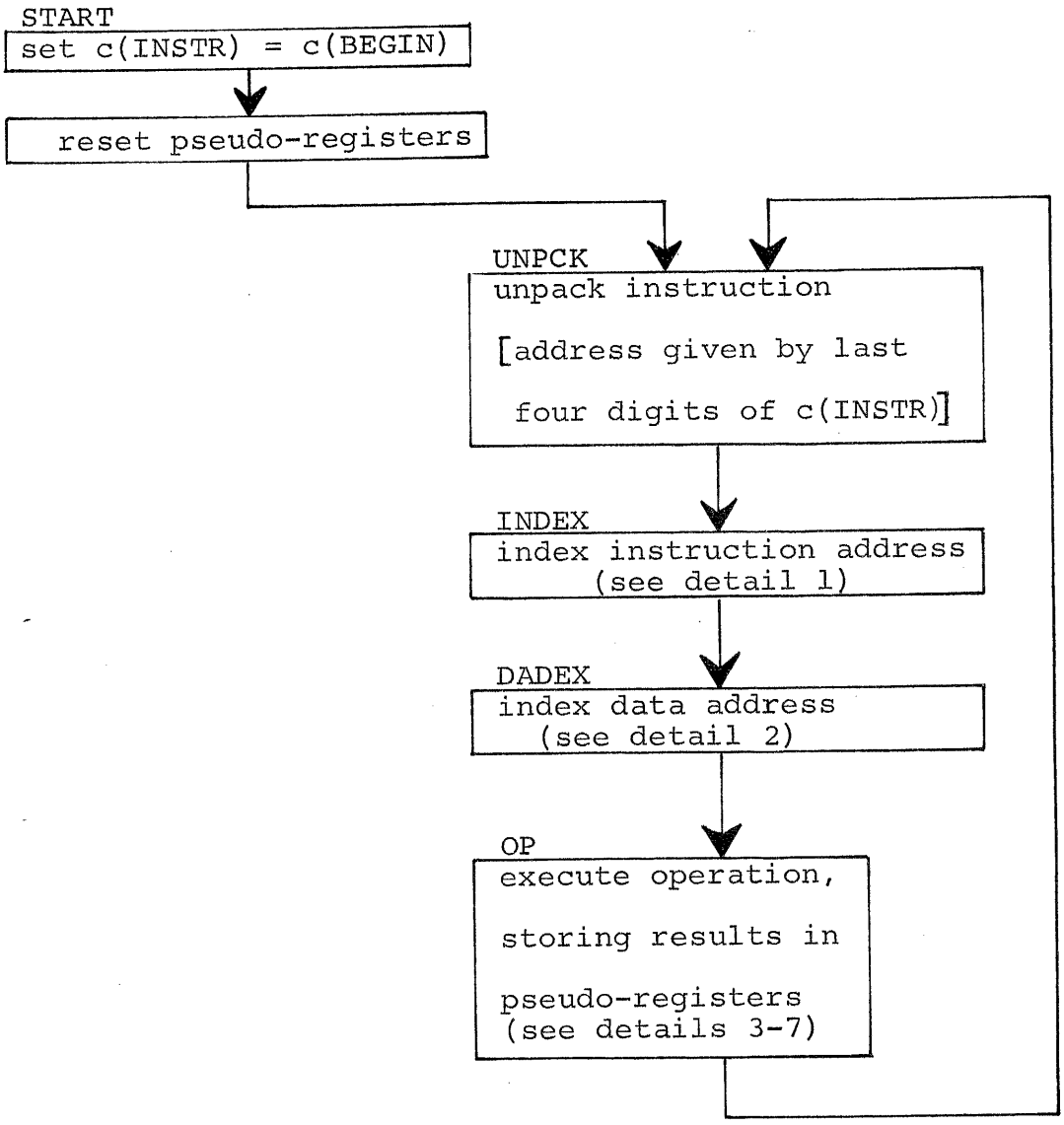
Register	Soap Name	Address	Contents
1. Distributor	DISTR	3001	Current contents of distributor.
2. Lower Accumulator	LOWER	3002	Current contents of lower accumulator.
3. Upper Accumulator	UPPER	3003	Current contents of upper accumulator.
4. Indexing Register A	IRA	3005	Current contents of indexing register A.
5. Indexing Register B	IRB	3006	Current contents of indexing register B.
6. Indexing Register C	IRC	3007	Current contents of indexing register C.
7. Operation Code	OP	3008	Last two digits are current operation code.
8. Data Address	DATA	3009	Data portion is current data address.
9. Instruction Address	INSTR	3010	Instruction portion is current instruction address.
10. Contents of Data Address	CDATA	3011	Contents of current data address.

PROGRAMMED STOPS

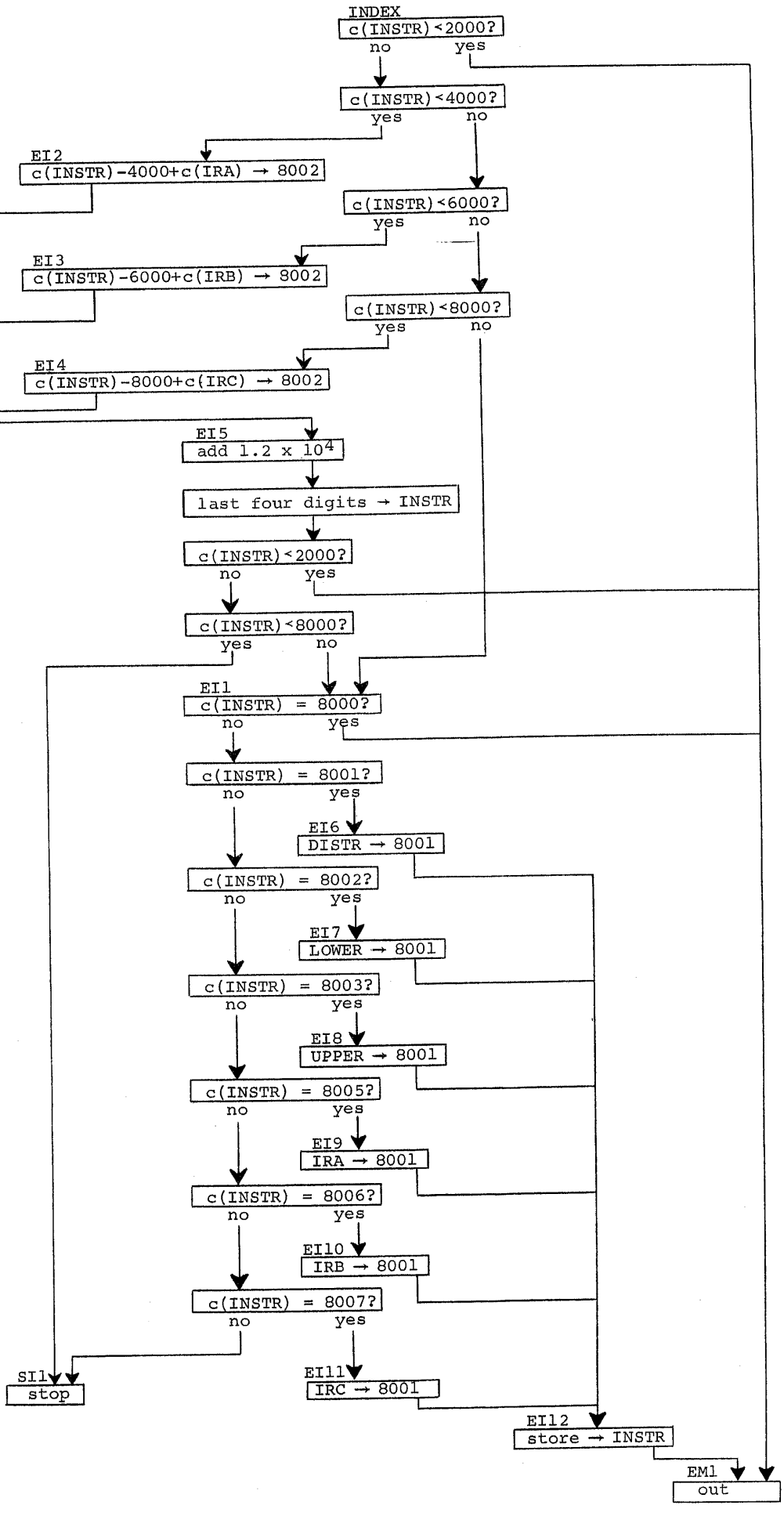
The instruction in parentheses will be found in the program register. The correspondence with the original program can be established by using the table of pseudo-registers to reconstruct the instruction currently being interpreted and examining the operands.

1.	SI1 (01 2138 2138)	Illegal instruction address.
2.	SD1 (01 2136 2136)	Illegal data address.
3.	2001 (01 3009 2113)	Programmed stop in original program (press program start button to continue).
4.	20XX (01 20XX 20XX)	Illegal operation code.
5.	S341 (01 2378 2378)	Zero divisor.
6.	S342 (01 2216 2216)	Mantissa of the divisor has more leading zeros than mantissa of the dividend.

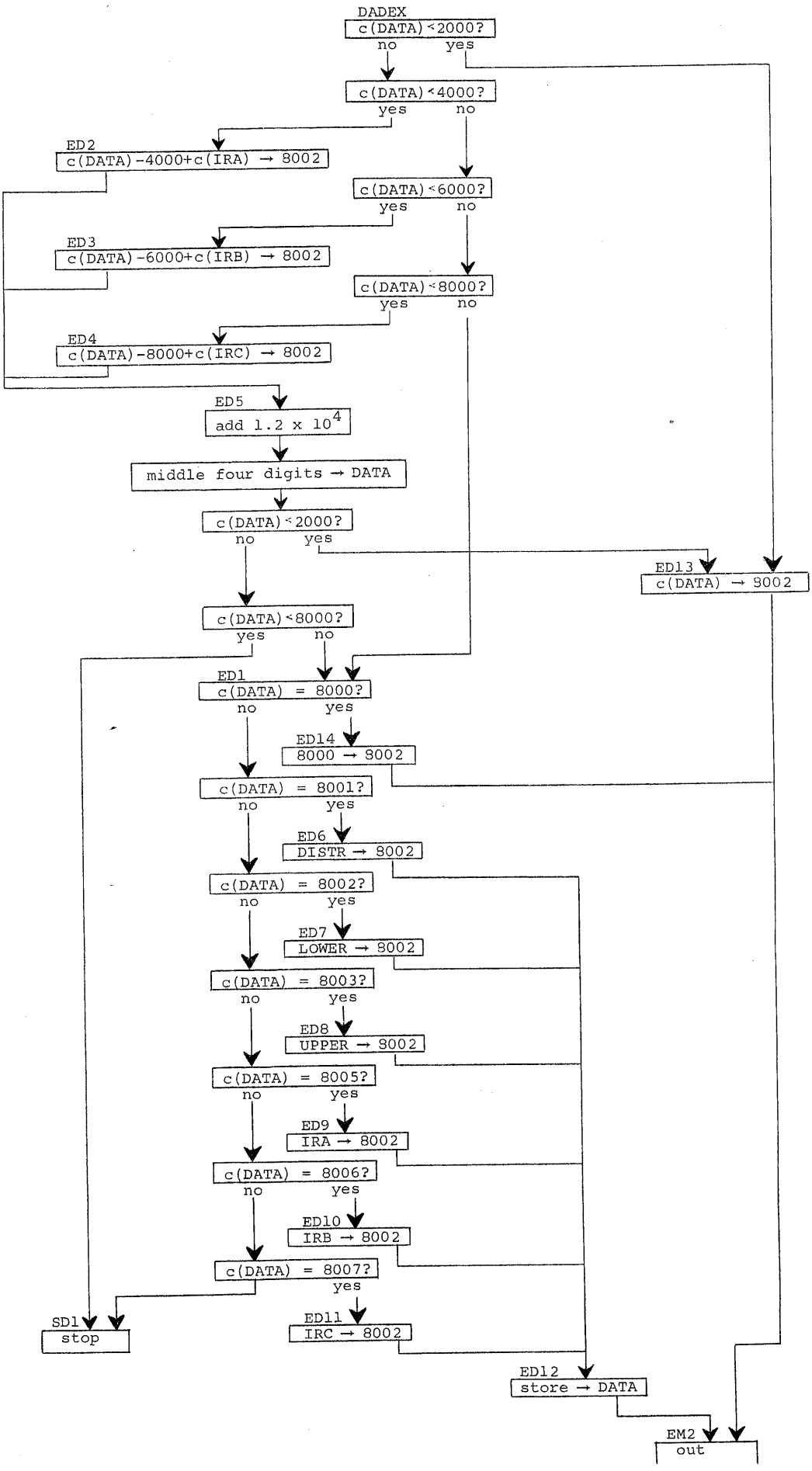
Master Flow Chart



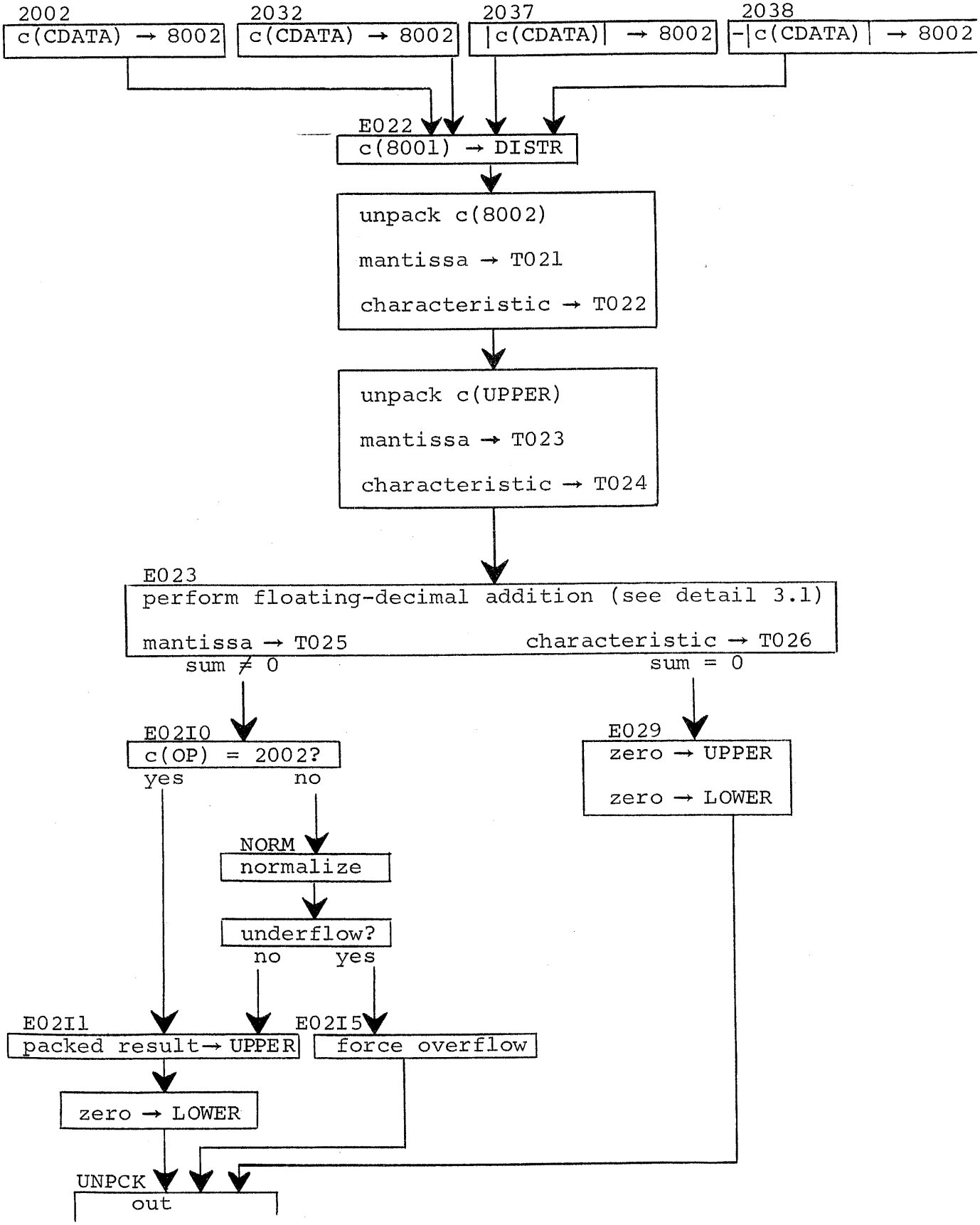
DETAIL 1. Instruction Address Indexing Routine



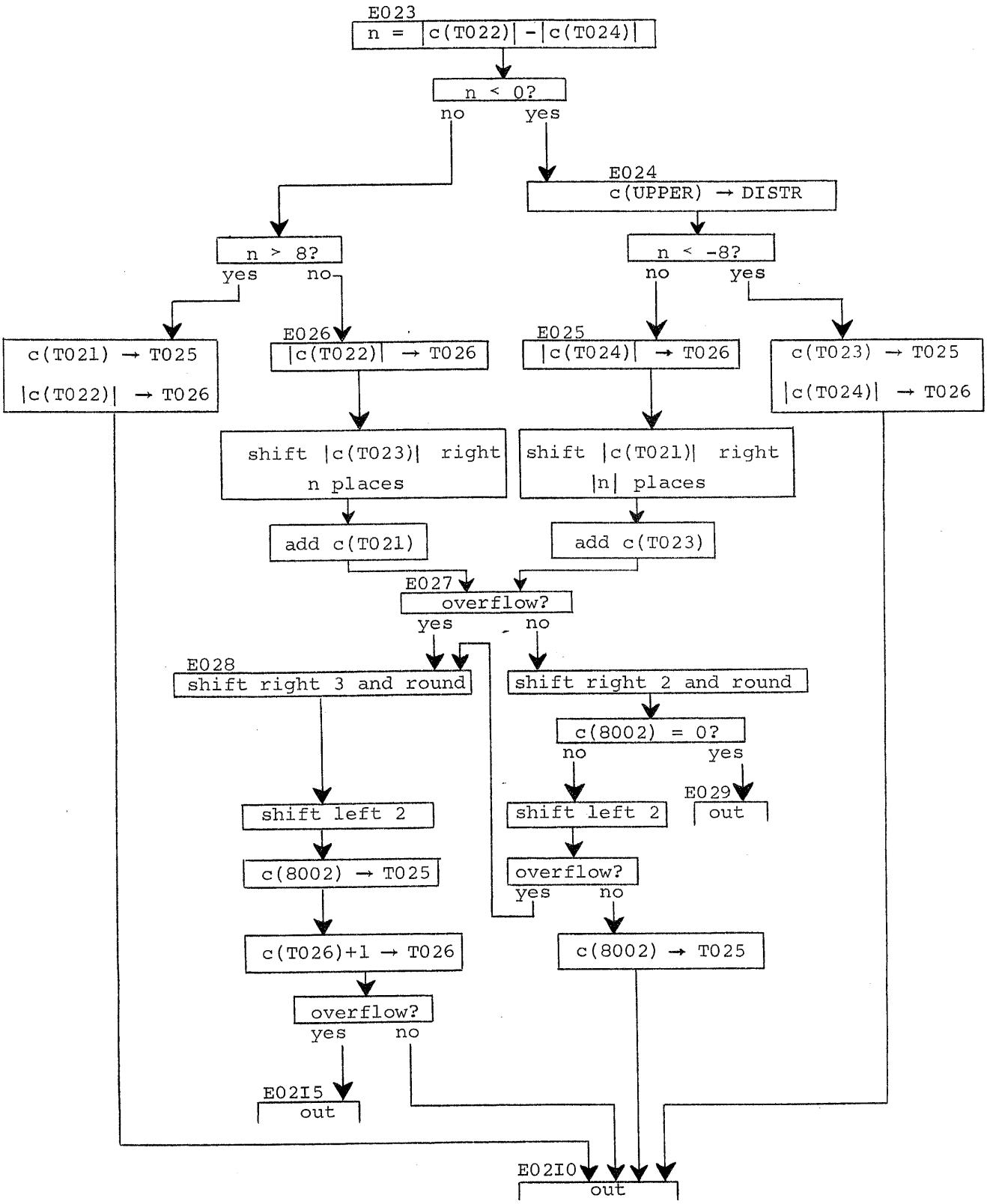
DETAIL 2. Data Address Indexing Routine



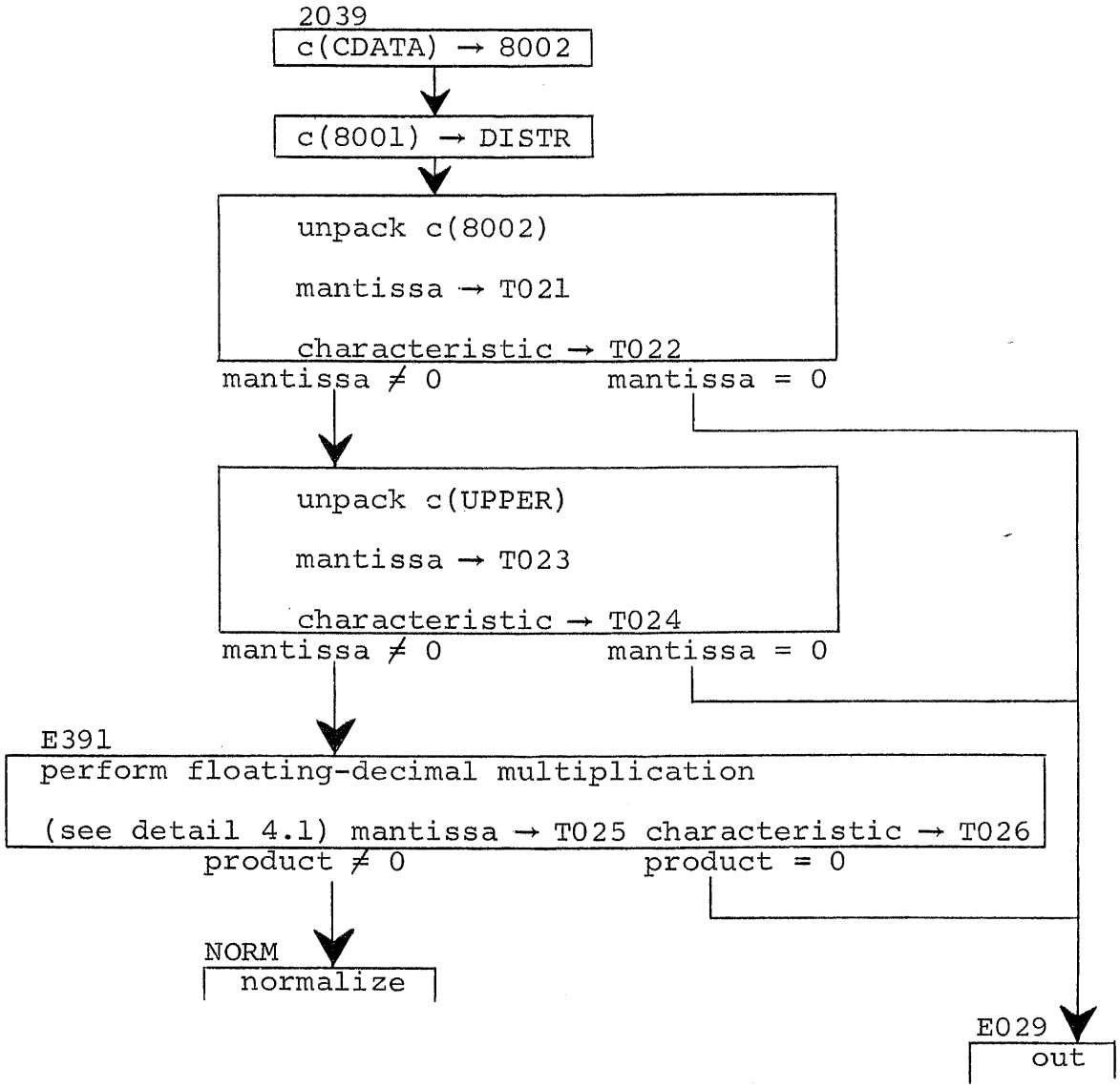
DETAIL 3. Floating-Decimal Addition Routine



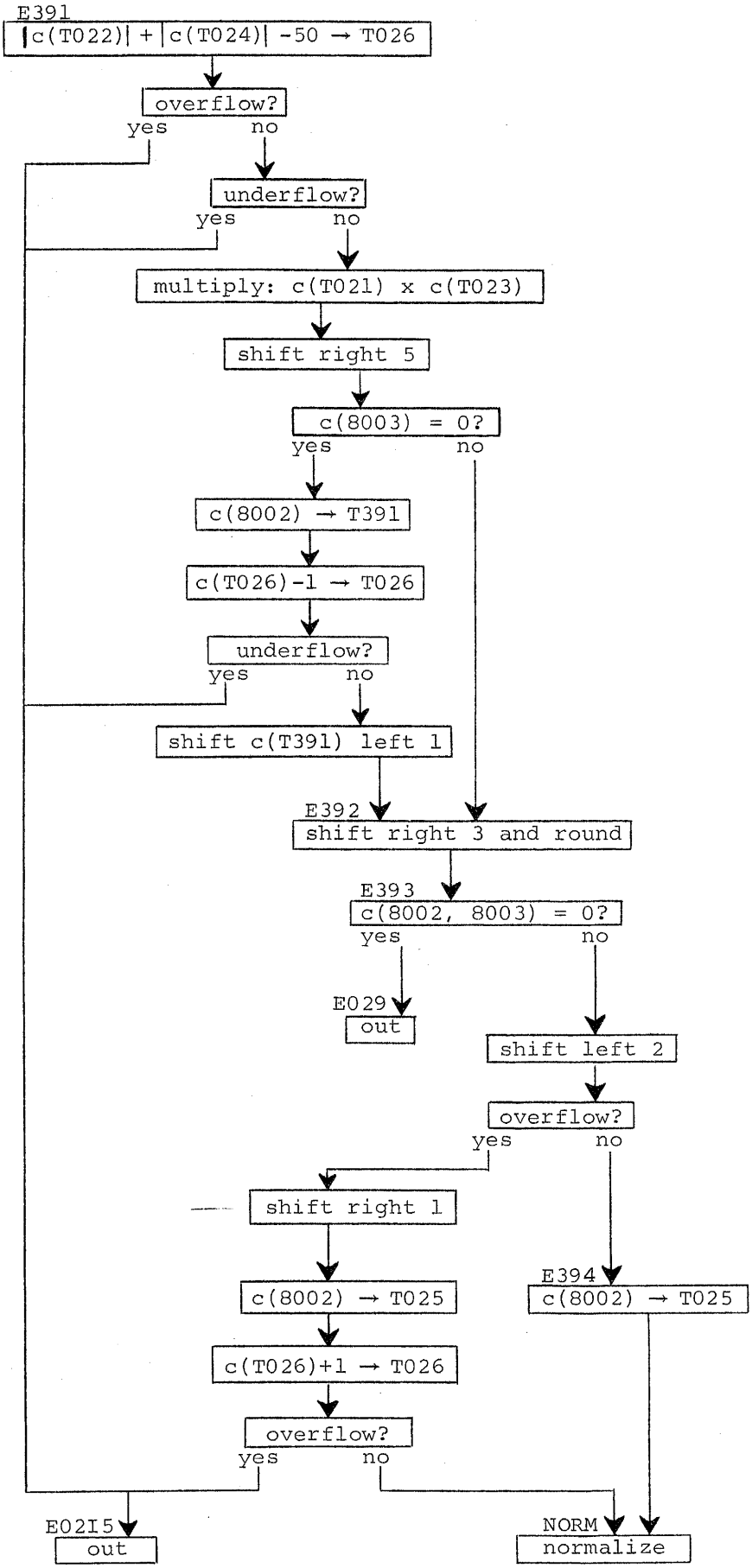
DETAIL3.1 Floating-Decimal Addition



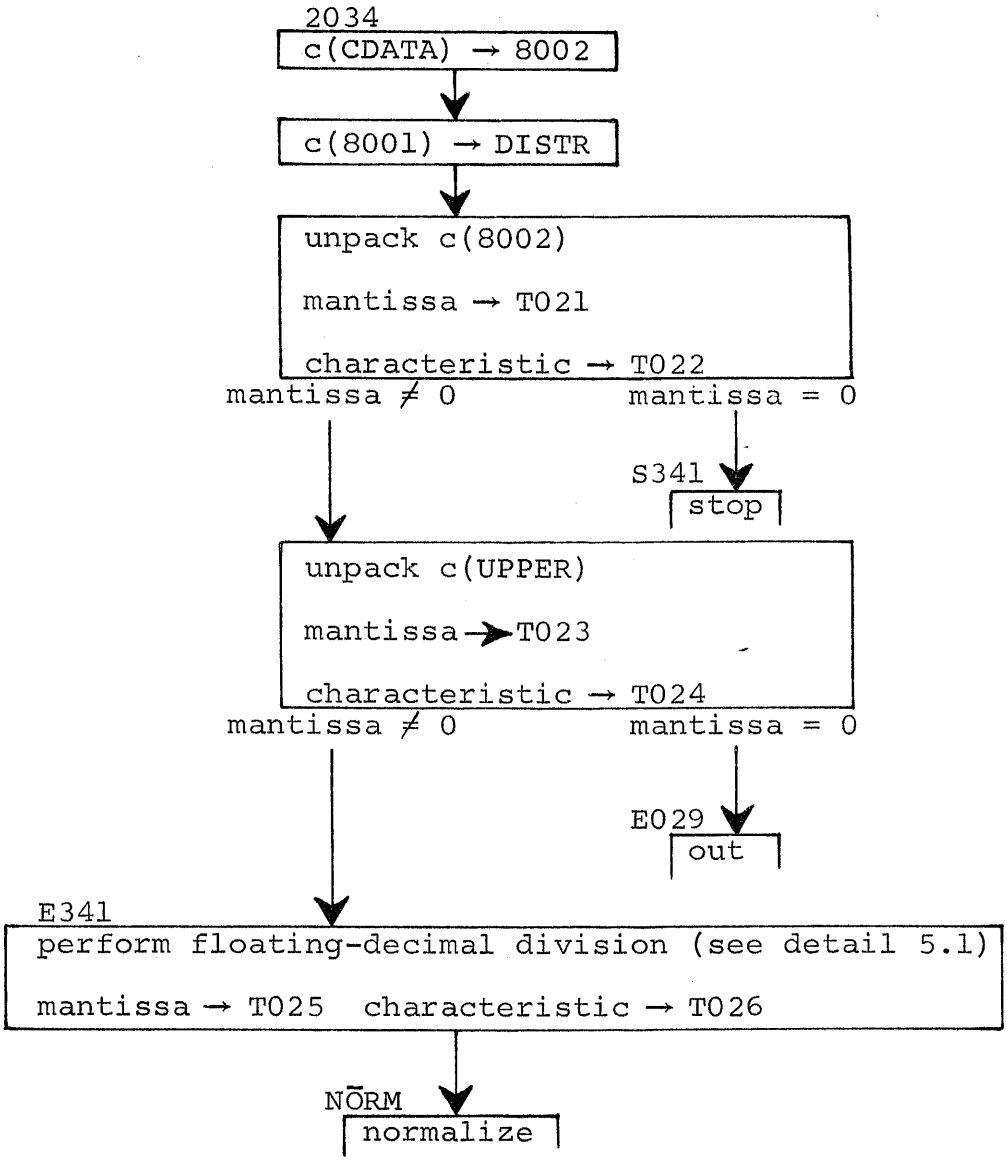
DETAIL 4. Floating-Decimal Multiplication Routine



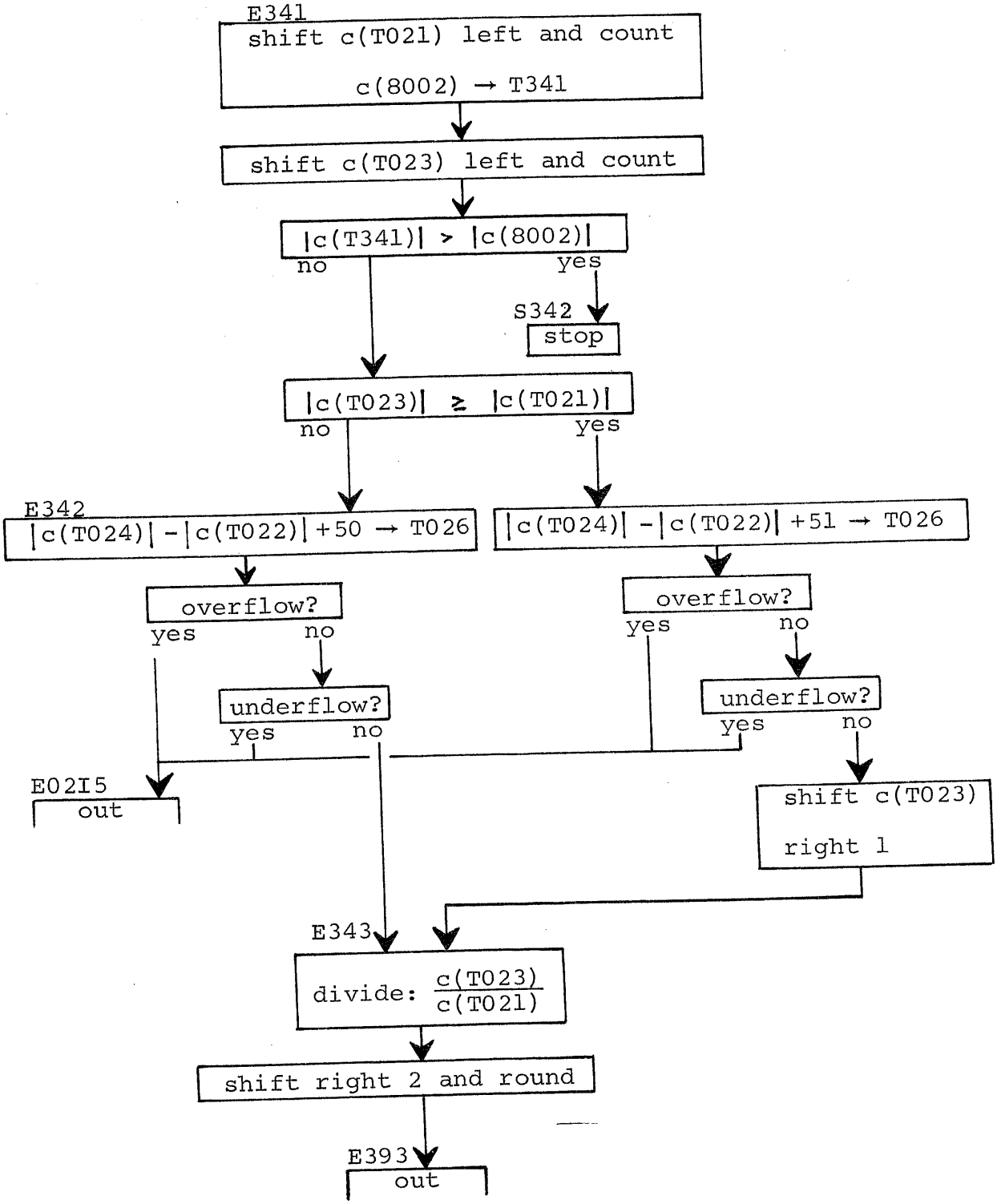
DETAIL 4.1 Floating-Decimal Multiplication



DETAIL 5. Floating-Decimal Division Routine



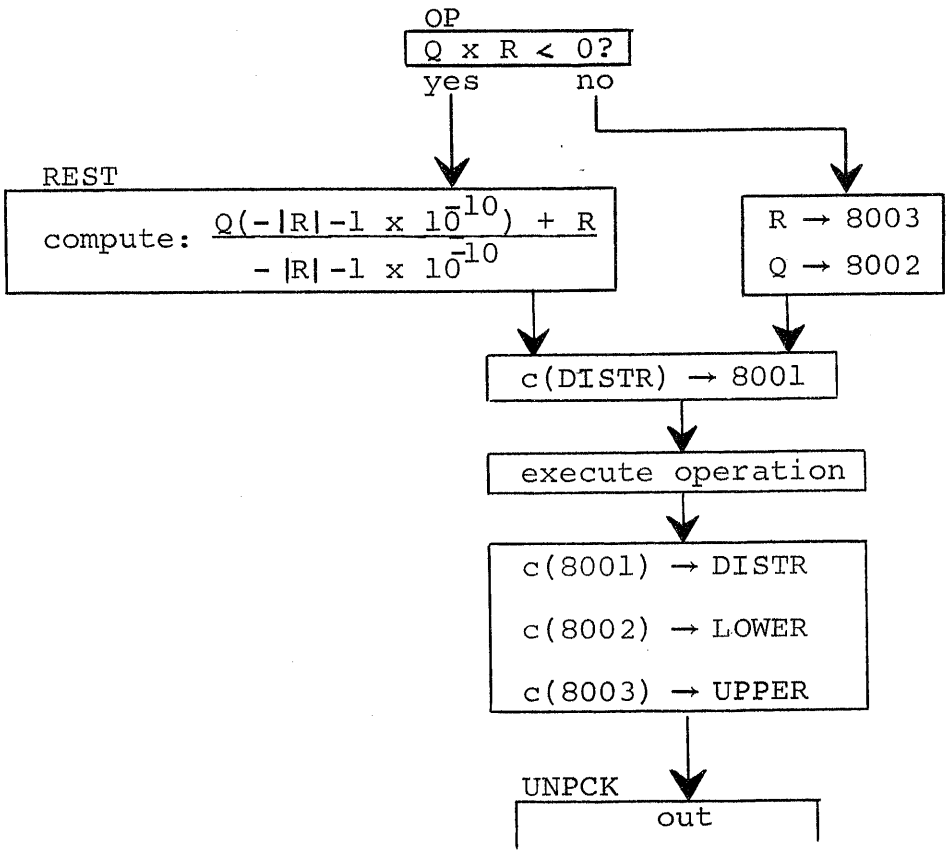
DETAIL 5.1 Floating-Decimal Division



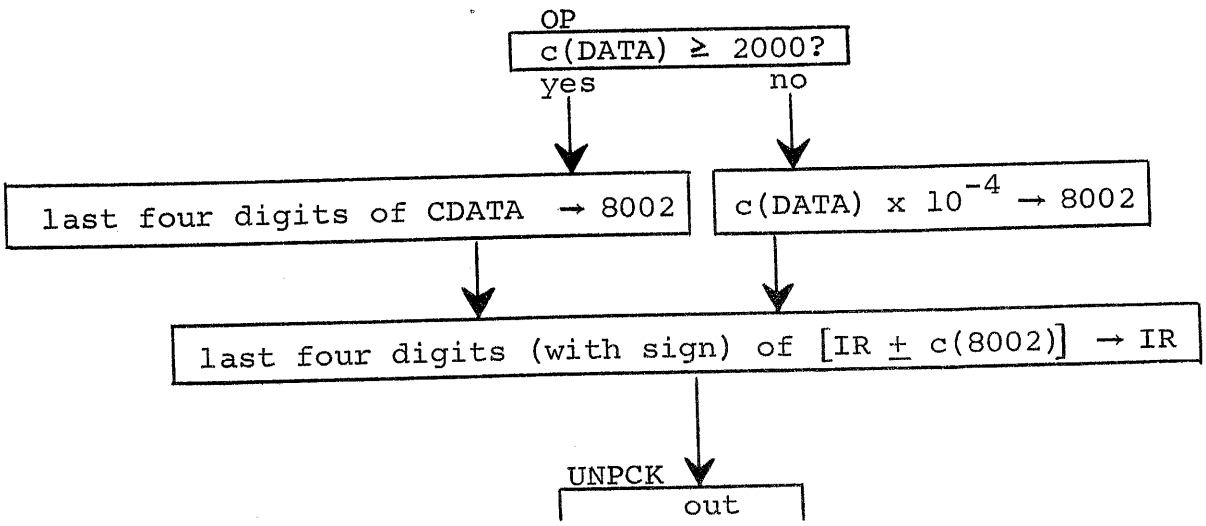
DETAIL 6. Execution of a Basic 650 Arithmetic Operation

Q ≡ c(LOWER)

R ≡ c(UPPER)



DETAIL 7. Execution of an Arithmetic Indexing Register Operation



```
        SYN  START    3000                  1
        SYN  BEGIN    3999                  2
        SYN  DISTR    3001                  3
        SYN  LOWER    3002                  4
        SYN  UPPER    3003                  5
        SYN  IRA      3005                  6
        SYN  IRB      3006                  7
        SYN  IRC      3007                  8
        SYN  OP       3008                  9
        SYN  DATA     3009                 10
        SYN  INSTR    3010                 11
        SYN  CDATA    3011                 12
        BLR   0000    2099                 13
        BLR   3012    3999                 14
START   RAL  BEGIN            MAIN         15  3000    65  3999  2103
        STU  DISTR            PROGRAM      16  2103    21  3001  2104
        STU  LOWER                         17  2104    21  3002  2105
        STU  UPPER                         18  2105    21  3003  2106
        STU  IRA                           19  2106    21  3005  2108
        STU  IRB                           20  2108    21  3006  2109
        STU  IRC                           21  2109    21  3007  2110
        STL  INSTR    UNPCK                22  2110    20  3010  2113
UNPCK   RAL  INSTR                         23  2113    65  3010  2115
        SLT   0004                         24  2115    35  0004  2125
        ALO  C1        8002                25  2125    15  2128  8002
C1      RAM   0000                         26  2128    67  0000  2155
        LDD   8003                         27  2155    69  8003  2112
        SIA  INSTR                         28  2112    23  3010  2163
        LDD   8003                         29  2163    69  8003  2120
        SDA  DATA                          30  2120    22  3009  2162
        SLT   0002                         31  2162    35  0002  2119
        AUP  C13                           32  2119    10  2122  2127
        STU  OP                            33  2127    21  3008  2111
        RAL  INSTR    INDEX                34  2111    65  3010  2165
EM1     RAL  DATA     DADEX                35  2100    65  3009  2213
EM2     ALO  C34       8002                36  2150    15  2153  8002
C34     LDD   0000                         37  2153    69  0000  2203
        STD  CDATA    OP                   38  2203    24  3011  3008
INDEX   SLO  C2               INDEX        39  2165    16  2118  2123
        BMI  EM1              INSTR        40  2123    46  2100  2177
        SLO  C2               ADDRESS      41  2177    16  2118  2173
        BMI  EI2                           42  2173    46  2126  2227
        SLO  C2                            43  2227    16  2118  2223
        BMI  EI3                           44  2223    46  2176  2277
        SLO  C2                            45  2277    16  2118  2273
        BMI  EI4      EI1                  46  2273    46  2226  2327
EI2     ALO  IRA      EI5                  47  2126    15  3005  2159
EI3     ALO  IRB      EI5                  48  2176    15  3006  2159
EI4     ALO  IRC      EI5                  49  2226    15  3007  2159
EI5     ALO  C36                           50  2159    15  2212  2117
        LDD   8003                         51  2117    69  8003  2124
        SIA  INSTR                         52  2124    23  3010  2263
        RAL   8001                         53  2263    65  8001  2169
        SLO  C2                            54  2169    16  2118  2323
        BMI  EM1                           55  2323    46  2100  2377
        SLO  C4                            56  2377    16  2130  2135
        BMI  SI1      EI1                  57  2135    46  2138  2327
```

```
EI1     NZE                 EM1
        SLO   C15
        NZE                 EI6
        SLO   C15
        NZE                 EI7
        SLO   C15
        NZE                 EI8
        SLO   C37
        NZE                 EI9
        SLO   C15
        NZE                 EI10
        SLO   C15
        NZE   SI1           EI11
EI6     LDD   C16           EI12
EI7     LDD   C17           EI12
EI8     LDD   C18           EI12
EI9     LDD   C19           EI12
EI10    LDD   C20           EI12
EI11    LDD   C21           EI12
EI12    STD   INSTR         EM1
SI1     HLT   SI1           SI1
DADEX   SLO   C38
        BMI   ED13
        SLO   C38
        BMI   ED2
        SLO   C38
        BMI   ED3
        SLO   C38
        BMI   ED4           ED1
ED2     SRT     0004
        ALO   IRA
        SLT     0004        ED5
ED3     SRT     0004
        ALO   IRB
        SLT     0004        ED5
ED4     SRT     0004
        ALO   IRC
        SLT     0004        ED5
ED5     ALO   C39
        LDD     8003
        SDA   DATA
        RAL     8001
        SLO   C38
        BMI   ED13
        SLO   C48
        BMI   SD1           ED1
ED1     NZE                 ED14
        SLO   C40
        NZE                 ED6
        SLO   C40
        NZE                 ED7
        SLO   C40
        NZE                 ED8
        SLO   C41
        NZE                 ED9
        SLO   C40
```

INDEX	DATA ADDRESS			
58	2327	45	2180	2100
59	2180	16	2133	2137
60	2137	45	2140	2141
61	2140	16	2133	2187
62	2187	45	2190	2191
63	2190	16	2133	2237
64	2237	45	2240	2241
65	2240	16	2143	2147
66	2147	45	2200	2101
67	2200	16	2133	2287
68	2287	45	2290	2291
69	2290	16	2133	2337
70	2337	45	2138	2341
71	2141	69	2144	2197
72	2191	69	2194	2197
73	2241	69	2244	2197
74	2250	69	2253	2197
75	2291	69	2294	2197
76	2341	69	2344	2197
77	2197	24	3010	2100
78	2138	1	2138	2138
79	2213	16	2116	2121
80	2121	46	2174	2175
81	2175	16	2116	2171
82	2171	46	2224	2225
83	2225	16	2116	2221
84	2221	46	2274	2275
85	2275	16	2116	2271
86	2271	46	2324	2325
87	2224	30	0004	2185
88	2185	15	3005	2209
89	2209	35	0004	2219
90	2274	30	0004	2235
91	2235	15	3006	2161
92	2161	35	0004	2219
93	2324	30	0004	2285
94	2285	15	3007	2211
95	2211	35	0004	2219
96	2219	15	2172	2427
97	2427	69	8003	2134
98	2134	22	3009	2262
99	2262	65	8001	2269
100	2269	16	2116	2321
101	2321	46	2174	2375
102	2375	16	2178	2183
103	2183	46	2136	2325
104	2325	45	2228	2129
105	2228	16	2131	2335
106	2335	45	2188	2139
107	2188	16	2131	2385
108	2385	45	2238	2189
109	2238	16	2131	2435
110	2435	45	2288	2239
111	2288	16	2391	2145
112	2145	45	2148	2149
113	2148	16	2131	2485

```
            SLO   C40
            NZE                 ED8
            SLO   C41
            NZE                 ED9
            SLO   C40
```

```
109  2238    16  2131  2435
110  2435    45  2288  2239
111  2288    16  2391  2145
112  2145    45  2148  2149
113  2148    16  2131  2485
```

```
            NZE                 ED10
            SLO   C40
            NZE   SD1           ED11
ED6         RAL   C42           ED12
ED7         RAL   C43           ED12
ED8         RAL   C44           ED12
ED9         RAL   C45           ED12
ED10        RAL   C46           ED12
ED11        RAL   C47           ED12
ED12        STD   DATA          EM2
ED13        ALO    8001         EM2
ED14        RAL   C49           EM2
SD1         HLT   SD1           SD1
REST        STD   ER2                       RESTORE
            RAU   UPPER
            BMI   ER1
            RSU    8003         ER1
ER1         SUP   C15
            STU   TR1
            MPY   LOWER
            ALO   UPPER
            DIV   TR1           ER2
  2000      NOP    0000         UNPCK       NOP
  2001      HLT   DATA          UNPCK       HLT
  2002      RAL   CDATA         E022        UFA
  2032      RAL   CDATA         E022        FAD
  2033      RSL   CDATA         E022        FSB
  2037      RAM   CDATA         E022        FAM
  2038      RSM   CDATA         E022        FSM
E022        STD   DISTR
            SLT    0008
            STU   T021
            STL   T022
            RAL   UPPER
            SLT    0008
            STU   T023
            STL   T024          E023
E023        RSM    8002
            AML   T022
            STL   N
            BMI   E024
            RAL   C10
            SLO   N
            BMI                 E026
            RAU   T021
            SLT    0002
            STU   T025
            RAM   T022
            STL   T026          E0210
E026        RAM   T022
            STL   T026
            RAL   N
            SRT    0004
            ALO   C11
            STL   T023
```

```
114  2485    45  2338  2289
115  2338    16  2131  2535
116  2535    45  2136  2339
117  2139    65  2142  2247
118  2189    65  2192  2247
119  2239    65  2242  2247
120  2149    65  2102  2247
121  2289    65  2292  2247
122  2339    65  2342  2247
123  2247    24  3009  2150
124  2174    15  8001  2150
125  2129    65  2132  2150
126  2136     1  2136  2136
127  2300    24  2303  2156
128  2156    60  3003  2107
129  2107    46  2160  2261
130  2261    61  8003  2160
131  2160    11  2133  2387
132  2387    21  2392  2195
133  2195    19  3002  2373
134  2373    15  3003  2157
135  2157    14  2392  2303
136  2000          2113
137  2001     1  3009  2113
138  2002    65  3011  2215
139  2032    65  3011  2215
140  2033    66  3011  2215
141  2037    67  3011  2215
142  2038    68  3011  2215
143  2215    24  3001  2154
144  2154    35  0008  2423
145  2423    21  2278  2181
146  2181    20  2585  2388
147  2388    65  3003  2207
148  2207    35  0008  2425
149  2425    21  2230  2233
150  2233    20  2437  2340
151  2340    68  8002  2199
152  2199    17  2585  2389
153  2389    20  2193  2146
154  2146    46  2249  2350
155  2350    65  2353  2257
156  2257    16  2193  2297
157  2297    46  2400  2151
158  2400    60  2278  2283
159  2283    35  0002  2439
160  2439    21  2394  2347
161  2347    67  2585  2489
162  2489    20  2243  2196
163  2151    67  2585  2539
164  2539    20  2243  2246
165  2246    65  2193  2397
166  2397    30  0004  2307
167  2307    15  2210  2265
168  2265    20  2319  2222
```

```
E0212   AUP  T021      E027
E024    LDD  UPPER
        STD  DISTR
        RAL  N
        ALO  C10
        BMI              E025
        RAU  T023
        SLT    0002
        STU  T025
        RAM  T024
        STL  T026       E0210
E025    RAM  T024
        STL  T026
        RAM  N
        SRT    0004
        ALO  C22
        STL  T027
        RAU  T021       T027
E0213   AUP  T023       E027
E027    SRT    0008
        NZU  E028
        SRD    0002
        NZE              E029
        SLT    0002
        NZU  E028
        STL  T025       E0210
E028    SRD    0003
        SLT    0002
        STL  T025
        RAL  T026
        ALO  C23
        STL  T026
        NZU  E0215      E0210
E0210   RAU  OP
        SUP  C24
        NZU  NORM
        RAL  T026
        SRT    0008
        STL  T026       E0211
NORM    RAU  T025
        SCT    0000
        STL  T028
        STU  T025
        RAL  T026
        SRT    0008
        SML  T028
        STL  T026
        BMI  E0215      E0211
E0211   RAL  T025
        BMI  E0217
        ALO  T026       E0216
E0217   SLO  T026       E0216
E0216   STL  UPPER
        STU  LOWER      UNPCK
E029    LDD  C14
        STD  UPPER
```

170	2450	10	2278	2333
171	2249	69	3003	2206
172	2206	24	3001	2204
173	2204	65	2193	2447
174	2447	15	2353	2357
175	2357	46	2260	2311
176	2260	60	2230	2635
177	2635	35	0002	2441
178	2441	21	2394	2497
179	2497	67	2437	2491
180	2491	20	2243	2196
181	2311	67	2437	2541
182	2541	20	2243	2296
183	2296	67	2193	2547
184	2547	30	0004	2407
185	2407	15	2310	2315
186	2315	20	2319	2272
187	2272	60	2278	2319
188	2500	10	2230	2333
189	2333	30	0008	2201
190	2201	44	2205	2256
191	2256	31	0002	2365
192	2365	45	2168	2369
193	2168	35	0002	2475
194	2475	44	2205	2280
195	2280	20	2394	2196
196	2205	31	0003	2415
197	2415	35	0002	2371
198	2371	20	2394	2597
199	2597	65	2243	2647
200	2647	15	2550	2255
201	2255	20	2243	2346
202	2346	44	2299	2196
203	2196	60	3008	2313
204	2313	11	2166	2421
205	2421	44	2525	2276
206	2276	65	2243	2697
207	2697	30	0008	2465
208	2465	20	2243	2396
209	2525	60	2394	2349
210	2349	36	0000	2471
211	2471	20	2575	2328
212	2328	21	2394	2747
213	2747	65	2243	2797
214	2797	30	0008	2515
215	2515	18	2575	2179
216	2179	20	2243	2446
217	2446	46	2299	2396
218	2396	65	2394	2399
219	2399	46	2152	2403
220	2403	15	2243	2847
221	2152	16	2243	2847
222	2847	20	3003	2306
223	2306	21	3002	2113
224	2369	69	2322	2625
225	2625	24	3003	2356

STD LOWER UNPCK

226	2356	24	3002	2113
227	2299	60	2202	2457

```
E0216    STL  UPPER
         STU  LOWER     UNPCK
E029     LDD  C14
         STD  UPPER
```

```
221  2152    16  2243  2847
222  2847    20  3003  2306
223  2306    21  3002  2113
224  2369    69  2322  2625
225  2625    24  3003  2356
```

```
         STD  LOWER     UNPCK
E0215    RAU  C26
         AUP   8001     UNPCK
 2039    RAL  CDATA              FMP
         STD  DISTR
         SLT   0008
         NZU            E029
         STU  T021
         STL  T022
         RAL  UPPER
         SLT   0008
         NZU            E029
         STU  T023
         RAM   8002     E391
E391     AML  T022
         SLO  C26
         STL  T026
         NZU  E0215
         BMI  E0215
         RAU  T021
         MPY  T023
         SRT   0005
         NZU  E392
         STL  T391
         RAL  T026
         SLO  C23
         STL  T026
         BMI  E0215
         RAL  T391
         SLT   0001     E392
E392     SRD   0003     E393
E393     NZE            E029
         SLT   0002
         NZU            E394
         SRT   0001
         STL  T025
         RAL  T026
         ALO  C23
         STL  T026
         NZU  E0215     NORM
E394     STL  T025      NORM
 2034    RAL  CDATA              FDV
         STD  DISTR
         SLT   0008
         NZU            S341
         STU  T021
         STL  T022
         RAL  UPPER
         SLT   0008
         NZU            E029
         STU  T023
         STL  T024      E341
E341     RAU  T021
         SCT   0000
         STL  T341
         RAU  T023
```

```
226  2356    24  3002  2113
227  2299    60  2202  2457
228  2457    10  8001  2113
229  2039    65  3011  2565
230  2565    24  3001  2254
231  2254    35  0008  2473
232  2473    44  2477  2369
233  2477    21  2278  2231
234  2231    20  2585  2438
235  2438    65  3003  2507
236  2507    35  0008  2675
237  2675    44  2229  2369
238  2229    21  2230  2383
239  2383    67  8002  2591
240  2591    17  2585  2589
241  2589    16  2202  2557
242  2557    20  2243  2496
243  2496    44  2299  2600
244  2600    46  2299  2304
245  2304    60  2278  2433
246  2433    19  2230  2251
247  2251    30  0005  2363
248  2363    44  2167  2218
249  2218    20  2523  2326
250  2326    65  2243  2897
251  2897    16  2550  2305
252  2305    20  2243  2546
253  2546    46  2299  2650
254  2650    65  2523  2527
255  2527    35  0001  2167
256  2167    31  0003  2577
257  2577    45  2330  2369
258  2330    35  0002  2487
259  2487    44  2641  2442
260  2641    30  0001  2947
261  2947    20  2394  2997
262  2997    65  2243  2198
263  2198    15  2550  2355
264  2355    20  2243  2596
265  2596    44  2299  2525
266  2442    20  2394  2525
267  2034    65  3011  2615
268  2615    24  3001  2354
269  2354    35  0008  2573
270  2573    44  2627  2378
271  2627    21  2278  2281
272  2281    20  2585  2488
273  2488    65  3003  2607
274  2607    35  0008  2725
275  2725    44  2279  2369
276  2279    21  2230  2483
277  2483    20  2437  2390
278  2390    60  2278  2533
279  2533    36  0000  2405
280  2405    20  2259  2312
281  2312    60  2230  2685
```

```
                SCT   0000
                RAM   8002
                SML   T341
                BMI   S342
                RAM   T023
                SML   T021
                BMI   E342
                RAM   T024
                SML   T022
                ALO   C35
                STL   T026
                NZU   E0215
                BMI   E0215
                RAU   T023
                SRT   0001    E343
E342            RAM   T024
                SML   T022
                ALO   C26
                STL   T026
                NZU   E0215
                BMI   E0215
                RAU   T023    E343
E343            DVR   T021
                SRD   0002    E393
S341            HLT   S341    S341
S342            HLT   S342    S342
  2010          RAU   UPPER           AUP
                MPY   LOWER
                BMI           E101
                LDD   E102    REST
E101            RAU   UPPER
                ALO   LOWER   E102
E102            AUP   CDATA   E103
E103            STD   DISTR   E104
E104            STU   UPPER
                STL   LOWER   UNPCK
  2011          RAU   UPPER           SUP
                MPY   LOWER
                BMI           E111
                LDD   E112    REST
E111            RAU   UPPER
                ALO   LOWER   E112
E112            SUP   CDATA   E103
  2014          RAU   UPPER           DIV
                MPY   LOWER
                BMI           E141
                LDD   E142    REST
E141            RAU   UPPER
                ALO   LOWER   E142
E142            DIV   CDATA   E103
  2015          RAU   UPPER           ALO
                MPY   LOWER
                BMI           E151
                LDD   E152    REST
E151            RAU   UPPER
                ALO   LOWER   E152
```

```
282  2685    36  0000  2657
283  2657    67  8002  2665
284  2665    18  2259  2413
285  2413    46  2216  2217
286  2217    67  2230  2735
287  2735    18  2278  2583
288  2583    46  2186  2537
289  2537    67  2437  2691
290  2691    18  2585  2639
291  2639    15  2492  2248
292  2248    20  2243  2646
293  2646    44  2299  2700
294  2700    46  2299  2404
295  2404    60  2230  2785
296  2785    30  0001  2741
297  2186    67  2437  2791
298  2791    18  2585  2689
299  2689    15  2202  2707
300  2707    20  2243  2696
301  2696    44  2299  2750
302  2750    46  2299  2454
303  2454    60  2230  2741
304  2741    64  2278  2739
305  2739    31  0002  2577
306  2378     1  2378  2378
307  2216     1  2216  2216
308  2010    60  3003  2757
309  2757    19  3002  2623
310  2623    46  2376  2677
311  2376    69  2329  2300
312  2677    60  3003  2807
313  2807    15  3002  2329
314  2329    10  3011  2715
315  2715    24  3001  2504
316  2504    21  3003  2406
317  2406    20  3002  2113
318  2011    60  3003  2857
319  2857    19  3002  2673
320  2673    46  2426  2727
321  2426    69  2379  2300
322  2727    60  3003  2907
323  2907    15  3002  2379
324  2379    11  3011  2715
325  2014    60  3003  2957
326  2957    19  3002  2723
327  2723    46  2476  2777
328  2476    69  2429  2300
329  2777    60  3003  2158
330  2158    15  3002  2429
331  2429    14  3011  2715
332  2015    60  3003  2208
333  2208    19  3002  2773
334  2773    46  2526  2827
335  2526    69  2479  2300
336  2827    60  3003  2258
337  2258    15  3002  2479
```



```
338  2479    15  3011  2715
```

```
                BMI                 E151
                LDD   E152          REST
E151            RAU   UPPER
                ALO   LOWER         E152
```

```
333  2208    19  3002  2773
334  2773    46  2526  2827
335  2526    69  2479  2300
336  2827    60  3003  2258
337  2258    15  3002  2479
```

```
E152            ALO   CDATA         E103
  2016          RAU   UPPER                 SLO
                MPY   LOWER
                BMI                 E161
                LDD   E162          REST
E161            RAU   UPPER
                ALO   LOWER         E162
E162            SLO   CDATA         E103
  2017          RAU   UPPER                 AML
                MPY   LOWER
                BMI                 E171
                LDD   E172          REST
E171            RAU   UPPER
                ALO   LOWER         E172
E172            AML   CDATA         E103
  2018          RAU   UPPER                 SML
                MPY   LOWER
                BMI                 E181
                LDD   E182          REST
E181            RAU   UPPER
                ALO   LOWER         E182
E182            SML   CDATA         E103
  2019          RAU   UPPER                 MPY
                MPY   LOWER
                BMI                 E191
                LDD   E192          REST
E191            RAU   UPPER
                ALO   LOWER         E192
E192            MPY   CDATA         E103
  2020          RAL   DATA                  STL
                LDD   C6
                SDA   E202
                LDD   LOWER         E202
E201            STO   DISTR         UNPCK
  2021          RAL   DATA                  STU
                LDD   C6
                SDA   E202
                LDD   UPPER         E202
  2022          RAL   DATA                  SDA
                LDD   C7            E221
E221            SDA   E202
                RAL   LOWER
                LDD   DISTR         E202
  2023          RAL   DATA                  SIA
                LDD   C8            E221
  2024          RAL   DATA                  STD
                LDD   C9
                SDA   E202
                LDD   DISTR         E202
  2030          RAL   DATA                  SRT
                LDD   C27           E301
E301            SDA   E202
                RAU   UPPER
                MPY   LOWER
                BMI                 E302
                LDD   E202          REST
```

```
338  2479    15  3011  2715
339  2016    60  3003  2308
340  2308    19  3002  2823
341  2823    46  2576  2877
342  2576    69  2529  2300
343  2877    60  3003  2358
344  2358    15  3002  2529
345  2529    16  3011  2715
346  2017    60  3003  2408
347  2408    19  3002  2873
348  2873    46  2626  2927
349  2626    69  2579  2300
350  2927    60  3003  2458
351  2458    15  3002  2579
352  2579    17  3011  2715
353  2018    60  3003  2508
354  2508    19  3002  2923
355  2923    46  2676  2977
356  2676    69  2629  2300
357  2977    60  3003  2558
358  2558    15  3002  2629
359  2629    18  3011  2715
360  2019    60  3003  2608
361  2608    19  3002  2973
362  2973    46  2726  2428
363  2726    69  2679  2300
364  2428    60  3003  2658
365  2658    15  3002  2679
366  2679    19  3011  2715
367  2020    65  3009  2463
368  2463    69  2266  2419
369  2419    22  2374  2478
370  2478    69  3002  2374
371  2800    24  3001  2113
372  2021    65  3009  2513
373  2513    69  2266  2469
374  2469    22  2374  2528
375  2528    69  3003  2374
376  2022    65  3009  2563
377  2563    69  2316  2519
378  2519    22  2374  2578
379  2578    65  3002  2708
380  2708    69  3001  2374
381  2023    65  3009  2613
382  2613    69  2366  2519
383  2024    65  3009  2663
384  2663    69  2416  2569
385  2569    22  2374  2628
386  2628    69  3001  2374
387  2030    65  3009  2713
388  2713    69  2466  2619
389  2619    22  2374  2678
390  2678    60  3003  2758
391  2758    19  3002  2424
392  2424    46  2728  2778
393  2728    69  2374  2300
```

```
E302    RAU  UPPER
        ALO  LOWER    E202
  2031  RAL  DATA              SRD
        LDD  C28      E301
  2035  RAL  DATA              SLT
        LDD  C29      E301
  2036  RAL  DATA              SCT
        LDD  C30      E301
  2040  RAL  IRA      E401     NZA
E401    NZE  E402     UNPCK
E402    RAL  DATA
        SRT   0004
        STL  INSTR    UNPCK
  2041  RAL  IRA      E411     BMA
E411    BMI  E402     UNPCK
  2042  RAL  IRB      E401     NZB
  2043  RAL  IRB      E411     BMB
  2044  RAL  UPPER    E401     NZU
  2045  RAU  UPPER             NZE
        ALO  LOWER    E401
  2046  RAU  C50                BMI
        MPY  LOWER    E411
  2047  BOV  E402     UNPCK    BOV
  2048  RAL  IRC      E401     NZC
  2049  RAL  IRC      E411     BMC
  2050  RAL  DATA     E504     AXA
E504    SLO  C25
        BMI           E501
        ALO   8001
        SRT   0004    E502
E501    RAL  CDATA    E503
E503    LDD   8003
        SIA  T501
        RAL   8001    E502
E502    ALO  IRA
        LDD   8003
        SIA  IRA      UNPCK
  2051  RAL  DATA     E512     SXA
E512    SLO  C25
        BMI           E511
        RSL  DATA
        SRT   0004    E502
E511    RSL  CDATA    E503
  2052  RAL  DATA     E524     AXB
E524    SLO  C25
        BMI           E521
        ALO   8001
        SRT   0004    E522
E521    RAL  CDATA    E523
E523    LDD   8003
        SIA  T521
        RAL   8001    E522
E522    ALO  IRB
        LDD   8003
        SIA  IRB      UNPCK
  2053  RAL  DATA     E532     SXB
```

```
394  2778    60  3003  2808
395  2808    15  3002  2374
396  2031    65  3009  2763
397  2763    69  2516  2619
398  2035    65  3009  2813
399  2813    69  2566  2619
400  2036    65  3009  2863
401  2863    69  2616  2619
402  2040    65  3005  2309
403  2309    45  2362  2113
404  2362    65  3009  2913
405  2913    30  0004  2474
406  2474    20  3010  2113
407  2041    65  3005  2359
408  2359    46  2362  2113
409  2042    65  3006  2309
410  2043    65  3006  2359
411  2044    65  3003  2309
412  2045    60  3003  2858
413  2858    15  3002  2309
414  2046    60  2449  2453
415  2453    19  3002  2359
416  2047    47  2362  2113
417  2048    65  3007  2309
418  2049    65  3007  2359
419  2050    65  3009  2963
420  2963    16  2666  2521
421  2521    46  2524  2775
422  2524    15  8001  2331
423  2331    30  0004  2841
424  2775    65  3011  2765
425  2765    69  8003  2372
426  2372    23  2825  2828
427  2828    65  8001  2841
428  2841    15  3005  2409
429  2409    69  8003  2716
430  2716    23  3005  2113
431  2051    65  3009  2114
432  2114    16  2666  2571
433  2571    46  2574  2875
434  2574    66  3009  2164
435  2164    30  0004  2841
436  2875    66  3011  2765
437  2052    65  3009  2214
438  2214    16  2666  2621
439  2621    46  2624  2925
440  2624    15  8001  2381
441  2381    30  0004  2891
442  2925    65  3011  2815
443  2815    69  8003  2422
444  2422    23  2975  2878
445  2878    65  8001  2891
446  2891    15  3006  2361
447  2361    69  8003  2268
448  2268    23  3006  2113
449  2053    65  3009  2264
```

```
     2264    16  2666  2671
```

```
E522   RAL  0001   E522                    445  2878   65  8001  2891
       ALO  IRB                            446  2891   15  3006  2361
       LDD  8003                           447  2361   69  8003  2268
       SIA  IRB    UNPCK                   448  2268   23  3006  2113
 2053  RAL  DATA   E532    SXB             449  2053   65  3009  2264

E532   SLO  C25                            450  2264   16  2666  2671
       BMI         E531                    451  2671   46  2674  2776
       RSL  DATA                           452  2674   66  3009  2314
       SRT  0004   E522                    453  2314   30  0004  2891
E531   RSL  CDATA  E523                    454  2776   66  3011  2815
 2058  RAL  DATA   E584    AXC             455  2058   65  3009  2364
E584   SLO  C25                            456  2364   16  2666  2721
       BMI         E581                    457  2721   46  2724  2826
       ALO  8001                           458  2724   15  8001  2431
       SRT  0004   E582                    459  2431   30  0004  2941
E581   RAL  CDATA  E583                    460  2826   65  3011  2865
E583   LDD  8003                           461  2865   69  8003  2472
       SIA  T581                           462  2472   23  2876  2729
       RAL  8001   E582                    463  2729   65  8001  2941
E582   ALO  IRC                            464  2941   15  3007  2411
       LDD  8003                           465  2411   69  8003  2318
       SIA  IRC    UNPCK                   466  2318   23  3007  2113
 2059  RAL  DATA   E592    SXC             467  2059   65  3009  2414
E592   SLO  C25                            468  2414   16  2666  2771
       BMI         E591                    469  2771   46  2774  2926
       RSL  DATA                           470  2774   66  3009  2464
       SRT  0004   E582                    471  2464   30  0004  2941
E591   RSL  CDATA  E583                    472  2926   66  3011  2865
 2060  RAU  CDATA  E103    RAU             473  2060   60  3011  2715
 2061  RSU  CDATA  E103    RSU             474  2061   61  3011  2715
 2064  RAU  UPPER          DVR             475  2064   60  3003  2908
       MPY  LOWER                          476  2908   19  3002  2824
       BMI         E641                    477  2824   46  2928  2978
       LDD  E642   REST                    478  2928   69  2481  2300
E641   RAU  UPPER                          479  2978   60  3003  2958
       ALO  LOWER  E642                    480  2958   15  3002  2481
E642   DVR  CDATA  E103                    481  2481   64  3011  2715
 2065  RAL  CDATA  E103    RAL             482  2065   65  3011  2715
 2066  RSL  CDATA  E103    RSL             483  2066   66  3011  2715
 2067  RAM  CDATA  E103    RAM             484  2067   67  3011  2715
 2068  RSM  CDATA  E103    RSM             485  2068   68  3011  2715
 2069  LDD  CDATA          LDD             486  2069   69  3011  2514
       STD  DISTR  UNPCK                   487  2514   24  3001  2113
 2070  RAL  DATA           RCD             488  2070   65  3009  2564
       ALO  C31     8002                   489  2564   15  2267  8002
 2071  RAL  DATA           PCH             490  2071   65  3009  2614
       ALO  C32     8002                   491  2614   15  2317  8002
 2080  RAL  DATA           RAA             492  2080   65  3009  2664
       STU  IRA    E504                    493  2664   21  3005  2963
 2081  RAL  DATA           RSA             494  2081   65  3009  2714
       STU  IRA    E512                    495  2714   21  3005  2114
 2082  RAL  DATA           RAB             496  2082   65  3009  2764
       STU  IRB    E524                    497  2764   21  3006  2214
 2083  RAL  DATA           RSB             498  2083   65  3009  2814
       STU  IRB    E532                    499  2814   21  3006  2264
 2084  RAL  DATA           TLU             500  2084   65  3009  2864
       LDD  C33                            501  2864   69  2367  2170
       SDA  E202                           502  2170   22  2374  2779
       RAL  LOWER                          503  2779   65  3002  2459
       LDD  DISTR  E202                    504  2459   69  3001  2374
E841   STL  LOWER  UNPCK                   505  2850   20  3002  2113
```

```
2088    RAL  DATA          E584    RAC
        STU  IRC
2089    RAL  DATA          E592    RSC
        STU  IRC
2090    LDD  DISTR         UNPCK   BD0
        BD0  E402
2091    LDD  DISTR         UNPCK   BD1
        BD1  E402
2092    LDD  DISTR         UNPCK   BD2
        BD2  E402
2093    LDD  DISTR         UNPCK   BD3
        BD3  E402
2094    LDD  DISTR         UNPCK   BD4
        BD4  E402
2095    LDD  DISTR         UNPCK   BD5
        BD5  E402
2096    LDD  DISTR         UNPCK   BD6
        BD6  E402
2097    LDD  DISTR         UNPCK   BD7
        BD7  E402
2098    LDD  DISTR         UNPCK   BD8
        BD8  E402
2099    LDD  DISTR         UNPCK   BD9
        BD9  E402
 2003   HLT   2003          2003
 2004   HLT   2004          2004
 2005   HLT   2005          2005
 2006   HLT   2006          2006
 2007   HLT   2007          2007
 2008   HLT   2008          2008
 2009   HLT   2009          2009
 2012   HLT   2012          2012
 2013   HLT   2013          2013
 2025   HLT   2025          2025
 2026   HLT   2026          2026
 2027   HLT   2027          2027
 2028   HLT   2028          2028
 2029   HLT   2029          2029
 2054   HLT   2054          2054
 2055   HLT   2055          2055
 2056   HLT   2056          2056
 2057   HLT   2057          2057
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C12               1        00
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C17                       LOWER
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C19                       IRA
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C21                       IRC
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