NASA Contractor Report 3315

Segmentation, Dynamic Storage, and Variable Loading on CDC Equipment

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CONTRACT NAS1-16000
SEPTEMBER 1980

NASA

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Prepared for
Langley Research Center
under Contract NAS1-16000

National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

1980

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SUMMARY

Techniques for varying the segmented load structure of a program and for varying the dynamic storage allocation, depending upon whether a batch type or interactive type run is desired, are explained and demonstrated. All changes are based on a single data input to the program. The techniques involve:

1. Code within the program to suppress scratch pad input/output (IØ) for a "batch" run or translate the in-core data storage area from blank common to the end-of-code+1 address of a particular segment for an "interactive" run;

2. Automatic editing of the segload directives prior to loading, based upon data input to the program, to vary the structure of the load for "interactive" and "batch" runs; and

3. Automatic editing of the load map to determine the initial addresses for in-core data storage for an "interactive" run.

INTRODUCTION

The purpose of this paper is to explain a successful method of incorporating the advantages of overlay into segmented loads while retaining all the dynamic load advantages of segmentation. The user is allowed to automatically load a program in a variable manner, based solely upon data input, to maintain field lengths under 100K for interactive use, which allows improved turn-a-round time and program interaction, or to maintain minimal IØ for batch runs, and thereby reduce job costs.

The overlay loader allows a program to be structured into portions, called overlays, only one of which resides in core at a time. However, this structuring has to be set up in program code, and changes in structure require changes in code and re-compilation of the program. The segment loader allows a relocatable binary program to be structured into portions, called segments, at load time. No re-coding and no re-compilation are necessary.

This paper presents the three basic steps necessary to allow automatic varying of the dynamic storage allocation and the loading structure to best suit the mode of operation desired - batch or interactive. They are:

1. Suppression of IØ for batch type runs or the translation of in-core data storage areas from blank

common to the end-of-code+1 address of a given segment for interactive runs;

2. Altering of the loading directives to vary the structure of the loads for interactive or batch type runs; and

3. Determination of the initial addresses from the load map, needed for the in-core data storage in step 1.

All these steps, accomplished by the programmer in pre-written code and small files of editing commands, are automatically performed in the job stream with no action required by the user except to change one data card.

SECTION I: PROBLEM DESCRIPTION

The basic problem which was solved using the techniques described herein was the necessity to keep the field length of a large applications program below 100K while being run interactively for program development or for quick interim analytical results and plots, where fast turn-a-round time was desirable. The same program was also used to obtain results which required many iterations through the entire program and a large amount of execution time. For this case, actual execution costs due exclusively to excessive IØ as a result of loading different segments and data during each program iteration, became increasingly significant. At this point it became desirable to run the program in the batch mode allowing the field length to increase in order to decrease the IØ.

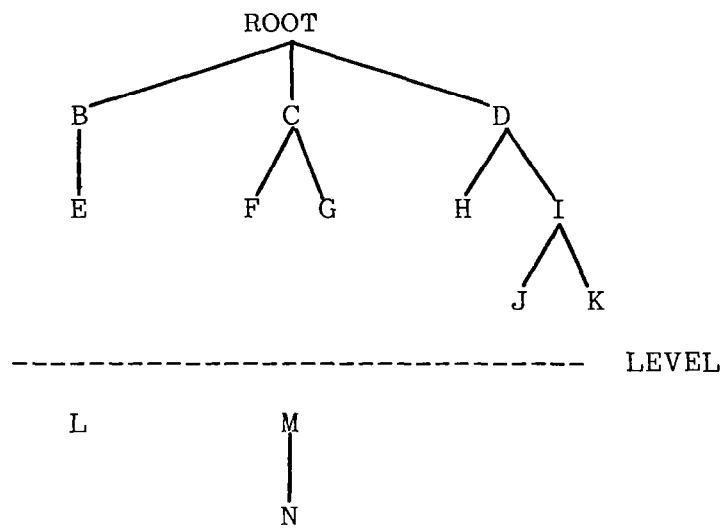
The solution to this problem is to vary the type of loading structure for interactive and batch runs, loading small segments of the program at one time during interactive runs and the entire program during batch runs. Some difficulty arises when the entire program is too large to load into core at one time in the batch mode. In this case the program must also be separated into segments, but the segments may be larger and the IØ involved in loading these segments and storing data in and out of core may be reduced.

SECTION II: PROBLEM SOLUTION

Load Structures

The first step in solving the problem is to determine which portions or segments of the program must be in core simultaneously. This dictates the basic tree structure for the interactive run (See ref.2 - Segmentation). A tree structure diagram is simply a diagram indicating which subroutines are to be loaded at one time and where.

ILLUSTRATION 1: Tree or Branching Diagram



The above diagram indicates that if subroutine J, for instance, were called, then all the subroutines between the ROOT and J, namely the branch containing D, I, and J, would be loaded if they were not already in core. If, say, F were then called, F and C would be loaded, over-writing D, I, and J. If L were then called, F and C would remain, untouched, since L is loaded starting at the second level. That is, subroutines residing at one level remain intact when loading subroutines into a different level.

For the batch run, cost can be effectively reduced by loading the segments or branches (combinations of segments) which are called repetitively into core simultaneously at different levels. (See ref.2 - Segmentation)

Data Requirements for Each Branch

Once the tree structure is set up for each type of run, the data required by each segment or branch has to be determined. The data can then be stored out of core on mass storage and read into core only when its presence in core is required (See Ref.1 - Dynamic Storage Allocation). Note here, however, that unlike overlays in which blank common is loaded at the end of each overlay, requiring corresponding data to be read into core each time an overlay is loaded, in segmented loads, blank common is loaded at a level starting at the highest address of all the segments or branches which might reside in core at one time. The advantage of this when field length is not a major factor is that loading of different segments does not affect the data already in blank common. Consequently, the IØ activity associated with repetative data reads required when incorporating dynamic storage allocation into overlay structures can be eliminated with segmentation. The disadvantage comes in interactive runs when field length is the overriding constraint for program execution.

End-of-Code Addresses

If the objective is to reduce field length and allow as much room as possible for storage of data required by each branch (as in an interactive run), it is essential to load data immediately after the actual program code of the branch currently in core. This necessitates obtaining the actual end-of-code+1 address of each branch to be used later as an initial address for in-core data storage.

Programming Steps

The changes in storage and access of data and the changes in the program loads are accomplished by

1. Setting up code within the program to

   a. bypass unnecessary data reads and writes in the batch run where data is stored dynamically in core, starting with the first word of blank common, or

   b. read data from mass storage, translating the initial address to the end-of-code+1 address in the interactive run.

2. Creating a file of editing commands to alter the segload directives from "batch" to "interactive" load directives, based upon an input parameter to

the program which the editor determines by scanning the input file.

3. Creating a file of editing commands which the editor will use to edit the load map and create an address file of initial addresses for data storage, to be input to the program during interactive runs.

SECTION III: ILLUSTRATIONS OF TECHNIQUES

The above techniques are illustrated by exercising a sample program which is intended to simulate a large applications program. The program manipulates matrices and plots results. It does not perform any actual analyses and the results, which are not intended to be meaningful in themselves, are presented only to allow comparison between interactive and batch modes of operation.

The following illustration is an outline of the program which is to be structured at load time in two different ways. The complete program is listed in Appendix A.

ILLUSTRATION 2: Outline of Sample Program

```
      PROGRAM MAIN(TAPE5,TAPE6,...)
      COMMON /IADRESS/ ...
      COMMON /CONTROL/ ...
                     .
                     .
      CALL DATAIN
      TIME=TIME0-DTIME
                     .
                     .
 10   CONTINUE
      TIME=TIME+DTIME
      CALL ANALYS1
      CALL ANALYS2
      IF(TIME.LT.TEND)GO TO 10
                     .
      CALL PLOT
      CALL DATAOUT
      STOP
      END
          ----------------------
      SUBROUTINE DATAIN
      COMMON /IADRESS/ ...
      COMMON /CONTROL/ ...
```

```
COMMON X(1)
                .
                .
CALL XINPUT
END
    --------------------
SUBROUTINE ANALYS1
COMMON /IADRESS/ ...
COMMON /CONTROL/ ...
COMMON X(1)
                .
CALL A
END
    --------------------
SUBROUTINE ANALYS2
COMMON /IADRESS/ ...
COMMON /CONTROL/ ...
COMMON X(1)
                .
CALL B
                .
CALL C
END
    --------------------
SUBROUTINE A
                .
CALL D
                .
CALL E
                .
END
    ---------------------
SUBROUTINE B
                .
CALL E
                .
CALL F
                .
END
    ---------------------
SUBROUTINE C
                .
CALL G
                .
CALL H
                .
END
    --------------------
SUBROUTINE PLOT
COMMON /IADRESS/ ...
COMMON /CONTROL/ ...
```

```
      COMMON X(1)
                  .
      CALL PSEUDO
                  .
      CALL PLOTTER
      END
         --------------------
      SUBROUTINE PSEUDO
```

(Langley graphics routine containing entry points CALPLT and NFRAME, used by most plot routines. refer to ref.3)

```
      END
          --------------------
      SUBROUTINE PLOTTER
                  .
      CALL CALPLT  (in PSEUDO)
                  .
      CALL NOTATE
                  .
      CALL BSCALE
                  .
      CALL AXES
                  .
      CALL LINPLT
                  .
      CALL NFRAME  (in PSEUDO)
                  .
      END
          --------------------
      SUBROUTINE DATAOUT
      COMMON /IADRESS/ ...
      COMMON /CONTROL/ ...
      COMMON X(1)
                  .
      CALL XOUTPUT
                  .
      END
```

Branches and Program Code for Interactive Case

The first step as outlined in the previous section is to determine the segments or portions of the program which must reside in core simultaneously. We draw a "calling sequence" diagram, figure 1, to determine this, based upon the calling sequences in the program.

A and B both call E, hence E must reside in core whenever either A or B is in core. However, A is in the branch beginning with ANALYS1 and B is in the branch beginning with ANALYS2; therefore,

E should be loaded above ANALYS1 and ANALYS2 (See figure 2). Since PSEUDO contains entry points CALPLT and NFRAME, which are called by most plotting routines (ref.3), PSEUDO must reside in core whenever other plotting routines are in core. Furthermore, since PLOTTER calls subroutines AXES and NOTATE, and AXES also calls NOTATE (See Ref.3 - Subroutine AXES), NOTATE must be loaded whenever AXES is. Thus follows the branching diagram depicted in figure 2. Only subroutines in the same branch can reside in core at the same time. For example, G and H are in different branches and would reside in core at the same address, thus over-writing each other when loaded into core.

Now the code for the basic dynamic storage allocation (ref.1)can be inserted into the program. For this program, that means setting up initial addresses in subroutines: DATAIN, ANALYS1, ANALYS2, PLOT, and DATAOUT corresponding to each of the five primary branches. To do this, the end-of-code+1 addresses for each of these branches must have been determined and must be available for input into the program. For the sample program, these addresses will be called: IADIN, IADAN1, IADAN2, IADPLT, IADOUT. The address for the beginning of blank common will be called IADBLNK. The basic idea is to translate the beginning data storage location from blank common back to the end-of-code+1 location by giving the array word in blank common a negative index (subscript). For example, in the sample program, the array word in blank common is X(1). (Note the COMMON X(1) statement in the program.) Thus X(1) is stored at the starting address of blank common = IADBLNK. This address, established by the segment loader, is an invariant location during the entire job execution.

ILLUSTRATION 3: Negative Indexing

```
X(1)    is at IADBLNK
X(0)    is at IADBLNK-1
X(-1)   is at IADBLNK-2
           .
           .
X(-10) is at IADBLNK-11
          etc.
```

If IADBLNK = 75000 (octal) and the end-of-code+1 address for the current branch is 65000, then X(65000-75000+1) = X(-7777) is at the first address after the end of code. Specifically, X(IADIN-IADBLNK+1) is the first location after the end of code of the branch starting with DATAIN, and now corresponds to the address of the first piece of array data required by any of the segments in this branch. Figure 3 depicts the beginning data storage addresses for each branch. The address of the last piece of data required by each branch is computed in the program and

only the storage actually needed is called for. This may actually be less than IADBLNK for some of the branches. However, at least one branch will have an end-of-code+1 address = X(1) = IADBLNK. In the sample program, the plotting branch is the one ending just prior to blank common; i.e., X(IADPLT-IADBLNK+1)=X(1).

The code in the sample program (Appendix A) related to the dynamic storage allocation in the interactive case is marked by a (**). This means the deviations from normal dynamic storage allocation (ref.1) are marked by a (**) in program MAIN and subroutines DATAIN, ANALYS1, ANALYS2, PLOT, and DATAOUT, and, the code for reading and writing the arrays to a scratch file are marked by a (**) in subroutines XINPUT, A, B, C, PLOTTER, and XOUTPUT.

Branches and Program Code for Batch Case

ANALYS1 and ANALYS2 might be called many times during an execution, so that for a batch run it would be desirable to load these two branches simultaneously. In this case, there are several possibilities, two of which are depicted in figures 4(a) and 4(b).

If there is sufficient field length to load and execute the program using the branching structure of figure 4(b), then this would be the best choice of the two options shown for two reasons. First, during the execution of B and C, no re-loading of segments would be necessary. Second, PSEUDO is put at the second level because normally PSEUDO and its corresponding plot routines require so much core that they would drastically increase the starting location of the second level if put into the first level, thus increasing the overall field length unnecessarily. In the following discussion and illustrations, the assumption is made that figure 4(b) is the optimal load structure for batch runs.

Earlier, it was mentioned that data in blank common is not overwritten by the segment loader when loading different segments. In the batch case, advantage can be taken of this fact in two ways. One, data used by more than one segment can be stored in the beginning of blank common. The starting address of work areas for each of these segments can then begin with the word following the last word used by these "common" arrays. (Note the beginning index = ILAST in subroutines ANALYS1 and ANALYS2, in Appendix A.) Secondly, these "common" arrays need not be stored out of core between segment calls, so the scratch-pad "writes" and "reads" can be by-passed in the batch runs. The space used by arrays which are not common to more than one branch is overwritten by successive branches. These "non-common" arrays are stored out of core only if they need to be saved for later use. Code used for the dynamic storage allocation in the batch case are marked by a (****) in Appendix A.

Load Directives

The next step is to set up the load directives for each type of load. Refer to figure 2 and figure 4(b), which depict the load structures to be used for the interactive and batch runs, respectively. Example 1 is the set of load directives for the interactive run, corresponding to figure 2, and Example 2 is the set of load directives for the batch run, corresponding to figure 4(b). Both of these sets of load directives will probably need to be modified slightly, after looking at the initial load map, with some "global" and "include" directives (see ref.2 - Segmentation) in order to globalize certain commons used by system and library routines and to adjust the locations of some of these routines. Appendix B is a listing of the final sets of load directives used for the sample program.

EXAMPLE 1: Load Directives for Interactive Load

```
ROOT    TREE      MAIN-(IN,EE,PLT,OUT)
MAIN    GLOBAL    IADRESS,CONTROL
IN      TREE      DATAIN-XINPUT
EE      TREE      E-(AN1,AN2)
AN1     TREE      ANALYS1-A-D
PLT     TREE      PLOT-PLOTTER-PSE
OUT     TREE      DATAOUT-XOUTPUT
AN2     TREE      ANALYS2-(B-F,C-(G,H))
PSE     TREE      PSEUDO-(BSCALE,NOTATE-AXES,LINPLT)
```

EXAMPLE 2: Load Directives for Batch Load

```
ROOT    TREE      MAIN-(IN,EE,PLT,OUT)
MAIN    GLOBAL    IADRESS,CONTROL
IN      TREE      DATAIN-XINPUT
EE      TREE      E-AN1
AN1     TREE      ANALYS1-A-D
PLT     TREE      PLOT-PLOTTER
OUT     TREE      DATAOUT-XOUTPUT
   LEVEL
AN2     TREE      ANALYS2-B-F-C-G-H
PSE     TREE      PSEUDO-BSCALE-NOTATE-AXES-LINPLT
```

Editing Commands for Conversion of Load Directives

Now that the load structures and the corresponding load directives have been determined, a file of editing commands to alter the segload directives from the "batch" load to the "interactive" load (or vice verse) is required. The first data card on file TAPE5 contains either a "1" or a "0", 1 for batch, and 0 for interactive. Thus, the following command file, Example 3, will perform the conversion from "batch" to "interactive" load directives using the XEDIT editor.

EXAMPLE 3: Editing Commands for Conversion of Load Directives from Batch Load to Interactive Load

```
IB2                     (Insert 2 lines of text before present line)
*START                  (Insert a "*START" at the top of load di-
                         rective file)
*END                    (Insert a *END after *START statement)
^READ TAPE5             (Insert TAPE5 data in front of *END-line)
^N                      (Go to second line of file)
IF$0$                   (Determine if first data card is a "0")
L$AN1$                  (Locate the line containing the word "AN1")
C$-AN1$-(AN1,AN2)$      (Change character string)
L$PLOTTER$              (Locate line containing string "PLOTTER")
C$TER$TER-PSE$          (Change character string)
Z;L$LEVEL$;D            (Locate and delete line containing "LEVEL")
C$B-F-C-G-H$(B-F,C-(G,H))$1  (Change character string on next line)
L$PSEUDO$               (locate line containing "PSEUDO")
C$BSCALE-NOTATE-AXES-LINPLT$(BSCALE,NOTATE-AXES,LINPLT)$
                        (Change character string)
ELSE                    (Skip to here if first data card did not
                         contain a "0")
ENDIF
TOP                     (Go to top of file)
COPYD DUMMY $*END$      (Delete all lines down to *END statement)
END,LOADIR              (End editing, rename file LOADIR)
```

Editing Commands to Create Address File

The next step is to create a file of editing commands which the editor will use to edit the load map and create an address file of initial addresses for data storage, to be input to the program during interactive runs. Note that these editing commands might have to be altered if the original tree structures are changed.

The first address to be determined is IADBLNK. Consider the following portion of the load map (Appendix C) for the interactive run.

```
FWA OF THE LOAD              1054
LWA+1 OF THE LOAD           46275
CM BLANK COMMON FWA         46274

WRITTEN TO FILE      SAMABS

TRANSFER ADDRESS -- MAIN              16204
```

Since IADBLNK is the first word of blank common, the statement

```
CM BLANK COMMON FWA
```

must be located. The following commands will locate this statement, modify it to conform to data input for the program, and copy it to a file named ADRESS.

```
Z;L$ CM BLANK $;YQM
##########&IADBLNK=#&&&&&&&&&              B,##########################
COPY ADRESS
```

The next address to be generated is IADIN. This is the end-of-code+1 address for the branch beginning with DATAIN. Since XINPUT is the last segment in this branch, (see figure 2.-Branching Diagram for Interactive runs or Appendix B), the portion of the load map which corresponds to the segment XINPUT must be studied.

```
-------- SEGMENT - XINPUT


         PROGRAM AND BLOCK ASSIGNMENTS.

         BLOCK        ADDRESS   LENGTH    FILE      DATE      PROCSSR

         /IADRESS/ S     1061       25
         /CONTROL/ S     1106       22
         (XINPUT)       35767        0
         XINPUT         35767      167    LGO       80/04/17  FTN
```

XINPUT is the only subroutine in this segment, therefore, it is necessary to locate the address of XINPUT = IADIN, and its length

= IPIN, output both to file ADRESS and allow the program to add the length to the address of XINPUT to obtain the index for end-of-code+1 for the primary branch - DATAIN. The following commands will locate the line containing the proper address, modify it, and copy it to file ADRESS.

```
Z;L$ (XINPUT)$;N;YQM
##########&IADIN=&&          , IPIN= #,############################
C$,$B,$
COPY ADRESS
```

The other addresses are obtained similarly. However, in obtaining the address for the primary branch - ANALYS2, care must be exercised. Refering to figure 2 again, note that segments F, G, and H are all final segments in this branch. To be sure that no segment will overwrite the data for this branch, the address must be derived from the longest section of the branch. Consider the following portions of the load map:

-------- SEGMENT - F

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(F)	36664	0			
F	36664	65	LGO	80/04/17	FTN

-------- SEGMENT - G

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(G)	36620	0			
G	36620	72	LGO	80/04/17	FTN

-------- SEGMENT - H

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(H)	36620	0			
H	36620	46	LGO	80/04/17	FTN

Subroutine F in SEGMENT - F has the highest address and length combination for this branch. Hence, the following commands will generate the correct values for IADAN2 and IPAN2 (address and length) to be copied to file ADRESS.

```
Z;L$ (F) $;N;YQM
##########&IADAN2=&          , IPAN2=#,############################
C$,$B,$
COPY ADRESS
```

This same care must be taken in determining the address for the plot branch. Refering to figure 2, segments BSCALE, AXES, and LINPLT must be considered:

-------- SEGMENT - BSCALE

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(BSCALE)	42272	0			
BSCALE	42272	506	UL-LRCGOSF	79/12/10	FTN
LEGVAR	43000	4	SL-FORTRAN	79/12/07	COMPASS
EXP.	43004	72	SL-FORTRAN	79/12/07	COMPASS
XTOY.	43076	31	SL-FORTRAN	79/12/07	COMPASS

-------- SEGMENT - LINPLT

PROGRAM AND BLOCK ASSIGNMENTS.

```
BLOCK          ADDRESS    LENGTH     FILE       DATE      PROCSSR

(LINPLT)         42272         0
LINPLT           42272       504  UL-LRCGOSF  79/12/10  FTN
CIRCLE           42776       165  UL-LRCGOSF  79/12/10  FTN
CNTRLN           43163       134  UL-LRCGOSF  79/12/10  FTN
GRID             43317       134  UL-LRCGOSF  79/12/10  FTN
PNTPLT           43453       524  UL-LRCGOSF  79/12/10  FTN
SQRT.            44177        32  SL-FORTRAN  79/12/07  COMPASS
```

-------- SEGMENT - AXES

PROGRAM AND BLOCK ASSIGNMENTS.

```
BLOCK          ADDRESS    LENGTH     FILE       DATE      PROCSSR

/FCL.C./  S      1130        26
/Q8.IO./  S      1156       100
/SETCHAR/ S     37050        56
(AXES)           44236         0
/APOS/           44236        17
AXES             44255      1524  UL-LRCGOSF  79/12/10  FTN
NUMBER           46001       167  UL-LRCGOSF  79/12/10  FTN
ENCODE=          46170       104  SL-FORTRAN  79/12/07  COMPASS
```

In this case, subroutine ENCODE= in SEGMENT - AXES has the highest address and length combination. The commands to generate the correct values for IADPLT and IPPLT are as follows:

```
Z;L$ ENCODE= $;YQM
##########&IADPLT&=          , IPPLT=#,############################
C$,$B,$
COPY ADRESS
```

Appendix E contains a complete listing of the command file used for editing the load map to generate addresses for the sample program. Since the addresses are not necessary for the batch

version, this editing need not be done if the first data card on file TAPE5 contains a "1". For this reason, the same bypass instructions were used as for editing the SEGLOAD directives.

SECTION IV: RESULTS

The use of an interactive terminal to debug and execute jobs can result in sizable savings in time and effort, but use of an interactive terminal requires that job field lengths be minimized. Methods have been described that allow automatic, variable structuring and execution of a program for interactive and batch modes of operation. It was stated that these methods could significantly reduce field lengths for interactive operation or reduce IØ and mass storage costs in batch operation. To demonstrate this, these methods were applied to the sample program as previously discussed, and both types of runs were made. The following is a comparison of the resulting field lengths and costs of the two runs.

Illustration 4 presents a comparison of the Interactive and batch field length requirements for the problem that was run. These would change with different size problems.

ILLUSTRATION 4: Field Lengths Used for Batch and Interactive Runs

	BATCH	INTERACTIVE
FIELD LENGTH - DATAIN -	052166	037050
FIELD LENGTH - ANALYS1 -	053107	040361
FIELD LENGTH - ANALYS2 -	052546	040223
FIELD LENGTH - PLOT -	052251	046460
FIELD LENGTH - DATAOUT -	052251	037253

The field lengths dropped 10-13K (octal), except for the plotting segment, which dropped by 4K (octal), giving an average reduction of 11K (octal) , or 22%, and a minimum reduction for the 4K of 9.5%. Larger programs can realize an even greater savings, enough usually to maintain field lengths under 100K, depending on the size of the problem, which in this case was reflected in the size of the matrices.

The CP (Central Processor) times for the batch and interactive runs were essentially the same, 19.379 seconds for the batch run and 19.758 seconds for the interactive run. The SRU (Standard Resource Unit) costs were not the same, however. The interactive run cost 94.455 SRU's as compared to only 81.174 SRU's for the batch run. This 14% reduction reflects the difference in IØ and mass storage costs of the two versions, and this reduction would increase steadily with increased number of iterations through the program. The batch version costs less to execute, but turn-a-round time is longer. The interactive version can give much more immediate results.

Identical numerical results were obtained by the batch and interactive versions of the program as can be seen by examining the plot outputs in figures 5 (a) and (b). Tabulated results are given in Appendices F and G as further evidence of correct operation of both versions.

The control deck required for job execution was the same for both batch and interactive operation. It is listed in Appendix H. All changes in restructuring and IØ are performed by prewritten code and only require the user to change a single piece of data on the first data card.

CONCLUDING REMARKS

The results of this sample program illustrate the dramatic savings in either field lengths or IØ costs that can be realized by variable structuring of a program. By using such techniques, large programs which normally could not be run interactively can often be sufficiently reduced in size to be executed from an interactive terminal. This is accomplished without detracting from the cost effective advantages of the batch runs. Additionally, the segment loader eliminates the necessity to re-code and re-compile in order to restructure the load to best suit each mode of operation.

APPENDIX A

SAMPLE PROGRAM LISTING

```
**          PROGRAM MAIN(TAPE5,TAPE6,OUTPUT,ADRESS,SCRTCH,PLTDAT)
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C               ,IXX,IY1,IY2,NPLOT
           COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
**         COMMON /INDEX/ INDEX(11)
           NAMELIST /INPUT/ N1,N2,TIME0,TEND,DTIME,DTX,IPLOT

           REWIND 5
           IPLTDAT=6LPLTDAT
           REWIND IPLTDAT
           REWIND 6
**         READ(5,*)IBATCH
**         IF(IBATCH.EQ.1)GO TO 1
           CALL OPENMS(6LSCRTCH,INDEX,11,0)
**         IADRESS=6LADRESS
**         READ(IADRESS,50)IADBLNK,IADIN,IPIN,IADAN1,IPAN1
**         C               ,IADAN2,IPAN2,IADPLT,IPPLT,IADOUT,IPOUT
**          WRITE(6,50)IADBLNK,IADIN,IPIN,IADAN1,IPAN1
**         C               ,IADAN2,IPAN2,IADPLT,IPPLT,IADOUT,IPOUT
**   50     FORMAT(23X,O6/(13X,O6,10X,O6))
**         IADIN=IADIN+IPIN
**         IADAN1=IADAN1+IPAN1
**         IADAN2=IADAN2+IPAN2
**         IADPLT=IADPLT+IPPLT
**         IADOUT=IADOUT+IPOUT
**   1     CONTINUE

           READ(5,INPUT)

**   C*  SET SUFFICIENT FIELD LENGTH TO LOAD DATAIN, IF INTERACTIVE RUN
**         IF(IADIN.NE.0)CALL RFL(IADIN+100B)
           CALL DATAIN
           TIME=TIME0-DTIME
     10    CONTINUE

           TIME=TIME+DTIME

**   C*  SET SUFFICIENT FIELD LENGTH TO LOAD ANALYS1, IF INTERACTIVE
**         IF(IADAN1.NE.0)CALL RFL(IADAN1+100B)

           CALL ANALYS1

**   C*  SET SUFFICIENT FIELD LENGTH TO LOAD ANALYS2, IF INTERACTIVE
**         IF(IADAN2.NE.0)CALL RFL(IADAN2+100B)

           CALL ANALYS2

           IF(TIME.LT.TEND)GO TO 10

           IF(IPLOT.NE.1)GO TO 15
```

```
**    C*  SET FIELD LENGTH TO LOAD PLOTTER, IF INTERACTIVE
**          IF(IADPLT.NE.0)CALL RFL(IADPLT+100B)

            CALL PLOT
      15    CONTINUE

**    C*  SET FIELD LENGTH TO OUTPUT RESULTS, IF INTERACTIVE
**          IF(IADOUT.NE.0)CALL RFL(IADOUT+100B)
            CALL DATAOUT

            STOP
            END
*****************************************************************************
            BLOCK DATA INITIAL
**          COMMON /IADRESS/ IAD(21)
            COMMON /CONTROL/ ICON(8)
**          COMMON /INDEX/ INDEX(11)

**          DATA IAD/21*0/
           C              ,ICON/8*0/
**         C              ,INDEX/11*0/
            END
*****************************************************************************
                IDENT   RFL
                ENTRY   RFL
      RFL       DATA    0
                SA1     X1
                BX6     X1
                LX6     30
                SA6     MEM
                MEMORY  CM,MEM,R
                EQ      RFL
      MEM       DATA    0
                END
*****************************************************************************
```

```
            SUBROUTINE DATAIN
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C               ,IXX,IY1,IY2,NPLOT
            COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
            COMMON X(1)

     C*   ASSUMING ARRAYS AA,BB,CC ARE TO BE INPUT AND USED BY ANALYS1
     C*   AND ANALYS2, SET UP INITIAL STARTING ADDRESSES FOR DATA.

            IAA=1
**          IF(IBATCH.EQ.0)IAA=IADIN-IADBLNK+1
            IBB=IAA+N1
            ICC=IBB+N1*N2
****        ILAST=ICC+N2*N2

            IFL=ICC+N2*N2+100B+LOCF(X(1))
            CALL RFL(IFL)
            WRITE(6,50)IFL
     50     FORMAT(//* FIELD LENGTH FOR BRANCH --  DATAIN  -- IS *,O6)
            CALL XINPUT(X(IAA),X(IBB),X(ICC),N1,N2)
            END
**********************************************************************
            SUBROUTINE XINPUT(AA,BB,CC,J1,J2)
            DIMENSION AA(J1),BB(J1,J2),CC(J2,J2)
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C               ,IXX,IY1,IY2,NPLOT
            COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT

            READ(5,*)(AA(I),I=1,N1)
            READ(5,*)((BB(I,J),J=1,N2),I=1,N1)
            READ(5,*)((CC(I,J),J=1,N2),I=1,N2)

**     C*   STORE DATA ON SCRATCH FILE IF INTERACTIVE RUN
**          IF(IBATCH.EQ.1)GO TO 10

**          CALL WRITMS(6LSCRTCH,AA,N1,1,-1,0)
**          CALL WRITMS(6LSCRTCH,BB,N1*N2,2,-1,0)
**          CALL WRITMS(6LSCRTCH,CC,N2*N2,3,-1,0)

**     10   CONTINUE
            RETURN
            END
**********************************************************************
```

```
            SUBROUTINE ANALYS1
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C               ,IXX,IY1,IY2,NPLOT
            COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
            COMMON X(1)
      C*   ASSUMING INPUT ARRAYS AA AND BB, AND ARRAYS DD,EE,FF,AND PIVOT
      C*   ARE TO BE USED BY SUBROUTINE A,D,AND E,SET UP INITIAL ADDRESSES
      C*   STARTING WITH FF, BECAUSE FF IS TO BE GENERATED FOR USE BY ANALYS2

****          IF(TIME.EQ.TIME0)IFF=ILAST
****          IF(IBATCH.EQ.1)GO TO 10
**            IAA=IADAN1-IADBLNK+1
              IBB=IAA+N1
              IFF=IBB+N1*N2

**** 10       CONTINUE
****          IF(TIME.EQ.TIME0)ILAST=IFF+N1*N1
              IDD=IFF+N1*N1
              IEE=IDD+N2**2
              IPIV=IEE+N1*N1

              IFL=IPIV+4*N1+100B+LOCF(X(1))
              CALL RFL(IFL)
              IF(TIME.EQ.TIME0)WRITE(6,50)IFL
      50      FORMAT(//* FIELD LENGTH FOR BRANCH --  ANALYS1  -- IS *,O6)

              CALL A(X(IAA),X(IBB),X(IDD),X(IEE),X(IFF),X(IPIV),N1,N2)
              RETURN
              END
*****************************************************************
              SUBROUTINE A(AA,BB,DD,EE,FF,IPIV,J1,J2)
              DIMENSION AA(J1),BB(J1,J2),DD(J2,J2),EE(J1,J1),FF(J1,J1)
              DIMENSION IPIV(1)
**            COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**           C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**           C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**           C               ,IXX,IY1,IY2,NPLOT
              COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT

**      C*   READ ARRAYS AA AND BB INTO CORE IF INTERACTIVE RUN
**            IF(IBATCH.EQ.1)GO TO 10

**            CALL READMS(6LSCRTCH,AA,N1,1)
**            CALL READMS(6LSCRTCH,BB,N1*N2,2)

**      10    CONTINUE

      C*   CALL SUBROUTINE D TO GENERATE
      C*                   DD=(BB-AA*I*TIME)'*(BB-AA*I*TIME)  ('=TRANSPOSE)
```

```
C*                    EE=AA*AA'
C*                    FF=BB*DD*BB'- EE

      CALL D(AA,BB,DD,EE,FF,N1,N2,TIME)

C*  CALL SUBROUTINE E TO COMPUTE FF-INVERSE & DET(FF)

      CALL E(FF,N1,DUMMY,0,KEY,DET,IPIV,IPIV(1+N1),IPIV(1+3*N1))

      IPLTDAT=6LPLTDAT
      WRITE(IPLTDAT)TIME,DET

**    C*  STORE FF-INVERSE ON SCRATCH IF INTERACTIVE RUN
      IF(IBATCH.EQ.0)CALL WRITMS(6LSCRTCH,FF,N1*N1,4,-1,0)

      RETURN
      END
*********************************************************************
      SUBROUTINE D(AA,BB,DD,EE,FF,I1,I2,TIME)
      DIMENSION AA(I1),BB(I1,I2),DD(I2,I2),EE(I1,I2),FF(I1,I1)

C*  COMPUTE DD=(BB-I*AA*TIME)'(BB-I*AA*TIME)

      DO 2 I=1,I1
      DO 1 J=1,I2
1     EE(I,J)=BB(I,J)
2     EE(I,I)=BB(I,I)-AA(I)*TIME

      DO 3 J=1,I2
      DO 3 I=1,I2
      DD(I,J)=0.
      DO 3 K=1,I1
3     DD(I,J)=DD(I,J)+EE(K,I)*EE(K,J)


C*  COMPUTE EE=AA*AA'

      DO 10 J=1,I2
      DO 10 I=1,I1
10    EE(I,J)=AA(I)*AA(J)


C*  COMPUTE FF=BB*DD*BB'- EE

      DO 20 J=1,I1
      DO 20 I=1,I1
      FF(I,J)=-EE(I,J)
      DO 20 K=1,I2
      DO 20 L=1,I2
20    FF(I,J)=FF(I,J)+BB(I,K)*DD(K,L)*BB(J,L)

      RETURN
```

```
      END
*********************************************************************
      SUBROUTINE E(A,N,B,M,KEY,DETERM,IPIVOT,INDEX,PIVOT)
      DIMENSION A(N,1),B(1),IPIVOT(1),INDEX(N,2),PIVOT(1)
C     INITIALIZATION
    5 KEY = N
   10 DETERM=1.
   15 DO 20 J=1,N
   20 IPIVOT(J)=0
   30 DO 550 I=1,N
C
C     SEARCH FOR PIVOT ELEMENT
   40 AMAX=0.0
   45 DO 105 J=1,N
   50 IF (IPIVOT(J)-1) 60,105,60
   60 DO 100 K=1,N
   70 IF (IPIVOT(K)-1) 80,100,740
   80 IF(ABS(AMAX)-ABS(A(J,K))) 85,100,100
   85 IROW=J
   90 ICOLUM=K
   95 AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      ZERO=1.E-16
  107 IF(ABS(AMAX)-ZERO)745,745,110
  110 IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
  130 IF (IROW-ICOLUM) 140,260,140
  140 DETERM=-DETERM

  150 DO 200 L=1,N
  160 SWAP=A(IROW,L)
  170 A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
  205 IF(M) 260,260,210
  210 SWAP = B(IROW)
  230 B(IROW) = B(ICOLUM)
  250 B(ICOLUM) = SWAP
  260 INDEX(I,1)=IROW
  270 INDEX(I,2)=ICOLUM
  310 PIVOT(I)=A(ICOLUM,ICOLUM)
C
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
  330 A(ICOLUM,ICOLUM)=.1E+1
  340 DO 350 L=1,N
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
  355 IF(M) 380,380,360
  360 B(ICOLUM) = B(ICOLUM)/PIVOT(I)
```

```
C
C     REDUCE NON-PIVOT ROWS
C
  380 DO 550 L1=1,N
  390 IF(L1-ICOLUM) 400,550,400
  400 T=A(L1,ICOLUM)
  420 A(L1,ICOLUM)=0.0
  430 DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
  455 IF(M) 550,550,460
  460 B(L1) = B(L1) - B(ICOLUM)*T
  550 CONTINUE
C
C     INTERCHANGE COLUMNS
C
  600 DO 710 I=1,N
  610 L=N+1-I
  620 IF (INDEX(L,1)-INDEX(L,2)) 630,710,630
  630 JROW=INDEX(L,1)
  640 JCOLUM=INDEX(L,2)
  650 DO 705 K=1,N
  660 SWAP=A(K,JROW)
  670 A(K,JROW)=A(K,JCOLUM)
  700 A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
      DO 800 I=1,N
      J=N+1-I
  800 DETERM=DETERM*PIVOT(J)

  740 RETURN
  745 DETERM=0.0
  746 KEY = I - 1
  750 RETURN
      END
*****************************************************************************
```

```
      SUBROUTINE ANALYS2
**    COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**   C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**   C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**   C               ,IXX,IY1,IY2,NPLOT
      COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
      COMMON X(1)

C*  ASSUMING "COMMON" ARRAYS AA,BB,CC,FF,AND ARRAYS FFB,GG,AND
C*  PIVOT ARE TO BE USED BY B AND C, SET UP INITIAL ADDRESSES

****  IFFB=ILAST
****  IF(IBATCH.EQ.1)GO TO 10

**    IAA=IADAN2-IADBLNK+1
      IBB=IAA+N1
      ICC=IBB+N1*N2
      IFF=ICC+N2*N2
      IFFB=IFF+N1*N1

**** 10  CONTINUE
      IPIV=IFFB+N1*N1
      IFL=IPIV+4*N1+LOCF(X(1))+100B
      CALL RFL(IFL)
      IF(TIME.EQ.TIME0)WRITE(6,50)IFL
   50 FORMAT(//* FIELD LENGTH FOR BRANCH --  ANALYS2  -- IS *,O6)

      CALL B(X(IAA),X(IBB),X(IFF),X(IFFB),X(IPIV),N1,N2)

      IGG=IFFB
      CALL C(X(IFF),X(IBB),X(ICC),X(IGG),N1,N2)

      RETURN
      END
**********************************************************************
      SUBROUTINE B(AA,BB,FF,FFB,IPIV,J1,J2)
      DIMENSION BB(J1,J2),AA(J1),FF(J1,J1),FFB(J1,J1),IPIV(1)
**    COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**   C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**   C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**   C               ,IXX,IY1,IY2,NPLOT
      COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT

**  C*  READ ARRAYS AA,BB,AND,FF,INTO CORE IF INTERACTIVE RUN
**    IF(IBATCH.EQ.1)GO TO 10

**    CALL READMS(6LSCRTCH,AA,N1,1)
**    CALL READMS(6LSCRTCH,BB,N1*N2,2)
**    CALL READMS(6LSCRTCH,FF,N1*N1,4)

**  10  CONTINUE
C*  COMPUTE FFB=FF*BB*BB'
```

```
      CALL F(FF,BB,FFB,N1,N2)

C*    SOLVE FFB*XX=AA
      DO 20 I=1,N1
20    FF(I,1)=AA(I)

      CALL E(FFB,N1,FF,1,KEY,DET,IPIV,IPIV(1+N1),IPIV(1+3*N1))

      RETURN
      END
*********************************************************************
      SUBROUTINE F(X,Y,Z,I1,I2)
      DIMENSION X(I1,I1),Y(I1,I2),Z(I1,I1)

C*    COMPUTE Z=X*Y*Y'

      DO 1 J=1,I1
      DO 1 I=1,I1
      Z(I,J)=0.
      DO 1 K=1,I1
      DO 1 L=1,I2
1     Z(I,J)=Z(I,J)+X(I,K)*Y(K,L)*Y(J,L)

      RETURN
      END
*********************************************************************
      SUBROUTINE C(FF,BB,CC,GG,J1,J2)
      DIMENSION FF(J1),BB(J1,J2),CC(J2,J2),GG(J1,J1)
**    COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**   C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**   C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**   C               ,IXX,IY1,IY2,NPLOT
      COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT

**    IF(IBATCH.EQ.0)CALL READMS(6LSCRTCH,CC,N2*N2,3)

C*    COMPUTE GG=BB*CC*BB'
      CALL G(BB,CC,GG,N1,N2)

C*    COMPUTE FOFT=(GG*FF)'*(GG*FF)
      CALL H(FF,GG,FOFT,N1)

      IPLTDAT=6LPLTDAT
      WRITE(IPLTDAT) FOFT
      RETURN
      END
*********************************************************************
      SUBROUTINE G(X,Y,Z,I1,I2)
      DIMENSION X(I1,I2),Y(I2,I2),Z(I1,I1)

C*    COMPUTE Z=X*Y*X'
      DO 10 J=1,I1
```

```
            DO 10 I=1,I1
            Z(I,J)=0.
            DO 10 K=1,I2
            DO 10 L=1,I2
      10    Z(I,J)=Z(I,J)+X(I,K)*Y(K,L)*X(J,L)

            RETURN
            END
*************************************************************************
            SUBROUTINE H(X,Y,FOFT,I1)
            DIMENSION X(I1),Y(I1,I1)

            FOFT=0.
            DO 10 J=1,I1
            SUM=0.
            DO 20 K=1,I1
      20    SUM=SUM+X(K)*Y(K,J)
      10    FOFT=FOFT+SUM*SUM

            RETURN
            END
*************************************************************************
```

```
      SUBROUTINE PLOT
**    COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**   C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**   C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**   C               ,IXX,IY1,IY2,NPLOT
      COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
      COMMON X(1)

C*    COMPUTE NUMBER OF PLOT POINTS
      NPLOT=(TEND-TIME0)/DTIME+1

**** C*  SINCE THE FF ARRAY IS NO LONGER NEEDED, PLOT ARRAYS
**** C*  CAN BE LOCATED STARTING IN FF LOCATION FOR BATCH RUNS

****  IXX=IFF

**    IF(IBATCH.EQ.0)IXX=IADPLT-IADBLNK+1
      IY1=IXX+NPLOT+2
      IY2=IY1+NPLOT+2
      IFL=IY2+NPLOT+2+LOCF(X(1))+100B
      CALL RFL(IFL)
      WRITE(6,50)IFL
50    FORMAT(//* FIELD LENGTH FOR BRANCH --  PLOT  -- IS *,O6)
      CALL PSEUDO
      CALL PLOTTER(X(IXX),X(IY1),X(IY2))
      RETURN
      END
**********************************************************************
      SUBROUTINE PLOTTER(XX,Y1,Y2)
**    COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**   C               ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**   C               ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**   C               ,IXX,IY1,IY2,NPLOT
      COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
      DIMENSION XX(1),Y1(1),Y2(1)
      DIMENSION TITLE(5)
      DATA TITLE/10H    PLOTS ,10HVS. TIME F,
     C10HOR SAMPLE ,10HPROGRAM - /

      TITLE(5)=10HINTERACTIV
      IF(IBATCH.EQ.1)TITLE(5)=10HBATCH
      CALL NOTATE(.5,.5,.2,TITLE,0.,50)
      CALL CALPLT(1.5,1.5,-3)
      IPLTDAT=6LPLTDAT
      REWIND IPLTDAT

      DO 10 I=1,NPLOT
      READ(IPLTDAT)XX(I),Y1(I)
10    READ(IPLTDAT)Y2(I)
**  C*  WRITE ALL PLOT DATA OUT TO SCRATCH FILE FOR USE IN XOUPUT
**  C*  IF INTERACTIVE RUN
**    IF(IBATCH.EQ.0)CALL WRITMS(6LSCRTCH,XX,3*(NPLOT+2),5,-1,0)
```

```
      CALL BSCALE(Y1,4.,NPLOT,1,1.,0,0.)
      CALL BSCALE(Y2,4.,NPLOT,1,1.,-1,0.)

      DIFF=TEND-TIME0
      SCF=DIFF/6.
      XX(NPLOT+1)=TIME0
      XX(NPLOT+2)=SCF
      IF(DTX.EQ.0.)DTX=DTIME
      TMAJ=6.*DTX/DIFF
      TMIN=2./TMAJ
      CALL AXES(0.,0.,0.,6.,TIME0,SCF,TMAJ,TMIN,4HTIME,.2,-4)
      CALL AXES(0.,0.,90.,4.,Y1(NPLOT+1),Y1(NPLOT+2),1.,2.,3HDET,.2,3)
      CALL LINPLT(XX,Y1,NPLOT,1,1,22,1,0)
      CALL CALPLT(0.,5.,-3)
      CALL AXES(0.,0.,0.,6.,TIME0,SCF,TMAJ,TMIN,4HTIME,.2,-4)
      CALL AXES(0.,0.,90.,4.,Y2(NPLOT+1),Y2(NPLOT+2),1.,2.,
     C 4HF(T),.2,4)
      CALL LINPLT(XX,Y2,NPLOT,1,1,22,1,0)
      CALL NFRAME

      RETURN
      END
*********************************************************************
```

```
            SUBROUTINE DATAOUT
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C              ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C              ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C              ,IXX,IY1,IY2,NPLOT
            COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT
            COMMON X(1)

      C*  OUTPUT INPUT DATA AND PLOT DATA

****        IF(IBATCH.EQ.1)GO TO 10
**          IAA=IADOUT-IADBLNK+1
            IBB=IAA+N1
            ICC=IBB+N1*N2
            IXX=ICC+N2*N2
            IY1=IXX+NPLOT+2
            IY2=IY1+NPLOT+2

**** 10     CONTINUE
            IFL=IY2+NPLOT+2+LOCF(X(1))+100B
            CALL RFL(IFL)
            WRITE(6,50)IFL
      50    FORMAT(//* FIELD LENGTH FOR BRANCH --  DATAOUT  -- IS *,O6)
            CALL XOUTPUT(X(IAA),X(IBB),X(ICC),X(IXX),X(IY1),X(IY2),N1,N2)
            RETURN
            END
**********************************************************************
            SUBROUTINE XOUTPUT(AA,BB,CC,XX,Y1,Y2,J1,J2)
            DIMENSION AA(J1),BB(J1,J2),CC(J2,J2),XX(1),Y1(1),Y2(1)
**          COMMON /IADRESS/ IADBLNK,IADIN,IADAN1,IADAN2,IADPLT,IADOUT
**         C              ,IPIN,IPAN1,IPAN2,IPPLT,IPOUT
**         C              ,IBATCH,ILAST,IAA,IBB,ICC,IFF
**         C              ,IXX,IY1,IY2,NPLOT
            COMMON /CONTROL/ N1,N2,TIME0,TEND,DTIME,DTX,TIME,IPLOT

      C*  READ IN ARRAYS AA,BB,CC,XX,Y1,AND Y2 IF INTERACTIVE RUN

**          IF(IBATCH.EQ.1)GO TO 10

**          CALL READMS(6LSCRTCH,AA,N1,1)
**          CALL READMS(6LSCRTCH,BB,N1*N2,2)
**          CALL READMS(6LSCRTCH,CC,N2*N2,3)
**          CALL READMS(6LSCRTCH,XX,3*(NPLOT+2),5)
**
**    10    CONTINUE

      C*    WRITE OUTPUT

            WRITE(6,100)(AA(I),I=1,N1)
      100   FORMAT(/* INITIAL AA ARRAY*/(5G15.7))
            WRITE(6,200)N1,N2
      200   FORMAT(//* INITIAL BB(*I3*,*I3*) ARRAY*)
```

```
      DO 20 I=1,N1
20    WRITE(6,201)(BB(I,J),J=1,N2)
201   FORMAT(5G15.7)
      WRITE(6,300)N2,N2
300   FORMAT(//* INITIAL CC(*I3*,*I3*) ARRAY*)
      DO 30 I=1,N2
30    WRITE(6,201)(CC(I,J),J=1,N2)
      WRITE(6,400)
400   FORMAT(T10*TIME*T20*DET*T35*F(T)*/)
      DO 40 I=1,NPLOT
40    WRITE(6,401)XX(I),Y1(I),Y2(I)
401   FORMAT(3G15.4)

      RETURN
      END
```

APPENDIX B

SEGLOAD DIRECTIVES AND TREE DIAGRAMS FOR BATCH AND INTERACTIVE RUNS

SEGLOAD DIRECTIVES. (For Interactive Runs)

```
ROOT    TREE      MAIN-(IN,EE,PLT,OUT)
MAIN    GLOBAL    IADRESS,CONTROL
MAIN    GLOBAL    FCL.C.,Q8.IO.,FCL=ENT,IO.BUF.
IN      TREE      DATAIN-XINPUT
EE      TREE      E-(AN1,AN2)
AN1     TREE      ANALYS1-A-D
PLT     TREE      PLOT-PLOTTER-PSE
OUT     TREE      DATAOUT-XOUTPUT
AN2     TREE      ANALYS2-(B-F,C-(G,H))
PSE     TREE      PSEUDO-(BSCALE,NOTATE-AXES,LINPLT)
PSEUDO  GLOBAL    SETCHAR,LANGLEY
         END
```

TREE DIAGRAM. (For Interactive Runs)

```
*MAIN
 ?
 ?_DATAIN
 ? ?
 ? ?_XINPUT
 ?
 ?_E
 ? ?
 ? ?_ANALYS1
 ? ? ?
 ? ? ?_A
 ? ?   ?
 ? ?   ?_D
 ? ?
 ? ?_ANALYS2
 ?   ?
 ?   ?_B
 ?   ? ?
 ?   ? ?_F
 ?   ?
 ?   ?_C
 ?     ?
 ?     ?_G
 ?     ?
 ?     ?_H
 ?
 ?_PLOT
 ? ?
 ? ?_PLOTTER
 ?   ?
 ?   ?_PSEUDO
 ?     ?
```

```
 ?      ?_BSCALE
 ?      ?
 ?      ?_NOTATE
 ?      ? ?
 ?      ? ?_AXES
 ?      ?
 ?      ?_LINPLT
 ?
 ?_DATAOUT
   ?
   ?_XOUTPUT
```

SEGLOAD DIRECTIVES. (For Batch Runs)

```
ROOT    TREE        MAIN-(IN,EE,PLT,OUT)
MAIN    GLOBAL      IADRESS,CONTROL
MAIN    GLOBAL      FCL.C.,Q8.IO.,FCL=ENT,IO.BUF.
IN      TREE        DATAIN-XINPUT
EE      TREE        E-AN1
AN1     TREE        ANALYS1-A-D
PLT     TREE        PLOT-PLOTTER
PLOT     INCLUDE    PLOT,NOTATE
OUT     TREE        DATAOUT-XOUTPUT
   LEVEL
AN2     TREE        ANALYS2-B-F-C-G-H
PSE     TREE        PSEUDO
PSEUDO   INCLUDE    PSEUDO,AXES,CHARACT,CHNGSET,WHERE
PSEUDO  GLOBAL      SETCHAR,LANGLEY
         END
```

TREE DIAGRAM. (For Batch Runs)

```
*MAIN
 ?
 ?_DATAIN
 ? ?
 ? ?_XINPUT
 ?
 ?_E
 ? ?
 ? ?_ANALYS1
 ?   ?
 ?   ?_A
 ?     ?
 ?     ?_D
 ?
 ?_PLOT
 ? ?
 ? ?_PLOTTER
 ?
 ?_DATAOUT
```

```
   ?
   ?_XOUTPUT
```

```
==========================================================================
```

```
*ANALYS2
 ?
 ?_B
   ?
   ?_F
     ?
     ?_C
       ?
       ?_G
         ?
         ?_H

*PSEUDO
 ?
 ?_BSCALE
   ?
   ?_NOTATE
     ?
     ?_AXES
       ?
       ?_LINPLT
```

APPENDIX C

LOAD MAP FOR INTERACTIVE RUN

```
FWA OF THE LOAD              1054
LWA+1 OF THE LOAD           46275
CM BLANK COMMON FWA         46274

WRITTEN TO FILE      SAMABS

TRANSFER ADDRESS -- MAIN              16204


-------- SEGMENT - MAIN


PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK          ADDRESS    LENGTH     FILE      DATE      PROCSSR

(MAIN)            1054         5
/IADRESS/ G       1061        25


BLOCK          ADDRESS    LENGTH     FILE      DATE      PROCSSR

/CONTROL/ G       1106        22
/FCL.C./  G       1130        26
/Q8.IO./  G       1156       100
/FCL=ENT/ G       1256        40
/IO.BUF./ G       1316       227
/INDEX/           1545        13
/STP.END/         1560         1
MAIN              1561     14645     LGO       80/04/17 FTN
INITIAL          16426         0     LGO       80/04/17 FTN
RFL              16426        10     LGO       80/04/17 COMPASS
Q2NTRY=          16436         0 SL-FORTRAN   79/12/07 COMPASS
COMIO=           16436        33 SL-FORTRAN   79/12/07 COMPASS
FCL=FDL          16471        40 SL-FORTRAN   79/12/07 COMPASS
FECMSK=          16531        41 SL-FORTRAN   79/12/07 COMPASS
FEIFST=          16572         3 SL-FORTRAN   79/12/07 COMPASS
FLTIN=           16575       156 SL-FORTRAN   79/12/07 COMPASS
FLTOUT=          16753       311 SL-FORTRAN   79/12/07 COMPASS
FMTAP=           17264       357 SL-FORTRAN   79/12/07 COMPASS
FORSYS=          17643       300 SL-FORTRAN   79/12/07 COMPASS
FORUTL=          20143        46 SL-FORTRAN   79/12/07 COMPASS
GETFIT=          20211        57 SL-FORTRAN   79/12/07 COMPASS
INCOM=           20270       145 SL-FORTRAN   79/12/07 COMPASS
INPC=            20435       207 SL-FORTRAN   79/12/07 COMPASS
INPF=            20644       241 SL-FORTRAN   79/12/07 COMPASS
KODER=           21105       451 SL-FORTRAN   79/12/07 COMPASS
KRAKER=          21556       375 SL-FORTRAN   79/12/07 COMPASS
LDIN=            22153       260 SL-FORTRAN   79/12/07 COMPASS
```

```
NAMIN=          22433      523 SL-FORTRAN  79/12/07 COMPASS
OPENMS          23156       13 SL-FORTRAN  79/12/07 COMPASS
OUTC=           23171      150 SL-FORTRAN  79/12/07 COMPASS
OUTCOM=         23341      154 SL-FORTRAN  79/12/07 COMPASS
READMS          23515       13 SL-FORTRAN  79/12/07 COMPASS
REWIND=         23530       33 SL-FORTRAN  79/12/07 COMPASS
SPA=            23563       11 SL-FORTRAN  79/12/07 COMPASS
STLCRM=         23574       21 SL-FORTRAN  79/12/07 COMPASS
STLIBI.         23615       24 SL-FORTRAN  79/12/07 COMPASS
STLICO.         23641       16 SL-FORTRAN  79/12/07 COMPASS
STLOBI.         23657       15 SL-FORTRAN  79/12/07 COMPASS
STLOCO.         23674       12 SL-FORTRAN  79/12/07 COMPASS
STLREW.         23706       14 SL-FORTRAN  79/12/07 COMPASS
WRITMS          23722       13 SL-FORTRAN  79/12/07 COMPASS
SYSAID=         23735        1 SL-FORTRAN  79/12/07 COMPASS
RANCAP=         23736      410 SL-FORTRAN
CPU.SYS         24346       40 SL-SYSLIB   79/06/05 COMPASS
CTL$PTL         24406       34 SL-SYSLIB   80/01/09 COMPASS
CTL$RM          24442      434 SL-SYSLIB   80/01/09 COMPASS
CTL$WR          25076       40 SL-SYSLIB   80/01/09 COMPASS
RBL$RM          25136        0 SL-SYSLIB   80/01/09 COMPASS
CPUCPM          25136        5 SL-SYSLIB   80/01/17 COMPASS
ERR$RM          25143       25 SL-SYSLIB   80/01/09 COMPASS
LIST$RM         25170       67 SL-SYSLIB   80/01/09 COMPASS
ERRCAP=         25257      321 SL-FORTRAN
FERCAP=         25600      202 SL-FORTRAN
FCL$RM          26002       42 SL-BAMLIB   80/01/09 COMPASS
PLG$RM          26044        0 SL-BAMLIB   80/01/09 COMPASS
CLSF$RM         26044      430 SL-BAMLIB
DF$CRM          26474      226 SL-BAMLIB
EF$CRM          26722      446 SL-BAMLIB
GET$SQ          27370      574 SL-BAMLIB
GET$W           30164       50 SL-BAMLIB
GET$Z           30234      130 SL-BAMLIB
GET$WA          30364      173 SL-BAMLIB
GPTM$SQ         30557      424 SL-BAMLIB
OPEN$RM         31203     1324 SL-BAMLIB
PUT$SQ          32527      532 SL-BAMLIB
PUT$CI          33261       65 SL-BAMLIB
PUT$W           33346      215 SL-BAMLIB
PUT$Z           33563       64 SL-BAMLIB
PUT$WA          33647      170 SL-BAMLIB
REW$SQ          34037      125 SL-BAMLIB
SKFL$SQ         34164       36 SL-BAMLIB
WEOX$SQ         34222      137 SL-BAMLIB
CLSV$SQ         34361      220 SL-BAMLIB
COMM$WA         34601      306 SL-BAMLIB
GET$FU          35107      113 SL-BAMLIB
LBUF$RM         35222      134 SL-BAMLIB
```

```
RPE$SQ          35356       155 SL-BAMLIB
WAR$SQ          35533       160 SL-BAMLIB


-------- SEGMENT - DATAIN


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS    LENGTH     FILE      DATE      PROCSSR

        /IADRESS/ S     1061        25
        /CONTROL/ S     1106        22
        (DATAIN)       35713         1
        DATAIN         35714        53     LGO       80/04/17 FTN


-------- SEGMENT - XINPUT


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS    LENGTH     FILE      DATE      PROCSSR

        /IADRESS/ S     1061        25
        /CONTROL/ S     1106        22
        (XINPUT)       35767         0
        XINPUT         35767       167     LGO       80/04/17 FTN


-------- SEGMENT - E


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS    LENGTH     FILE      DATE      PROCSSR

        /IO.BUF./ S     1316       227
        (E)            35713         0


        BLOCK        ADDRESS    LENGTH     FILE      DATE      PROCSSR

        E              35713       321     LGO       80/04/17 FTN
```

```
OUTB=          36234      174 SL-FORTRAN  79/12/07 COMPASS


-------- SEGMENT - ANALYS1


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS   LENGTH    FILE      DATE      PROCSSR

        /IADRESS/ S     1061       25
        /CONTROL/ S     1106       22
        (ANALYS1)      36430        1
        ANALYS1        36431      105    LGO       80/04/17 FTN


-------- SEGMENT - ANALYS2


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS   LENGTH    FILE      DATE      PROCSSR

        /IADRESS/ S     1061       25
        /CONTROL/ S     1106       22
        (ANALYS2)      36430        2
        ANALYS2        36432      102    LGO       80/04/17 FTN


-------- SEGMENT - A


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK        ADDRESS   LENGTH    FILE      DATE      PROCSSR

        /IADRESS/ S     1061       25
        /CONTROL/ S     1106       22
        (A)            36536        1
        A              36537      142    LGO       80/04/17 FTN
```

-------- SEGMENT - B

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
/IADRESS/ S	1061	25			
/CONTROL/ S	1106	22			
(B)	36534	1			
B	36535	127	LGO	80/04/17	FTN

-------- SEGMENT - C

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
/IADRESS/ S	1061	25			
/CONTROL/ S	1106	22			
(C)	36534	2			
C	36536	62	LGO	80/04/17	FTN

-------- SEGMENT - D

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(D)	36701	0			
D	36701	206	LGO	80/04/17	FTN

-------- SEGMENT - F

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR

```
(F)              36664         0
F                36664        65     LGO       80/04/17 FTN


-------- SEGMENT - G


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

        (G)             36620         0
        G               36620        72     LGO       80/04/17 FTN


-------- SEGMENT - H


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

        (H)             36620         0
        H               36620        46     LGO       80/04/17 FTN


-------- SEGMENT - PLOT


        PROGRAM AND BLOCK ASSIGNMENTS.

        BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

        /IADRESS/ S      1061        25
        /CONTROL/ S      1106        22
        (PLOT)          35713         2
        PLOT            35715        63     LGO       80/04/17 FTN
```

-------- SEGMENT - PLOTTER

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK		ADDRESS	LENGTH	FILE	DATE	PROCSSR
/IADRESS/	S	1061	25			
/CONTROL/	S	1106	22			
/FCL.C./	S	1130	26			
/IO.BUF./	S	1316	227			

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(PLOTTER)	36000	14			
PLOTTER	36014	373	LGO	80/04/17	FTN
INPB=	36407	362	SL-FORTRAN	79/12/07	COMPASS
CTL$SKP	36771	57	SL-SYSLIB	80/01/09	COMPASS

-------- SEGMENT - PSEUDO

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK		ADDRESS	LENGTH	FILE	DATE	PROCSSR
/FCL.C./	S	1130	26			
(PSEUDO)		37050	0			
/SETCHAR/	G	37050	56			
/LANGLEY/	G	37126	25			
PSEUDO		37153	2334	UL-LRCGOSF	79/12/10	COMPASS
NUMARG		41507	114	UL-LRCGOSF	79/12/10	COMPASS
WHERE		41623	31	UL-LRCGOSF	79/12/10	FTN
SYSTEM		41654	26	SL-FORTRAN	79/12/07	COMPASS
ALOG.		41702	63	SL-FORTRAN	79/12/07	COMPASS
EXP.MSG		41765	16	SL-FORTRAN	79/12/07	COMPASS
SINCOS.		42003	60	SL-FORTRAN	79/12/07	COMPASS
SYS=1ST		42063	63	SL-FORTRAN	79/12/07	COMPASS
SYS=AID		42146	7	SL-FORTRAN	79/12/07	COMPASS
XTOI.		42155	63	SL-FORTRAN	79/12/07	COMPASS
CPU.CIO		42240	13	SL-SYSLIB	79/06/05	COMPASS
CPU.WTO		42253	17	SL-SYSLIB	79/06/05	COMPASS

-------- SEGMENT - BSCALE

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(BSCALE)	42272	0			
BSCALE	42272	506	UL-LRCGOSF	79/12/10	FTN
LEGVAR	43000	4	SL-FORTRAN	79/12/07	COMPASS
EXP.	43004	72	SL-FORTRAN	79/12/07	COMPASS
XTOY.	43076	31	SL-FORTRAN	79/12/07	COMPASS

-------- SEGMENT - NOTATE

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
/SETCHAR/ S	37050	56			
(NOTATE)	42272	0			
/APOS/	42272	17			
/NOTESET/	42311	416			
NOTATE	42727	234	UL-LRCGOSF	79/12/10	FTN
CHARACT	43163	567	UL-LRCGOSF	79/12/10	FTN
CHNGSET	43752	63	UL-LRCGOSF	79/12/10	FTN
DECOD1	44035	7	UL-LRCGOSF	79/12/10	COMPASS
NEWSYMR	44044	172	UL-LRCGOSF	79/12/10	FTN

-------- SEGMENT - LINPLT

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	DATE	PROCSSR
(LINPLT)	42272	0			
LINPLT	42272	504	UL-LRCGOSF	79/12/10	FTN

```
CIRCLE          42776       165 UL-LRCGOSF   79/12/10 FTN
CNTRLN          43163       134 UL-LRCGOSF   79/12/10 FTN
GRID            43317       134 UL-LRCGOSF   79/12/10 FTN
PNTPLT          43453       524 UL-LRCGOSF   79/12/10 FTN
SQRT.           44177        32 SL-FORTRAN   79/12/07 COMPASS
```

-------- SEGMENT - AXES

PROGRAM AND BLOCK ASSIGNMENTS.

```
BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

/FCL.C./  S      1130        26
/Q8.IO./  S      1156       100
/SETCHAR/ S     37050        56
(AXES)          44236         0
/APOS/          44236        17
AXES            44255      1524 UL-LRCGOSF   79/12/10 FTN
NUMBER          46001       167 UL-LRCGOSF   79/12/10 FTN
ENCODE=         46170       104 SL-FORTRAN   79/12/07 COMPASS
```

-------- SEGMENT - DATAOUT

PROGRAM AND BLOCK ASSIGNMENTS.

```
BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

/IADRESS/ S      1061        25

BLOCK         ADDRESS    LENGTH     FILE      DATE      PROCSSR

/CONTROL/ S      1106        22
(DATAOUT)       35713         1
DATAOUT         35714        71     LGO       80/04/17 FTN
```

-------- SEGMENT - XOUTPUT

```
PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK          ADDRESS    LENGTH     FILE       DATE       PROCSSR

/IADRESS/ S      1061         25
/CONTROL/ S      1106         22
(XOUTPUT)       36005          0
XOUTPUT         36005        271     LGO        80/04/17 FTN

     4.708 CP SECONDS                   53700B CM STORAGE USED
```

APPENDIX D

ADDRESS FILE FOR INTERACTIVE RUN

```
IADBLNK=              46274B,
IADIN=      35767B,IPIN=      167B,
IADAN1 =    36701B,IPAN1=     206B,
IADAN2=     36664B,IPAN2=      65B,
IADPLT =    46170B,IPPLT=     104B,
IADOUT =    36005B,IPOUT=     271B,
```

APPENDIX E

EDITING COMMAND FILE TO GENERATE ADDRESSES FROM LOAD MAP

```
BRIEF
F,,R
IB2
*START
*END
^READ TAPE5
^N
IF$0$
W 80
Z;L$ CM BLANK $;YQM
##########&IADBLNK=#&&&&&&&&&           B,##########################
COPY ADRESS
Z;L$ (XINPUT)$;N;YQM
##########&IADIN=&&          , IPIN= #,##############################
C$,$B,$
COPY ADRESS
TOP
Z;L$ (D) $;N;YQM
##########&IADAN1&=          , IPAN1=#,##############################
C$,$B,$
COPY ADRESS
Z;L$ (F) $;N;YQM
##########&IADAN2=&          , IPAN2=#,##############################
C$,$B,$
COPY ADRESS
Z;L$ ENCODE= $;YQM
##########&IADPLT&=          , IPPLT=#,##############################
C$,$B,$
COPY ADRESS
Z;L$    XOUTPUT$;YQM
##########&IADOUT&=          , IPOUT=#,##############################
C$,$B,$
COPY ADRESS
ELSE
ENDIF
END
```

APPENDIX F

OUTPUT FILE FOR INTERACTIVE RUN

```
                    051063
            035757          000167
            036671          000206
            036654          000065
            051044          000017
            035775          000271

FIELD LENGTH FOR BRANCH --  DATAIN  -- IS 037050


FIELD LENGTH FOR BRANCH --  ANALYS1  -- IS 040361


FIELD LENGTH FOR BRANCH --  ANALYS2  -- IS 040223


FIELD LENGTH FOR BRANCH --  PLOT  -- IS 046460


FIELD LENGTH FOR BRANCH --  DATAOUT  -- IS 037253

INITIAL AA(10) ARRAY
  2.000000    -7.000000     30.00000      4.000000    -10.00000
  2.000000     7.000000     8.000000     -8.000000    -1.000000

INITIAL BB(10,15) ARRAY
  1.000000     2.000000     3.000000     4.000000     5.000000
  6.000000     7.000000     8.000000     9.000000     10.00000
  11.00000     12.00000     13.00000     14.00000     15.00000
  1.500000     2.500000     3.500000     4.500000     5.500000
  6.500000     7.500000     8.500000     9.500000     10.50000
  11.50000     12.50000     13.50000     14.50000     15.50000
 -1.000000    -2.000000    -3.000000    -4.000000    -5.000000
 -6.000000    -7.000000    -8.000000    -9.000000    -10.00000
 -11.00000    -12.00000    -13.00000    -14.00000    -15.00000
 0.            1.000000     2.000000     3.000000     4.000000
  5.000000     6.000000     7.000000     8.000000     9.000000
  10.00000     11.00000     12.00000     13.00000     14.00000
  .5000000     1.500000     2.500000     3.500000     4.500000
  5.500000     6.500000     7.500000     8.500000     9.500000
  10.50000     11.50000     12.50000     13.50000     14.50000
 0.           -1.000000    -2.000000    -3.000000    -4.000000
 -5.000000    -6.000000    -7.000000    -8.000000    -9.000000
 -10.00000    -11.00000    -12.00000    -13.00000    -14.00000
 0.           0.            1.000000     2.000000     3.000000
  4.000000     5.000000     6.000000     7.000000     8.000000
  9.000000     10.00000     11.00000     12.00000     13.00000
 0.           0.            .5000000     1.500000     2.500000
  3.500000     4.500000     5.500000     6.500000     7.500000
  8.500000     9.500000     10.50000     11.50000     12.50000
  13.50000    0.           0.           -1.000000    -2.000000
```

```
 -3.000000     -4.000000     -5.000000     -6.000000     -7.000000
 -8.000000     -9.000000     -10.00000     -11.00000     -12.00000
 -13.00000      1.000000     0.             1.000000     0.
  1.000000     0.             1.000000     0.             1.000000
 0.             1.000000     0.             1.000000     0.

INITIAL CC(15,15) ARRAY
   1.000000      1.000000     -2.000000      3.000000     -4.000000
   5.000000     -6.000000      7.000000     -8.000000      9.000000
  -10.00000      11.00000     -12.00000      13.00000     -14.00000
   15.00000      2.000000      4.000000      3.000000      6.000000
   5.000000      8.000000      7.000000      10.00000      9.000000
   12.00000      11.00000      14.00000      13.00000      16.00000
   15.00000     0.             1.000000     0.             2.000000
 0.              3.000000     0.             4.000000     0.
   5.000000     0.             6.000000     0.             7.000000
 0.             0.             0.             1.000000     0.
 0.              2.000000     0.             0.             3.000000
 0.             0.             4.000000     0.             0.
   5.000000      1.000000     0.             0.            -1.000000
 0.             0.             2.000000     0.             0.
 -2.000000      0.             0.             3.000000     0.
 0.            -9.000000     0.            -8.000000     0.
 -7.000000      0.            -6.000000     0.            -5.000000
 0.            -4.000000     0.            -3.000000     0.
 -2.000000      1.000000      2.000000      1.000000      2.000000
  1.000000      2.000000      1.000000      2.000000      1.000000
  2.000000      1.000000      2.000000      1.000000      2.000000
  1.000000     -1.000000      2.000000     -1.000000      2.000000
 -1.000000      2.000000     -1.000000      2.000000      2.000000
 -1.000000      2.000000     -1.000000      2.000000     -1.000000
  2.000000     0.             0.             0.             1.000000
 0.             0.             0.            -1.000000     0.
 0.             0.             1.000000     0.             0.
 0.             0.             0.             0.             0.
 0.             0.             0.             0.             0.
 0.             0.             0.             0.             0.
  1.000000     0.             0.             0.             0.
 0.             0.             0.             0.             0.
 0.             0.             0.             0.             1.000000
 0.             0.             0.             0.             0.
 0.             0.             0.             0.             0.
 0.             0.             0.             1.000000     0.
 0.             0.             0.            0.             0.
 0.             0.             0.            0.             0.
 0.             0.             1.000000     0.             0.
 0.             0.            0.             0.             0.
 0.             0.            0.             0.             0.
 0.              1.000000     0.             0.             0.
 0.             0.             0.             0.             0.
 0.             0.             0.             0.             0.
  1.000000     0.             0.             0.             0.
```

TIME	DET	F(T)
0.	-.2100E-13	.8637E+14
.2000	.2700E-10	.2704E+17
.4000	-.4958E-09	.2800E+15
.6000	-.4696E-07	.8174E+16
.8000	-.1171E-06	.4611E+17
1.000	.7658E-07	.9089E+17
1.200	-.6696E-10	.4738E+12
1.400	-.4338E-06	.1323E+18
1.600	.1966E-06	.7200E+14
1.800	.6426E-06	.8781E+17
2.000	.1055E-06	.3308E+17
2.200	.5434E-07	.1338E+14
2.400	-.7532E-04	.2013E+18
2.600	.6969E-05	.2403E+18
2.800	.1902E-05	.6555E+17

APPENDIX G

OUTPUT FILE FOR BATCH RUN

```
FIELD LENGTH FOR BRANCH --  DATAIN  -- IS 052166

FIELD LENGTH FOR BRANCH --  ANALYS1  -- IS 053107

FIELD LENGTH FOR BRANCH --  ANALYS2  -- IS 052546

FIELD LENGTH FOR BRANCH --  PLOT  -- IS 052251

FIELD LENGTH FOR BRANCH --  DATAOUT  -- IS 052251

INITIAL AA(10) ARRAY
  2.000000    -7.000000     30.00000      4.000000    -10.00000
  2.000000     7.000000     8.000000     -8.000000    -1.000000


INITIAL BB(10,15) ARRAY
  1.000000     2.000000     3.000000     4.000000     5.000000
  6.000000     7.000000     8.000000     9.000000     10.00000
  11.00000     12.00000     13.00000     14.00000     15.00000
  1.500000     2.500000     3.500000     4.500000     5.500000
  6.500000     7.500000     8.500000     9.500000     10.50000
  11.50000     12.50000     13.50000     14.50000     15.50000
 -1.000000    -2.000000    -3.000000    -4.000000    -5.000000
 -6.000000    -7.000000    -8.000000    -9.000000    -10.00000
 -11.00000    -12.00000    -13.00000    -14.00000    -15.00000
 0.            1.000000     2.000000     3.000000     4.000000
  5.000000     6.000000     7.000000     8.000000     9.000000
  10.00000     11.00000     12.00000     13.00000     14.00000
  .5000000     1.500000     2.500000     3.500000     4.500000
  5.500000     6.500000     7.500000     8.500000     9.500000
  10.50000     11.50000     12.50000     13.50000     14.50000
 0.           -1.000000    -2.000000    -3.000000    -4.000000
 -5.000000    -6.000000    -7.000000    -8.000000    -9.000000
 -10.00000    -11.00000    -12.00000    -13.00000    -14.00000
 0.           0.            1.000000     2.000000     3.000000
  4.000000     5.000000     6.000000     7.000000     8.000000
  9.000000     10.00000     11.00000     12.00000     13.00000
 0.           0.            .5000000     1.500000     2.500000
  3.500000     4.500000     5.500000     6.500000     7.500000
  8.500000     9.500000     10.50000     11.50000     12.50000
  13.50000    0.           0.           -1.000000    -2.000000
 -3.000000    -4.000000    -5.000000    -6.000000    -7.000000
 -8.000000    -9.000000    -10.00000    -11.00000    -12.00000
 -13.00000     1.000000    0.            1.000000    0.
  1.000000    0.            1.000000    0.            1.000000
 0.            1.000000    0.            1.000000    0.
```

```
INITIAL CC(15,15) ARRAY
  1.000000     1.000000    -2.000000     3.000000    -4.000000
  5.000000    -6.000000     7.000000    -8.000000     9.000000
 -10.00000     11.00000    -12.00000     13.00000    -14.00000
  15.00000     2.000000     4.000000     3.000000     6.000000
  5.000000     8.000000     7.000000     10.00000     9.000000
  12.00000     11.00000     14.00000     13.00000     16.00000
  15.00000    0.            1.000000    0.            2.000000
 0.            3.000000    0.            4.000000    0.
  5.000000    0.            6.000000    0.            7.000000
 0.           0.           0.            1.000000    0.
 0.            2.000000    0.           0.            3.000000
 0.           0.            4.000000    0.           0.
  5.000000     1.000000    0.           0.           -1.000000
 0.           0.            2.000000    0.           0.
 -2.000000    0.           0.            3.000000    0.
 0.           -9.000000    0.           -8.000000    0.
 -7.000000    0.           -6.000000    0.           -5.000000
 0.           -4.000000    0.           -3.000000    0.
 -2.000000     1.000000     2.000000     1.000000     2.000000
  1.000000     2.000000     1.000000     2.000000     1.000000
  2.000000     1.000000     2.000000     1.000000     2.000000
  1.000000    -1.000000     2.000000    -1.000000     2.000000
 -1.000000     2.000000    -1.000000     2.000000     2.000000
 -1.000000     2.000000    -1.000000     2.000000    -1.000000
  2.000000    0.           0.           0.            1.000000
 0.           0.           0.           -1.000000    0.
 0.           0.            1.000000    0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
  1.000000    0.           0.           0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.            1.000000
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.            1.000000    0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
 0.           0.            1.000000    0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
 0.            1.000000    0.           0.           0.
 0.           0.           0.           0.           0.
 0.           0.           0.           0.           0.
  1.000000    0.           0.           0.           0.
    TIME            DET          F(T)

   0.           -.2100E-13     .8637E+14
    .2000        .2700E-10     .2704E+17
    .4000       -.4958E-09     .2800E+15
    .6000       -.4696E-07     .8174E+16
```

.8000	-.1171E-06	.4611E+17
1.000	.7658E-07	.9089E+17
1.200	-.6696E-10	.4738E+12
1.400	-.4338E-06	.1323E+18
1.600	.1966E-06	.7200E+14
1.800	.6426E-06	.8781E+17
2.000	.1055E-06	.3308E+17
2.200	.5434E-07	.1338E+14
2.400	-.7532E-04	.2013E+18
2.600	.6969E-05	.2403E+18
2.800	.1902E-05	.6555E+17

APPENDIX H

CONTROL CARD FILE TO EXECUTE PROGRAM FROM RELOCATABLE BINARY

```
.PROC,PROSAM,SAMMAP.
REWIND,SAMMAP,SAMABS,LOADIR.
GET,LGO=SAMBIN.
GET,EDILOAD,BATLOAD.
GET,TAPE5=SAMPDAT.
ATTACH,FTNMLIB,LRCGOSF/UN=LIBRARY.
XEDIT,BATLOAD,L=NOPRINT./CALL EDILOAD/
SEGLOAD,B=SAMABS,I=LOADIR,LO=DT.
LDSET,LIB=FTNMLIB/LRCGOSF,MAP=/SAMMAP,PRESET=ZERO.
LOAD,LGO.
NOGO.
XEDIT,SAMMAP,L=NOPRINT,W=132./CALL EDIMAP/
SAMABS.
REVERT.*** END LOAD SEQUENCE FOR SAMABS ***
EXIT.
REVERT,ABORT.*** ERROR IN LOAD SEQUENCE ***
```

Note: Binary file SAMBIN was generated using the "static" option on the FTN control card in order to allow for the dynamic data storage allocation:

```
FTN,I=SAMPLE,B=SAMBIN,STATIC.
```

The "static" option is unnecessary if employing only variable loading techniques, without dynamic storage allocation.

REFERENCES

1. Tiffany, Sherwood H.; Newsom, Jerry R.: Some Programming Techniques for Increasing Program Versatility and Efficiency on CDC Equipment. NASA CR-3033, August,1978.

2. Control Data Corporation: Cyber Loader Version 1 Reference Manual. Publication No.60429800, 1979.

3. Langley Research Center: Graphic Output System Users Guide. NASA Langley Research Center Computer Programming Manual, Vol.IV, 1979.

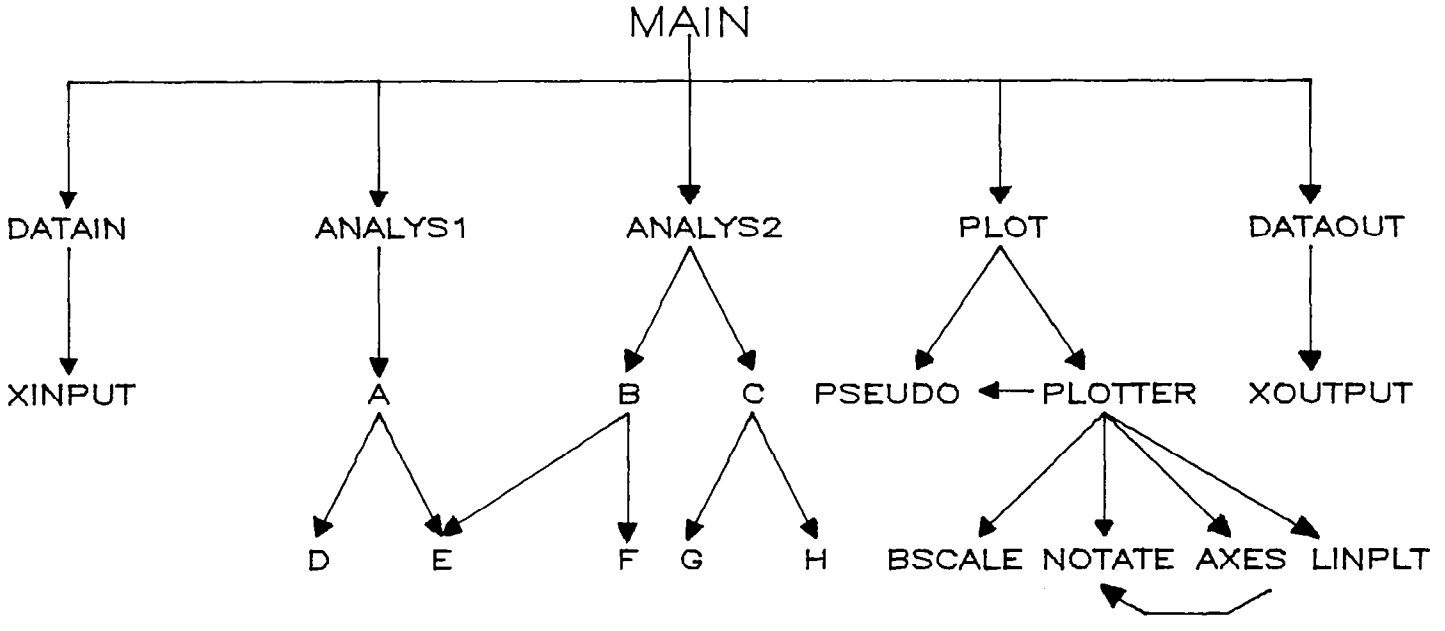


Figure 1.- Calling sequence diagram.

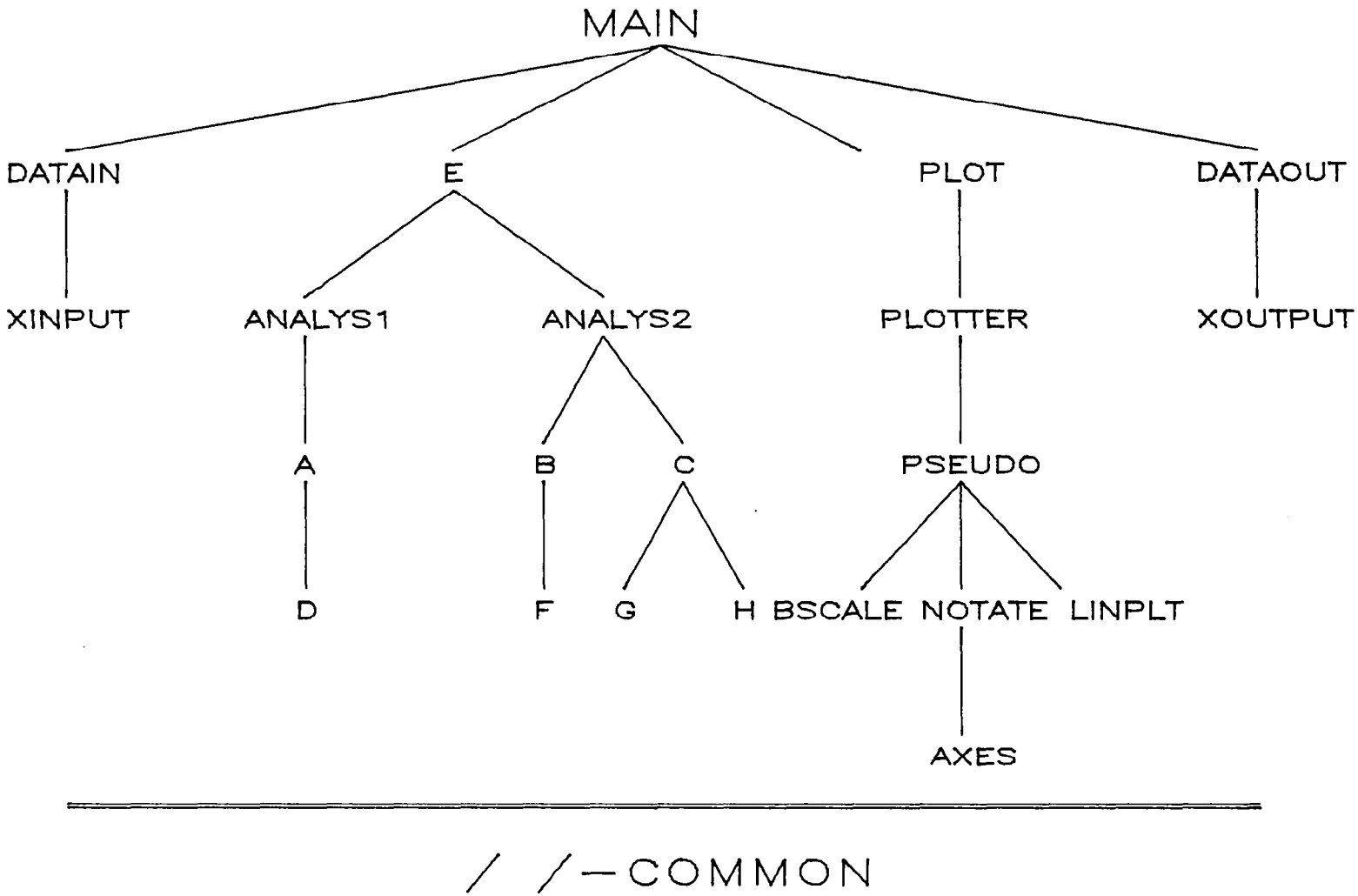


Figure 2.- Branching diagram for interactive run.

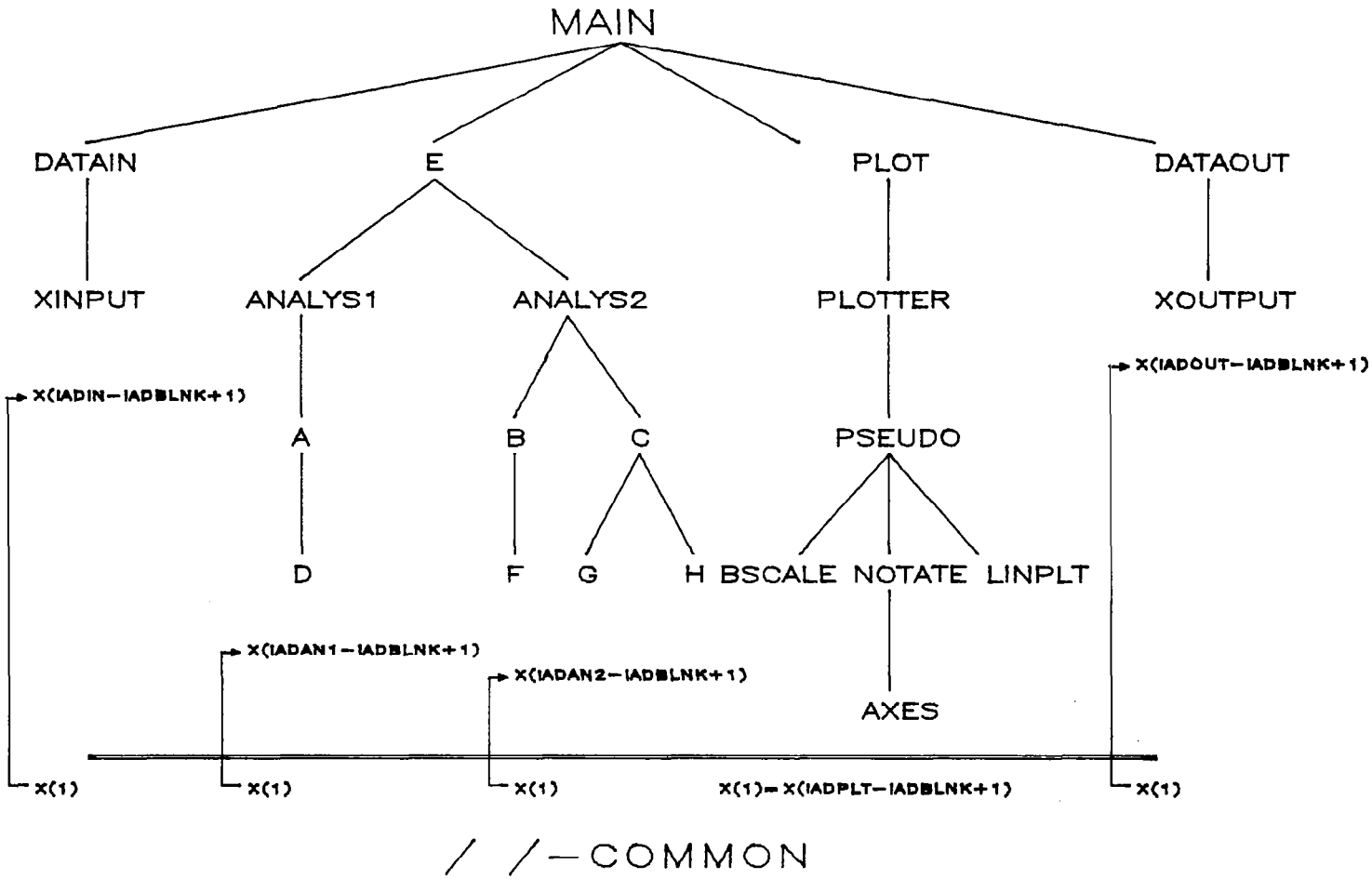
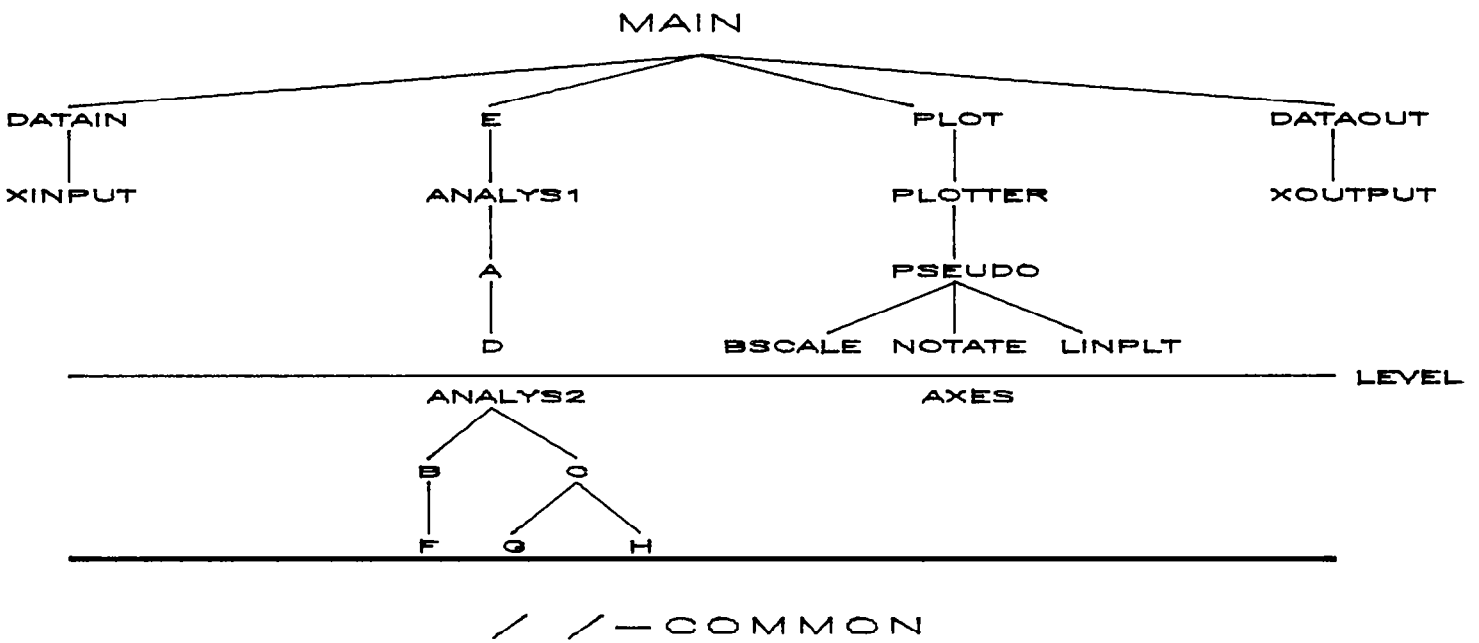
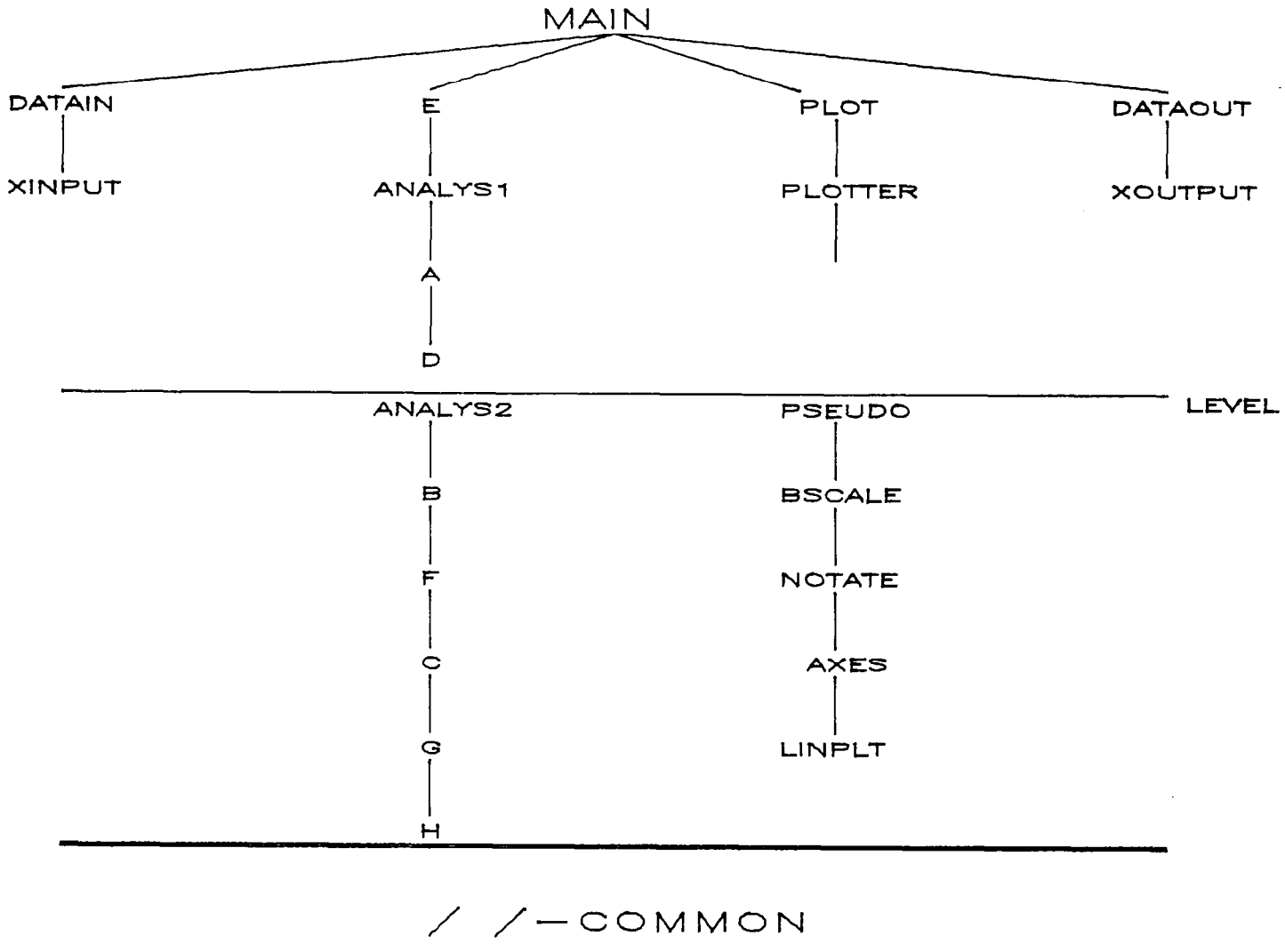


Figure 3.- Beginning data storage addresses for interactive run.



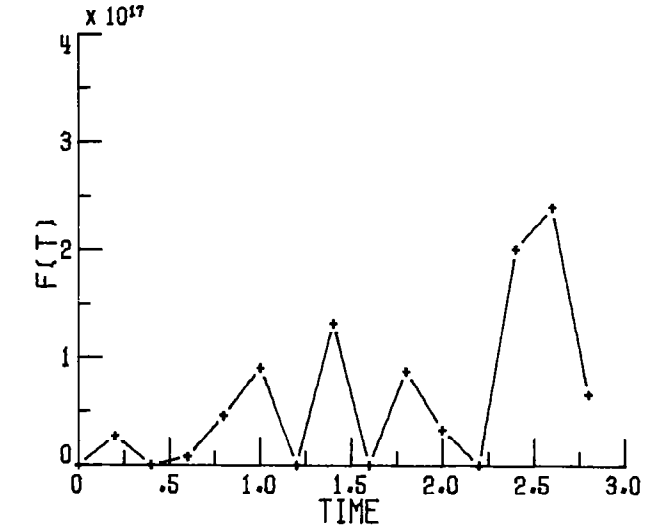
(a) Branch diagram 1

Figure 4.- Possible branching diagrams for batch run.

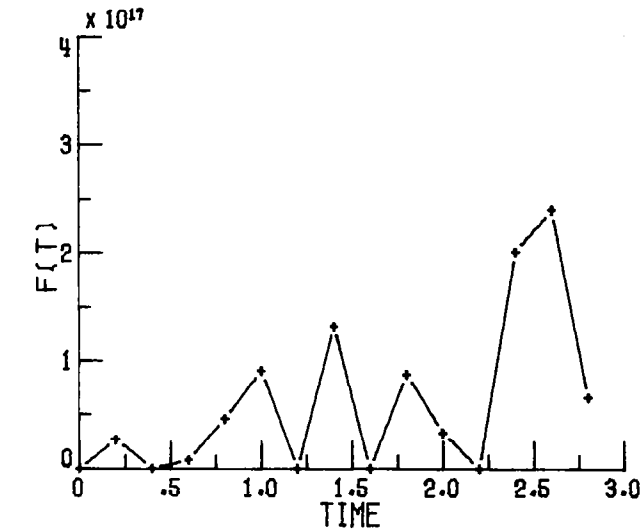


(b) Branch diagram 2

Figure 4.- Concluded.



(a) Interactive run



(b) Batch run

Figure 5.- Sample plots from interactive and batch runs.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-3315		

4. Title and Subtitle	5. Report Date
SEGMENTATION, DYNAMIC STORAGE, AND VARIABLE LOADING ON CDC EQUIPMENT	September 1980
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Sherwood H. Tiffany	
	10. Work Unit No.
9. Performing Organization Name and Address	
Kentron International, Inc. Hampton Technical Center 3221 North Armistead Avenue Hampton, VA 23666	11. Contract or Grant No. NAS1-16000
	13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address	
National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

Technical Monitor: William M. Adams, Jr.
Topical Report

16. Abstract

Techniques for varying the segmented load structure of a program and for varying the dynamic storage allocation, depending upon whether a batch type or interactive type run is desired, are explained and demonstrated. All changes are based on a single data input to the program. The techniques involve code within the program to suppress scratch pad input/output (IØ) for a "batch" run or translate the in-core data storage area from blank common to the end-of-code+1 address of a particular segment for an "interactive" run; automatic editing of the segload directives prior to loading, based upon data input to the program, to vary the structure of the load for "interactive" and "batch" runs; and automatic editing of the load map to determine the initial addresses for in-core data storage for an "interactive" run.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Automatic variable loading Segmentation Dynamic Storage allocation	Unclassified - Unlimited Subject Category 61

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	70	A04

For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1980