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**MOVIES, PLOTTING AND PRINTING OF OUTPUT
FROM SERIAL CALCULATIONS**

by

W.J. TURNER

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ABSTRACT

A description is given of four digital computer programs for displaying the output from large computer calculations which repeatedly evaluate a set of parameters (e.g. the system parameters at each time step of the simulation of a physical system, or during an iterative procedure.) The MOVIE program produces moving graphs on the screen of a GT40 or GT44 Dataway terminal. The PLOT program allows the user to edit a set of plot commands, view the resulting plots and save the plots and the final set of commands. The PRINT program prints output data on the main printer. IPRINT prints data at the terminal. The data base for all these programs is a dump file written by inserting calls to two supplied subroutines in the original serial calculations.

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The following descriptors have been selected from the INIS Thesaurus to describe the subject content of this report for information retrieval purposes. For further details please refer to IAEA-INIS-12 (INIS: Manual for Indexing) and IAEA-INIS-13 (INIS: Thesaurus) published in Vienna by the International Atomic Energy Agency.

CONTENTS

1. INTRODUCTION	1
2. WRITING THE DUMP FILE	2
3. MOVIES	4
3.1 General	4
3.2 Example of MOVIE Generation	4
3.3 Terminal Input	6
3.4 Attention Commands	7
3.5 Other Input	8
4. BATCH PRINTING	8
4.1 Example of Use of the PRINT Program	9
4.1.1 Input deck	9
4.1.2 Output	9
5. INTERACTIVE PRINTING	10
5.1 Example of Use of the IPRINT Program	10
5.1.1 Input deck	10
5.1.2 Terminal Session	11
5.1.3 Unit 3 output	11
6. PLOTTING	11
6.1 General	11
6.2 Example of Use of the PLOT program	12
6.2.1 Input deck for interactive plotting	12
6.2.2 Terminal session	13
6.2.3 Unit 3 output	14
6.2.4 Input deck for batch plotting	15
6.3 Commands	15
6.3.1 DATA	15
6.3.2 PAPE	16
6.3.3 XFMT	17
6.3.4 YFMT	18
6.3.5 FAKE	18
6.3.6 FRAM	18
6.3.7 LINE	19

6.3.8	LINS	19
6.3.9	PNTS	19
6.3.10	CONX	20
6.3.11	CONS	20
6.3.12	NAME	20
6.3.13	HEAD	20
6.3.14	NAMX	21
6.3.15	NAMY	21
6.3.16	LEGO	21
6.3.17	LEGH	21
6.3.18	LEG	21
6.3.19	LEGS	22
6.3.20	MARK	22
6.3.21	PEN	22
6.3.22	SKEW	23
6.3.23	WAY	23
6.3.24	COPY	23
6.3.25	EDIT	23
6.3.26	READ	24
6.3.27	SUSP	24
6.3.28	STOP	24
6.3.29	?	24
6.4	Interrupts	24
7.	ACKNOWLEDGEMENTS	24
8.	REFERENCES	25
Figure 1	Third frame of MOVIE example	27
Figure 2	Plot produced by plot example	28

1. INTRODUCTION

The programs described in this report have greatly assisted interpretation of the results of large, digital computer, serial calculations. The serial calculation can be the simulation of the behaviour of a physical system in time, an iterative procedure, or any other procedure in which a set of parameters is evaluated many times during the procedure. Such digital computer programs commonly produce large amounts of output data which may require hours or even days of work before the results are fully grasped. The moving and static graph plotting programs described in this report have proved valuable tools in this task and greatly reduce the time and effort required for this interpretation.

The first step in using these programs is to insert calls to the supplied subroutines, WDUMP and TDUMP, into the serial calculation so that a 'dump' file is written. This dump file is then used as input data to the following programs:

MOVIE - which produces a moving graph on the screen of a GT40 or GT44 Dataway* terminal,

PRINT - for batch printing,

IPRINT - for interactive printing, and

PLOT - for interactive and batch plotting.

Executable load modules of these programs and load modules of WDUMP and TDUMP are contained on the library WJT.MOVIE.PLOT.PROGRAMS and can be executed by use of the catalogued procedure PROGRUN. The sources of all these programs and of WDUMP and TDUMP are on the data set WJT.MOVIE.PLOT.UNED. All are in FORTRAN, except for TDUMP and a subroutine of MOVIE called TIME which are in assembler.

Complete jobs to produce the sample problems for this report are also in this data set. All numeric input data required by the programs are read by the free input subroutine SCAN [Bennett and Pollard 1967].

* The Lucas Heights Research Laboratories' data transmission network.

2. WRITING THE DUMP FILE

A complete input deck to produce a dump file is shown below.

```
//WJTWSAMP JOB (*****/P22APLCA',N1),W.J.TURNER
// EXEC FORTGCLG,PLIB='WJT.MOVIE.PLOT.PROGRAMS'
C SAMPLE PROGRAM TO WRITE DUMP FILE
  INTEGER NHEAD(31)/'SAMPLE DUMP FILE'/
  REAL*8 X(7)/0.,.1,.2,.3,.4,.5,.6/,TIME/0./,Y(7)
  CALL DATIM(NHEAD(21),NHEAD(24))
  CALL XTODAY(NHEAD(30),NHEAD(31))
  CALL WDUMP(8,1,NHEAD)
  DO 2 I=1,9
  DO 1 J=1,7
1  Y(J)=DEXP(X(J)-TIME)
  CALL TDUMP(8,TIME,1,Y,7)
2  TIME=TIME+.2D0
  STOP
  END
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLE.DUMP,DISP=(NEW,CATLG),
// DCB=(BLKSIZE=19000,LRECL=19000,RECFM=VBS),SPACE=(40,10),
// UNIT=SYSDA
```

Each dump file consists of a header record and double precision data records, both unformatted. A particular data set may contain any number of dump files. They are separated by the hexadecimal number 8000000000000001 which appears at the start of every header record. This hexadecimal number is an unnormalised double precision number (approximately -10^{-94}) and must not appear at the start of a data record. A header record is written by a call to

WDUMP(NU,NFILE,NHEAD)

where NU is the reference number of the required data set,
 NFILE is the required dump file number on the data set,
 NHEAD is the required heading (31 words of 4 bytes).

If NFILE < 0 the dump file is written at the start of the data set
 = 0 the dump file is written at the end of the data set
 = I overwrites the Ith file (placed at the end if less than I files).

A message is written on unit 3 (the printer) indicating the position of the

dump file and quoting the file heading information.

The movie, plot and print programs expect that the contents of NHEAD are as follows:

1 to 20	80 character EBDIC heading
21 to 23	12 character EBDIC date, e.g. 23 JUN 81
24 to 29	24 character EBDIC time, e.g. 17 HRS 27 MIN 57.42 SEC
30	Hexadecimal year and day number (printed with format Z5) e.g. 81174
31	Integer time after midnight in hundredths of a second

This information is obtained from the AAE.FORTLIB routines DATIM and XTODAY by execution of the following:

```
CALL DATIM(NHEAD(21),NHEAD(24))
CALL XTODAY(NHEAD(30),NHEAD(31))
```

Data records which, for a particular dump file, must all contain the same number of entries, are written by a call to

```
TDUMP(NU,ARRAY1,N1,ARRAY2,N2 ...)
```

where NU is the data set reference number,
NI are the number of double precision words to be written
from array ARRAYI

and any odd number of arguments may be supplied. Alternatively, data records can be written with the FORTRAN statement

```
WRITE(NU)(ARRAY1(I),I=1,N1),(ARRAY2(I),I=1,N2) ... etc.
```

The recommended DCB for a dump data set is BLKSIZE=LRECL=19000, RECFM=VBS. A large block size is particularly important for rapid access during interactive plotting and movies.

3. MOVIES

3.1 General

Execution of this interactive program produces moving graphs on the screen of a GT40 or GT44 Dataway terminal. For example, consider a serial computer program in which the variation in time of pressure and flow in a pipeline network is calculated and which, at each time step, writes a dump data record containing the pressures and flows at selected points along the pipes in the network. MOVIE displays selected graphs of pressure and flow against position and a moving picture is produced by continually updating these graphs using successive dump records. Each graph consists of one or more segments, each segment containing two or more points joined by a line; in the example above, each segment would be a pipe in the network. The last point of a segment is not joined to the first of the next. Up to 10 graphs may be selected, but scales are only drawn for the first three. Also, up to four images or ghosts of earlier dump records may be displayed, thus allowing close examination of the changes during each time step. The speed of a movie (including reversal and skipping of dump records) is controlled by single character attention commands typed during the movie. The maximum speed of the movie is roughly proportional to the number of nodes times the number of graphs. Ghosts have little effect on speed as they are retained by means of the GT40 or GT44 multiple display file facility. All numerical data are read with SCAN [Bennett and Pollard 1967].

3.2 Example of MOVIE Generation

Input Deck

The following input deck initiates a movie of the sample dump file written in Section 2

```
//WJTMOVIE JOB (*****P22APLCA',M1),W.J.TURNER,
// CLASS=I,TIME=15
// EXEC PROGRUN,MEM=MOVIE,LIB='WJT.MOVIE.PLOT.PROGRAMS'
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLE.DUMP,DISP=SHR
1 SEGMENT
7 NODES
0(.1).6
```

Terminal Session

All text typed by MOVIE (except for the page of information) is underlined.

```
$RUN
ID:
JOB: WJTMOVIE
TESTING WJTMOVIE
WJTMOVIE (JOB 97) READY
```

The MOVIE program now begins by clearing the screen and displaying the following page of information and prompting several data entries

THE MOVIE PROGRAM

ATTENTION COMMANDS
(TYPED WITHOUT CARRIAGE RETURN DURING A MOVIE)

0 TO 9	SKIP RECORDS
QWERTYUIOP (TOP ROW OF KEYBOARD)	INTRODUCE DELAYS OF 0.06 0.12 0.25 0.5 1 2 4 8 16 SECONDS BETWEEN FRAMES
+ AND -	FORWARD AND BACKWARDS
H	HOLD
G	GO
N	NEXT FRAME
F	FINISH

```
-----
LOGICAL UNIT NUMBER:8
FILE NO. 1
SAMPLE DUMP FILE
4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8
WINDOW ENTRY:2
Y LIMS-BLANK RETAINS OLD LIMS,1 LIMS OF DATA 0 1
WINDOW ENTRY:0
```

The screen is cleared and the movie begins. Control is exercised by the attention commands described above. The third frame of this movie is shown in Figure 1. The frame rate and other information is displayed after an F command. This remains on the screen until any key is pressed on the keyboard; then the screen is cleared and the page of information again displayed, and input for a further movie requested.

LOGICAL UNIT NUMBER:0

This instructs MOVIE to end. The screen is cleared and the GT40/44 restored to normal.

END OF RUN
END OF INTERACTION
END:RUN

3.3 Terminal Input

In the following, the text typed by the program is underlined:

LOGICAL UNIT NUMBER: NU

NU = 0 program stops

NU \neq 0 reference number of data set containing the dump file of interest. DD cards must be provided in the GO step for every reference number used.

FILE NO: \pm NFILE

NFILE is the number of the dump file on the specified data set. If negative, then no further terminal input data are required and a movie is produced using terminal input data from the previous movie.

WINDOW ENTRY: \pm NW

This entry and the next are required for each graph in the movie. NW is the position in all dump data records of the y coordinate of the first point on the graph. The other y coordinates must follow immediately after. If zero, then no further terminal input data are required and a movie is produced of the graphs specified to date using the same options as the previous movie or, if none, the default values. If negative, then the input dialogue proceeds to GHOSTS below.

Y LIMS - BLANK RETAINS OLD LIMS, 1 LIMS OF DATA

Two numbers (YMIN and YMAX), a blank or a one are entered. These data determine the scale of this graph in the y direction. If a blank is entered the limits are the same as in the previous movie. If a one is entered the limits are taken equal to the upper and lower limits of the data to be plotted. Next the input dialogue returns to WINDOW ENTRY above where data specifying the next graph are requested.

GHOSTS: NG

From zero to four ghosts may be selected. The default is zero.

HEAD:

Any heading entered here will appear above the graph during the movie. If no heading is entered (immediate carriage return), the dump file heading appears above the graph.

XLAB:

Any label entered here will appear below the graph during the movie.

DASHED LINES (Y/N)?

Eight different line types are available on the GT40 and GT44. If dashed lines are requested, then successive graphs use successive line types. Otherwise, full lines are used for all graphs. The default is dashed lines.

X LIMS - BLANK RETAINS OLD LIMS; 1 LIMS OF DATA

These data determine the x axis scale for all graphs in the same way as YLIMS above for the y axis scale.

3.4 Attention Commands

These single character commands are typed at the terminal during a movie. They must not be followed by a carriage return. The bell is rung when the command has been read and cleared. The commands are listed below:

0 to 9 Number of dump records skipped between displayed records. Use of this facility enables rapid skipping through uninteresting

parts of the movie.

QWERTYUIOP (top row of keyboard) These commands introduce a delay between displayed frames. The delays are 0, 0.06, 0.12, 0.25, 0.5, 1, 2, 4, 8 and 16 seconds respectively.

+ and - Forward and backwards. Backwards is toward the start of the dump file.

H Hold. Further attention commands will be read about every second while in this state and during introduced delays.

G Go. Any Hold is removed and the movie continues.

N Next. Display next frame.

F Finish. The frame rate and other information are displayed until any key is pressed.

3.5 Other Input

These data, which are read from unit 1, specify the x coordinates of all graphs. It is usually part of the geometry of the source problem and cannot be changed during a run. The data are

NS Number of segments; then for each segment
 NP Number of points
 X x coordinate of each point (NP values).

4. BATCH PRINTING

Selected members of every k^{th} dump data record are written on unit 3 (the printer). The input data (free format on unit 1) are as follows:

NU Data set reference number of required data set
 NFILE File number of dump file on data set

K Only every kth dump data record is printed

N Number of items to be printed from each kth dump data record
(maximum 10)

I1,I2,...,IN N numbers giving the position in the dump data record of
the items to be printed

H1,H2,...,HN N headings (1 to 4 characters) separated by blanks

The complete input block may be repeated as often as desired. The file header from the dump file and the headings from the input data are printed first, followed by the requested data in format 1P10E13.5.

4.1 Example of Use of the PRINT Program

4.1.1 Input deck

```
//WJTPRINT JOB ('*****'/P22APLCA',M1),W.J.TURNER
// EXEC PROGRAM, MEM=PRINT, LIB='WJT.MOVIE.PLOT.PROGRAMS'
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLE.DUMP, DISP=SHR
8 1 1 5 1(1)5
TIME Y1 Y2 Y3 Y4
```

4.1.2 Output

```
8 1 1 5 1(1)5
TIME Y1 Y2 Y3 Y4
SAMPLE DUMP FILE
```

TIME	Y1	Y2	Y3	Y4
0.0	1.00000D+00	1.10517D+00	1.22140D+00	1.34986D+00
2.00000D-01	8.18731D-01	9.04837D-01	1.00000D+00	1.10517D+00
4.00000D-01	6.70320D-01	7.40818D-01	8.18731D-01	9.04837D-01
6.00000D-01	5.48812D-01	6.06531D-01	6.70320D-01	7.40818D-01
8.00000D-01	4.49329D-01	4.96585D-01	5.48812D-01	6.06531D-01
1.00000D+00	3.67879D-01	4.06570D-01	4.49329D-01	4.96585D-01
1.20000D+00	3.01194D-01	3.32871D-01	3.67879D-01	4.06570D-01
1.40000D+00	2.46597D-01	2.72532D-01	3.01194D-01	3.32871D-01
1.60000D+00	2.01897D-01	2.23130D-01	2.46597D-01	2.72532D-01

EOF ON UNIT 1
RETURN TO USERS PROGRAM

5. INTERACTIVE PRINTING

This program is intended for use on terminals which print slowly. The user is able to print, at the terminal, selected numbers or groups of numbers from a dump file. The selected information is also printed on unit 3 (the printer). The input data which are read with the free format routine SCAN are as follows:

UNIT,FILE:

Data set reference number of required data set and file number of required dump file on this data set. If the reference number is zero, the job ends. The heading of the selected dump file is printed.

TIME,ENTRY,STOP: T,NE,NS

Time is assumed to be the first entry on each data record. The first data record with time greater than T is selected and the first entry and the entries from NE to NS printed. Printing from following data records continues until interrupted by an entry from the terminal. Then further T,NE,NS data are requested. Note that file searching proceeds in the forward direction only. If T is negative, then the input dialogue returns to UNIT above.

5.1 Example of Use of the IPRINT Program

5.1.1 Input deck

```
//WJTIPRT JOB (*****P22APLCA',N1),W.J.TURNER,
//          CLASS=I,TIME=(,30)
// EXEC PROGRAM,MEM=IPRINT,LIB='WJT.MOVIE.PLOT.PROGRAMS'
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLE.DUMP,DISP=SHR
```

5.1.2 Terminal Session

Characters typed by IPRINT are underlined.

\$RUN

ID:

JOB: WJTIPRT

TESTING WJTIPRT

WJTIPRT (JOB 410) READY

UNIT,FILE:8 1

SAMPLE DUMP FILE

4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8

TIME,ENTRY,STOP: .8 3 5

1.0000D+00 4.0657D-01 4.4933D-01 4.9659D-01

1.2000D+00 3.3287D-01 3.6788D-01 4.0657D-01

1.4000D+00 2.7253D-01 3.0119D-01 3.3287D-01

1.6000D+00 2.2313D-01 2.4660D-01 2.7253D-01

END OF PSEUDOFIL 1 AT 1.599999428E+00

UNIT,FILE:0

END OF INTERACTION

END:RUN

5.1.3 Unit 3 output

UNIT 8 FILE 1

SAMPLE DUMP FILE

4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8

1 1.000000000000000D+00

3 4.06569645200535D-01 4 4.49328958760803D-01 5 4.96585280112378D-01

6. PLOTTING6.1 General

The PLOT program produces graphs in the batch plot queue (as specified in the JCL) and/or on the screen of a GT40 or GT44 Dataway terminal. In batch mode, commands describing the required plots are read from unit 1 and the plots are placed in the batch plot queue.

If no commands are found on unit 1, interactive mode is assumed. In this mode the program is always in one of two phases:

Plot Phase. Commands describing plots or other actions are executed. Any plots directed to the terminal by these commands appear on the screen. The commands are either read from the terminal, (immediate commands), or read from a stored file of commands called the command file on unit 4. Thus the JCL for interactive mode must include a DD card for a sequential file suitable for card images with DDNAME FT04F001. Commands and interrupts are available which switch the source of commands from the terminal to the command file and vice versa. At the beginning of each plot phase the source is always the command file.

Edit Phase. At the beginning of each edit phase the current command file is listed. Next, edit instructions are read from the terminal and the file modified as required. A single instruction then initiates saving of the new command file and execution of the file in the plot phase, beginning at the first command.

During interactive execution of the program, two display files are present in the GT40 or GT44; all graphical information is placed in file 2 and all text in file 1. File 1 may be cleared by CONTROL A or temporarily turned off by pressing the ATTN or ESC key. File 2 may be turned off and on by the HASTE attention commands +2 and -2 respectively.

Once a satisfactory set of commands has been deduced, it can be used in a batch job. Section 6.2 shows an input deck, terminal session and output from an interactive plot job. The plot produced on the screen during this job is shown in Figure 2. This same plot is produced by the batch job shown in Section 6.2.4.

6.2 Example of Use of the PLOT program

6.2.1 Input deck for interactive plotting

```
//WJTIPL0T JOB (*****/P22APLCA',M1),W.J.TURNER,
// CLASS=I,TIME=15
/*ROUTE PUNCH VIEW
// EXEC BUFFPROG
// EXEC PROGRUN,MEM=PLOT,LIB='WJT.MOVIE.PLOT.PROGRAMS'
//GO.FT04F001 DD DSN=WJT.IPLTPGM,DISP=SHR
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLF.DUMP,DISP=SHR
```

6.2.2 Terminal session

Characters typed by PLOT are underlined.

```
$RUN
ID:
JOB: WJTIPLT
TESTING WJTIPLT
WJTIPLT (JOB 411) READY
```

Execution of the PLOT program begins by clearing the screen. Next the DATA command is executed. This command (see below) was placed on the command file before execution of PLOT.

```
DUMP FILE IS:
SAMPLE DUMP FILE
4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8
END OF COMMAND FILE - FILE NOW REWOUND
COMMAND:EDIT
EDIT
100 CARDS MAXIMUM
LOADED
TABS: 7,11,21,31,41,51,61,71, 0
=0010 DATA 8 1 4 1 2 4 7
=2
-0020 PAPE 0 -8 -6 1 1 -3 2 3 4
-0030 NAME
-0040 NAMX"TIME ( IS! )" 
-0050 NAMY"Y" 
-0060
=E
EDIT COMPLETE
SAVED
END OF EDIT
DUMP FILE IS:
SAMPLE DUMP FILE
4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8
```

At this point the execution of the PAPE command clears the screen and the plot is drawn on the screen.

```
END OF COMMAND FILE - FILE NOW REWOUND
COMMAND:COPY BOTH
```

The screen is cleared during execution of a COPY command.

```
COMMAND:READ
DUMP FILE IS:
SAMPLE DUMP FILE
4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216 NO OF ENTRIES 8
```

The screen is again cleared and the plot drawn. The same plot (Figure 6) is placed in the batch plot queue.

END OF COMMAND FILE - FILE NOW REWOUND
COMMAND:STOP

This command instructs PLOT to finish. The screen is cleared and the GT40/44 returned to normal.

END OF RUN
END OF INTERACTION
END:RUN

6.2.3 Unit 3 output

```

EOF ON UNIT    1
RETURN TO USERS PROGRAM
      DATA 8 1 4 1 2 4 7
DUMP FILE IS:
SAMPLE DUMP FILE
  4 AUG 81  10 HRS 51 MIN 21.02 SEC  81216  NO OF ENTRIES  8
EOF ON UNIT    4
RETURN TO USERS PROGRAM
      EDIT
      DATA 8 1 4 1 2 4 7
DUMP FILE IS:
SAMPLE DUMP FILE
  4 AUG 81  10 HRS 51 MIN 21.02 SEC  81216  NO OF ENTRIES  8
      PAPE 0 -8 -6 1 1 -3 2 3 4
      NAME
      NAMX"TIME ( IS! )"
      NAMY"Y"
EOF ON UNIT    4
RETURN TO USERS PROGRAM
      COPY BOTH
      READ
      DATA 8 1 4 1 2 4 7
DUMP FILE IS:
SAMPLE DUMP FILE
  4 AUG 81  10 HRS 51 MIN 21.02 SEC  81216  NO OF ENTRIES  8
      PAPE 0 -8 -6 1 1 -3 2 3 4
      NAME
      NAMX"TIME ( IS! )"
      NAMY"Y"
EOF ON UNIT    4
RETURN TO USERS PROGRAM
      STOP

```

6.2.4 Input deck for batch plotting

The following deck will produce Figure 6.

```
//WJTPLOT JOB (*****/P22APLCA',M1),W.J.TURNER
/*ROUTE PUNCH VIEW
// EXEC BUFFPROG
// EXEC PROGRUN, MEM=PLOT, LIB='WJT.MOVIE.PLOT.PROGRAMS'
//GO.FT08F001 DD DSN=WJT.MOVIE.PLOT.SAMPLE.DUMP, DISP=SHR
DATA 8 1 4 1 2 4 7
PAPE 0 -8 -6 1 1 -3 2 3 4
NAME
NAMX"TIME ( IS! )"
NAMY"Y"
```

6.3 Commands

All commands comprise a keyword and data. Examples refer to the dump file of Section 2 on unit 8, file 1 containing eight entries which are time and Y at each of seven nodes.

6.3.1 DATA

This command initiates reading of the dump file. It should be the first command executed. The required data are:

NU Data set reference number of the required data set (unit number).

±NF Number of the dump file on this data set. If negative, a further integer K is read, and only every K^{th} data record from the dump file is read.

N Number of items actually required for plotting (maximum 20).

K An array of N numbers giving the positions in dump data records of the N items requires.

For example: DATA 8 1 4 1 2 4 7

retrieves four items, items 1,2,4 and 7, from every data record of dump file 1, unit 8.

In commands following a data command, the items retrieved are identified by their position 1 to N in the data command rather than by their position in dump data records. Thus Y at node 3 (the 4th entry in the sample dump data records) would be item 3.

The very first command to be executed differs from later commands because

- . it is assumed to be a DATA command,
- . the key word DATA may be omitted, and
- . it is executed before interaction begins, thus reducing the delay at the terminal while data are being read.

6.3.2 PAPE

This command explicitly or implicitly defines the scales, draws the graph rectangle and annotates the axes. The explicit form is:

```
PAPE  H  V  X1  X2  Y1  Y2
```

where H = length of x-axis in inches,
 V = length of y-axis in inches,
 H,V = < 0 linear scale, or
 > 0 log scale,
 X1 = minimum x value required,
 X2 = maximum x value required,
 Y1 = minimum y value required, and
 Y2 = maximum y value required.

The implicit form is:

```
PAPE 0  H  V  { 0  X1  X2          } { 0  Y1  Y2          }
                { I  L1  L2...LI  } { J  M1  M2...MJ  }
```

where the upper and lower lines inside the braces are alternatives. In this form, the x limits are either on the PAPE card if I=0, or they are the range of a specified subgroup of the items loaded by the DATA command. I is the number of items in this subgroup and the item numbers are L1 to LI. The y

limits are specified in the same way.

The x and y ranges defined in the PAPE command are rounded out, e.g. a range of 1.2174 to 1.9846 becomes 1.2 to 2.0.

If J is negative, the commands:

```

LINE  L1  M1  1
LINE  L1  M2  0
      .
      .
      .
LINE  L1  MJ  0

```

are executed after the PAPE card. The LINE command is described below. If the x limits were given explicitly, then L1 is assumed to be 1.

An example is:

```
PAPE 0 -10 8 0 2 10 -3 2 4
```

This command produces a 10-inch linear x scale from 2 to 10, an 8-inch log arithmetic y scale with limits chosen to include the range of entries 2 and 4 (Y at nodes 1 and 6 in our example) and graphs of these latter two variables versus item 1 are drawn.

6.3.3 XFMT

XFMT changes the x-axis annotation format used by PAPE. The data are

K an option:

```

K=2  floating point numbers to be written
K=1  integers to be written
K=0  revert to standard annotation
K=-1 no annotation

```

L only required for K>0 in which case it is either:

(a) maximum length of string to be written - the string, with leading and trailing blanks removed, is centred under the tick mark at each annotation

point, or

- (b) maximum length of string to be written plus 50 times the particular half-character position (blanks counted) of the string required under the tick mark, e.g. the space between characters 2 and 3 would be selected by adding 250 to the string length.

In both cases the maximum string length is used to determine an annotation interval such that overwriting does not occur. "FMT" = FORMAT to be used. Only required for K>0.

Examples: XFMT 1 5 "(I5)"

would result in the x axis being annotated with integers and the resulting string centred under the tick mark.

 XFMT 2 406 "(F6.2)"

would cause the x axis to be annotated with floating point numbers with the decimal point always under the tick mark.

6.3.4 YFMT

This command changes the y axis annotation format used by PAPE. The data are the same as XFMT except that L specifies the starting position of the format field. The field begins L plus one half character spaces to the left of the y axis. Leading blanks in the annotation strings are not removed.

6.3.5 FAKE

This command defines invisible graph paper. It is identical to the PAPE command except that no graph box or axes are drawn, and the given x and y ranges are not rounded out.

6.3.6 FRAM

This command draws a rectangle coincident with the graph box.

6.3.7 LINE

Once a PAPE or FAKE command has been executed, data may be plotted with LINE commands. This command has three forms:

```
LINE IX IY ±L
```

connects the given data by straight lines where

IX = item number for the x variable,
 IY = item number for the y variable,
 L = line type, where L=1 is a solid line,
 L=2,....,10 are distinct dashed lines,
 L=0 is the next line type in rotation, and if negative,
 plot symbols are drawn at each point.

```
LINE 0 N L X1,Y1,...,XN,YN
```

and

```
LINE 0 -N L X1,X2,...,XN,Y1,Y2,...,YN
```

connect the N given data points by straight lines of type L. The latter two commands can be used for plotting experimental results.

6.3.8 LINS

Several lines may be plotted with this command:

```
LINS IX K L1 L2,...,LK
```

where IX = item number of the x variable for all lines
 K = number of lines to be plotted
 K>0 the line type rotates; K<0 all lines are unbroken
 LM = item number of the y variable for the Mth
 line.

6.3.9 PNTS

This command plots points in a similar way to the LINE command.

```
PNTS IX IY NS ISIZE
```

draws a plot symbol at each data point, where

IX = item number for the x variable,

IY = item number for the y variable,

NS = plot symbol number, where $NX=1, \dots, 8$ are distinct plot symbols
and $NX=0$ rotates,

ISIZE = plot symbol size, where the actual size is 0.04
times ISIZE inches.

PNTS 0 N NS ISIZE X1,Y1,...,XN,YN and

PNTS 0 -N NS ISIZE X1,X2,...,XN,Y1,Y2,...,YN

draw a plot symbol at each given data point.

6.3.10 CONX

All x ordinate data are scaled to $A+Bx$ before plotting by the command

CONX A B

The scale remains in force until a new PAPE, FAKE or CONX command.

6.3.11 CONS

Similarly, y ordinate data are scaled to $A+By$ by

CONS A B

6.3.12 NAME

The dump file header record is written above the graph, the run title on the top line and the date and time on the next line.

6.3.13 HEAD

An up-to-80 character heading is centred above the graph on a single line. Further HEAD and NAME commands space downwards, beginning two lines above the graph. Letters between alphabetic shift characters ! are written in lower case. A change to characters of half-size, in positions ranging from super to subscript, are written after @1, @2, @3, @4 respectively; and @0

restores to normal. For example, the heading command

```
HEAD "S!TEPS !D!OWN! L@1L@2L@3L@4L@0L"
```

would produce the heading

```
Steps Down L ^ ^ ^ ^ ^
```

centred on the line above the graph.

6.3.14 NAMX

The command writes an up-to-80 character label centred below the graph. Subsequent NAMX commands space downwards. The alphabetic and vertical shift characters (Section 6.3.13) apply. Example: NAMX"TIME(!S)" would produce TIME(s) below the graph.

6.3.15 NAMY

The command writes an up-to-80 character label sideways centred to the left of the y axis annotation. Subsequent calls space to the left. The alphabetic and vertical shift characters (Section 6.3.13) apply. Example: NAMY"MASS VELOCITY(!KG M@2-2@ S@2-1@!)" for MASS VELOCITY ($\text{kg m}^{-2} \text{s}^{-1}$).

6.3.16 LEGO

The position of the top left corner of the legend block is set. Data are H and V which are the horizontal and vertical displacements in inches of this corner of the legend block from the bottom left corner of the graph box.

6.3.17 LEGH

This command writes a heading at the top of the legend block. The alphabetic and vertical shift characters apply.

6.3.18 LEG

Legend entries are written with this command. The data are

N "ANY TEXT"

where N = 1 current plot symbol followed by the given text
 = 2 current line type followed by the given text
 = 3 current line type and plot symbol followed by the given text
 = 4 histogram in current line type followed by the given text
 = 0 the given text only

Successive calls space down the legend block. Shift characters apply.

6.3.19 LEGS

Parameters relevant to legends are reset by this command. The data are

SIZE character height in inches (default 0.14)
 WIDTH width of symbol or line field in inches (default 1.2)
 SPACE downward spacing from successive LEG commands (default 0.25 inches)

6.3.20 MARK

This command can be used to mark time steps in the source calculation. Vertical lines are placed parallel to the y axis with values of x equal to the set of values in the most recent x item used in a PAPE, FAKE, LINE or LINS command. If no item was specified then item 1 is used. The data are

Y vertical position on the y scale in y scale units of the start of the lines,
 V length of lines in inches above (+ve) or below (-ve) the designated position,
 "TEXT" text centred above the set of lines.

6.3.21 PEN

This command initiates display of the coordinates in inches and by plot scale of points located by the light pen and the cursor. It is useful for reading points from graphs and for locating legend origins. Once the cursor

has been manoeuvred into the required position, press either the space bar, in which case a further point may be determined, or any other key which concludes the PEN command.

6.3.22 SKEW

The plot beginning at the next FAKE or PAPE command is written over the top of the current plot in a new graph box. Thus several graphs can be produced on the one plot area. The data are H and V which are the horizontal and vertical displacements in inches of the new bottom left box corner from the old.

6.3.23 WAY

For some applications it is desirable to plot with the x axis along the left edge and the y axis across the top. The command WAY 2 has this effect at the next PAPE or FAKE command. Normal plotting orientation is restored after a WAY 1 command.

6.3.24 COPY

Plots can be directed by this command

```
COPY  CALC  directs plots to the normal batch plotting
           queue
COPY  DISP  directs plots to the terminal (default for
           interactive mode)
COPY  BOTH  directs plots to both
```

Note that a plot is terminated by a COPY command. This command is ignored in batch mode, when all plots are sent to the normal batch plotting queue.

6.3.25 EDIT

Editing of the command file is initiated by this command. Editing is done by means of the EDIT subroutine from PHYS.FORTLIB, which is a FORTRAN version of the LOGON program of Backstrom [1976]. A summary of edit commands can be obtained by a . The EDIT command is ignored in batch mode.

6.3.26 READ

This command switches the source of commands between the command file and the terminal. Thus, if read from the command file, execution of the file will cease and a command will be requested from the terminal. Execution of the command file resumes when an immediate READ command is given. Thus a viewing pause is introduced between plots drawn under command file instruction. This command is ignored in batch mode.

6.3.27 SUSP

All plots are terminated and interaction is suspended by this command. On resuming, a command is requested from the terminal. This command is ignored in batch mode.

6.3.28 STOP

The job is completed and execution ceases.

6.3.29 ?

A list of all commands is written at the terminal. This command is ignored in batch mode.

6.4 Interrupts

Execution of commands can be interrupted by typing any character at the terminal. When this is detected, a command is requested from the terminal.

7. ACKNOWLEDGEMENTS

The first version of the movie, printing and batch plotting programs were written by Mr G.D. Trimble. The movie and plotting programs make extensive use of the subroutine package XYPLOT [Trimble 1978]. Assistance in the development of the movie and plotting program was given by Dr B.E. Clancy and Mr R.J. Cawley, who wrote the TIME subroutine of the MOVIE program.

8. REFERENCES

Backstrom, R.P. [1976] - LOGON - an interactive job submission facility for the IBM360 computer. AAEC unpublished report.

Bennett, N.W. and Pollard, J.P. [1967] - AAEC/TM399.

Cawley, R.J. and Trimble, G.D. [1977] - AAEC/E425.

Trimble, G.D. [1978] - AAEC/E437.

TIME 6.00000D-01 STEP 2.00D-01 NO. 3 SKIP 0 DELAY 0.0
FILE DATE 4 AUG 81 10 HRS 51 MIN 21.02 SEC 81216

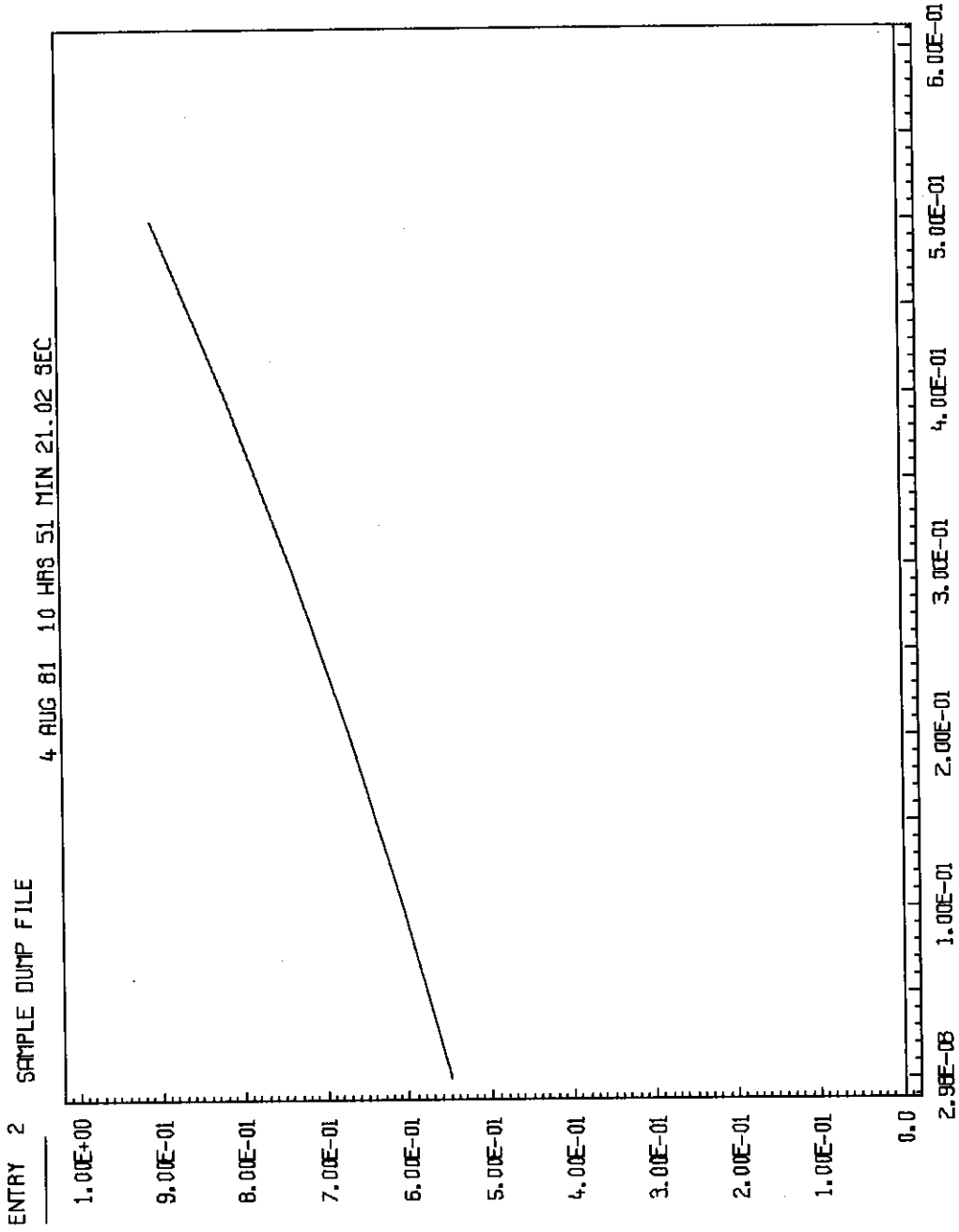


FIGURE 1. THIRD FRAME OF MOVIE EXAMPLE

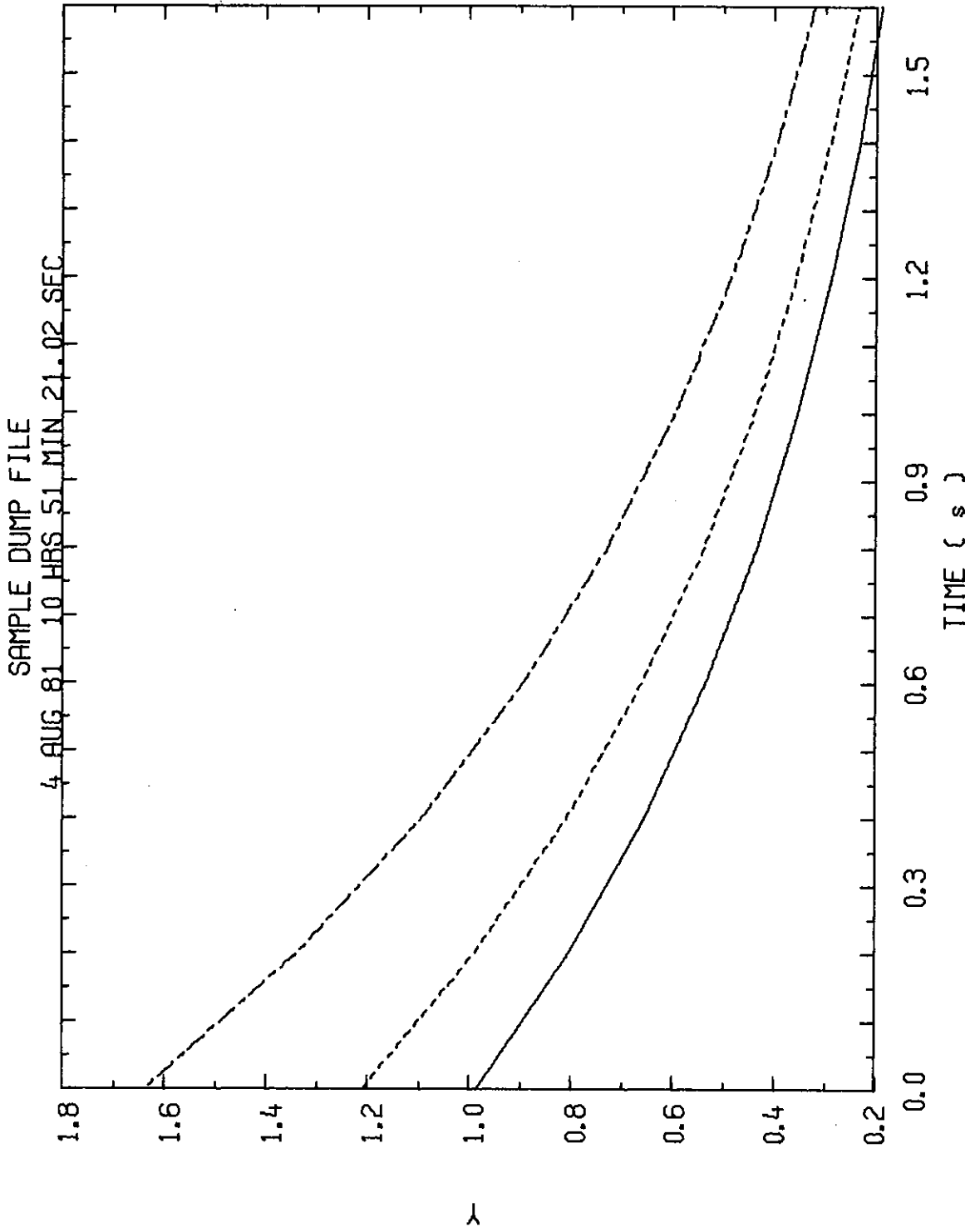


FIGURE 2. PLOT PRODUCED BY PLOT EXAMPLE