R - 746

SIRU DEVELOPMENT — FINAL REPORT

VOLUME III
SOFTWARE DESCRIPTION AND PROGRAM DOCUMENTATION

by

John Oehrle

March 1973

CHARLES STARK DRAPER LABORATORY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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ACKNOWLEDGEMENT

This report was prepared under our Project No. 55-32600, sponsored by the Lyndon B. Johnson Space Center of the National Aeronautics and Space Administration through Contract No. NAS 9-8242.

The SIRU System's success in its present state of hardware, software and analytical maturity represents the dedicated efforts of many people from the NASA L. B. Johnson Space Center and The Draper Laboratory to synthesize, design, fabricate and test a redundant, body mounted inertial system employing state-of-the-art redundancy management techniques.

Singular acknowledgement for contributions to the Software developed and documented in the volume is made to :

Richard McKern for his guidance and directions,

James Keenan for the development of the calibrations and data handling programs and for the implementation of the DOS operating system,

Stephan Helfant for his aid in compiling and preparing this document for printing.

SIRU DEVELOPMENT FINAL REPORT

ABSTRACT

This report presents a complete description of the development and initial evaluation of the Strapdown Inertial Reference Unit (SIRU) system sponsored by the NASA Johnson Space Center under Contract NAS9-8242.

The SIRU configuration is a modular inertial subsystem with hardware and software features that achieve fault tolerant operational capabilities. The SIRU redundant hardware design is formulated about a six gyro and six accelerometer instrument module package. The modules are mounted in this package so that their measurement input axes form a unique symmetrical pattern that corresponds to the array of perpendiculars to the faces of a regular dodecahedron. This six axes array provides redundant independent sensing and the symmetry enables the formulation of an optimal software redundant data processing structure with self-contained fault detection and isolation (FDI) capabilities.

This report consists of four volumes.

Volume I, System Development, documents the system mechanization with the analytic formulation of the FDI and processing structure; the hardware redundancy design and the individual modularity features; the computational structure and facilities; and the initial subsystem evaluation results.

Volume II, Gyro Module, is devoted specifically to the Gyro Module, the inertial instrument and its digital strapdown torque-to-balance loop, the mechanical, thermal, and electronic design and function, test procedures and test equipment and performance results and analysis.

Volume III, Software, documents the basic SIRU software coding system used in the DDP-516 computer. The documentation covers the instrument compensation software, reorganizational and FDI processing, and the inertial attitude and velocity algorithm routines as well as servicing, input/output, etc. software.

Volume IV, Accelerometer Module, is devoted specifically to the Accelerometer Module, the inertial instrument and its digital strapdown torque-to-balance loop, the mechanical, thermal and electronic design and function and performance results and analysis, as it differs from the Gyro Module.

In addition to this report, SIRU Utilization Report R-747, has been issued documenting analyses, software and evaluation activities in the application of advanced statistical FDI algorithms, calibration and alignment techniques to the SIRU system.

April 1973

SIRU SOFTWARE DESCRIPTION

and

PROGRAM DOCUMENTATION

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INTRODUCTION:

The purpose of creating the SIRU operating system was to implement and verify operation of the algorithms shown in Figure 1 on an available laboratory computer (Honeywell DDP-516) at an update rate of 100 times/sec. These algorithms can be divided into two sets, an accelerometer data processor and a gyro data processor. In the strapdown implementation it is important to process the accelerometer information into the inertial frame using the average attitude information over the ΔV accumulation period.

The system begins to accumulate ΔV pulses from the torque to balance instrument loops after initialization. After 5 ms the system begins to accumulate $\Delta\theta$ pulses. Five ms later or 10 ms from initialization the accelerometer pulse counters give an interrupt and the accelerometer data processors perform the proper algorithms on the 10 ms of ΔV accumulation. Five ms later the 10 ms of $\Delta\theta$ accumulation is processed to update attitude. The accelerometer and gyro algorithm processing loops are performed alternately every 5 ms thereafter resulting in the required staggering of these tasks. (This software has also been run at an update rate of 50 times/second. Ref. SIRU Utilization Report R-747).

Figure 1 shows what is done during either the accelerometer or gyro 5 ms updates. On the accelerometer side we require the system to do the following tasks.

TASKS

- A1) Read the 6 accelerometer counters.
- A2) Compensate accelerometers for average scale factor, bias and the misalignments of each accelerometer's input axis around their input and penduluous reference axes.
- A3) Compensate accelerometers for errors due to $R\omega^2$ and $R\dot{\omega}$ as a function of the accelerometers' positions relative to one another.
- A4) Accumulate corrected accelerometer body output for failure detection and isolation.
- A5) Perform failure detection and isolation resulting in a current failure status.

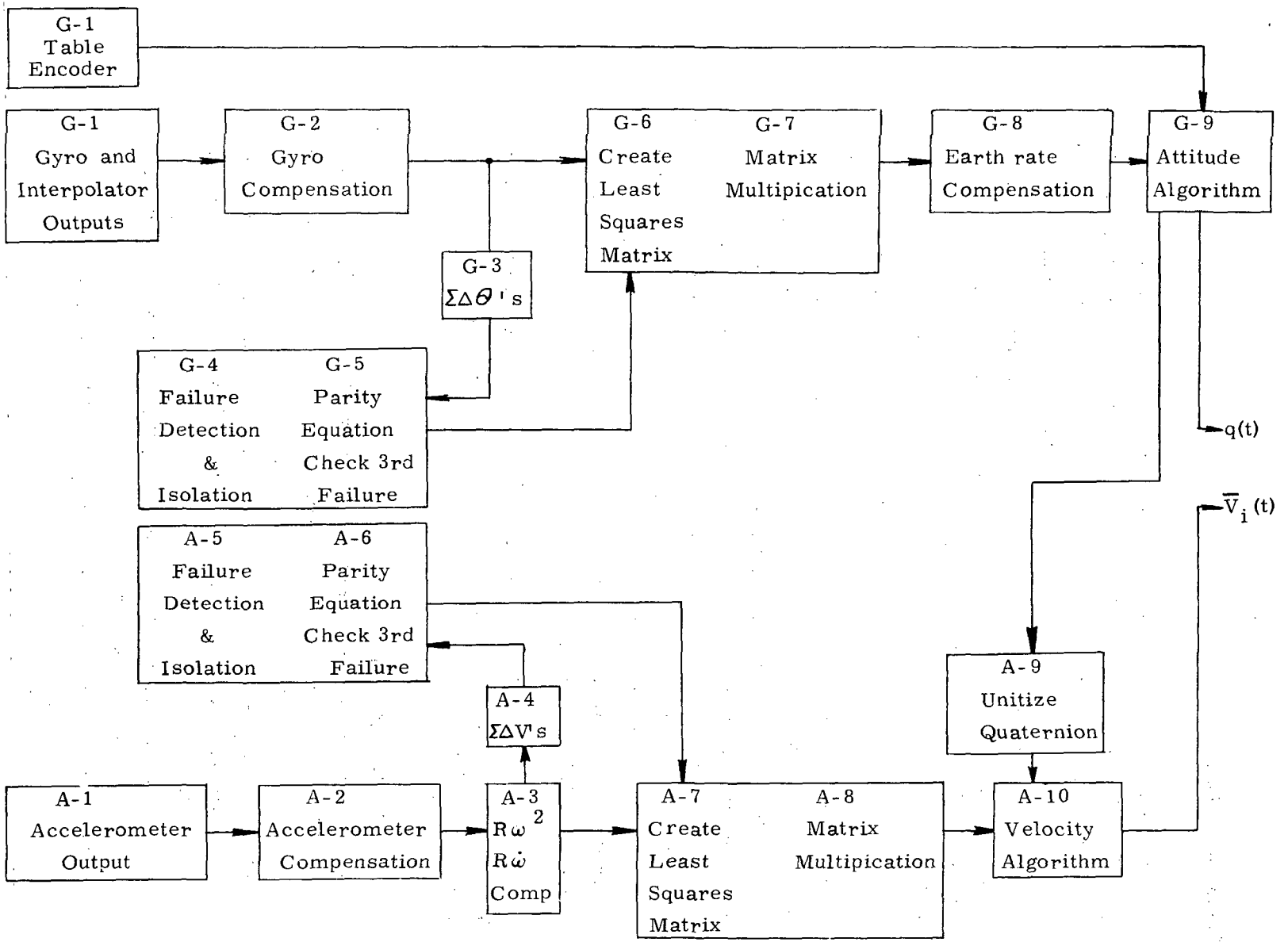


FIGURE 1 SIRU DATA PROCESSING

A6) Check parity equation for third fail.

A7) Create least squares matrix (as a function of fail status) to transform the 6 compensated ΔV's into the X, Y, Z body frame.

A8) Do the 6 to 3 matrix multiplication.

A9) Unitize attitude quaternion prior to velocity algorithm processing.

A10) Do the velocity algorithm, i.e., use the current attitude quaternion to generate the velocity transformation matrix and transform the incremental body velocity into the inertial frame.

A11) Accumulate $\Delta\bar{V}$ inertial for output processing.

On the gyro side we presently require the system to do the following tasks:

G1) Read the table angle encoder, the six gyros & interpolators.

G2) Compensate the gyros for $\pm\Delta$SF, NBD, ADIA, ADOA, ADSRA, anisoelasticity, misalignments, anisoinertia, SRA cross-coupling and OA coupling.

G3) Accumulate the corrected gyro body output for failure detection and isolation.

G4) Perform the failure detection and isolation processing resulting in a current failure status.

G5) Check the parity equation for third fail.

G6) Create the least squares matrix (as a function of failure status) to transform the six compensated $\Delta\theta$'s into the X, Y, Z body frame.

G7) Do the 6 to 3 matrix multiplication.

G8) Compensate for earth rate.

G9) Update the quaternion attitude.

In the time remaining, output of the system's status is performed either on the teletype, the CRT display or on an incremental digistor tape for further analysis. The format is shown in the documentation of the output programs. The information outputted includes the quaternion of attitude, $\Delta\bar{V}_I$ accumulated over some interval, a squared error monitor and fail status for gyros and accelerometers, test-table angle encoder and time since initialization.

SYSTEM ORGANIZATION:

The main program (MPRO) in turn calls all the subroutines to accomplish the tasks described in the introduction. These programs are documented in the following sections in the order listed below:

Preceeding the documentation of these programs is a load map showing the core location of each subroutine.

SYSTEM LOAD MAP

```
LDRX 23665 1000 64
GO
MN
I BMPRO
MR
C BREAD
MR
C BGFIS
MR
C BGCOM
MR
C BERC6
MR
C BEMIN
MR
C BGMIN
MR
C BDCOA
MR
C BACOM
MR
C BDCMT
MR
C BMV63
MR
C BMG63
MR
C BVESP
MR
C BPFIS
MR
C BAA6S
MR
C BVACU
MR
C BSPUN
MR
C BPREX
MR
C BERDE
MR
C BCESE
MR
C BGARC
MR
C BALPO
MR
C BFPOUT
MR
C BXOU
MR
C FTL1BY
```

```
MR
C BGPMA
MR
C BPPEX
MR
C BGPRT
MR
C BPRTY
MR
C BDGS
MR
C BROMS
LC
M
*START  01000
*HIGH   14370
*NAMES  17132
*COMM   23777
*BASE   00244
LIST    00001
RUPT    01450
ASCT    01506
ICINIT  01656
INPIP   01731
INGYRO  01764
GFIS    02070
KEYG    02225
GCOM    02242
ERCO    02726
EMIN    03034
GMIN    03100
DCOA    03144
AOAP    03252
BOAP    03254
COAP    03256
DOAP    03260
EOAP    03262
FOAP    03264
ACOM    03274
DCMI    03476
DCMT    03551
MP63    03664
MG63    04012
VELA    04206
FXX     04654
FXY     04656
FXZ     04660
FYX     04662
FYY     04664
FYZ     04666
FZX     04670
FZY     04672
FZZ     04674
```

```
PFIS    04726
KEYP    05050
ATTA    05060
VACU    05506
SPUN    05560
PARC    06040
PACC    06166
ERDE    06172
SECA    06524
GARC    07344
GACC    07524
OUTPUT  07530
DODSP   07600
FPOUTC  10340
OUT100  10552
IOMODE  10604
X1OU    10636
XNOU    10642
XNOUA   10646
XOOCT   10652
CNOU    10670
CNOUA   10675
COOCT   10750
C1OU    11004
DOPAGE  11176
CRTOUT  11476
CRTOUA  11504
SQRTX   11614
F$AT    11614
ARG$    11676
T1OU    11747
TNOUA   11772
TNOU    11777
TOOCT   12047
MATR    12102
GMAT    12136
PPRT    12630
GPRT    12712
PRTY    12774
DGSWRT  13250
DGSRD   13311
ROMS    14000
WXPR    14333
WYPR    14334
WZPR    14335
        23777
LC
OK
SAVE RMPRO 64 14370 1000
OK
```

PROGRAM NAME
SOURCE: MPRO
BINARY: BMPRO
STARTING LOCATION: '1000
GENERAL DESCRIPTION:

This is the main executive of the system operating program which calls the appropriate subroutines to accomplish the algorithms defined in the introduction and the definition of system tasks. It is divided into three sections of code. First is initialization and the enabling of interrupt. Next is a waiting loop (location LOOP) which checks to see if it is time for output and if so, calls the proper output routines. When this waiting loop is interrupted (every 5 milliseconds), the program sequence goes to the last section (location RUPT) which in turn decides whether its time to update the PIPA or gyro algorithms, goes to either PDO or GDO, saves the processing registers as they were at time of interrupt, calls the appropriate algorithms following PDO or GDO, restores the processing registers and returns to whatever was being processed at time of interrupt.

The initialization section first calls DCMI (see documentation for program source name DCMT) to enable the gyro OA misalignment parameters to be taken from the base sector and saved elsewhere in core. It then zeroes out all locations in the base sector that don't contain compensation parameters (namely locations '260-'421, '430-'477, '574-'677 and '744-'777). It zeroes out the gyro and PIPA error accumulator residuals accessible through the indexed external addresses CCAG and CCAP (see programs with source names GARC and PREX). It zeroes out the 6 previous OA coupling offsets (AOAP-FOAP accessible in the program DCOA through the external address PAOA-PAOF). It zerces the four erroneous interrupt counters (disk, ASR-33 teletype, miscellaneous and clock). It zeroes out the gyro and PIPA fail keys (KEYG and KEYP) in programs GFIS and PFIS). It zeroes WXPR, WYPR and WZPR (see program ROMS) and sets GACC and PACC to equal -6001 (used to wait 60 seconds in the error accumulator programs GARC and PREX). TCNT (the time counter for the output loop) is set to its maximum of '77777 so that an output will be done at t=0. It puts a round of '40000 in the low order residuals of the gyro pulse counts,

PIPA pulse counts, gyro x, y and z delta thetas, PIPA x, y and z delta Vs, the quaternion and the delta V inertial accumulators. The '40000 it stores in '460 is to set lamda of the quaternion equal to 1. It then generates the gyro and PIPA 6 x 3 matrices by calling GMIN and EMIN. It stores the address to go to when interrupted in '63 and calls ICINIT, which sets up the interrupt cycle (see documentation for program source name READ). Finally it does a JST (internal call) to GETM in order to set up the timing and MODE for whichever of three output modes is desired.

The output waiting loop simply checks the time counter (TCNT) to see if it is greater than or equal to the time at which to output (CRIT).* If TCNT is less than CRIT (i.e., it is not time to output) and if sense switches three and four are not reset and set respectively**, the waiting loop will just continue to loop. The waiting loop continues to get interrupted so that the PIPA and gyro processing can be updated every five milliseconds.

When enough updates have occurred and TCNT becomes greater than CRIT, the program jumps to OUT, where output is started. If sense switches three and four are set, the program will first initialize the quaternion to 1,0,0,0 (see documentation for AA6S). The program then continues at NOQZ where all the data to be output is saved in a 52 word buffer called QTMP as follows:

---

*Note that TCNT is incremented by 1 after every gyro algorithm loop so it counts in hundredths of a second. CRIT is set up by GETM and depends on the output mode.

**To stop this program and return to DOS (the disk operating system) sense switch four is set while sense switch three is left reset. By setting sense switch three and then setting sense switch four, the quaternion will be initialized at the time the next output starts.

Location	Contents
QTMP-QTMP+7	quaternion
QTMP+8-QTMP+13	Sum of delta V inertial since the last output
QTMP+14-QTMP+15	First and second gyro fail status
QTMP+16-QTMP+17	First and second PIPA fail status
QTMP+18-QTMP+19	Time elapsed since start of program
QTMP+20-QTMP+21	Encoder angle of test table
QTMP+22-QTMP+23	gyro and PIPA third fail indicators
QTMP+24-QTMP+37	gyro squared errors
QTMP+38-QTMP+51	PIPA squared errors

The delta V accumulators and the time counter are then zeroed after which the proper output mode is gotten. Parts of QTMP are then rescaled so that the output routine can handle them. Finally, a call to OUTPUT is made with the addresses of QTMP and MODE. Upon return from output a jump back to LOOP is made.

The last section of this main program, starting at RUPT, handles the PIPA and gyro interrupts as they come along every five milliseconds. The first interrupt, by the PIPA's, and every other one thereafter, will cause program control to "jump store" to RUPT where the SKS '507 instruction will not skip and the jump to PDO is executed. Here the processing registers (A register, keys, B register and index register) are saved and calls to the subroutines necessary to update the PIPA algorithms are made (see the introduction and description of implementation methods). The PIPA squared errors are then saved in the buffer PISE for future output, then the processing registers are restored and a JMP* RUPT causes program control to go back to where it was when last interrupted.

The second interrupt, by the gyros, and every other one thereafter, will cause control to "jump store" to RUPT where the SKS '507 instruction

*See previous page

will skip and the SKS '407 instruction will not, and the jump to GDO is executed. Here the processing registers are saved. The table angle encoder is read after which calls to the subroutines necessary to update the gyro algorithms are made (see the introduction and description of implementation methods). The output timer, TCNT, and the overall timer, TIME are incremented before a jump to COMN restores the processing registers and returns to where the program control was when the gyro interrupt occurred.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                              REL
0002 00000    0 10 00000          CALL  DCMI
0003 00001    000007              DBL
0004 00002    0 02 00342          DLD   DZRO
0005 00003    0 35 00654          LDX   =-98
0006 00004    1 04 00422          DST   '422,1
0007 00005    0 12 00000          IRS   0
0008 00006    0 12 00000          IRS   0
0009 00007    0 01 00004          JMP   *-3
0010 00010    0 35 00653          LDX   =-40
0011 00011    1 04 00500          DST   '500,1
0012 00012    0 12 00000          IRS   0
0013 00013    0 12 00000          IRS   0
0014 00014    0 01 00011          JMP   *-3
0015 00015    0 35 00652          LDX   =-68
0016 00016    1 04 00700          DST   '700,1
0017 00017    0 12 00000          IRS   0
0018 00020    0 12 00000          IRS   0
0019 00021    0 01 00016          JMP   *-3
0020 00022    0 35 00651          LDX   =-28
0021 00023    1 04 01000          DST   '1000,1
0022 00024   -0 04 00337          DST*  CCAG
0023 00025   -0 04 00340          DST*  CCAP
0024 00026    0 12 00000          IRS   0
0025 00027    0 12 00000          IRS   0
0026 00030    0 01 00023          JMP   *-5
0027 00031   -0 04 00324          DST*  PAOA
0028 00032   -0 04 00325          DST*  PAOB
0029 00033   -0 04 00326          DST*  PAOC
0030 00034   -0 04 00327          DST*  PAOD
0031 00035   -0 04 00330          DST*  PAOE
0032 00036   -0 04 00331          DST*  PAOF
0033 00037    000005              SGL
0034 00040    0 04 00507          STA   DSCT
0035 00041    0 04 00506          STA   ASCT
0036 00042    0 04 00510          STA   MSCT
0037 00043    0 04 00511          STA   ICNT
0038 00044   -0 04 00332          STA*  GYEK
0039 00045   -0 04 00333          STA*  PYEK
0040 00046   -0 04 00334          STA*  RPXW
0041 00047   -0 04 00335          STA*  RPYW
0042 00050   -0 04 00336          STA*  RPZW
0043 00051    0 02 00650          LDA   =-6001
0044 00052   -0 04 00337          STA*  CCAG
0045 00053   -0 04 00340          STA*  CCAP
0046 00054    0 02 00647          LDA   ='77777
0047 00055    0 04 00637          STA   TCNT
0048 00056    0 02 00646          LDA   ='40000
0049 00057    0 04 00401          STA   '401
0050 00060    0 04 00403          STA   '403
0051 00061    0 04 00405          STA   '405
0052 00062    0 04 00407          STA   '407
0053 00063    0 04 00411          STA   '411
0054 00064    0 04 00413          STA   '413
0055 00065    0 04 00601          STA   '601
0056 00066    0 04 00603          STA   '603
0057 00067    0 04 00605          STA   '605
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0058 00070    0 04 00607        STA   '607
0059 00071    0 04 00611        STA   '611
0060 00072    0 04 00613        STA   '613
0061 00073    0 04 00415        STA   '415
0062 00074    0 04 00417        STA   '417
0063 00075    0 04 00421        STA   '421
0064 00076    0 04 00615        STA   '615
0065 00077    0 04 00617        STA   '617
0066 00100    0 04 00621        STA   '621
0067 00101    0 04 00460        STA   '460
0068 00102    0 04 00463        STA   '463
0069 00103    0 04 00467        STA   '467
0070 00104    0 04 00473        STA   '473
0071 00105    0 04 00477        STA   '477
0072 00106    0 04 00447        STA   '447
0073 00107    0 04 00453        STA   '453
0074 00110    0 04 00457        STA   '457
0075 00111    0 10 00000        CALL  GMIN
0076 00112    0 10 00000        CALL  EMIN
0077 00113    0 02 00323        LDA   RDAD
0078 00114    0 04 00063        STA   '63
0079 00115    0 10 00000        CALL  ICINIT
0080 00116    0 02 00645        LDA   =6
0081 00117   74 0020            SMK   '20
0082 00120    0 10 00310        JST   GETM                TO SET UP TIME
0083                        *
0084                        *
0085 00121   000401       LOOP ENB
0086 00122    0 02 00637        LDA   TCNT
0087 00123    0 11 00635        CAS   CRIT
0088 00124   101000             NOP
0089 00125    0 01 00141        JMP   OUT
0090 00126   000201             IAB
0091 00127   101002             SS4
0092 00130    0 01 00121        JMP   LOOP
0093 00131   100004             SR3
0094 00132    0 01 00121        JMP   LOOP
0095                        *
0096                        * EXIT CODING
0097                        *
0098 00133   14 0047            OCP   '47
0099 00134   14 0057            OCP   '57
0100 00135   140040             CRA
0101 00136   74 0020            SMK   '20
0102 00137   001001             INH
0103 00140  -0 01 00631        JMP*  DOS
0104                        *
0105                        *
0106 00141   100004        OUT  SR3
0107 00142   101002             SS4
0108 00143    0 01 00165        JMP   NOOZ
0109 00144   000007             DBL
0110 00145    0 02 00342        DLD   DZRO
0111 00146    0 04 00460        DST   '460
0112 00147    0 04 00462        DST   '462
0113 00150    0 04 00464        DST   '464
0114 00151    0 04 00466        DST   '466
```

```
0115 00152   0 04 00470        DST   '470
0116 00153   0 04 00472        DST   '472
0117 00154   0 04 00474        DST   '474
0118 00155   0 04 00476        DST   '476
0119 00156   000005            SGL
0120 00157   0 02 00646        LDA   ='40000
0121 00160   0 04 00460        STA   '460
0122 00161   0 04 00463        STA   '463
0123 00162   0 04 00467        STA   '467
0124 00163   0 04 00473        STA   '473
0125 00164   0 04 00477        STA   '477
0126 00165   000007      NOQZ  DBL
0127 00166   0 02 00460        DLD   '460
0128 00167   0 04 00346        DST   QTMP
0129 00170   0 02 00464        DLD   '464
0130 00171   0 04 00350        DST   QTMP+2
0131 00172   0 02 00470        DLD   '470
0132 00173   0 04 00352        DST   QTMP+4
0133 00174   0 02 00474        DLD   '474
0134 00175   0 04 00354        DST   QTMP+6
0135 00176   0 02 00444        DLD   '444
0136 00177   0 04 00356        DST   QTMP+8
0137 00200   0 02 00450        DLD   '450
0138 00201   0 04 00360        DST   QTMP+10
0139 00202   0 02 00454        DLD   '454
0140 00203   0 04 00362        DST   QTMP+12
0141 00204   0 02 00316        DLD   '316
0142 00205   0 04 00364        DST   QTMP+14
0143 00206   0 02 00320        DLD   '320
0144 00207   0 04 00366        DST   QTMP+16
0145 00210   0 02 00776        DLD   TIME
0146 00211   0 04 00370        DST   QTMP+18
0147 00212   0 02 00322        DLD   '322
0148 00213   0 04 00374        DST   QTMP+22
0149 00214   0 02 00324        DLD   '324
0150 00215   0 04 00372        DST   QTMP+20
0151 00216   0 02 00326        DLD   '326
0152 00217   0 04 00376        DST   QTMP+24
0153 00220   0 02 00330        DLD   '330
0154 00221   0 04 00400        DST   QTMP+26
0155 00222   0 02 00332        DLD   '332
0156 00223   0 04 00402        DST   QTMP+28
0157 00224   0 02 00436        DLD   '436
0158 00225   0 04 00404        DST   QTMP+30
0159 00226   0 02 00440        DLD   '440
0160 00227   0 04 00406        DST   QTMP+32
0161 00230   0 02 00442        DLD   '442
0162 00231   0 04 00410        DST   QTMP+34
0163 00232   0 02 00574        DLD   '574
0164 00233   0 04 00412        DST   QTMP+36
0165 00234   0 02 00432        DLD   PISE
0166 00235   0 04 00414        DST   QTMP+38
0167 00236   0 02 00434        DLD   PISE+2
0168 00237   0 04 00416        DST   QTMP+40
0169 00240   0 02 00436        DLD   PISE+4
0170 00241   0 04 00420        DST   QTMP+42
0171 00242   0 02 00440        DLD   PISE+6
```

```
0172 00243    0 04 00422        DST   QTMP+44
0173 00244    0 02 00442        DLD   PISE+8
0174 00245    0 04 00424        DST   QTMP+46
0175 00246    0 02 00444        DLD   PISE+10
0176 00247    0 04 00426        DST   QTMP+48
0177 00250    0 02 00446        DLD   PISE+12
0178 00251    0 04 00430        DST   QTMP+50
0179 00252    0 02 00342        DLD   DZRO
0180 00253    0 04 00444        DST   '444
0181 00254    0 04 00450        DST   '450
0182 00255    0 04 00454        DST   '454
0183 00256    000005            SGL
0184 00257    0 04 00637        STA   TCNT
0185 00260    0 10 00310        JST   GETM                GET MODE
0186 00261    000007            DBL
0187 00262    0 02 00356        DLD   QTMP+8
0188 00263    0411 71           LLS   7
0189 00264    0 04 00356        DST   QTMP+8
0190 00265    0 02 00360        DLD   QTMP+10
0191 00266    0411 71           LLS   7
0192 00267    0 04 00360        DST   QTMP+10
0193 00270    0 02 00362        DLD   QTMP+12
0194 00271    0411 71           LLS   7
0195 00272    0 04 00362        DST   QTMP+12
0196 00273    0 35 00651        LDX   =-28
0197 00274    1 02 00432        DLD   QTMP+52,1
0198 00275    0411 67           LLS   9
0199 00276    1 04 00432        DST   QTMP+52,1
0200 00277    0 12 00000        IRS   0
0201 00300    0 12 00000        IRS   0
0202 00301    0 01 00274        JMP   *-5
0203 00302    000005            SGL
0204 00303    0 10 00000        CALL  OUTPUT
0205 00304    0 000346          DAC   QTMP
0206 00305    0 000636          DAC   MODE
0207 00306    000000            OCT   0
0208 00307    0 01 00121        JMP   LOOP
0209                       *
0210 00310    0 000000    GETM  DAC   **
0211 00311    140040            CRA
0212 00312    100020            SR1
0213 00313    141206            AOA
0214 00314    100010            SR2
0215 00315    0 02 00644        LDA   =2
0216 00316    0 04 00636        STA   MODE
0217                       *
0218 00317    0 04 00000        STA   0
0219 00320    1 02 00632        LDA   TCON,1
0220 00321    0 04 00635        STA   CRIT
0221 00322   -0 01 00310        JMP*  GETM
0222                       *
0223 00323    0 000000    RDAD  XAC   RUPT
0224 00324    0 000000    PAOA  XAC   AOAP
0225 00325    0 000000    PAOB  XAC   BOAP
0226 00326    0 000000    PAOC  XAC   COAP
0227 00327    0 000000    PAOD  XAC   DOAP
0228 00330    0 000000    PAOE  XAC   EOAP
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0229 00331    0 000000    PAOF XAC    FOAP
0230 00332    0 000000    GYEK XAC    KEYG
0231 00333    0 000000    PYEK XAC    KEYP
0232 00334    0 000000    RPXW XAC    WXPR
0233 00335    0 000000    RPYW XAC    WYPR
0234 00336    0 000000    RPZW XAC    WZPR
0235 00337    1 000000    CCAG XAC    GACC,1
0236 00340    1 000000    CCAP XAC    PACC,1
0237 00342    000000      DZRO DBP    0
     00343    000000
0238 00344    000000      DONE OCT    0,1
     00345    000001
0239 00346    000000      QTMP BSZ    52
     00347    000000
     00350    000000
     00351    000000
     00352    000000
     00353    000000
     00354    000000
     00355    000000
     00356    000000
     00357    000000
     00360    000000
     00361    000000
     00362    000000
     00363    000000
     00364    000000
     00365    000000
     00366    000000
     00367    000000
     00370    000000
     00371    000000
     00372    000000
     00373    000000
     00374    000000
     00375    000000
     00376    000000
     00377    000000
     00400    000000
     00401    000000
     00402    000000
     00403    000000
     00404    000000
     00405    000000
     00406    000000
     00407    000000
     00410    000000
     00411    000000
     00412    000000
     00413    000000
     00414    000000
     00415    000000
     00416    000000
     00417    000000
     00420    000000
     00421    000000
     00422    000000
```

```
      00423   000000
      00424   000000
      00425   000000
      00426   000000
      00427   000000
      00430   000000
      00431   000000
0240  00432   000000      PTSE BSZ   14
      00433   000000
      00434   000000
      00435   000000
      00436   000000
      00437   000000
      00440   000000
      00441   000000
      00442   000000
      00443   000000
      00444   000000
      00445   000000
      00446   000000
      00447   000000
0241                      *
0242                      *
0243                           SUBR  RUPT
0244                           SUBR  ASCT
0245                           REL
0246  00450   0 000000    RUPT  DAC   **
0247  00451   14 0102           OCP   '102          SHUT OFF DGS
0248  00452   34 0507           SKS   '507
0249  00453   0 01 00512        JMP   PDO
0250  00454   34 0407           SKS   '407
0251  00455   0 01 00565        JMP   GDO
0252  00456   34 0607           SKS   '607
0253  00457   0 01 00501        JMP   ICLK
0254  00460   34 0425           SKS   '425
0255  00461   0 01 00475        JMP   DISK          DISK RUPT
0256  00462   34 0404           SKS   '404
0257  00463   0 01 00467        JMP   ASR           ASR RUPT
0258  00464   0 12 00510        IRS   MSCT          MISCELLANEOUS
0259  00465   000401      RSM   ENB
0260  00466  -0 01 00450        JMP*  RUPT
0261                      *
0262  00467   14 0004     ASR   OCP   4
0263  00470   54 0004           INA   4             DUMMPY
0264  00471   101000            NOP
0265  00472   0 12 00506        IRS   ASCT
0266  00473   101000            NOP                 IN CASE OF SKIP
0267  00474   0 01 00465        JMP   RSM
0268                      *
0269  00475   14 1425     DISK  OCP   '1425
0270  00476   0 12 00507        IRS   DSCT
0271  00477   101000            NOP                 IN CASE OF SKIP
0272  00500   0 01 00465        JMP   RSM
0273                      *
0274  00501   0 12 00511  ICLK  IRS   ICNT
0275  00502   101000            NOP
0276  00503   14 0027           OCP   '27
```

```
0277 00504    14 0067          OCP   '67
0278 00505    0 01 00465       JMP   RSM
0279 00506    000000     ASCT  BSZ   1
0280 00507    000000     DSCT  BSZ   1
0281 00510    000000     MSCT  BSZ   1
0282 00511    000000     ICNT  BSZ   1
0283                     *
0284                     *
0285 00512    0 13 00640 PDO   IMA   AREG
0286 00513    000043           INK
0287 00514    000005           SGL
0288 00515    0 04 00641       STA   KEYS
0289 00516    000201           IAB
0290 00517    0 04 00642       STA   BREG
0291 00520    0 15 00643       STX   XREG
0292                     *
0293                     *
0294                     *
0295                     *
0296 00521    0 10 00000       CALL  INPIP
0297 00522    000401           ENB
0298 00523    0 10 00000       CALL  ACOM
0299 00524    0 10 00000       CALL  ROMS
0300 00525    0 10 00000       CALL  PARC
0301 00526    0 10 00000       CALL  PPIS
0302 00527    0 10 00000       CALL  PPRT
0303 00530    0 10 00000       CALL  EMIN
0304 00531    0 10 00000       CALL  MP63
0305 00532    0 10 00000       CALL  SPUN
0306 00533    0 10 00000       CALL  VELA
0307 00534    0 10 00000       CALL  VACU
0308 00535    000007           DBL
0309 00536    0 02 00326       DLD   '326
0310 00537    0 04 00432       DST   PISE
0311 00540    0 02 00330       DLD   '330
0312 00541    0 04 00434       DST   PISE+2
0313 00542    0 02 00332       DLD   '332
0314 00543    0 04 00436       DST   PISE+4
0315 00544    0 02 00436       DLD   '436
0316 00545    0 04 00440       DST   PISE+6
0317 00546    0 02 00440       DLD   '440
0318 00547    0 04 00442       DST   PISE+8
0319 00550    0 02 00442       DLD   '442
0320 00551    0 04 00444       DST   PISE+10
0321 00552    0 02 00574       DLD   '574
0322 00553    0 04 00446       DST   PISE+12
0323 00554    000005           SGL
0324                     *
0325                     *
0326 00555    0 35 00643 COMN  LDX   XREG
0327 00556    0 02 00642       LDA   BREG
0328 00557    000201           IAB
0329 00560    0 02 00641       LDA   KEYS
0330 00561    171020           OTK
0331 00562    0 13 00640       IMA   AREG
0332 00563    000401           ENB
0333 00564   -0 01 00450       JMP*  RUPT
```

```
0334                              *
0335                              *
0336 00565    0 13 00640 GDO   IMA    AREG
0337 00566    000043           INK
0338 00567    000005           SGL
0339 00570    0 04 00641       STA    KEYS
0340 00571    000201           IAB
0341 00572    0 04 00642       STA    BREG
0342 00573    0 15 00643       STX    XREG
0343                              *
0344                              *
0345 00574    34 0007          SKS    '007          WAIT FOR DIGISEC
0346 00575    0 01 00574       JMP    *-1
0347 00576    14 0406          OCP    '406          HOLD
0348 00577    0401 62          LRS    14            WAIT 8 MCT'S
0349 00600    54 1016          INA    '1016         HIGH HALF
0350 00601    101000           NOP
0351 00602    0 04 00324       STA    '324
0352 00603    54 1006          INA    '1006         LOW HALF
0353 00604    101000           NOP
0354 00605    0 04 00325       STA    '325
0355 00606    14 0006          OCP    '006          END HOLD
0356 00607    0 10 00000       CALL   INGYRO
0357 00610    000401           ENB
0358 00611    0 10 00000       CALL   DCMT
0359 00612    0 10 00000       CALL   GCOM
0360 00613    0 10 00000       CALL   GARC
0361 00614    0 10 00000       CALL   GFIS
0362 00615    0 10 00000       CALL   GPRT
0363 00616    0 10 00000       CALL   GMIN
0364 00617    0 10 00000       CALL   MG63
0365 00620    0 10 00000       CALL   ERCO
0366 00621    0 10 00000       CALL   ATTA
0367 00622    0 12 00637       IRS    TCNT
0368 00623    000007           DBL
0369 00624    0 02 00776       DLD    TIME
0370 00625    0 06 00344       DAD    DONE
0371 00626    0 04 00776       DST    TIME
0372 00627    000005           SGL
0373                              *
0374                              *
0375 00630    0 01 00555       JMP    COMN
0376                              *
0377                              *
0378                              *
0379 00631    030000      DOS  OCT    30000
0380 00632    013560      TCON DEC    6000          30 SEC FOR TTY
0381 00633    000620           DEC    400           4 SEC FOR CRT
0382 00634    000144           DEC    100           .4 SEC FOR DGS
0383                              *
0384 00635    000000      CRIT BSZ    1
0385 00636    000000      MODE BSZ    1
0386 00637    077777      TCNT OCT    77777
0387 00640    000000      AREG BSZ    1
0388 00641    000000      KEYS BSZ    1
0389 00642    000000      BREG BSZ    1
0390 00643    000000      XREG BSZ    1
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0391            000776      TIME EQU    '776
0392 00644      000002           END
     00645      000006
     00646      040000
     00647      077777
     00650      164217
     00651      177744
     00652      177674
     00653      177730
     00654      177636
```

PROGRAM NAME (Note: this is a FORTRAN program)
SOURCE: ALPO
BINARY: BALPO
ENTRY POINTS (location): OUTPUT ('07530), DODSP ('07600)
GENERAL DESCRIPTION:

When called, this subroutine will output the information about the system status either on the teletype or the CRT screen in the format shown in Figure 2 or as a block of 104 bytes (6 single precision numbers giving gyro and PIPA fail status and third fail indication and 23 double precision numbers; 4 for the quaternion, 3 for ΔV_I, 14 for gyro and PIPA squared errors, 1 for time and 1 for the encoder) on digistor tape. See the documentation for MPRO (the main program which calls OUTPUT) and for the output subroutines SDGS, SXOU and SFPOUT.

```
                    (NO FAILS INDICATED)

QUAT          0.999999      0.000016      0.000069  -     0.000035
 DELVRF  -  979.664062        8.601562  -   8.453125
ERRORS      0.25          1.89
            0.01          1.89          A-F PIPA
  A-F Gyro  0.01          0.01
            0.06          3.51          Squared
  Squared   0.39          0.39          Error
  Error     0.14          0.56
            0.87          8.26      Total Squared Error

GYRO FAIL
PIPA FAIL
TIME        180.00 (sec)
TABLE ANGLE 0.761531 (IN REVOLUTIONS)
```

Fig. 2 CRT System Status Display

```
    MICROCOMP TELECOMMUNICATED DATA
          DDP-516 ASSEMBLY LISTING
      SUBROUTINE OUTPUT(ARG,MODE)
000000     DAC    000000
000001     CALL   F$AT
000002     OCT    000002
000003     DAC    000000
000004     DAC    000000
      INTEGER ARG(52),MODE,MODSAV
      DATA MODSAV /-1/
000005     JMP    000000
000006     OCT    177777
      IF(MODE.EQ.2) GOTO 100
           STG    000005
000007     LDA*   MODE
000010     SUB    ='000002
000011     SZE    000000
000012     JMP    000000
000013     JMP    _100
           STG    000012
      IF(MODE.EQ.MODSAV) GOTO 50
000014     LDA*   MODE
000015     SUB    MODSAV
000016     SZE    000000
000017     JMP    000000
000020     JMP    _50
           STG    000017
      CALL IOMODE(MODE)
000021     CALL   IOMODE
000022     DAC*   MODE
      MODSAV=MODE
000023     LDA*   MODE
000024     STA    MODSAV
50    CALL DODSP(ARG)
           STG    _50
000025     CALL   DODSP
000026     DAC*   ARG
      IF(MODSAV.EQ.1) CALL C1OU(2H ¬)
000027     LDA    MODSAV
000030     SUB    ='000001
000031     SZE    000000
000032     JMP    000000
000033     CALL   C1OU
000034     DAC    ='120336
           STG    000032
      RETURN
C
C DIGISTOR OUTPUT
C
000035     JMP*   000000
100   CALL DGSWRT(ARG,52)
           STG    _100
000036     CALL   DGSWRT
000037     DAC*   ARG
000040     DAC    ='000064
000041     OCT    000000
      RETURN
000042     JMP*   000000
      END
```

```
     MICROCOMP TELECOMMUNICATED DATA
           DDP-516 ASSEMBLY LISTING
C
C
C
                STG   ='000001
000043          OCT   000001
                STG   ='000002
000044          OCT   000002
000003          DAC   ARG
000004          DAC   MODE
                STG   =!000064
000045          OCT   000064
000006          DAC   MODSAV
000036          DAC   _100
000025          DAC   _50
000000          DAC   IOMODE
000000          DAC   DODSP
000000          DAC   C1OU
                STG   ='120336
000046          OCT   120336
000000          DAC   DGSWRT
      SUBROUTINE DODSP(ARG)
000000          DAC   000000
000001          CALL  F$AT
000002          OCT   000001
000003          DAC   000000
      COMMON/LIST/ LIST(1)
      LOGICAL LIST
      INTEGER ARG(24)
      CALL XNOUA(8HQUAT     ,8)
000004          JMP   000000
                STG   000004
000005          JMP   000000
000006          OCT   150725
000007          OCT   140724
000010          OCT   120240
000011          OCT   120240
                STG   000005
000012          CALL  XNOUA
000013          DAC   000006
000014          DAC   ='000010
000015          OCT   000000
      DO 10 I=1,7,2
000016          LDA   ='000001
000017          STA   I
      CALL FPOUTC(ARG(I),1,6)
000020          LDA   I
000021          ADD   ARG
000022          ADD   000024
000023          JMP   000025
000024          OCT   177777
000025          STA   T$1000
000026          CALL  FPOUTC
000027          DAC*  T$1000
000030          DAC   ='000001
000031          DAC   ='000006
000032          OCT   000000
10      CALL XNOUA(2H   ,2)
```

```
    MICROCOMP TELECOMMUNICATED DATA
          DDP-516 ASSEMBLY LISTING
000033     CALL  XNOUA
000034     DAC   ='120240
000035     DAC   ='000002
000036     OCT   000000
000037     LDA   I
000040     ADD   ='000002
000041     CAS   ='000007
000042     JMP   000045
000043     JMP   000017
000044     JMP   000017
      CALL X1OU(138)
000045     CALL  X1OU
000046     DAC   ='000212
      CALL XNOUA(8HDELVRF  ,8)
000047     JMP   000000
000050     OCT   142305
000051     OCT   146326
000052     OCT   151306
000053     OCT   120240
           STG   000047
000054     CALL  XNOUA
000055     DAC   000050
000056     DAC   ='000010
000057     OCT   000000
      DO 20 I=9,13,2
000060     LDA   ='000011
000061     STA   I
      CALL FPOUTC(ARG(I),15,6)
000062     LDA   I
000063     ADD   ARG
000064     ADD   000066
000065     JMP   000067
000066     OCT   177777
000067     STA   T$1000
000070     CALL  FPOUTC
000071     DAC*  T$1000
000072     DAC   ='000017
000073     DAC   ='000006
000074     OCT   000000
20    CALL XNOUA(2H  ,2)
000075     CALL  XNOUA
000076     DAC   ='120240
000077     DAC   ='000002
000100     OCT   000000
000101     LDA   I
000102     ADD   ='000002
000103     CAS   ='000015
000104     JMP   000107
000105     JMP   000061
000106     JMP   000061
      CALL X1OU(138)
000107     CALL  X1OU
000110     DAC   ='000212
      CALL XNOUA(8HERRORS  ,8)
000111     JMP   000000
000112     OCT   142722
000113     OCT   151317
```

```
    MICROCOMP TELECOMMUNICATED DATA
          DDP-516 ASSEMBLY LISTING
000114      OCT    151323
000115      OCT    120240
            STG    000111
000116      CALL   XNOUA
000117      DAC    000112
000120      DAC    ='000010
000121      OCT    000000
      DO 25 I=1,13,2
000122      LDA    ='000001
000123      STA    I
      CALL FPOUTC(ARG(I+24),15,2)
000124      LDA    I
000125      ADD    ARG
000126      ADD    000130
000127      JMP    000131
000130      OCT    000027
000131      STA    T$1000
000132      CALL   FPOUTC
000133      DAC*   T$1000
000134      DAC    ='000017
000135      DAC    ='000002
000136      OCT    000000
      CALL XNOUA(2H  ,2)
000137      CALL   XNOUA
000140      DAC    ='120240
000141      DAC    ='000002
000142      OCT    000000
      CALL FPOUTC(ARG(I+38),15,2)
000143      LDA    I
000144      ADD    ARG
000145      ADD    000147
000146      JMP    000150
000147      OCT    000045
000150      STA    T$1000
000151      CALL   FPOUTC
000152      DAC*   T$1000
000153      DAC    ='000017
000154      DAC    ='000002
000155      OCT    000000
      CALL X10U(138)
000156      CALL   X10U
000157      DAC    ='000212
25    CALL XNOUA(8H       ,8)
000160      JMP    000000
000161      OCT    120240
000162      OCT    120240
000163      OCT    120240
000164      OCT    120240
            STG    000160
000165      CALL   XNOUA
000166      DAC    000161
000167      DAC    ='000010
000170      OCT    000000
000171      LDA    I
000172      ADD    ='000002
000173      CAS    ='000015
000174      JMP    000177
```

```
000175     JMP    000123
000176     JMP    000123
      CALL X1OU(138)
000177     CALL   X1OU
000200     DAC    ='000212
      CALL XNOUA(10HGYRO FAIL ,10)
000201     JMP    000000
000202     OCT    143731
000203     OCT    151317
000204     OCT    120306
000205     OCT    140711
000206     OCT    146240
           STG    000201
000207     CALL   XNOUA
000210     DAC    000202
000211     DAC    ='000012
000212     OCT    000000
      IF(ARG(15).EQ.0) GO TO 35
000213     LDA    ARG
000214     ADD    000216
000215     JMP    000217
000216     OCT    000016
000217     STA    T$1000
000220     LDA*   T$1000
000221     SZE    000000
000222     JMP    000000
000223     JMP    _35
           STG    000222
      CALL XNOUA(4H     ,4)
000224     JMP    000000
000225     OCT    120240
000226     OCT    120240
           STG    000224
000227     CALL   XNOUA
000230     DAC    000225
000231     DAC    ='000004
000232     OCT    000000
      CALL X1OU(ARG(15)+192)
000233     LDA    ARG
000234     ADD    000236
000235     JMP    000237
000236     OCT    000016
000237     STA    T$1000
000240     LDA*   T$1000
000241     ADD    ='000300
000242     STA    T$1001
000243     CALL   X1OU
000244     DAC    T$1001
      IF(ARG(16).EQ.0) GO TO 35
000245     LDA    ARG
000246     ADD    000250
000247     JMP    000251
000250     OCT    000017
000251     STA    T$1000
000252     LDA*   T$1000
000253     SZE    000000
000254     JMP    000000
```

```
000255      JMP    _35
            STG    000254
        CALL XNOUA(4H     ,4)
000256      JMP    000000
000257      OCT    120240
000260      OCT    120240
            STG    000256
000261      CALL   XNOUA
000262      DAC    000257
000263      DAC    ='000004
000264      OCT    000000
        CALL X10U(ARG(16)+192)
000265      LDA    ARG
000266      ADD    000270
000267      JMP    000271
000270      OCT    000017
000271      STA    T$1000
000272      LDA*   T$1000
000273      ADD    ='000300
000274      STA    T$1001
000275      CALL   X10U
000276      DAC    T$1001
      IF(ARG(23).NE.0) CALL XNOUA(10H     THIRD ,10)
000277      LDA    ARG
000300      ADD    000302
000301      JMP    000303
000302      OCT    000026
000303      STA    T$1000
000304      LDA*   T$1000
000305      SNZ    000000
000306      JMP    000000
000307      JMP    000000
000310      OCT    120240
000311      OCT    120240
000312      OCT    152310
000313      OCT    144722
000314      OCT    142240
            STG    000307
000315      CALL   XNOUA
000316      DAC    000310
000317      DAC    ='000012
000320      OCT    000000
            STG    000306
35      CALL X10U(138)
            STG    _35
000321      CALL   X10U
000322      DAC    ='000212
      CALL XNOUA(10HPIPA FAIL ,10)
000323      JMP    000000
000324      OCT    150311
000325      OCT    150301
000326      OCT    120306
000327      OCT    140711
000330      OCT    146240
            STG    000323
000331      CALL   XNOUA
000332      DAC    000324
```

```
000333     DAC    ='000012
000334     OCT    000000
      IF(ARG(17).EQ.0) GO TO 40
000335     LDA    ARG
000336     ADD    000340
000337     JMP    000341
000340     OCT    000020
000341     STA    T$1000
000342     LDA*   T$1000
000343     SZE    000000
000344     JMP    000000
000345     JMP    _40
           STG    000344
      CALL XNOUA(4H     ,4)
000346     JMP    000000
000347     OCT    120240
000350     OCT    120240
           STG    000346
000351     CALL   XNOUA
000352     DAC    000347
000353     DAC    ='000004
000354     OCT    000000
      CALL X10U(ARG(17)+192)
000355     LDA    ARG
000356     ADD    000360
000357     JMP    000361
000360     OCT    000020
000361     STA    T$1000
000362     LDA*   T$1000
000363     ADD    ='000300
000364     STA    T$1001
000365     CALL   X10U
000366     DAC    T$1001
      IF(ARG(18).EQ.0) GO TO 40
000367     LDA    ARG
000370     ADD    000372
000371     JMP    000373
000372     OCT    000021
000373     STA    T$1000
000374     LDA*   T$1000
000375     SZE    000000
000376     JMP    000000
000377     JMP    _40
           STG    000376
      CALL XNOUA(4H     ,4)
000400     JMP    000000
000401     OCT    120240
000402     OCT    120240
           STG    000400
000403     CALL   XNOUA
000404     DAC    000401
000405     DAC    ='000004
000406     OCT    000000
      CALL X10U(ARG(18)+192)
000407     LDA    ARG
000410     ADD    000412
000411     JMP    000413
```

```
    MICROCOMP TELECOMMUNICATED DATA
          DDP-516 ASSEMBLY LISTING
000412     OCT    000021
000413     STA    T$1000
000414     LDA*   T$1000
000415     ADD    ='000300
000416     STA    T$1001
000417     CALL   X10U
000420     DAC    T$1001
      IF(ARG(24).NE.0) CALL XNOUA(10H    THIRD ,10)
000421     LDA    ARG
000422     ADD    000424
000423     JMP    000425
000424     OCT    000027
000425     STA    T$1000
000426     LDA*   T$1000
000427     SNZ    000000
000430     JMP    000000
000431     JMP    000000
000432     OCT    120240
000433     OCT    120240
000434     OCT    152310
000435     OCT    144722
000436     OCT    142240
           STG    000431
000437     CALL   XNOUA
000440     DAC    000432
000441     DAC    ='000012
000442     OCT    000000
           STG    000430
40    CALL X10U(138)
           STG    _40
000443     CALL   X10U
000444     DAC    ='000212
      CALL XNOUA(8HTIME    ,8)
000445     JMP    000000
000446     OCT    152311
000447     OCT    146705
000450     OCT    120240
000451     OCT    120240
           STG    000445
000452     CALL   XNOUA
000453     DAC    000446
000454     DAC    ='000010
000455     OCT    000000
      CALL OUT100(ARG(19))
000456     LDA    ARG
000457     ADD    000461
000460     JMP    000462
000461     OCT    000022
000462     STA    T$1000
000463     CALL   OUT100
000464     DAC*   T$1000
      CALL X10U(138)
000465     CALL   X10U
000466     DAC    ='000212
      CALL XNOUA(8HTABLE   ,8)
000467     JMP    000000
000470     OCT    152301
```

```
    MICROCOMP TELECOMMUNICATED DATA
          DDP-516 ASSEMBLY LISTING
000471      OCT    141314
000472      OCT    142640
000473      OCT    120240
            STG    000467
000474      CALL   XNOUA
000475      DAC    000470
000476      DAC    ='000010
000477      OCT    000000
       CALL FPOUTC(ARG(21),0,6)
000500      LDA    ARG
000501      ADD    000503
000502      JMP    000504
000503      OCT    000024
000504      STA    T$1000
000505      CALL   FPOUTC
000506      DAC*   T$1000
000507      DAC    ='000000
000510      DAC    ='000006
000511      OCT    000000
       CALL X10U(138)
000512      CALL   X10U
000513      DAC    ='000212
       CALL X10U(138)
000514      CALL   X10U
000515      DAC    ='000212
       RETURN
000516      JMP*   000000
       END
            STG    ='000001
000517      OCT    000001
            STG    ='000002
000520      OCT    000002
            STG    ='000004
000521      OCT    000004
            STG    ='000006
000522      OCT    000006
000003      DAC    ARG
000000      DAC    LIST
000000      DAC    XNOUA
            STG    ='000010
000523      OCT    000010
000033      DAC    _10
            STG    I
000524      OCT    004640
            STG    ='000007
000525      OCT    000007
000000      DAC    FPOUTC
            STG    T$1000
000526      OCT    012244
            STG    ='120240
000527      OCT    120240
000000      DAC    X10U
            STG    ='000212
000530      OCT    000212
000075      DAC    _20
            STG    ='000011
000531      OCT    000011
```

```
     MICROCOMP TELECOMMUNICATED DATA
           DDP-516 ASSEMBLY LISTING
           STG    ='000015
000532     OCT    000015
           STG    ='000017
000533     OCT    000017
000160     DAC    _25
           STG    ='000012
000534     OCT    000012
           STG    ='000000
000535     OCT    000000
000321     DAC    _35
           STG    ='000300
000536     OCT    000300
           STG    T$1001
000537     OCT    012244
000443     DAC    _40
000000     DAC    OUT100
$0
```

PROGRAM NAME:
SOURCE: SFPOUT
BINARY: BFPOUT
ENTRY POINT (location): FPOUTC ('10340), OUT100 ('10552)
GENERAL DESCRIPTION:

FPOUTC is called by the output subroutine ALPO and prints on the teletype or displays on the CRT (See documentation for subroutine SXOU) a decimal number representation of the binary number designated by the call. The call in FORTRAN is

CALL FPOUTC (ARG, S, P)

or in DAP

```
CALL    FPOUTC
DAC     ARG
DAC     S
DAC     P
OCT     0
```

where ARG is the number to be printed, S is the number of bits after the sign bit before the binary point, and P is how many decimal digits to print after the decimal point.

OUT100 is also called by ALPO and is used to print on the teletype or display on the CRT 1/100 of a double precision integer. It is only used tc print out the variable TIME, which is really a count of updates and needs to be divided by 100 to scale it to seconds. The call in FORTRAN is CALL OUT100 (TIME), or in DAP

```
CALL    OUT100
DAC     TIME
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                              SUBR   FPOUTC
0002                              REL
0003 00000    0 000000    FPOU    DAC    **
0004 00001    0 10 00000        CALL   F$AT
0005 00002    000003      DEC3  OCT    3
0006 00003    0 00 00000  ARG   PZE
0007 00004    0 00 00000  SCAL  PZE
0008 00005    0 00 00000  PREC  PZE
0009 00006    140040            CRA
0010 00007    0 04 00166        STA    SGFL              SIGN FLAG
0011 00010    0 04 00173        STA    INT
0012 00011    0 02 00202        LDA    BLBL
0013 00012    0 04 00170        STA    STR
0014 00013    0 04 00171        STA    STR+1
0015 00014    0 04 00172        STA    STR+2             OVERLAYS CNTR
0016 00015    0 02 00206        LDA    SIX
0017 00016    0 04 00167        STA    PPTR
0018                            *
0019 00017    0 35 00003        LDX    ARG
0020 00020    1 02 00001        LDA    1,1
0021 00021    000201            IAB
0022 00022    1 02 00000        LDA    0,1
0023 00023    000007            DBL
0024 00024    0 04 00174        DST    FRAC
0025 00025    101400            SMI
0026 00026    0 01 00033        JMP    ARGP
0027 00027    0 12 00166        IRS    SGFL
0028 00030    0 07 00174        DSB    FRAC
0029 00031    0 07 00174        DSB    FRAC
0030 00032    0 04 00174        DST    FRAC
0031                            *
0032 00033    000005      ARGP  SGL
0033 00034   -0 02 00004        LDA*   SCAL
0034 00035    101040            SNZ
0035 00036    0 01 00051        JMP    SDON
0036 00037    101400            SMI
0037 00040    0 01 00144        JMP    TPLS
0038 00041    0 03 00210        ANA    OC77
0039 00042    0 05 00201        ERA    RSI
0040 00043    0 04 00046        STA    INS2
0041 00044    000007            DBL
0042 00045    0 02 00174        DLD    FRAC
0043 00046    0 00 00000  INS2  ***
0044 00047    0 04 00174        DST    FRAC
0045 00050    000005            SGL
0046                            *
0047 00051    0 02 00173  SDON  LDA    INT
0048 00052    0400 60     NEXT  LRL    16
0049 00053    0 17 00207        DIV    TEN
0050 00054    0 04 00173        STA    INT
0051 00055    000201            IAB
0052 00056    0 06 00176        ADD    FRMT
0053                            *
0054 00057    000201            IAB
0055 00060    0 02 00167        LDA    PPTR
0056 00061    0 07 00205        SUB    ONE
0057 00062    0 04 00167        STA    PPTR
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0058 00063    0404 77          LGR   1
0059 00064    0 04 00000       STA   0
0060 00065    1 02 00170       LDA   STR,1
0061 00066    100001           SRC
0062 00067    000201           IAB
0063 00070    0414 70          LGL   8
0064 00071    0402 70          LRR   8
0065 00072    1 04 00170       STA   STR,1
0066                     *
0067 00073    0 02 00173       LDA   INT
0068 00074    100040           SZE
0069 00075    0 01 00052       JMP   NEXT
0070 00076    0 02 00166       LDA   SGFL
0071 00077    101040           SNZ
0072 00100    0 01 00104       JMP   SOUT
0073 00101    0 02 00170       LDA   STR
0074 00102    0 05 00204       ERA   NEGS
0075 00103    0 04 00170       STA   STR
0076 00104    0 10 00000 SOUT  CALL  XNOUA
0077 00105    0 000170         DAC   STR
0078 00106    0 000206         DAC   SIX
0079 00107    000000           OCT   0
0080                     *
0081 00110   -0 02 00005       LDA*  PREC
0082 00111    140407           TCA
0083 00112    101400           SMI
0084 00113   -0 01 00000       JMP*  FPOU
0085 00114    0 04 00172       STA   CNTR
0086 00115    0 10 00000       CALL  X10U
0087 00116    0 000203         DAC   DOTC
0088                     *
0089 00117    0 02 00175 FLP   LDA   LOW
0090 00120    0 16 00207       MPY   TEN
0091 00121    000007           DBL
0092 00122    0 04 00166       DST   TEMP
0093 00123    0 02 00174       DLD   HIGH
0094 00124    0 16 00207       MPY   TEN
0095 00125    0 06 00176       DAD   FRMT
0096 00126    0 13 00173       IMA   DGT
0097 00127    140040           CRA
0098 00130    000201           IAB
0099 00131    0 06 00166       DAD   TEMP
0100 00132    100001           SRC
0101 00133    0 12 00173       IRS   DGT
0102 00134    140100           SSP
0103 00135    0 04 00174       DST   FRAC
0104 00136    000005           SGL
0105 00137    0 10 00000       CALL  X10U
0106 00140    0 000173         DAC   DGT
0107 00141    0 12 00172       IRS   CNTR
0108 00142    0 01 00117       JMP   FLP
0109 00143   -0 01 00000       JMP*  FPOU
0110                     *
0111 00144    0 05 00200 TPLS  ERA   LSI
0112 00145    141206           AOA
0113 00146    0 04 00153       STA   INS1
0114 00147    0 35 00002       LDX   DEC3
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0115 00150    140040           CRA
0116 00151    000201           IAB
0117 00152    1 02 00172 TPLP  LDA   INT-1,1
0118 00153    0 00 00000 INS1  ***
0119 00154    140100           SSP
0120 00155    1 13 00172       IMA   INT-1,1
0121 00156    000201           IAB
0122 00157    0 02 00000       LDA   0
0123 00160    0 07 00205       SUB   ONE
0124 00161    0 04 00000       STA   0
0125 00162    100040           SZE
0126 00163    0 01 00152       JMP   TPLP
0127 00164    0 01 00051       JMP   SDON
0128                           *
0129                           *
0130                           *
0131 00166    000000     TEMP  DBP   0
     00167    000000
0132 00170    000000     STR   DBP   0
     00171    000000
0133 00172    000000     CNTR  BSZ   1
0134 00173    000000     INT   BSZ   1
0135 00174    000000     FRAC  DBP   0
     00175    000000
0136          000173     DGT   EQU   INT
0137          000174     HIGH  EQU   FRAC
0138          000175     LOW   EQU   FRAC+1
0139          000166     SGFL  EQU   TEMP
0140          000167     PPTR  EQU   TEMP+1
0141                           *
0142 00176    000260     FRMT  OCT   260,0
     00177    000000
0143 00200    0411 77    LSI   LLS   1
0144 00201    0401 00    RSI   LRS   0
0145 00202    120240     BIBL  OCT   120240
0146 00203    000256     DOTC  OCT   256
0147 00204    006400     NEGS  OCT   6400
0148                           *
0149 00205    000001     ONE   DEC   1
0150 00206    000006     SIX   DEC   6
0151 00207    000012     TEN   OCT   12
0152 00210    000077     OC77  DEC   63
0153 00211    000000     ZERE  OCT   0
0154                           FIN
0155                           *
0156                           *
0157                           SUBR  OUT100
0158                           REL
0159 00212    0 000000   OUT1  DAC   **
0160 00213    0 10 00000       CALL  ARG$
0161 00214   -0 000212         DAC*  OUT1
0162 00215    1 02 00001       LDA   1,1
0163 00216    000201           IAB
0164 00217    1 02 00000       LDA   0,1
0165 00220    0 17 00240       DIV   D100
0166 00221    0 04 00236       STA   OTMP
0167 00222    140040           CRA
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0168 00223    000201            IAB
0169 00224    0 17 00240        DIV    D100
0170 00225    141206            AOA
0171 00226    0 04 00237        STA    OTMP+1
0172 00227    0 10 00000        CALL   FPOUTC
0173 00230    0 000236          DAC    OTMP
0174 00231    0 000242          DAC    =15
0175 00232    0 000241          DAC    =2
0176 00233    000000            OCT    0
0177 00234    0 12 00212        IPS    OUT1
0178 00235   -0 01 00212        JMP*   OUT1
0179                       *
0180 00236    000000      OTMP  BSZ    2
     00237    000000
0181 00240    000144      D100  DEC    100
0182 00241    000002            END
     00242    000017
```

PROGRAM NAME
SOURCE: SXOU
BINARY: BXOU
ENTRY POINTS (location): IOMODE ('10604), X1OU ('10636), XNOU ('10642), XNOUA ('10646), XOOCT ('10652)
GENERAL DESCRIPTION:

This subroutine is really an intermediary to the output calls to either the FORTRAN teletype output routines (T1OU, TNOU, TNOUA and TOOCT), or the CRT output routines (C1OU, CNOU, CNOUA and COOCT). The subroutine ALPO (see documentation) first calls IOMODE with the argument 0 if it wants to output on the teltype or 1 if it wants to output on the CRT. From then on, every call to X1OU, XNOU or XOOCT will be rerouted to look like the proper call to either the teletype or CRT routines.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    SUBR   IOMODE
0002                                    SUBR   X1OU
0003                                    SUBR   XNOU,XNO
0004                                    SUBR   XNOUA,XNOA
0005                                    SUBR   XOOCT
0006                                    REL
0007                              *
0008 00000    0 000000    IOMO  DAC    **
0009 00001    0 35 00000        LDX    IOMO
0010 00002   -1 02 00000        LDA*   0,1
0011 00003    0 35 00063        LDX    =0
0012 00004    100040            SZE
0013 00005    0 35 00062        LDX    =4
0014 00006    000007            DBL
0015 00007    1 02 00022        DLD    ADL,1
0016 00010    0 04 00016        DST    LST
0017 00011    1 02 00024        DLD    ADL+2,1
0018 00012    0 04 00020        DST    LST+2
0019 00013    000005            SGL
0020 00014    0 12 00000        IRS    IOMO
0021 00015   -0 01 00000        JMP*   IOMO
0022                              *
0023 00016    000000      LST   DBP    0
     00017    000000
0024 00020    000000            DBP    0
     00021    000000
0025 00022    0 000000    ADL   XAC    T1OU
0026 00023    0 000000          XAC    TNOU
0027 00024    0 000000          XAC    TNOUA
0028 00025    0 000000          XAC    TOOCT
0029 00026    0 000000          XAC    C1OU
0030 00027    0 000000          XAC    CNOU
0031 00030    0 000000          XAC    CNOUA
0032 00031    0 000000          XAC    COOCT
0033                              *
0034                              *
0035 00032    0 000000    X1OU  DAC    **
0036 00033    0 35 00063        LDX    =0
0037 00034    0 02 00032        LDA    X1OU
0038 00035    0 01 00051        JMP    COMN
0039                              *
0040 00036    0 000000    XNO   DAC    **
0041 00037    0 35 00061        LDX    =1
0042 00040    0 02 00036        LDA    XNO
0043 00041    0 01 00051        JMP    COMN
0044                              *
0045 00042    0 000000    XNOA  DAC    **
0046 00043    0 35 00060        LDX    =2
0047 00044    0 02 00042        LDA    XNOA
0048 00045    0 01 00051        JMP    COMN
0049                              *
0050 00046    0 000000    XOOC  DAC    **
0051 00047    0 35 00057        LDX    =3
0052 00050    0 02 00046        LDA    XOOC
0053                              *
0054 00051   -1 04 00016 COMN  STA*   LST,1
0055 00052    1 02 00016        LDA    LST,1
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0056 00053    141206           AOA
0057 00054    0 04 00056       STA    TEMP
0058 00055   -0 01 00056       JMP*   TEMP
0059                          *
0060 00056    000000           TEMP BSZ    1
0061                          *
0062 00057    000003           END
     00060    000002
     00061    000001
     00062    000004
     00063    000000
```

PROGRAM NAME
SOURCE: SDGS
BINARY: BDGS
ENTRY POINTS (location): DGSRD ('13311), DGSWRT ('13250)
GENERAL DESCRIPTION:

These two subroutines are for reading and writing words on the digistor tape. The SIRU system only writes on the digistor tape. A fortran statement; CALL DGSWRT (ARG, 52), or the DAP instructions,

```
CALL    DGSWRT
DAC     ARG
DAC     ='64
OCT     0
```

when executed, will cause this subroutine to write a heading, 52 words of information starting with ARG, and one word of parity on the digistor tape. It will then return.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   DGSRD
0003                                  SUBR   DGSWRT
0004                            *
0005 00000    0 000000        DGSW    DAC    **
0006 00001    0 10 00000              CALL   F$AT
0007 00002    000002                  OCT    2
0008 00003    0 00 00000      WARY    PZE
0009 00004    0 00 00000      WCNT    PZE
0010 00005   -0 02 00004              LDA*   WCNT
0011 00006    140407                  TCA
0012 00007    101400                  SMI
0013 00010   -0 01 00000              JMP*   DGSW
0014 00011    0 04 00004              STA    WCNT
0015 00012    140040                  CRA
0016 00013    0 04 00143              STA    ACC
0017 00014    0 02 00145              LDA    ='201
0018 00015    0 10 00127              JST    WRT
0019 00016    0 10 00127              JST    WRT
0020 00017    0 02 00144              LDA    ='177777
0021 00020    0 10 00127              JST    WRT
0022 00021    0 10 00127              JST    WRT
0023                            *
0024 00022   -0 02 00003      WLUP    LDA*   WAPY
0025 00023    141340                  ICA
0026 00024    0 10 00127              JST    WRT
0027 00025    141340                  ICA
0028 00026    0 10 00127              JST    WRT
0029 00027    0 10 00122              JST    PRTY
0030 00030    0 12 00003              IRS    WARY
0031 00031    0 12 00004              IRS    WCNT
0032 00032    0 01 00022              JMP    WLUP
0033                            *
0034 00033    0 02 00143              LDA    ACC
0035 00034    141340                  ICA
0036 00035    0 10 00127              JST    WRT
0037 00036    141340                  ICA
0038 00037    0 10 00127              JST    WRT
0039 00040   -0 01 00000              JMP*   DGSW
0040                            *
0041                            *
0042                            *
0043 00041    0 000000        DGSR    DAC    **
0044 00042    0 10 00000              CALL   F$AT
0045 00043    000002                  OCT    2
0046 00044    0 00 00000      RARY    PZE
0047 00045    0 00 00000      RCNT    PZE
0048 00046   -0 02 00045              LDA*   RCNT
0049 00047    140407                  TCA
0050 00050    101400                  SMI
0051 00051   -0 01 00041              JMP*   DGSR
0052 00052    0 04 00045              STA    RCNT
0053 00053    140040                  CRA
0054 00054    0 04 00143              STA    ACC
0055 00055    140040          RLOK    CRA
0056 00056    0 10 00135              JST    RD
0057 00057    0 05 00145              ERA    ='201
```

```
0058 00060   100040           SZE
0059 00061   0 01 00055       JMP   RLOK
0060 00062   140040           CRA
0061 00063   0 10 00135       JST   RD
0062 00064   0 05 00145       ERA   ='201
0063 00065   100040           SZE
0064 00066   0 01 00055       JMP   RLOK
0065 00067   140040           CRA
0066 00070   0 10 00135       JST   RD
0067 00071   141340           ICA
0068 00072   0 10 00135       JST   RD
0069 00073   0 05 00144       ERA   ='177777
0070 00074   100040           SZE
0071 00075   0 01 00055       JMP   RLOK
0072                     *
0073 00076   140040     RLUP  CRA
0074 00077   0 10 00135       JST   RD
0075 00100   141340           ICA
0076 00101   0 10 00135       JST   RD
0077 00102  -0 04 00044       STA*  RARY
0078 00103   0 10 00122       JST   PRTY
0079 00104   0 12 00044       IRS   RARY
0080 00105   0 12 00045       IRS   RCNT
0081 00106   0 01 00076       JMP   RLUP
0082                     *
0083 00107   140040           CRA
0084 00110   0 10 00135       JST   RD
0085 00111   141340           ICA
0086 00112   0 10 00135       JST   RD
0087 00113   0 05 00143       ERA   ACC
0088 00114   101040           SNZ
0089 00115   0 01 00120       JMP   *+3
0090 00116   140040           CRA
0091 00117   100000           SKP
0092 00120   141206           AOA
0093 00121  -0 01 00041       JMP*  DGSR
0094                     *
0095                     *
0096                     *
0097 00122   0 000000   PRTY  DAC   **
0098 00123   0 05 00143       ERA   ACC
0099 00124   0416 77          ALR   1
0100 00125   0 04 00143       STA   ACC
0101 00126  -0 01 00122       JMP*  PRTY
0102                     *
0103 00127   0 000000   WRT   DAC   **
0104 00130   14 0002          OCP   '2
0105 00131   74 0002          OTA   '2
0106 00132   0 01 00130       JMP   *-2
0107 00133   14 0102          OCP   '102
0108                     *
0109 00134  -0 01 00127       JMP*  WRT
0110                     *
0111 00135   0 000000   RD    DAC   **
0112 00136   14 0001          OCP   '1
0113 00137   54 0001          INA   '1
0114 00140   0 01 00137       JMP   *-1
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0115 00141    14 0101          OCP    '101
0116 00142  -0 01 00135        JMP*   RD
0117                         *
0118 00143    000000         ACC    BSZ    1
0119                         *
0120 00144    177777               END
     00145    000201
```

PROGRAM NAME
SOURCE: READ
BINARY: BREAD
ENTRY POINTS (location): ICINIT ('01656), INPIP ('01731),
INGYRO ('01764)
GENERAL DESCRIPTION:

The subroutine ICINIT will set up the gyro and PIPA interface to interrrupt the main program every 5 milliseconds. The first interrupt will be a PIPA interrupt and will occur when the PIPA counters have 10 milliseconds of data in them. The next interrupt will be a gyro interrupt 5 milliseconds later and will occur when the gyro counters have 10 milliseconds of data in them. From then on every 5 milliseconds the interrupts will occur alternately. ICINIT will also read the initial interpolator values of the gyros.

The subroutine INPIP will read the 6 PIPA pulse counters and store them in the locations indicated by the listing with a scaling of 2^{-6} pulses. For example, an octal 000400 represents one pulse or 4 cm/sec of ΔV.

The subroutine INGYRO will read the 6 gyro pulse counters, subtract the old interpolator values, add the new interpolator values and store them in the locations indicated by the listing. These are also scaled at 2^{-6} pulses. For example, an octal 000400 represents one pulse or 7×2^{-15} radians.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                SUBR  ICINIT
0002                                REL
0003 00000   0 000000   ICIN  DAC   **
0004 00001   14 0047            OCP   '47              DISABLE GYRO
0005 00002   14 0057            OCP   '57              DISABLE PIP
0006 00003   14 0077            OCP   '77              RESET PRESET
0007 00004   0 02 00210         LDA   =47
0008 00005   74 0077            OTA   '77              SET PRESET
0009 00006   0 01 00005         JMP   *-1
0010 00007   14 0027            OCP   '27              CLR & ENB CLOCK
0011 00010   34 0207            SKS   '207             WAIT FOR PULSE
0012 00011   0 01 00010         JMP   *-1
0013 00012   0400 56            LRL   18              WAIT 10 MICSEC.
0014 00013   14 0017            OCP   '17              CLR AND ENABLE PIPA
0015 00014   0 35 00207         LDX   =-24
0016 00015   14 0027     WLUP   OCP   '27              CLR & ENB CLOCK
0017 00016   34 0207            SKS   '207             WAIT FOR PULSE
0018 00017   0 01 00016         JMP   *-1
0019 00020   0 12 00000         IRS   0
0020 00021   0 01 00015         JMP   WLUP             WAIT FOR 22
0021 00022   14 0027            OCP   '27
0022 00023   14 0067            OCP   '67              DISABLE CLOCK
0023 00024   0400 56            LRL   18              WAIT 18 MICSEC.
0024 00025   14 0007            OCP   '7               ENABLE GYRO
0025 00026   34 0307            SKS   '307             SKIP IF INTRPLTR REDY
0026 00027   0 01 00026         JMP   *-1
0027                        * READ INITIAL INTERPOLATOR DATA
0028 00030   54 1307            INA   '1307
0029 00031   0 01 00030         JMP   *-1
0030 00032   0 04 00430         STA   '430             OLD INTRPPLTR DATA
0031 00033   54 1317            INA   '1317
0032 00034   0 01 00033         JMP   *-1
0033 00035   0 04 00431         STA   '431
0034 00036   54 1327            INA   '1327
0035 00037   0 01 00036         JMP   *-1
0036 00040   0 04 00432         STA   '432
0037 00041   54 1337            INA   '1337
0038 00042   0 01 00041         JMP   *-1
0039 00043   0 04 00433         STA   '433
0040 00044   54 1347            INA   '1347
0041 00045   0 01 00044         JMP   *-1
0042 00046   0 04 00434         STA   '434
0043 00047   54 1357            INA   '1357
0044 00050   0 01 00047         JMP   *-1
0045 00051   0 04 00435         STA   '435
0046 00052  -0 01 00000         JMP*  ICIN
0047                        *
0048                        *
0049                        *
0050                                SUBR  INPIP
0051                                REL
0052 00053   0 000000   INPI  DAC   **
0053 00054   54 1107            INA   '1107
0054 00055   0 01 00054         JMP   *-1
0055 00056   141240            ICR
0056 00057   0 04 00600         STA   PIPA
0057 00060   54 1117            INA   '1117
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0058 00061   0 01 00060      JMP   *-1
0059 00062   141240          ICR
0060 00063   0 04 00602      STA   PIPB
0061 00064   54 1127         INA   '1127
0062 00065   0 01 00064      JMP   *-1
0063 00066   141240          ICR
0064 00067   0 04 00604      STA   PIPC
0065 00070   54 1137         INA   '1137
0066 00071   0 01 00070      JMP   *-1
0067 00072   141240          ICR
0068 00073   0 04 00606      STA   PIPD
0069 00074   54 1147         INA   '1147
0070 00075   0 01 00074      JMP   *-1
0071 00076   141240          ICR
0072 00077   0 04 00610      STA   PIPE
0073 00100   54 1157         INA   '1157
0074 00101   0 01 00100      JMP   *-1
0075 00102   141240          ICR
0076 00103   0 04 00612      STA   PIPF
0077 00104   14 0017         OCP   '17              CLEAR AND ENABLE
0078 00105  -0 01 00053      JMP*  INPI
0079                        *
0080                        *
0081         000600         PIPA  EQU   '600
0082         000602         PIPB  EQU   PIPA+2
0083         000604         PIPC  EQU   PIPB+2
0084         000606         PIPD  EQU   PIPC+2
0085         000610         PIPE  EQU   PIPD+2
0086         000612         PIPF  EQU   PIPE+2
0087                        *
0088                        *
0089                        SUBR  INGYRO
0090                        REL
0091                        *
0092 00106   0 000000       INGY  DAC   **
0093 00107   54 1007         INA   '1007
0094 00110   0 01 00107      JMP   *-1
0095 00111   141240          ICR
0096 00112   0 07 00430      SUB   '430
0097 00113   0 04 00400      STA   GYRA
0098 00114   54 1017         INA   '1017
0099 00115   0 01 00114      JMP   *-1
0100 00116   141240          ICR
0101 00117   0 07 00431      SUB   '431
0102 00120   0 04 00402      STA   GYRB
0103 00121   54 1027         INA   '1027
0104 00122   0 01 00121      JMP   *-1
0105 00123   141240          ICR
0106 00124   0 07 00432      SUB   '432
0107 00125   0 04 00404      STA   GYRC
0108 00126   54 1037         INA   '1037
0109 00127   0 01 00126      JMP   *-1
0110 00130   141240          ICR
0111 00131   0 07 00433      SUB   '433
0112 00132   0 04 00406      STA   GYRD
0113 00133   54 1047         INA   '1047
0114 00134   0 01 00133      JMP   *-1
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0115 00135    141240            ICR
0116 00136    0 07 00434        SUB    '434
0117 00137    0 04 00410        STA    GYRE
0118 00140    54 1057           INA    '1057
0119 00141    0 01 00140        JMP    *-1
0120 00142    141240            ICR
0121 00143    0 07 00435        SUB    '435
0122 00144    0 04 00412        STA    GYRF
0123 00145    14 0007           OCP    '7                    CLEAR AND ENABLE
0124                          * READ INTERPOLATORS
0125 00146    34 0307           SKS    '307
0126 00147    0 01 00146        JMP    *-1
0127 00150    54 1307           INA    '1307
0128 00151    0 01 00150        JMP    *-1
0129 00152    0 04 00430        STA    '430
0130 00153    0 06 00400        ADD    GYRA
0131 00154    0 04 00400        STA    GYRA
0132 00155    54 1317           INA    '1317
0133 00156    0 01 00155        JMP    *-1
0134 00157    0 04 00431        STA    '431
0135 00160    0 06 00402        ADD    GYRB
0136 00161    0 04 00402        STA    GYRB
0137 00162    54 1327           INA    '1327
0138 00163    0 01 00162        JMP    *-1
0139 00164    0 04 00432        STA    '432
0140 00165    0 06 00404        ADD    GYRC
0141 00166    0 04 00404        STA    GYRC
0142 00167    54 1337           INA    '1337
0143 00170    0 01 00167        JMP    *-1
0144 00171    0 04 00433        STA    '433
0145 00172    0 06 00406        ADD    GYRD
0146 00173    0 04 00406        STA    GYRD
0147 00174    54 1347           INA    '1347
0148 00175    0 01 00174        JMP    *-1
0149 00176    0 04 00434        STA    '434
0150 00177    0 06 00410        ADD    GYRE
0151 00200    0 04 00410        STA    GYRE
0152 00201    54 1357           INA    '1357
0153 00202    0 01 00201        JMP    *-1
0154 00203    0 04 00435        STA    '435
0155 00204    0 06 00412        ADD    GYRF
0156 00205    0 04 00412        STA    GYRF
0157 00206   -0 01 00106        JMP*   INGY
0158                          *
0159                          *
0160          000400          GYRA   EQU    '400
0161          000402          GYRB   EQU    GYRA+2
0162          000404          GYRC   EQU    GYRB+2
0163          000406          GYRD   EQU    GYRC+2
0164          000410          GYRE   EQU    GYRD+2
0165          000412          GYRF   EQU    GYRE+2
0166                          *
0167 00207    177750               END
     00210    000057
```

PROGRAM NAME
SOURCE: ACOM
BINARY: BACOM
ENTRY POINTS (location): ACOM ('03274)
GENERAL DESCRIPTION:

This subroutine compensates the accelerometers for scale factor, bias and two misalignments, SO and SP, expressed as misalignments toward the negative X, Y and Z axes. Considering just the A accelerometer, the following equations are programmed.

$$AAPC = AAPC + AABD + \frac{1}{2^6} AASF\ AAPC$$

where

AAPC is accelerometer A's pulse count
AABD is accelerometer A's bias

and

AASF is 2^6X accelerometer A's Δ scale factor

then

$$AAPC = \frac{1}{2^9}(DVXB\ AAMX + DVYB\ AAMY + DVZB\ AAMZ)$$

DVXB, DVYB, DVZB are the $\Delta V_{x,y,z}$ outputs in the body frame and AAMX, Y, Z are 2^9X accelerometer A's misalignments in the negative X, Y, Z directions. See listing for coding.

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0001                                    REL
0002                                    SUBR    ACOM
0003 00000    0 000000    ACOM DAC      **
0004 00001    0 02 00600       LDA      AAPC
0005 00002    0 16 00700       MPY      AASF
0006 00003    000007           DBL
0007 00004    0401 72          LRS      6
0008 00005    0 06 00706       DAD      AABD
0009 00006    0 06 00600       DAD      AAPC
0010 00007    0 04 00600       DST      AAPC
0011 00010    0 02 00602       DLD      ABPC
0012 00011    0 16 00701       MPY      ABSF
0013 00012    0401 72          LRS      6
0014 00013    0 06 00710       DAD      ABBD
0015 00014    0 06 00602       DAD      ABPC
0016 00015    0 04 00602       DST      ABPC
0017 00016    0 02 00604       DLD      ACPC
0018 00017    0 16 00702       MPY      ACSF
0019 00020    0401 72          LRS      6
0020 00021    0 06 00712       DAD      ACBD
0021 00022    0 06 00604       DAD      ACPC
0022 00023    0 04 00604       DST      ACPC
0023 00024    0 02 00606       DLD      ADPC
0024 00025    0 16 00703       MPY      ADSF
0025 00026    0401 72          LRS      6
0026 00027    0 06 00714       DAD      ADBD
0027 00030    0 06 00606       DAD      ADPC
0028 00031    0 04 00606       DST      ADPC
0029 00032    0 02 00610       DLD      AEPC
0030 00033    0 16 00704       MPY      AESF
0031 00034    0401 72          LRS      6
0032 00035    0 06 00716       DAD      AEBD
0033 00036    0 06 00610       DAD      AEPC
0034 00037    0 04 00610       DST      AEPC
0035 00040    0 02 00612       DLD      AFPC
0036 00041    0 16 00705       MPY      AFSF
0037 00042    0401 72          LRS      6
0038 00043    0 06 00720       DAD      AFBD
0039 00044    0 06 00612       DAD      AFPC
0040 00045    0 04 00612       DST      AFPC
0041 00046    0 02 00614       DLD      DVXB
0042 00047    0 16 00722       MPY      AAMX
0043 00050    0 04 00166       DST      TACM
0044 00051    0 02 00614       DLD      DVXB
0045 00052    0 16 00723       MPY      ABMX
0046 00053    0 04 00170       DST      TBCM
0047 00054    0 02 00614       DLD      DVXB
0048 00055    0 16 00724       MPY      ACMX
0049 00056    0 04 00172       DST      TCCM
0050 00057    0 02 00614       DLD      DVXB
0051 00060    0 16 00725       MPY      ADMX
0052 00061    0 04 00174       DST      TDCM
0053 00062    0 02 00614       DLD      DVXB
0054 00063    0 16 00726       MPY      AEMX
0055 00064    0 04 00176       DST      TECM
0056 00065    0 02 00614       DLD      DVXB
0057 00066    0 16 00727       MPY      AFMX
```

```
0058 00067    0 04 00200       DST   TPCM
0059 00070    0 02 00616       DLD   DVYB
0060 00071    0 16 00730       MPY   AAMY
0061 00072    0 06 00166       DAD   TACM
0062 00073    0 04 00166       DST   TACM
0063 00074    0 02 00616       DLD   DVYB
0064 00075    0 16 00731       MPY   ABMY
0065 00076    0 06 00170       DAD   TBCM
0066 00077    0 04 00170       DST   TBCM
0067 00100    0 02 00616       DLD   DVYB
0068 00101    0 16 00732       MPY   ACMY
0069 00102    0 06 00172       DAD   TCCM
0070 00103    0 04 00172       DST   TCCM
0071 00104    0 02 00616       DLD   DVYB
0072 00105    0 16 00733       MPY   ADMY
0073 00106    0 06 00174       DAD   TDCM
0074 00107    0 04 00174       DST   TDCM
0075 00110    0 02 00616       DLD   DVYB
0076 00111    0 16 00734       MPY   AEMY
0077 00112    0 06 00176       DAD   TECM
0078 00113    0 04 00176       DST   TECM
0079 00114    0 02 00616       DLD   DVYB
0080 00115    0 16 00735       MPY   AFMY
0081 00116    0 06 00200       DAD   TPCM
0082 00117    0 04 00200       DST   TPCM
0083 00120    0 02 00620       DLD   DVZB
0084 00121    0 16 00736       MPY   AAMZ
0085 00122    0 06 00166       DAD   TACM
0086 00123    0401 67          LRS   9
0087 00124    0 06 00600       DAD   AAPC
0088 00125    0 04 00600       DST   AAPC
0089 00126    0 02 00620       DLD   DVZB
0090 00127    0 16 00737       MPY   ABMZ
0091 00130    0 06 00170       DAD   TBCM
0092 00131    0401 67          LRS   9
0093 00132    0 06 00602       DAD   ABPC
0094 00133    0 04 00602       DST   ABPC
0095 00134    0 02 00620       DLD   DVZB
0096 00135    0 16 00740       MPY   ACMZ
0097 00136    0 06 00172       DAD   TCCM
0098 00137    0401 67          LRS   9
0099 00140    0 06 00604       DAD   ACPC
0100 00141    0 04 00604       DST   ACPC
0101 00142    0 02 00620       DLD   DVZB
0102 00143    0 16 00741       MPY   ADMZ
0103 00144    0 06 00174       DAD   TDCM
0104 00145    0401 67          LRS   9
0105 00146    0 06 00606       DAD   ADPC
0106 00147    0 04 00606       DST   ADPC
0107 00150    0 02 00620       DLD   DVZB
0108 00151    0 16 00742       MPY   AEMZ
0109 00152    0 06 00176       DAD   TECM
0110 00153    0401 67          LRS   9
0111 00154    0 06 00610       DAD   AEPC
0112 00155    0 04 00610       DST   AEPC
0113 00156    0 02 00620       DLD   DVZB
0114 00157    0 16 00743       MPY   AFMZ
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0115 00160    0 06 00200        DAD    TFCM
0116 00161    0401 67           LRS    9
0117 00162    0 06 00612        DAD    AFPC
0118 00163    0 04 00612        DST    AFPC
0119 00164    000005            SGL
0120 00165   -0 01 00000        JMP*   ACOM
0121          000600      AAPC  EQU    '600
0122          000602      ABPC  EQU    AAPC+2
0123          000604      ACPC  EQU    AAPC+4
0124          000606      ADPC  EQU    AAPC+6
0125          000610      AEPC  EQU    AAPC+8
0126          000612      AFPC  EQU    AAPC+10
0127          000700      AASP  EQU    '700
0128          000701      ABSP  EQU    AASP+1
0129          000702      ACSP  EQU    AASP+2
0130          000703      ADSP  EQU    AASP+3
0131          000704      AESP  EQU    AASP+4
0132          000705      AFSP  EQU    AASP+5
0133          000706      AABD  EQU    '706
0134          000710      ABBD  EQU    AABD+2
0135          000712      ACBD  EQU    AABD+4
0136          000714      ADBD  EQU    AABD+6
0137          000716      AEBD  EQU    AABD+8
0138          000720      AFBD  EQU    AABD+10
0139          000722      AAMX  EQU    '722
0140          000723      ABMX  EQU    AAMX+1
0141          000724      ACMX  EQU    AAMX+2
0142          000725      ADMX  EQU    AAMX+3
0143          000726      AEMX  EQU    AAMX+4
0144          000727      AFMX  EQU    AAMX+5
0145          000730      AAMY  EQU    AAMX+6
0146          000731      ABMY  EQU    AAMX+7
0147          000732      ACMY  EQU    AAMX+8
0148          000733      ADMY  EQU    AAMX+9
0149          000734      AEMY  EQU    AAMX+10
0150          000735      AFMY  EQU    AAMX+11
0151          000736      AAMZ  EQU    AAMX+12
0152          000737      ABMZ  EQU    AAMX+13
0153          000740      ACMZ  EQU    AAMX+14
0154          000741      ADMZ  EQU    AAMX+15
0155          000742      AEMZ  EQU    AAMX+16
0156          000743      AFMZ  EQU    AAMX+17
0157          000614      DVXB  EQU    '614
0158          000616      DVYB  EQU    DVXB+2
0159          000620      DVZB  EQU    DVXB+4
0160 00166    000000      TACM  DBP    0
     00167    000000
0161 00170    000000      TBCM  DBP    0
     00171    000000
0162 00172    000000      TCCM  DBP    0
     00173    000000
0163 00174    000000      TDCM  DBP    0
     00175    000000
0164 00176    000000      TECM  DBP    0
     00177    000000
0165 00200    000000      TFCM  DBP    0
     00201    000000
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0166                          END
```

PROGRAM NAME
SOURCE: GCOM
BINARY: BGCOM
ENTRY POINT (location): GCOM ('02242)
GENERAL DESCRIPTION:

This subroutine compensates the gyros for ±ΔSF, NBD, ADIA, ADOA, ADSRA, major compliance, GO, GS and OA coupling (by calling the OA coupling compensation subroutine, DCOA). Considering just the A gyro its compensation parameters are:

GANS = 2^6 X gyro A negative ΔSF
GAPS = 2^6 X gyro A positive ΔSF
GABD = gyro A's NBD
ADAX, Y, Z = 2^{12} x Acceleration dependent drifts of gyro A for accelerations on the X, Y and Z axes (a function of ADIA, OA, SRA)
AASD = 2^6 x A gyro acceleration squared drift or major compliance
GAMX, Y, Z = 2^{10} x gyro A's misalignment along the negative X, Y and Z axes (functions of GO and GS).

For the A gyro the following equations are implemented.

$$GAPC = GAPC + GABD + \frac{1}{2^6} \begin{matrix} GAPS \\ or \\ GANS \end{matrix}$$

where GAPC is Gyro A's pulse count

$$GAPC = \frac{1}{2^{12}}(ADAX\ DVXB + ADAY\ DVYB + ADAZ\ DVZB)$$

where DVXB, DVYB and DVZB are the accelerations (in units of $\Delta V_{x,y,z}$ per update).

$$GAPC = GAPC + \frac{1}{2^6}(DVZB\ DVZB - DVXB\ DVXB - DVXB\ DVZB)\ AASD$$

where the parenthesized expression is proportional to DVAIA DVASRA, the product of the accelerations on A gyros IA and SRA.

CALL DCOA (see documentation for subroutine DCOA)

$$GAPC = GAPC + \frac{1}{2^{10}}(GAMX\ DTXB + GAMY\ DTYB + GAMZ\ DTZB)$$

where DTXB, DTYB and DTZB are $\Delta\theta_x$, $\Delta\theta_y$ and $\Delta\theta_z$ during the last update. (Note, since ACOM is the subroutine which compensates the accelerometers and is a little simpler, it might be better to read its documentation first).

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                REL
0002                                SUBR   GCOM
0003 00000   0 000000    GCOM      DAC    **
0004 00001   0 02 00400            LDA    GAPC
0005 00002   000007                DBL
0006 00003   101400                SMI
0007 00004   0 01 00007            JMP    *+3
0008 00005   0 16 00506            MPY    GANS
0009 00006   100000                SKP
0010 00007   0 16 00500            MPY    GAPS
0011 00010   0401 72                LRS    6
0012 00011   0 06 00514            DAD    GABD
0013 00012   0 06 00400            DAD    GAPC
0014 00013   0 04 00400            DST    GAPC
0015 00014   0 02 00402            DLD    GBPC
0016 00015   101400                SMI
0017 00016   0 01 00021            JMP    *+3
0018 00017   0 16 00507            MPY    GBNS
0019 00020   100000                SKP
0020 00021   0 16 00501            MPY    GBPS
0021 00022   0401 72                LRS    6
0022 00023   0 06 00516            DAD    GBBD
0023 00024   0 06 00402            DAD    GBPC
0024 00025   0 04 00402            DST    GBPC
0025 00026   0 02 00404            DLD    GCPC
0026 00027   101400                SMI
0027 00030   0 01 00033            JMP    *+3
0028 00031   0 16 00510            MPY    GCNS
0029 00032   100000                SKP
0030 00033   0 16 00502            MPY    GCPS
0031 00034   0401 72                LRS    6
0032 00035   0 06 00520            DAD    GCBD
0033 00036   0 06 00404            DAD    GCPC
0034 00037   0 04 00404            DST    GCPC
0035 00040   0 02 00406            DLD    GDPC
0036 00041   101400                SMI
0037 00042   0 01 00045            JMP    *+3
0038 00043   0 16 00511            MPY    GDNS
0039 00044   100000                SKP
0040 00045   0 16 00503            MPY    GDPS
0041 00046   0401 72                LRS    6
0042 00047   0 06 00522            DAD    GDBD
0043 00050   0 06 00406            DAD    GDPC
0044 00051   0 04 00406            DST    GDPC
0045 00052   0 02 00410            DLD    GEPC
0046 00053   101400                SMI
0047 00054   0 01 00057            JMP    *+3
0048 00055   0 16 00512            MPY    GENS
0049 00056   100000                SKP
0050 00057   0 16 00504            MPY    GEPS
0051 00060   0401 72                LRS    6
0052 00061   0 06 00524            DAD    GEBD
0053 00062   0 06 00410            DAD    GEPC
0054 00063   0 04 00410            DST    GEPC
0055 00064   0 02 00412            DLD    GFPC
0056 00065   101400                SMI
0057 00066   0 01 00071            JMP    *+3
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0058 00067    0 16 00513       MPY    GFNS
0059 00070    100000           SKP
0060 00071    0 16 00505       MPY    GFPS
0061 00072    0401 72          LRS    6
0062 00073    0 06 00526       DAD    GFBD
0063 00074    0 06 00412       DAD    GFPC
0064 00075    0 04 00412       DST    GFPC
0065 00076    0 02 00614       DLD    DVXB
0066 00077    0 16 00530       MPY    ADAX
0067 00100    0 04 00450       DST    TACM
0068 00101    0 02 00614       DLD    DVXB
0069 00102    0 16 00531       MPY    ADBX
0070 00103    0 04 00452       DST    TBCM
0071 00104    0 02 00614       DLD    DVXB
0072 00105    0 16 00532       MPY    ADCX
0073 00106    0 04 00454       DST    TCCM
0074 00107    0 02 00614       DLD    DVXB
0075 00110    0 16 00533       MPY    ADDX
0076 00111    0 04 00456       DST    TDCM
0077 00112    0 02 00614       DLD    DVXB
0078 00113    0 16 00534       MPY    ADEX
0079 00114    0 04 00460       DST    TECM
0080 00115    0 02 00614       DLD    DVXB
0081 00116    0 16 00535       MPY    ADFX
0082 00117    0 04 00462       DST    TFCM
0083 00120    0 02 00616       DLD    DVYB
0084 00121    0 16 00536       MPY    ADAY
0085 00122    0 06 00450       DAD    TACM
0086 00123    0 04 00450       DST    TACM
0087 00124    0 02 00616       DLD    DVYB
0088 00125    0 16 00537       MPY    ADBY
0089 00126    0 06 00452       DAD    TBCM
0090 00127    0 04 00452       DST    TBCM
0091 00130    0 02 00616       DLD    DVYB
0092 00131    0 16 00540       MPY    ADCY
0093 00132    0 06 00454       DAD    TCCM
0094 00133    0 04 00454       DST    TCCM
0095 00134    0 02 00616       DLD    DVYB
0096 00135    0 16 00541       MPY    ADDY
0097 00136    0 06 00456       DAD    TDCM
0098 00137    0 04 00456       DST    TDCM
0099 00140    0 02 00616       DLD    DVYB
0100 00141    0 16 00542       MPY    ADEY
0101 00142    0 06 00460       DAD    TECM
0102 00143    0 04 00460       DST    TECM
0103 00144    0 02 00616       DLD    DVYB
0104 00145    0 16 00543       MPY    ADFY
0105 00146    0 06 00462       DAD    TFCM
0106 00147    0 04 00462       DST    TFCM
0107 00150    0 02 00620       DLD    DVZB
0108 00151    0 16 00544       MPY    ADAZ
0109 00152    0 06 00450       DAD    TACM
0110 00153    0401 64          LRS    12
0111 00154    0 06 00400       DAD    GAPC
0112 00155    0 04 00400       DST    GAPC
0113 00156    0 02 00620       DLD    DVZB
0114 00157    0 16 00545       MPY    ADBZ
```

```
0115 00160    0 06 00452      DAD   TBCM
0116 00161    0401 64         LRS   12
0117 00162    0 06 00402      DAD   GBPC
0118 00163    0 04 00402      DST   GBPC
0119 00164    0 02 00620      DLD   DVZB
0120 00165    0 16 00546      MPY   ADCZ
0121 00166    0 06 00454      DAD   TCCM
0122 00167    0401 64         LRS   12
0123 00170    0 06 00404      DAD   GCPC
0124 00171    0 04 00404      DST   GCPC
0125 00172    0 02 00620      DLD   DVZB
0126 00173    0 16 00547      MPY   ADDZ
0127 00174    0 06 00456      DAD   TDCM
0128 00175    0401 64         LRS   12
0129 00176    0 06 00406      DAD   GDPC
0130 00177    0 04 00406      DST   GDPC
0131 00200    0 02 00620      DLD   DVZB
0132 00201    0 16 00550      MPY   ADEZ
0133 00202    0 06 00460      DAD   TECM
0134 00203    0401 64         LRS   12
0135 00204    0 06 00410      DAD   GEPC
0136 00205    0 04 00410      DST   GEPC
0137 00206    0 02 00620      DLD   DVZB
0138 00207    0 16 00551      MPY   ADFZ
0139 00210    0 06 00462      DAD   TFCM
0140 00211    0401 64         LRS   12
0141 00212    0 06 00412      DAD   GFPC
0142 00213    0 04 00412      DST   GFPC
0143 00214    0 02 00614      DLD   DVXB
0144 00215    0 16 00614      MPY   DVXB
0145 00216    0 04 00434      DST   XSQU
0146 00217    0 02 00616      DLD   DVYB
0147 00220    0 16 00616      MPY   DVYB
0148 00221    0 04 00436      DST   YSQU
0149 00222    0 02 00620      DLD   DVZB
0150 00223    0 16 00620      MPY   DVZB
0151 00224    0 04 00440      DST   ZSQU
0152 00225    0 02 00614      DLD   DVXB
0153 00226    0 16 00616      MPY   DVYB
0154 00227    0 04 00442      DST   XWHY
0155 00230    0 02 00614      DLD   DVXB
0156 00231    0 16 00620      MPY   DVZB
0157 00232    0 04 00444      DST   XZEE
0158 00233    0 02 00616      DLD   DVYB
0159 00234    0 16 00620      MPY   DVZB
0160 00235    0 04 00446      DST   YZEE
0161 00236    0 02 00440      DLD   ZSQU
0162 00237    0 07 00434      DSB   XSQU
0163 00240    0 07 00444      DSB   XZEE
0164 00241    0 16 00422      MPY   AASD
0165 00242    0401 72         LRS   6
0166 00243    0 06 00400      DAD   GAPC
0167 00244    0 04 00400      DST   GAPC
0168 00245    0 02 00440      DLD   ZSQU
0169 00246    0 07 00434      DSB   XSQU
0170 00247    0 06 00444      DAD   XZEE
0171 00250    0 16 00423      MPY   BASD
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0172 00251    0401 72          LRS   6
0173 00252    0 06 00402       DAD   GBPC
0174 00253    0 04 00402       DST   GBPC
0175 00254    0 02 00434       DLD   XSQU
0176 00255    0 07 00436       DSB   YSQU
0177 00256    0 07 00442       DSB   XWHY
0178 00257    0 16 00424       MPY   CASD
0179 00260    0401 72          LRS   6
0180 00261    0 06 00404       DAD   GCPC
0181 00262    0 04 00404       DST   GCPC
0182 00263    0 02 00434       DLD   XSQU
0183 00264    0 07 00436       DSB   YSQU
0184 00265    0 06 00442       ADD   XWHY
0185 00266    0 16 00425       MPY   DASD
0186 00267    0401 72          LRS   6
0187 00270    0 06 00406       DAD   GDPC
0188 00271    0 04 00406       DST   GDPC
0189 00272    0 02 00436       DLD   YSQU
0190 00273    0 07 00440       DSB   ZSQU
0191 00274    0 07 00446       DSB   YZEE
0192 00275    0 16 00426       MPY   EASD
0193 00276    0401 72          LRS   6
0194 00277    0 06 00410       DAD   GEPC
0195 00300    0 04 00410       DST   GEPC
0196 00301    0 02 00436       DLD   YSQU
0197 00302    0 07 00440       DSB   ZSQU
0198 00303    0 06 00446       ADD   YZEE
0199 00304    0 16 00427       MPY   FASD
0200 00305    0401 72          LRS   6
0201 00306    0 06 00412       DAD   GFPC
0202 00307    0 04 00412       DST   GFPC
0203 00310    000005           SGL
0204 00311    0 10 00000       CALL  DCOA
0205 00312    000007           DBL
0206 00313    0 02 00414       DLD   DTXB
0207 00314    0 16 00552       MPY   GAMX
0208 00315    0 04 00450       DST   TACM
0209 00316    0 02 00414       DLD   DTXB
0210 00317    0 16 00553       MPY   GBMX
0211 00320    0 04 00452       DST   TBCM
0212 00321    0 02 00414       DLD   DTXB
0213 00322    0 16 00554       MPY   GCMX
0214 00323    0 04 00454       DST   TCCM
0215 00324    0 02 00414       DLD   DTXB
0216 00325    0 16 00555       MPY   GDMX
0217 00326    0 04 00456       DST   TDCM
0218 00327    0 02 00414       DLD   DTXB
0219 00330    0 16 00556       MPY   GEMX
0220 00331    0 04 00460       DST   TECM
0221 00332    0 02 00414       DLD   DTXB
0222 00333    0 16 00557       MPY   GFMX
0223 00334    0 04 00462       DST   TFCM
0224 00335    0 02 00416       DLD   DTYB
0225 00336    0 16 00560       MPY   GAMY
0226 00337    0 06 00450       DAD   TACM
0227 00340    0 04 00450       DST   TACM
0228 00341    0 02 00416       DLD   DTYB
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0229 00342    0 16 00561       MPY    GBMY
0230 00343    0 06 00452       DAD    TBCM
0231 00344    0 04 00452       DST    TBCM
0232 00345    0 02 00416       DLD    DTYB
0233 00346    0 16 00562       MPY    GCMY
0234 00347    0 06 00454       DAD    TCCM
0235 00350    0 04 00454       DST    TCCM
0236 00351    0 02 00416       DLD    DTYB
0237 00352    0 16 00563       MPY    GDMY
0238 00353    0 06 00456       DAD    TDCM
0239 00354    0 04 00456       DST    TDCM
0240 00355    0 02 00416       DLD    DTYB
0241 00356    0 16 00564       MPY    GEMY
0242 00357    0 06 00460       DAD    TECM
0243 00360    0 04 00460       DST    TECM
0244 00361    0 02 00416       DLD    DTYB
0245 00362    0 16 00565       MPY    GFMY
0246 00363    0 06 00462       DAD    TFCM
0247 00364    0 04 00462       DST    TFCM
0248 00365    0 02 00420       DLD    DTZB
0249 00366    0 16 00566       MPY    GAMZ
0250 00367    0 06 00450       DAD    TACM
0251 00370    0401 66          LRS    10
0252 00371    0 06 00400       DAD    GAPC
0253 00372    0 04 00400       DST    GAPC
0254 00373    0 02 00420       DLD    DTZB
0255 00374    0 16 00567       MPY    GBMZ
0256 00375    0 06 00452       DAD    TBCM
0257 00376    0401 66          LRS    10
0258 00377    0 06 00402       DAD    GBPC
0259 00400    0 04 00402       DST    GBPC
0260 00401    0 02 00420       DLD    DTZB
0261 00402    0 16 00570       MPY    GCMZ
0262 00403    0 06 00454       DAD    TCCM
0263 00404    0401 66          LRS    10
0264 00405    0 06 00404       DAD    GCPC
0265 00406    0 04 00404       DST    GCPC
0266 00407    0 02 00420       DLD    DTZB
0267 00410    0 16 00571       MPY    GDMZ
0268 00411    0 06 00456       DAD    TDCM
0269 00412    0401 66          LRS    10
0270 00413    0 06 00406       DAD    GDPC
0271 00414    0 04 00406       DST    GDPC
0272 00415    0 02 00420       DLD    DTZB
0273 00416    0 16 00572       MPY    GEMZ
0274 00417    0 06 00460       DAD    TECM
0275 00420    0401 66          LRS    10
0276 00421    0 06 00410       DAD    GEPC
0277 00422    0 04 00410       DST    GEPC
0278 00423    0 02 00420       DLD    DTZB
0279 00424    0 16 00573       MPY    GFMZ
0280 00425    0 06 00462       DAD    TFCM
0281 00426    0401 66          LRS    10
0282 00427    0 06 00412       DAD    GFPC
0283 00430    0 04 00412       DST    GFPC
0284 00431    000005           SGL
0285 00432   -0 01 00000       JMP*   GCOM
```

```
0286          000400      GAPC  EQU   '400
0287          000402      GBPC  EQU   GAPC+2
0288          000404      GCPC  EQU   GAPC+4
0289          000406      GDPC  EQU   GAPC+6
0290          000410      GEPC  EQU   GAPC+8
0291          000412      GFPC  EQU   GAPC+10
0292          000500      GAPS  EQU   '500
0293          000501      GBPS  EQU   GAPS+1
0294          000502      GCPS  EQU   GAPS+2
0295          000503      GDPS  EQU   GAPS+3
0296          000504      GEPS  EQU   GAPS+4
0297          000505      GFPS  EQU   GAPS+5
0298          000506      GANS  EQU   GAPS+6
0299          000507      GBNS  EQU   GAPS+7
0300          000510      GCNS  EQU   GAPS+8
0301          000511      GDNS  EQU   GAPS+9
0302          000512      GENS  EQU   GAPS+10
0303          000513      GFNS  EQU   GAPS+11
0304          000514      GABD  EQU   '514
0305          000516      GBBD  EQU   GABD+2
0306          000520      GCBD  EQU   GABD+4
0307          000522      GDBD  EQU   GABD+6
0308          000524      GEBD  EQU   GABD+8
0309          000526      GFBD  EQU   GABD+10
0310          000530      ADAX  EQU   '530
0311          000531      ADBX  EQU   ADAX+1
0312          000532      ADCX  EQU   ADAX+2
0313          000533      ADDX  EQU   ADAX+3
0314          000534      ADEX  EQU   ADAX+4
0315          000535      ADFX  EQU   ADAX+5
0316          000536      ADAY  EQU   ADAX+6
0317          000537      ADBY  EQU   ADAX+7
0318          000540      ADCY  EQU   ADAX+8
0319          000541      ADDY  EQU   ADAX+9
0320          000542      ADEY  EQU   ADAX+10
0321          000543      ADFY  EQU   ADAX+11
0322          000544      ADAZ  EQU   ADAX+12
0323          000545      ADBZ  EQU   ADAX+13
0324          000546      ADCZ  EQU   ADAX+14
0325          000547      ADDZ  EQU   ADAX+15
0326          000550      ADEZ  EQU   ADAX+16
0327          000551      ADFZ  EQU   ADAX+17
0328          000552      GAMX  EQU   '552
0329          000553      GBMX  EQU   GAMX+1
0330          000554      GCMX  EQU   GAMX+2
0331          000555      GDMX  EQU   GAMX+3
0332          000556      GEMX  EQU   GAMX+4
0333          000557      GFMX  EQU   GAMX+5
0334          000560      GAMY  EQU   GAMX+6
0335          000561      GBMY  EQU   GAMX+7
0336          000562      GCMY  EQU   GAMX+8
0337          000563      GDMY  EQU   GAMX+9
0338          000564      GEMY  EQU   GAMX+10
0339          000565      GFMY  EQU   GAMX+11
0340          000566      GAMZ  EQU   GAMX+12
0341          000567      GBMZ  EQU   GAMX+13
0342          000570      GCMZ  EQU   GAMX+14
```

```
0343           000571     GDMZ EQU   GAMX+15
0344           000572     GEMZ EQU   GAMX+16
0345           000573     GFMZ EQU   GAMX+17
0346           000422     AASD EQU   '422
0347           000423     BASD EQU   AASD+1
0348           000424     CASD EQU   AASD+2
0349           000425     DASD EQU   AASD+3
0350           000426     EASD EQU   AASD+4
0351           000427     FASD EQU   AASD+5
0352           000614     DVXB EQU   '614
0353           000616     DVYB EQU   DVXB+2
0354           000620     DVZB EQU   DVXB+4
0355           000414     DTXB EQU   '414
0356           000416     DTYB EQU   DTXB+2
0357           000420     DTZB EQU   DTXB+4
0358 00434     000000     XSQU DBP   0
     00435     000000
0359 00436     000000     YSQU DBP   0
     00437     000000
0360 00440     000000     ZSQU DBP   0
     00441     000000
0361 00442     000000     XWHY DBP   0
     00443     000000
0362 00444     000000     XZEE DBP   0
     00445     000000
0363 00446     000000     YZEE DBP   0
     00447     000000
0364 00450     000000     TACM DBP   0
     00451     000000
0365 00452     000000     TBCM DBP   0
     00453     000000
0366 00454     000000     TCCM DBP   0
     00455     000000
0367 00456     000000     TDCM DBP   0
     00457     000000
0368 00460     000000     TECM DBP   0
     00461     000000
0369 00462     000000     TFCM DBP   0
     00463     000000
0370                            END
```

PROGRAM NAME
SOURCE: DCMT
BINARY: BDCMT
ENTRY POINTS (location): DCMI ('03476), DCMT ('03551)
GENERAL DESCRIPTION:

The subroutine DCMT modifies the misalignments of the SIRU gyros about their output axes as a function of W_{IA}, their input axis rate which is poportional to the number of pulses each gyro got in one update (Δt = .01 sec.). The subroutine DCMI is called by the initialization section of the main program and gets these misalignments from the base sector and stores them in the buffer section between the subroutines DCMI and DCMT. It does this only once and sets the word ONLO to 1 so that if the main program is restarted, it won't get misalignments from the base sector that are already modified.

Subroutine DCMT, which is called every update, takes these OA misalignments stored in the buffer, modifies them according to the gyro's IA rate and stores them back in the base sector to be used by the gyro compensation program GCOM.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   DCMI
0003                                  SUBR   DCMT
0004 00000    0 000000    DCMI        DAC    **
0005 00001    0 02 00036              LDA    ONLO
0006 00002    100040                  SZE
0007 00003   -0 01 00000              JMP*   DCMI
0008 00004    0 02 00552              LDA    GAMX
0009 00005    0 04 00037              STA    AMXB
0010 00006    0 02 00566              LDA    GAMZ
0011 00007    0 04 00040              STA    AMZB
0012 00010    0 02 00553              LDA    GBMX
0013 00011    0 04 00041              STA    BMXB
0014 00012    0 02 00567              LDA    GBMZ
0015 00013    0 04 00042              STA    BMZB
0016 00014    0 02 00554              LDA    GCMX
0017 00015    0 04 00043              STA    CMXB
0018 00016    0 02 00562              LDA    GCMY
0019 00017    0 04 00044              STA    CMYB
0020 00020    0 02 00555              LDA    GDMX
0021 00021    0 04 00045              STA    DMXB
0022 00022    0 02 00563              LDA    GDMY
0023 00023    0 04 00046              STA    DMYB
0024 00024    0 02 00564              LDA    GEMY
0025 00025    0 04 00047              STA    EMYB
0026 00026    0 02 00572              LDA    GEMZ
0027 00027    0 04 00050              STA    EMZB
0028 00030    0 02 00565              LDA    GFMY
0029 00031    0 04 00051              STA    FMYB
0030 00032    0 02 00573              LDA    GFMZ
0031 00033    0 04 00052              STA    FMZB
0032 00034    0 12 00036              IRS    ONLO
0033 00035   -0 01 00000              JMP*   DCMI
0034 00036    000000      ONLO      OCT    0
0035          000552      GAMX      EQU    '552
0036          000566      GAMZ      EQU    GAMX+12
0037          000553      GBMX      EQU    GAMX+1
0038          000567      GBMZ      EQU    GAMX+13
0039          000554      GCMX      EQU    GAMX+2
0040          000562      GCMY      EQU    GAMX+8
0041          000555      GDMX      EQU    GAMX+3
0042          000563      GDMY      EQU    GAMX+9
0043          000564      GEMY      EQU    GAMX+10
0044          000572      GEMZ      EQU    GAMX+16
0045          000565      GFMY      EQU    GAMX+11
0046          000573      GFMZ      EQU    GAMX+17
0047 00037    000000      AMXB      OCT    0
0048 00040    000000      AMZB      OCT    0
0049 00041    000000      BMXB      OCT    0
0050 00042    000000      BMZB      OCT    0
0051 00043    000000      CMXB      OCT    0
0052 00044    000000      CMYB      OCT    0
0053 00045    000000      DMXB      OCT    0
0054 00046    000000      DMYB      OCT    0
0055 00047    000000      EMYB      OCT    0
0056 00050    000000      EMZB      OCT    0
0057 00051    000000      FMYB      OCT    0
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0058 00052    000000        FMZB OCT    0
0059 00053    0 000000      DCMT DAC    **
0060 00054    0 02 00400          LDA   GAPC
0061 00055    0 16 00151          MPY   APRX
0062 00056    0401 00             LRS   0
0063 00057    0 06 00037          ADD   AMXB
0064 00060    0 04 00552          STA   GAMX
0065 00061    0 02 00400          LDA   GAPC
0066 00062    0 16 00152          MPY   APRZ
0067 00063    0401 00             LRS   0
0068 00064    0 06 00040          ADD   AMZB
0069 00065    0 04 00566          STA   GAMZ
0070 00066    0 02 00402          LDA   GBPC
0071 00067    0 16 00153          MPY   BPRX
0072 00070    0401 00             LRS   0
0073 00071    0 06 00041          ADD   BMXB
0074 00072    0 04 00553          STA   GBMX
0075 00073    0 02 00402          LDA   GBPC
0076 00074    0 16 00154          MPY   BPRZ
0077 00075    0401 00             LRS   0
0078 00076    0 06 00042          ADD   BMZB
0079 00077    0 04 00567          STA   GBMZ
0080 00100    0 02 00404          LDA   GCPC
0081 00101    0 16 00155          MPY   CPRX
0082 00102    0401 00             LRS   0
0083 00103    0 06 00043          ADD   CMXB
0084 00104    0 04 00554          STA   GCMX
0085 00105    0 02 00404          LDA   GCPC
0086 00106    0 16 00156          MPY   CPRY
0087 00107    0401 00             LRS   0
0088 00110    0 06 00044          ADD   CMYB
0089 00111    0 04 00562          STA   GCMY
0090 00112    0 02 00406          LDA   GDPC
0091 00113    0 16 00157          MPY   DPRX
0092 00114    0401 00             LRS   0
0093 00115    0 06 00045          ADD   DMXB
0094 00116    0 04 00555          STA   GDMX
0095 00117    0 02 00406          LDA   GDPC
0096 00120    0 16 00160          MPY   DPRY
0097 00121    0401 00             LRS   0
0098 00122    0 06 00046          ADD   DMYB
0099 00123    0 04 00563          STA   GDMY
0100 00124    0 02 00410          LDA   GEPC
0101 00125    0 16 00161          MPY   EPRY
0102 00126    0401 00             LRS   0
0103 00127    0 06 00047          ADD   EMYB
0104 00130    0 04 00564          STA   GEMY
0105 00131    0 02 00410          LDA   GEPC
0106 00132    0 16 00162          MPY   EPRZ
0107 00133    0401 00             LRS   0
0108 00134    0 06 00050          ADD   EMZB
0109 00135    0 04 00572          STA   GEMZ
0110 00136    0 02 00412          LDA   GFPC
0111 00137    0 16 00163          MPY   FPRY
0112 00140    0401 00             LRS   0
0113 00141    0 06 00051          ADD   FMYB
0114 00142    0 04 00565          STA   GFMY
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0115 00143    0 02 00412        LDA    GFPC
0116 00144    0 16 00164        MPY    FPRZ
0117 00145    0401 00           LRS    0
0118 00146    0 06 00052        ADD    FMZB
0119 00147    0 04 00573        STA    GFMZ
0120 00150   -0 01 00053        JMP*   DCMT
0121          000400      GAPC  EQU    '400
0122          000402      GBPC  EQU    GAPC+2
0123          000404      GCPC  EQU    GAPC+4
0124          000406      GDPC  EQU    GAPC+6
0125          000410      GEPC  EQU    GAPC+8
0126          000412      GFPC  EQU    GAPC+10
0127 00151    000000      APRX  OCT    0
0128 00152    000000      APRZ  OCT    0
0129 00153    000000      BPRX  OCT    0
0130 00154    000000      BPRZ  OCT    0
0131 00155    000000      CPRX  OCT    0
0132 00156    000000      CPRY  OCT    0
0133 00157    000000      DPRX  OCT    0
0134 00160    000000      DPRY  OCT    0
0135 00161    000000      EPRY  OCT    0
0136 00162    000000      EPRZ  OCT    0
0137 00163    000000      FPRY  OCT    0
0138 00164    000000      FPRZ  OCT    0
0139                            END
```

PROGRAM NAME
SOURCE: DCOA
BINARY: BDCOA
ENTRY POINT (location): DCOA ('03144)
ACCESSIBLE VARIABLES (location): AOAP ('03252)
BOAP ('03254), COAP ('03256), DOAP ('03260), EOAP ('03262),
FOAP ('03264)
GENERAL DESCRIPTION:

The SIRU gyros sense not only a rotational input about their input axes, i.e., the $\Delta\theta$ pulses over some interval would equal the integral of W_{IRA} over that interval, but also they sense a change in the rotational input about their output axes, i.e., the $\Delta\theta$ pulses over some interval would equal (-I)/H times the integral of W_{ORA} over that interval. The latter can essentially be considered an error source since the gyro output is supposed to represent only the former input axis rotation.

The integral of W_{ORA} from t_1 to t_2 is simply $W_{ORA}(t_2) - W_{ORA}(t_1)$. The $\Delta\theta$ error during that interval is simply $(-I)/H\ W_{ORA}(t_2) - (-I)/H\ W_{ORA}(t_1)$. To compensate this error, one simply has to add $((I)/H)(W_{ORA}(t_2))$ and subtract $((I)/H)(W_{ORA}(t_1))$ at time t_2. Over one update interval the rate W_{ORA} (for say the E gyro) equals

$$\frac{\Delta\theta_x}{\Delta t}$$

Since Δt is constant, we can express W_{ORA} as $K\Delta\theta_X$ and rewrite the compensation quantity as

$$+(\tfrac{I}{H}K)\ \Delta\theta_x(t_2) - (\tfrac{I}{H}K)\ \Delta\theta_x(t_1)\ .$$

This subroutine is called once per update and calculates the first of the two compensation terms above. The second term is saved from the previous update. DTXB, DTYB and DTZB are $\Delta\theta_X$, $\Delta\theta_Y$ and $\Delta\theta_z$ respectively.
GAIH, GBIH . . . . . GFIH are the scaled constants equal to

$$(\tfrac{I}{H}K)$$

(Note that since the E gyro has its ORA along the plus x axis, GEIH will be positive whereas the F gyro, whose ORA is along the minus X axis will have a negative GFIH.) The method for compensating the E gyro is as follows: (the others are analogous)

$$\text{EOAO} = \text{DTXB GEIH} = \Delta\theta_x(t_2)\left(\frac{I}{H}K\right)$$

and

$$\text{GEPC} = \text{EOAO} + \text{GEPC} - \text{EOAP}$$

where $\text{EOAP} = \Delta\theta_x(t_1)\left(\frac{I}{H}K\right)$

(Note, EOAP (previous EOAO) must be set to zero at t = 0 and is therefore an accessible variable to the main program).

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   DCOA
0003                                  SUBR   AOAP
0004                                  SUBR   BOAP
0005                                  SUBR   COAP
0006                                  SUBR   DOAP
0007                                  SUBR   EOAP
0008                                  SUBR   FOAP
0009 00000    0 000000    DCOA        DAC    **
0010 00001    0 02 00414            LDA    DTXB
0011 00002    000007                DBI
0012 00003    0 16 00126            MPY    GEIH
0013 00004    0 04 00102            DST    EOAO
0014 00005    0 02 00414            DLD    DTXB
0015 00006    0 16 00127            MPY    GFIH
0016 00007    0 04 00104            DST    FOAO
0017 00010    0 02 00416            DLD    DTYB
0018 00011    0 16 00122            MPY    GAIH
0019 00012    0 04 00072            DST    AOAO
0020 00013    0 02 00416            DLD    DTYB
0021 00014    0 16 00123            MPY    GBIH
0022 00015    0 04 00074            DST    BOAO
0023 00016    0 02 00420            DLD    DTZB
0024 00017    0 16 00124            MPY    GCIH
0025 00020    0 04 00076            DST    COAO
0026 00021    0 02 00420            DLD    DTZB
0027 00022    0 16 00125            MPY    GDIH
0028 00023    0 04 00100            DST    DOAO
0029 00024    0 06 00406            DAD    GDPC
0030 00025    0 07 00114            DSB    DOAP
0031 00026    0 04 00406            DST    GDPC
0032 00027    0 02 00072            DLD    AOAO
0033 00030    0 06 00400            DAD    GAPC
0034 00031    0 07 00106            DSB    AOAP
0035 00032    0 04 00400            DST    GAPC
0036 00033    0 02 00074            DLD    BOAO
0037 00034    0 06 00402            DAD    GBPC
0038 00035    0 07 00110            DSB    BOAP
0039 00036    0 04 00402            DST    GBPC
0040 00037    0 02 00076            DLD    COAO
0041 00040    0 06 00404            DAD    GCPC
0042 00041    0 07 00112            DSB    COAP
0043 00042    0 04 00404            DST    GCPC
0044 00043    0 02 00102            DLD    EOAO
0045 00044    0 06 00410            DAD    GEPC
0046 00045    0 07 00116            DSB    EOAP
0047 00046    0 04 00410            DST    GEPC
0048 00047    0 02 00104            DLD    FOAO
0049 00050    0 06 00412            DAD    GFPC
0050 00051    0 07 00120            DSB    FOAP
0051 00052    0 04 00412            DST    GFPC
0052 00053    0 02 00072            DLD    AOAO
0053 00054    0 04 00106            DST    AOAP
0054 00055    0 02 00074            DLD    BOAO
0055 00056    0 04 00110            DST    BOAP
0056 00057    0 02 00076            DLD    COAO
0057 00060    0 04 00112            DST    COAP
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0058 00061    0 02 00100        DLD    DOAO
0059 00062    0 04 00114        DST    DOAP
0060 00063    0 02 00102        DLD    EOAO
0061 00064    0 04 00116        DST    EOAP
0062 00065    0 02 00104        DLD    FOAO
0063 00066    0 04 00120        DST    FOAP
0064 00067    000005            SGL
0065 00070   -0 01 00000        JMP*   DCOA
0066 00072    000000      AOAO  DBP    0
     00073    000000
0067 00074    000000      BOAO  DBP    0
     00075    000000
0068 00076    000000      COAO  DBP    0
     00077    000000
0069 00100    000000      DOAO  DBP    0
     00101    000000
0070 00102    000000      EOAO  DBP    0
     00103    000000
0071 00104    000000      FOAO  DBP    0
     00105    000000
0072 00106    000000      AOAP  DBP    0
     00107    000000
0073 00110    000000      BOAP  DBP    0
     00111    000000
0074 00112    000000      COAP  DBP    0
     00113    000000
0075 00114    000000      DOAP  DBP    0
     00115    000000
0076 00116    000000      EOAP  DBP    0
     00117    000000
0077 00120    000000      FOAP  DBP    0
     00121    000000
0078 00122    000000      GAIH  OCT    0
0079 00123    000000      GBIH  OCT    0
0080 00124    000000      GCIH  OCT    0
0081 00125    000000      GDIH  OCT    0
0082 00126    000000      GEIH  OCT    0
0083 00127    000000      GFIH  OCT    0
0084          000400      GAPC  EQU    '400
0085          000402      GBPC  EQU    GAPC+2
0086          000404      GCPC  EQU    GAPC+4
0087          000406      GDPC  EQU    GAPC+6
0088          000410      GEPC  EQU    GAPC+8
0089          000412      GFPC  EQU    GAPC+10
0090          000414      DTXB  EQU    '414
0091          000416      DTYB  EQU    DTXB+2
0092          000420      DTZB  EQU    DTXB+4
0093                            END
```

PROGRAM NAME
SOURCE: ROMS
BINARY: BROMS
ENTRY POINTS (location): ROMS ('14000)
ACCESSIBLE VARIABLES: WXPR ('14333),
WYPR ('14334), WZPR ('14335)
GENERAL DESCRIPTION:

When the SIRU strapdown system is subjected to a rotational environment its accelerometers will sense acceleration due to $\omega^2 R$ and $\dot{\omega} R$. Since the accelerometers do not all sense acceleration at the same point, these rotation-induced accelerations will make the accelerometers appear to be in disagreement. This subroutine compensates the accelerometers to make them look as if they are all sensing acceleration at the same point (since the location of this point is not critical we pick the center of the A accelerometer so that at least the A accelerometer need not be compensated).

Consider some point which has an R vector from the center of the A accelerometer of (RX, RY, RZ). The acceleration sensed at this point different from the acceleration sensed at the center of the A accelerometer is:

$$\bar{i}(\omega_x\omega_y RY + \omega_x\omega_z RZ - \omega_y{}^2 R_x - \omega_z{}^2 RX + \dot{\omega}_y RZ - \dot{\omega}_z RY)$$

$$+ \bar{j}(\omega_y\omega_z RZ + \omega_y\omega_x RX - \omega_x{}^2 RY - \omega_z{}^2 RY + \dot{\omega}_z RX - \dot{\omega}_x RZ)$$

$$+ \bar{k}(\omega_z\omega_x RX + \omega_z\omega_y RY - \omega_x{}^2 RZ - \omega_y{}^2 RZ + \dot{\omega}_x RY - \dot{\omega}_y RX)$$

B, C, D, E and F accelerometers can be corrected by adding the negative of the acceleration each one senses due to rotation. For the F accelerometer this would be

-S (Z axis acceleration) + C (Y axis acceleration)

where

C = cosine, S = sine

or

$$-S(\omega_z\omega_x RFX + \omega_z\omega_y RFY - \omega_x^2 RFZ - \omega_y^2 RFZ + \dot{\omega}_x RFY - \dot{\omega}_y RFX)$$

$$+C(\omega_y\omega_z RFZ + \omega_y\omega_x RFX - \omega_x^2 RFY - \omega_z^2 RFY + \dot{\omega}_z RFX - \dot{\omega}_x RFZ)$$

these terms can be combined to give:

$$C\ RFX(\omega_y\omega_x + \dot{\omega}_z)$$

$$+ C\ RFY(-\omega_x^2 - \omega_z^2)$$

$$+ C\ RFZ(\omega_y\omega_z - \dot{\omega}_x)$$

$$+ S\ RFX(-\omega_z\omega_x + \dot{\omega}_y)$$

$$+ S\ RFY(-\omega_z\omega_y - \dot{\omega}_x)$$

$$+ S\ RFY(\omega_x^2 + \omega_y^2)$$

a similar set of corrections can be derived for accelerometers B, C, D and E.

This subroutine first calculates $\omega_x\omega_y$, $\omega_x\omega_z$, $\omega_y\omega_z$, ω_x^2, ω_y^2, ω_z^2, $\dot{\omega}_x$, $\dot{\omega}_y$ and $\dot{\omega}_z$ using $\Delta\theta_x$, $\Delta\theta_y$ and $\Delta\theta_z$ over one update interval as an indication of ω_x, ω_y and ω_z. It then calculates

$$PAR1 = \omega_y\omega_x + \dot{\omega}_z$$

$$PAR2 = \omega_x^2 + \omega_z^2$$

$$PAR3 = \omega_y\omega_z - \dot{\omega}_x$$

$$PAR4 = \omega_z\omega_x - \dot{\omega}_y$$

$$PAR5 = \omega_z\omega_y - \dot{\omega}_x$$

$$PAR6 = \omega_x^2 + \omega_y^2$$

$$PAR7 = \omega_y^2 + \omega_z^2$$

$$PAR8 = \omega_x\omega_y - \dot{\omega}_z$$

$$PAR9 = \omega_x\omega_z + \dot{\omega}_y$$

F's correction can now be defined as:

C RFX PAR1
-C RFY PAR2
+C RFZ PAR3
-S RFX PAR4
-S RFY PAR5
+S RFZ PAR6

Without doing the whole derivation B's correction can be defined as:

-C RBX PAR4
-C RBY PAR5
+C RBZ PAR6
-S RBX PAR7
+S RBY PAR8
+S RBZ PAR9

C, D and E have similar corrections.

The terms in the above equations such as -C RBX are constants and are stored as such in this subroutine. They are functions of the following table of distances which was made from detailed drawings of the SIRU PI-frame and SIRU accelerometers.

AXIS / R(cm)	A	B	C	D	E	F
X	0	-8.603	13.937	13.937	2.718	0.902
Y	0	-1.816	-24.021	-15.418	-27.081	11.130
Z	0	0	2.482	0.665	1.085	1.085

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0001                                ABS
0002                                ORG     '14000
0003                                SUBR    WXPR
0004                                SUBR    WYPR
0005                                SUBR    WZPR
0006                                SUBR    ROMS
0007 14000    0 000000    ROMS      DAC     **
0008 14001    0 02 00414            LDA     WX
0009 14002    0 16 00416            MPY     WY
0010 14003    0 04 14322            STA     WXWY
0011 14004    0 02 00414            LDA     WX
0012 14005    0 16 00420            MPY     WZ
0013 14006    0 04 14323            STA     WXWZ
0014 14007    0 02 00416            LDA     WY
0015 14010    0 16 00420            MPY     WZ
0016 14011    0 04 14324            STA     WYWZ
0017 14012    0 02 00414            LDA     WX
0018 14013    0 16 00414            MPY     WX
0019 14014    0 04 14325            STA     WXSQ
0020 14015    0 02 00416            LDA     WY
0021 14016    0 16 00416            MPY     WY
0022 14017    0 04 14326            STA     WYSQ
0023 14020    0 02 00420            LDA     WZ
0024 14021    0 16 00420            MPY     WZ
0025 14022    0 04 14327            STA     WZSQ
0026 14023    0 02 00414            LDA     WX
0027 14024    0 07 14333            SUB     WXPR
0028 14025    0415 72               ALS     6
0029 14026    0 04 14330            STA     WXDT
0030 14027    0 02 00416            LDA     WY
0031 14030    0 07 14334            SUB     WYPR
0032 14031    0415 72               ALS     6
0033 14032    0 04 14331            STA     WYDT
0034 14033    0 02 00420            LDA     WZ
0035 14034    0 07 14335            SUB     WZPR
0036 14035    0415 72               ALS     6
0037 14036    0 04 14332            STA     WZDT
0038 14037    0 06 14322            ADD     WXWY
0039 14040    0 04 14262            STA     PAR1
0040 14041    0 16 14336            MPY     CRFX
0041 14042    000007                DBL
0042 14043    0 04 14304            DST     CORF
0043 14044    000005                SGL
0044 14045    0 02 14325            LDA     WXSQ
0045 14046    0 06 14327            ADD     WZSQ
0046 14047    0 04 14264            STA     PAR2
0047 14050    0 16 14337            MPY     CRFY
0048 14051    000007                DBL
0049 14052    0 06 14304            DAD     CORF
0050 14053    0 04 14304            DST     CORF
0051 14054    000005                SGL
0052 14055    0 02 14324            LDA     WYWZ
0053 14056    0 07 14330            SUB     WXDT
0054 14057    0 04 14266            STA     PAR3
0055 14060    0 16 14340            MPY     CRFZ
0056 14061    000007                DBL
0057 14062    0 04 14316            DST     TEM1
```

```
0058 14063   0 06 14304      DAD   CORF
0059 14064   0 04 14304      DST   CORF
0060 14065   000005         SGL
0061 14066   0 02 14323      LDA   WXWZ
0062 14067   0 07 14331      SUB   WYDT
0063 14070   0 04 14270      STA   PAR4
0064 14071   0 16 14341      MPY   SRFX
0065 14072   000007         DBL
0066 14073   0 06 14304      DAD   CORF
0067 14074   0 04 14304      DST   CORF
0068 14075   000005         SGL
0069 14076   0 02 14324      LDA   WYWZ
0070 14077   0 07 14330      SUB   WXDT
0071 14100   0 04 14272      STA   PAR5
0072 14101   0 16 14342      MPY   SRFY
0073 14102   000007         DBL
0074 14103   0 06 14304      DAD   CORF
0075 14104   0 04 14304      DST   CORF
0076 14105   000005         SGL
0077 14106   0 02 14325      LDA   WXSQ
0078 14107   0 06 14326      ADD   WYSQ
0079 14110   0 04 14274      STA   PAR6
0080 14111   0 16 14343      MPY   SRFZ
0081 14112   000007         DBL
0082 14113   0 04 14306      DST   CORE
0083 14114   0 06 14304      DAD   CORF
0084 14115   0401 67         LRS   9
0085 14116   0 06 00612      DAD   '612
0086 14117   0 04 00612      DST   '612
0087 14120   000005         SGL
0088 14121   0 02 14326      LDA   WYSQ
0089 14122   0 06 14327      ADD   WZSQ
0090 14123   0 04 14276      STA   PAR7
0091 14124   0 16 14351      MPY   CRDX
0092 14125   000007         DBL
0093 14126   0 04 14310      DST   CORD
0094 14127   0 04 14312      DST   CORC
0095 14130   000005         SGL
0096 14131   0 02 14322      LDA   WXWY
0097 14132   0 07 14332      SUB   WZDT
0098 14133   0 04 14300      STA   PAR8
0099 14134   0 16 14352      MPY   CRDY
0100 14135   000007         DBL
0101 14136   0 06 14310      DAD   CORD
0102 14137   0 04 14310      DST   CORD
0103 14140   000005         SGL
0104 14141   0 02 14323      LDA   WXWZ
0105 14142   0 06 14331      ADD   WYDT
0106 14143   0 04 14302      STA   PAR9
0107 14144   0 16 14353      MPY   CRDZ
0108 14145   000007         DBL
0109 14146   0 06 14310      DAD   CORD
0110 14147   0 04 14310      DST   CORD
0111 14150   0 02 14264      DLD   PAR2
0112 14151   0 16 14345      MPY   CREY
0113 14152   0 06 14306      DAD   CORE
0114 14153   0 07 14316      DSB   TEM1
```

```
0115 14154   0 04 14306      DST   CORE
0116 14155   0 02 14270      DLD   PAR4
0117 14156   0 16 14346      MPY   SREX
0118 14157   0 06 14306      DAD   CORE
0119 14160   0 04 14306      DST   CORE
0120 14161   0 02 14272      DLD   PAR5
0121 14162   0 16 14350      MPY   SREY
0122 14163   0 06 14306      DAD   CORE
0123 14164   0401 67         LRS   9
0124 14165   0 06 00610      DAD   '610
0125 14166   0 04 00610      DST   '610
0126 14167   0 02 14262      DLD   PAR1
0127 14170   0 16 14354      MPY   SRDX
0128 14171   0 04 14320      DST   TEM2
0129 14172   0 06 14310      DAD   CORD
0130 14173   0 04 14310      DST   CORD
0131 14174   0 02 14264      DLD   PAR2
0132 14175   0 16 14355      MPY   SRDY
0133 14176   0 06 14310      DAD   CORD
0134 14177   0 04 14310      DST   CORD
0135 14200   0 02 14266      DLD   PAR3
0136 14201   0 16 14356      MPY   SRDZ
0137 14202   0 06 14310      DAD   CORD
0138 14203   0401 67         LRS   9
0139 14204   0 06 00606      DAD   '606
0140 14205   0 04 00606      DST   '606
0141 14206   0 02 14300      DLD   PAR8
0142 14207   0 16 14357      MPY   CRCY
0143 14210   0 06 14312      DAD   CORC
0144 14211   0 07 14320      DSB   TEM2
0145 14212   0 04 14312      DST   CORC
0146 14213   0 02 14302      DLD   PAR9
0147 14214   0 16 14360      MPY   CRCZ
0148 14215   0 06 14312      DAD   CORC
0149 14216   0 04 14312      DST   CORC
0150 14217   0 02 14264      DLD   PAR2
0151 14220   0 16 14361      MPY   SRCY
0152 14221   0 06 14312      DAD   CORC
0153 14222   0 04 14312      DST   CORC
0154 14223   0 02 14266      DLD   PAR3
0155 14224   0 16 14362      MPY   SRCZ
0156 14225   0 06 14312      DAD   CORC
0157 14226   0401 67         LRS   9
0158 14227   0 06 00604      DAD   '604
0159 14230   0 04 00604      DST   '604
0160 14231   0 02 14270      DLD   PAR4
0161 14232   0 16 14363      MPY   CRBX
0162 14233   0 04 14314      DST   CORB
0163 14234   0 02 14272      DLD   PAR5
0164 14235   0 16 14364      MPY   CRBY
0165 14236   0 06 14314      DAD   CORB
0166 14237   0 04 14314      DST   CORB
0167 14240   0 02 14276      DLD   PAR7
0168 14241   0 16 14365      MPY   SRBX
0169 14242   0 06 14314      DAD   CORB
0170 14243   0 04 14314      DST   CORB
0171 14244   0 02 14300      DLD   PAR8
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0172 14245    0 16 14366       MPY    SRBY
0173 14246    0 06 14314       DAD    CORB
0174 14247    0401 67          LRS    9
0175 14250    0 06 00602       DAD    '602
0176 14251    0 04 00602       DST    '602
0177 14252    000005           SGL
0178 14253    0 02 00414       LDA    WX
0179 14254    0 04 14333       STA    WXPR
0180 14255    0 02 00416       LDA    WY
0181 14256    0 04 14334       STA    WYPR
0182 14257    0 02 00420       LDA    WZ
0183 14260    0 04 14335       STA    WZPR
0184 14261   -0 01 14000       JMP*   ROMS
0185 14262    000000      PAR1 DBP    0
     14263    000000
0186 14264    000000      PAR2 DBP    0
     14265    000000
0187 14266    000000      PAR3 DBP    0
     14267    000000
0188 14270    000000      PAR4 DBP    0
     14271    000000
0189 14272    000000      PAR5 DBP    0
     14273    000000
0190 14274    000000      PAR6 DBP    0
     14275    000000
0191 14276    000000      PAR7 DBP    0
     14277    000000
0192 14300    000000      PAR8 DBP    0
     14301    000000
0193 14302    000000      PAR9 DBP    0
     14303    000000
0194 14304    000000      CORF DBP    0
     14305    000000
0195 14306    000000      CORE DBP    0
     14307    000000
0196 14310    000000      CORD DBP    0
     14311    000000
0197 14312    000000      CORC DBP    0
     14313    000000
0198 14314    000000      CORB DBP    0
     14315    000000
0199 14316    000000      TEM1 DBP    0
     14317    000000
0200 14320    000000      TEM2 DBP    0
     14321    000000
0201 14322    000000      WXWY OCT    0
0202 14323    000000      WXWZ OCT    0
0203 14324    000000      WYWZ OCT    0
0204 14325    000000      WXSQ OCT    0
0205 14326    000000      WYSQ OCT    0
0206 14327    000000      WZSQ OCT    0
0207 14330    000000      WXDT OCT    0
0208 14331    000000      WYDT OCT    0
0209 14332    000000      WZDT OCT    0
0210 14333    000000      WXPR OCT    0
0211 14334    000000      WYPR OCT    0
0212 14335    000000      WZPR OCT    0
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0213 14336   001145      CRFX  DEC   76.703B12
0214 14337   161152      CRFY  DEC   -946.8B12
0215 14340   001342      CRFZ  DEC   92.26B12
0216 14341   177205      SRFX  DEC   -47.405B12
0217 14342   166667      SRFY  DEC   -585.15B12
0218 14343   000710      SRFZ  DEC   57.02B12
0219 14344   174307      CREX  DEC   -231.19B12
0220 14345   134003      CREY  DEC   -2303.69B12
0221 14346   135670      SREX  DEC   -142.88
     14347   107535
0222 14350   026176      SREY  DEC   1423.76B12
0223 14351   155364      CRDX  DEC   -1185.55B12
0224 14352   153404      CRDY  DEC   -1311.52B12
0225 14353   000704      CRDZ  DEC   56.609B12
0226 14354   164433      SRDX  DEC   -732.71B12
0227 14355   163254      SRDY  DEC   -810.56B12
0228 14356   177351      SRDZ  DEC   -34.986B12
0229 14357   140046      CRCY  DEC   -2043.33B12
0230 14360   003230      CRCZ  DEC   211.096B12
0231 14361   023566      SRCY  DEC   1262.85B12
0232 14362   002023      SRCZ  DEC   130.464B12
0233 14363   013336      CRBX  DEC   731.813B12
0234 14364   002323      CRBY  DEC   154.49B12
0235 14365   007042      SRBX  DEC   452.29B12
0236 14366   176405      SRBY  DEC   -95.48B12
0237         000414      WX    EQU   '414
0238         000416      WY    EQU   '416
0239         000420      WZ    EQU   '420
0240                           END
```

PROGRAM NAME:
SOURCE: PREX
BINARY: BPREX
ENTRY POINTS (location): PARC ('06040)
ACCESSABLE VARIABLES (location): PACC ('06166)
GENERAL DESCRIPTION:

This subroutine is essentially equivalent to GARC, the gyro error accumulator, except it only accumulates compensated pulses from the six PIPAs. The only other difference is that when it is time to purge the PIPA accumulators, it puts a 1 in location '765 (note the instruction IRS '765) which clues the PIPA parity equation solver (program source name PPEX, subroutine entry point PPRT) not to do its calculation. This feature is solely for timing considerations.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    REL
0002                                    SUBR  PARC
0003                                    SUBR  PACC
0004 00000   0 000000   PARC DAC   **
0005 00001   0 12 00126      IRS   PACC
0006 00002   0 01 00023      JMP   NPCC
0007 00003   0 12 00765      IRS   '765
0008 00004   0 02 00131      LDA   =-6000
0009 00005   0 04 00126      STA   PACC
0010 00006   0 35 00130      LDX   =-12
0011 00007   000007         DBL
0012 00010   1 02 00316 LUPE DLD   PAPA+12,1
0013 00011   1 07 00106      DSB   ARES+12,1
0014 00012   1 04 00316      DST   PAPA+12,1
0015 00013   1 02 00124      DLD   ARRS+12,1
0016 00014   1 07 00106      DSB   ARES+12,1
0017 00015   1 04 00106      DST   ARES+12,1
0018 00016   1 02 00316      DLD   PAPA+12,1
0019 00017   1 04 00124      DST   ARRS+12,1
0020 00020   0 12 00000      IRS   0
0021 00021   0 12 00000      IRS   0
0022 00022   0 01 00010      JMP   LUPE
0023 00023   0 02 00600 NPCC LDA   PAPC
0024 00024   000007         DBL
0025 00025   0401 61         LRS   15
0026 00026   0 06 00302      DAD   PAPA
0027 00027   0 04 00302      DST   PAPA
0028 00030   0401 73         LRS   5
0029 00031   0 04 00744      DST   AARP
0030 00032   0 02 00602      DLD   PBPC
0031 00033   0401 61         LRS   15
0032 00034   0 06 00304      DAD   PBPA
0033 00035   0 04 00304      DST   PBPA
0034 00036   0401 73         LRS   5
0035 00037   0 04 00746      DST   BARP
0036 00040   0 02 00604      DLD   PCPC
0037 00041   0401 61         LRS   15
0038 00042   0 06 00306      DAD   PCPA
0039 00043   0 04 00306      DST   PCPA
0040 00044   0401 73         LRS   5
0041 00045   0 04 00750      DST   CARP
0042 00046   0 02 00606      DLD   PDPC
0043 00047   0401 61         LRS   15
0044 00050   0 06 00310      DAD   PDPA
0045 00051   0 04 00310      DST   PDPA
0046 00052   0401 73         LRS   5
0047 00053   0 04 00752      DST   DARP
0048 00054   0 02 00610      DLD   PEPC
0049 00055   0401 61         LRS   15
0050 00056   0 06 00312      DAD   PEPA
0051 00057   0 04 00312      DST   PEPA
0052 00060   0401 73         LRS   5
0053 00061   0 04 00754      DST   EARP
0054 00062   0 02 00612      DLD   PFPC
0055 00063   0401 61         LRS   15
0056 00064   0 06 00314      DAD   PFPA
0057 00065   0 04 00314      DST   PFPA
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0058 00066    0401 73          LRS    5
0059 00067    0 04 00756       DST    FARP
0060 00070    000005           SGL
0061 00071   -0 01 00000       JMP*   PARC
0062          000600      PAPC EQU    '600
0063          000602      PBPC EQU    PAPC+2
0064          000604      PCPC EQU    PAPC+4
0065          000606      PDPC EQU    PAPC+6
0066          000610      PEPC EQU    PAPC+8
0067          000612      PFPC EQU    PAPC+10
0068          000302      PAPA EQU    '302
0069          000304      PBPA EQU    PAPA+2
0070          000306      PCPA EQU    PAPA+4
0071          000310      PDPA EQU    PAPA+6
0072          000312      PEPA EQU    PAPA+8
0073          000314      PFPA EQU    PAPA+10
0074          000744      AARP EQU    '744
0075          000746      BARP EQU    AARP+2
0076          000750      CARP EQU    AARP+4
0077          000752      DARP EQU    AARP+6
0078          000754      EARP EQU    AARP+8
0079          000756      FARP EQU    AARP+10
0080 00072    000000      ARES DBP    0
     00073    000000
0081 00074    000000      BRES DBP    0
     00075    000000
0082 00076    000000      CRES DBP    0
     00077    000000
0083 00100    000000      DRES DBP    0
     00101    000000
0084 00102    000000      ERES DBP    0
     00103    000000
0085 00104    000000      FRES DBP    0
     00105    000000
0086 00106    000000      SRES DBP    0
     00107    000000
0087 00110    000000      ARRS DBP    0
     00111    000000
0088 00112    000000      BRRS DBP    0
     00113    000000
0089 00114    000000      CRRS DBP    0
     00115    000000
0090 00116    000000      DRRS DBP    0
     00117    000000
0091 00120    000000      ERRS DBP    0
     00121    000000
0092 00122    000000      FRRS DBP    0
     00123    000000
0093 00124    000000      SRRS DBP    0
     00125    000000
0094 00126    164217      PACC DEC    -6001
0095 00127    000000      STSE OCT    0
0096 00130    177764           END
     00131    164220
```

PROGRAM NAME:
SOURCE: GARC
BINARY: BGARC
ENTRY POINTS (location): GARC ('07344)
ACCESSABLE VARIABLES (location): GACC ('07524)
GENERAL DESCRIPTION:

This subroutine accumulates the 6 compensated gyro pulse counts (GAPC, GBPC, GCPC, GDPC, GEPC and GFPC) in the six gyro pulse accumulators (GAPA, GBPA, GCPA, GDPA, GEPA and GFPA) and then stores the accumulations in the six arguments (AARG, BARG, CARG, DARG, EARG, and FARG) for the squared error calculator (see documentation for program source name CFSE, subroutine entry point SECA). It also accumulates

$$\sum \left| \Delta\theta X \right| + \left| \Delta\theta Y \right| + \left| \Delta\theta Z \right|$$

to be used to increase the maximum allowable total squared error to allow for dynamic scale factor and misalignment errors (see documentation for GFIS).

The 6 compensated gyro pulse counts are double precision numbers with the high order word being of significance and the low order word being carried along as a residual. Thus, every time an LRS 15 instruction operates on a gyro pulse count in the accumulator, it is simply to shift the residual out. Scaling can best be expressed by giving the representation of one gyro pulse for GAPC, GAPA and AARG.

```
GAPC oct 00400, 00000
GAPA oct 00000, 00400
AARG oct 00000, 00010
```

Therefore, the bit granularity of the arguments used by the squared error calculator is $\pm 1/8$ pulse.

In order that the gyro pulse accumulators don't overflow, they are periodically purged of old accumulation. Define A (t_1, t_2) to be the accumulation of gyro pulses between times t_1 and t_2. Every minute starting at $t = 60$, the following purge is performed (let us look just at the A gyro accumulator).

GAPA = GAPA - ARES
ARES = ARRS - ARES
ARRS = GAPA

ARES = A gyro residual.
ARRS = A gyro residual residual.

following this procedure we get:

at time = 60

GAPA = GAPA - ARES
GAPA = A (0, 60) - 0 = A (0, 60)
ARES = ARRS - ARES = 0 - 0 = 0
ARRS = GAPA = A (0, 60)

at time = 120

GAPA = GAPA - ARES
GAPA = A (0, 120) - 0 = A (0, 120)
ARES = ARRS - ARES = A (0, 60) - 0 = A (0, 60)
ARRS = GAPA = A (0, 120)

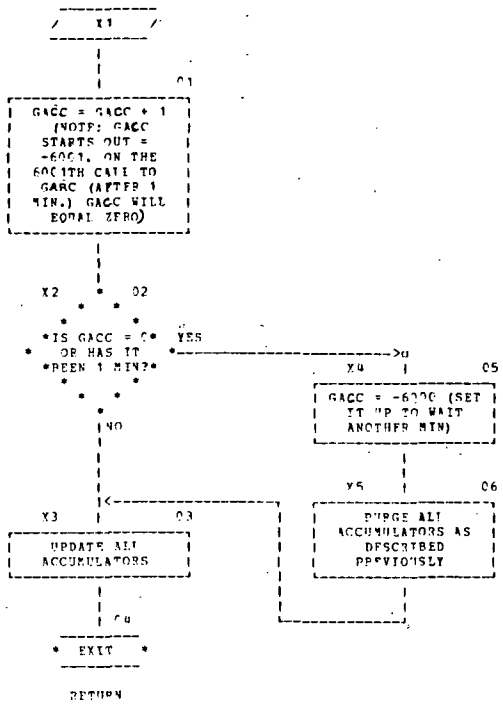
at time = 180

GAPA = GAPA - ARES
GAPA = A (0, 180) - A (0, 60) = A (60, 180)
ARES = ARRS - ARES = A (0, 120) - A (0, 60) = A (60, 120)
ARRS = GAPA = A (60, 180)

at time = 240

GAPA = GAPA - ARES
GAPA = A (60, 240) - A (60, 120) = A (120, 240)
ARES = ARRS - ARES = A (60, 180) - A (60, 120) = A (120, 180)
ARRS = GAPA = A (120, 240) etc.

the flow chart follows.



FLOWCHART - GARC

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   GARC
0003                                  SUBR   GACC
0004 00000    0 000000    GARC    DAC    **
0005 00001    0 12 00160        IRS    GACC
0006 00002    0 01 00032        JMP    NGCC
0007 00003    0 02 00163        LDA    =-6000
0008 00004    0 04 00160        STA    GACC
0009 00005    0 35 00162        LDX    =-12
0010 00006    000007            DBL
0011 00007    1 02 00302  LUPE  DLD    GAPA+12,1
0012 00010    1 07 00140        DSB    ARES+12,1
0013 00011    1 04 00302        DST    GAPA+12,1
0014 00012    1 02 00156        DLD    ARRS+12,1
0015 00013    1 07 00140        DSB    ARES+12,1
0016 00014    1 04 00140        DST    ARES+12,1
0017 00015    1 02 00302        DLD    GAPA+12,1
0018 00016    1 04 00156        DST    ARRS+12,1
0019 00017    0 12 00000        IRS    0
0020 00020    0 12 00000        IRS    0
0021 00021    0 01 00007        JMP    LUPE
0022 00022    0 02 00774        DLD    SUDT
0023 00023    0 07 00140        DSB    SRES
0024 00024    0 04 00774        DST    SUDT
0025 00025    0 02 00156        DLD    SRRS
0026 00026    0 07 00140        DSB    SRES
0027 00027    0 04 00140        DST    SRES
0028 00030    0 02 00774        DLD    SUDT
0029 00031    0 04 00156        DST    SRRS
0030 00032    0 02 00400  NGCC  LDA    GAPC
0031 00033    000007            DBL
0032 00034    0401 61           LRS    15
0033 00035    0 06 00266        DAD    GAPA
0034 00036    0 04 00266        DST    GAPA
0035 00037    0401 73           LRS    5
0036 00040    0 04 00744        DST    AARG
0037 00041    0 02 00402        DLD    GBPC
0038 00042    0401 61           LRS    15
0039 00043    0 06 00270        DAD    GBPA
0040 00044    0 04 00270        DST    GBPA
0041 00045    0401 73           LRS    5
0042 00046    0 04 00746        DST    BARG
0043 00047    0 02 00404        DLD    GCPC
0044 00050    0401 61           LRS    15
0045 00051    0 06 00272        DAD    GCPA
0046 00052    0 04 00272        DST    GCPA
0047 00053    0401 73           LRS    5
0048 00054    0 04 00750        DST    CARG
0049 00055    0 02 00406        DLD    GDPC
0050 00056    0401 61           LRS    15
0051 00057    0 06 00274        DAD    GDPA
0052 00060    0 04 00274        DST    GDPA
0053 00061    0401 73           LRS    5
0054 00062    0 04 00752        DST    DARG
0055 00063    0 02 00410        DLD    GEPC
0056 00064    0401 61           LRS    15
0057 00065    0 06 00276        DAD    GEPA
```

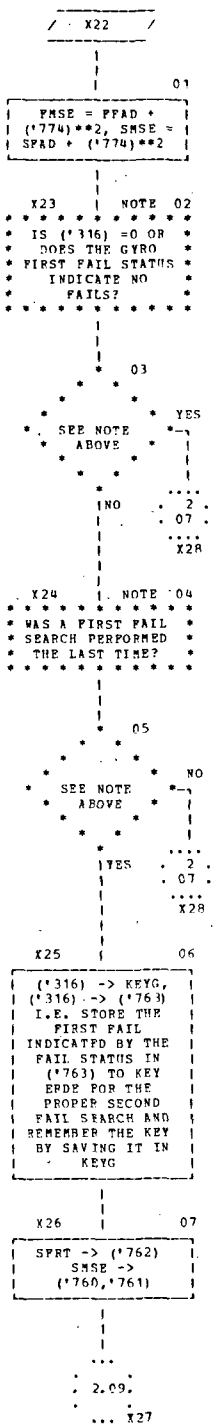
```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0058 00066    0 04 00276        DST    GEPA
0059 00067    0401 73           LRS    5
0060 00070    0 04 00754        DST    EARG
0061 00071    0 02 00412        DLD    GFPC
0062 00072    0401 61           LRS    15
0063 00073    0 06 00300        DAD    GFPA
0064 00074    0 04 00300        DST    GFPA
0065 00075    0401 73           LRS    5
0066 00076    0 04 00756        DST    FARG
0067 00077    000005            SGL
0068 00100    0 02 00414        LDA    DTXB
0069 00101    100400            SPL
0070 00102    140407            TCA
0071 00103    0 04 00161        STA    STSE
0072 00104    0 02 00416        LDA    DTYB
0073 00105    100400            SPL
0074 00106    140407            TCA
0075 00107    0 06 00161        ADD    STSE
0076 00110    0 04 00161        STA    STSE
0077 00111    0 02 00420        LDA    DTZB
0078 00112    100400            SPL
0079 00113    140407            TCA
0080 00114    0 06 00161        ADD    STSE
0081 00115    000007            DBL
0082 00116    0401 61           LRS    15
0083 00117    0 06 00774        DAD    SUDT
0084 00120    0 04 00774        DST    SUDT
0085 00121    000005            SGL
0086 00122   -0 01 00000        JMP*   GARC
0087          000400      GAPC  EQU    '400
0088          000402      GBPC  EQU    GAPC+2
0089          000404      GCPC  EQU    GAPC+4
0090          000406      GDPC  EQU    GAPC+6
0091          000410      GEPC  EQU    GAPC+8
0092          000412      GFPC  EQU    GAPC+10
0093          000266      GAPA  EQU    '266
0094          000270      GBPA  EQU    GAPA+2
0095          000272      GCPA  EQU    GAPA+4
0096          000274      GDPA  EQU    GAPA+6
0097          000276      GEPA  EQU    GAPA+8
0098          000300      GFPA  EQU    GAPA+10
0099          000744      AARG  EQU    '744
0100          000746      BARG  EQU    AARG+2
0101          000750      CARG  EQU    AARG+4
0102          000752      DARG  EQU    AARG+6
0103          000754      EARG  EQU    AARG+8
0104          000756      FARG  EQU    AARG+10
0105          000414      DTXB  EQU    '414
0106          000416      DTYB  EQU    DTXB+2
0107          000420      DTZB  EQU    DTXB+4
0108          000774      SUDT  EQU    '774
0109 00124    000000      ARES  DBP    0
     00125    000000
0110 00126    000000      BRES  DBP    0
     00127    000000
0111 00130    000000      CRES  DBP    0
     00131    000000
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0112 00132   000000      DRES DBP   0
     00133   000000
0113 00134   000000      ERES DBP   0
     00135   000000
0114 00136   000000      FRES DBP   0
     00137   000000
0115 00140   000000      SRES DBP   0
     00141   000000
0116 00142   000000      ARRS DBP   0
     00143   000000
0117 00144   000000      BRRS DBP   0
     00145   000000
0118 00146   000000      CRRS DBP   0
     00147   000000
0119 00150   000000      DRRS DBP   0
     00151   000000
0120 00152   000000      ERRS DBP   0
     00153   000000
0121 00154   000000      FRRS DBP   0
     00155   000000
0122 00156   000000      SRRS DBP   0
     00157   000000
0123 00160   164217      GACC DEC   -6001
0124 00161   000000      STSE OCT   0
0125 00162   177764           END
     00163   164220
```

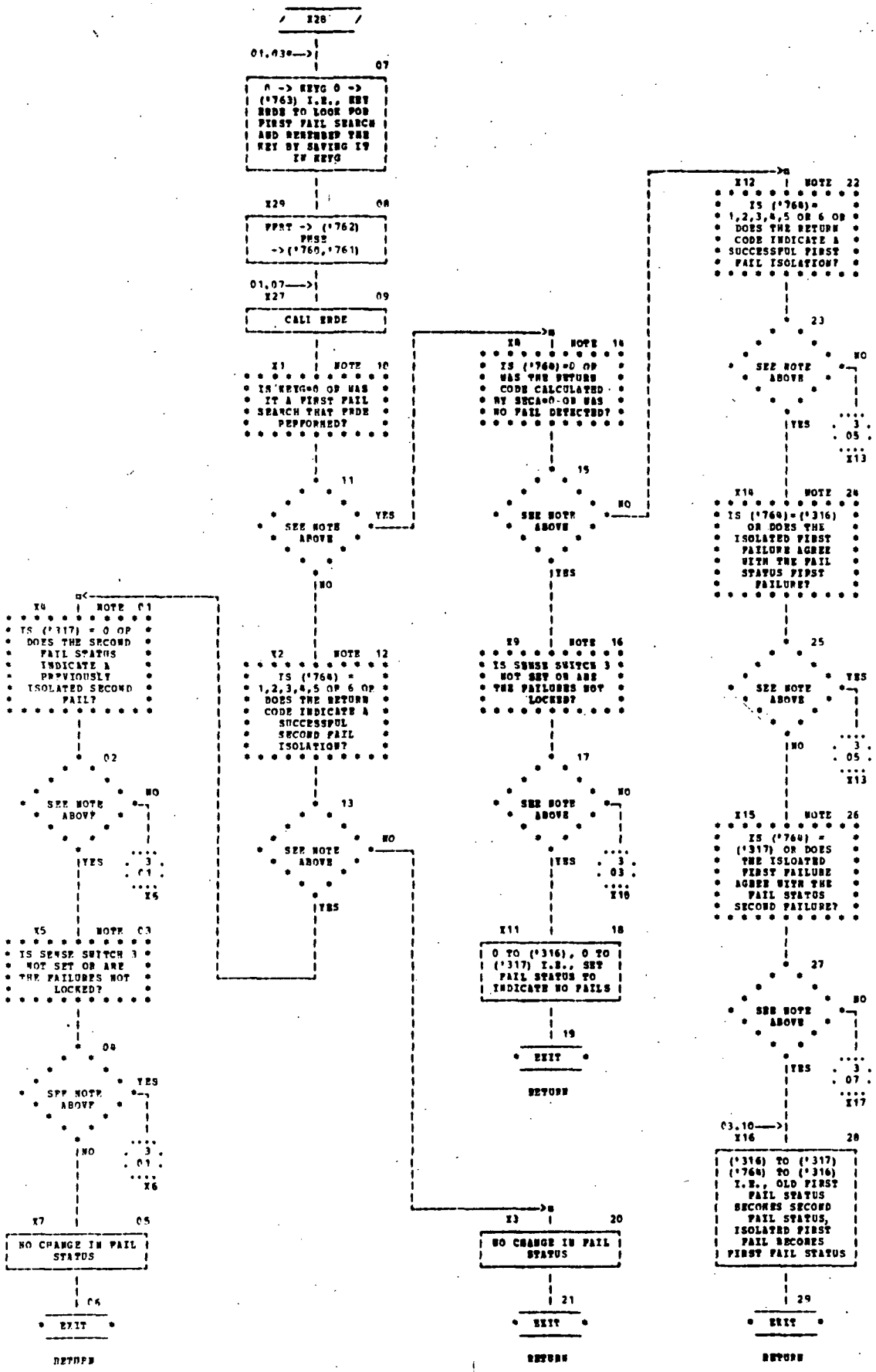
PROGRAM NAME
SOURCE: GFIS
BINARY: BGFIS
ENTRY POINTS (location): GFIS ('2070)
ACCESSABLE VARIABLES (location): KEYG ('2225)
GENERAL DESCRIPTION:

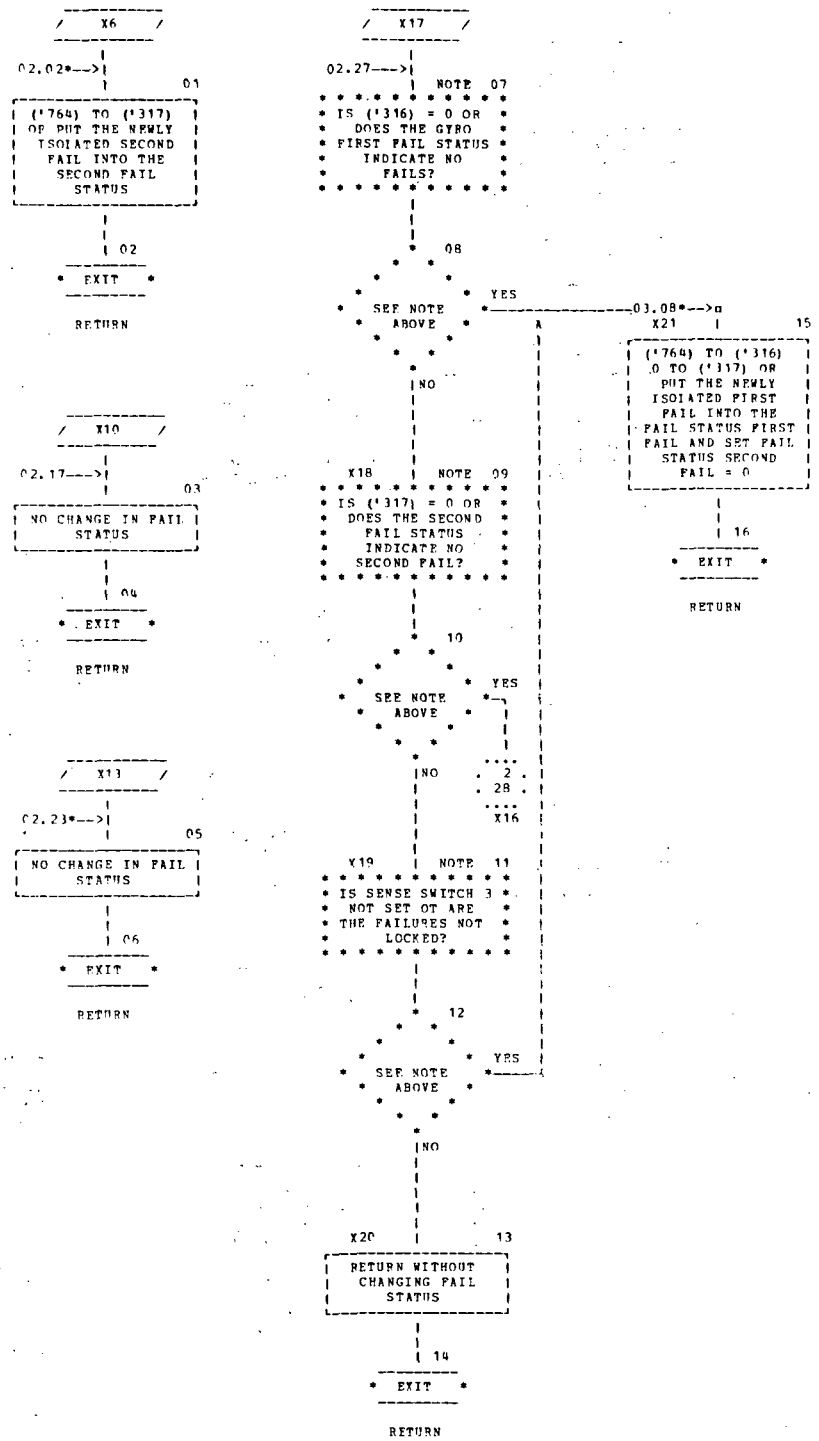
This subroutine controls the logic for the gyro failure detection and isolation. When called (once every gyro update) it decides which failure (first or second) should be searched for using such considerations as gyro fail status and which search it made the previous time. It will then store in locations '760 and '761 the maximum allowable total squared error (MASE) for either the first (FMSE) or second (SMSE) failure search. (FMSE and SMSE are modified at the beginning of this subroutine to allow for dynamic errors. Location '774 contains a proportion of the sum of the absolute values of the total rotations about axes X, Y and Z. Adding the square of this sum to FFAD and SFAD gives the modified maximum allowable total squared errors FMSE and SMSE).

It will store in location '762 the squared error ratio for either the first fail (FFRT) or second fail (SFRT) isolation criteria (see documentation for SECA, program source name CFSE). In location '763 it will store the number of the instrument to be considered failed (see documentation for ERDE). It will then call ERDE which, in turn, calls the squared error calculator SECA (program source name CFSE). Since the gyro error accumulator (GARC) has been called prior to GFIS, SECA has the proper arguments for the instrument accumulated measurements. GFIS gives SECA the proper total allowable squared error and the proper squared error ratio. After the squared errors have been calculated and a decision of detection and/or isolation has been made, ERDE will store the decision code in location '764 and return to GFIS. GFIS will then decide what the gyro fail status should be and store the number of the gyro first and second failures in location '316 and '317 respectively. The logic of this program is shown in the following flow chart. Note that sense switch 3, if set, will prevent any failure from healing.



FLOWCHART - GFIS


X28
01,03
07
0 -> KEYG 0 -> ('763) I.E., SET ERDE TO LOOK FOR FIRST FAIL SEARCH AND REMEMBER THE KEY BY SAVING IT IN KEYG
X29
08
FPRT -> ('762) PHSE ->('760,'761)
01,07
X27
09
CALL ERDE
X1
NOTE 10
IS KEYG=0 OR WAS IT A FIRST FAIL SEARCH THAT ERDE PERFORMED?
11
SEE NOTE ABOVE
YES
NO
X2
NOTE 12
IS ('764) = 1,2,3,4,5 OR 6 OR DOES THE RETURN CODE INDICATE A SUCCESSFUL SECOND FAIL ISOLATION?
13
SEE NOTE ABOVE
NO
YES
X4
NOTE 01
IS ('317) = 0 OR DOES THE SECOND FAIL STATUS INDICATE A PREVIOUSLY ISOLATED SECOND FAIL?
02
SEE NOTE ABOVE
NO
YES
. 3 .
. 01 .
X5
X5
NOTE 03
IS SENSE SWITCH 3 NOT SET OR ARE THE FAILURES NOT LOCKED?
04
SEE NOTE ABOVE
YES
NO
. 3 .
. 01 .
X6
X7
05
NO CHANGE IN FAIL STATUS
06
EXIT
RETURN
X8
NOTE 14
IS ('760)=0 OR WAS THE RETURN CODE CALCULATED BY SECA=0 OR WAS NO FAIL DETECTED?
15
SEE NOTE ABOVE
NO
YES
X9
NOTE 16
IS SENSE SWITCH 3 NOT SET OR ARE THE FAILURES NOT LOCKED?
17
SEE NOTE ABOVE
NO
YES
. 3 .
. 03 .
X10
X11
18
0 TO ('316), 0 TO ('317) I.E., SET FAIL STATUS TO INDICATE NO FAILS
19
EXIT
RETURN
X3
20
NO CHANGE IN FAIL STATUS
21
EXIT
RETURN
X12
NOTE 22
IS ('768)= 1,2,3,4,5 OR 6 OR DOES THE RETURN CODE INDICATE A SUCCESSFUL FIRST FAIL ISOLATION?
23
SEE NOTE ABOVE
NO
YES
. 3 .
. 05 .
X13
X14
NOTE 24
IS ('764)=('316) OR DOES THE ISOLATED FIRST FAILURE AGREE WITH THE FAIL STATUS FIRST FAILURE?
25
SEE NOTE ABOVE
YES
NO
. 3 .
. 05 .
X13
X15
NOTE 26
IS ('764) = ('317) OR DOES THE ISLOATED FIRST FAILURE AGREE WITH THE FAIL STATUS SECOND FAILURE?
27
SEE NOTE ABOVE
NO
YES
. 3 .
. 07 .
X17
03,10
X16
28
('316) TO ('317) ('764) TO ('316) I.E., OLD FIRST FAIL STATUS BECOMES SECOND FAIL STATUS, ISOLATED FIRST FAIL BECOMES FIRST FAIL STATUS
29
EXIT
RETURN


X6
02.02*-->
01
('764) TO ('317) OR PUT THE NEWLY ISOLATED SECOND FAIL INTO THE SECOND FAIL STATUS
02
EXIT
RETURN
X10
02.17-->
03
NO CHANGE IN FAIL STATUS
04
EXIT
RETURN
X11
02.23*-->
05
NO CHANGE IN FAIL STATUS
06
EXIT
RETURN
X17
02.27-->
NOTE 07
IS ('316) = 0 OR DOES THE GYRO FIRST FAIL STATUS INDICATE NO FAILS?
08
YES
SEE NOTE ABOVE
03.08*-->
X21
15
('764) TO ('316) 0 TO ('317) OR PUT THE NEWLY ISOLATED FIRST FAIL INTO THE FAIL STATUS FIRST FAIL AND SET FAIL STATUS SECOND FAIL = 0
16
EXIT
RETURN
NO
X18
NOTE 09
IS ('317) = 0 OR DOES THE SECOND FAIL STATUS INDICATE NO SECOND FAIL?
10
YES
SEE NOTE ABOVE
NO
2
28
X16
X19
NOTE 11
IS SENSE SWITCH 3 NOT SET OT ARE THE FAILURES NOT LOCKED?
12
YES
SEE NOTE ABOVE
NO
X20
13
RETURN WITHOUT CHANGING FAIL STATUS
14
EXIT
RETURN

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                REL
0002                                SUBR  GFIS
0003                                SUBR  KEYG
0004 00000    0 000000    GFIS  DAC   **
0005 00001    0 02 00774        LDA   '774
0006 00002    0405 75           ARS   3
0007 00003    0 04 00142        STA   ALOP
0008 00004    0 16 00142        MPY   ALOP
0009 00005    000007            DBL
0010 00006    0 04 00142        DST   ALOP
0011 00007    0 06 00144        DAD   FFAD
0012 00010    0 04 00136        DST   FMSE
0013 00011    0 02 00142        DLD   ALOP
0014 00012    0 06 00146        DAD   SFAD
0015 00013    0 04 00140        DST   SMSE
0016 00014    000005            SGL
0017 00015    0 02 00316        LDA   '316
0018 00016    100040            SZE
0019 00017    0 01 00032        JMP   ALOF
0020 00020    140040      FFTR  CRA
0021 00021    0 04 00135        STA   KEYG
0022 00022    0 04 00763        STA   '763
0023 00023    0 02 00133        LDA   FFRT
0024 00024    0 04 00762        STA   '762
0025 00025    000007            DBL
0026 00026    0 02 00136        DLD   FMSE
0027 00027    0 04 00760        DST   '760
0028 00030    000005            SGL
0029 00031    0 01 00046        JMP   COCA
0030 00032    0 02 00135  ALOF  LDA   KEYG
0031 00033    100040            SZE
0032 00034    0 01 00020        JMP   FFTR
0033 00035    0 02 00316        LDA   '316
0034 00036    0 04 00135        STA   KEYG
0035 00037    0 04 00763        STA   '763
0036 00040    0 02 00134        LDA   SFRT
0037 00041    0 04 00762        STA   '762
0038 00042    000007            DBI
0039 00043    0 02 00140        DLD   SMSE
0040 00044    0 04 00760        DST   '760
0041 00045    000005            SGL
0042 00046    0 10 00000  COCA  CALL  ERDE
0043 00047    0 02 00135        LDA   KEYG
0044 00050    100040            SZE
0045 00051    0 01 00117        JMP   SFSR
0046 00052    0 02 00764        LDA   '764
0047 00053    100040            SZE
0048 00054    0 01 00063        JMP   NOZE
0049 00055    100004            SR3
0050 00056   -0 01 00000        JMP*  GFIS
0051 00057    140040            CRA
0052 00060    0 04 00316        STA   '316
0053 00061    0 04 00317        STA   '317
0054 00062   -0 01 00000        JMP*  GFIS
0055 00063    0 07 00150  NOZE  SUB   =7
0056 00064    101400            SMI
0057 00065   -0 01 00000        JMP*  GFIS
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0058 00066    0 02 00764        LDA    '764
0059 00067    0 11 00316        CAS    '316
0060 00070    0 01 00072        JMP    *+2
0061 00071   -0 01 00000        JMP*   GFIS
0062 00072    0 11 00317        CAS    '317
0063 00073    0 01 00075        JMP    *+2
0064 00074    0 01 00112        JMP    SPCA
0065 00075    0 02 00316        LDA    '316
0066 00076    101040            SNZ
0067 00077    0 01 00105        JMP    *+6
0068 00100    0 02 00317        LDA    '317
0069 00101    101040            SNZ
0070 00102    0 01 00112        JMP    SPCA
0071 00103    100004            SR3
0072 00104   -0 01 00000        JMP*   GFIS
0073 00105    0 02 00764        LDA    '764
0074 00106    0 04 00316        STA    '316
0075 00107    140040            CRA
0076 00110    0 04 00317        STA    '317
0077 00111   -0 01 00000        JMP*   GFIS
0078 00112    0 02 00316 SPCA   LDA    '316
0079 00113    0 04 00317        STA    '317
0080 00114    0 02 00764        LDA    '764
0081 00115    0 04 00316        STA    '316
0082 00116   -0 01 00000        JMP*   GFIS
0083 00117    0 02 00764 SFSR   LDA    '764
0084 00120    0 07 00150        SUB    =7
0085 00121    101400            SMI
0086 00122   -0 01 00000        JMP*   GFIS
0087 00123    0 02 00317        LDA    '317
0088 00124    101040            SNZ
0089 00125    0 01 00130        JMP    *+3
0090 00126    100004            SR3
0091 00127   -0 01 00000        JMP*   GFIS
0092 00130    0 02 00764        LDA    '764
0093 00131    0 04 00317        STA    '317
0094 00132   -0 01 00000        JMP*   GFIS
0095 00133    034343      FFRT  OCT    34343
0096 00134    030600      SFRT  OCT    30600
0097 00135    000000      KEYG  OCT    0
0098 00136    000000      FMSE  DBP    0
     00137    000000
0099 00140    000000      SMSE  DBP    0
     00141    000000
0100 00142    000000      ALOP  DBP    0
     00143    000000
0101 00144    000000      FFAD  OCT    0,2200
     00145    002200
0102 00146    000000      SFAD  OCT    0,1632
     00147    001632
0103 00150    000007            END
```

PROGRAM NAME
SOURCE: ERDE
BINARY: BERDE
ENTRY POINTS (location: ERDE ('06172)
GENERAL DESCRIPTION:

This subroutine is called by either the gyro failure detection and isolation logic subroutine (GFIS) or the PIPA failure detection and isolation logic subroutine (PFIS) and in turn calls the squared error calculator (SECA, program source name CFSE). Core location '763 tells this subroutine which instrument is to be considered failed. If location '763 is zero, it means that no instrument is to be considered failed and when it calls SECA, it must indicate this with a -7 in the index register. SECA will then calculate the no fail squared error equations and return with a code in the A register which ERDE will store in core location '764 so that its calling program (either GFIS or PFIS) can use the result.

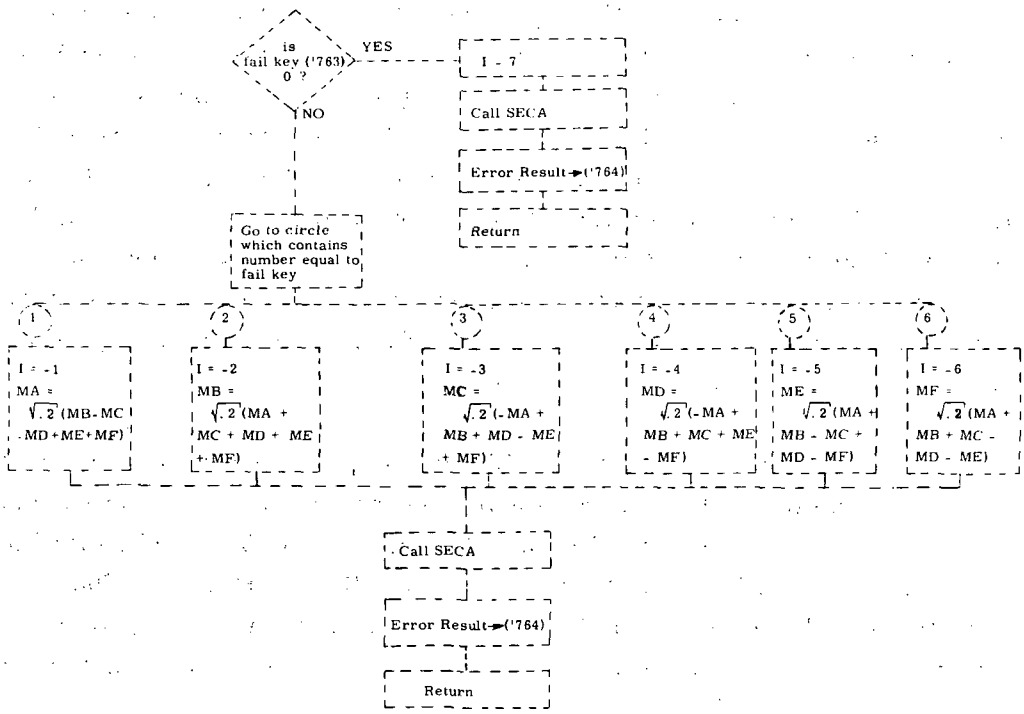
If the failure key (location '763) is a 1, 2, 3, 4, 5 or 6, it indicates that the second fail squared error equations are to be calculated considering A, B, C, D, E or F as the failed instrument. Again, ERDE will store the return from SECA in location '764 for use by GFIS or PFIS. If '763 is a 1 and instrument A is to be considered failed, MA (see description of SECA, program source name CFSE), the accumulated measurement of instrument A, must be replaced by

$$\sqrt{0.2}\,(MB - MC - MD + ME + MF)$$

the calculation of MA using MB, MC, MD, ME and MF. Then when SECA calculates the first fail squared error equations using the new MA and the old MB, MC, MD, ME and MF, it gets the same results it would have gotten had it used the second fail squared error equations considering A failed. Similarly, if the fail key ('763) is a 2, B is considered failed and MB must be replaced by

$$\sqrt{0.2}\,(MA + MC + MD + ME + MF)$$

Also, with instrument B failed, the index register must contain a -2 when SECA is called. Similar steps are taken when instruments C, D, E or F are to be considered failed. The flow chart for the subroutine ERDE follows:



FLOWCHART - ERDE

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   ERDE
0003 00000    0 000000    ERDE DAC    **
0004 00001    0 02 00763         LDA    '763
0005 00002    100040             SZE
0006 00003    0 01 00010         JMP    AROF
0007 00004    0 35 00331         LDX    =-7
0008 00005    0 10 00000         CALL   SECA
0009 00006    0 04 00764         STA    '764
0010 00007   -0 01 00000         JMP*   ERDE
0011 00010    0 04 00000 AROF  STA    0
0012 00011   -1 01 00011 EASE  JMP*   EASE,1
0013 00012    0 000020           DAC    AFAL
0014 00013    0 000057           DAC    BFAL
0015 00014    0 000116           DAC    CFAL
0016 00015    0 000166           DAC    DFAL
0017 00016    0 000225           DAC    EFAL
0018 00017    0 000264           DAC    FFAL
0019 00020    000007       AFAL  DBL
0020 00021    0 02 00746         LDA    MB
0021 00022    0 06 00754         ADD    ME
0022 00023    0 06 00756         ADD    MF
0023 00024    0 07 00750         SUB    MC
0024 00025    0 07 00752         SUB    MD
0025 00026    0 04 00160         STA    TEM1
0026 00027    0 16 00155         MPY    RPTT
0027 00030    0 04 00162         STA    TEM2
0028 00031    0 02 00160         LDA    TEM1
0029 00032    000201             IAB
0030 00033    0 16 00155         MPY    RPTT
0031 00034    0 06 00164         ADD    HALF
0032 00035    000201             IAB
0033 00036    140040             CRA
0034 00037    0 06 00162         ADD    TEM2
0035 00040    0 04 00162         STA    TEM2
0036 00041    0 02 00160         LDA    TEM1
0037 00042    0 16 00156         MPY    RPTT+1
0038 00043    0 06 00164         ADD    HALF
0039 00044    140320             CSA
0040 00045    000201             IAB
0041 00046    140040             CRA
0042 00047    100001             SRC
0043 00050    140401             CMA
0044 00051    0 06 00162         ADD    TEM2
0045 00052    0 04 00744         STA    MA
0046 00053    0 35 00327         LDX    =-1
0047 00054    0 10 00000         CALL   SECA
0048 00055    0 04 00764         STA    '764
0049 00056   -0 01 00000         JMP*   ERDE
0050 00057    000007       BFAL  DBL
0051 00060    0 02 00744         LDA    MA
0052 00061    0 06 00750         ADD    MC
0053 00062    0 06 00752         ADD    MD
0054 00063    0 06 00754         ADD    ME
0055 00064    0 06 00756         ADD    MF
0056 00065    0 04 00160         STA    TEM1
0057 00066    0 16 00155         MPY    RPTT
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0058 00067    0 04 00162        STA    TEM2
0059 00070    0 02 00160        LDA    TEM1
0060 00071    000201            IAB
0061 00072    0 16 00155        MPY    RPTT
0062 00073    0 06 00164        ADD    HALF
0063 00074    000201            IAB
0064 00075    140040            CRA
0065 00076    0 06 00162        ADD    TEM2
0066 00077    0 04 00162        STA    TEM2
0067 00100    0 02 00160        LDA    TEM1
0068 00101    0 16 00156        MPY    RPTT+1
0069 00102    0 06 00164        ADD    HALF
0070 00103    140320            CSA
0071 00104    000201            IAB
0072 00105    140040            CRA
0073 00106    100001            SPC
0074 00107    140401            CMA
0075 00110    0 06 00162        ADD    TEM2
0076 00111    0 04 00746        STA    MB
0077 00112    0 35 00326        LDX    =-2
0078 00113    0 10 00000        CALL   SECA
0079 00114    0 04 00764        STA    '764
0080 00115   -0 01 00000        JMP*   ERDE
0081 00116    000007      CFAL  DBL
0082 00117    0 02 00746        LDA    MB
0083 00120    0 06 00752        ADD    MD
0084 00121    0 06 00756        ADD    MF
0085 00122    0 07 00744        SUB    MA
0086 00123    0 07 00754        SUB    ME
0087 00124    0 04 00160        STA    TEM1
0088 00125    0 16 00155        MPY    RPTT
0089 00126    0 04 00162        STA    TEM2
0090 00127    0 02 00160        LDA    TEM1
0091 00130    000201            IAB
0092 00131    0 16 00155        MPY    RPTT
0093 00132    0 06 00164        ADD    HALF
0094 00133    000201            IAB
0095 00134    140040            CRA
0096 00135    0 06 00162        ADD    TEM2
0097 00136    0 04 00162        STA    TEM2
0098 00137    0 02 00160        LDA    TEM1
0099 00140    0 16 00156        MPY    RPTT+1
0100 00141    0 06 00164        ADD    HALF
0101 00142    140320            CSA
0102 00143    000201            IAB
0103 00144    140040            CRA
0104 00145    100001            SPC
0105 00146    140401            CMA
0106 00147    0 06 00162        ADD    TEM2
0107 00150    0 04 00750        STA    MC
0108 00151    0 35 00325        LDX    =-3
0109 00152    0 10 00000        CALL   SECA
0110 00153    0 04 00764        STA    '764
0111 00154   -0 01 00000        JMP*   ERDE
0112 00155    034476      RPTT  DEC    .4472135955BB0
     00156    022705
0113 00160    000000      TEM1  DBP    0
```

```
     00161   000000
0114 00162   000000      TEM2 DBP   0
     00163   000000
0115 00164   000000      HALF OCT   0,40000
     00165   040000
0116 00166   000007      DPAI DBL
0117 00167   0 02 00746       LDA   MB
0118 00170   0 06 00750       ADD   MC
0119 00171   0 06 00754       ADD   ME
0120 00172   0 07 00744       SUB   MA
0121 00173   0 07 00756       SUB   MF
0122 00174   0 04 00160       STA   TEM1
0123 00175   0 16 00155       MPY   RPTT
0124 00176   0 04 00162       STA   TEM2
0125 00177   0 02 00160       LDA   TEM1
0126 00200   000201           IAB
0127 00201   0 16 00155       MPY   RPTT
0128 00202   0 06 00164       ADD   HALF
0129 00203   000201           IAB
0130 00204   140040           CRA
0131 00205   0 06 00162       ADD   TEM2
0132 00206   0 04 00162       STA   TEM2
0133 00207   0 02 00160       LDA   TEM1
0134 00210   0 16 00156       MPY   RPTT+1
0135 00211   0 06 00164       ADD   HALF
0136 00212   140320           CSA
0137 00213   000201           IAB
0138 00214   140040           CRA
0139 00215   100001           SRC
0140 00216   140401           CMA
0141 00217   0 06 00162       ADD   TEM2
0142 00220   0 04 00752       STA   MD
0143 00221   0 35 00330       LDX   =-4
0144 00222   0 10 00000       CALL  SECA
0145 00223   0 04 00764       STA   '764
0146 00224  -0 01 00000       JMP*  ERDE
0147 00225   000007      EPAL DBL
0148 00226   0 02 00744       LDA   MA
0149 00227   0 06 00746       ADD   MB
0150 00230   0 06 00752       ADD   MD
0151 00231   0 07 00750       SUB   MC
0152 00232   0 07 00756       SUB   MF
0153 00233   0 04 00160       STA   TEM1
0154 00234   0 16 00155       MPY   RPTT
0155 00235   0 04 00162       STA   TEM2
0156 00236   0 02 00160       LDA   TEM1
0157 00237   000201           IAB
0158 00240   0 16 00155       MPY   RPTT
0159 00241   0 06 00164       ADD   HALF
0160 00242   000201           IAB
0161 00243   140040           CRA
0162 00244   0 06 00162       ADD   TEM2
0163 00245   0 04 00162       STA   TEM2
0164 00246   0 02 00160       LDA   TEM1
0165 00247   0 16 00156       MPY   RPTT+1
0166 00250   0 06 00164       ADD   HALF
0167 00251   140320           CSA
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0168 00252   000201           IAB
0169 00253   140040           CRA
0170 00254   100001           SRC
0171 00255   140401           CMA
0172 00256   0 06 00162       ADD    TEM2
0173 00257   0 04 00754       STA    ME
0174 00260   0 35 00324       LDX    =-5
0175 00261   0 10 00000       CALL   SECA
0176 00262   0 04 00764       STA    '764
0177 00263  -0 01 00000       JMP*   ERDE
0178 00264   000007      FFAL DBL
0179 00265   0 02 00744       LDA    MA
0180 00266   0 06 00746       ADD    MB
0181 00267   0 06 00750       ADD    MC
0182 00270   0 07 00752       SUB    MD
0183 00271   0 07 00754       SUB    ME
0184 00272   0 04 00160       STA    TEM1
0185 00273   0 16 00155       MPY    RPTT
0186 00274   0 04 00162       STA    TEM2
0187 00275   0 02 00160       LDA    TEM1
0188 00276   000201           IAB
0189 00277   0 16 00155       MPY    RPTT
0190 00300   0 06 00164       ADD    HALF
0191 00301   000201           IAB
0192 00302   140040           CRA
0193 00303   0 06 00162       ADD    TEM2
0194 00304   0 04 00162       STA    TEM2
0195 00305   0 02 00160       LDA    TEM1
0196 00306   0 16 00156       MPY    RPTT+1
0197 00307   0 06 00164       ADD    HALF
0198 00310   140320           CSA
0199 00311   000201           IAB
0200 00312   140040           CRA
0201 00313   100001           SRC
0202 00314   140401           CMA
0203 00315   0 06 00162       ADD    TEM2
0204 00316   0 04 00756       STA    MF
0205 00317   0 35 00323       LDX    =-6
0206 00320   0 10 00000       CALL   SECA
0207 00321   0 04 00764       STA    '764
0208 00322  -0 01 00000       JMP*   ERDE
0209         000744      MA   EQU    '744
0210         000746      MB   EQU    MA+2
0211         000750      MC   EQU    MA+4
0212         000752      MD   EQU    MA+6
0213         000754      ME   EQU    MD+2
0214         000756      MF   EQU    MD+4
0215 00323   177772           END
     00324   177773
     00325   177775
     00326   177776
     00327   177777
     00330   177774
     00331   177771
```

PROGRAM NAME
SOURCE: CFSE
BINARY: BCFSE
RELATED MEMOS: FAILURE ISOLATION IN SIRU (OEHRLE)
ENTRY POINTS (location): SECA ('06524)
GENERAL DESCRIPTION:

This subroutine, when called, will calculate either the first or second squared errors of instruments A-F from a set of accumulated measurements (MA - MF) stored in the base sector of the DDP 516, decide whether the total squared error is greater than some limit (also stored in the base sector) and if it is, decide if any instruments squared error exceeds a certain fraction (also stored in the base sector) of the total squared error. Then it will return with a code in the A register indicating the result of the above decisions. If during the calculations the error in any instrument exceeds or equals 2^{12} pulses (an overflow condition), or if the total squared error exceeds or equals 2^{24} pulses squared, the return code in the A register will indicate that the calculations could not be completed due to huge errors in one or more instruments.

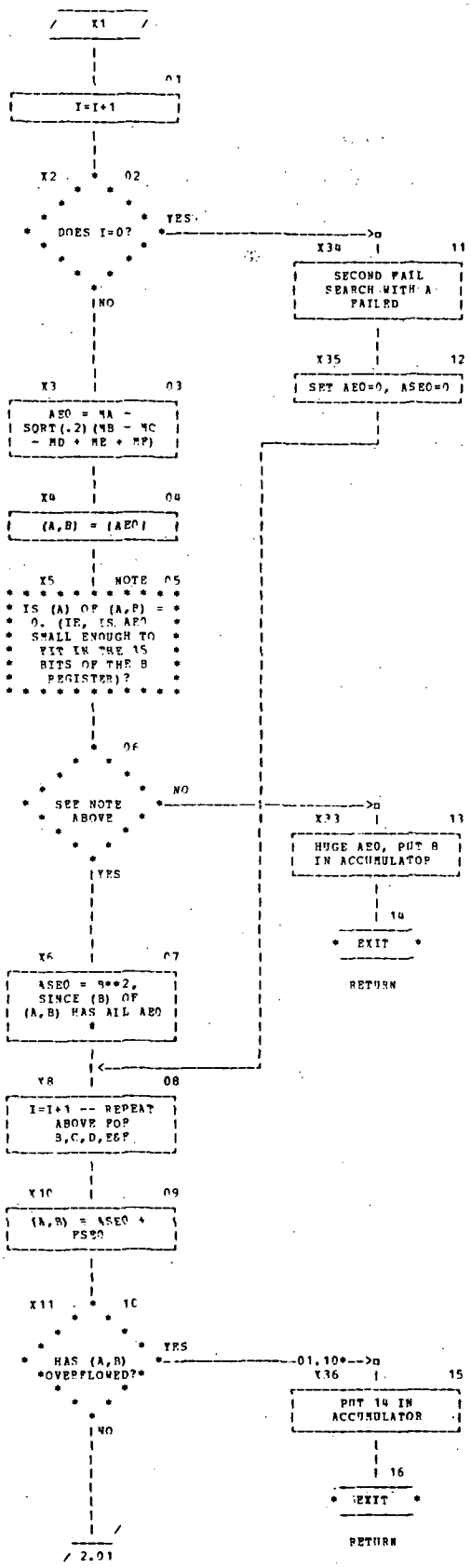
The arguments MA - MF (see documentation for subroutines GARC + PREX) are stored in locations '744 - '757 and are six double precision numbers. If the calling program (see documentation for subroutine ERDE) wishes the squared errors calculated for the second fail detection with say instrument A failed, it will replace MA with what MB - MF calculate for MA (substituting this new MA and the old MB - MF into the first fail equations calculates the second fail squared errors for instruments B - F and therefore, eliminates writing 6 sets of second fail equations) and put a -1 in the index register. If instrument B is failed it will calculate MB from the other 5 measurements and put a -2 in the index register, etc.

The following are the return codes:

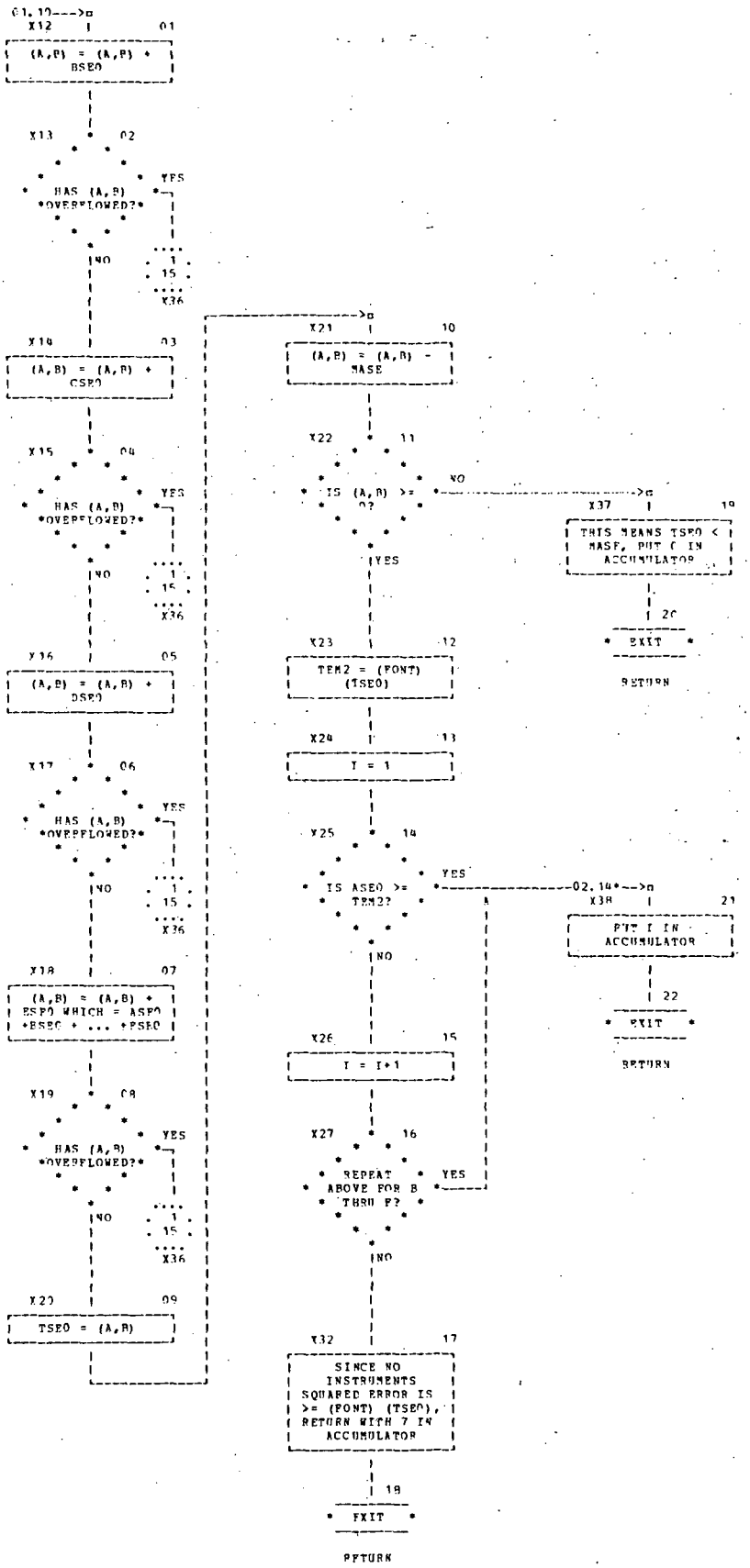
code	meaning
0	TSE (total squared error) did not exceed MASE (maximum allowable squared error stored in the base sector in location '760).
1-6	TSE0 did exceed MASE and the squared error of instrument A (for code 1) B (for code 2) etc. exceeded FONT TSE0 (FONT is the squared error ratio criteria to isolate a failure. It is .44 for a first fail isolation and .38 for a second fail isolation and is put in the base sector in location '762 by the calling program (see documentation for subroutines GFIS & PFIS).
7	TSE0 exceeded MASE but no instrument's squared error exceeded FONT TSE0
8-13	There was a huge error $\geq 2^{12}$ pulses when calculating the error of instrument A (for code of 8) B (for code of 9) etc.

14	In summing ASE0 through FSEO (A squared error through F squared error) to get TSE0, an overflow occurred (the sum was $\geq 2^{24}$ pulses squared)

The subroutine flow chart follows:



FLOWCHART - SECA


01,10---->α
X12
01
(A,B) = (A,B) + BSE0
X13
02
HAS (A,B) OVERFLOWED?
YES
NO
1, 15
X36
X14
03
(A,B) = (A,B) + CSE0
X15
04
HAS (A,B) OVERFLOWED?
YES
NO
1, 15
X36
X16
05
(A,B) = (A,B) + DSE0
X17
06
HAS (A,B) OVERFLOWED?
YES
NO
1, 15
X36
X18
07
(A,B) = (A,B) + ESE0 WHICH = ASE0 *BSE0 + ... +ZSE0
X19
08
HAS (A,B) OVERFLOWED?
YES
NO
1, 15
X36
X20
09
TSE0 = (A,B)
X21
10
(A,B) = (A,B) - BASE
X22
11
IS (A,B) >= 0?
NO
YES
X37
19
THIS MEANS TSE0 < BASE, PUT 0 IN ACCUMULATOR
20
EXIT
RETURN
X23
12
TEM2 = (FONT) (TSE0)
X24
13
I = 1
X25
14
IS ASE0 >= TEM2?
YES
NO
02, 14*-->α
X38
21
PUT I IN ACCUMULATOR
22
EXIT
RETURN
X26
15
I = I+1
X27
16
REPEAT ABOVE FOR B THRU Z?
YES
NO
X32
17
SINCE NO INSTRUMENTS SQUARED ERROR IS >= (FONT) (TSE0), RETURN WITH 7 IN ACCUMULATOR
18
EXIT
RETURN

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                SUBR  SECA
0002                                REL
0003 00000   0 000000   SECA DAC   **
0004 00001   000007         DBL
0005 00002   0 12 00000     IRS   0
0006 00003   0 01 00012     JMP   ACAL
0007 00004   140040         CRA
0008 00005   000201         IAB
0009 00006   140040         CRA
0010 00007   0 04 00224     STA   AE0
0011 00010   0 04 00326     STA   ASE0
0012 00011   0 01 00060     JMP   BTFC
0013 00012   0 02 00750 ACAL LDA   MC
0014 00013   0 06 00752     ADD   MD
0015 00014   0 07 00746     SUB   MB
0016 00015   0 07 00754     SUB   ME
0017 00016   0 07 00756     SUB   MF
0018 00017   0 04 00216     STA   TEM1
0019 00020   0 16 00213     MPY   RPTT
0020 00021   0 04 00220     STA   TEM2
0021 00022   0 02 00216     LDA   TEM1
0022 00023   000201         IAB
0023 00024   0 16 00213     MPY   RPTT
0024 00025   0 06 00222     ADD   HALF
0025 00026   000201         IAB
0026 00027   140040         CRA
0027 00030   0 06 00220     ADD   TEM2
0028 00031   0 04 00220     STA   TEM2
0029 00032   0 02 00216     LDA   TEM1
0030 00033   0 16 00214     MPY   RPTT+1
0031 00034   0 06 00222     ADD   HALF
0032 00035   140320         CSA
0033 00036   000201         IAB
0034 00037   140040         CRA
0035 00040   100001         SRC
0036 00041   140401         CMA
0037 00042   0 06 00220     ADD   TEM2
0038 00043   0 06 00744     ADD   MA
0039 00044   0 04 00224     STA   AE0
0040 00045   101400         SMI
0041 00046   0 01 00051     JMP   AEPO
0042 00047   0 07 00224     SUB   AE0
0043 00050   0 07 00224     SUB   AE0
0044 00051   101040   AEPO SNZ
0045 00052   0 01 00054     JMP   SESE
0046 00053   0 01 00565     JMP   HUAE
0047 00054   000201   SESE IAB
0048 00055   0 04 00326     STA   ASE0
0049 00056   0 16 00326     MPY   ASE0
0050 00057   0 04 00326     STA   ASE0
0051 00060   0 12 00000 BTFC IRS   0
0052 00061   0 01 00070     JMP   BCAL
0053 00062   140040         CRA
0054 00063   000201         IAB
0055 00064   140040         CRA
0056 00065   0 04 00226     STA   BE0
0057 00066   0 04 00330     STA   BSE0
```

```
0058 00067   0 01 00141      JMP   CTPC
0059 00070   140040     BCAL CRA
0060 00071   000201          IAB
0061 00072   140040          CRA
0062 00073   0 07 00744      SUB   MA
0063 00074   0 07 00750      SUB   MC
0064 00075   0 07 00752      SUB   MD
0065 00076   0 07 00754      SUB   ME
0066 00077   0 07 00756      SUB   MF
0067 00100   0 04 00216      STA   TEM1
0068 00101   0 16 00213      MPY   RPTT
0069 00102   0 04 00220      STA   TEM2
0070 00103   0 02 00216      LDA   TEM1
0071 00104   000201          IAB
0072 00105   0 16 00213      MPY   RPTT
0073 00106   0 06 00222      ADD   HALF
0074 00107   000201          IAB
0075 00110   140040          CRA
0076 00111   0 06 00220      ADD   TEM2
0077 00112   0 04 00220      STA   TEM2
0078 00113   0 02 00216      LDA   TEM1
0079 00114   0 16 00214      MPY   RPTT+1
0080 00115   0 06 00222      ADD   HALF
0081 00116   140320          CSA
0082 00117   000201          IAB
0083 00120   140040          CRA
0084 00121   100001          SRC
0085 00122   140401          CMA
0086 00123   0 06 00220      ADD   TEM2
0087 00124   0 06 00746      ADD   MB
0088 00125   0 04 00226      STA   BE0
0089 00126   101400          SMI
0090 00127   0 01 00132      JMP   BEPO
0091 00130   0 07 00226      SUB   BE0
0092 00131   0 07 00226      SUB   BE0
0093 00132   101040     BEPO SNZ
0094 00133   0 01 00135      JMP   LTSE
0095 00134   0 01 00570      JMP   HUBE
0096 00135   000201     LTSE IAB
0097 00136   0 04 00330      STA   BSE0
0098 00137   0 16 00330      MPY   BSE0
0099 00140   0 04 00330      STA   BSE0
0100 00141   0 12 00000 CTPC IRS   0
0101 00142   0 01 00151      JMP   CCAL
0102 00143   140040          CRA
0103 00144   000201          IAB
0104 00145   140040          CRA
0105 00146   0 04 00230      STA   CE0
0106 00147   0 04 00332      STA   CSE0
0107 00150   0 01 00244      JMP   DTFC
0108 00151   0 02 00744 CCAL LDA   MA
0109 00152   0 06 00754      ADD   ME
0110 00153   0 07 00746      SUB   MB
0111 00154   0 07 00752      SUB   MD
0112 00155   0 07 00756      SUB   MF
0113 00156   0 04 00216      STA   TEM1
0114 00157   0 16 00213      MPY   RPTT
```

```
0115 00160   0 04 00220        STA   TEM2
0116 00161   0 02 00216        LDA   TEM1
0117 00162   000201            IAB
0118 00163   0 16 00213        MPY   RPTT
0119 00164   0 06 00222        ADD   HALF
0120 00165   000201            IAB
0121 00166   140040            CRA
0122 00167   0 06 00220        ADD   TEM2
0123 00170   0 04 00220        STA   TEM2
0124 00171   0 02 00216        LDA   TEM1
0125 00172   0 16 00214        MPY   RPTT+1
0126 00173   0 06 00222        ADD   HALF
0127 00174   140320            CSA
0128 00175   000201            IAB
0129 00176   140040            CRA
0130 00177   100001            SRC
0131 00200   140401            CMA
0132 00201   0 06 00220        ADD   TEM2
0133 00202   0 06 00750        ADD   MC
0134 00203   0 04 00230        STA   CE0
0135 00204   101400            SMI
0136 00205   0 01 00210        JMP   CEPO
0137 00206   0 07 00230        SUB   CE0
0138 00207   0 07 00230        SUB   CE0
0139 00210   101040     CEPO  SNZ
0140 00211   0 01 00240        JMP   NBSE
0141 00212   0 01 00573        JMP   HUCE
0142 00213   034476     RPTT  DEC   .4472135955BB0
     00214   022705
0143 00216   000000     TEM1  DBP   0
     00217   000000
0144 00220   000000     TEM2  DBP   0
     00221   000000
0145 00222   000000     HALF  OCT   0,40000
     00223   040000
0146 00224   000000     AE0   DBP   0
     00225   000000
0147 00226   000000     BE0   DBP   0
     00227   000000
0148 00230   000000     CE0   DBP   0
     00231   000000
0149 00232   000000     DE0   DBP   0
     00233   000000
0150 00234   000000     EE0   DBP   0
     00235   000000
0151 00236   000000     FE0   DBP   0
     00237   000000
0152         000326     ASE0  EQU   '326
0153         000330     BSE0  EQU   '330
0154         000332     CSE0  EQU   '332
0155         000436     DSE0  EQU   '436
0156         000440     ESE0  EQU   '440
0157         000442     FSE0  EQU   '442
0158         000574     TSE0  EQU   '574
0159 00240   000201     NBSE  IAB
0160 00241   0 04 00332        STA   CSE0
0161 00242   0 16 00332        MPY   CSE0
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0162 00243    0 04 00332       STA   CSE0
0163 00244    0 12 00000 DTFC  IRS   0
0164 00245    0 01 00254       JMP   DCAL
0165 00246    140040           CRA
0166 00247    000201           IAB
0167 00250    140040           CRA
0168 00251    0 04 00232       STA   DE0
0169 00252    0 04 00436       STA   DSE0
0170 00253    0 01 00322       JMP   ETFC
0171 00254    0 02 00744 DCAL  LDA   MA
0172 00255    0 06 00756       ADD   MF
0173 00256    0 07 00746       SUB   MB
0174 00257    0 07 00750       SUB   MC
0175 00260    0 07 00754       SUB   ME
0176 00261    0 04 00216       STA   TEM1
0177 00262    0 16 00213       MPY   RPTT
0178 00263    0 04 00220       STA   TEM2
0179 00264    0 02 00216       LDA   TEM1
0180 00265    000201           IAB
0181 00266    0 16 00213       MPY   RPTT
0182 00267    0 06 00222       ADD   HALF
0183 00270    000201           IAB
0184 00271    140040           CRA
0185 00272    0 06 00220       ADD   TEM2
0186 00273    0 04 00220       STA   TEM2
0187 00274    0 02 00216       LDA   TEM1
0188 00275    0 16 00214       MPY   RPTT+1
0189 00276    0 06 00222       ADD   HALF
0190 00277    140320           CSA
0191 00300    000201           IAB
0192 00301    140040           CRA
0193 00302    100001           SRC
0194 00303    140401           CMA
0195 00304    0 06 00220       ADD   TEM2
0196 00305    0 06 00752       ADD   MD
0197 00306    0 04 00232       STA   DE0
0198 00307    101400           SMI
0199 00310    0 01 00313       JMP   DEPO
0200 00311    0 07 00232       SUB   DE0
0201 00312    0 07 00232       SUB   DE0
0202 00313    101040     DEPO  SNZ
0203 00314    0 01 00316       JMP   RSSE
0204 00315    0 01 00576       JMP   HUDE
0205 00316    000201     RSSE  IAB
0206 00317    0 04 00436       STA   DSE0
0207 00320    0 16 00436       MPY   DSE0
0208 00321    0 04 00436       STA   DSE0
0209 00322    0 12 00000 ETFC  IRS   0
0210 00323    0 01 00332       JMP   ECAL
0211 00324    140040           CRA
0212 00325    000201           IAB
0213 00326    140040           CRA
0214 00327    0 04 00234       STA   EE0
0215 00330    0 04 00440       STA   ESE0
0216 00331    0 01 00400       JMP   FTFC
0217 00332    0 02 00750 ECAL  LDA   MC
0218 00333    0 06 00756       ADD   MF
```

```
0219 00334    0 07 00744        SUB   MA
0220 00335    0 07 00746        SUB   MB
0221 00336    0 07 00752        SUB   MD
0222 00337    0 04 00216        STA   TEM1
0223 00340    0 16 00213        MPY   RPTT
0224 00341    0 04 00220        STA   TEM2
0225 00342    0 02 00216        LDA   TEM1
0226 00343    000201            IAB
0227 00344    0 16 00213        MPY   RPTT
0228 00345    0 06 00222        ADD   HALF
0229 00346    000201            IAB
0230 00347    140040            CRA
0231 00350    0 06 00220        ADD   TEM2
0232 00351    0 04 00220        STA   TEM2
0233 00352    0 02 00216        LDA   TEM1
0234 00353    0 16 00214        MPY   RPTT+1
0235 00354    0 06 00222        ADD   HALF
0236 00355    140320            CSA
0237 00356    000201            IAB
0238 00357    140040            CRA
0239 00360    100001            SRC
0240 00361    140401            CMA
0241 00362    0 06 00220        ADD   TEM2
0242 00363    0 06 00754        ADD   ME
0243 00364    0 04 00234        STA   EE0
0244 00365    101400            SMI
0245 00366    0 01 00371        JMP   EEPO
0246 00367    0 07 00234        SUB   EE0
0247 00370    0 07 00234        SUB   EE0
0248 00371    101040    EEPO    SNZ
0249 00372    0 01 00374        JMP   LESE
0250 00373    0 01 00601        JMP   HUEE
0251 00374    000201    LESE    IAB
0252 00375    0 04 00440        STA   ESE0
0253 00376    0 16 00440        MPY   ESE0
0254 00377    0 04 00440        STA   ESE0
0255 00400    0 12 00000 FTFC   IRS   0
0256 00401    0 01 00410        JMP   FCAL
0257 00402    140040            CRA
0258 00403    000201            IAB
0259 00404    140040            CRA
0260 00405    0 04 00236        STA   FE0
0261 00406    0 04 00442        STA   FSE0
0262 00407    0 01 00456        JMP   NTFC
0263 00410    0 02 00752 FCAL   LDA   MD
0264 00411    0 06 00754        ADD   ME
0265 00412    0 07 00744        SUB   MA
0266 00413    0 07 00746        SUB   MB
0267 00414    0 07 00750        SUB   MC
0268 00415    0 04 00216        STA   TEM1
0269 00416    0 16 00213        MPY   RPTT
0270 00417    0 04 00220        STA   TEM2
0271 00420    0 02 00216        LDA   TEM1
0272 00421    000201            IAB
0273 00422    0 16 00213        MPY   RPTT
0274 00423    0 06 00222        ADD   HALF
0275 00424    000201            IAB
```

```
0276 00425   140040          CRA
0277 00426   0 06 00220       ADD   TEM2
0278 00427   0 04 00220       STA   TEM2
0279 00430   0 02 00216       LDA   TEM1
0280 00431   0 16 00214       MPY   RPTT+1
0281 00432   0 06 00222       ADD   HALF
0282 00433   140320          CSA
0283 00434   000201          IAB
0284 00435   140040          CRA
0285 00436   100001          SRC
0286 00437   140401          CMA
0287 00440   0 06 00220       ADD   TEM2
0288 00441   0 06 00756       ADD   MF
0289 00442   0 04 00236       STA   FE0
0290 00443   101400          SMI
0291 00444   0 01 00447       JMP   FEPO
0292 00445   0 07 00236       SUB   FE0
0293 00446   0 07 00236       SUB   FE0
0294 00447   101040      FEPO SNZ
0295 00450   0 01 00452       JMP   VMSE
0296 00451   0 01 00604       JMP   HUFE
0297 00452   000201      VMSE IAB
0298 00453   0 04 00442       STA   FSE0
0299 00454   0 16 00442       MPY   FSE0
0300 00455   0 04 00442       STA   FSE0
0301 00456   0 06 00326 NTFC  ADD   ASE0
0302 00457   100001          SRC
0303 00460   0 01 00562       JMP   OVFL
0304 00461   0 06 00330       ADD   BSE0
0305 00462   100001          SRC
0306 00463   0 01 00562       JMP   OVFL
0307 00464   0 06 00332       ADD   CSE0
0308 00465   100001          SRC
0309 00466   0 01 00562       JMP   OVFL
0310 00467   0 06 00436       ADD   DSE0
0311 00470   100001          SRC
0312 00471   0 01 00562       JMP   OVFL
0313 00472   0 06 00440       ADD   ESE0
0314 00473   100001          SRC
0315 00474   0 01 00562       JMP   OVFL
0316 00475   0 04 00574       STA   TSE0
0317 00476   0 07 00760       SUB   MASE
0318 00477   102400          SPL
0319 00500   0 01 00557       JMP   ZRTU
0320 00501   0 02 00574       LDA   TSE0
0321 00502   0 16 00762       MPY   FONT
0322 00503   0 04 00220       STA   TEM2
0323 00504   0 02 00574       LDA   TSE0
0324 00505   000201          IAB
0325 00506   0 16 00762       MPY   FONT
0326 00507   000201          IAB
0327 00510   140040          CRA
0328 00511   0 06 00220       ADD   TEM2
0329 00512   0 04 00220       STA   TEM2
0330 00513   0 35 00617       LDX   =1
0331 00514   0 02 00326       LDA   ASE0
0332 00515   0 07 00220       SUB   TEM2
```

```
0333 00516   101400            SMI
0334 00517   0 01 00554         JMP   FOND
0335 00520   0 12 00000         IRS   0
0336 00521   0 02 00330         LDA   BSE0
0337 00522   0 07 00220         SUB   TEM2
0338 00523   101400            SMI
0339 00524   0 01 00554         JMP   FOND
0340 00525   0 12 00000         IRS   0
0341 00526   0 02 00332         LDA   CSE0
0342 00527   0 07 00220         SUB   TEM2
0343 00530   101400            SMI
0344 00531   0 01 00554         JMP   FOND
0345 00532   0 12 00000         IRS   0
0346 00533   0 02 00436         LDA   DSE0
0347 00534   0 07 00220         SUB   TEM2
0348 00535   101400            SMI
0349 00536   0 01 00554         JMP   FOND
0350 00537   0 12 00000         IRS   0
0351 00540   0 02 00440         LDA   ESE0
0352 00541   0 07 00220         SUB   TEM2
0353 00542   101400            SMI
0354 00543   0 01 00554         JMP   FOND
0355 00544   0 12 00000         IRS   0
0356 00545   0 02 00442         LDA   FSE0
0357 00546   0 07 00220         SUB   TEM2
0358 00547   101400            SMI
0359 00550   0 01 00554         JMP   FOND
0360 00551   000005            SGL
0361 00552   0 02 00616         LDA   =7
0362 00553  -0 01 00000         JMP*  SECA
0363 00554   000005      FOND  SGL
0364 00555   0 02 00000         LDA   0
0365 00556  -0 01 00000         JMP*  SECA
0366 00557   000005      ZPTU  SGL
0367 00560   140040            CRA
0368 00561  -0 01 00000         JMP*  SECA
0369 00562   000005      OVFL  SGL
0370 00563   0 02 00615         LDA   =14
0371 00564  -0 01 00000         JMP*  SECA
0372 00565   000005      HUAE  SGL
0373 00566   0 02 00614         LDA   =8
0374 00567  -0 01 00000         JMP*  SECA
0375 00570   000005      HUBE  SGL
0376 00571   0 02 00613         LDA   =9
0377 00572  -0 01 00000         JMP*  SECA
0378 00573   000005      HUCE  SGL
0379 00574   0 02 00612         LDA   =10
0380 00575  -0 01 00000         JMP*  SECA
0381 00576   000005      HUDE  SGL
0382 00577   0 02 00611         LDA   =11
0383 00600  -0 01 00000         JMP*  SECA
0384 00601   000005      HUEE  SGL
0385 00602   0 02 00610         LDA   =12
0386 00603  -0 01 00000         JMP*  SECA
0387 00604   000005      HUFE  SGL
0388 00605   0 02 00607         LDA   =13
0389 00606  -0 01 00000         JMP*  SECA
```

```
0390           000762      FONT EQU   '762
0391           000744      MA   EQU   '744
0392           000746      MB   EQU   MA+2
0393           000750      MC   EQU   MA+4
0394           000752      MD   EQU   MA+6
0395           000754      ME   EQU   MD+2
0396           000756      MF   EQU   MD+4
0397           000760      MASE EQU   '760
0398 00607     000015           END
     00610     000014
     00611     000013
     00612     000012
     00613     000011
     00614     000010
     00615     000016
     00616     000007
     00617     000001
```

PROGRAM NAME
SOURCE: PFIS
BINARY: BPFIS
ENTRY POINTS (location): PFIS ('04725)
ACCESSIBLE VARIABLES (location): KEYP ('05050)
GENERAL DESCRIPTION:

This subroutine controls the logic for the PIPA failure detection and isolation. It is identical to the subroutine GFIS, which controls the gyro failure detection and isolation, except that the PIPA fail status is contained in location '320 and '321 instead of '316 and '317 and that the PIPA maximum allowable squared errors (FMSE and SMSE) are not modified at the beginning of this subroutine as are the gyro's at the beginning of GFIS. So see documentation for the subroutine GFIS.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR  PFIS
0003                                  SUBR  KEYP
0004 00000    0 000000    PFIS DAC    **
0005 00001    0 02 00320       LDA    '320
0006 00002    100040           SZE
0007 00003    0 01 00016       JMP    ALOF
0008 00004    140040      FFTR CRA
0009 00005    0 04 00122       STA    KEYP
0010 00006    0 04 00763       STA    '763
0011 00007    0 02 00117       LDA    FFRT
0012 00010    0 04 00762       STA    '762
0013 00011    000007           DBL
0014 00012    0 02 00124       DLD    FMSE
0015 00013    0 04 00760       DST    '760
0016 00014    000005           SGL
0017 00015    0 01 00032       JMP    COCA
0018 00016    0 02 00122 ALOF  LDA    KEYP
0019 00017    100040           SZE
0020 00020    0 01 00004       JMP    FFTR
0021 00021    0 02 00320       LDA    '320
0022 00022    0 04 00122       STA    KEYP
0023 00023    0 04 00763       STA    '763
0024 00024    0 02 00120       LDA    SFRT
0025 00025    0 04 00762       STA    '762
0026 00026    000007           DBL
0027 00027    0 02 00126       DLD    SMSE
0028 00030    0 04 00760       DST    '760
0029 00031    000005           SGL
0030 00032    0 10 00000 COCA  CALL   ERDE
0031 00033    0 02 00122       LDA    KEYP
0032 00034    100040           SZE
0033 00035    0 01 00103       JMP    SFSR
0034 00036    0 02 00764       LDA    '764
0035 00037    100040           SZE
0036 00040    0 01 00047       JMP    NOZE
0037 00041    100004           SR3
0038 00042   -0 01 00000       JMP*   PFIS
0039 00043    140040           CRA
0040 00044    0 04 00320       STA    '320
0041 00045    0 04 00321       STA    '321
0042 00046   -0 01 00000       JMP*   PFIS
0043 00047    0 07 00130 NOZE  SUB    =7
0044 00050    101400           SMI
0045 00051   -0 01 00000       JMP*   PFIS
0046 00052    0 02 00764       LDA    '764
0047 00053    0 11 00320       CAS    '320
0048 00054    0 01 00056       JMP    *+2
0049 00055   -0 01 00000       JMP*   PFIS
0050 00056    0 11 00321       CAS    '321
0051 00057    0 01 00061       JMP    *+2
0052 00060    0 01 00076       JMP    SPCA
0053 00061    0 02 00320       LDA    '320
0054 00062    101040           SNZ
0055 00063    0 01 00071       JMP    *+6
0056 00064    0 02 00321       LDA    '321
0057 00065    101040           SNZ
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0058 00066    0 01 00076       JMP   SPCA
0059 00067    100004           SR3
0060 00070   -0 01 00000       JMP*  PFIS
0061 00071    0 02 00764       LDA   '764
0062 00072    0 04 00320       STA   '320
0063 00073    140040           CRA
0064 00074    0 04 00321       STA   '321
0065 00075   -0 01 00000       JMP*  PFIS
0066 00076    0 02 00320 SPCA  LDA   '320
0067 00077    0 04 00321       STA   '321
0068 00100    0 02 00764       LDA   '764
0069 00101    0 04 00320       STA   '320
0070 00102   -0 01 00000       JMP*  PFIS
0071 00103    0 02 00764 SFSR  LDA   '764
0072 00104    0 07 00130       SUB   =7
0073 00105    101400           SMI
0074 00106   -0 01 00000       JMP*  PFIS
0075 00107    0 02 00321       LDA   '321
0076 00110    101040           SNZ
0077 00111    0 01 00114       JMP   *+3
0078 00112    100004           SR3
0079 00113   -0 01 00000       JMP*  PFIS
0080 00114    0 02 00764       LDA   '764
0081 00115    0 04 00321       STA   '321
0082 00116   -0 01 00000       JMP*  PFIS
0083 00117    034343      FFRT OCT   34343
0084 00120    030600      SFRT OCT   30600
0085 00122    000000      KEYP DBP   0
     00123    000000
0086 00124    000000      FMSE OCT   0,20000
     00125    020000
0087 00126    000000      SMSE OCT   0,14632
     00127    014632
0088 00130    000007           END
```

PROGRAM NAME
SOURCE: GPRT
BINARY: BGPRT
ENTRY POINT (location): GPRT ('12712)
GENERAL DESCRIPTION:

This subroutine, when called, will in turn call PRTY to solve for the gyro parity equation if there are already 2 gyro failures. If the appropriate parity equation indicates an overflow or exceeds a certain limit it will store a 1 in octal location 322. Otherwise, octal location 322 will stay zero. The limit the equation must exceed (GMSE) is three pulses (GBSE = OCT 0, 30) plus some appropriate fraction of the

$$\sum \left|\Delta\theta_x\right| + \left|\Delta\theta_y\right| + \left|\Delta\theta_z\right|$$

which is stored in '774 by the gyro error accumulator GARC and allows for dynamic errors. This limit is calculated by the first four instructions of this subroutine.

GPRT will then set ('322) to zero and determine if there are 2 gyro failures (the gyro first and second fails are stored in octal locations 316 and 317). If there are not 2 failures, it will return. Otherwise, it calculates in the A register the code necessary to tell PRTY which parity equation to calculate. The codes are:

Parity Equation	2 failures	code
CDEF	A, B	0
BDEF	A, C	7
BCEF	A, D	14
BCDF	A, E	21
BCDE	A, F	28
ADEF	B, C	35
ACEF	B, D	42
ACDF	B, E	49
ACDE	B, F	56
ABEF	C, D	63
ABDF	C, E	70
ABDE	C, F	77
ABCF	D, E	84
ABCE	D, F	91
ABCD	E, F	98

The general method for calculating the code is the same as that used by GMIN for the gyro matrix generator. When PRTY returns, GPRT determines if the parity equation either exceeds its limit or has overflowed. In either case, it will indicate so by changing octal location 322 to a 1 before returning.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                              SUBR  GPRT
0002                              REL
0003 00000    0 000000    GPRT  DAC   **
0004 00001    0 02 00774        LDA   '774
0005 00002    0405 75           ARS   3
0006 00003    0 06 00053        ADD   GBSE+1
0007 00004    0 04 00051        STA   GMSE+1
0008 00005    140040            CRA
0009 00006    0 04 00322        STA   '322
0010 00007    0 02 00317        LDA   '317
0011 00010    101040            SNZ
0012 00011   -0 01 00000        JMP*  GPRT
0013 00012    0 11 00316        CAS   '316
0014 00013    0 01 00024        JMP   SFLA
0015 00014    101000            NOP
0016 00015    0 06 00045        ADD   ADST
0017 00016    0 04 00046        STA   IDPT
0018 00017    0 02 00316        LDA   '316
0019 00020    0415 75           ALS   3
0020 00021    0 07 00316        SUB   '316
0021 00022   -0 06 00046        ADD*  IDPT
0022 00023    0 01 00033        JMP   PRCL
0023 00024    0 02 00316 SFLA   LDA   '316
0024 00025    0 06 00045        ADD   ADST
0025 00026    0 04 00046        STA   IDPT
0026 00027    0 02 00317        LDA   '317
0027 00030    0415 75           ALS   3
0028 00031    0 07 00317        SUB   '317
0029 00032   -0 06 00046        ADD*  IDPT
0030 00033    0 10 00000 PRCL   CALL  PRTY
0031 00034    101000            NOP
0032 00035    100400            SPL
0033 00036    0 01 00042        JMP   OVRF
0034 00037    000007            DBL
0035 00040    0 07 00050        DSB   GMSE
0036 00041    101400            SMI
0037 00042    0 12 00322 OVRF   IRS   '322
0038 00043    000005            SGL
0039 00044   -0 01 00000        JMP*  GPRT
0040 00045    0 000054    ADST  DAC   CRPS
0041 00046    000000      IDPT  DBP   0
     00047    000000
0042 00050    000000      GMSE  OCT   0,30
     00051    000030
0043 00052    000000      GBSE  OCT   0,30
     00053    000030
0044 00054    000000      CRPS  OCT   0,177762,16,43,61,70
     00055    177762
     00056    000016
     00057    000043
     00060    000061
     00061    000070
0045                              END
```

PROGRAM NAME:
SOURCE: PRTY
BINARY: BPRTY
ENTRY POINTS (location): PRTY ('12774)
GENERAL DESCRIPTION:

This subroutine calculates the parity equation used to detect third failures from the arguments stored in locations '744 - '757 by the gyro or PIPA error accumulators. It is called by GPRT if and when the gyro fail status indicates 2 failures and by PPRT (program source name PPEX) if and when the PIPA fail status indicates 2 failures. When called the A register contains a code to tell which of the fifteen parity equations to calculate (see documentation for GPRT). For example, if instruments C and F were failed, the code would be 77 (octal 115) and the JMP* PONT, the fifth instruction in PRTY would effect a jump to the block of code: (note, at this point the (A, B) register contains a double precision zero).

```
DSB     MB
DSB     ME
DST     SINT
DLD     MA
DAD     MD
DST     COST
JMP     CALC
```

SINT is the sine term of the parity equation = - MB - ME. COST is the cosine term of the parity equation = MA + MD. Each of the 15 parity equations has a block of code (7 instructions each) similar to the block above. The jump to CALC will start a sequence of instructions which will multiply SINT by SINE = sine α and COST by COSN = cosine α and then add the two results and take the absolute value. If the high order word of this double precision result is zero (which indicates that the absolute value of the parity equation is less than 2^{15} or 2^{12} instrument pulses), this subroutine will return with the parity equation result in the (A, B) register. If the high order word is not zero, (A, B) will contain a double precision -1 at the return.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    SUBR  PRTY
0002                                    REL
0003 00000    0 000000    PRTY  DAC     **
0004 00001    0 06 00252        ADD     ADAB
0005 00002    0 04 00253        STA     PONT
0006 00003    000007            DBL
0007 00004    0 02 00232        DLD     DZRO
0008 00005   -0 01 00253        JMP*    PONT
0009 00006    0 02 00752  ABFA  DLD     MD
0010 00007    0 07 00750        DSB     MC
0011 00010    0 04 00236        DST     COST
0012 00011    0 02 00756        DLD     MF
0013 00012    0 07 00754        DSB     ME
0014 00013    0 04 00234        DST     SINT
0015 00014    0 01 00156        JMP     CALC
0016 00015    0 02 00752        DLD     MD
0017 00016    0 06 00754        DAD     ME
0018 00017    0 04 00234        DST     SINT
0019 00020    0 02 00756        DLD     MF
0020 00021    0 07 00746        DSB     MB
0021 00022    0 04 00236        DST     COST
0022 00023    0 01 00156        JMP     CALC
0023 00024    0 02 00750        DLD     MC
0024 00025    0 06 00756        DAD     MF
0025 00026    0 04 00234        DST     SINT
0026 00027    0 02 00754        DLD     ME
0027 00030    0 07 00746        DSB     MB
0028 00031    0 04 00236        DST     COST
0029 00032    0 01 00156        JMP     CALC
0030 00033    0 07 00746        DSB     MB
0031 00034    0 07 00750        DSB     MC
0032 00035    0 04 00234        DST     SINT
0033 00036    0 02 00752        DLD     MD
0034 00037    0 06 00756        DAD     MF
0035 00040    0 04 00236        DST     COST
0036 00041    0 01 00156        JMP     CALC
0037 00042    0 07 00746        DSB     MB
0038 00043    0 07 00752        DSB     MD
0039 00044    0 04 00234        DST     SINT
0040 00045    0 02 00750        DLD     MC
0041 00046    0 06 00754        DAD     ME
0042 00047    0 04 00236        DST     COST
0043 00050    0 01 00156        JMP     CALC
0044 00051    0 02 00754        DLD     ME
0045 00052    0 07 00744        DSB     MA
0046 00053    0 04 00236        DST     COST
0047 00054    0 02 00756        DLD     MF
0048 00055    0 07 00752        DSB     MD
0049 00056    0 04 00234        DST     SINT
0050 00057    0 01 00156        JMP     CALC
0051 00060    0 02 00744        DLD     MA
0052 00061    0 07 00756        DSB     MF
0053 00062    0 04 00236        DST     COST
0054 00063    0 02 00750        DLD     MC
0055 00064    0 07 00754        DSB     ME
0056 00065    0 04 00234        DST     SINT
0057 00066    0 01 00156        JMP     CALC
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0058 00067   0 02 00744       DLD   MA
0059 00070   0 07 00752       DSB   MD
0060 00071   0 04 00234       DST   SINT
0061 00072   0 02 00750       DLD   MC
0062 00073   0 07 00756       DSB   MF
0063 00074   0 04 00236       DST   COST
0064 00075   0 01 00156       JMP   CALC
0065 00076   0 02 00744       DLD   MA
0066 00077   0 07 00750       DSB   MC
0067 00100   0 04 00234       DST   SINT
0068 00101   0 02 00752       DLD   MD
0069 00102   0 07 00754       DSB   ME
0070 00103   0 04 00236       DST   COST
0071 00104   0 01 00156       JMP   CALC
0072 00105   0 07 00744       DSB   MA
0073 00106   0 07 00746       DSB   MB
0074 00107   0 04 00234       DST   SINT
0075 00110   0 02 00754       DLD   ME
0076 00111   0 06 00756       DAD   MF
0077 00112   0 04 00236       DST   COST
0078 00113   0 01 00156       JMP   CALC
0079 00114   0 02 00744       DLD   MA
0080 00115   0 06 00756       DAD   MF
0081 00116   0 04 00234       DST   SINT
0082 00117   0 02 00752       DLD   MD
0083 00120   0 07 00746       DSB   MB
0084 00121   0 04 00236       DST   COST
0085 00122   0 01 00156       JMP   CALC
0086 00123   0 07 00746       DSB   MB
0087 00124   0 07 00754       DSB   ME
0088 00125   0 04 00234       DST   SINT
0089 00126   0 02 00744       DLD   MA
0090 00127   0 06 00752       DAD   MD
0091 00130   0 04 00236       DST   COST
0092 00131   0 01 00156       JMP   CALC
0093 00132   0 07 00746       DSB   MB
0094 00133   0 07 00756       DSB   MF
0095 00134   0 04 00234       DST   SINT
0096 00135   0 02 00744       DLD   MA
0097 00136   0 06 00750       DAD   MC
0098 00137   0 04 00236       DST   COST
0099 00140   0 01 00156       JMP   CALC
0100 00141   0 02 00744       DLD   MA
0101 00142   0 06 00754       DAD   ME
0102 00143   0 04 00234       DST   SINT
0103 00144   0 02 00750       DLD   MC
0104 00145   0 07 00746       DSB   MB
0105 00146   0 04 00236       DST   COST
0106 00147   0 01 00156       JMP   CALC
0107 00150   0 02 00744       DLD   MA
0108 00151   0 07 00746       DSB   MB
0109 00152   0 04 00236       DST   COST
0110 00153   0 02 00750       DLD   MC
0111 00154   0 06 00752       DAD   MD
0112 00155   0 04 00234       DST   SINT
0113 00156   0 02 00234 CALC  DLD   SINT
0114 00157   0 16 00245       MPY   SINE+1
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0115 00160    0401 77          LRS    1
0116 00161    0 04 00240       DST    TEM1
0117 00162    0 02 00244       DLD    SINE
0118 00163    0 16 00235       MPY    SINT+1
0119 00164    0401 77          LRS    1
0120 00165    0 06 00240       DAD    TEM1
0121 00166    0 06 00250       DAD    HALF
0122 00167    0401 62          LRS    14
0123 00170    0 04 00240       DST    TEM1
0124 00171    0 02 00234       DLD    SINT
0125 00172    0 16 00244       MPY    SINE
0126 00173    0 06 00240       DAD    TEM1
0127 00174    0 04 00234       DST    SINT
0128 00175    0 02 00236       DLD    COST
0129 00176    0 16 00247       MPY    COSN+1
0130 00177    0401 77          LRS    1
0131 00200    0 04 00240       DST    TEM1
0132 00201    0 02 00246       DLD    COSN
0133 00202    0 16 00237       MPY    COST+1
0134 00203    0401 77          LRS    1
0135 00204    0 06 00240       DAD    TEM1
0136 00205    0 06 00250       DAD    HALF
0137 00206    0401 62          LRS    14
0138 00207    0 04 00240       DST    TEM1
0139 00210    0 02 00236       DLD    COST
0140 00211    0 16 00246       MPY    COSN
0141 00212    0 06 00240       DAD    TEM1
0142 00213    0 06 00234       DAD    SINT
0143 00214    0 04 00236       DST    COST
0144 00215    101400           SMI
0145 00216    0 01 00222       JMP    *+4
0146 00217    0 07 00236       DSB    COST
0147 00220    0 07 00236       DSB    COST
0148 00221    0 04 00236       DST    COST
0149 00222    100040           SZE
0150 00223    0 01 00226       JMP    HUER
0151 00224    000005           SGL
0152 00225   -0 01 00000       JMP*   PRTY
0153 00226    0 02 00242 HUER  DLD    NEG1
0154 00227    000005           SGL
0155 00230   -0 01 00000       JMP*   PRTY
0156          000744      MA   EQU    '744
0157          000746      MB   EQU    MA+2
0158          000750      MC   EQU    MA+4
0159          000752      MD   EQU    MA+6
0160          000754      ME   EQU    MA+8
0161          000756      MF   EQU    MA+10
0162 00232    000000      DZRO DBP    0
     00233    000000
0163 00234    000000      SINT DBP    0
     00235    000000
0164 00236    000000      COST DBP    0
     00237    000000
0165 00240    000000      TEM1 DBP    0
     00241    000000
0166 00242    177777      NEG1 OCT    177777,77777
     00243    077777
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0167 00244   041513     SINE OCT   41513,12033
     00245   012033
0168 00246   066342     COSN OCT   66342,10027
     00247   010027
0169 00250   000000     HALF OCT   0,20000
     00251   020000
0170 00252   0 000006   ADAB DAC   ABFA
0171 00253   000000     PONT OCT   0
0172                          END
```

PROGRAM NAME
SOURCE: PPEX
BINARY: BPPEX
ENTRY POINT (location): PPRT ('12360)
GENERAL DESCRIPTION:

This subroutine determines PIPA third failures in a similar way to the way GPRT determines gyro third failures. However, it does not allow for dynamic errors as does GPRT and will not do its parity equation calculation if octal location 765 is set to 1. This would indicate that on this update the PIPA error accumulator (program source name PREX, subroutine entry point PARC) is purging its accumulation. The timing considerations are so stringent that at times, doing both jobs would be impossible. Other than the above considerations, look to GPRT for documentation of the methods used.

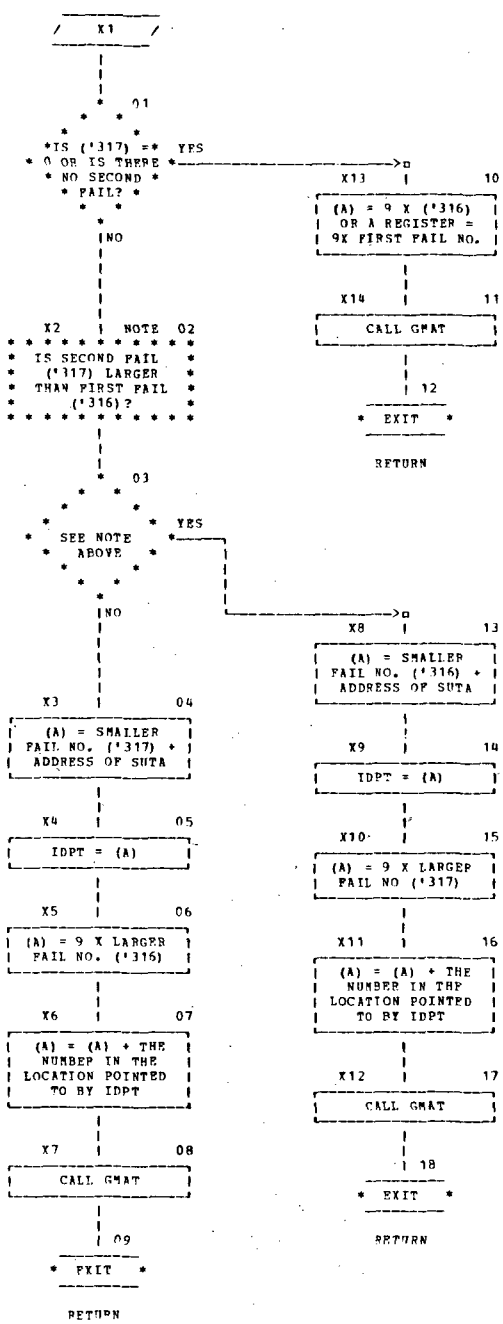
```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                SUBR  PPRT
0002                                REL
0003 00000    0 000000    PPRT  DAC   **
0004 00001    0 02 00765        LDA   '765
0005 00002    101040            SNZ
0006 00003    0 01 00007        JMP   GOAH
0007 00004    140040            CRA
0008 00005    0 04 00765        STA   '765
0009 00006   -0 01 00000        JMP*  PPRT
0010 00007    140040      GOAH  CRA
0011 00010    0 04 00323        STA   '323
0012 00011    0 02 00321        LDA   '321
0013 00012    101040            SNZ
0014 00013   -0 01 00000        JMP*  PPRT
0015 00014    0 11 00320        CAS   '320
0016 00015    0 01 00026        JMP   SFLA
0017 00016    101000            NOP
0018 00017    0 06 00047        ADD   ADST
0019 00020    0 04 00050        STA   IDPT
0020 00021    0 02 00320        LDA   '320
0021 00022    0415 75           ALS   3
0022 00023    0 07 00320        SUB   '320
0023 00024   -0 06 00050        ADD*  IDPT
0024 00025    0 01 00035        JMP   PRCL
0025 00026    0 02 00320  SFLA  LDA   '320
0026 00027    0 06 00047        ADD   ADST
0027 00030    0 04 00050        STA   IDPT
0028 00031    0 02 00321        LDA   '321
0029 00032    0415 75           ALS   3
0030 00033    0 07 00321        SUB   '321
0031 00034   -0 06 00050        ADD*  IDPT
0032 00035    0 10 00000  PRCL  CALL  PRTY
0033 00036    101000            NOP
0034 00037    100400            SPL
0035 00040    0 01 00044        JMP   OVRF
0036 00041    000007            DBL
0037 00042    0 07 00052        DSB   PMSE
0038 00043    101400            SMI
0039 00044    0 12 00323  OVRF  IRS   '323
0040 00045    000005            SGL
0041 00046   -0 01 00000        JMP*  PPRT
0042 00047    0 000054    ADST  DAC   CRPS
0043 00050    000000      IDPT  DBP   0
     00051    000000
0044 00052    000000      PMSE  OCT   0,40
     00053    000040
0045 00054    000000      CRPS  OCT   0,177762,16,43,61,70
     00055    177762
     00056    000016
     00057    000043
     00060    000061
     00061    000070
0046                                END
```

PROGRAM NAME
SOURCE: GMIN
BINARY: BGMIN
ENTRY POINTS (location): GMIN ('03100)
GENERAL DESCRIPTION:

This subroutine, when called, will calculate, using the gyro fail status from locations '316 and '317, the code which tells the gyro least squares matrix generator (see documentation for program source name GPMA, subroutine entry point GMAT) which of the 22 matrices to generate. Prior to the call to GMAT, this code is put in the A register. The codes are:

fail status	code
no fail	0
A fail	9
B fail	18
C fail	27
D fail	36
E fail	45
F fail	54
AB fail	63
AC fail	72
AD fail	81
AE fail	90
AF fail	99
BC fail	108
BD fail	117
BE fail	126
BF fail	135
CD fail	144
CE fail	153
CF fail	162
DE fail	171
DF fail	180
EF fail	189

If there is no second fail, i.e., ('317) = 0, then the code is simply 9 x ('316), or the number of the first fail (0 - 6) times 9. If there is a second fail, first a decision is made as to which of the two fails is larger, i.e., F fail (6) is larger than B fail (2). The code is then generated by taking 9 x the larger fail plus 45 if the smaller fail is A (1), 81 if the smaller fail is B (2), 108 if the smaller fail is C (3), 126 if the smaller fail is D (4), or 135 if the smaller fail is E (5). 45, 81, 108, 126 and 135 have the octal equivalents 55, 121, 154, 176 and 207 respectively. The program flow chart follows.



FLOWCHART - GMIN

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   GMIN
0003 00000    0 000000    GMIN DAC    **
0004 00001    0 02 00317         LDA    '317
0005 00002    101040             SNZ
0006 00003    0 01 00026         JMP    OOFA
0007 00004    0 11 00316         CAS    '316
0008 00005    0 01 00016         JMP    SFLA
0009 00006    0 01 00026         JMP    OOFA
0010 00007    0 06 00033         ADD    ADST
0011 00010    0 04 00034         STA    IDPT
0012 00011    0 02 00316         LDA    '316
0013 00012    0415 75            ALS    3
0014 00013    0 06 00316         ADD    '316
0015 00014   -0 06 00034         ADD*   IDPT
0016 00015    0 01 00031         JMP    PMCL
0017 00016    0 02 00316 SFLA    LDA    '316
0018 00017    0 06 00033         ADD    ADST
0019 00020    0 04 00034         STA    IDPT
0020 00021    0 02 00317         LDA    '317
0021 00022    0415 75            ALS    3
0022 00023    0 06 00317         ADD    '317
0023 00024   -0 06 00034         ADD*   IDPT
0024 00025    0 01 00031         JMP    PMCL
0025 00026    0 02 00316 OOFA    LDA    '316
0026 00027    0415 75            ALS    3
0027 00030    0 06 00316         ADD    '316
0028 00031    0 10 00000 PMCL    CALL   GMAT
0029 00032   -0 01 00000         JMP*   GMIN
0030 00033    0 000035    ADST DAC    SUTA
0031 00034    000000      IDPT BSZ    1
0032 00035    000000      SUTA OCT    0,55,121,154,176,207
     00036    000055
     00037    000121
     00040    000154
     00041    000176
     00042    000207
0033                                  END
```

PROGRAM NAME
SOURCE: GPMA
BINARY: BGPMA
ENTRY POINTS (location): MATR ('12102), GMAT ('12136)
GENERAL DESCRIPTION:

This program contains the two subroutines GMAT and MATR which generate the appropriate gyro or PIPA 6 x 3 least square matrix when called (with the proper code in the A register) by GMIN or EMIN (see documentation for GMIN and EMIN). These subroutines make use of two tables. The first, the double precision data table (DPDT), contains all the double precision fractions used in any of the 22 (1 no fail, 6 single fail and 15 double fail) least square matrices. For example, the first fraction in the table is a double precision 0(DBP 0), the second is

$$\frac{\sin e\,\alpha}{2} = 0.26865556403$$

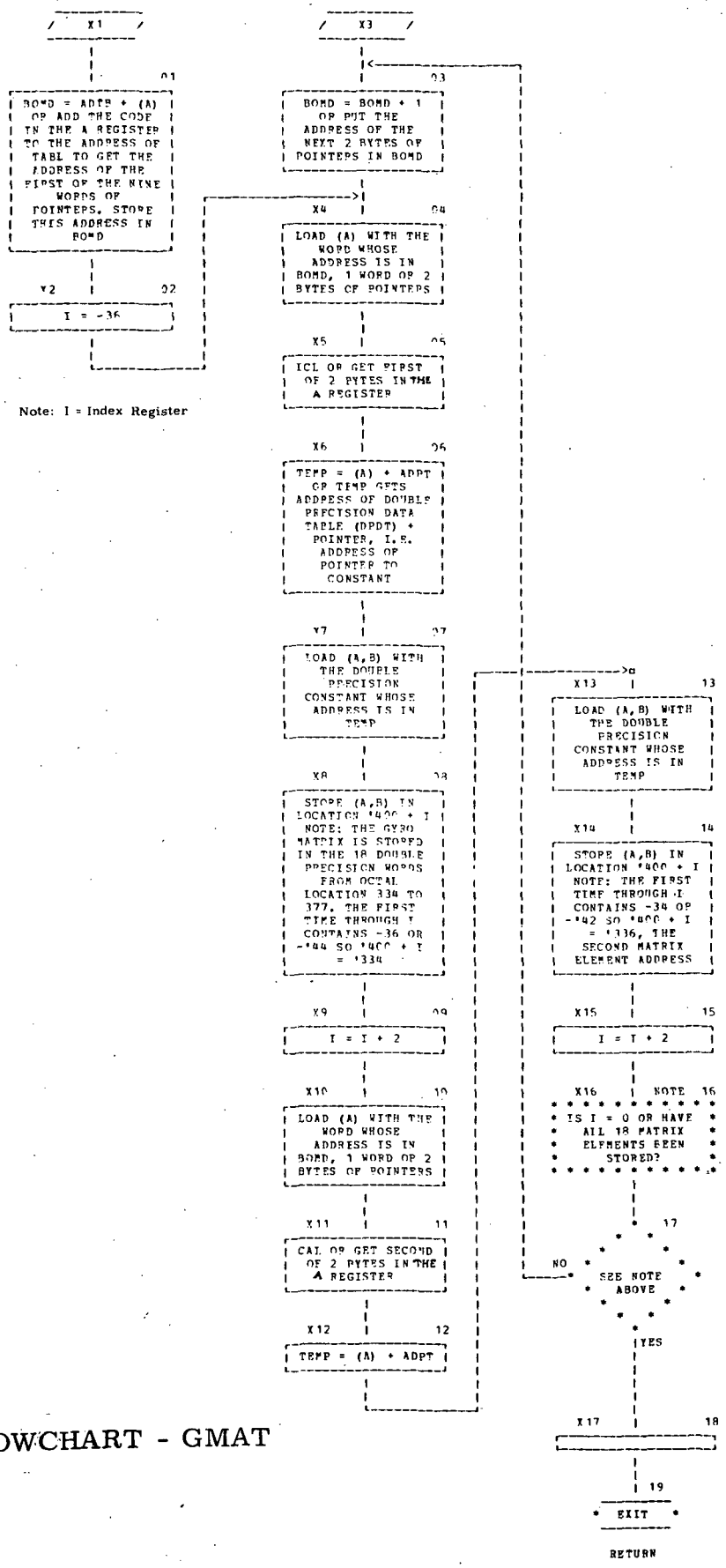
(OCT 20645, 45016), the third is

$$-\frac{\sin e\,\alpha}{2}\text{ , the fourth is }\frac{\cos\alpha}{2}$$

The second table (TABL) contains 22 sets of pointers, each set of which indicates which constants from the first table belong to a particular matrix. Each set is made of 9 16 bit words, or 18 bytes. Since there are 18 elements to each 6 x 3 matrix, each byte points to one element. For example, the first nine words (octal 1000, 3004,6, 4004, 10, 1000, 6, 1000, 4002) point to the constants for the no fail matrix. The next nine point to the constants for the A fail matrix. The code that GMIN or EMIN generates before calling GMAT or MATR tells where in the TABL to get the first of the nine words that point to the matrix corresponding to the gyro or PIPA fail status. Consider again the first nine words in TABL pointing to the no fail matrix constants. The first of the nine words is octal 1000 or binary 00000010 00000000, which when broken into bytes becomes octal 2, 0. All nine broken in to bytes become 2, 0, 6, 4, 0, 6, 10, 4, 0, 10, 2, 0, 0, 6, 2, 0, 10, 2. Calling sine α S and cos α C, these 18 bytes point respectively to

$$\frac{S}{2}\text{ , }0\text{, }\frac{C}{2}\text{ , }-\frac{S}{2}\text{ , }0\text{, }\frac{C}{2}\text{ , }-\frac{C}{2}\text{ , }-\frac{S}{2}\text{ , }0\text{, }-\frac{C}{2}\text{ , }\frac{S}{2}\text{ , }0\text{, }0\text{, }\frac{C}{2}\text{ , }\frac{S}{2}\text{ , }0\text{, }-\frac{C}{2}\text{ and }\frac{S}{2}\text{ ,}$$

which are the 18 elements of the no fail matrix. The flow chart for GMAT (MATR is analogous) follows:



FLOWCHART - GMAT

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                SUBR   MATR
0002                                SUBR   GMAT
0003                                REL
0004 00000    0 000000    MATR  DAC    **
0005 00001    0 06 00070        ADD    ADTB
0006 00002    0 04 00071        STA    BOMD
0007 00003    0 35 00524        LDX    ='177734
0008 00004    0 01 00006        JMP    BEGN
0009 00005    0 12 00071  FULL  IRS    BOMD
0010 00006   -0 02 00071  BEGN  LDA*   BOMD
0011 00007    141140            ICL
0012 00010    0 06 00073        ADD    ADPT
0013 00011    0 04 00072        STA    TEMP
0014 00012    000007            DBL
0015 00013   -0 02 00072        DLD*   TEMP
0016 00014    1 04 00666        DST    '666,1
0017 00015    000005            SGL
0018 00016    0 12 00000        IRS    0
0019 00017    0 12 00000        IRS    0
0020 00020   -0 02 00071        LDA*   BOMD
0021 00021    141050            CAL
0022 00022    0 06 00073        ADD    ADPT
0023 00023    0 04 00072        STA    TEMP
0024 00024    000007            DBL
0025 00025   -0 02 00072        DLD*   TEMP
0026 00026    1 04 00666        DST    '666,1
0027 00027    000005            SGL
0028 00030    0 12 00000        IRS    0
0029 00031    0 12 00000        IRS    0
0030 00032    0 01 00005        JMP    FULL
0031 00033   -0 01 00000        JMP*   MATR
0032 00034    0 000000    GMAT  DAC    **
0033 00035    0 06 00070        ADD    ADTB
0034 00036    0 04 00071        STA    BOMD
0035 00037    0 35 00524        LDY    ='177734
0036 00040    0 01 00042        JMP    GEGN
0037 00041    0 12 00071  GULL  IRS    BOMD
0038 00042   -0 02 00071  GEGN  LDA*   BOMD
0039 00043    141140            ICL
0040 00044    0 06 00073        ADD    ADPT
0041 00045    0 04 00072        STA    TEMP
0042 00046    000007            DBL
0043 00047   -0 02 00072        DLD*   TEMP
0044 00050    1 04 00400        DST    '400,1
0045 00051    000005            SGL
0046 00052    0 12 00000        IRS    0
0047 00053    0 12 00000        IRS    0
0048 00054   -0 02 00071        LDA*   BOMD
0049 00055    141050            CAL
0050 00056    0 06 00073        ADD    ADPT
0051 00057    0 04 00072        STA    TEMP
0052 00060    000007            DBL
0053 00061   -0 02 00072        DLD*   TEMP
0054 00062    1 04 00400        DST    '400,1
0055 00063    000005            SGL
0056 00064    0 12 00000        IRS    0
0057 00065    0 12 00000        IRS    0
```

```
0058 00066   0 01 00041        JMP   GULL
0059 00067  -0 01 00034        JMP*  GMAT
0060 00070   0 000216    ADTB  DAC   TABL
0061 00071   000000      BOMD  BSZ   1
0062 00072   000000      TEMP  BSZ   1
0063 00073   0 000074    ADPT  DAC   DPDT
0064 00074   000000      DPDT  DBP   0
     00075   000000
0065 00076   020645          OCT   20645,45016
     00077   045016
0066 00100   157132          OCT   157132,32762
     00101   032762
0067 00102   033161          OCT   33161,04013
     00103   004013
0068 00104   144616          OCT   144616,73765
     00105   073765
0069 00106   011231          OCT   11231,36014
     00107   036014
0070 00110   166546          OCT   166546,41764
     00111   041764
0071 00112   047311          OCT   47311,72023
     00113   072023
0072 00114   130466          OCT   130466,5755
     00115   005755
0073 00116   034776          OCT   34776,33025
     00117   033025
0074 00120   143001          OCT   143001,44753
     00121   044753
0075 00122   042575          OCT   42575,13015
     00123   013015
0076 00124   135202          OCT   135202,64763
     00125   064763
0077 00126   007414          OCT   7414,7002
     00127   007002
0078 00130   170363          OCT   170363,70776
     00131   070776
0079 00132   014130          OCT   14130,66010
     00133   066010
0080 00134   163647          OCT   163647,11770
     00135   011770
0081 00136   045474          OCT   45474,43011
     00137   043011
0082 00140   132303          OCT   132303,34767
     00141   034767
0083 00142   074674          OCT   74674,16047
     00143   016047
0084 00144   103103          OCT   103103,61731
     00145   061731
0085 00146   003155          OCT   03155,03010
     00147   003010
0086 00150   174622          OCT   174622,74770
     00151   074770
0087 00152   043503          OCT   43503,66422
     00153   066422
0088 00154   134274          OCT   134274,11356
     00155   011356
0089 00156   040326          OCT   40326,63412
```

```
      00157   063412
0090  00160   137451          OCT   137451,14366
      00161   014366
0091  00162   050651          OCT   50651,46021
      00163   046021
0092  00164   127126          OCT   127126,31757
      00165   031757
0093  00166   031170          OCT   31170,27424
      00167   027424
0094  00170   146607          OCT   146607,50354
      00171   050354
0095  00172   046660          OCT   46660,71432
      00173   071432
0096  00174   131117          OCT   131117,6346
      00175   006346
0097  00176   076664          OCT   76664,72435
      00177   072435
0098  00200   101113          OCT   101113,5343
      00201   005343
0099  00202   024022          OCT   24022,50026
      00203   050026
0100  00204   153755          OCT   153755,27752
      00205   027752
0101  00206   005145          OCT   05145,57377
      00207   057377
0102  00210   172632          OCT   172632,20401
      00211   020401
0103  00212   026013          OCT   26013,24414
      00213   024414
0104  00214   151764          OCT   151764,53364
      00215   053364
0105  00216   001000    TABL  OCT   1000,3004,6
      00217   003004
      00220   000006
0106  00221   004004          OCT   4004,10,1000
      00222   000010
      00223   001000
0107  00224   000006          OCT   6,1000,4002
      00225   001000
      00226   004002
0108  00227   000000          OCT   0,14,16
      00230   000014
      00231   000016
0109  00232   014004          OCT   14004,20030,1040
      00233   020030
      00234   001040
0110  00235   015006          OCT   15006,11032,4022
      00236   011032
      00237   004022
0111  00240   005000          OCT   5000,7000,0
      00241   007000
      00242   000000
0112  00243   014004          OCT   14004,17030,1036
      00244   017030
      00245   001036
0113  00246   016006          OCT   16006,11034,4022
      00247   011034
```

```
      00250   004022
0114  00251   011032          OCT   11032,3024,16006
      00252   003024
      00253   016006
0115  00254   000000          OCT   0,20,5000
      00255   000020
      00256   005000
0116  00257   017026          OCT   17026,1040,14002
      00260   001040
      00261   014002
0117  00262   011034          OCT   11034,3024,15006
      00263   003024
      00264   015006
0118  00265   010014          OCT   10014,0,0
      00266   000000
      00267   000000
0119  00270   020026          OCT   20026,1036,14002
      00271   001036
      00272   014002
0120  00273   001036          OCT   1036,13004,17026
      00274   013004
      00275   017026
0121  00276   004024          OCT   4024,16010,11032
      00277   016010
      00300   011032
0122  00301   000000          OCT   0,0,10012
      00302   000000
      00303   010012
0123  00304   001040          OCT   1040,13004,20026
      00305   013004
      00306   020026
0124  00307   004024          OCT   4024,15010,11034
      00310   015010
      00311   011034
0125  00312   000016          OCT   16,5000,0
      00313   005000
      00314   000000
0126  00315   000000          OCT   0,0,0
      00316   000000
      00317   000000
0127  00320   022004          OCT   22004,44,1000
      00321   000044
      00322   001000
0128  00323   000006          OCT   6,23000,4046
      00324   023000
      00325   004046
0129  00326   000000          OCT   0,110,46056
      00327   000110
      00330   046056
0130  00331   000000          OCT   0,104,25120
      00332   000104
      00333   025120
0131  00334   027066          OCT   27066,37054,32072
      00335   037054
      00336   032072
0132  00337   000000          OCT   0,110,45056
      00340   000110
```

```
      00341   045056
0133  00342   042054          OCT   42054,50000,0
      00343   050000
      00344   000000
0134  00345   026062          OCT   26062,35056,34076
      00346   035056
      00347   034076
0135  00350   000000          OCT   0,54,47102
      00351   000054
      00352   047102
0136  00353   034100          OCT   34100,30064,35054
      00354   030064
      00355   035054
0137  00356   000000          OCT   0,112,30106
      00357   000112
      00360   030106
0138  00361   000000          OCT   0,54,50102
      00362   000054
      00363   050102
0139  00364   032074          OCT   32074,26070,37060
      00365   026070
      00366   037060
0140  00367   045056          OCT   45056,43000,0
      00370   043000
      00371   000000
0141  00372   043112          OCT   43112,27000,0
      00373   027000
      00374   000000
0142  00375   000000          OCT   0,104,25116
      00376   000104
      00377   025116
0143  00400   025062          OCT   25062,35060,34076
      00401   035060
      00402   034076
0144  00403   043114          OCT   43114,27000,0
      00404   027000
      00405   000000
0145  00406   042054          OCT   42054,47000,0
      00407   047000
      00410   000000
0146  00411   030066          OCT   30066,37052,32072
      00412   037052
      00413   032072
0147  00414   025116          OCT   25116,41000,0
      00415   041000
      00416   000000
0148  00417   032074          OCT   32074,25070,37056
      00420   025070
      00421   037056
0149  00422   000000          OCT   0,114,30106
      00423   000114
      00424   030106
0150  00425   025120          OCT   25120,41000,0
      00426   041000
      00427   000000
0151  00430   034100          OCT   34100,27064,35052
      00431   027064
```

```
      00432   035052
0152  00433   046056          OCT   46056,43000,0
      00434   043000
      00435   000000
0153  00436   023000          OCT   23000,3050,6
      00437   003050
      00440   000006
0154  00441   000000          OCT   0,0,0
      00442   000000
      00443   000000
0155  00444   000042          OCT   42,1000,22002
      00445   001000
      00446   022002
0156  00447   037056          OCT   37056,33074,25062
      00450   033074
      00451   025062
0157  00452   000000          OCT   0,60,43112
      00453   000060
      00454   043112
0158  00455   000000          OCT   0,120,42052
      00456   000120
      00457   042052
0159  00460   035054          OCT   35054,31100,30066
      00461   031100
      00462   030066
0160  00463   000000          OCT   0,60,43114
      00464   000060
      00465   043114
0161  00466   047102          OCT   47102,25000,0
      00467   025000
      00470   000000
0162  00471   035052          OCT   35052,31100,27066
      00472   031100
      00473   027066
0163  00474   030110          OCT   30110,46000,0
      00475   046000
      00476   000000
0164  00477   000000          OCT   0,116,42052
      00500   000116
      00501   042052
0165  00502   037060          OCT   37060,33074,26062
      00503   033074
      00504   026062
0166  00505   030110          OCT   30110,45000,0
      00506   045000
      00507   000000
0167  00510   050102          OCT   50102,25000,0
      00511   025000
      00512   000000
0168  00513   001000          OCT   1000,21004,42
      00514   021004
      00515   000042
0169  00516   004050          OCT   4050,10,23000
      00517   000010
      00520   023000
0170  00521   000000          OCT   0,0,0
      00522   000000
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
     00523    000000
0171 00524    177734            END
```

PROGRAM NAME
SOURCE: EMIN
BINARY: BEMIN
ENTRY POINTS (location): EMIN ('03034)
GENERAL DESCRIPTION:

This subroutine, when called, will calculate, using the PIPA fail status from locations '320 and '321, the code which tells the PIPA least squares matrix generator (see documentation for program source name GPMA, subroutine entry point MATR) which of the 22 matrices to generate. Prior to the call to MATR, this code is put in the A register. For an explanation of the codes and a flow chart of this subroutine, see documentation for program source name GMIN.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   EMIN
0003 00000    0 000000    EMIN DAC    **
0004 00001    0 02 00321       LDA    '321
0005 00002    101040           SNZ
0006 00003    0 01 00026       JMP    OOFA
0007 00004    0 11 00320       CAS    '320
0008 00005    0 01 00016       JMP    SFLA
0009 00006    0 01 00026       JMP    OOFA
0010 00007    0 06 00033       ADD    ADST
0011 00010    0 04 00034       STA    IDPT
0012 00011    0 02 00320       LDA    '320
0013 00012    0415 75          ALS    3
0014 00013    0 06 00320       ADD    '320
0015 00014   -0 06 00034       ADD*   IDPT
0016 00015    0 01 00031       JMP    PMCL
0017 00016    0 02 00320 SFLA  LDA    '320
0018 00017    0 06 00033       ADD    ADST
0019 00020    0 04 00034       STA    IDPT
0020 00021    0 02 00321       LDA    '321
0021 00022    0415 75          ALS    3
0022 00023    0 06 00321       ADD    '321
0023 00024   -0 06 00034       ADD*   IDPT
0024 00025    0 01 00031       JMP    PMCL
0025 00026    0 02 00320 OOFA  LDA    '320
0026 00027    0415 75          ALS    3
0027 00030    0 06 00320       ADD    '320
0028 00031    0 10 00000 PMCL  CALL   MATR
0029 00032   -0 01 00000       JMP*   EMIN
0030 00033    0 000035    ADST DAC    SUTA
0031 00034    000000      IDPT BSZ    1
0032 00035    000000      SUTA OCT    0,55,121,154,176,207
     00036    000055
     00037    000121
     00040    000154
     00041    000176
     00042    000207
0033                                  END
```

PROGRAM NAME
SOURCE: MG63
BINARY: BMG63
ENTRY POINTS (location): MG63 ('04012)
GENERAL DESCRIPTION:

This subroutine performs the 6 x 3 matrix multiplication which transforms the six gyro $\Delta\theta$ outputs into the x, y, z frame. The 6 x 3 matrix is stored as double precision fractions in locations '334 — '377 and it is the least squares matrix corresponding to the gyro fail status. The six gyro pulse counts are single precision fractions scaled at $7\ 2^{-8}$ radians (for example, 1 gyro pulse would be represented as an octal 000400 = $7\ 2^{15}$ radians) and are stored in locations '400, '402, '404, '406, '410, and '412 respectively.

$\Delta\theta$X, $\Delta\theta$Y and $\Delta\theta$Z are first formed in temporary double precision accumulators DTXU, DTYU and DTZU, double precision fractions scaled at $7\ 2^{-8}$ radians. These are then multiplied by 7/4 and added into DTXB, DTYB and DTZB (locations) '414-'415, '416-'417 and '420-'421), which are double precision fractions now scaled at 2^{-6} radians. Since the attitude algorithm (see documentation for ATTA, program name AA6S) only uses the high order of DTXB, DTYB and DTZB, the low order is saved as a residual and at the beginning of MG63 only the high order is zeroed.

The internal subroutine MUPY will do three single by double multiplies and adds, performing the functions expressed by the following equations:

DTXU = DTXU + (GMAT + I) PTMP
DTYU = DTYU + (GMAT + 2 + I) PTMP
DTZU = DTZU + (GMAT + 4 + I) PTMP

where (GMAT + 2 + I) is the double precision fractional matrix element stored in locations '334 + 2 + I and '334 + 3 + I, where I is the contents of the index register. If, for example, I = 6 and PTMP = GBPC (gyro B

pulse count), the above equations can be written:

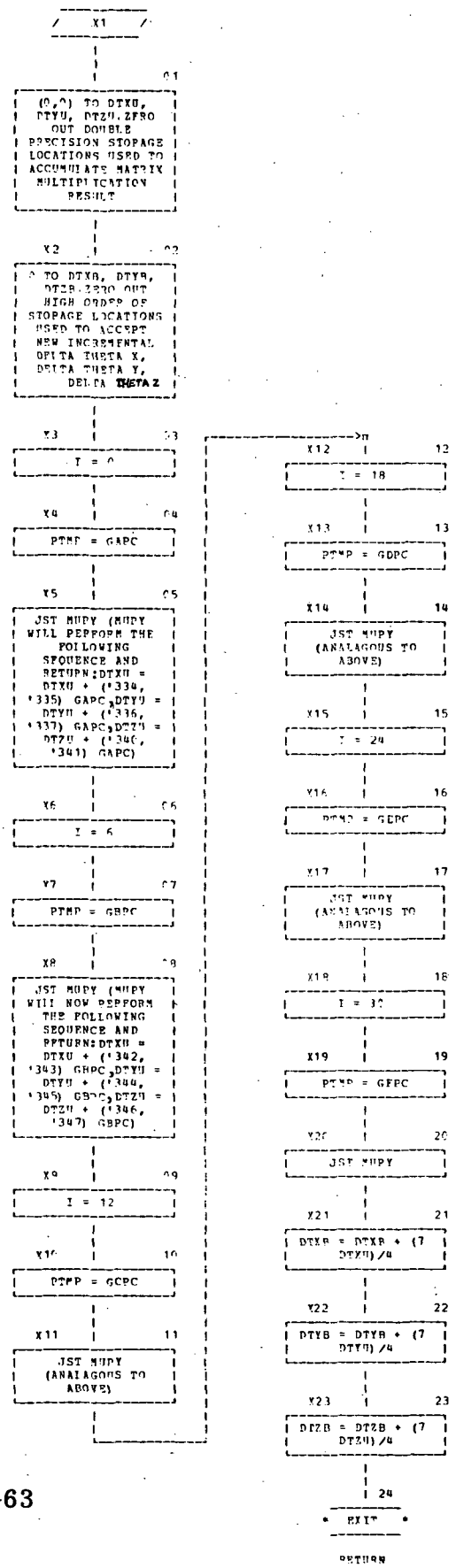
DTXU = DTXU + ('342, '343) GBPC
DTYU = DTYU + ('344, '345) GBPC
DTZU = DTZU + ('346, '347) GBPC

The 6 x 3 matrix is shown below and it can be seen that the above example shows how all of gyro B's contribution to the X, Y and Z axes can be gotten by setting I = 6, PTMP = GBPC and doing the internal subroutine MUPY.

('334, '335) ('342, '343) ('350, '351) ('356, '357) ('364, '365) ('372, '373)
('336, '337) ('344, '345) ('352, '353) ('360, '361) ('366, '367) ('374, '375)
('340, '341) ('346, '347) ('354, '355) ('362, '363) ('370, '371) ('376, '377)

6 x 3 matrix storage locations.

The flow chart for MG63 follows:



FLOWCHART - MG63

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    REL
0002                                    SUBR   MG63
0003 00000    0 000000    MG63          DAC    **
0004 00001    140040                    CRA
0005 00002    0 04 00102                STA    DTXU
0006 00003    0 04 00103                STA    DTXU+1
0007 00004    0 04 00104                STA    DTYU
0008 00005    0 04 00105                STA    DTYU+1
0009 00006    0 04 00106                STA    DTZU
0010 00007    0 04 00107                STA    DTZU+1
0011 00010    0 04 00414                STA    DTXB
0012 00011    0 04 00416                STA    DTYB
0013 00012    0 04 00420                STA    DTZB
0014 00013    0 04 00000                STA    0
0015 00014    0 02 00400                LDA    GAPC
0016 00015    0 04 00100                STA    PTMP
0017 00016    0 10 00112                JST    MUPY
0018 00017    0 35 00173                LDX    =6
0019 00020    0 02 00402                LDA    GBPC
0020 00021    0 04 00100                STA    PTMP
0021 00022    0 10 00112                JST    MUPY
0022 00023    0 35 00172                LDX    =12
0023 00024    0 02 00404                LDA    GCPC
0024 00025    0 04 00100                STA    PTMP
0025 00026    0 10 00112                JST    MUPY
0026 00027    0 35 00171                LDX    =18
0027 00030    0 02 00406                LDA    GDPC
0028 00031    0 04 00100                STA    PTMP
0029 00032    0 10 00112                JST    MUPY
0030 00033    0 35 00170                LDX    =24
0031 00034    0 02 00410                LDA    GEPC
0032 00035    0 04 00100                STA    PTMP
0033 00036    0 10 00112                JST    MUPY
0034 00037    0 35 00167                LDX    =30
0035 00040    0 02 00412                LDA    GFPC
0036 00041    0 04 00100                STA    PTMP
0037 00042    0 10 00112                JST    MUPY
0038 00043    000007                    DBL
0039 00044    0 02 00074                DLD    DBP0
0040 00045    0 07 00102                DSB    DTXU
0041 00046    0401 76                   LRS    2
0042 00047    0 06 00102                DAD    DTXU
0043 00050    0 06 00102                DAD    DTXU
0044 00051    0 06 00414                DAD    DTXB
0045 00052    0 04 00414                DST    DTXB
0046 00053    0 02 00074                DLD    DBP0
0047 00054    0 07 00104                DSB    DTYU
0048 00055    0401 76                   LRS    2
0049 00056    0 06 00104                DAD    DTYU
0050 00057    0 06 00104                DAD    DTYU
0051 00060    0 06 00416                DAD    DTYB
0052 00061    0 04 00416                DST    DTYB
0053 00062    0 02 00074                DLD    DBP0
0054 00063    0 07 00106                DSB    DTZU
0055 00064    0401 76                   LRS    2
0056 00065    0 06 00106                DAD    DTZU
0057 00066    0 06 00106                DAD    DTZU
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0058 00067    0 06 00420        DAD    DTZB
0059 00070    0 04 00420        DST    DTZB
0060 00071    000005            SGL
0061 00072   -0 01 00000        JMP*   MG63
0062 00074    000000      DBP0  DBP    0
     00075    000000
0063 00076    000000      TEMP  DBP    0
     00077    000000
0064 00100    000000      PTMP  DBP    0
     00101    000000
0065 00102    000000      DTXU  DBP    0
     00103    000000
0066 00104    000000      DTYU  DBP    0
     00105    000000
0067 00106    000000      DTZU  DBP    0
     00107    000000
0068 00110    000000      HALF  OCT    0,40000
     00111    040000
0069          000414      DTXB  EQU    '414
0070          000416      DTYB  EQU    DTXB+2
0071          000420      DTZB  EQU    DTXB+4
0072          000400      GAPC  EQU    '400
0073          000402      GBPC  EQU    GAPC+2
0074          000404      GCPC  EQU    GAPC+4
0075          000406      GDPC  EQU    GAPC+6
0076          000410      GEPC  EQU    GAPC+8
0077          000412      GFPC  EQU    GAPC+10
0078          000334      GMAT  EQU    '334
0079 00112    0 000000    MUPY  DAC    **
0080 00113    000007            DBL
0081 00114    1 16 00334        MPY    GMAT,1
0082 00115    0 04 00076        DST    TEMP
0083 00116    0 02 00100        DLD    PTMP
0084 00117    1 16 00335        MPY    GMAT+1,1
0085 00120    0 06 00110        DAD    HALF
0086 00121    140320            CSA
0087 00122    000201            IAB
0088 00123    140040            CRA
0089 00124    100001            SRC
0090 00125    140401            CMA
0091 00126    0 06 00076        DAD    TEMP
0092 00127    0 06 00102        DAD    DTXU
0093 00130    0 04 00102        DST    DTXU
0094 00131    0 02 00100        DLD    PTMP
0095 00132    1 16 00336        MPY    GMAT+2,1
0096 00133    0 04 00076        DST    TEMP
0097 00134    0 02 00100        DLD    PTMP
0098 00135    1 16 00337        MPY    GMAT+3,1
0099 00136    0 06 00110        DAD    HALF
0100 00137    140320            CSA
0101 00140    000201            IAB
0102 00141    140040            CRA
0103 00142    100001            SRC
0104 00143    140401            CMA
0105 00144    0 06 00076        DAD    TEMP
0106 00145    0 06 00104        DAD    DTYU
0107 00146    0 04 00104        DST    DTYU
```

```
MICROCOMP TELECOMMUNICATED DATA
        DDP-516 ASSEMBLY LISTING
0108 00147    0 02 00100        DLD    PTMP
0109 00150    1 16 00340        MPY    GMAT+4,1
0110 00151    0 04 00076        DST    TEMP
0111 00152    0 02 00100        DLD    PTMP
0112 00153    1 16 00341        MPY    GMAT+5,1
0113 00154    0 06 00110        DAD    HALF
0114 00155    140320            CSA
0115 00156    000201            IAB
0116 00157    140040            CRA
0117 00160    100001            SRC
0118 00161    140401            CMA
0119 00162    0 06 00076        DAD    TEMP
0120 00163    0 06 00106        DAD    DTZU
0121 00164    0 04 00106        DST    DTZU
0122 00165    000005            SGL
0123 00166   -0 01 00112        JMP*   MUPY
0124 00167    000036            END
     00170    000030
     00171    000022
     00172    000014
     00173    000006
```

PROGRAM NAME
SOURCE: MV63
BINARY BMV63
ENTRY POINTS (location): MP63 ('03664)
GENERAL DESCRIPTION:

This subroutine performs the 6 x 3 matrix multiplication which transforms the 6 PIPA ΔV outputs into the X, Y, Z frame. It is an almost identical program to MG63 (see documentation for MG63) except that ΔVX, ΔVY and ΔVZ do not have to be scaled by 7/4 as in the gyro 6 x 3 multiplication.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   MP63
0003 00000    0 000000    MP63 DAC    **
0004 00001    140040             CRA
0005 00002    0 04 00614         STA    DVXB
0006 00003    0 04 00616         STA    DVYB
0007 00004    0 04 00620         STA    DVZB
0008 00005    0 04 00000         STA    0
0009 00006    0 02 00600         LDA    AAPC
0010 00007    0 04 00040         STA    PTMP
0011 00010    0 10 00044         JST    MUPY
0012 00011    0 35 00125         LDX    =6
0013 00012    0 02 00602         LDA    ABPC
0014 00013    0 04 00040         STA    PTMP
0015 00014    0 10 00044         JST    MUPY
0016 00015    0 35 00124         LDX    =12
0017 00016    0 02 00604         LDA    ACPC
0018 00017    0 04 00040         STA    PTMP
0019 00020    0 10 00044         JST    MUPY
0020 00021    0 35 00123         LDX    =18
0021 00022    0 02 00606         LDA    ADPC
0022 00023    0 04 00040         STA    PTMP
0023 00024    0 10 00044         JST    MUPY
0024 00025    0 35 00122         LDX    =24
0025 00026    0 02 00610         LDA    AEPC
0026 00027    0 04 00040         STA    PTMP
0027 00030    0 10 00044         JST    MUPY
0028 00031    0 35 00121         LDX    =30
0029 00032    0 02 00612         LDA    AFPC
0030 00033    0 04 00040         STA    PTMP
0031 00034    0 10 00044         JST    MUPY
0032 00035   -0 01 00000         JMP*   MP63
0033 00036    000000       TEMP DBP    0
     00037    000000
0034 00040    000000       PTMP DBP    0
     00041    000000
0035 00042    000000       HALF OCT    0,40000
     00043    040000
0036          000614       DVXB EQU    '614
0037          000616       DVYB EQU    DVXB+2
0038          000620       DVZB EQU    DVXB+4
0039          000600       AAPC EQU    '600
0040          000602       ABPC EQU    AAPC+2
0041          000604       ACPC EQU    AAPC+4
0042          000606       ADPC EQU    AAPC+6
0043          000610       AEPC EQU    AAPC+8
0044          000612       AFPC EQU    AAPC+10
0045          000622       PMAT EQU    '622
0046 00044    0 000000    MUPY DAC    **
0047 00045    000007             DBL
0048 00046    1 16 00622         MPY    PMAT,1
0049 00047    0 04 00036         DST    TEMP
0050 00050    0 02 00040         DLD    PTMP
0051 00051    1 16 00623         MPY    PMAT+1,1
0052 00052    0 06 00042         DAD    HALF
0053 00053    140320             CSA
0054 00054    000201             IAB
```

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0055 00055   140040          CRA
0056 00056   100001          SRC
0057 00057   140401          CMA
0058 00060   0 06 00036      DAD   TEMP
0059 00061   0 06 00614      DAD   DVXB
0060 00062   0 04 00614      DST   DVXB
0061 00063   0 02 00040      DLD   PTMP
0062 00064   1 16 00624      MPY   PMAT+2,1
0063 00065   0 04 00036      DST   TEMP
0064 00066   0 02 00040      DLD   PTMP
0065 00067   1 16 00625      MPY   PMAT+3,1
0066 00070   0 06 00042      DAD   HALF
0067 00071   140320          CSA
0068 00072   000201          IAB
0069 00073   140040          CRA
0070 00074   100001          SRC
0071 00075   140401          CMA
0072 00076   0 06 00036      DAD   TEMP
0073 00077   0 06 00616      DAD   DVYB
0074 00100   0 04 00616      DST   DVYB
0075 00101   0 02 00040      DLD   PTMP
0076 00102   1 16 00626      MPY   PMAT+4,1
0077 00103   0 04 00036      DST   TEMP
0078 00104   0 02 00040      DLD   PTMP
0079 00105   1 16 00627      MPY   PMAT+5,1
0080 00106   0 06 00042      DAD   HALF
0081 00107   140320          CSA
0082 00110   000201          IAB
0083 00111   140040          CRA
0084 00112   100001          SRC
0085 00113   140401          CMA
0086 00114   0 06 00036      DAD   TEMP
0087 00115   0 06 00620      DAD   DVZB
0088 00116   0 04 00620      DST   DVZB
0089 00117   000005          SGL
0090 00120  -0 01 00044      JMP*  MUPY
0091 00121   000036          END
     00122   000030
     00123   000022
     00124   000014
     00125   000006
```

PROGRAM NAME
SOURCE: SPUN
BINARY: BSPUN
ENTRY POINTS (location): SPUN ('05560)
GENERAL DESCRIPTION:

This subroutine when called will correct the quaternion in order to maintain it as a unit quaternion. It imposes the constraint that

$$\lambda^2 + \rho_x^2 + \rho_y^2 + \rho_z^2 = 1.$$

Ideally the equations to be implemented would be

$$\lambda' = \lambda\, d$$
$$\rho_x' = \rho_x\, d$$
$$\rho_y' = \rho_y\, d$$
$$\rho_z' = \rho_z\, d$$

where

$$d = \frac{1}{\sqrt{\lambda^2 + \rho_x^2 + \rho_y^2 + \rho_z^2}}$$

However, since the sum of the squares of the elements of the quaternion never deviates significantly from 1, we can simplify as follows:

$$\epsilon = \lambda^2 + \rho_x^2 + \rho_y^2 + \rho_z^2 - 1$$

or

$$\lambda^2 + \rho_x^2 + \rho_y^2 + \rho_z^2 = 1 + \epsilon$$

$$\sqrt{\lambda^2 + \rho_x^2 + \rho_y^2 + \rho_z^2} = \sqrt{1 + \epsilon} \simeq 1 + \frac{\epsilon}{2}$$

$$d \simeq \frac{1}{1 + \frac{\epsilon}{2}} \simeq 1 - \frac{\epsilon}{2}$$

so

$$\lambda' \simeq \lambda(1 - \frac{\epsilon}{2})$$

$$\rho_x' \simeq \rho_x(1 - \frac{\epsilon}{2})$$

$$\rho_y' \simeq \rho_y(1 - \frac{\epsilon}{2})$$

$$\rho_z' \simeq \rho_z(1 - \frac{\epsilon}{2})$$

Using the scaling and terminology for the quaternion described in the program AA6S

$$(\text{i.e., } L = \frac{\lambda}{2},\ RX = \frac{\rho_x}{2},\ RY = \frac{\rho_y}{2} \text{ and } RZ = \frac{\rho_z}{2})$$

we derive the new constraint that

$$L^2 + RX^2 + RY^2 + RZ^2 \text{ equal } 1/4$$

$$L' = L\ D$$
$$RX' = RX\ D$$
$$RY' = RY\ D$$
$$RZ' = RZ\ D$$

where

$$D = \frac{1}{2\sqrt{L^2 + RX^2 + RY^2 + RZ^2}}$$

$$E = L^2 + RX^2 + RY^2 + RZ^2 - \frac{1}{4}$$

$$L^2 + RX^2 + RY^2 + RZ^2 = \frac{1}{4} + E$$

$$\sqrt{L^2 + RY^2 + RY^2 + RZ^2} = \sqrt{\frac{1}{4} + E} \simeq \frac{1}{2} + E$$

$$D \simeq \frac{1}{1 + 2E} \simeq 1 - 2E$$

so

$$L' = L\ (1-2E)$$
$$RX' = RX\ (1-2E)$$
$$RY' = RY\ (1-2E)$$
$$RZ' = RZ\ (1-2E)$$

or

$$\Delta L = -2E\ L$$
$$\Delta RX = -2E\ RX$$
$$\Delta RY = -2E\ RY$$
$$\Delta RZ = -2E\ RZ$$

Now expand the ΔL term (the ΔRX, ΔRY and ΔRZ terms are analogous). Since ΔL is very small we shall really calculate

$$2^{24}\Delta L = -2^{25}E\ L.$$

define $FACT = -2^{25}E$. Then

$$\Delta L = \frac{FACT\ L}{2^{24}}$$

since

$$L = L1 + \frac{L2}{2^{15}} + \frac{L3}{2^{30}}$$

then

$$\Delta L = \frac{FACT\ L1}{2^{24}} + \frac{FACT\ L2}{2^{39}} + \frac{FACT\ L3}{2^{54}}$$

and we need only calculate

$$\Delta L = \frac{FACT\ L1}{2^{24}}$$

repeating we have

$$E = L^2 + RX^2 + RY^2 + RZ^2 - 1/4$$

and

$$L^2 = L1^2 + \frac{L2^2}{2^{30}} + \frac{L3^2}{2^{60}} + \frac{L1\ L2}{2^{14}} + \frac{L1\ L3}{2^{29}} + \frac{L2\ L3}{2^{44}}$$

$$RX^2 = RX1^2 + \frac{RX2^2}{2^{30}} + \frac{RX3^2}{2^{60}} + \frac{RX1\ RX2}{2^{14}} + \frac{RX1\ RX3}{2^{29}} + \frac{RX2\ RX3}{2^{44}}$$

$$RY^2 = \ldots$$
$$RZ^2 = \ldots$$

substituting and gathering terms we get

$$E = L1^2 + RX1^2 + RY1^2 + RZ1^2$$

$$+ \frac{L2^2 + RX2^2 + RY2^2 + RZ2^2}{2^{30}} + \frac{L3^2 + RX3^2 + RY3^2 + RZ3^2}{2^{60}}$$

$$+ \frac{L1\ L2 + RX1\ RX2 + RY1\ RY2 + RZ1\ RZ2}{2^{14}}$$

$$+ \frac{L1\ L3 + RX1\ RX3 + RY1\ RY3 + RZ1\ RZ3}{2^{29}}$$

$$+ \frac{L2\ L3 + RX2\ RX3 + RY2\ RY3 + RZ2\ RZ3}{2^{44}} - \frac{1}{4}$$

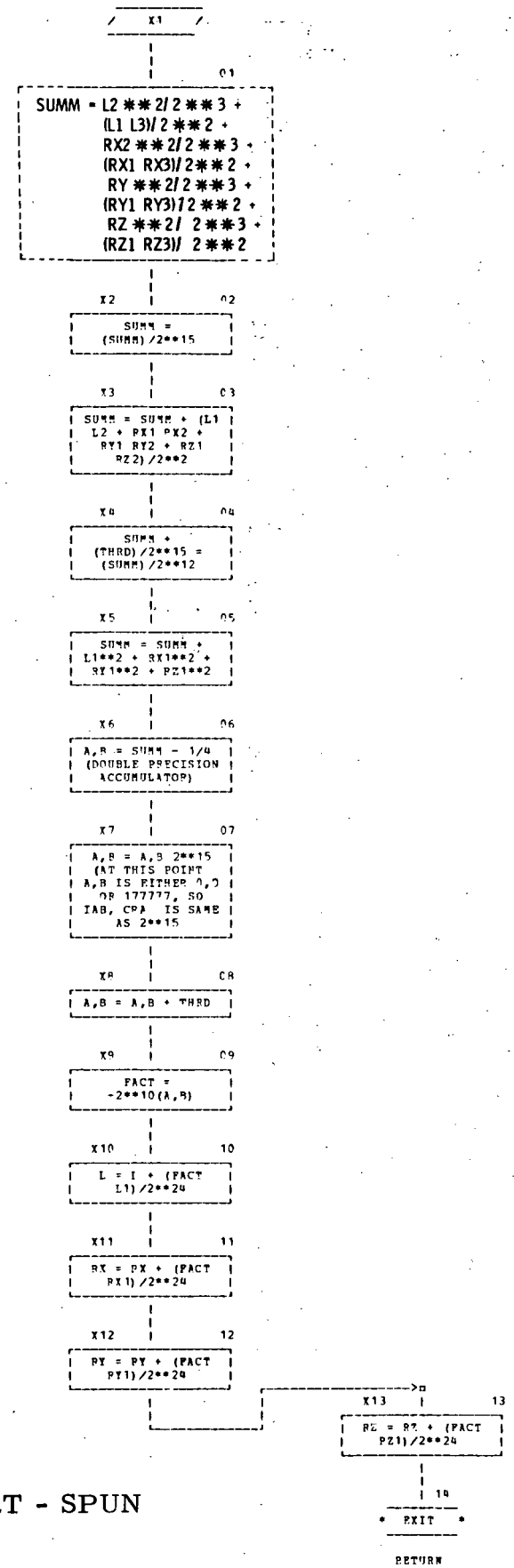
We now want to calculate

$$FACT = -2^{25}E$$

Since FACT has only 15 bits of significance, all terms contributing to E with denominators greater than 2^{40} can be ignored. This eliminates the terms

$$\frac{L3^2\ldots}{2^{60}} \text{ and } \frac{L2\ L3\ldots}{2^{44}}$$

The flow chart for the implementation on the DDP516 of the above derivation follows.



FLOWCHART - SPUN

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR  SPUN
0003 00000   0 000000    SPUN DAC     **
0004 00001   0 02 00461        LDA     L2
0005 00002   000007            DBL
0006 00003   0 16 00461        MPY     L2
0007 00004   0401 77           LRS     1
0008 00005   0 04 00244        DST     OVFP
0009 00006   0 02 00462        DLD     L3
0010 00007   000201            IAB
0011 00010   0 07 00254        DSB     FUDG
0012 00011   0 16 00460        MPY     L1
0013 00012   0 06 00244        DAD     OVFP
0014 00013   0401 76           LRS     2
0015 00014   0 04 00242        DST     SUMM
0016 00015   0 02 00464        DLD     RX1
0017 00016   000201            IAB
0018 00017   0 16 00465        MPY     RX2
0019 00020   0401 77           LRS     1
0020 00021   0 04 00244        DST     OVFP
0021 00022   0 02 00466        DLD     RX3
0022 00023   000201            IAB
0023 00024   0 07 00254        DSB     FUDG
0024 00025   0 16 00464        MPY     RX1
0025 00026   0 06 00244        DAD     OVFP
0026 00027   0401 76           LRS     2
0027 00030   0 06 00242        DAD     SUMM
0028 00031   0 04 00242        DST     SUMM
0029 00032   0 02 00470        DLD     RY1
0030 00033   000201            IAB
0031 00034   0 16 00471        MPY     RY2
0032 00035   0401 77           LRS     1
0033 00036   0 04 00244        DST     OVFP
0034 00037   0 02 00472        DLD     RY3
0035 00040   000201            IAB
0036 00041   0 07 00254        DSB     FUDG
0037 00042   0 16 00470        MPY     RY1
0038 00043   0 06 00244        DAD     OVFP
0039 00044   0401 76           LRS     2
0040 00045   0 06 00242        DAD     SUMM
0041 00046   0 04 00242        DST     SUMM
0042 00047   0 02 00474        DLD     RZ1
0043 00050   000201            IAB
0044 00051   0 16 00475        MPY     RZ2
0045 00052   0401 77           LRS     1
0046 00053   0 04 00244        DST     OVFP
0047 00054   0 02 00476        DLD     RZ3
0048 00055   000201            IAB
0049 00056   0 07 00254        DSB     FUDG
0050 00057   0 16 00474        MPY     RZ1
0051 00060   0 06 00244        DAD     OVFP
0052 00061   0401 76           LRS     2
0053 00062   0 06 00242        DAD     SUMM
0054 00063   0401 61           LRS     15
0055 00064   0 04 00242        DST     SUMM
0056 00065   0 02 00460        DLD     L1
0057 00066   0 16 00461        MPY     L2
```

```
0058 00067    0 04 00244       DST   OVFP
0059 00070    0 02 00464       DLD   RX1
0060 00071    0 16 00465       MPY   RX2
0061 00072    0 06 00244       DAD   OVFP
0062 00073    0 04 00244       DST   OVFP
0063 00074    0 02 00470       DLD   RY1
0064 00075    0 16 00471       MPY   RY2
0065 00076    0 06 00244       DAD   OVFP
0066 00077    0 04 00244       DST   OVFP
0067 00100    0 02 00474       DLD   RZ1
0068 00101    0 16 00475       MPY   RZ2
0069 00102    0 06 00244       DAD   OVFP
0070 00103    0401 76          LRS   2
0071 00104    0 06 00242       DAD   SUMM
0072 00105    0 04 00242       DST   SUMM
0073 00106    0411 75          LLS   3
0074 00107    140040           CRA
0075 00110    0 04 00252       DST   THRD
0076 00111    0 02 00242       DLD   SUMM
0077 00112    0401 64          LRS   12
0078 00113    0 04 00242       DST   SUMM
0079 00114    0 02 00460       DLD   L1
0080 00115    0 16 00460       MPY   L1
0081 00116    0 06 00242       DAD   SUMM
0082 00117    0 04 00242       DST   SUMM
0083 00120    0 02 00464       DLD   RX1
0084 00121    0 16 00464       MPY   RX1
0085 00122    0 06 00242       DAD   SUMM
0086 00123    0 04 00242       DST   SUMM
0087 00124    0 02 00470       DLD   RY1
0088 00125    0 16 00470       MPY   RY1
0089 00126    0 06 00242       DAD   SUMM
0090 00127    0 04 00242       DST   SUMM
0091 00130    0 02 00474       DLD   RZ1
0092 00131    0 16 00474       MPY   RZ1
0093 00132    0 06 00242       DAD   SUMM
0094 00133    0 07 00250       DSB   TWNZ
0095 00134    000201           IAB
0096 00135    140040           CRA
0097 00136    000201           IAB
0098 00137    0 06 00252       DAD   THRD
0099 00140    0411 66          LLS   10
0100 00141    0 06 00256       DAD   HALF
0101 00142    140407           TCA
0102 00143    0 04 00246       DST   FACT
0103 00144    0 16 00460       MPY   L1
0104 00145    0 06 00256       DAD   HALF
0105 00146    000201           IAB
0106 00147    140040           CRA
0107 00150    000201           IAB
0108 00151    0401 67          LRS   9
0109 00152    0 06 00462       DAD   L3
0110 00153    0 04 00244       DST   OVFP
0111 00154    140040           CRA
0112 00155    0 04 00462       DST   L3
0113 00156    0 02 00244       DLD   OVFP
0114 00157    0401 61          LRS   15
```

```
0115 00160    0 06 00460        DAD    L1
0116 00161    0 04 00460        DST    L1
0117 00162    0 02 00464        DLD    RX1
0118 00163    0 16 00246        MPY    FACT
0119 00164    0 06 00256        DAD    HALF
0120 00165    000201            IAB
0121 00166    140040            CRA
0122 00167    000201            IAB
0123 00170    0401 67           LRS    9
0124 00171    0 06 00466        DAD    RX3
0125 00172    0 04 00244        DST    OVFP
0126 00173    140040            CRA
0127 00174    0 04 00466        DST    RX3
0128 00175    0 02 00244        DLD    OVFP
0129 00176    0401 61           LRS    15
0130 00177    0 06 00464        DAD    RX1
0131 00200    0 04 00464        DST    RX1
0132 00201    0 02 00470        DLD    RY1
0133 00202    0 16 00246        MPY    FACT
0134 00203    0 06 00256        DAD    HALF
0135 00204    000201            IAB
0136 00205    140040            CRA
0137 00206    000201            IAB
0138 00207    0401 67           LRS    9
0139 00210    0 06 00472        DAD    RY3
0140 00211    0 04 00244        DST    OVFP
0141 00212    140040            CRA
0142 00213    0 04 00472        DST    RY3
0143 00214    0 02 00244        DLD    OVFP
0144 00215    0401 61           LRS    15
0145 00216    0 06 00470        DAD    RY1
0146 00217    0 04 00470        DST    RY1
0147 00220    0 02 00474        DLD    RZ1
0148 00221    0 16 00246        MPY    FACT
0149 00222    0 06 00256        DAD    HALF
0150 00223    000201            IAB
0151 00224    140040            CRA
0152 00225    000201            IAB
0153 00226    0401 67           LRS    9
0154 00227    0 06 00476        DAD    RZ3
0155 00230    0 04 00244        DST    OVFP
0156 00231    140040            CRA
0157 00232    0 04 00476        DST    RZ3
0158 00233    0 02 00244        DLD    OVFP
0159 00234    0401 61           LRS    15
0160 00235    0 06 00474        DAD    RZ1
0161 00236    0 04 00474        DST    RZ1
0162 00237    000005            SGL
0163 00240   -0 01 00000        JMP*   SPUN
0164 00242    000000      SUMM  DBP    0
     00243    000000
0165 00244    000000      OVFP  DBP    0
     00245    000000
0166 00246    000000      FACT  DBP    0
     00247    000000
0167 00250    020000      TWNZ  OCT    20000,0
     00251    000000
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0168 00252   000000      THRD DBP   0
     00253   000000
0169 00254   040000      FUDG OCT   40000,0
     00255   000000
0170 00256   000000      HALF OCT   0,40000
     00257   040000
0171         000460      L1   EQU   '460
0172         000461      L2   EQU   L1+1
0173         000462      L3   EQU   L1+2
0174         000464      RX1  EQU   L1+4
0175         000465      RX2  EQU   L1+5
0176         000466      RX3  EQU   L1+6
0177         000470      RY1  EQU   L1+8
0178         000471      RY2  EQU   L1+9
0179         000472      RY3  EQU   L1+10
0180         000474      RZ1  EQU   L1+12
0181         000475      RZ2  EQU   L1+13
0182         000476      RZ3  EQU   L1+14
0183                           END
```

PROGRAM NAME
SOURCE: VESP
BINARY: BVESP
RELATED MEMOS: T-493
ENTRY POINTS (location): VELA ('04206)
ACCESSABLE VARIABLES (location): FXX ('04654),
FXY ('04656), FXZ ('04660), FYX ('04662), FYY ('04664),
FYZ ('04666), FZX ('04670), FZY ('04672),
PZZ ('04674)
GENERAL DESCRIPTION:

This subroutine, when called, will construct a cosine matrix from the quaternion which transforms a vector in the body frame to the inertial frame. It will then multiply the ΔV in the body frame by this matrix to get ΔV in the inertial frame. The cosine matrix can be expressed in terms of the quaternion elements as:

$$C(Q) = \begin{bmatrix} 1 - 2(\rho_y^2 + \rho_z^2) & 2(\rho_x\rho_y - \lambda\rho_z) & 2(\rho_x\rho_z + \lambda\rho_y) \\ 2(\rho_x\rho_y + \lambda\rho_z) & 1 - 2(\rho_x^2 + \rho_z^2) & 2(\rho_y\rho_z - \lambda\rho_x) \\ 2(\rho_x\rho_z - \lambda\rho_y) & 2(\rho_y\rho_z + \lambda\rho_x) & 1 - 2(\rho_x^2 + \rho_y^2) \end{bmatrix}$$

This can be written as:

$$\begin{bmatrix} f_{xx} & f_{xy} & f_{xz} \\ f_{yx} & f_{yy} & f_{yz} \\ f_{zx} & f_{zy} & f_{zz} \end{bmatrix}$$

where

$$f_{xx} = 1 - 2(\rho_y^2 + \rho_z^2)$$

$$f_{xy} = 2(\rho_x\rho_y - \lambda\rho_z)$$

$$f_{xz} = 2(\rho_x\rho_z + \lambda\rho_y)$$

.
.
.

$$f_{zz} = 1 - 2(\rho_x^2 + \rho_y^2)$$

Observe that all elements of the matrix consist of various combinations of the nine quaternion products: ρ_x^2, ρ_y^2, ρ_z^2, $\rho_x\rho_y$, $\rho_x\rho_z$, $\rho_y\rho_z$, $\lambda\rho_x$, $\lambda\rho_y$ and $\lambda\rho_z$. Therefore, in the subroutine implementation the nine quaternion products are first calculated. Only 30 bits of each quaternion element is used and the cosine matrix elements are calculated to have a word size of 30 bits also. Scaling is as follows:

$$\lambda = 2L1 + \frac{L2}{2^{14}}$$

$$\rho_x = 2RX1 + \frac{RX2}{2^{14}}$$

$$\rho_y = 2RY1 + \frac{RY2}{2^{14}}$$

$$\rho_z = 2RZ1 + \frac{RZ2}{2^{14}}$$

$$\rho_x^2 = 4RX1^2 + \frac{RX1\ RX2}{2^{12}} + \frac{RXZ^2}{2^{28}}$$

or

$$RXSQ = \frac{\rho_x^2}{2} = 2RX1^2 + \frac{RX1\ RX2}{2^{13}} + \frac{RX2^2}{2^{29}}$$

the other 8 quaternion products are scaled the same as ρ_x^2.

We also define:

$$FXX = \frac{f_{xx}}{4} = \frac{1}{4} - \left(\frac{\rho_y^2}{2} + \frac{\rho_z^2}{2}\right)$$

$$\vdots$$

$$FZZ = \frac{f_{zz}}{4} = \frac{1}{4} - \left(\frac{\rho_x^2}{2} + \frac{\rho_y^2}{2}\right)$$

or

$$FXX = \frac{1}{4} - RYSQ - RZSQ$$

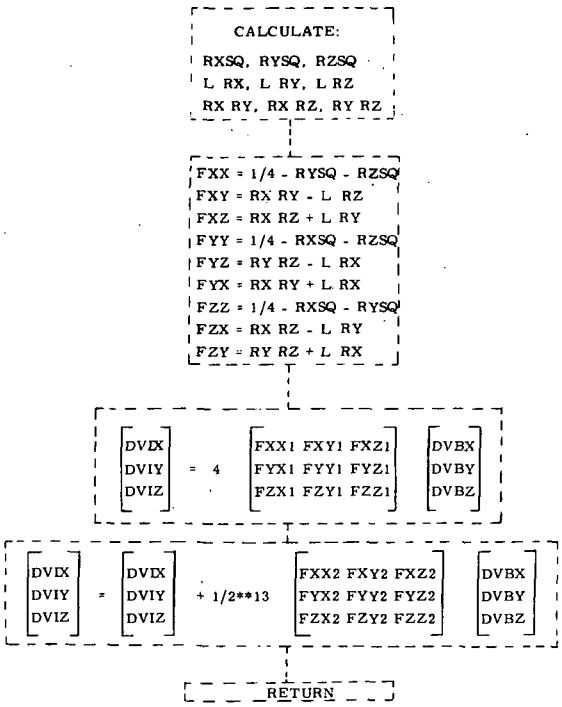
$$\vdots$$

$$FZZ = \frac{1}{4} - RXSQ - RYSQ$$

Now we can write the equations to be implemented as:

$$DVIX = 4\,(FXX\ DVXB + FXY\ DVYB + FXZ\ DVZB)$$
$$DVIY = 4\,(FYX\ DVXB + FYY\ DVYB + FYZ\ DVZB)$$
$$DVIZ = 4\,(FZX\ DVXB + FZY\ DVYB + FZZ\ DVZB)$$

where DVIX is ΔV in the inertial frame scaled the same as DVBX, ΔV in the body frame. The flow chart for the implementation on the DDP-516 of the above derivation follows:



FLOWCHART - VELA

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    REL
0002                                    SUBR   FXX
0003                                    SUBR   FXY
0004                                    SUBR   FXZ
0005                                    SUBR   FYX
0006                                    SUBR   FYY
0007                                    SUBR   FYZ
0008                                    SUBR   FZX
0009                                    SUBR   FZY
0010                                    SUBR   FZZ
0011                                    SUBR   VELA
0012 00000    0 000000    VELA          DAC    **
0013 00001    0 02 00465              LDA    RX2
0014 00002    000007                  DBL
0015 00003    0 16 00465              MPY    RX2
0016 00004    000201                  IAB
0017 00005    140040                  CRA
0018 00006    0401 77                 LRS    1
0019 00007    0 04 00444              DST    T1
0020 00010    0 02 00464              DLD    RX1
0021 00011    0 16 00465              MPY    RX2
0022 00012    0 06 00444              DAD    T1
0023 00013    0 06 00512              DAD    SQRD
0024 00014    0401 63                 LRS    13
0025 00015    0 04 00444              DST    T1
0026 00016    0 02 00464              DLD    RX1
0027 00017    0 16 00464              MPY    RX1
0028 00020    0411 77                 LLS    1
0029 00021    0 06 00444              DAD    T1
0030 00022    0 04 00470              DST    RXSQ
0031 00023    0 02 00470              DLD    RY1
0032 00024    000201                  IAB
0033 00025    0 16 00471              MPY    RY2
0034 00026    000201                  IAB
0035 00027    140040                  CRA
0036 00030    0401 77                 LRS    1
0037 00031    0 04 00444              DST    T1
0038 00032    0 02 00470              DLD    RY1
0039 00033    0 16 00471              MPY    RY2
0040 00034    0 06 00444              DAD    T1
0041 00035    0 06 00512              DAD    SQRD
0042 00036    0401 63                 LRS    13
0043 00037    0 04 00444              DST    T1
0044 00040    0 02 00470              DLD    RY1
0045 00041    0 16 00470              MPY    RY1
0046 00042    0411 77                 LLS    1
0047 00043    0 06 00444              DAD    T1
0048 00044    0 04 00472              DST    RYSQ
0049 00045    0 02 00474              DLD    RZ1
0050 00046    000201                  IAB
0051 00047    0 16 00475              MPY    RZ2
0052 00050    000201                  IAB
0053 00051    140040                  CRA
0054 00052    0401 77                 LRS    1
0055 00053    0 04 00444              DST    T1
0056 00054    0 02 00474              DLD    RZ1
0057 00055    0 16 00475              MPY    RZ2
```

```
0058 00056   0 06 00444      DAD   T1
0059 00057   0 06 00512      DAD   SQRD
0060 00060   0401 63         LRS   13
0061 00061   0 04 00444      DST   T1
0062 00062   0 02 00474      DLD   RZ1
0063 00063   0 16 00474      MPY   RZ1
0064 00064   0411 77         LLS   1
0065 00065   0 06 00444      DAD   T1
0066 00066   0 04 00474      DST   RZSQ
0067 00067   0 02 00460      DLD   L1
0068 00070   000201          IAB
0069 00071   0 16 00465      MPY   RX2
0070 00072   000201          IAB
0071 00073   140040          CRA
0072 00074   0 04 00444      DST   T1
0073 00075   0 02 00460      DLD   L1
0074 00076   0 16 00465      MPY   RX2
0075 00077   0 06 00444      DAD   T1
0076 00100   0 04 00444      DST   T1
0077 00101   0 02 00464      DLD   RX1
0078 00102   0 16 00461      MPY   L2
0079 00103   0 06 00444      DAD   T1
0080 00104   0 06 00514      DAD   CPRD
0081 00105   0401 62         LRS   14
0082 00106   0 04 00444      DST   T1
0083 00107   0 02 00460      DLD   L1
0084 00110   0 16 00464      MPY   RX1
0085 00111   0411 77         LLS   1
0086 00112   0 06 00444      DAD   T1
0087 00113   0 04 00476      DST   LRX
0088 00114   0 02 00460      DLD   L1
0089 00115   000201          IAB
0090 00116   0 16 00471      MPY   RY2
0091 00117   000201          IAB
0092 00120   140040          CRA
0093 00121   0 04 00444      DST   T1
0094 00122   0 02 00460      DLD   L1
0095 00123   0 16 00471      MPY   RY2
0096 00124   0 06 00444      DAD   T1
0097 00125   0 04 00444      DST   T1
0098 00126   0 02 00470      DLD   RY1
0099 00127   0 16 00461      MPY   L2
0100 00130   0 06 00444      DAD   T1
0101 00131   0 06 00514      DAD   CPRD
0102 00132   0401 62         LRS   14
0103 00133   0 04 00444      DST   T1
0104 00134   0 02 00460      DLD   L1
0105 00135   0 16 00470      MPY   RY1
0106 00136   0411 77         LLS   1
0107 00137   0 06 00444      DAD   T1
0108 00140   0 04 00500      DST   LRY
0109 00141   0 02 00460      DLD   L1
0110 00142   000201          IAB
0111 00143   0 16 00475      MPY   RZ2
0112 00144   000201          IAB
0113 00145   140040          CRA
0114 00146   0 04 00444      DST   T1
```

```
0115 00147   0 02 00460      DLD   L1
0116 00150   0 16 00475      MPY   RZ2
0117 00151   0 06 00444      DAD   T1
0118 00152   0 04 00444      DST   T1
0119 00153   0 02 00474      DLD   RZ1
0120 00154   0 16 00461      MPY   L2
0121 00155   0 06 00444      DAD   T1
0122 00156   0 06 00514      DAD   CPRD
0123 00157   0401 62         LRS   14
0124 00160   0 04 00444      DST   T1
0125 00161   0 02 00460      DLD   L1
0126 00162   0 16 00474      MPY   RZ1
0127 00163   0411 77         LLS   1
0128 00164   0 06 00444      DAD   T1
0129 00165   0 04 00502      DST   LRZ
0130 00166   0 02 00464      DLD   RX1
0131 00167   000201         IAB
0132 00170   0 16 00471      MPY   RY2
0133 00171   000201         IAB
0134 00172   140040         CRA
0135 00173   0 04 00444      DST   T1
0136 00174   0 02 00464      DLD   RX1
0137 00175   0 16 00471      MPY   RY2
0138 00176   0 06 00444      DAD   T1
0139 00177   0 04 00444      DST   T1
0140 00200   0 02 00470      DLD   RY1
0141 00201   0 16 00465      MPY   RX2
0142 00202   0 06 00444      DAD   T1
0143 00203   0 06 00514      DAD   CPRD
0144 00204   0401 62         LRS   14
0145 00205   0 04 00444      DST   T1
0146 00206   0 02 00464      DLD   RX1
0147 00207   0 16 00470      MPY   RY1
0148 00210   0411 77         LLS   1
0149 00211   0 06 00444      DAD   T1
0150 00212   0 04 00504      DST   RXRY
0151 00213   0 02 00464      DLD   RX1
0152 00214   000201         IAB
0153 00215   0 16 00475      MPY   RZ2
0154 00216   000201         IAB
0155 00217   140040         CRA
0156 00220   0 04 00444      DST   T1
0157 00221   0 02 00464      DLD   RX1
0158 00222   0 16 00475      MPY   RZ2
0159 00223   0 06 00444      DAD   T1
0160 00224   0 04 00444      DST   T1
0161 00225   0 02 00474      DLD   RZ1
0162 00226   0 16 00465      MPY   RX2
0163 00227   0 06 00444      DAD   T1
0164 00230   0 06 00514      DAD   CPRD
0165 00231   0401 62         LRS   14
0166 00232   0 04 00444      DST   T1
0167 00233   0 02 00464      DLD   RX1
0168 00234   0 16 00474      MPY   RZ1
0169 00235   0411 77         LLS   1
0170 00236   0 06 00444      DAD   T1
0171 00237   0 04 00506      DST   RXRZ
```

```
0172 00240   0 02 00470      DLD   RY1
0173 00241   000201          IAB
0174 00242   0 16 00475      MPY   RZ2
0175 00243   000201          IAB
0176 00244   140040          CRA
0177 00245   0 04 00444      DST   T1
0178 00246   0 02 00470      DLD   RY1
0179 00247   0 16 00475      MPY   RZ2
0180 00250   0 06 00444      DAD   T1
0181 00251   0 04 00444      DST   T1
0182 00252   0 02 00474      DLD   RZ1
0183 00253   0 16 00471      MPY   RY2
0184 00254   0 06 00444      DAD   T1
0185 00255   0 06 00514      DAD   CPRD
0186 00256   0401 62         LRS   14
0187 00257   0 04 00444      DST   T1
0188 00260   0 02 00470      DLD   RY1
0189 00261   0 16 00474      MPY   RZ1
0190 00262   0411 77         LLS   1
0191 00263   0 06 00444      DAD   T1
0192 00264   0 04 00510      DST   RYRZ
0193 00265   0 02 00516      DLD   ONQT
0194 00266   0 07 00472      DSB   RYSQ
0195 00267   0 07 00474      DSB   RZSQ
0196 00270   0 04 00446      DST   FXX
0197 00271   0 02 00504      DLD   RXRY
0198 00272   0 07 00502      DSB   LRZ
0199 00273   0 04 00450      DST   FXY
0200 00274   0 02 00506      DLD   RXRZ
0201 00275   0 06 00500      DAD   LRY
0202 00276   0 04 00452      DST   FXZ
0203 00277   0 02 00516      DLD   ONQT
0204 00300   0 07 00470      DSB   RXSQ
0205 00301   0 07 00474      DSB   RZSQ
0206 00302   0 04 00456      DST   FYY
0207 00303   0 02 00510      DLD   RYRZ
0208 00304   0 07 00476      DSB   LRX
0209 00305   0 04 00460      DST   FYZ
0210 00306   0 02 00504      DLD   RXRY
0211 00307   0 06 00502      DAD   LRZ
0212 00310   0 04 00454      DST   FYX
0213 00311   0 02 00516      DLD   ONQT
0214 00312   0 07 00470      DSB   RXSQ
0215 00313   0 07 00472      DSB   RYSQ
0216 00314   0 04 00466      DST   FZZ
0217 00315   0 02 00506      DLD   RXRZ
0218 00316   0 07 00500      DSB   LRY
0219 00317   0 04 00462      DST   FZX
0220 00320   0 02 00510      DLD   RYRZ
0221 00321   0 06 00476      DAD   LRX
0222 00322   0 04 00464      DST   FZY
0223 00323   0 02 00446      DLD   FXX
0224 00324   0 16 00614      MPY   DVBX
0225 00325   0 04 00666      DST   DVIX
0226 00326   0 02 00450      DLD   FXY
0227 00327   0 16 00616      MPY   DVBY
0228 00330   0 06 00666      DAD   DVIX
```

```
0229 00331    0 04 00666        DST    DVIX
0230 00332    0 02 00452        DLD    FXZ
0231 00333    0 16 00620        MPY    DVBZ
0232 00334    0 06 00666        DAD    DVIX
0233 00335    0411 76           LLS    2
0234 00336    0 04 00666        DST    DVIX
0235 00337    0 02 00454        DLD    FYX
0236 00340    0 16 00614        MPY    DVBX
0237 00341    0 04 00670        DST    DVIY
0238 00342    0 02 00456        DLD    FYY
0239 00343    0 16 00616        MPY    DVBY
0240 00344    0 06 00670        DAD    DVIY
0241 00345    0 04 00670        DST    DVIY
0242 00346    0 02 00460        DLD    FYZ
0243 00347    0 16 00620        MPY    DVBZ
0244 00350    0 06 00670        DAD    DVIY
0245 00351    0411 76           LLS    2
0246 00352    0 04 00670        DST    DVIY
0247 00353    0 02 00462        DLD    FZX
0248 00354    0 16 00614        MPY    DVBX
0249 00355    0 04 00672        DST    DVIZ
0250 00356    0 02 00464        DLD    FZY
0251 00357    0 16 00616        MPY    DVBY
0252 00360    0 06 00672        DAD    DVIZ
0253 00361    0 04 00672        DST    DVIZ
0254 00362    0 02 00466        DLD    FZZ
0255 00363    0 16 00620        MPY    DVBZ
0256 00364    0 06 00672        DAD    DVIZ
0257 00365    0411 76           LLS    2
0258 00366    0 04 00672        DST    DVIZ
0259 00367    0 02 00614        DLD    DVBX
0260 00370    0 16 00447        MPY    FXX+1
0261 00371    0 04 00444        DST    T1
0262 00372    0 02 00616        DLD    DVBY
0263 00373    0 16 00451        MPY    FXY+1
0264 00374    0 06 00444        DAD    T1
0265 00375    0 04 00444        DST    T1
0266 00376    0 02 00620        DLD    DVBZ
0267 00377    0 16 00453        MPY    FXZ+1
0268 00400    0 06 00444        DAD    T1
0269 00401    0 06 00512        DAD    SQRD
0270 00402    0401 63           LRS    13
0271 00403    0 06 00666        DAD    DVIX
0272 00404    0 04 00666        DST    DVIX
0273 00405    0 02 00614        DLD    DVBX
0274 00406    0 16 00455        MPY    FYX+1
0275 00407    0 04 00444        DST    T1
0276 00410    0 02 00616        DLD    DVBY
0277 00411    0 16 00457        MPY    FYY+1
0278 00412    0 06 00444        DAD    T1
0279 00413    0 04 00444        DST    T1
0280 00414    0 02 00620        DLD    DVBZ
0281 00415    0 16 00461        MPY    FYZ+1
0282 00416    0 06 00444        DAD    T1
0283 00417    0 06 00512        DAD    SQRD
0284 00420    0401 63           LRS    13
0285 00421    0 06 00670        DAD    DVIY
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0286 00422    0 04 00670        DST    DVIY
0287 00423    0 02 00614        DLD    DVBX
0288 00424    0 16 00463        MPY    FZX+1
0289 00425    0 04 00444        DST    T1
0290 00426    0 02 00616        DLD    DVBY
0291 00427    0 16 00465        MPY    FZY+1
0292 00430    0 06 00444        DAD    T1
0293 00431    0 04 00444        DST    T1
0294 00432    0 02 00620        DLD    DVBZ
0295 00433    0 16 00467        MPY    FZZ+1
0296 00434    0 06 00444        DAD    T1
0297 00435    0 06 00512        DAD    SQRD
0298 00436    0401 63           LRS    13
0299 00437    0 06 00672        DAD    DVIZ
0300 00440    0 04 00672        DST    DVIZ
0301 00441    000005            SGL
0302 00442   -0 01 00000        JMP*   VELA
0303 00444    000000      T1    DBP    0
     00445    000000
0304 00446    000000      FXX   DBP    0
     00447    000000
0305 00450    000000      FXY   DBP    0
     00451    000000
0306 00452    000000      FXZ   DBP    0
     00453    000000
0307 00454    000000      FYX   DBP    0
     00455    000000
0308 00456    000000      FYY   DBP    0
     00457    000000
0309 00460    000000      FYZ   DBP    0
     00461    000000
0310 00462    000000      FZX   DBP    0
     00463    000000
0311 00464    000000      FZY   DBP    0
     00465    000000
0312 00466    000000      FZZ   DBP    0
     00467    000000
0313 00470    000000      RXSQ  DBP    0
     00471    000000
0314 00472    000000      RYSQ  DBP    0
     00473    000000
0315 00474    000000      RZSQ  DBP    0
     00475    000000
0316 00476    000000      LRX   DBP    0
     00477    000000
0317 00500    000000      LRY   DBP    0
     00501    000000
0318 00502    000000      LRZ   DBP    0
     00503    000000
0319 00504    000000      RXRY  DBP    0
     00505    000000
0320 00506    000000      RXRZ  DBP    0
     00507    000000
0321 00510    000000      RYRZ  DBP    0
     00511    000000
0322 00512    000000      SQRD  OCT    0,10000
     00513    010000
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0323 00514   000000      CPRD OCT   0,20000
     00515   020000
0324 00516   020000      ONQT OCT   20000,0
     00517   000000
0325         000460      L1   EQU   '460
0326         000461      L2   EQU   L1+1
0327         000464      RX1  EQU   L1+4
0328         000465      RX2  EQU   L1+5
0329         000470      RY1  EQU   L1+8
0330         000471      RY2  EQU   L1+9
0331         000474      RZ1  EQU   L1+12
0332         000475      RZ2  EQU   L1+13
0333         000614      DVBX EQU   '614
0334         000616      DVBY EQU   DVBX+2
0335         000620      DVBZ EQU   DVBX+4
0336         000666      DVIX EQU   '666
0337         000670      DVIY EQU   DVIX+2
0338         000672      DVIZ EQU   DVIX+4
0339                           END
```

PROGRAM NAME:
SOURCE: VACU
BINARY: BVACU
ENTRY POINTS (location): VACU ('05506)
GENERAL DESCRIPTION:

This subroutine, when called, accumulates delta velocity in the inertial frame (DVIX, DVIY and DVIZ calculated by the velocity algorithm, program source name VESP subroutine entry point VELA). The three accumulators (XAV1-XAV3, YAV1-YAV3 and ZAV1-ZAV3) are triple precision accumulators and a brief examination of this subroutine will show that it performs the following three tasks:

$$XAV = XAV + \frac{DVIX}{2^{15}}$$

$$YAV = YAV + \frac{DVIY}{2^{15}}$$

$$ZAV = ZAV + \frac{DVIZ}{2^{15}}$$

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                REL
0002                                SUBR  VACU
0003 00000   0 000000    VACU      DAC   **
0004 00001   000007                DBL
0005 00002   0 02 00666             DLD   DVIX
0006 00003   140040                CRA
0007 00004   0 06 00446             DAD   XAV3
0008 00005   0 04 00446             DST   XAV3
0009 00006   000201                IAB
0010 00007   140040                CRA
0011 00010   000201                IAB
0012 00011   0 06 00666             DAD   DVIX
0013 00012   0401 61                LRS   15
0014 00013   0 06 00444             DAD   XAV1
0015 00014   0 04 00444             DST   XAV1
0016 00015   0 02 00670             DLD   DVIY
0017 00016   140040                CRA
0018 00017   0 06 00452             DAD   YAV3
0019 00020   0 04 00452             DST   YAV3
0020 00021   000201                IAB
0021 00022   140040                CRA
0022 00023   000201                IAB
0023 00024   0 06 00670             DAD   DVIY
0024 00025   0401 61                LRS   15
0025 00026   0 06 00450             DAD   YAV1
0026 00027   0 04 00450             DST   YAV1
0027 00030   0 02 00672             DLD   DVIZ
0028 00031   140040                CRA
0029 00032   0 06 00456             DAD   ZAV3
0030 00033   0 04 00456             DST   ZAV3
0031 00034   000201                IAB
0032 00035   140040                CRA
0033 00036   000201                IAB
0034 00037   0 06 00672             DAD   DVIZ
0035 00040   0401 61                LRS   15
0036 00041   0 06 00454             DAD   ZAV1
0037 00042   0 04 00454             DST   ZAV1
0038 00043   000005                SGL
0039 00044   140040                CRA
0040 00045   0 04 00446             STA   XAV3
0041 00046   0 04 00452             STA   YAV3
0042 00047   0 04 00456             STA   ZAV3
0043 00050  -0 01 00000             JMP*  VACU
0044          000666     DVIX      EQU   '666
0045          000670     DVIY      EQU   DVIX+2
0046          000672     DVIZ      EQU   DVIX+4
0047          000444     XAV1      EQU   '444
0048          000446     XAV3      EQU   XAV1+2
0049          000450     YAV1      EQU   XAV1+4
0050          000452     YAV3      EQU   XAV1+6
0051          000454     ZAV1      EQU   XAV1+8
0052          000456     ZAV3      EQU   XAV1+10
0053                                END
```

PROGRAM NAME
SOURCE: ERC6
BINARY: BERC6
ENTRY POINTS (location): ERCO ('2726)
GENERAL DESCRIPTION:

This subroutine will do the equivalent of torquing a gyro in a gimbal IMU. It essentially compensates the gyros for a drift in the inertial frame and is used to take out WIE, earth rate, thus the acronym ERCO or earth rate compensation. It does this by transforming the negative of the drift in the inertial frame into the body frame and adding it to the gyros as an equivalent NBD. It makes use of the cosine matrix (C_B^I developed from the quaternion by the subroutine VELA which transforms the ΔV_B into ΔV_I. The gyro drift in the body frame due to earth rate is:

$$\begin{bmatrix} \omega_{IEXB} \\ \omega_{IEYB} \\ \omega_{IEZB} \end{bmatrix} = C_B^{I^T} \begin{bmatrix} \omega_{IEXI} \\ \omega_{IEYI} \\ \omega_{IEZI} \end{bmatrix}$$

C_B^I is created by VELA and its elements are FXX, FXY, FXZ, FYX, FYY, FYZ, FZX, FZY and FZZ. This subroutine gains access to the constants by using the pseudo-op XAC or external address constant. For example, the pseudo-op XFXX XAC FXX puts the address of FXX in the location called XFXX. Of course, the transpose of the above matrix (C_B^{IT}) is FXX, FYX, FZX, FXY, FYY, FZY, FXZ, FYZ and FZZ.

The X, Y and Z inertial rates to be compensated for are stored in octal locations 250, 251 and 252 respectively. These are specially scaled constants that are the negative of the earth rate sensed on these inertial axes. If, for example, the X, Y and Z inertial axes were north, east and down at this latitude (42^o, 21', 51''), locations 250, 251 and 252 would contain the octal constants -44121, 0 and 40763. The $\Delta\theta_X$, $\Delta\theta_Y$ and $\Delta\theta_Z$ to be compensated are contained in octal locations 414, 416 and 420. The subroutine itself is so straight-forward that no flow chart is necessary.

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                    REL
0002                                    SUBR  ERCO
0003 00000    0 000000    ERCO  DAC     **
0004 00001    000007            DBL
0005 00002   -0 02 00074        DLD*    XFXX
0006 00003    0 06 00072        DAD     MRRD
0007 00004    0 16 00250        MPY     '250
0008 00005    0 04 00064        DST     XERC
0009 00006   -0 02 00077        DLD*    XFYX
0010 00007    0 06 00072        DAD     MRRD
0011 00010    0 16 00251        MPY     '251
0012 00011    0 06 00064        DAD     XERC
0013 00012    0 04 00064        DST     XERC
0014 00013   -0 02 00102        DLD*    XFZX
0015 00014    0 06 00072        DAD     MRRD
0016 00015    0 16 00252        MPY     '252
0017 00016    0 06 00064        DAD     XERC
0018 00017    0401 64           LRS     12
0019 00020    0 06 00414        DAD     '414
0020 00021    0 04 00414        DST     '414
0021 00022   -0 02 00075        DLD*    XFXY
0022 00023    0 06 00072        DAD     MRRD
0023 00024    0 16 00250        MPY     '250
0024 00025    0 04 00066        DST     YERC
0025 00026   -0 02 00100        DLD*    XFYY
0026 00027    0 06 00072        DAD     MRRD
0027 00030    0 16 00251        MPY     '251
0028 00031    0 06 00066        DAD     YERC
0029 00032    0 04 00066        DST     YERC
0030 00033   -0 02 00103        DLD*    XFZY
0031 00034    0 06 00072        DAD     MRRD
0032 00035    0 16 00252        MPY     '252
0033 00036    0 06 00066        DAD     YERC
0034 00037    0401 64           LRS     12
0035 00040    0 06 00416        DAD     '416
0036 00041    0 04 00416        DST     '416
0037 00042   -0 02 00076        DLD*    XFXZ
0038 00043    0 06 00072        DAD     MRRD
0039 00044    0 16 00250        MPY     '250
0040 00045    0 04 00070        DST     ZERC
0041 00046   -0 02 00101        DLD*    XFYZ
0042 00047    0 06 00072        DAD     MRRD
0043 00050    0 16 00251        MPY     '251
0044 00051    0 06 00070        DAD     ZERC
0045 00052    0 04 00070        DST     ZERC
0046 00053   -0 02 00104        DLD*    XFZZ
0047 00054    0 06 00072        DAD     MRRD
0048 00055    0 16 00252        MPY     '252
0049 00056    0 06 00070        DAD     ZERC
0050 00057    0401 64           LRS     12
0051 00060    0 06 00420        DAD     '420
0052 00061    0 04 00420        DST     '420
0053 00062    000005            SGL
0054 00063   -0 01 00000        JMP*    ERCO
0055 00064    000000      XERC  DBP     0
     00065    000000
0056 00066    000000      YERC  DBP     0
```

```
MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
     00067   000000
0057 00070   000000      ZFRC DBP   0
     00071   000000
0058 00072   000000      MRRD OCT   0,40000
     00073   040000
0059 00074   0 000000    XFXX XAC   FXX
0060 00075   0 000000    XFXY XAC   FXY
0061 00076   0 000000    XFXZ XAC   FXZ
0062 00077   0 000000    XFYX XAC   FYX
0063 00100   0 000000    XFYY XAC   FYY
0064 00101   0 000000    XFYZ XAC   FYZ
0065 00102   0 000000    XFZX XAC   FZX
0066 00103   0 000000    XFZY XAC   FZY
0067 00104   0 000000    XFZZ XAC   FZZ
0068                          END
```

PROGRAM NAME
SOURCE: AA6S
BINARY: BAA6S
RELATED MEMOS: T-493
ENTRY POINTS (location): ATTA ('05060)
GENERAL DESCRIPTION:

This subroutine when called will perform a third order attitude algorithm to update the quaternion of rotation. The equation representing the algorithm can be expressed as:

$$\rho_x' = \lambda S\alpha_x + R\rho_x + S(\rho_y\alpha_z - \rho_z\alpha_y)$$

$$\rho_y' = \lambda S\alpha_y + R\rho_y + S(\rho_z\alpha_x - \rho_x\alpha_z)$$

$$\rho_z' = \lambda S\alpha_z + R\rho_z + S(\overline{\rho}_z\alpha_y - \rho_y\alpha_x)$$

$$\lambda' = -S(\overline{\rho} \cdot \overline{\alpha}) + R\lambda$$

where

$$\overline{\alpha} = \Delta\frac{\theta}{2}$$

$$M = \overline{\alpha} \cdot \overline{\alpha}$$

$$R = (1 - \frac{1}{2}M)$$

$$S = (1 - \frac{1}{6}M)$$

expanding this equation, if we define $\Delta = \Delta\theta_x\Delta\theta_x + \Delta\theta_y\Delta\theta_y + \Delta\theta_z\Delta\theta_z$

$$\rho_x' = \lambda(1 - \frac{\Delta}{24})\frac{\Delta\theta x}{2} + (1 - \frac{\Delta}{8})\rho_x + (1 - \frac{\Delta}{24})\left(\frac{\rho_y\Delta\theta_z - \rho_z\Delta\theta_y}{2}\right)$$

therefore:

$$\rho_x' = \rho_x + \frac{\lambda\Delta\theta_x}{2} - \frac{\lambda\Delta\Delta\theta_x}{48} - \frac{\Delta\rho_x}{8} + \frac{\rho_y\Delta\theta_z - \rho_2\Delta\theta_y}{2} - \Delta\frac{(\rho_y\Delta\theta_z - \rho_2\Delta\theta_y)}{48}$$

to determine ρ_y', replace x, y, z subscripts by y, z, x in the equation for ρ_x'. To determine ρ_z', replace x, y, z subscripts by z, x, y in the equation

for ρ_x'. Then,

$$\lambda' = -S(\bar{\rho} \cdot \bar{\alpha}) + R\lambda$$

therefore:

$$\lambda' = \lambda - \frac{\Delta}{8}\lambda - \frac{(\rho_x \Delta\theta_x + \rho_y \Delta\theta_y + \rho_z \Delta\theta_z)}{2} + \frac{\Delta}{48}(\rho_x \Delta\theta_x + \rho_y \Delta\theta_y + \rho_z \Delta\theta_z)$$

In the present DDP516 implementation the actual numbers in the computer are scaled as follows:

$$DX = 2^6 \Delta\theta_x \text{ or } \Delta\theta_x = DX\, 2^{-6}$$

$$DY = 2^6 \Delta\theta_y \text{ or } \Delta\theta_y = DY\, 2^{-6}$$

$$DZ = 2^6 \Delta\theta_z \text{ or } \Delta\theta_z = DZ\, 2^{-6}$$

$$RX = \frac{\rho_x}{2} \text{ or } \rho_x = 2RX$$

$$RY = \frac{\rho_y}{2} \text{ or } \rho_y = 2RY$$

$$RZ = \frac{\rho_z}{2} \text{ or } \rho_z = 2RZ$$

$$L = \frac{\lambda}{2} \text{ or } \lambda = 2L$$

$$D^2 = 2^{12}\Delta \text{ or } \Delta = D^2\, 2^{-12} = (DX^2 + DY^2 + DZ^2)\, 2^{-12}$$

now substituting this scaling into the equation given above we find:

$$2RX' = 2RX + \frac{L\, DX}{2^6} - \frac{L\, D^2\, DX}{3\, 2^{21}} - \frac{D^2\, RX}{2^{14}}$$

$$+ \frac{RY\, DZ - RZ\, DY}{2^6} - \frac{D^2(RY\, DZ - RZ\, DY)}{3\, 2^{21}}$$

if we define

$$\Delta RX = RX' - RX$$

then,

$$\Delta RX = \frac{L\,DX}{2^7} - \frac{L\,D^2\,DX}{3\,2^{22}} - \frac{D^2\,RX}{2^{15}} + \frac{RY\,DZ - RZ\,DY}{2^7} - \frac{D^2(RY\,DZ - DZ\,DY)}{3\,2^{22}}$$

also,

$$2L' = 2L - \frac{D^2\,L}{2^{14}} - \frac{RX\,DX + RY\,DY + RZ\,DZ}{2^6}$$

$$+ \frac{D^2(RX\,DX + RY\,DY + RZ\,DZ)}{3\,2^{21}}$$

and if

$$\Delta L = L' - L,$$

$$\Delta L = -\frac{D^2 L}{2^{15}} - \frac{RX\,DX + RY\,DY + RZ\,DZ}{2^7} + \frac{D^2(RX\,DX + RY\,DY + RZ\,DZ)}{3\,2^{22}}$$

The equations for ΔRY and ΔRZ are obtained in a similar manner.

A 16 bit word in the DDP516 is made up of a sign bit and 15 bits of fraction. For example, 0110 000 000 000 000 represents +.75 decimal. Each quaternion component is made up of three of these numbers. For example, L will be represented by

$$L1 + \frac{L2}{2^{15}} + \frac{L3}{2^{30}},$$

which is equivalent to a 45 bit signed fraction where the sign bits of L2 and L3 are ignored. In core L1 is in location '460, L2 in '461 and L3 + '40000* is in '463. Location '462 is normally zero except when '463 overflows into '462 which is then added to '461. RX, RY and RZ follow L in core in locations '464, '470 and '474 respectively. A unit quaternion in core

$$(\lambda = 1, \rho_x = 0, \rho_y = 0, \rho_z = 0$$

or

$$L = 1/2, RX = 0, RY = 0, RZ = 0)$$

would look like the following (in octal):

---

*Since only L1 and L2 are used in the velocity algorithm, the '40000 (1/2) added to L3 is for rounding.

loc.	'460	'461	'462	'463
L	040000	000000	000000	040000
	L1	L2		L3+'40000
loc.	'464	'465	'466	'467
RX	000000	000000	000000	040000
	RX1	RX2		RX3+'40000
loc.	'470	'471	'472	'473
RY	000000	000000	000000	040000
	RY1	RY2		RY3+'40000
loc.	'474	'475	'476	'477
RZ	000000	000000	000000	040000
	RZ1	RZ2		RZ3+'40000

DX, DY and DZ are single precision fractions. However, D^2 will be 30 bits and will be represented by

$$D^2_1 + \frac{D^2_2}{2^{15}}$$

With these considerations in mind the quaternion update equations can be expanded as:

$$\begin{aligned}
\Delta RX = {} & \frac{L1\ DX}{2^7} + \frac{L2\ DX}{2^{22}} + \frac{L3\ DX}{2^{37}} \\
& - \frac{DX\ D^2_1\ L1}{3\times 2^{22}} - \frac{DX\ D^2_1\ L2}{3\times 2^{37}} - \frac{DX\ D^2_1\ L3}{3\times 2^{52}} \\
& - \frac{DX\ D^2_2\ L1}{3\times 2^{37}} - \frac{DX\ D^2_2\ L2}{3\times 2^{52}} - \frac{DX\ D^2_2\ L3}{3\times 2^{67}} \\
& - \frac{D^2_1\ RX1}{2^{15}} - \frac{D^2_1\ RX2}{2^{30}} - \frac{D^2_1\ RX3}{2^{45}} \\
& - \frac{D^2_2\ RX1}{2^{30}} - \frac{D^2_2\ RX2}{2^{45}} - \frac{D^2_2\ RX3}{2^{60}} \\
& + \frac{RY1\ DZ}{2^7} + \frac{RY2\ DZ}{2^{22}} + \frac{RY3\ DZ}{2^{37}} \\
& - \frac{RZ1\ DY}{2^7} - \frac{RZ2\ DY}{2^{22}} - \frac{RZ3\ DY}{2^{37}}
\end{aligned}$$

$$- \frac{D^2 1\ RY1\ DZ}{3\times 2^{22}} - \frac{D^2 1\ RY^2\ DZ}{3\times 2^{37}} - \frac{D^2 1\ RY3\ DZ}{3\times 2^{52}}$$

$$+ \frac{D^2 1\ RZ1\ DY}{3\times 2^{22}} + \frac{D^2 1\ RZ2\ DY}{3\times 2^{37}} + \frac{D^2 1\ RZ3\ DY}{3\times 2^{52}}$$

$$- \frac{D^2 2\ RY1\ DZ}{3\times 2^{37}} - \frac{D^2 2\ RY2\ DZ}{3\times 2^{52}} - \frac{D^2 2\ RY3\ DZ}{3\times 2^{67}}$$

$$+ \frac{D^2 2\ RZ1\ DY}{3\times 2^{37}} + \frac{D^2 2\ RZ2\ DY}{3\times 2^{52}} + \frac{D^2 2\ RZ3\ DY}{3\times 2^{67}}$$

$$\Delta L = - \frac{D^2 1\ L1}{2^{15}} - \frac{D^2 1\ L2}{2^{30}} - \frac{D^2 1\ L3}{2^{45}} - \frac{D^2 2\ L1}{2^{30}} - \frac{D^2 2\ L2}{2^{45}} - \frac{D^2 2\ L3}{2^{60}}$$

$$- \frac{RX1\ DX}{2^{7}} - \frac{RX2\ DX}{2^{22}} - \frac{RX3\ DX}{2^{37}} - \frac{RY1\ DY}{2^{7}} - \frac{RY2\ DY}{2^{22}} - \frac{RY3\ DY}{2^{37}}$$

$$- \frac{RZ1\ DZ}{2^{7}} - \frac{RZ2\ DZ}{2^{22}} - \frac{RZ3\ DZ}{2^{37}}$$

$$+ \frac{D^2 1\ RX1\ DX}{3\times 2^{22}} + \frac{D^2 1\ RX2\ DX}{3\times 2^{37}} + \frac{D^2 1\ RX3\ DX}{3\times 2^{52}}$$

$$+ \frac{D^2 1\ RY1\ DY}{3\times 2^{22}} + \frac{D^2 1\ RY2\ DY}{3\times 2^{37}} + \frac{D^2 1\ RY3\ DY}{3\times 2^{52}}$$

$$+ \frac{D^2 1\ RZ1\ DZ}{3\times 2^{22}} + \frac{D^2 1\ RZ2\ DZ}{3\times 2^{37}} + \frac{D^2 1\ RZ3\ DZ}{3\times 2^{52}}$$

$$+ \frac{D^2 2\ RX1\ DX}{3\times 2^{37}} + \frac{D^2 2\ RX2\ DX}{3\times 2^{52}} + \frac{D^2 2\ RX3\ DX}{3\times 2^{67}}$$

$$+ \frac{D^2 2\ RY1\ DY}{3\times 2^{37}} + \frac{D^2 2\ RY2\ DY}{3\times 2^{52}} + \frac{D^2 2\ RY3\ DY}{3\times 2^{67}}$$

$$+ \frac{D^2 2\ RZ1\ DZ}{3\times 2^{37}} + \frac{D^2 2\ RZ2\ DZ}{3\times 2^{52}} + \frac{D^2 2\ RZ3\ DZ}{3\times 2^{67}}$$

With ΔRY and ΔRZ defined in a similar manner.

The algorithm that is written considers L, RX, RY and RZ to have only 37 bits of significance. Therefore, all terms in the final equations with denominators greater than 2^{37} can be ignored. This simplifies the final equations to be programmed to:

$$\Delta RX = \frac{L1\ DX}{2^7} + \frac{L2\ DX}{2^{22}} - \frac{DX\ D^2 1\ L1}{3\times 2^{22}}$$

$$- \frac{D^2 1\ RX1}{2^{15}} - \frac{D^2 1\ RX2}{2^{30}} - \frac{D^2 2\ RX1}{2^{30}}$$

$$+ \frac{RY1\ DZ}{2^7} + \frac{RY2\ DZ}{2^{22}} - \frac{RZ1\ DY}{2^7} - \frac{RZ2\ DY}{2^{22}}$$

$$- \frac{D^2 1\ RY1\ DZ}{3\times 2^{22}} + \frac{D^2 1\ RZ1\ DY}{3\times 2^{22}}$$

and,

$$\Delta L = -\frac{D^2 1\ L1}{2^{15}} - \frac{D^2 1\ L2}{2^{30}} - \frac{D^2 2\ L1}{2^{30}}$$

$$- \frac{RX1\ DX}{2^7} - \frac{RX2\ DX}{2^{22}} - \frac{RY1\ DY}{2^7} - \frac{RY2\ DY}{2^{22}} - \frac{RZ1\ DZ}{2^7} - \frac{RZ2\ DZ}{2^{22}}$$

$$+ \frac{D^2 1\ RX1\ DX}{3\times 2^{22}} + \frac{D^2 1\ RY1\ DY}{3\times 2^{22}} + \frac{D^2 1\ RZ1\ DZ}{3\times 2^{22}}$$

The final simplification is to replace

$$(-2D^2 1)/3$$

with a variable called D3 and to calculate $2^7\ \Delta RX$, $2^7\ \Delta RY$, $2^7\ \Delta RZ$ and $2^7\ \Delta L$ before deriving ΔRX, ΔRY, ΔRZ and ΔL. The program equations then are:

$$2^7\ \Delta RX = L1\ DX + \frac{L2\ DX}{2^{15}} + \frac{DX\ D3\ L1}{2^{16}}$$

$$- \frac{D^2 1\ RX1}{2^8} - \frac{D^2 1\ RX2}{2^{23}} - \frac{D^2 2\ RX1}{2^{23}}$$

$$+ RY1\ DZ + \frac{RY2\ DZ}{2^{15}} - RZ1\ DY - \frac{RZ2\ DY}{2^{15}}$$

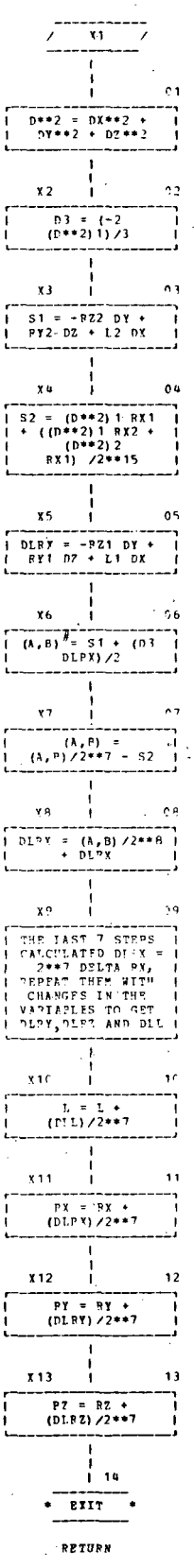
$$+ \frac{D3\ RY1\ DZ}{2^{16}} - \frac{D3\ RZ1\ DY}{2^{16}}$$

and,

$$2^7 \Delta L = -\frac{D^2_1 \, L1}{2^8} - \frac{D^2_1 \, L2}{2^{23}} - \frac{D^2_2 \, L1}{2^{23}}$$

$$- RX1 \, DX - \frac{RX2 \, DX}{2^{15}} - RY1 \, DY - \frac{RY2 \, DY}{2^{15}} - RZ1 \, DZ - \frac{RZ2 \, DZ}{2^{15}}$$

$$- \frac{D3 \, RX1 \, DX}{2^{16}} - \frac{D3 \, RY1 \, DY}{2^{16}} - \frac{D3 \, RZ1 \, DZ}{2^{16}}$$



FLOWCHART - ATTA

The Double Precision Accumulator

```
MICROCOMP TELECOMMUNICATED DATA
      DDP-516 ASSEMBLY LISTING
0001                                  REL
0002                                  SUBR   ATTA
0003 00000    0 000000    ATTA        DAC    **
0004 00001    0 02 00414              LDA    DX
0005 00002    000007                  DBL
0006 00003    0 16 00414              MPY    DX
0007 00004    0 04 00410              DST    D1
0008 00005    0 02 00416              DLD    DY
0009 00006    0 16 00416              MPY    DY
0010 00007    0 06 00410              DAD    D1
0011 00010    0 04 00410              DST    D1
0012 00011    0 02 00420              DLD    DZ
0013 00012    0 16 00420              MPY    DZ
0014 00013    0 06 00410              DAD    D1
0015 00014    0 04 00410              DST    D1
0016 00015    0 16 00424              MPY    ='125253
0017 00016    0 06 00420              DAD    TRND
0018 00017    0 04 00412              DST    D3
0019 00020    0 02 00416              DLD    DY
0020 00021    0 16 00475              MPY    RZ2
0021 00022    0 04 00414              DST    S1
0022 00023    0 02 00420              DLD    DZ
0023 00024    0 16 00471              MPY    RY2
0024 00025    0 07 00414              DSB    S1
0025 00026    0 04 00414              DST    S1
0026 00027    0 02 00414              DLD    DX
0027 00030    0 16 00461              MPY    L2
0028 00031    0 06 00414              DAD    S1
0029 00032    0 04 00414              DST    S1
0030 00033    0 02 00464              DLD    RX1
0031 00034    0 16 00411              MPY    D2
0032 00035    0 04 00416              DST    S2
0033 00036    0 02 00410              DLD    D1
0034 00037    0 16 00465              MPY    RX2
0035 00040    0 06 00416              DAD    S2
0036 00041    0401 61                 LRS    15
0037 00042    0 04 00416              DST    S2
0038 00043    0 02 00410              DLD    D1
0039 00044    0 16 00464              MPY    RX1
0040 00045    0 06 00416              DAD    S2
0041 00046    0 04 00416              DST    S2
0042 00047    0 02 00416              DLD    DY
0043 00050    0 16 00474              MPY    RZ1
0044 00051    0 04 00402              DST    DLRX
0045 00052    0 02 00420              DLD    DZ
0046 00053    0 16 00470              MPY    RY1
0047 00054    0 07 00402              DSB    DLRX
0048 00055    0 04 00402              DST    DLRX
0049 00056    0 02 00414              DLD    DX
0050 00057    0 16 00460              MPY    L1
0051 00060    0 06 00402              DAD    DLRX
0052 00061    0 04 00402              DST    DLRX
0053 00062    0 16 00412              MPY    D3
0054 00063    0401 77                 LRS    1
0055 00064    0 06 00414              DAD    S1
0056 00065    0401 71                 LRS    7
0057 00066    0 07 00416              DSB    S2
```

```
0058 00067   0 06 00422      DAD   SRND
0059 00070   0401 70         LRS   8
0060 00071   0 06 00402      DAD   DLRX
0061 00072   0 04 00402      DST   DLRX
0062 00073   0 02 00420      DLD   DZ
0063 00074   0 16 00465      MPY   RX2
0064 00075   0 04 00414      DST   S1
0065 00076   0 02 00414      DLD   DX
0066 00077   0 16 00475      MPY   RZ2
0067 00100   0 07 00414      DSB   S1
0068 00101   0 04 00414      DST   S1
0069 00102   0 02 00416      DLD   DY
0070 00103   0 16 00461      MPY   L2
0071 00104   0 06 00414      DAD   S1
0072 00105   0 04 00414      DST   S1
0073 00106   0 02 00470      DLD   RY1
0074 00107   0 16 00411      MPY   D2
0075 00110   0 04 00416      DST   S2
0076 00111   0 02 00410      DLD   D1
0077 00112   0 16 00471      MPY   RY2
0078 00113   0 06 00416      DAD   S2
0079 00114   0401 61         LRS   15
0080 00115   0 04 00416      DST   S2
0081 00116   0 02 00410      DLD   D1
0082 00117   0 16 00470      MPY   RY1
0083 00120   0 06 00416      DAD   S2
0084 00121   0 04 00416      DST   S2
0085 00122   0 02 00420      DLD   DZ
0086 00123   0 16 00464      MPY   RX1
0087 00124   0 04 00404      DST   DLRY
0088 00125   0 02 00414      DLD   DX
0089 00126   0 16 00474      MPY   RZ1
0090 00127   0 07 00404      DSB   DLRY
0091 00130   0 04 00404      DST   DLRY
0092 00131   0 02 00416      DLD   DY
0093 00132   0 16 00460      MPY   L1
0094 00133   0 06 00404      DAD   DLRY
0095 00134   0 04 00404      DST   DLRY
0096 00135   0 16 00412      MPY   D3
0097 00136   0401 77         LRS   1
0098 00137   0 06 00414      DAD   S1
0099 00140   0401 71         LRS   7
0100 00141   0 07 00416      DSB   S2
0101 00142   0 06 00422      DAD   SRND
0102 00143   0401 70         LRS   8
0103 00144   0 06 00404      DAD   DLRY
0104 00145   0 04 00404      DST   DLRY
0105 00146   0 02 00414      DLD   DX
0106 00147   0 16 00471      MPY   RY2
0107 00150   0 04 00414      DST   S1
0108 00151   0 02 00416      DLD   DY
0109 00152   0 16 00465      MPY   RX2
0110 00153   0 07 00414      DSB   S1
0111 00154   0 04 00414      DST   S1
0112 00155   0 02 00420      DLD   DZ
0113 00156   0 16 00461      MPY   L2
0114 00157   0 06 00414      DAD   S1
```

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MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0115 00160    0 04 00414       DST    S1
0116 00161    0 02 00474       DLD    RZ1
0117 00162    0 16 00411       MPY    D2
0118 00163    0 04 00416       DST    S2
0119 00164    0 02 00410       DLD    D1
0120 00165    0 16 00475       MPY    RZ2
0121 00166    0 06 00416       DAD    S2
0122 00167    0401 61          LRS    15
0123 00170    0 04 00416       DST    S2
0124 00171    0 02 00410       DLD    D1
0125 00172    0 16 00474       MPY    RZ1
0126 00173    0 06 00416       DAD    S2
0127 00174    0 04 00416       DST    S2
0128 00175    0 02 00414       DLD    DX
0129 00176    0 16 00470       MPY    RY1
0130 00177    0 04 00406       DST    DLRZ
0131 00200    0 02 00416       DLD    DY
0132 00201    0 16 00464       MPY    RX1
0133 00202    0 07 00406       DSB    DLRZ
0134 00203    0 04 00406       DST    DLRZ
0135 00204    0 02 00420       DLD    DZ
0136 00205    0 16 00460       MPY    L1
0137 00206    0 06 00406       DAD    DLRZ
0138 00207    0 04 00406       DST    DLRZ
0139 00210    0 16 00412       MPY    D3
0140 00211    0401 77          LRS    1
0141 00212    0 06 00414       DAD    S1
0142 00213    0401 71          LRS    7
0143 00214    0 07 00416       DSB    S2
0144 00215    0 06 00422       DAD    SRND
0145 00216    0401 70          LRS    8
0146 00217    0 06 00406       DAD    DLRZ
0147 00220    0 04 00406       DST    DLRZ
0148 00221    0 02 00414       DLD    DX
0149 00222    0 16 00465       MPY    RX2
0150 00223    0 04 00414       DST    S1
0151 00224    0 02 00416       DLD    DY
0152 00225    0 16 00471       MPY    RY2
0153 00226    0 06 00414       DAD    S1
0154 00227    0 04 00414       DST    S1
0155 00230    0 02 00420       DLD    DZ
0156 00231    0 16 00475       MPY    RZ2
0157 00232    0 06 00414       DAD    S1
0158 00233    0 04 00414       DST    S1
0159 00234    0 02 00460       DLD    L1
0160 00235    0 16 00411       MPY    D2
0161 00236    0 04 00416       DST    S2
0162 00237    0 02 00410       DLD    D1
0163 00240    0 16 00461       MPY    L2
0164 00241    0 06 00416       DAD    S2
0165 00242    0401 61          LRS    15
0166 00243    0 04 00416       DST    S2
0167 00244    0 02 00410       DLD    D1
0168 00245    0 16 00460       MPY    L1
0169 00246    0 06 00416       DAD    S2
0170 00247    0 04 00416       DST    S2
0171 00250    0 02 00414       DLD    DX
```

```
0172 00251   0 16 00464      MPY   RX1
0173 00252   0 04 00400      DST   DLL
0174 00253   0 02 00416      DLD   DY
0175 00254   0 16 00470      MPY   RY1
0176 00255   0 06 00400      DAD   DLL
0177 00256   0 04 00400      DST   DLL
0178 00257   0 02 00420      DLD   DZ
0179 00260   140407          TCA
0180 00261   0 16 00474      MPY   RZ1
0181 00262   0 07 00400      DSB   DLL
0182 00263   0 04 00400      DST   DLL
0183 00264   0 16 00412      MPY   D3
0184 00265   0401 77         LRS   1
0185 00266   0 07 00414      DSB   S1
0186 00267   0401 71         LRS   7
0187 00270   0 07 00416      DSB   S2
0188 00271   0 06 00422      DAD   SRND
0189 00272   0401 70         LRS   8
0190 00273   0 06 00400      DAD   DLL
0191 00274   0 04 00400      DST   DLL
0192 00275   140040          CRA
0193 00276   000201          IAB
0194 00277   0401 71         LRS   7
0195 00300   140040          CRA
0196 00301   0 06 00462      DAD   L3
0197 00302   0 04 00462      DST   L3
0198 00303   000201          IAB
0199 00304   140040          CRA
0200 00305   0 06 00460      DAD   L1
0201 00306   0 04 00460      DST   L1
0202 00307   0 02 00400      DLD   DLL
0203 00310   0401 71         LRS   7
0204 00311   0 06 00460      DAD   L1
0205 00312   0 04 00460      DST   L1
0206 00313   0 02 00402      DLD   DLRX
0207 00314   140040          CRA
0208 00315   000201          IAB
0209 00316   0401 71         LRS   7
0210 00317   140040          CRA
0211 00320   0 06 00466      DAD   RX3
0212 00321   0 04 00466      DST   RX3
0213 00322   000201          IAB
0214 00323   140040          CRA
0215 00324   0 06 00464      DAD   RX1
0216 00325   0 04 00464      DST   RX1
0217 00326   0 02 00402      DLD   DLRX
0218 00327   0401 71         LRS   7
0219 00330   0 06 00464      DAD   RX1
0220 00331   0 04 00464      DST   RX1
0221 00332   0 02 00404      DLD   DLRY
0222 00333   140040          CRA
0223 00334   000201          IAB
0224 00335   0401 71         LRS   7
0225 00336   140040          CRA
0226 00337   0 06 00472      DAD   RY3
0227 00340   0 04 00472      DST   RY3
0228 00341   000201          IAB
```

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MICROCOMP TELECOMMUNICATED DATA
       DDP-516 ASSEMBLY LISTING
0229 00342   140040           CRA
0230 00343   0 06 00470       DAD    RY1
0231 00344   0 04 00470       DST    RY1
0232 00345   0 02 00404       DLD    DLRY
0233 00346   0401 71          LRS    7
0234 00347   0 06 00470       DAD    RY1
0235 00350   0 04 00470       DST    RY1
0236 00351   0 02 00406       DLD    DLRZ
0237 00352   140040           CRA
0238 00353   000201           IAB
0239 00354   0401 71          LRS    7
0240 00355   140040           CRA
0241 00356   0 06 00476       DAD    RZ3
0242 00357   0 04 00476       DST    RZ3
0243 00360   000201           IAB
0244 00361   140040           CRA
0245 00362   0 06 00474       DAD    RZ1
0246 00363   0 04 00474       DST    RZ1
0247 00364   0 02 00406       DLD    DLRZ
0248 00365   0401 71          LRS    7
0249 00366   0 06 00474       DAD    RZ1
0250 00367   0 04 00474       DST    RZ1
0251 00370   000005           SGL
0252 00371   140040           CRA
0253 00372   0 04 00462       STA    L3
0254 00373   0 04 00466       STA    RX3
0255 00374   0 04 00472       STA    RY3
0256 00375   0 04 00476       STA    RZ3
0257 00376  -0 01 00000       JMP*   ATTA
0258 00400   000000      DLL  DBP    0
     00401   000000
0259 00402   000000      DLRX DBP    0
     00403   000000
0260 00404   000000      DLRY DBP    0
     00405   000000
0261 00406   000000      DLRZ DBP    0
     00407   000000
0262 00410   000000      D1   OCT    0
0263 00411   000000      D2   OCT    0
0264 00412   000000      D3   DBP    0
     00413   000000
0265 00414   000000      S1   DBP    0
     00415   000000
0266 00416   000000      S2   DBP    0
     00417   000000
0267 00420   000000      TRND OCT    0,40000
     00421   040000
0268 00422   000000      SRND OCT    0,200
     00423   000200
0269         000414      DX   EQU    '414
0270         000416      DY   EQU    DX+2
0271         000420      DZ   EQU    DX+4
0272         000460      L1   EQU    '460
0273         000461      L2   EQU    L1+1
0274         000462      L3   EQU    L1+2
0275         000464      RX1  EQU    L1+4
0276         000465      RX2  EQU    L1+5
```

```
0277            000466      RX3   EQU   L1+6
0278            000470      RY1   EQU   L1+8
0279            000471      RY2   EQU   L1+9
0280            000472      RY3   EQU   L1+10
0281            000474      RZ1   EQU   L1+12
0282            000475      RZ2   EQU   L1+13
0283            000476      RZ3   EQU   L1+14
0284 00424      125253            END
```

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