

# NASA Technical Memorandum 78720

{NASA-TM-78720} USER'S GUIDE FOR A MODULAR  
FLUTTER ANALYSIS SOFTWARE SYSTEM {FAST  
VERSION 1.0} {NASA} 147 p HC A07/MF A01

N78-28101

CSCCL 01C

Unclas

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## USER'S GUIDE FOR A MODULAR FLUTTER ANALYSIS SOFTWARE SYSTEM (FAST VERSION 1.0)

Robert N. Desmarais

and

Robert M. Bennett

May 1978



National Aeronautics and  
Space Administration

Langley Research Center  
Hampton, Virginia 23665

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## SUMMARY

The use and operation of a group of computer programs to perform a flutter analysis of a single planar wing are described. This system of programs is called FAST for Flutter Analysis System, and consists of five programs. Each program performs certain portions of a flutter analysis and can be run sequentially as a job step or individually. FAST uses natural vibration modes as input data and performs a conventional V-g type of solution. The unsteady aerodynamics programs in FAST are based on the subsonic kernel function lifting-surface theory although other aerodynamic programs can be used. Application of the programs is illustrated by a sample case of a complete flutter calculation that exercises each program.

## INTRODUCTION

With recent advances in computer technology, computations for a relatively detailed aircraft flutter analysis are now practical. However, both computer resources and manhours used in performing such an analysis can be large for exploring a flight envelope or for a variety of configurations as might be required in design. Since the resources used can be significantly affected by the overall organization of the flutter analysis software, one approach that has been used is to divide the flutter analysis tasks among several programs that treat specialized portions of the flutter analysis. This method has several advantages. First, the programs can be run sequentially in a job-stepping mode or as individual units depending upon the availability of input data or the task to be performed. Second, the programs can be easily optimized for trade offs of central processing time and storage. Third, the versatility of the programs and the ability to make changes to the programs are enhanced. Additional complexity in the use of job control language is, however, a penalty for using this approach. Several programs have been developed for flutter analysis using the modular program approach and are called FAST for Flutter Analysis System. This paper gives a user's guide for each of the five programs and describes the overall operation to perform a flutter analysis. A sample case of a complete flutter analysis of a clipped delta wing, beginning with input natural vibration modes and concluding with V-g plots and flutter eigenvalues, is used to illustrate the application of the programs.

The division of flutter analysis tasks into separate programs depends significantly on the type of computing system used, the type of graphics available, and the use made of the programs such as for design or analysis. The five programs presented herein have been in use at Langley Research Center for some time on the CDC CYBER series machines with the NOS operating systems and the FTN compiler. The version of FAST described here, version 1.0, is a conversion of some earlier programs for the current computer operating system and compiler.

## GENERAL DESCRIPTION

An overview of the FAST flutter analysis procedure is given in figure 1. Natural vibration modes of the structure are considered to be known from previous calculations or measurements. The generalized aerodynamic forces are calculated and the flutter eigenvalues are generated to obtain the flutter speeds and frequencies. This procedure is performed by the sequence of five programs shown in figure 2 and discussed in the following paragraphs.

The first program, MPROC, processes the vibration modes to give modal deflections, streamwise slopes, and certain integrals of the mode shapes used in calculating generalized aerodynamic forces. In addition, contour and oblique projection plots of the mode shapes can be generated. The input requires wing geometry, vibration modes, and plotting information and is thus independent of aerodynamic variables such as Mach number and aerodynamic density. The modal file output from MPROC is TAPE2 and is renamed MODEFL for input to the generalized aerodynamic force program, GENFLU. Normally MPROC is run as a separate job to permit inspection of the modal plots prior to further calculations, and TAPE2 is saved for subsequent use. The user's guide for MPROC is given in Appendix A.

Program SUBCMAT generates the complex matrix elements used in solving the subsonic downwash integral equation by a method similar to that of reference 2. SUBCMAT requires only a small amount of central memory but can require a significant amount of central processing time for execution. The input for SUBCMAT includes the Mach number and reduced frequency specifications, and the same wing geometry specification as MPROC. Normally the execution of SUBCMAT is followed by LUCMAT which can be a large field length, short execution time program. The user's guide for SUBCMAT is given in Appendix B. . . .

Program LUCMAT performs an L-U decomposition of the complex matrices generated by SUBCMAT. The L-U decomposition is based on the method presented in chapter I/7 of reference 3. Normally, LUCMAT is run as a job-step with SUBCMAT and file LUF saved as a permanent file if flutter calculations are to be made for several sets of vibration modes for the same aerodynamic configuration (such as during a design process or for different fuel conditions). Since neither SUBCMAT nor LUCMAT require any modal information, these two programs can be executed before the vibration modes have been measured or computed. Because file LUF can be large and can overflow nominal permanent file space allocation in some instances, saving LUF may require the use of tape. APPENDIX C is the user's guide for LUCMAT.

Program GENFLU calculates the generalized aerodynamic forces using the modal output from MPROC and the L-U matrices output by LUCMAT. The output of GENFLU depends both on Mach number and vibration mode data but is independent of air density. File GENFLU normally is saved as a permanent file to permit reentry to the flutter eigenvalue program for various densities or plotting scales. APPENDIX D gives the user's guide for GENFLU.

The last of the programs in this group is the parametric flutter analysis program called FLUTDET. The capabilities and techniques used in FLUTDET are described in reference 4 (with the exception that a different spline technique is used exclusively for interpolating the generalized aerodynamic forces). Program FLUTDET reads the generalized aerodynamic forces from file GENF, and reads the other information required to perform a flutter analysis from the INPUT file. Required on INPUT are the generalized masses, modal frequencies, and air density information. The flutter speeds and frequencies are printed on the OUTPUT file, and V-g plots are generated. The user's guide is given in APPENDIX E.

Each program has been set up in absolute binary form and is normally kept as a semi-private, indirect-access permanent file (on cluster 1 in the LRC system). The programs can be obtained by the following instructions.

```
GET,MPROC/UN=052061N,PW=MPROCV1.  
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.  
GET,LUCMAT/UN=052061N,PW=LUCMTV1.  
GET,GENFLU/UN=052061N,PW=GNFLUV1.  
GET,FLUTDET/UN=052061N,PW=FLTDTV1.
```

In addition, the absolute programs are kept on tape NA0818. In the event the programs cannot be obtained from the above instructions, they can be accessed by using the control card

```
LABEL,T1,NT,D=1600,PO=R,VSN=NA0818.
```

and performing a COPYBF,T1,BPROG. for each program. The five files on the tape are MPROC, SUBCMAT, LUCMAT, GENFLU, and FLUTDET and are in the order named.

The input data for the sample case are also kept as indirect access permanent files (cluster 1) and can be accessed as follows:

```
GET,INMPROC/UN=052061N. - Input for MPROC  
GET,HDHFOC/UN=052061N. - Tape 2 of MPROC and MODEF for GENFLU  
GET,INSBCMT/UN=052061N. - Input for SUBCMAT  
GET,INFLTDT/UN=052061N. - Input for FLUTDET
```

The coded files for the above data sets and for the source decks are also maintained in card image form on tape NC0302. They can be accessed with the control card.

```
LABEL,T2,NT,D=1600,PO=R,VSN=NC0302.
```



and obtained by

COPYBF,T2,COEDF.

The location of each coded file on the tape is

INMPROC	File 1
MPROC	File 2
HDHFQC	File 3
INSBCMT	File 4
SUBCMAT	File 5
LUCMAT	File 7
GENFLU	File 9
INFLTDT	File 11
FLUTDET	File 12

Further information on the use of these files is given in the user's guides in the Appendices.

## APPENDIX A

### SURFACE SPLINE MODE PROCESSING PROGRAM, MPROC

Program MPROC interpolates input vibration mode shapes, generates contour and orthographic plots of the mode shapes, and calculates the slopes, deflections, and weighted integrals of the mode shapes for use in the unsteady aerodynamics programs. This version of the mode processing program is designed to interface with the current version of the subsonic kernel function generalized force program GENFLU. The program is dimensioned for 12 pressure functions in each of the chordwise or spanwise directions for a total of 144 collocation points maximum for calculating input to the generalized force program.

The spline matrix generation overlay is set up for dynamic storage for up to 250 modal (x and y) input points (nearly machine capacity). The storage required for the spline matrix is calculated, and the program field length is set from within the program. The field length used is given in a DAYFILE message. For a case of 69 modal input data points, the program requires 34,300<sub>8</sub> words of central memory. The computing time depends strongly on the type of contour plots generated and, in particular, on the GRID parameter for plotted contours.

The absolute binary program is stored on the permanent file system as an indirect access, semiprivate file named MPROC (the overlay file name). Access to MPROC is obtained by the control card

```
GET,MPROC/UN=052061N,PW=MPROCV1.
```

The files declared by the program are (in order) INPUT, OUTPUT, TAPE1, TAPE2.

The plots generated by MPROC for the sample case are presented in figure 3.

## Control Deck

A typical BATCH processing control deck is

```
MODEPRC,T2000,CM60000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRG)
GET,MPROC/UN=052061N,PW=MPROCV1.
MPROC.
SAVE,TAPE2=STPE2.              (save TAPE2 as permanent
REWIND,TAPE2.                  file named STPE2.
COPYSBF,TAPE2.
DISPOSE,TAPE2=P9.             (if punch cards desired)
ATTACH,PLOT/UN=LIBRARY.
PLOT,VARIAN                    (for Varian plots)
EXIT.
REWIND,TAPE2.                 (or other desired error processing)
COPYSBF,TAPE2.
DISPOSE,TAPE2=P9.
ATTACH,PLOT/UN=LIBRARY
PLOT.VARIAN
--eor--
INPUT DATA
--eoi--
```

## Data Setup

All input x,y quantities must be in consistent units (dimensional or dimensionless) and must be referenced to the same x,y coordinate system. The x-axis of the coordinate system must point downstream.

The detailed contents of the input cards are listed below:

<u>Contents</u>	<u>Format</u>	<u>No. of Cards</u>	<u>See Note</u>
ID	(8A10)	1	
XLR, XTR, XLT, XTT	(4E20.12)	1	
YROOT, YTIP, NL, NT	(2E20.12, 214)	1	
(YL(I), XL(I), I=1, NL)	(2E20.12)	NL	(1)
(YT(I), XT(I), I=1, NT)	(2E20.12)	NT	(2)
MS, NC, LP, LSYM	(4I4)	1	
IN	(8A10)	1	(3)
(XP(L), YP(L), L=1, LP)	IN	"D"	(3)
NI, ISYM, ISAVE	(3I4)	1	
IN	(8A10)	1	
(XI(I), YI(I), I=1, NI)	IN	"D"	
CMIN, CINT, NCON, GRID, PAPER, HN, SPACE	(2F10.2, I10, 4F10.2)	1	
MODES	(I4)	1	
IN	(8A10)	1	
MODE	(I4)	1	
ZN, (ZI(I), I=1, NI)	IN	"D"	
MODE	(I4)	1	
ZN, (ZI(I), I=1, NI)	IN	"D"	

For all data sets where a user-furnished format "IN" is used, the number of cards depends on both the loop delimiter (LP or NI) and the format. This situation is indicated by "D" in the number of cards column.

NOTES:

- (1) Omit this card set if NL = 0
- (2) Omit this card set if NT = 0
- (3) Omit this card set if LP = 0

The definitions of the input variable names are:

ID	case identification card
XLR	x coordinate of leading edge at root
XTR	x coordinate of trailing edge at root
XLT	x coordinate of leading edge at tip
XTT	x coordinate of trailing edge at tip
YROOT	y coordinate of root
YTIP	y coordinate of tip
NL	number of discontinuities on leading edge

NT            number of discontinuities on trailing edge  
 YL, XL        location of leading edge discontinuities  
 YT, XT        location of trailing edge discontinuities  
  
               The quantity y must appear before x on the YL, XL  
               or YT, XT cards. These cards must appear in the order  
               of increasing y.  
  
 MS            number of spanwise varying pressure functions  
  
 NC            number of chordwise varying pressure functions  
  
 LP            number of downwash collocation points  
               If LP = 0, the program will compute downwash collocation  
               points at MS by NC Gaussian stations.  
  
 LSYM          load symmetry  
               If LSYM = 1, force quadrature coefficients are computed  
               for antisymmetric loading.  
               If LSYM = 2, they are computed for symmetric loading  
  
 IN            the variable format to be used to read the real numbers  
               that follow the format card  
               Any real format that can be expressed in 80 characters  
               (left adjusted) or less can be used. Be sure to include  
               the format-delimiting parentheses. These cards are used  
               to specify formats for (XP, YP), (XI, YI), and (ZN, ZI).  
               A different format can be used each time.

XP            x coordinates of collocation points  
  
 YP            y coordinates of collocation points  
  
 NI            number of modal deflection input points  
  
 ISYM          interpolation symmetry parameter  
               ISYM = 1        antisymmetric spline  
               ISYM = 2        symmetric spline  
               ISYM = 3        nonsymmetric spline  
  
 ISAVE        if zero or blank, the program generates TAPE1 containing  
               the inverted spline matrix. Otherwise the user must  
               furnish TAPE1. It is a single binary file and depends  
               only on NI, ISYM, and (XI(I), YI(I), I = 1, NI). For a  
               large case (NI>100), TAPE1 should be computed only for  
               first set of modes with the same definition points.

XI            x coordinates of modal definition points  
 YI            y coordinates of modal definition points  
 CMIN          minimum contour in normalized z-units  
 CINT          contour interval in normalized z-units  
 NCON          number of contours (i.e.,  $C_{MAX} = C_{MIN} + (NCON-1) * C_{INT}$ )  
               If  $NCON > 0$ , both line printer and plotter contour plots  
               will be generated.  
               If  $NCON = 0$ , no contour plots will be generated.  
               If  $NCON < 0$ , only line printer contour plots will be  
               generated.  
 GRID          grid size (0.2 to 0.6 usually), in plotter inches  
 PAPER          length of semispan on paper, in plotter inches  
 HN            height of numbers, in plotter inches  
 SPACE          frame advance in addition to that generated by NFRAME  
               If 0, program will compute SPACE, in plotter inches.  
 MODES          the number of modes to be processed  
 MODE          an integer designator for the mode (used only to label  
               the plot)  
 ZN            the normalization value of z  
               All the  $ZI(I)$  will be divided by ZN in the program.  
               For unnormalized modes, set ZN to 1.0  
 ZI            the modal deflection z  
                $ZI(I)$  is the deflection at  $(XI(I), YI(I))$ .

#### Program Limits

Limits on the various integer input quantities are listed below.

NL            0 through 20  
 NT            0 through 20  
 MS            1 through 12  
 NC            1 through 12  
 LP            0 through 144 (if 0 program computes MS by NC)

LSYM	any integer If not 1, LSYM is set to 2.
NI	3 through 250 Can be raised to 300 by program modification.
ISYM	2 or 3 However, other interpolation schemes may be added later.
ISAVE	any integer (usually blank)
NCON	1 through 180
MODES	1 through 1000 Note that CPU time is proportional to MODES.
MODE	no limit If more than three digits, it will overflow the format on the plot.

All input quantities are FORTRAN BCD (no NAMELIST or binary information).

Thus

1. Blanks are read as zero.
2. Integers must be right adjusted in their fields.
3. Exponents on real number are optional and if used must be right adjusted.
4. The nonexponent part of real numbers may be placed anywhere in the field if the decimal point is punched on the card.
5. Slashes and unlimited group delimiting parentheses can be used if all of the cards to be read by format IN are not configured the same (For example, suppose that ZN is to be read from a card by itself in format F4.2 and that (ZI(I), I = 1, NI) are to be read six numbers per card in format 6F10.6. Then IN should be punched on the card, left adjusted, as (F4.2/(6F10.6)).

#### Program Output

Four output files are used:

OUTPUT	contains ID card printing and line printer version of contour plot
SAVPLT	contains plot vector file defined by PSEUDO It can be saved or post processed.

TAPE2            contains input for subsonic kernel program GENFLU  
                 It should be routed to the BCD punch or saved as a permanent  
                 file. It can be copied to output by

REWIND,TAPE2.  
COPYSBF,TAPE2.

TAPE1            contains interpolation save matrix  
                 Usually ignored by the user, but it can be saved as a  
                 permanent file or rewound and copied onto a save tape if  
                 many modes with the same (x,y) values are to be processed  
                 at different times.



Listing of Sample INPUT Data

MEASURED MODES FOR FLUTTER SUPPRESSION WING - MEASURED AMPLITUDES  
 0.00 69.41 60.59  
 0.00 50.00

69.41

6 6  
 69 2  
 (6F6,2)  
 4.18 0.00 10.90 0.00 17.63 0.00  
 24.35 0.00 31.08 0.00 37.80 0.00  
 44.52 0.00 51.25 0.00 57.97 0.00  
 10.41 6.03 17.24 6.03 24.07 6.03  
 30.91 6.03 38.36 6.03 45.81 6.03  
 52.64 6.03 59.47 6.03 66.30 6.03  
 23.88 17.73 29.15 17.73 34.42 17.73  
 39.70 17.73 45.45 17.73 51.20 17.73  
 56.47 17.73 61.74 17.73 67.01 17.73  
 36.16 28.40 40.01 28.40 43.86 28.40  
 47.71 28.40 51.91 28.40 56.11 28.40  
 59.96 28.40 63.81 28.40 67.66 28.40  
 46.55 37.42 49.20 37.42 51.84 37.42  
 54.49 37.42 57.38 37.42 60.27 37.42  
 67.91 37.42 65.56 37.42 68.21 37.42  
 54.43 44.27 56.17 44.27 57.90 44.27  
 59.64 44.27 61.53 44.27 63.42 44.27  
 65.15 44.27 66.89 44.27 68.62 44.27  
 59.36 48.55 60.33 48.55 61.69 48.55  
 62.85 48.55 64.12 48.55 65.39 48.55  
 66.55 48.55 67.72 48.55 68.88 48.55  
 67.29 22.34 62.64 22.34 57.98 22.34  
 66.63 11.44 60.52 11.44 54.41 11.44  
 =2.00 0.10 181 0.25 6.00 0.10 5.00

9  
 (F3/(7F10))

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 0.0000000 0.0000000 0.0092677 0.0684530 0.0126286 0.0163968 0.0213871  
 .0270903 .0354415 .0367655 .0525512 .0388023 .0541807 .0715959  
 .0916627 .1141664 .1403402 .1672268 .1903452 .2393319 .1777167  
 .2131582 .2397393 .2095794 .3019656 .3440264 .3864956 .4207149  
 .4586007 .4372136 .4457684 .4883389 .5245952 .5590182 .5920155  
 .6181892 .6557694 .7031266 .7021082 .7320501 .7500764 .7743151  
 .8084326 .8327732 .8566045 .8814543 .9119055 .9405235 .9394032  
 .9639843 .9931765 1.0214889 1.0149710 1.0390060 1.0412466 1.0736328  
 .3282412 .2832264 .2481923 .1263876 .0945106 .0839189

ORIGINAL PAGE IS  
 OF POOR QUALITY

2  
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.1251857 .1134940 .1032233 .0844907 .0597507 .0317809 0.0000000  
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.3286609 .3450036 .3523028 .6057102 .6186939 .6416252 .6694658  
.6858084 .7066727 .7216588 .7241780 .7482721 .9153155 .9365674  
.9504554 .9740327 .9998708 1.0092371 1.0343001 1.0350753 1.0403075  
-.1385569 -.0906272 -.0364318 -.1089723 -.0620761 -.0252568

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0.0000000 0.0000000 -.0005920 -.0088797 .0155394 .0236791 .0269350  
-.0338908 -.0459824 -.0695575 -.1161758 -.1513985 .1761137 .1870655  
-.1891372 -.1589463 -.1676780 .1435548 .0913127 .0118396 .4247447  
-.4063934 -.3523753 -.3008732 .2252479 .1354151 .0389226 .0664496  
.1801095 .3651029 .2770460 .1913571 .0945686 .0180554 .1311233  
.2286518 .3461595 .4632233 .1022643 .2068966 .3066450 .4095013  
.5181243 .6187657 .7100784 .7984313 .8858961 .6738197 .7473731  
.82891.2 .9075033 1.0001480 1.0742933 1.1786296 1.2353115 1.2942134  
.2424155 .0350747 -.1153639 .2606186 .1513985 -.1047802

4  
1.  
0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
0.0000000 0.0000000 -.0025809 -.0072149 .0112623 .0144298 .0126115  
-.0107344 -.0038714 .0265134 .0810652 .0940286 .1050563 .1116847  
-.1089277 -.0987799 .0844087 .0524402 .0056312 .0483341 .2443102  
-.2351009 -.2085875 -.1859456 -.1556781 -.1245894 .0943219 .0652863  
-.0358400 .1958588 .1492257 .0997184 .0427030 .0245190 .0903918  
.1510441 .2267128 .2924097 .2019592 .2675387 .5396293 .4289066  
.5053379 .5812999 .6430080 .7066518 .7690638 .7429611 .7972783  
.8730643 .9182309 .9931370 1.0595378 1.1141483 1.1466448 1.2120483  
-.0408846 -.0678085 -.0941459 .2099366 .0555490 -.0177733

5  
1.  
0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
0.0000000 0.0000000 .0100275 .0092411 .0184821 .0340149 .0648840  
.1051907 .1464805 .1572945 .1268187 .0228077 .0114039 .0137633  
.0434526 .0845458 .1215100 .1376327 .1069603 .0564294 .2335824  
-.2263075 -.1930790 .1626032 .1165946 .0741250 .0446323 .0165159  
.0098309 .5841526 .5114039 .4431773 .3468344 .2363350 .1289815  
-.0265435 .1012584 .2141172 .3273692 .1816752 .0487613 .0941801  
.2475423 .3928431 .5300826 .6604404 .8094770 .4976406 .6114825  
.7502949 .8779001 1.0222179 1.1690916 1.3191113 1.4410145 1.5644908  
-.0057019 .0438459 .0668502 .0786473 .1173810 .1655525

6  
1.  
0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
0.0000000 0.0000000 .0163785 .0252355 .0233376 .0144805 .0095600  
-.0382398 .0586953 .0504710 .0144805 .2291579 .2081400 .1508506  
-.0631942 .0485027 .1614649 .2350626 .2085618 .1179530 .6103613  
-.5317025 .3907634 .2581892 .1014340 .0403487 .1424856 .2293688  
.3047940 1.1710952 .9745536 .8074652 .6047378 .3731899 .1275130  
.0907493 .3385351 .5956699 .9481934 .6959792 .4394067 .1900042  
.0919443 .3643329 .6225221 .8690826 1.1313089 .0659356 .2922114  
.5217208 .7395614 1.0035850 1.2725292 1.5168002 1.7259947 1.9569099  
-.0732462 .1480388 .2406861 .0316431 .1203430 .1447350

7

1.	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
0.0000000	0.0000000	.0225063	.0310281	.0363087	.0395863	.0334681	
.0296078	.0279326	.0241815	.0205761	.1935249	.1947267	.1733494	
.1415201	.0997851	.0604902	.0393678	.0385666	.0564842	.2656324	
.1939619	.1148986	.0410066	-.0392949	-.1107105	-.1696711	-.2286318	
-.2842784	-.0241451	-.0724353	-.1236753	-.1663971	-.2123530	-.2553990	
-.2961142	-.3047088	-.3529990	.0207218	.0573218	.0957792	.1301941	
.1679595	.2091846	.2336939	.2655960	.3038348	.6976947	.7683455	
.8412542	.9072435	1.0022579	1.0534979	1.1454168	1.1991333	1.2538694	
.0363451	-.0089588	-.0231254	.0033504	.0343785	.0443935		

8

1.	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
0.0000000	0.0000000	.0335308	.0490915	.0571228	.0607369	.0475856	
.0340327	.0250979	.0177693	.0088345	.5228592	.3187431	.2795904	
.2152394	.1339223	.0555165	.0078305	.0063247	.0397550	.4651139	
.3616103	.2425459	.1237828	-.0107419	-.1349262	-.2326072	-.3252685	
-.4086939	.2629254	.1570123	.0499950	-.0564200	-.1732758	-.2935448	
-.5984557	-.4809758	-.6107820	.2369240	.2231704	.2103202	.1949603	
.1872302	.1575143	.1246871	.0963759	.0719807	.8667804	.8956932	
.9254091	.9399438	.9983937	1.0309206	1.0638490	1.0730850	1.0940669	
.0560185	-.0396547	-.0683666	.0172673	.0260014	.0365425		

9

1.	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
0.0000000	0.0000000	.0415286	.0635601	.0719438	.0668746	.0360694	
-.0033145	-.0473777	-.0832521	-.0846169	.3893547	.3562098	.2879704	
.2014038	.0980698	-.0019497	-.0877364	-.1395984	-.1951647	.2940144	
.1883408	.1085982	.0506921	.0374342	.0770131	.1279002	.1963346	
.2756873	.6092806	-.5829596	-.5381166	-.4663677	-.3597192	-.2357185	
-.1191265	.0491324	.1877559	-.9631507	-.7611620	-.5667771	-.3589394	
-.1177617	.1132774	.3293040	.5453305	.7714954	.0372392	.2497563	
.5117957	.7646715	1.0138429	1.2895301	1.5260285	1.7907974	2.0017547	
.0185221	.0302203	.0358744	.0155976	-.1197114	-.0933905		





ELEVATION Z	SYMBOLS # +
=2,0000000000	/ A
=1,9000000000	A B
=1,8000000000	B C
=1,7000000000	C D
=1,6000000000	D E
=1,5000000000	E F
=1,4000000000	F G
=1,3000000000	G H
=1,2000000000	H I
=1,1000000000	I J
=1,0000000000	J K
=,900000000000	K L
=,800000000000	L M
=,700000000000	M N
=,600000000000	N O
=,500000000000	O P
=,400000000000	P Q
=,300000000000	Q R
=,200000000000	R S
=,100000000000E+00	S T
,333066907388E+13	T U
,100000000000	U V
,200000000000	V W
,300000000000	W X
,400000000000	X Y
,500000000000	Y Z
,600000000000	Z 0
,700000000000	0 1
,800000000000	1 2
,900000000000	2 3
1,000000000000	3 4
1,100000000000	4 5
1,200000000000	5 6
1,300000000000	6 7
1,400000000000	7 8
1,500000000000	8 9
1,600000000000	9 +
1,700000000000	+ *
1,800000000000	* /
1,900000000000	/ A
2,000000000000	A B
2,100000000000	A B
⋮	
14,9000000000	I J
15,0000000000	J K
15,1000000000	K L
15,2000000000	L M
15,3000000000	M N
15,4000000000	N O
15,5000000000	O P
15,6000000000	P Q
15,7000000000	Q R
15,8000000000	R S
15,9000000000	S T
16,0000000000	T U

ORIGINAL PAGE IS  
OF POOR QUALITY

THE PLOT CONTROL CARD IMAGE IS,

PLOT,CALPOST,FB(FSH=28.,FSV=14.)  
//PAPER 12, LERDY PEN SIZE .5, MULTIPLE MODE//

FRAME	XN	YO	XN	YM	CAL. POS
1	0.	0.	1.000000E+00	1.000000E+00	0.
2	0.	0.	1.000000E+00	1.000000E+00	0.
3	0.	0.	1.000000E+00	1.000000E+00	0.
⋮					
25	0.	0.	1.000000E+00	1.000000E+00	0.
26	0.	0.	1.000000E+00	1.000000E+00	0.
27	0.	0.	1.000000E+00	1.000000E+00	0.
28	0.	0.	1.000000E+00	1.000000E+00	0.

JOB NAME == 4AFQGF  
DELIVERY == 8648 RB R M BENNETT/EXT2661

THE PLOT CONTROL CARD IMAGE IS,

PLOT,CALPOST,FB(FSH=28.,FSV=14.)  
//PAPER 12, LERDY PEN SIZE .5, MULTIPLE MODE//

OPERATIONS CONTROL MESSAGES.

SET BLKNO 2\*\*\*  
PLEASE CHANGE PAPER

⋮

SET BLKNO 28\*\*\*  
PLEASE CHANGE PAPER

THIS FILE CONTAINS 28 FRAMES,  
57 PLOTS,  
83632 POINTS,  
ESTIMATED PLOTTING TIME 2 HRS 17 MINS,  
ESTIMATED PLOTTING 24.4 FEET  
AVERAGE POS 0. PERCENT

PLOT TAPE NO. PLT195 ON CALCOMP PLATED.  
DATE - 7R/05/10. TIME - 08.54.PF.

08.45.02.MODEPRC,T4000,CM060000.  
08.45.02.B648 RB R H BENNETT/EXT2661 29  
08.45.02.USER,052061N,  
08.45.02.CHARGE,100652,LRC.  
08.45.03.GET,MPROC/UN=052061N,PW= .  
08.45.06.MPROC.  
08.45.07. 034300 CM REQUIRED FOR OVERLAY (2,2).  
08.49.20. END MPROGT  
08.49.20. 706.385 CP SECONDS EXECUTION TIME .  
08.49.20.SAVE,TAPE2=SAVTPE2.  
08.49.21.ATTACH,PLOT/UN=LIBRARY.  
08.49.21.PLOT.CALPOST,F8(FSH=28.,FSV=14.)  
08.49.23.CONT./PAPER 12, LEROY PEN SIZE .5, MULT  
08.49.23.IPLE MODE//  
08.49.24. THIS JOB HAS \*\*\*\*\* PLOT \*\*\*\*\* OUTPUT  
08.52.55. CFO. PLT195.  
08.53.42.MT25, ASSIGNED TO CALTPE , VSN=PLT195.  
08.54.30. \*\*\*\*\* PLOT OUTPUT COMPLETED \*\*\*\*\*  
08.54.30.UEAD, 0.003KUNS.  
08.54.30.UEPF, 0.179KUNS.  
08.54.30.UEMT, 2.001KUNS.  
08.54.30.UEMS, 18.129KUNS.  
08.54.30. 175 CPU SEC = UECP/S  
08.54.30.UECP, 910.340SECS.  
08.54.30.AESR, 740.070UNTS.

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OF POOR QUALITY



Listing of TAPE2

MEASURED MODES FOR FLUTTER SUPPRESSION WING - MEASURED AMPLITUDES

9  
(DZDX(L),L=1, 36) FOR MODE 1  
-2.516463634038E=03 2.398314574859E=02 2.361470134117E=02 4.689782896095E=02  
2.161976577079E=02 4.164751597156E=01 7.478133735905E=02 1.135156326362E=01  
1.328738483997E=01 1.818792576894E=01 2.995246613125E=01 3.970255315994E=01  
2.935506462664E=01 2.292946613312E=01 2.613786354101E=01 3.899245431672E=01  
3.165430672789E=01 4.867026451198E=01 8.989631533964E=02 6.032740134325E=01  
4.109582918346E=01 3.317571673902E=01 6.163875025074E=01 5.900492933787E=01  
6.021978936149E=01 3.341857962505E=01 6.498314902179E=01 4.830724948311E=01  
5.901212478909E=01 7.006970674088E=01 -1.356604193396E=02 8.634134413717E=01  
8.599192894226E=01 8.625271365759E=01 9.563888380970E=01 7.560694098168E=01  
(ZP(L),L=1, 36) FOR MODE 1  
9.273068047908E=03 9.824754983450E=03 1.821622177909E=02 3.105062300025E=02  
3.713631541809E=02 7.467203756818E=02 3.950682161130E=02 6.273761464072E=02  
1.027884741379E=01 1.546647772716E=01 2.029832790235E=01 2.580737435919E=01  
1.799178466843E=01 2.772967214483E=01 2.850888005635E=01 3.666660664489E=01  
4.314296665278E=01 4.750866852324E=01 4.378832326931E=01 4.657098833468E=01  
5.420997786105E=01 6.053728171364E=01 6.701222992162E=01 7.179371662276E=01  
7.042865379118E=01 7.419206981413E=01 7.914853629849E=01 8.452417012001E=01  
8.903804654629E=01 9.231355827364E=01 9.404684034791E=01 9.507814509549E=01  
1.009792518338E=00 1.027007584333E=00 1.049140396739E=00 1.082537583845E=00  
((PQC(N,M),M=1, 6),N=1, 6) FOR MODE 1  
5.093654248311E=01 5.819160805964E=01 7.404639269235E=02 -1.334923829468E=02  
7.246563736370E=03 2.043382998642E=03 1.089260036563E=01 4.273595419183E=02  
-4.463329337455E=02 1.702048005595E=02 -3.650125622797E=03 -1.790264089398E=03  
9.926454814598E=03 -1.076153427969E=03 -2.864335799118E=03 1.567694807741E=03  
-1.506176522904E=03 2.665829495078E=03 3.016333850743E=04 -1.956086470624E=03  
-7.061285848390E=04 1.927677155308E=03 -1.065308670200E=03 -3.033616766527E=03  
2.624313612074E=03 1.568944385333E=03 2.347111986097E=04 -1.644309476518E=03  
2.288306591512E=04 5.573877173833E=03 -2.863239965332E=04 -3.111995102855E=05  
1.059087161549E=03 4.495491632580E=04 -1.598562411016E=03 -1.114963906394E=03

(DZDX(L),L=1, 36) FOR MODE 2  
4.611306644555E=03 3.572220087173E=03 1.800672903429E=02 4.222592957246E=02  
-1.232882510216E=01 -2.332244589604E=01 6.458867444464E=03 -3.293362528508E=02  
-9.403741642808E=02 -2.49558828742E=01 -4.877988812102E=01 -5.649797598322E=02  
-3.643078649773E=02 1.125140628845E=01 -1.567404208932E=01 -2.544804120827E=01  
-3.868695572664E=01 1.216021847592E=01 -3.128306145416E=02 4.6123704066807E=02  
7.791143395640E=02 1.496333408109E=02 7.940323621787E=02 2.067118921461E=01  
2.363427888009E=01 4.064216988822E=01 2.724093480758E=01 3.128332313542E=01  
4.810429410335E=01 4.036678411843E=01 6.794184071232E=01 3.784588628707E=01  
7.450513632008E=01 8.472666041289E=01 1.551832110028E=01 1.102912230801E=01  
(ZP(L),L=1, 36) FOR MODE 2  
7.480093761471E=03 9.095939965212E=03 6.807068193143E=03 4.215569720730E=03  
-3.293767779680E=02 -6.889824210586E=02 4.350124027887E=02 4.394922455077E=02  
2.559699804877E=02 -2.083897176536E=02 -1.164148466497E=01 -1.669286509748E=01  
1.294567716297E=01 1.196299643611E=01 9.479828904822E=02 4.574503344398E=02  
-1.313900519255E=02 -3.467147690797E=02 3.053498193193E=01 3.050053233589E=01  
3.153233636824E=01 3.269847769942E=01 3.477652447388E=01 3.569322880363E=01  
6.066953036057E=01 6.294927323090E=01 6.784495582063E=01 7.161107307010E=01  
7.305293826960E=01 7.559032147129E=01 9.166247637240E=01 9.432360450286E=01  
9.880748001288E=01 1.022645031119E+00 1.036001318141E+00 1.041511535015E+00  
(FQC(N,M),M=1, 6) FOR MODE 2  
3.270075091668E=01 4.709860252537E=01 1.698009817450E=01 1.533109728568E=02  
-4.960050589312E=03 -5.394025678425E=04 -3.234132142100E=02 3.373906614770E=02  
3.727687247421E=02 -2.611332899151E=02 -9.276367581356E=04 2.997351774174E=03  
-2.202705345836E=02 9.840921301834E=03 4.217159009789E=03 -1.326570062893E=02  
7.559468925543E=03 5.918054149828E=04 -5.884868175778E=03 1.491790267359E=03  
-5.156216197968E=04 -1.582469912603E=03 2.704583992206E=03 -1.425529866564E=03  
-5.998792996316E=04 -1.798882099624E=03 -8.666555023204E=05 -1.05222797800E=03  
-9.084946618885E=04 -7.829696002024E=04 9.323656990811E=05 2.940403791324E=04  
-7.118797451567E=04 6.969394446654E=04 -7.513973122276E=07 3.744544235962E=04  
(DZDX(L),L=1, 36) FOR MODE 2  
-1.458544058619E=02 -3.138905051204E=03 -1.285468449791E=02 -6.313252350705E=02  
-3.274834812139E=01 5.025423206871E=02 -1.645219735645E=01 -6.494398078732E=02  
2.175956306976E=01 1.700615178723E=01 4.711655775315E=01 8.837601222764E=01  
2.781922771108E=02 5.133886037289E=01 6.311381078309E=01 8.74740008401E=01  
9.943232217103E=01 1.521889651820E+00 1.013637708819E+00 1.109924394490E=00  
1.3554780892970E+00 1.259316439029E+00 1.508889244909E+00 1.642263884747E+00  
1.971260058619E+00 1.984594158910E+00 2.00094129060E+00 1.835888875274E+00  
1.739876906158E+00 1.951942842798E+00 2.188498829377E+00 2.471583745102E+00  
2.604031132989E+00 3.317275237711E+00 1.791442497479E+00 1.510592889818E+00  
(ZP(L),L=1, 36) FOR MODE 3  
-7.138607809334E=04 -1.243772370690E=02 -2.557417813448E=02 -3.912794780861E=02  
-8.897118744646E=02 -1.221672377732E=01 -1.530193918766E=01 -1.832688732874E=01  
-1.737958694853E=01 -1.590382066962E=01 -7.038079512032E=02 -2.957549360391E=02  
-4.246853801932E=01 -3.808290883941E=01 -2.655616948776E=01 -8.685306366446E=02  
1.008379176533E=01 2.317300165093E=01 -3.599416853338E=01 -2.336195564000E=01  
-3.891760545557E=02 1.811936667708E=01 3.824292200398E=01 5.030459029971E=01  
1.092491568929E=01 2.582767160364E=01 4.644856595457E=01 6.669630626789E=01  
8.256678608336E=01 9.171431447665E=01 6.784058073915E=01 7.879335483085E=01  
9.545146130917E=01 1.129363059081E+00 1.252982715188E+00 1.311005126685E+00  
(FQC(N,M),M=1, 6) FOR MODE 3  
-2.692294654825E=01 1.334951010244E=01 4.718823480479E=01 3.243372100052E=02  
-2.529014463115E=02 9.824051882679E=03 1.786650045192E=01 2.198525920225E=01  
-6.449824749749E=02 -3.683935121117E=02 2.494529311006E=02 -1.404827854266E=02  
3.456983461622E=02 3.955882223715E=03 -3.335070018228E=02 2.296423341110E=02  
-2.459508166606E=03 2.285116995849E=04 -6.400031692667E=03 6.360737768919E=05  
1.980834433839E=04 1.875034213579E=03 -3.887785966200E=03 2.889147417502E=03  
1.369571891773E=03 2.725827941216E=03 -5.343210463245E=03 3.474276702224E=03  
-2.258964003010E=03 1.115442469673E=04 1.580186969554E=03 -1.31518965927E=03  
2.522028474174E=04 2.908995713342E=04 -4.650620913681E=03 4.445002127729E=03

(DZDX(L),L=1, 36)	FOR MODE 4		
-1.229197266245E=02	-1.990373081727E=02	1.039186756088E=02	3.206920093928E=02
2.458656984722E=01	7.156613576581E=01	-7.998153134101E=02	-4.495022216507E=02
6.326334543324E=02	2.158342419221E=01	3.506485221733E=01	6.182793192279E=01
1.625943036291E=03	2.528579693165E=01	2.540299278150E=01	2.738833151247E=01
1.672674712994E=01	8.991476992682E=01	5.075597088262E=01	6.44411519237E=01
8.119127173705E=01	7.839055605317E=01	8.159413407909E=01	1.151270031627E+00
1.220930499616E+00	1.425732606486E+00	1.368969426731E+00	1.220620639716E+00
1.212650423964E+00	1.564201278027E+00	1.576328741975E+00	2.399122543074E+00
2.131099151800E+00	1.680073260557E+00	1.986648455312E+00	1.423696389413F, 11
(ZP(L),L=1, 36)	FOR MODE 4		
-2.672190641447E=03	-9.471302242105E=03	-1.388361870754E=02	-8.884301888570E=03
4.067680344837E=02	1.239662554130E=01	-9.483729904564E=02	-1.095181817546E=01
-1.044928743055E=01	-7.025867420804E=02	1.124386167165E=02	7.596968380818E=02
-2.443925264513E=01	-2.224204097236E=01	-1.715607972456E=01	-1.089394389942E=01
-5.939805434008E=02	-8.416075182773E=03	-1.932449708330E=01	-1.243649596945E=01
-9.464064412104E=02	1.211183455044E=01	2.70064747955E=01	3.192056231741E=01
2.063720843272E=01	3.029812595203E=01	4.686635366035E=01	6.142791009998E=01
7.257748617867E=01	7.936935326286E=01	7.462137016283E=01	8.359587042803E=01
9.537739007293E=01	1.089860204495E+00	1.164930961654E+00	1.228744486904E+00
((FQC(N,M),M=1, 6)	FOR MODE 4		
-1.104212324010E=01	1.830269664739E=01	3.842288947989E=01	6.018605230214E=02
-1.625276011769E=02	3.723347351464E=03	1.142977871527E=01	1.260214586067E=01
-1.586172299087E=03	-2.693625468113E=02	-5.285573224834E=03	3.183099635451E=03
2.867045515286E=02	-9.44125154921E=03	-6.354368012464E=03	4.673990303752E=03
-6.856815581428E=03	8.750359249757E=03	1.991623580283E=03	-8.663619981431E=03
4.549779052971E=03	-1.258702620570E=03	-1.279852130616E=03	2.935190255984E=03
3.422228461242E=03	6.184793035422E=04	8.304439686102E=04	-3.996888076320E=04
1.382931103389E=03	-1.875434248922E=03	4.548243814126E=04	-1.300815854359E=03
2.036577102970E=03	-1.463612350635E=03	2.235318244737E=05	8.181328052042E=04
(DZDX(L),L=1, 36)	FOR MODE 5		
1.335052795295E=02	5.051733894634E=02	1.469932427633E=01	2.287195254812E=01
-2.178995080025E=01	-3.050698139258E=01	7.900762775535E=02	1.724809057533E=01
2.523565953628E=01	1.141652948394E=01	-4.443794598864E=01	-2.956073750249E=01
1.854842149194E=02	3.224930385851E=01	3.898485036113E=01	2.589984477337E=01
1.339399710312E=01	8.126553060893E=01	7.233674804889E=01	8.584964840347E=01
1.330557681253E+00	1.328448279209E+00	1.328449832392E+00	2.085572167873E+00
2.617505813571E+00	2.620067016953E+00	2.823954394850E+00	2.775705743124E+00
2.926640310363E+00	3.470506071425E+00	3.324083626893E+00	4.242432781683E+00
3.961366261051E+00	4.587316516404E+00	3.821824260152E+00	2.755963363409E+00
(ZP(L),L=1, 36)	FOR MODE 5		
1.033861085295E=02	1.274816580128E=02	4.617466114808E=02	1.242859809763E=01
1.468265399425E=01	1.029350369678E=01	-2.195099114827E=02	8.856600577722E=05
6.369105569955E=02	1.333713667353E=01	8.536109303649E=02	3.745541128341E=02
-2.335242361375E=01	-2.113968069110E=01	-1.411099723722E=01	-5.825607528404E=02
-1.202089508869E=02	3.407103812966E=02	-5.808179239687E=01	-4.780541539677E=01
-2.920816028844E=01	-7.768313181717E=02	1.353042183142E=01	2.621169409881E=01
-3.182536899570E=01	-1.129828942542E=01	1.715733012240E=01	4.653604446996E=01
7.051137957014E=01	8.649245050519E=01	5.045950113691E=01	6.800837190198E=01
9.488595717462E=01	1.247995574424E+00	1.479745583007E+00	1.896054242055E+00
((FQC(N,M),M=1, 6)	FOR MODE 5		
-1.828054708879E=01	-1.686610922630E=01	3.392402677777E=01	2.782631041607E=01
3.233136449479E=03	-2.068732894872E=02	2.289488627697E=01	1.945157066375E=01
5.017632419991E=02	-3.814729556994E=02	-2.842126708771E=02	1.268520534564E=02
1.497978365808E=02	7.394317329291E=03	-2.365080118094E=03	-1.581449002195E=02
1.489339893043E=02	1.940246386716E=03	-2.140942066138E=02	5.206117647600E=03
3.893276785406E=03	-6.075083021520E=03	3.881697296788E=03	-3.103966475671E=03
-4.806343701453E=03	6.116586365521E=03	-3.602667961253E=03	1.098523511369E=03
1.156818848601E=03	-2.195671162928E=03	7.005777716607E=04	7.571302176737E=04
-1.612447300188E=03	-6.572582256121E=04	-1.305546081716E=03	5.661929177671E=04

ORIGINAL PAGE IS  
OF POOR QUALITY

(DZDX(L),L=1, 36) FOR MODE 6  
-4.853791246384E+03 1.328924156633E+02 1.151264363825E+01 1.067549659998E+01  
-2.537259610291E+01 1.624475866333E+01 1.233361824376E+01 3.847062992830E+01  
6.771019882147E+01 4.994470232617E+01 -7.806588675756E+01 -4.92601493547E+01  
5.638760387845E+01 1.322872916719E+00 1.310365479863E+00 9.074117386148E+01  
5.435936294484E+01 1.009784281049E+00 2.184524361547E+00 2.117831904365E+00  
2.769211531021E+00 2.838014839057E+00 3.315451538611E+00 3.610645265491E+00  
4.518188863513E+00 5.152143924450E+00 5.212586311075E+00 5.217115207104E+00  
5.183302526869E+00 5.914502765111E+00 6.534520072173E+00 6.906888609782E+00  
7.264073127436E+00 7.386882754569E+00 7.100301792297E+00 5.337855326407E+00  
(ZP(L),L=1, 36) FOR MODE 6  
-1.619909720818E+02 -2.496204372289E+02 -4.061897884039E+03 4.994349365991E+02  
3.634635891527E+02 1.435817280152E+02 -2.278273896666E+01 -1.835825774268E+01  
-8.676038360846E+03 2.078544906342E+01 1.721691937000E+01 8.335894772723E+02  
-6.062967155249E+01 -4.642707388005E+01 -1.812999972312E+01 9.672052217725E+02  
2.478482405444E+01 3.366744971895E+01 1.160716311344E+00 -8.896820790120E+01  
-4.915360331888E+01 -1.517514403352E+02 4.170724422809E+01 6.830194514508E+01  
-9.325915476927E+01 -5.640610689118E+01 -4.962224079588E+02 5.000763553710E+01  
9.487880108222E+01 1.225907324021E+00 7.980783154221E+02 4.082331896027E+01  
8.684386773531E+01 1.402439990849E+00 1.797488552800E+00 2.018075498221E+00  
(FQC(N,M),M=1, 6),N=1, 6) FOR MODE 6  
-6.186367910339E+01 -4.563763140767E+01 4.183765044748E+01 3.256084514943E+01  
5.199147991294E+02 -4.483693141019E+02 5.235516433744E+01 4.295439981350E+01  
-6.446873103530E+02 -1.399848826858E+02 3.898479926005E+02 1.370598616349E+02  
1.974243399800E+02 1.077038934982E+02 -4.307266168822E+03 -1.278265829435E+02  
3.135279548411E+03 1.299080013189E+02 -4.372507556914E+02 1.114666903124E+02  
1.393285571337E+02 -2.301818907152E+02 1.352533469743E+02 -1.716460331031E+03  
-6.981237447986E+03 9.908666304225E+03 -5.975327290168E+03 -9.331862677694E+04  
6.278319511496E+03 -9.494083374032E+03 1.043764769476E+03 5.101263200920E+04  
-6.620597672298E+04 -1.773234168534E+03 8.424593200788E+04 2.988253113593E+03  
(DZDX(L),L=1, 36) FOR MODE 7  
3.893858344692E+02 2.558844791578E+02 -3.215430134247E+02 -6.437760378171E+03  
-3.885805681932E+02 4.069190523164E+02 5.921056868731E+02 -1.476796270572E+01  
-2.542019225864E+01 -1.359134379224E+01 1.535631269133E+01 -6.692804225690E+02  
-5.328667294624E+01 -7.167999260799E+01 -6.689386689164E+01 -5.279488142294E+01  
-5.888397753612E+01 2.505664889285E+01 -7.144416955037E+01 -6.878980190966E+01  
-5.570948677069E+01 -5.720137181258E+01 -8.230269995222E+01 6.754964834213E+01  
4.797498304382E+01 7.709955014684E+01 6.864961456678E+01 4.575492620852E+01  
6.346094951076E+01 1.815806031731E+00 2.04488795553E+00 2.212032818896E+00  
2.760880472768E+00 2.960257036079E+00 1.750314498678E+00 7.710155303995E+01  
(ZP(L),L=1, 36) FOR MODE 7  
2.297389527720E+02 3.386588924133E+02 3.654111240579E+02 2.814567212242E+02  
2.196501616476E+02 2.116954624251E+02 1.941681073501E+01 1.860978175747E+01  
1.212804738973E+01 4.693160722881E+02 4.514848330147E+02 5.574440359804E+02  
2.617577997260E+01 1.531770894695E+01 1.654840934924E+04 -1.423494663835E+01  
-2.491115196599E+01 -2.809832248615E+01 -2.794281489012E+02 -9.899852937377E+02  
-1.898347882106E+01 -2.791863788191E+01 -3.217505110983E+01 -3.435053655282E+01  
2.243808735223E+02 7.770998474320E+02 1.491087323855E+01 2.230761574846E+01  
2.756951852568E+01 3.305725447867E+01 7.017132376751E+01 8.051049163674E+01  
9.556938203009E+01 1.100341447265E+00 1.216184622058E+00 1.263569500609E+00  
(FQC(N,M),M=1, 6),N=1, 6) FOR MODE 7  
2.085162648292E+01 3.910723743410E+02 9.462405654686E+02 3.068878642981E+01  
3.487753327577E+02 -1.608566698669E+02 -1.263926649000E+01 -3.460148957364E+03  
1.771867281057E+01 -7.547583299947E+03 -4.359141359648E+02 1.067406320721E+02  
-3.138012317406E+03 1.023389836635E+02 7.509499100968E+03 -3.924671024974E+03  
5.561477765915E+03 4.840977771293E+05 1.289126019214E+02 -7.147452536212E+03  
-5.267390869779E+03 9.381657370123E+03 -7.279515684405E+03 3.833211113652E+03  
-1.270119562778E+03 -6.722584365111E+04 3.365630868484E+03 -1.371540097788E+03  
-2.809353237694E+03 5.787890691479E+04 1.018413527937E+03 6.46474889425E+04  
-1.187144186136E+03 7.948780675115E+04 -7.113672608266E+05 -6.281512269663E+04

```

(DZDX(L),L=1, 36) FOR MODE 8
6,144632752185E=02 3,786310412028E=02 =6,635659453289E=02 =4,395139611069E=02
-4,895856039543E=02 -1,860590455083E=02 5,012819133876E=02 =2,640238838544E=01
-4,935160924899E=01 =3,143051573778E=01 3,067401208265E=01 =1,707725388810E=02
-7,965292349052E=01 -1,080822420958E+00 =1,119600814009E+00 =8,718373333404E=01
=8,136754198412E=01 -4,840869148790E=02 =1,372572271300E+00 =1,408197723675E+00
=1,400879339631E+00 -1,409841144941E+00 -1,937037392198E+00 =6,190157326213E=02
-4,915516957750E=01 =2,592836987656E=01 =9,841564029434E=02 =6,658063363018E=01
=6,659627059600E=01 8,521721473446E=01 9,046301163317E=01 8,82656004447E=01
1,065050744575E+00 1,047895903547E+00 7,257473743016E=01 =2,402323112082E=01
(ZP(L),L=1, 36) FOR MODE 8
3,420755360569E=02 5,369695783356E=02 5,488056118360E=02 2,837607383617E=02
1,508246286538E=02 7,582146675027E=03 3,234352183138E=01 3,027231125743E=01
1,7536247240A9E=01 2,599591604890E=02 1,995541480686E=02 4,425042428847E=02
4,592864037541E=01 3,014851890640E=01 5,649864827643E=02 -1,877550750857E=01
-3,536545259387E=01 =4,155008956194E=01 =2,559272955612E=01 1,023052213077E=01
-1,577020680909E=02 -3,509520745184E=01 =5,241538195234E=01 =6,211467044821E=01
2,352797815608E=01 2,175099788070E=01 1,925277737335E=01 1,410814466663E=01
8,641606790369E=02 8,216818137923E=02 8,68300999605E=01 9,097091715186E=01
9,789047373472E=01 1,048918009710E+00 1,079089791709E+00 1,092792532488E+00
((PQC(N,M),M=1, 6) FOR MODE 8
4,264027427874E=01 1,411652544248E=01 1,303607046941E=02 3,154467164325E=01
2,216073134111E=02 1,038237680011E=02 =2,828623927871E=01 =1,089328912088E=01
2,321924941183E=01 -2,879328090520E=03 =3,914607594751E=02 =2,380475830168E=03
-1,577020680909E=02 1,031635373123E=02 =7,683054970989E=02 =1,028151095974E=03
6,308959853957E=03 -2,761842241817E=03 2,501444952091E=02 =1,159086578991E=02
-1,101663342741E=02 1,702837A42497E=02 =1,188067930872E=02 6,847797468247E=03
5,767589219781E=04 =2,503791813779E=03 4,085535718755E=03 =6,065627833197E=05
-3,707354727431E=03 1,049252518A23E=04 =2,560212211635E=03 1,719204497183E=03
=6,350624828369E=05 1,231186991557E=03 =9,187553059792E=04 =9,935650080774E=04
(DZDX(L),L=1, 36) FOR MODE 9
1,284938299546E=01 3,998626914333E=02 =1,485471448202E=01 =2,322640915124E=01
-9,847577041650E=02 8,679713402661E=01 2,097108689036E=02 =4,529338845035E=01
=6,274341463391E=01 =5,822169006547E=01 =5,041652519284E=01 1,564962598248E+00
-7,834612844130E=01 =6,9888285464A6E=01 =1,114218590566E=01 4,563185221031E=01
6,567856664732E=01 8,064797121560E=01 =1,646074811224E=02 5,777642119929E=01
1,286483242738E+00 1,485257859288E+00 1,623003783754E+00 3,077407103768E+00
3,311963389694E+00 3,845891470030E+00 4,462764354115E+00 4,345865002643E+00
4,365179114854E+00 6,007816520746E+00 5,921105734122E+00 7,961746643211E+00
6,690673860789E+00 6,958386107600E+00 6,635060383561E+00 4,504810260325E+00
(ZP(L),L=1, 36) FOR MODE 9
4,317891934317E=02 7,048270513212E=02 5,318144950887E=02 =2,628905326933E=02
-9,176410409991E=02 =3,846179853488E=02 3,899813346516E=01 3,246497994267E=01
1,509262689660E=01 =4,913164834448E=02 =1,614156137871E=01 =1,363572423964E=01
2,883452188089E=01 1,431524800280E=01 3,636922517525E=02 1,012846920395E=01
2,182620027322E=01 3,023970284890E=01 =6,101469699134E=01 =5,635473161656E=01
-4,176480274989E=01 =1,792739792626E=01 8,957698018048E=02 2,562265698212E=01
-9,520084707803E=01 =6,612157983479E=01 =2,390487762532E=01 2,266811302141E=01
6,130442229251E=01 8,651630571485E=01 4,968337103716E=02 3,783947257786E=01
8,877795367802E=01 1,411348603426E+00 1,861975157824E+00 2,053237340719E+00
((PQC(N,M),M=1, 6) FOR MODE 9
6,240973111425E=02 =4,326915710A67E=01 =8,217331431060E=02 5,543339480553E=01
1,118019363605E=01 =3,091806901345E=02 =1,696159678116E=04 3,596885164298E=01
2,175287554237E=01 =1,240363013040E=01 2,460676907983E=02 =3,316527167178E=02
2,280827501957E=02 6,728800739115E=02 =6,612511351695E=02 =4,396322083811E=03
3,810729920730E=02 =2,484651677991E=02 =1,728038989455E=02 =1,966520376423E=02
=2,032174985362E=03 1,260161050017E=02 =1,086870855827E=02 4,654080039272E=03
=4,479368558827E=03 5,005951540175E=05 1,099371657840E=02 =7,574172874342E=03
2,211525557761E=03 1,695442718164E=03 1,340261602921E=03 1,743747023509E=05
-3,62428425A473E=03 =1,651625091747E=04 =8,932388286985E=04 =1,830274645166E=03

```

## APPENDIX B

### SUBSONIC KERNEL FUNCTION MATRIX ELEMENT PROGRAM, SUBCMAT

Program SUBCMAT calculates the complex matrix elements used in solving the subsonic downwash integral equation for an oscillating planar lifting surface. The solution of the matrix equation is subsequently performed by the L-U decomposition program LUCMAT, and the generalized force program GENFLU as job steps.

The program is dimensioned for up to 200 collocation points, requiring 22,000<sub>8</sub> words of central memory for execution. The wing geometry portion of the program uses the same cards used in MPROC. The abscissas and weights for several orders of the Laguerre-Gauss quadrature are stored permitting selection of the quadrature order during input.

The absolute binary program is stored on the permanent file system as an indirect access, semiprivate file named SUBCMAT (the overlay file name). Access to SUBCMAT is obtained by the control card

```
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
```

The files declared by the program are (in order) INPUT, OUTPUT, and CMATF. The matrix element file CMATF is equivalenced to TAPE8 in the program. The output file contains an error message summary for nonfatal error message 115. This situation results from the issuing of an error message under the CDC FTN compiler when the result of a call to CEXP underflows even though the result is set to zero. The message has been suppressed by a call to SYSTEMC in the main overlay and only the summary is printed.

A short program called CMTPRNT reads and lists the file CMATF and serves to document CMATF. A listing of CMTPRNT and a portion of its OUTPUT for the sample case are presented in this Appendix.

### Control Deck

A typical BATCH processing control deck is

```
SUBCMAT,T0600,CM023000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC)
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
SUBCMAT.
SAVE,CMATF=SAVCMT.              (save CMATF file as permanent file named SAVCMT)
--eor--
INPUT DATA
---eoi--
```

Generally the L-U decomposition program is run as the next job step. Only the L-U file is saved for future use as it is the fundamental structural

mode-independent file. A BATCH processing control deck for this case is

```

SBCMTLU,T0600,CM023000.          BLDG648          YOUR NAME
USER, . . .(your user number/your password)
CHARGE, . . .(your account number, LRC)
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
GET,LUCMAT/UN=052061N,PW=LUCMTV1.
SUBCMAT.
LUCMAT.
SAVE,LUF=SAVLUF.                  (save the LU file as a permanent file
--eor--                            named SAVLUF - Caution: this can be a
INPUT DATA (for SUBCMAT only)     large file)
--eoi--

```

### Data Setup

All input x,y quantities must be in consistent units (dimensional or dimensionless) and must be referenced to the same x,y coordinate system. The x-axis of the coordinate system must point downstream. The wing geometry portion of the input data is identical with that for program MPROC.

The detailed contents of the input cards are listed below:

<u>Contents</u>	<u>Format</u>	<u>No. of Cards</u>	<u>See Note</u>
ID	(8A10)	1	
XLR,XTR,XLT,XTT	(4E20.12)	1	
YROOT,YTIP,NL,NT	(2E20.12, 2I4)	1	
(YL(I),XL(I), I = 1, NL)	(2E20.12)	NL	(1)
(YT(I),XT(I), I = 1, NT)	(2E20.12)	NT	(2)
NK,NM,NC,NS,NCP,ISYM,NG,IPRINT	(20I4)	1	
RFMAX,RFMED,RFMIN,ZETA	(4E20.12)	1	
(EM(I), I = 1, NM)	(4E20.12)	(NM+3)/4	
(XP(I),YP(I), I = 1, NC*NS)	(4E20.12)	(NC*NS+1)/2	(3)

#### NOTES:

- (1) omit this card set if NL = 0
- (2) " " " " " NT = 0
- (3) " " " " " NCP  $\leq$  0

The definitions of the input variable names are:

```

ID      case identification card

XLR     x coordinate of leading edge at root

XTR     x coordinate of trailing edge at root

```

XLT        x coordinate of leading edge at tip  
 XIT        x coordinate of trailing edge at tip  
 YROOT      y coordinate of root  
 YTIP       y coordinate of tip  
 NL         number of discontinuities on leading edge  
 NT         number of discontinuities on trailing edge  
 YL, XL     location of leading edge discontinuities  
 YT, XT     location of trailing edge discontinuities  
  
           y must appear before x on the YL, XL or YT, XT  
           cards. These cards must be ordered on increasing  
           y and are the same cards used by MPROC.  
  
 NK         number of reduced frequencies, k, to be processed  
 NM         number of Mach numbers, EM, to be processed  
 NC         number of chordwise-varying pressure functions  
 NS         number of spanwise-varying pressure functions  
 NCP        flag for reading control point locations  
  
           NCP = 0, XP, YP are calculated at Gaussian  
           stations by the program  
  
           NCP  $\neq$  0, XP, YP are read as input data  
  
 ISYM       loading symmetry flag  
  
           ISYM = 0, symmetric spanwise loading is assumed  
           ISYM = 1, antisymmetric spanwise loading is assumed  
  
 NG         half order of the quadrature formula used  
  
           (If NG = 0, NG = 5 is used.)  
  
 IPRINT    printing flag  
  
           IPRINT = 0 XP,YP and XG,WG are not printed  
           IPRINT  $\neq$  0 XP,YP and XG,WG are printed



RFMAX     the maximum value of reduced frequency, k, to be calculated  
 RFMED     the median value of reduced frequency, k, to be calculated  
 RFMIN     the minimum value of reduced frequency, k, to be calculated

The program calculates the values of reduced frequency, k, processed from a bilinear formula in descending values of k. For equi-spaced values of k, RFMED should be (RFMAX-RFMIN)/2.0

ZETA     the normalized singular strip width used in spanwise integration. If ZETA is read as 0., the program resets it to 0.1

EM       array of Mach numbers to be processed

XP,YP    X and Y coordinates of the collocation points. The coordinates are normalized on local chord, and semispan such that  $-1 \leq XP \leq 1$  and  $0 \leq YP \leq 1$

#### Program Limits

The limits on the various integer input quantities are listed below.

NL       0 through 20  
 NT       0 through 20  
 NK       3 through 9999  
 NM       1 through 8  
 NC       1 through 44  
 NS       1 through 44  
 NCP      0 through 200 (If NCP = 0, then the program computes NCP as NC\*NS)  
 ISYM     0 or 1  
 NG       5 through 24 (If  $NG \leq 5$ , then the program uses  $NG = 5$ ;  
           if  $NG \geq 24$ , then the program uses  $NG = 24$ .)

#### Program Output

Two output files are used:

OUTPUT   contains a labeled reflection of the input data subject to the IPRINT flag

CMATF contains the complex matrix elements for all values of  $k$  and  $EM$  as a single binary file. File CMATF is rewound at the end of normal program execution. This file is documented by the listing of the program CMTPRNT which is presented after the sample case OUTPUT. A partial listing of CMATF for the sample case as generated by CMTPRNT is also presented.

Listing of Sample INPUT Data

SUBSONIC KERNEL CALCULATIONS USING L=U PROGRAM = FLUT. SUPP. W. = 6 X 6 NOMINAL

<sup>1.</sup>  
0. 1. 6 6 0 1.440714594439 0. 0.7458579455410 1.  
10 1 6 6 0 0 5 0 0 0  
10.  
.80 1. 0. 0.

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Listing of Sample OUTPUT

SUBSONIC KERNEL CALCULATIONS USING L=U PROGRAM = FLUT, SUPP. N. = 6 X 6 NOMINAL

PLANFORM PARAMETERS NORMALIZED BY THE ROOT SEMICHORD, BREF = 1.0000000000  
REFERENCE VOLUME = 1.72478773481      PANEL ASPECT RATIO = 1.27828198901  
MEAN CHORD = 1.12707102723      MEAN AERODYNAMIC CHORD = 1.35243540773  
PANEL AREA = 1.62378767790      SEMISPAN/BREF, S = 1.44071459444

NUMBER OF MACH NUMBERS, NM = 1  
(MACH(I), I = 1, NM) =  
.800000000000

NUMBER OF REDUCED FREQUENCIES, NK = 10      MEDIAN K, RFMED = 1.00000000000  
MAXIMUM K, RFMAX = 10.0000000000  
MINIMUM K, RFMIN = 0.

NUMBER OF COLLOCATION POINTS, N = 36      NUMBER OF CHORDWISE PRESSURE MODES, NC = 6  
LOADING SYMMETRY FLAG, ISYM = 0      NUMBER OF SPANWISE PRESSURE MODES, NS = 6  
XP, YP READ OR CALCULATE FLAG, NCP = 0

QUADRATURE HALF-ORDERS, NG = 5  
SINGULAR STRIP WIDTH, ZETA = .100000000000

PRINT OPTION, IPRINT = 0

ERROR SUMMARY

ERROR	TIMES
0115	0324

4AFQBHM. 78/05/08, NASA/LRC CY175=T NOS 1.2 (T11)

13.57.05.SUBCHAT, T1000, CH060000.  
13.57.05.8648 R8 K M BENNETT/EXT2661 29  
13.57.05.USER, 052061N, .  
13.57.06.CHARGE, 100692, LRC,  
13.57.07.GET, SUBCHAT/UN=052061N, PW#  
13.57.18.SUBCHAT.  
14.03.07. END SUBCHAT  
14.03.07. 271.450 CP SECONDS EXECUTION TIME  
14.03.07.SAVE, CHATF=SVCHAT8.  
14.03.11.UEAD, 0.002KUN8.  
14.03.11.UEPF, 0.253KUN8.  
14.03.11.UEMS, 1.017KUN8.  
14.03.11. 175 CPU SEC = UECP/5  
14.03.11.UECP, 271.540SEC8.  
14.03.11.AESR, 169.982UNT8.

## Listing of Program CMTPRINT (Prints File CMATF)

```

PROGRAM CMTPRINT( OUTPUT = 1008, CMATF = 10008, TAPE8 = CMATF)
*****
*
* PROGRAM CMTPRINT READS BINARY FILE CMATF (TAPE8) GENERATED BY PROGRAM *
* SUBCMAT AND PRINTS ITS CONTENTS ON THE OUTPUT FILE. *
*
*****
      REAL CMAT(2,200)
      INTEGER ID(8)
      READ (8) ID,BREF,VOLUME,NM,NK,NCP
      PRINT 100, ID
      PRINT 101, BREF,VOLUME
      PRINT 102, NM,NK,NCP
      DO 30 M = 1,NM
        READ (8) EMACH
        PRINT 103, EMACH
        DO 20 K = 1,NK
          READ (8) RF
          PRINT 104, RF
          DO 10 N = 1,NCP
            PRINT 105, N
            READ (8) (CMAT(1,I),CMAT(2,I), I = 1,NCP)
            PRINT 106, (CMAT(1,I),CMAT(2,I), I = 1,NCP)
          10 CONTINUE
        20 CONTINUE
      30 CONTINUE
100  FORMAT(1H1,///< CMATF ID = *8A10)
101  FORMAT(/* BREF =*G20.12* VOLUME =*G20.12)
102  FORMAT(* NO. MACH NOS. =*I4* NO. RED. FREQ. =*I4,
A      * NO. COLLOC. PTS. =*I4)
103  FORMAT(//* MACH NUMBER =*G20.12)
104  FORMAT(/* REDUCED FREQUENCY =*G20.12)
105  FORMAT(* N =*I4)
106  FORMAT(4X,2G20.12,8X,2G20.12)
      END

```

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Listing of Portion of File CMATF (OUTPUT of CMTPRINT)

CMATF ID = SUBSONIC KERNEL CALCULATIONS USING L=U PROGRAM = FLUT. SUPP. W. = 6 X 6 NOMINAL

BREF = 1.000000000000 VOLUME = 1.72478773481  
NO. MACH NOS. = 1 NO. RED. FREQ. = 10 NO. COLLOC. PTS. = 36

MACH NUMBER = .800000000000

REDUCED FREQUENCY = 10.0000000000

N = 1

.2.42261902064	.220711272360	2.28755510937	.171955056607
.2.03771469244	.676682585728E=01	1.66301100432	.674183855421E=01
.1.19493647290	.281495061361	.687700644000	.492433823383
2.13366102006	.333645888031	=2.02967593861	.294364726289
1.86158269274	.214928560200	=1.56453800135	.834155002966E=01
1.20092414227	.131514953222	=.787657990480	=.374568064906
=1.74918398595	.515536141760	1.71463806581	=.502174646994
=1.59799404991	.447650346689	1.36836726293	=.315755213722
=1.09342861603	.130010326169	.748700141381	.889518565941E=01
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.373782706620	.940885070801	=.411799383048	.862678637163
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•  
•  
•

REDUCED FREQUENCY = 2.80000000000

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## APPENDIX C

### COMPLEX MATRIX L-U DECOMPOSITION PROGRAM, LUCMAT

Program LUCMAT performs an L-U decomposition of the complex matrices generated by program SUBCMAT, the subsonic kernel function matrix element program. Normally, LUCMAT is run as a job step subsequent to the execution of SUBCMAT in the job stream for flutter analysis. The factored matrix is independent of the structural modes.

Program LUCMAT is set up for dynamic storage. It calculates the required central memory field length and reduces the field length to that required for execution. Approximately  $14,500_8 + NCP*(2*NCP + 1)$  words of central memory are required for execution (NCP = order of the matrix = number of collocation points). For NCP = 36, approximately 22,000<sub>8</sub> CM words are required.

The absolute binary program is stored on the permanent file system as an indirect access, semiprivate file named LUCMAT (the overlay file name). Access to LUCMAT is obtained by the control cards

```
GET,LUCMAT/UN=05206IN,PW=LUCMTV1.
```

The files declared by the program are (in order) OUTPUT, .CMATF and LUF. CMATF is equivalenced to TAPE8 in the program and LUF is equivalenced to TAPE9. Prior to completion of normal execution, file LUF is rewound. Note that there is no INPUT file. Program LUCMAT reads only from binary file CMAT which is described in the documentation of program SUBCMAT. File LUF contains the factored matrices as a single binary (unformatted) file for all values of Mach number and reduced frequency. The OUTPUT file is used by LUCMAT only for system error messages.

A short program called LUFPRNT reads and lists the file LUF, and serves to document file LUF. A listing of LUFPRNT and a portion of its OUTPUT for the sample case are presented in this Appendix.

#### Control Deck

A typical BATCH processing control deck for executing only LUCMAT is

```
BLUCMAT,TO200,CM023000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC)
GET,CMATF=SAVCMT.                (get previously saved CMATF)
GET,LUCMAT/UN=05206IN,PW=LUCMTV1.
LUCMAT.
SAVE,LUF=SAVLUF.                 (save LUF file as permanent file named SAVLUF)
--eoi--
```

Generally, the L-U decomposition program is run as the job step after SUBCMAT. Only the L-U file is saved for future use as it is the fundamental structural mode-independent file. A BATCH processing control deck for this case is

```
SBCMTLU,T0600,CM023000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC.)
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
GET,LUCMAT/UN=052061N,PW=LUCMTV1.
SUBCMAT.
LUCMAT.
SAVE,LUF=SAVLUF.                  (save the LU file as a permanent file named
--eor--                            SAVLUF - Caution: This can be a large file)
INPUT DATA (for SUBCMAT only)
---eoi--
```

Listing of Sample OUTPUT

4AFQBIC. 78/05/08,NASA/LRC CY175-T NOS 1.2 (T11)

14.05.46.LUCMAT,T0400,CM060000,  
14.05.46.8648 RB R M BENNETT/EXT2661 29  
14.05.46.USER,052061N,  
14.05.47.CHARGE,100652,LRC.  
14.05.48.GET,CMATP=SVCMATB.  
14.05.55.GET,LUCMAT/UN=052061N,PW# .  
14.05.58.LUCMAT,  
14.06.09. END LUCMAT  
14.06.09. 6.395 CP SECONDS EXECUTION TIME  
14.06.09.SAVE,LUF=LUFB,  
14.06.16.UEAD, 0.002KUNS,  
14.06.16.UEPF, 0.390KUNS,  
14.06.16.UEMS, 1.114KUNS,  
14.06.16. 175 CPU SEC = UECP/S  
14.06.16.UECP, 6.485SECS.  
14.06.16.AESR, 23.436UNTS,

Listing of Program LUFPRNT (Prints File LUF)

```

PROGRAM LUFPRNT( OUTPUT = 1008, LUF = 10008, TAPE9 = LUF)
*****
*
* PROGRAM LUFPRNT READS BINARY FILE LUF (TAPE9) GENERATED BY PROGRAM *
* LUCMAT AND PRINTS ITS CONTENTS ON THE OUTPUT FILE. *
*
*****
      COMPLEX CL(36,36),CU(36,36)
      INTEGER ID(8),INT(36)
      READ (9) ID,BREF,VOLUME,NM,NK,NCP
      PRINT 100, ID
      PRINT 101, BREF,VOLUME
      PRINT 102, NM,NK,NCP
      DO 30 M = 1,NM
        READ (9) EMACH
        PRINT 103, EMACH
        DO 20 K = 1,NK
          READ (9) RF
          PRINT 104, RF
          READ (9) (INT(IR), IR = 1,NCP)
          PRINT 105, (INT(IR), IR = 1,NCP)
          PRINT 106
          DO 5 IR = 1,NCP
            PRINT 107, IR
            READ (9) (CL(I,IR), I = 1,IR)
            PRINT 108, (CL(I,IR), I = 1,IR)
5          CONTINUE
          PRINT 109
          DO 10 J = 2,NCP
            IR = NCP+2-J
            IRL1 = IR-1
            PRINT 107, IRL1
            READ (9) (CU(I,IRL1), I = IR,NCP)
            PRINT 108, (CU(I,IRL1), I = IR,NCP)
10          CONTINUE
20          CONTINUE
30          CONTINUE
100         FORMAT(1H1,///< LUF ID = *8A10)
101         FORMAT(// * BREF = *G20,12 * VOLUME = *G20,12)
102         FORMAT(// * NO. MACH NOS. = *I4 * NO. RED. FREQ. = *I4,
A           * NO. COLLOC. PTS. = *I4)
103         FORMAT(// * MACH NUMBER = *G20,12)
104         FORMAT(1H1,///< REDUCED FREQUENCY = *G20,12)
105         FORMAT(// * INT ARRAY*(4X20I4))
106         FORMAT(// * L MATRIX*)
107         FORMAT(4X * IR = *I4)
108         FORMAT(4X,2E20,12,8X,2E20,12)
109         FORMAT(// * U MATRIX*)
      END

```

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## Listing of Portion of File LUF (OUTPUT of LUFPRNT)

LUF ID = SUBSONIC KERNEL CALCULATIONS USING L=U PROGRAM = FLUT. SUPP. W. = 6 X 6 NOMINAL  
BREF = 1.000000000000 VOLUME = 1.72478773481  
NO. MACH NOS. = 1 NO. RED. FREQ. = 10 NO. COLLOC. PTS. = 36  
MACH NUMBER = .000000000000

REDUCED FREQUENCY = 2.80000000000

INT ARRAY

36	36	36	35	35	35	32	32	32	33	33	33	30	31	31	31	31	31	28	29
25	24	28	25	26	36	36	36	36	35	35	34	34	36	36					

L MATRIX

IR = 1	.798619501932E+00	.476912555098E+01		
IR = 2	.116406028075E+01	.555129832677E+00	.182975099355E+00	.462292605296E+01
IR = 3	.112604922014E+01	.286230938748E+00	.433310897444E+01	.206591184011E+01
	.185425798986E+01	.194617609259E+01		
IR = 4	.122550090289E+01	.537329705430E+01	.298194759374E+01	.162274298558E+01
	.573598982871E+01	.852722179570E+01	.484495169837E+00	.456617698622E+01
IR = 5	.911238434692E+00	.177497766414E+00	.388760319569E+01	.306943083111E+00
	.571374305619E+00	.100558572469E+01	.141203188766E+00	.362151978406E+00
	.698306663655E+01	.131361559823E+01		
IR = 6	.739638869485E+00	.787865680954E+00	.262568846123E+01	.350255932539E+01
	.104528556596E+01	.513677324199E+00	.433955201798E+00	.450491535373E+00
	.405809623732E+00	.913990973274E+00	.763411798088E+01	.347152438929E+01
IR = 7	.509534380255E+00	.654690823744E+00	.174971714935E+00	.431064534156E+00
	.226704737272E+00	.125298174754E+01	.141404618204E+01	.277446850998E+01
	.193894521432E+00	.284069097173E+00	.751324441832E+00	.438363671405E+00
	.696270286331E+00	.257189621267E+00		
IR = 8	.123892428766E+01	.830025999319E+00	.480870571546E+01	.213264391314E+01
	.280330396035E+01	.360492019601E+00	.104018374014E+01	.327413765179E+00
	.224673326523E+01	.770267440089E+00	.101416328681E+01	.309024560625E+00
	.741678865284E+00	.692644646718E+00	.217933117868E+00	.213266005617E+00
IR = 9	.141574662625E+01	.744396878826E+01	.508857028322E+01	.629417986593E+00
	.216299799971E+01	.979417165933E+00	.508285965560E+00	.144695845329E+01
	.121492290363E+01	.256816223914E+00	.885645920929E+00	.755865970398E+00
	.694369386987E+00	.107753918219E+01	.226077914018E+01	.393433142796E+01
	.511617776688E+00	.298056122291E+00		

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 .696205339337E+00  
 .948461707464E+00

IR = 12

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 .185531008471E+01  
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IR = 13

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 .314721778172E+01  
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IR = 14

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.134330949504E+01	.781775236783E+01	.208518869064E+01	.134207963353E+01
.389517442471E+01	.100409697748E+01	.693972573648E+00	.511775079024E+01
.766156767972E+01	.104113228070E+02	.436525551928E+02	.306015606157E+01
.133745410147E+02	.706323081627E+00	.935822367220E+01	.349097900741E+00

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.242664998280E+02	.111169784063E+02	.777234410333E+02	.33208728A493E+02
.106354837965E+02	.103857388391E+02	.604260041745E+01	.305681701088E+01
.842639394641E+01	.461144243589E+01		

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.100062794014E+02	.471814872662E+01	.269460143742E+01	.125302495155E+01
.632010771711E+01	.537151259481E+01	.533659452250E+00	.890206492962E+00
.343832365454E+02	.187604131457E+01	.739203818561E+02	.768591482166E+02
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.627428842340E+01	.167977402715E+01	.812526949375E+01	.673664862259E+01
.724457831193E+01	.1227288497131E+02	.792193584967E+01	.259470081103E+01
.869501605529E+01	.528190525207E+01	.133978003776E+02	.342692776684E+01
.823988546256E+01	.379822779828E+02	.143239485812E+01	.285299812688E+02
.362745837737E+01	.549519849345E+00	.119586564048E+01	.131209803572E+01
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 .120808708902E+02  
 .471725333956E+02  
 .321473390621E+02  
 .625708333380E+00  
 .840097819223E+00  
 .292617140392E+01

.202152003364E+01  
 .752133540767E+01  
 .153064899973E+02  
 .735206959485E+01  
 .102554798819E+01  
 .801477721102E+01  
 .190954571118E+03  
 .212928508142E+02  
 .918728591590E+01  
 .169772424437E+02  
 .109594804861E+02  
 .847764835169E+01  
 .127949064751E+01

.145120642183E+01  
 .937443894866E+01  
 .917552913540E+01  
 .853901596073E+01  
 .467501784344E+01  
 .306432951983E+01  
 .111059207850E+03  
 .103241630062E+02  
 .233290787840E+01  
 .450359967667E+02  
 .157203975840E+02  
 .136330589039E+02  
 .674648205325E+01

IR = 28

.118657417042E+01  
 .347892307275E+01  
 .533694028786E+01  
 .539147621063E+01  
 .908178618910E+01  
 .507003465489E+01  
 .233493389208E+02  
 .716109733281E+01  
 .153451303509E+02  
 .470934998281E+02  
 .179084158793E+01  
 .256086724946E+00  
 .331392166414E+01  
 .258214286646E+01

.327912974654E+00  
 .318778615558E+01  
 .779911386279E+01  
 .306958754451E+01  
 .948126970248E+01  
 .712201815173E+01  
 .282871780450E+02  
 .295315506770E+01  
 .242164763003E+01  
 .112850618482E+03  
 .448834957075E+00  
 .172592518966E+01  
 .352048273042E+00  
 .678195126281E+01

.114054297461E+01  
 .106059946928E+02  
 .636071813041E+01  
 .520802989680E+01  
 .579624333708E+01  
 .110536275546E+02  
 .131578559846E+02  
 .112951976759E+01  
 .291385257099E+02  
 .378652637019E+01  
 .222602958375E+01  
 .293765696096E+01  
 .113077259187E+01  
 .212238631064E+01

.166024067712E+00  
 .945940960938E+00  
 .119254249278E+02  
 .795810029269E+01  
 .961927575526E+00  
 .334198702781E+00  
 .530808264901E+02  
 .240059835182E+01  
 .206121048531E+01  
 .144673132622E+01  
 .108899030358E+01  
 .723012741038E+00  
 .113271488642E+00  
 .228290878001E+01

IR = 29

.755856126034E+00  
 .200782204999E+01  
 .968324294414E+01  
 .214545813723E+00  
 .140485698209E+02  
 .232140540270E+01  
 .748930946811E+02  
 .180385714573E+02  
 .378356298389E+02  
 .129796988147E+02  
 .379876914856E+02  
 .295062924508E+01  
 .146366732480E+01  
 .327029072848E+01  
 .334581734558E+00

.102195070950E+01  
 .563317409694E+01  
 .562737248817E+01  
 .320483344716E+01  
 .688261598122E+01  
 .114163021483E+02  
 .784838818918E+01  
 .160996284117E+02  
 .252485482623E+02  
 .420605298522E+02  
 .243316852302E+02  
 .150857483279E+01  
 .108201160804E+01  
 .125939883073E+01  
 .254194786599E+00

.125937319529E+01  
 .331150966022E+01  
 .117449637505E+02  
 .394388514725E+01  
 .345891040269E+01  
 .115489565542E+02  
 .156977372634E+03  
 .249000912796E+02  
 .966613241289E+01  
 .447928095390E+02  
 .225081710524E+02  
 .220787360087E+01  
 .141347544133E+01  
 .415513747312E+00

.207520673579E+01  
 .117238179070E+02  
 .147913767621E+02  
 .110039415817E+02  
 .374333216615E+01  
 .783396359069E+00  
 .172228307683E+03  
 .237584761342E+01  
 .129840537353E+01  
 .422868537307E+02  
 .183762204638E+02  
 .883937504026E+01  
 .564220336321E+00  
 .226566473646E+00

IR = 30

.262409632278E+00  
 .108229206898E+01  
 .602219219506E+00  
 .441482912443E+02  
 .102659148074E+01  
 .323606470958E+01  
 .153511548912E+00  
 .164633731430E+00  
 .154389473047E+00  
 .109381749172E+00  
 .421245744133E+00  
 .603644590478E+00  
 .366924084430E+00  
 .260717297204E+00  
 .405304265685E+01

.110227137090E+01  
 .864452126307E+01  
 .780909009051E+00  
 .474700545694E+01  
 .688251648473E+01  
 .423697779764E+01  
 .148207658958E+00  
 .127403973326E+00  
 .271481763111E+00  
 .670060838700E+01  
 .914098823866E+00  
 .204530806932E+00  
 .401003435183E+00  
 .466066001636E+00  
 .874990659018E+01

.526816114946E+00  
 .609928323539E+00  
 .561520437614E+01  
 .438793149423E+01  
 .373883412698E+01  
 .147677150046E+01  
 .242542453874E+00  
 .318780925165E+01  
 .102838121801E+00  
 .614091536833E+00  
 .112613359582E+01  
 .294516123263E+00  
 .133723552873E+01  
 .688265860774E+00  
 .156614793276E+00

.448546619231E+01  
 .404940524360E+00  
 .421475094058E+00  
 .776371113004E+01  
 .118054924748E+00  
 .255161429504E+01  
 .489576552032E+00  
 .108815891048E+00  
 .592679351195E+02  
 .373247461921E+00  
 .521301638192E+00  
 .143824299825E+01  
 .691168278569E+00  
 .132157086639E+01  
 .231233902937E+00

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IR = 31

.123314367452E+01	.934935956634E+00	.371663116088E+01	.199039135710E+01
.539717427162E+01	.149321809614E+01	.671434424908E+01	.147498783766E+01
.830355321729E+01	.511588164515E+01	.495771023134E+01	.264090562168E+01
.179660488344E+01	.172606745800E+01	.566586467259E+01	.556689059901E+01
.10238844509AE+02	.239349739539E+01	.312459321728E+01	.146993328915E+01
.510275178436E+01	.912737729427E+00	.216869365795E+01	.986504119572E+00
.753070899104E+01	.130694175329E+02	.403494210185E+02	.545104739894E+01
.266703065573E+01	.639177172143E+01	.389283755677E+01	.127914528253E+01
.717721092692E+01	.318462609434E+01	.256108533358E+00	.312635981281E+00
.56593773A183E+01	.249532187428E+01	.522819972400E+00	.579931566557E+00
.11A92092A22AE+01	.461661014122E+00	.208406994496E+01	.721589586624E+00
.276432859629E+01	.584157683980E+00	.379891074895E+01	.84799A789684E+01
.163145144285E+00	.254076717684E+01	.400424578157E+01	.484451781136E+01
.701078419560E+01	.539202435904E+01	.739307945561E+01	.456624937248E+01
.433438909509E+02	.224482759753E+02	.243645259728E+01	.183584469937E+01
.3B2197590414E+01	.235377179523E+01		

IR = 32

.596851812553E+00	.108949837854E+01	.195961496842E+01	.302574738178E+01
.368195750689E+01	.316859164121E+01	.419758772419E+01	.142228924972E+01
.5630715A0419E+01	.854779762316E+01	.338937463994E+01	.392967688933E+00
.1A3922969277E+01	.289621689847E+01	.183967402573E+01	.1219745106A9E+02
.110423591241E+02	.157889196781E+01	.205237788843E+01	.215635696933E+01
.493464407217E+01	.728168495699E+01	.984416512137E+00	.850190131636E+00
.360896348615E+02	.727910240778E+01	.556606606966E+02	.992585156113E+02
.35791774A001E+01	.164666166059E+02	.111255991568E+02	.244937400329E+01
.75825657031AE+01	.177007096442E+02	.185015711241E+00	.134747399992E+01
.816938102430E+00	.899036574813E+00	.149768426568E+01	.130084647004E+01
.750696150411E+00	.24301A104751E+00	.170523275187E+01	.794558194171E+00
.347961533A74E+00	.508429A46026E+00	.217102685162E+01	.737519984713E+00
.189394697240E+00	.505211609918E+00	.737691788527E+00	.112773060216E+01
.519051AA1239E+00	.950867709123E+00	.150513464358E+01	.144937439603E+01
.84828A560A81E+01	.9041A5351431E+01	.105411227932E+01	.108934157926E+01
.191764566641E+01	.391644321660E+00	.280122289844E+00	.367457811022E+00

IR = 33

.111466964967E+01	.269705238611E+00	.850676759301E+01	.826993855692E+01
.606320103129E+01	.321620257365E+00	.866740032199E+01	.774104373220E+00
.161926341764E+02	.287499423584E+01	.282631618548E+01	.502878733560E+01
.773868760096E+01	.198916641980E+01	.128539528811E+02	.157629064501E+01
.192497729887E+01	.902305766487E+02	.603840772241E+01	.649289720689E+01
.911783429678E+02	.171096056417E+01	.432386182027E+02	.135078633880E+01
.749665143215E+01	.508968398255E+01	.401446159198E+01	.125841570018E+00
.213733110770E+01	.167517020072E+01	.371153125265E+01	.102361950734E+01
.385994796287E+01	.252932138743E+01	.126785571446E+01	.185266318406E+01
.300685241219E+02	.332935290324E+01	.744955737713E+02	.219784818069E+01
.640230073876E+01	.290637734160E+01	.580541806056E+01	.149227837009E+01
.471111202684E+01	.190965328143E+01	.160294534134E+00	.146859100247E+00
.312581620225E+00	.367201725209E+01	.178969999062E+00	.165918975413E+01
.348806969105E+00	.284664962605E+01	.247522696843E+01	.794203254215E+02
.463272811378E+00	.900810659818E+01	.210409797503E+00	.118681780903E+02
.553159557700E+00	.108179374478E+00	.181689998145E+01	.246046260928E+00
.196061906285E+00	.236703073753E+01		

IR = 34

.117506533515E+01	.248009350409E+01	.427653039529E+01	.452465789535E+00
.147326762835E+01	.158366698349E+01	.540304984966E+00	.171390839179E+01
.625744379399E+00	.256561895594E+01	.882981668750E+00	.986241698446E+00
.175281463104E+00	.244708237031E+01	.412603881787E+00	.814671134119E+01
.403371178344E+01	.175337073497E+01	.300790354849E+00	.106850062280E+01
.203035233981E+00	.125425388085E+01	.739105203347E+01	.279332482235E+00
.283611782883E+00	.158622923824E+00	.923122392974E+01	.104651599655E+01
.311008571681E+00	.229821279541E+00	.450547063690E+01	.502657742612E+02
.130825284339E+00	.110250550072E+00	.619520241015E+01	.155181476026E+00
.160306519709E+01	.103785059198E+00	.226182280364E+00	.107720054573E+01
.545149696032E+00	.897017824169E+00	.126121726984E+00	.114575108148E+01
.403524731475E+00	.682091944716E+00	.177770253504E+01	.151269732557E+01
.769796585327E+00	.461707041320E+02	.213446155214E+01	.148690469598E+01
.127534783690E+01	.770041656903E+00	.152046297325E+01	.137154791795E+01
.938626324576E+01	.924667724490E+01	.468115596756E+01	.239556249920E+01
.240634115683E+01	.433762817970E+00	.303947792454E+01	.162003129893E+01
.241136675945E+01	.113273719974E+01	.112229449705E+00	.389241438203E+01

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U MATRIX

IR = 35	.183026903763E+01	.213756283913E+00		
IR = 34	.347758892141E+00	.264538896582E-01	.132650956689E+01	.221353982064E+00
IR = 33	.159051029335E+01	.255412316498E+00	.369887367110E+00	.840673893364E+01
	.115015347245E+01	.391579998300E+00		
IR = 32	.121146434029E+00	.232395588029E+00	.160362439387E+01	.405278544049E+00
	.173284597581E+01	.122315351703E+00	.290247537604E+01	.987904042722E+00
IR = 31	.103730329456E+01	.215348464952E+00	.102290116237E+01	.845651614216E+01
	.112504900505E+01	.210280475237E+00	.863578160315E+00	.563832106546E+01
	.154126735107E+01	.476918662972E+00		
IR = 30	.131245164396E+01	.179241121812E+00	.946678148083E+00	.256528447132E+00
	.932729234205E+00	.266542914472E+00	.176215637961E+01	.176178598089E+00
	.136126900874E+01	.274555233233E+00	.305468657140E+01	.219530219243E+00
IR = 29	.181129000538E+01	.597692901778E+01	.327700910904E+00	.151977673806E+00
	.248363739394E+00	.102617469656E+00	.646498151828E+00	.206482486471E+00
	.635200176342E+00	.651480849755E+01	.181001442174E+01	.388599489250E+01
	.298659394437E+01	.104407236168E+00		
IR = 28	.617358215865E+01	.224524111530E+00	.920879356066E+01	.309705501994E+00
	.450685535092E+00	.149838863045E+00	.120054098046E+01	.332198957581E+00
	.145987999174E+01	.131372147163E+00	.544439541574E+00	.109906382714E+01
	.848643277791E+01	.140801921511E+01	.112664538865E+02	.291407843991E+01
IR = 27	.137942802734E+01	.147775071310E+00	.556041759455E+00	.208909785311E+00
	.425453712699E+00	.163294821284E+00	.207403841651E+00	.671071388189E+01
	.271857827983E+00	.190449079015E+00	.110328579309E+01	.293174893723E+00
	.136343467313E+01	.152674489889E+00	.258734276179E+01	.849244914178E+01
	.107329718714E+01	.411799146957E+00		
IR = 26	.956035602966E+00	.143035078539E+00	.112654263072E+01	.863511938540E+01
	.896289645601E+00	.554075393711E+01	.584661850209E+00	.194815539038E+00
	.104903075370E+00	.230590531593E+00	.929964182314E+00	.428367944025E+00
	.792443314260E+00	.327615356668E+00	.794865164251E+00	.370422896675E+00
	.383644822725E+00	.216769363156E-01	.346093056224E+00	.550172803169E+01

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IR = 25

.310115279398E+01	.132824231745E+00	.473183471385E+01	.309744153437E+00
.479174159705E+01	.475927596885E+00	.362304727990E+01	.394651733805E+00
.203903448744E+01	.310043473690E+00	.716181334043E+00	.829467423320E+01
.270467296089E+01	.368255768054E+00	.411039526038E+01	.500326632587E+00
.331075859837E+01	.258681964907E+00	.159270304653E+01	.257595424247E+00
.476553A77741E+00	.134247941937E+00		

IR = 24

.794662371185E+00	.164476963344E+00	.169504144216E+01	.474566859239E+00
.187258456362E+01	.726951755581E+00	.215158868029E+01	.647508892204E+00
.213149785050E+01	.719434099747E+00	.216272252001E+01	.335288332849E+00
.977239666786E+00	.153127559613E+00	.167378801979E+01	.174651492665E+00
.137169422934E+01	.466724922009E+00	.165777791871E+01	.291516120940E+01
.175863983410E+01	.128021683205E+00	.334055026130E+00	.103221235444E+00

IR = 23

.114772994978E+00	.259465868806E+01	.963621612268E+01	.150644915663E+01
.132434979385E+01	.295479108643E+01	.261811110503E+01	.289371095320E+01
.240864811030E+01	.407388145479E+01	.222271392291E+01	.361331214457E+01
.144419006350E+01	.441799751046E+01	.418380363235E+00	.238132474227E+01
.166369186020E+01	.261183885889E+01	.274025460561E+01	.969349995044E+00
.264726653056E+01	.328195405336E+01	.809837122289E+00	.296264517169E+01
.110639202227E+01	.322822804858E+00		

IR = 22

.601522828919E+00	.214541694644E+00	.238135576826E+01	.413908211845E+00
.182887214905E+01	.379575847371E+00	.438628690842E+01	.878328504839E+00
.580324267766E+01	.931033574581E+00	.776949700075E+01	.168262320334E+01
.600682984902E+01	.940241764294E+00	.532072170315E+01	.109640332865E+01
.195941819693E+01	.957104234597E+00	.397898547607E+01	.144285876090E+01
.482883331362E+01	.132664265614E+01	.524240946207E+01	.260299952090E+01
.385684521566E+01	.964626680548E+00	.677678048574E+00	.568242340750E+00

IR = 21

.240682118188E+00	.103618920693E+01	.106238507162E+01	.247390682282E+01
.187599556347E+01	.172877700181E+01	.112123661872E+01	.137418512217E+01
.278590348032E+01	.271798187826E+01	.434331880537E+01	.248393489703E+01
.431863989414E+01	.538959472889E+01	.428799968828E+01	.300661510503E+01
.341067258129E+01	.323115966231E+01	.199382563686E+01	.143479449236E+01
.347093066784E+01	.214165632536E+01	.285680524125E+01	.159320895507E+01
.502415836314E+01	.335363704697E+01	.302946680017E+01	.175838308843E+01
.159170421966E+00	.156290951492E+00		



IR = 20

.178230523902E+01	.590330650052E+01	.163099198595E+01	.648060219633E+00
.176634301204E+01	.738901883104E+01	.221247613374E+01	.813799176751E+00
.722897917630E+00	.803734086486E+00	.262197204676E+01	.578252046874E+00
.324417866129E+01	.564952919425E+00	.364059255363E+01	.178582007647E+01
.315348996205E+01	.752732300811E+00	.264250133554E+01	.107475614065E+01
.186498990554E+01	.645696968603E+00	.283994361492E+01	.401318006094E+00
.246860387295E+01	.484475501562E+00	.400393778876E+01	.775401825851E+00
.261247326091E+01	.681932392434E+00	.422543210984E+01	.670814871052E+01

IR = 19

.162953698507E+01	.757810825327E+01	.222217151222E+01	.581604650431E+01
.228850857294E+01	.763119061871E+01	.127353139998E+01	.309237978625E+00
.659782915579E+00	.278965956931E+01	.106391296297E+01	.561470389929E+00
.409150164197E+01	.197251581608E+00	.575691991193E+01	.628238935399E+00
.681538442151E+01	.764619430089E+00	.673258196174E+01	.500130865748E+00
.506718954575E+01	.294711843004E+00	.162511728420E+01	.402795797874E+01
.321537956482E+01	.739595447740E+00	.392940187423E+01	.667349380458E+00
.453481171833E+01	.937957448553E+00	.344175156863E+01	.592174251283E+00
.538137073077E+00	.473256540715E+00		

IR = 18

.398756057588E+01	.435538875030E+01	.753752076824E+01	.770183937825E+01
.106924870293E+02	.105174192220E+02	.101170028628E+02	.111028485221E+02
.429726243447E+01	.686127491151E+01	.344316601854E+01	.214172151555E+01
.367326264648E+01	.654200727570E+01	.191660557951E+02	.193963997057E+02
.261871132405E+02	.288826765368E+02	.311673242608E+02	.335513742111E+02
.315132944041E+02	.326155463543E+02	.232662005475E+02	.238022922713E+02
.680611532879E+01	.650431111702E+01	.192438946251E+02	.108181657724E+02
.241903992077E+02	.141925978206E+02	.264694636230E+02	.153525234856E+02
.191450777622E+02	.118157554039E+02	.615083952730E+01	.433809468515E+00

IR = 17

.156107655860E+01	.223772032235E+00	.387367457744E+01	.155879403741E+01
.770664491474E+01	.564168406412E+00	.106890074770E+02	.871012641206E+01
.109687388662E+02	.168335032630E+01	.565719972298E+01	.508671720375E+00
.235174235086E+01	.142088862740E+01	.509069652241E+01	.131142270453E+01
.176968191369E+02	.331899605740E+00	.265075568651E+02	.257158335474E+01
.295740643184E+02	.125744194779E+01	.518314230470E+02	.188427561040E+01
.208481201483E+02	.161390395434E+00	.559704963858E+01	.641886475438E+00
.138074494191E+02	.361321269776E+01	.193060346866E+02	.436272368888E+01
.188371713942E+02	.455795719237E+01	.146327215532E+02	.416544891901E+01
.337871328520E+01	.196583125873E+01		

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IR = 16

.401600334578E+00	.149101089827E+01	.107207417909E+01	.248537746829E+01
.776890190033E+01	.417431992331E+01	.164172932412E+02	.858851089920E+01
.226421600714E+02	.115180667461E+02	.242249608452E+02	.110728588512E+02
.118103928654E+02	.481722602661E+01	.191706187096E+01	.435910083858E+01
.117255065930E+02	.358795721029E+01	.373131206428E+02	.183088330448E+02
.563840572369E+02	.250122017760E+02	.647230811192E+02	.292955327985E+02
.650287068671E+02	.330627797630E+02	.448028190022E+02	.216904405061E+02
.100609046201E+02	.740814235625E+01	.247144071470E+02	.229724868297E+02
.348236874964E+02	.295906159502E+02	.343396084674E+02	.310626753465E+02
.240830847495E+02	.239396548526E+02	.635916818188E+01	.801603012440E+01

IR = 15

.640271358670E+00	.199265050266E+00	.114625828465E+01	.422338807586E+01
.815752255056E+00	.354577357642E+00	.523455737768E+00	.100211807630E+01
.432717338728E+00	.656849524928E+00	.760541014873E+00	.990766032352E+00
.920969987676E+00	.635006087201E+00	.520261217976E+00	.224553468510E+00
.189074261615E+01	.925451054443E+00	.261529902685E+01	.849648991062E+01
.116476728668E+01	.206288417008E+01	.441286678367E+01	.138502220280E+01
.413483249305E+01	.306918818755E+01	.404368440134E+01	.184166867775E+01
.306250222647E+01	.202989670201E+01	.171969092183E+01	.152627109702E+01
.148109432179E+01	.100805727484E+01	.333489455964E+01	.248975483578E+01
.290060433121E+01	.237334510885E+01	.202378135888E+01	.141437411362E+01
.712160010428E+00	.907519234010E+00		

IR = 14

.158036038615E+01	.467476140445E+00	.852438483825E+00	.411387403502E+00
.104215818681E+01	.231092233563E+00	.256634859654E+00	.408793767711E+00
.303873598111E+01	.144343849953E+00	.279292416912E+01	.166996434964E+00
.544398838853E+01	.630239226161E+00	.660943508804E+01	.421915472383E+00
.383142867909E+01	.385014471880E+00	.237351086501E+01	.893846465835E+00
.726083568814E+00	.235457852485E+01	.482813127243E+01	.111364354422E+01
.493476232880E+01	.364131762243E+01	.899606049769E+01	.397907050187E+01
.729544455987E+01	.274557395453E+01	.407929906847E+01	.262095396501E+01
.739164238972E+00	.185436430534E+01	.166374109245E+01	.401686603816E+00
.239888133057E+01	.148547378961E+01	.229820201682E+01	.107625931795E+01
.176291890581E+01	.544447833994E+01	.189255839326E+00	.314785599166E+00

IR = 15

.187905328503E+01	.285783550839E+01	.201641670807E+01	.419488829309E+01
.421526689690E+01	.240021166425E+01	.428279938183E+00	.205890982749E+01
.232043796027E+01	.596680801607E+00	.149833386326E+01	.784813637525E+01
.637377540755E+01	.700144288259E+01	.843749021413E+01	.143193307506E+02
.985516360857E+01	.165988481191E+02	.880150605742E+01	.111610540108E+02
.33502317729AE+01	.619234531252E+01	.591336835223E+01	.299718006087E+01
.242226399287E+01	.100513943504E+02	.114446621683E+02	.955544557827E+01
.833401602707E+01	.109496096693E+02	.109854303333E+02	.158109957444E+02
.974486623837E+01	.829253778047E+01	.375956022110E+01	.139843744931E+01
.408094940539E+01	.275288036523E+01	.164725835286E-01	.552883657568E+01
.182389087131E+01	.285468452683E+01	.216297400773E+01	.512767961472E+01
.154370037756E+01	.633923006106E+00		

IR = 12

.127508987770E+01	.156596618345E+01	.300438946226E+01	.441744764563E+01
.892242623014E+01	.431879776231E+01	.153116479434E+01	.594896632163E+01
.665583486338E+01	.358114233498E+01	.552042633890E+00	.156453797696E+01
.157146823247E+02	.144032282617E+02	.621282038611E+01	.135992474462E+01
.139277421917E+02	.164855701910E+02	.272865981940E+02	.165317552777E+02
.562821391668E+01	.100448948318E+02	.125977941157E+02	.826319170731E+01
.199150418973E+02	.211902780261E+01	.234410841507E+02	.125550062120E+02
.650562410556E+01	.109049483098E+02	.102982465849E+02	.150080897861E+02
.244986792453E+02	.160619943331E+02	.464841745563E+01	.845025803106E+01
.984493849749E+01	.935221597168E+01	.126902176710E+02	.794027383700E+01
.135968812906E+01	.113949061511E+01	.510372202401E+01	.899702698980E+00
.755791938668E+01	.433761845330E+01	.251061210055E+01	.385804401665E+00

IR = 11

.824362906985E+00	.141951552593E+00	.316539814034E+01	.240990009605E+01
.278832210444E+01	.336888716606E+00	.139740333711E+01	.298491407514E+01
.637590531318E+01	.276659663531E+01	.168223615076E+01	.832727338388E+00
.331702590978E+01	.175178817451E+01	.4844888985676E+01	.324827708864E+01
.120853700710E+02	.113430583010E+02	.121534790064E+02	.502560048862E+01
.776075217177E+01	.132620673538E+02	.172161905717E+02	.715762388182E+01
.131775487834E+00	.442004765139E+01	.124335792749E+02	.335165606740E+01
.515955430967E+01	.379735767809E+01	.135526862794E+02	.119279119595E+02
.813142095350E+01	.668908793258E+01	.838653201569E+01	.136639388429E+02
.935069934105E+01	.421490913429E+01	.685819740796E+01	.638279644454E+01
.329069077753E+01	.467952569568E+01	.664750518199E+01	.525662167227E+01
.388310426814E+00	.554519339546E+01	.289869382250E+01	.118848078065E+01
.657607556899E+02	.272000366243E+01		

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IR = 10

.226804718097E+00	.550456654337E+01	.645034947832E+00	.328508997614E+01
.226682079760E+01	.154991562223E+01	.454439768371E+01	.269344803356E+01
.518759199455E+01	.493251769089E+01	.725326116912E+01	.451754936809E+01
.324369371304E+01	.390407505529E+01	.186133724643E+01	.910525636030E+00
.307900661898E+01	.245724254708E+01	.143421067971E+02	.106482252752E+02
.186228738432E+02	.134527965757E+02	.211951369394E+02	.169126988441E+02
.184131774623E+02	.130223071667E+02	.799691481758E+01	.750657382396E+01
.516561723170E+01	.328464620582E+01	.634873317206E+01	.891539955012E+01
.149491242104E+02	.140071391540E+02	.151737164458E+02	.156657636432E+02
.172321322193E+02	.156152825655E+02	.124971705288E+02	.997218977280E+01
.229866750249E+01	.197728821407E+01	.241433805258E+01	.270082446793E+00
.556387737954E+01	.278039036692E+01	.377406436352E+01	.162787957023E+01
.396379062835E+01	.278080737329E+01	.481481019195E+01	.220837498585E+01

IR = 9

.696157916654E+00	.770047396841E+01	.149682748271E+01	.620746751063E+01
.875278134535E+00	.107834688092E+00	.149107719706E+01	.590216037018E+00
.697939701217E+01	.101203403525E+01	.265552842891E+00	.941965492626E+00
.241374221876E+01	.174826936326E+01	.129556657703E+01	.150306842574E+01
.252254900982E+01	.143834360816E+01	.384636424039E+01	.167146610605E+00
.395407467293E+01	.432703390071E+00	.128490457597E+01	.108431885119E+01
.197316143150E+01	.142591136706E+01	.114549124563E+01	.204759684408E+01
.326287025831E+00	.177019882781E+01	.442417149733E+01	.249337569456E+01
.336845363003E+01	.227846907489E+01	.388508353531E+01	.167046900969E+01
.154106852422E+01	.117855884130E+01	.232821639956E+01	.331966186399E+00
.561466747975E+00	.344820454273E+00	.368349646335E+00	.277387708241E+01
.803910229322E+00	.269079459940E+01	.589763748025E+01	.231486733415E+01
.993118268028E+00	.209951782613E+01	.801069623668E+01	.152160867008E+01
.108622437045E+01	.103249819463E+01		

IR = 8

.114476364093E+01	.539751494087E+00	.140326109917E+01	.825642683130E+01
.108513337796E+01	.112167630572E+01	.554421471818E+00	.351465191420E+00
.730073795404E+00	.615379761246E+00	.280956829473E+01	.107294508414E+00
.349369878153E+01	.125410840175E+00	.486587766801E+01	.171577183142E+01
.343828951831E+01	.121131929160E+01	.210360308680E+01	.194198487129E+01
.182067913277E+01	.159085861206E+01	.163750151862E+01	.221652531454E+01
.530799545332E+01	.305331106356E+00	.340798404671E+01	.114478511627E+01
.560960551140E+01	.169515788956E+01	.191312864383E+01	.651556916371E+00
.995741444328E+00	.325855532391E+01	.194752253029E+01	.188722497738E+01
.265934970925E+01	.358323683706E+01	.389371242118E+01	.478045365069E+00
.197834435146E+01	.244128741315E+01	.262786750011E+01	.234628161753E+00
.131417759393E+01	.920472965353E+00	.334707842113E+01	.155036815546E+01
.862783557972E+00	.550071774642E+00	.357694788401E+01	.186634122005E+01
.153593319887E+01	.527229684682E+00	.151324401962E+01	.137225418444E+01

IR = 7

.256690991171E+01	.382323152941E+00	.445729694323E+01	.586684571745E+00
.439941504078E+01	.167814573592E+01	.376277428169E+01	.124624038227E+01
.171581755515E+01	.995274907158E+00	.243511833770E+01	.105223815974E+01
.864428063625E+01	.875724485189E+00	.129973486744E+02	.113250309390E+01
.135396647429E+02	.169004154271E+01	.139882493021E+02	.134708535983E+01
.512904911567E+01	.101173140822E+01	.516482758457E+01	.203156031186E+01
.716497049485E+01	.127210100131E+01	.146309081962E+02	.467506844189E+01
.154497345936E+02	.259894203601E+01	.139873936701E+02	.411960858403E+01
.102232838694E+02	.822991830785E+00	.100359388711E+01	.125864674331E+01
.996413833623E+01	.286450007133E+01	.688043224503E+01	.402121761474E+01
.134031741629E+02	.459353601327E+01	.766260900241E+01	.355474510850E+01
.657420774598E+01	.304785490515E+01	.281266383428E+01	.147689297142E+01
.436109722090E+01	.330104926711E+01	.869625858439E+01	.256746755816E+00
.704238715264E+01	.359075780645E+01	.849629843971E+01	.882195819427E+00
.322992137788E+01	.177195265051E+01		

IR = 6

.572019700696E+00	.222190828574E+00	.457751832046E+01	.241518185960E+00
.139127783069E+01	.724079895812E+00	.492235175083E+00	.830654118277E+00
.710289170818E+00	.570271204777E+00	.134418238126E+01	.741995306686E+00
.713863042060E+00	.856695672026E+00	.136365230706E+01	.156480739195E+01
.124540690413E+01	.110553449030E+01	.429264190087E+00	.951776977455E+00
.317569846926E+01	.243724555832E+01	.167450543119E+01	.789038966518E+00
.240481326699E+01	.433900067549E+01	.653684335449E+00	.253491816458E+01
.196441601319E+01	.444401558383E+01	.202835876970E+01	.168049784806E+00
.197793843102E+00	.235458268625E+01	.302931522902E+01	.115105490894E+01
.497564912073E+01	.324506321784E+01	.564363834078E+01	.454652260514E+01
.314278803309E+01	.195823174818E+01	.460240454382E+01	.466079952106E+01
.108838837013E+01	.124829775987E+01	.133513959825E+01	.277845872386E+01
.415722359414E+01	.144433606336E+01	.365286107510E+01	.205161945321E+01
.446478537503E+01	.207378592707E+00	.319572883274E+01	.142814781431E+01
.388871336682E+01	.957077044428E+00	.218169374117E+01	.294390019242E+00

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IR 5

.942602484971E+00	.679188941949E+01	.580637881939E+00	.943767957035E+01
.796541103426E+00	.108526616495E+01	.354867284735E+00	.116819243753E+01
.296859415911E+01	.142875661853E+01	.161623666972E+01	.161884532282E+01
.138076367981E+01	.304107582002E+00	.185488114602E+01	.214152566003E+01
.965262094735E+00	.299522086366E+01	.918832827773E+00	.318733625672E+01
.938715595193E+00	.188897875592E+01	.985435650043E+00	.238527433347E+01
.235362478982E+01	.155899254201E+01	.324632454903E+01	.162059078844E+01
.315033363548E+01	.386856552403E+01	.176122719724E+01	.634612654566E+00
.158620534678E+01	.447710507961E+01	.467272258158E+00	.150006630945E+01
.914730469990E+00	.203616999226E+01	.444332161615E+01	.164255640128E+01
.398865485232E+01	.478362315804E+00	.383646561084E+01	.332153742360E+01
.260406149748E+01	.158465341263E+01	.223467751691E+01	.319369832322E+01
.651536329784E+00	.506708864677E+00	.286467751897E+01	.150931995548E+01
.281603993247E+01	.221363746721E+00	.283845140894E+01	.216880939419E+01
.279448617873E+01	.815447553375E+00	.257923024123E+01	.149258308965E+01
.221181442253E+01	.102682223409E+01		

IR 4

.283252833355E+01	.262548357564E+00	.125258606243E+01	.182639555180E+00
.381751776812E+00	.703518071778E+00	.202017537735E+00	.141439852186E+01
.730822140869E+01	.280319300323E+01	.218825858357E+00	.290633445870E+01
.489451633377E+00	.290847929610E+01	.719677586995E+00	.138542654125E+01
.942340068040E+00	.503576244257E+00	.354738351645E+00	.316985967290E+01
.890119177904E+00	.392941716486E+01	.489394038803E+00	.526595750396E+01
.296790303195E+00	.424688744721E+01	.906059964055E+00	.256563964896E+01
.982806304574E+00	.155859690574E+01	.165574620596E+01	.301413488831E+01
.107036259102E+02	.837505095780E+01	.146929423497E+01	.542242122355E+01
.699972599683E+00	.523211986814E+01	.230912032214E+00	.278592206005E+01
.153558254587E+01	.940246030136E+00	.502404113677E+00	.313138635150E+01
.203737197589E+01	.429851693599E+01	.212288108126E+00	.497875358874E+01
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.603600738063E+00	.241308796611E+00	.138825921263E+01	.194291694793E+01
.113888966702E+01	.207172971061E+01	.165695574324E+01	.281020537718E+01
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.477150140504E+01	.417837297099E+01	.924550722082E+02	.165810723026E+00
.156931131449E+00	.543537629254E+00	.622325167465E+00	.111923013740E+01
.104206081663E+01	.173322503945E+01	.118499610144E+01	.191716801060E+01
.990024939626E+00	.142339484089E+01	.986532310274E-01	.171761540011E+02
.215876295140E+00	.512387337958E+01	.158378370478E+00	.117112417807E+00
.391885600199E-01	.149835545985E+00	.745915384661E+01	.151454337227E+00
.116172900594E+00	.118024634342E+00	.830816741603E-01	.206355090460E-01
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.749070909744E-01	.308236421467E-01	.492567511647E-01	.226344507660E-01
.213078028037E-01	.113499583182E-01		



## APPENDIX D

### PROGRAM FOR COMPUTING AERODYNAMIC FORCES FROM SUBSONIC

#### KERNEL L-U MATRICES, GENFLU

Program GENFLU uses the vibration mode independent L-U matrices from program LUCMAT, and the vibration mode information from program MPROC to generate the complex generalized force matrices. Normally GENFLU is run as a job step subsequent to the execution of LUCMAT and prior to the execution of program FLUTDET in the flutter analysis job stream. As the generalized force matrices are independent of the flow density, the generalized force file should be saved for later use by FLUTDET for other density values.

Program GENFLU is set up for dynamic storage. It calculates the required central memory field length and reduces the field length to that required for execution. The central memory required is  $16,100g + (2*NCP + 5*NCP*NM + 2*NM**2)$ , where NCP = number of collocation points, and NM = number of vibration modes. For NCP = 36 and NM = 10, approximately 22,200g words are required.

The absolute binary program is stored on the permanent file system as an indirect access, semiprivate file named GENFLU (the overlay file name). Access to GENFLU is obtained by the control card

```
GET,GENFLU/UN=052061N,PW=GNFLUV1.
```

The files declared by the program are (in order) MODEF, LUF, GENF, and OUTPUT. File MODEF is equivalenced to TAPE7 in the program, LUF is equivalenced to TAPE9, and GENF is equivalenced to TAPE10. Note that there is no INPUT file. Program GENFLU reads from binary file LUF and coded file MODEF. These files contain all necessary data for the execution of GENFLU. The resulting aerodynamic forces are written on binary file GENF. File MODEF is described in the documentation of program MPROC, and file LUF is described in the documentation of program LUCMAT. Although LUF may contain the matrices for several reduced frequencies and several Mach numbers as a single binary file, program GENFLU writes an end-of-file mark on file GENF between Mach numbers. Thus the generalized forces for each Mach number on GENF can be selected by file manipulation, using the COPYBR control card, for execution of FLUTDET. File GENF is not rewound within program GENFLU. The OUTPUT file is used by GENFLU only for system error messages.

A short program called GNFPRNT reads and lists the file GENF and serves to document file GENF. A listing of GNFPRNT and its OUTPUT for the sample case are presented in this Appendix.

## Control Deck

A typical BATCH processing control deck for executing only GENFLU is

```
BGENFLU,T0200,CM023000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC)
GET,LUF=SAVLUF.                  (get previously saved LUF)
GET,MODEF=SAVMODE.              (get previously saved MODEF from
GET,GENFLU/UN=052061N,PW=GNFLUV1.  MPROC execution)
GENFLU.
SAVE,GENF=SAVGENT.              (save GENF file as permanent file
--eoi--                          named SAVGENF)
```

In the above example LUF and MODEF were available from previous executions of LUCMAT and MPROC, respectively. In many cases GENFLU is executed as a job step in the same run as LUCMAT and SUBMAT. A BATCH processing control deck for this case is

```
SUBGENF,T0600,CM023000.          BLDG648          YOUR NAME
USER,. . . (your user number/your password)
CHARGE, . . . (your account number, LRC.)
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
GET,LUCMAT/UN=052061N,PW=LUCMTV1.
GET,GENFLU/UN=052061N,PW=GNFLUV1.
GET,MODEF=SAVMODE.              (get previously saved MODEF)
SUBCMAT.
LUCMAT.
SAVE,LUF=SAVLUF.                (save the LU file as a permanent file
GENFLU.                          named SAVLUF - Caution: This can be
SAVE,GENF=SAVGENT.              a large file.)
--eor--                          (save GENF as permanent file named
INPUT DATA (for SUBCMAT only)  SAVGENF)
--eoi--
```

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Listing of Sample OUTPUT

4AFQBIT, 78/05/08,NASA/LRC CY175-T NOS 1.2 (T11)

14.13.35.GENFLU,T0400,CM060000,  
14.13.35.B648 RB R M BENNETT/EXT2661 29  
14.13.35.USER,052061N,.  
14.13.36.CHARGE,100652,LRC.  
14.13.36.GET,LUF=LUF8.  
14.13.40.GET,MODEF=STPE2.  
14.13.41.GET,GENFLU/UN=052061N,PW=  
14.13.47.GENFLU.  
14.13.59. END GENFLU  
14.13.59. 4.640 CP SECONDS EXECUTION TIME  
14.13.59.SAVE,GENF=GENF5.  
14.14.00.UEAD, 0.002KUNS.  
14.14.00.UEPF, 0.255KUNS.  
14.14.00.UEMS, 0.943KUNS.  
14.14.00. 175 CPU SEC = UECP/5  
14.14.00.UECP, 4.740SECS.  
14.14.00.AESR, 18.163UNTS.

Listing of Program GNFPRT (Prints File GENF)

08

```

PROGRAM GNFPRT( OUTPUT = 100B, GENF = 1000B, TAPE10 = GENF)
*****
*
* PROGRAM GNFPRT READS A SINGLE BINARY FILE FROM GENF (TAPE10)
* GENERATED BY PROGRAM GENFLU AND PRINTS ITS CONTENTS ON THE
* OUTPUT FILE.
*
*****
      COMPLEX A(24,24)
      INTEGER IDA(8),IOS(8)
      READ (10) IDA,IDS,EMACH,BREF,VOLUME,NDF,NRF
      PRINT 100, IDA,IDS
      PRINT 101, EMACH
      PRINT 102, BREF,VOLUME
      PRINT 103, NDF,NRF
      DO 10 K = 1,NRF
        READ (10) RF, ( (A(I,J), I = 1,NDF), J = 1,NDF)
        PRINT 104, RF
        PRINT 105, ( (A(I,J), I = 1,NDF), J = 1,NDF)
10      CONTINUE
100     FORMAT(1H1,///< GENF FILE, IDA = *8A10/11X* IOS = *8A10)
101     FORMAT(///< MACH NUMBER =*G20.12)
102     FORMAT(///< BREF =*G20.12* VOLUME =*G20.12)
103     FORMAT(///< NO. RED. FREQ. =*I4* NO. VIB. MODES =*I4)
104     FORMAT(1H1,///< REDUCED FREQUENCY =*G20.12/
      A      4X*( (A(I,J), I = 1,NDF), J =1,NDF) =*)
105     FORMAT(4X,2E20.12,8X,2E20.12)
      END

```

Listing of File GENF (OUTPUT OF GNFPRNT)

GENF FILE, IDA = SUBSONIC KERNEL CALCULATIONS USING L=U PROGRAM = FLUT, SUPP, W. = 6 X 6 NOMINAL  
INS = MEASURED MODES FOR FLUTTER SUPPRESSION WING = MEASURED AMPLITUDES

MACH NUMBER = .800000000000

BREF = 1.000000000000 VOLUME = 1.72478773481

NO. RED. FREQ. = 9 NO. VIB. MODES = 10

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REDUCED FREQUENCY = 10.000000000

( (A(I,J), I = 1,NDF), J = 1,NDF) =

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.149593587874E+01	.114979293218E+01	.165615336438E+01	.190557920734E+01
.135150251343E+01	.195174846268E+01	.370457485577E+01	.167180114996E+01
.188250986705E+01	.103283805006E+01	.229755405229E+01	.978009632399E+00
.820441315245E+00	.176871079984E+00	.134583984137E+01	.456630470171E+01
.828324242303E+00	.334039602703E+01	.712428970787E+00	.215082967312E+01
.868013382392E+00	.197785214137E+01	.125890844430E+01	.627710152109E+00
.149293215069E+01	.382208646364E+00	.535301350203E+00	.232552769017E+00
.298517499447E+00	.131114730784E+00	.943538416595E+00	.402705734853E+00
.847202156171E+00	.469561801184E+00	.669258650007E+00	.270470230190E+01
.731515624746E+00	.550262978418E+01	.203429587387E+00	.400121431264E+01
.266668937117E+00	.220522651325E+01	.169558712998E+01	.307573354361E+01
.513648959494E+00	.647653404274E+01	.110325175824E+01	.106790427053E+01
.101636287289E+01	.131138927034E+01	.114870300213E+00	.761289003599E+00
.231613387055E+00	.251480989125E+01	.749426421427E+00	.403218865631E+01
.393354270152E+01	.296565337002E+01	.653260077570E+01	.171146275812E+01
.191277074701E+01	.215626026211E+01	.473879342928E+00	.270557569965E+00
.973377875756E+00	.328352460529E+00	.135106575101E+01	.117436996356E+01
.170064821592E+01	.877568022665E+00	.114945673677E+01	.644714550059E+00
.458880562805E+00	.207252992328E+01	.513831190853E+00	.211102691711E+01
.833955479322E+00	.330239706478E+01	.127834093703E+01	.436410463729E+01
.142375559470E+01	.158159860817E+01	.158395192799E+01	.885736277331E+00
.150153620064E+01	.177378716946E+01	.433525994969E+01	.884063229108E+00
.310854936657E+01	.122787452930E+00	.124893250300E+01	.362542313492E+01
.121726600681E+01	.302641812807E+01	.101748456428E+01	.491427801542E+01
.163437343322E+01	.804688430068E+01	.152620850144E+01	.111455207659E+01
.164712982980E+01	.637129130388E+00	.128995322310E+01	.294690565345E+01
.106699387659E+01	.550602530168E+00	.232473796552E+00	.353250454337E+00
.747264520771E+00	.666370929541E+00	.412820369733E+01	.124119771743E+00
.104154013246E+01	.664931311119E+00	.586162282616E+00	.495281936992E+00
.165128631624E+01	.165839805478E+01	.199414348086E+01	.202816059785E+01
.942025178025E+00	.127487326839E+01	.243512420249E+01	.686453473774E+00
.108187694833E+01	.328297328814E+00	.680329480139E+00	.195512962877E+01
.463497770237E+00	.103593947328E+01	.132483849253E+01	.370130395851E+00
.369671756752E+00	.128249955331E+01	.199645460332E+01	.182164896296E+01
.247195038568E+01	.271605091334E+01	.742852893282E+00	.824304388824E+00
.196083379258E+01	.177594971050E+01	.254256002622E+01	.267487116964E+00
.327605510322E+01	.216039249654E+00	.104120547862E+01	.247771863356E+00
.189520912840E+01	.207273421143E+01	.947817871360E+01	.426734815294E+01
.297372149602E+01	.151599948150E+01	.381159065564E+01	.931107884656E+00
.228256049656E+00	.446229511728E+01		

REDUCED FREQUENCY = 4.70588235294

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=.455232926252E+00 = .345305051769E+00  
.685059722153E+00 = .113766722803E+01  
.188089234476E+01 = .865842332153E+00  
=.247835942673E+00 = .819104344085E+00  
=.186833712011E+00 = .585132210457E+01  
.418933248483E+00 = .104241786273E+01  
.150190885881E+00 = .515577764494E+00  
=.160960622794E+01 = .119212031322E+01  
=.121737163792E+01 = .138253965553E+01  
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.755495907536E+00 = .424496622417E+00

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OF POOR QUALITY.

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.203820834619E+00	.339796509487E+01	.645008951228E+00	.198837105122E+00
.131030092136E+00	.580433447114E+01	.331665015915E+00	.151587403453E+01
.394020568560E+00	.226127882397E+00	.405269893049E+00	.726305966256E+00
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.815373891700E+01	.304560410557E+01	.188865859932E+00	.283091724443E+02
.230677730850E+00	.238827851107E+00	.214725148655E+00	.385309144728E+00
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.20338099118AE+00	.386515834101E+00	.588859480094E+02	.976752074444E+01
.368655128226E+01	.217554942736E+00	.558237851328E+01	.153817613708E+00
.109246920328E+01	.600793443790E+00	.390137243845E+00	.406298944553E+00
.155607714690E+00	.744462747788E+00	.343462726972E+01	.472644221603E+00
.167702539718E+00	.110920463606E+00	.384569779122E+00	.496601241579E+00
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.502471283951E+00	.699441189568E+00	.393805568338E+00	.183092439498E+00
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.103022719468E+00	.159066594753E+00	.154323707859E+00	.181117659377E+00
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.442132243944E-01	.639667033245E+02	.284678543714E+00	.586889334254E+01
.805811194040E-01	.274946215211E+01	.180904301600E+00	.172092691548E+01
.155249302235E+00	.176859052628E+00	.117629759056E+00	.220057825073E+00
.479089216964E-01	.246481461234E+00	.894644981470E+01	.233006960699E+02
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.606679179169E-01	.335633706302E+00	.353140219860E+01	.933700851716E+01
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.464422029652E+00	.546997074269E+01	.278337157528E+00	.543159253602E+01
.187068759119E+00	.472774132759E+03	.540519543912E+00	.163202421464E+00
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.520112117183E+00	.405277029713E+00
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OF POOR QUALITY

REDUCED FREQUENCY = .526315789474

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.592111509611E+01	.839087018729E+02	.302654141079E+00	.187422145059E+01
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.175050935134E+01	.104469518774E+00	.136444879395E+00	.795419158213E+02
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## APPENDIX E

### PARAMETRIC FLUTTER EIGENVALUE PROGRAM, FLUTDET

Program FLUTDET reads the unsteady aerodynamic forces and calculates the flutter speed at a particular Mach number for several densities or altitudes using a conventional V-g type of analysis. Although designed to interface directly with program GENFLU, which calculates unsteady aerodynamic forces from subsonic kernel L-U matrices, other compatible sources may be used. The aerodynamic forces are input for a few selected values of reduced frequency and are interpolated by FLUTDET for additional, closely-spaced values. The flutter characteristics are calculated, and V-g plots are generated for each density.

The program is overlaid to reduce the central memory field length requirements. It is dimensioned for 16 vibration modes and requires approximately 32,000<sub>8</sub> words of central memory for execution.

The absolute binary program is stored on the permanent file system as an indirect access, semiprivate file named FLUTDET (the overlay file name). Access to FLUTDET is obtained by the control card

```
GET,FLUTDET/UN=052061N,PW=FLTDTVL.
```

The files declared by the program are (in order) INPUT, GENF, OUTPUT, FLSCH, TAPE4, and TAPE7. GENF is equivalenced to TAPE3 within the program, and FLSCH is equivalenced to TAPE8. TAPE4 is an internal disk file used to store the interpolated aerodynamic forces. FLSCH is an internal disk scratch file used during interpolation of the aerodynamic forces. TAPE7 is an internal disk file used to store the eigenvalues for the plotting overlay. In addition to the files declared for the program card, subroutine PSEUDO declares a file named SAVPLT which contains the plot vector file for subsequent post-processing for the desired plotter. File GENF is a binary (unformatted) file that contains the unsteady aerodynamic forces and is described in the section documenting program GENFLU.

The plots generated by FLUTDET for the sample case are presented in figure 4.



## Control Deck

A typical BATCH processing control deck for executing only FLUTDET for one Mach number is

```
BFLUTDT,T0600,CM060000.          BLDG648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC)
GET,GENF=SAVGENF.                (get previously saved GENF)
GET,FLUTDET/UN=052061N,PW=FLTDTV1.
FLUTDET.
ATTACH,PLOT/UN=LIBRARY.          (get plotting pose processor)
PLOT.VARIAN
EXIT.
ATTACH,PLOT/UN=LIBRARY.          (or other desired error
--eor--                          processing)
INPUT DATA FOR FLUTDET
--eoi--
```

File GENF is a multi-file if several Mach numbers are run with a single execution of SUBCMAT. A sample control deck for the second Mach number is

```
BFLUTDT,T0600,CM060000.          BLDG648          YOUR NAME
USER, . . . (your user number, your password)
CHARGE, . . . (your account number, LRC)
GET,GENF=SAVGENF.                (get previously saved GENF)
COPYBR,GENF,GF1.
COPYBR,GENF,GF2.
REWIND,GF1,GF2
GET,FLUTDET/UN=052061N,PW=FLTDTV1.
FLUTDET,,GF2.
ATTACH,PLOT/UN=LIBRARY,
PLOT.VARIAN
EXIT.
ATTACH,PLOT/UN=LIBRARY.
PLOT.VARIAN
--eor--
INPUT DATA for 2nd Mach number
--eoi--
```

In the above examples GENF was available from previous executions of GENFLU. In some cases FLUTDET will be executed as a job step in the same run as SUBCMAT, LUCMAT, and GENFLU. A BATCH processing control deck for this

case is

```
SUBFLTR,T1000,CM060000.          BLDG.648          YOUR NAME
USER, . . . (your user number/your password)
CHARGE, . . . (your account number, LRC.)
GET,SUBCMAT/UN=052061N,PW=SBCMTV1.
GET,LUCMAT/UN=052061N,PW=LUCMTV1.
GET,GENFLU/UN=052061N,PW=GNELUV1.
GET,FLUTDET/UN=052061N,PW=FLTDTV1.
GET,MODEF=SAVMODE.              (get previously saveddMODEF)
SUBCMAT.
LUCMAT.
SAVE,LUF=SAVLUF.                (save the LU file as a permanent
GENFLU.                          file named SAVLUF)
SAVE,GENF=SAVGENT.
REWIND,GENF.                    (save GENF as permanent file
FLUTDET.                        named SAVGENF)
ATTACH,PLOT/UN=LIBRARY.
PLOT.VARIAN
EXIT.
ATTACH,PLOT/UN=LIBRARY
PLOT.VARIAN
--eor--
INPUT DATA (for SUBCMAT only)
--eor--
INPUT DATA (for FLUTDET only)
--eoi--
```

In this example the L-U file and the generalized force file (GENF) are saved for future restart capability with different vibration modes or flutter parameters. For this case, program MPROC has been previously executed to generate file MODEF.

#### Description of the Flutter Determinant

The flutter equation solved by the program is

$$[\omega^2 - \omega_i^2(1 + ig_i + ig)]M_i q_i + \sum_{j=1}^n A_{ij} q_j = 0, \quad i = 1(1)n \quad (1)$$

where

$\omega$  is the frequency of vibration (radians/sec)

$\omega_i$  is the frequency of the  $i$ th natural vibration mode (radians/sec)

$g_i$  is the modal damping coefficient in the  $i$ th natural vibration mode (dimensionless)

$g$  is the incremental damping, a parameter introduced by the program so that linear eigenvalue techniques can be used (dimensionless)

$M_i$  is the generalized mass associated with the  $i$ th natural mode (kilograms)

$q_i$  is the component of the  $i$ th natural mode in the flutter eigenvector (meters)

$A_{ij}$  is the generalized aerodynamic force resulting from the pressure induced by the  $j$ th mode acting through the displacements of the  $i$ th mode (Newtons/meter)

$n$  is the number of vibration modes

The dimensional quantities above are given in metric units; however, any consistent set of units may be used.

The quantities  $M_i$  and  $A_{ij}$  are defined by integrals

$$\begin{aligned} M_i &= \iint_W m(x,y) h_i^2(x,y) dx dy \\ A_{ij} &= \iint_W h_i(x,y) \Delta p_j(x,y) dx dy \end{aligned} \quad (2)$$

where

$m(x,y)$  is the mass per unit area (kilograms/square meter)

$h_i(x,y)$  is the deflection in the  $i$ th mode (dimensionless)

$x,y$  are cartesian coordinates (meters)

$W$  is the lifting surface (or half of the lifting surface if the loading is symmetric or antisymmetric. However, it must be the same for both integrals.)

$\Delta p_j(x,y)$  is the difference in pressure between the upper and lower surfaces resulting from the downwash by the  $j$ th dimensionless natural mode (newtons per square meter per meter of displacement, i.e., newtons/cubic meter)

Equation (1) is in physical units. However, most unsteady aerodynamic programs will generate dimensionless generalized aerodynamic forces.

Let

$$\bar{A}_{ij} = \iint_w h_i(x,y) \frac{b_o \Delta p_j(x,y)}{\frac{1}{2} \rho V^2} \frac{dx}{b_o} \frac{dy}{b_o}$$

where

$$h_i(x,y), \frac{b_o \Delta p_j(x,y)}{\frac{1}{2} \rho V^2} \frac{dx}{b_o}, \text{ and } \frac{dy}{b_o} \quad (3)$$

are all dimensionless and

$b_o$  = reference length, meters, usually root semichord

$\rho$  = air density,  $\text{k/m}^3$

$V$  = velocity, m/s

Then

$$A_{ij} = \frac{1}{2} \rho V^2 b_o \bar{A}_{ij}$$

and noting that

$$(1 + ig_i + ig) \approx (1 + ig_i) (1 + ig)$$

as  $g_i$  or  $g \rightarrow 0$ , one may write equation (1) as

$$\left[ \left( \frac{\omega b_o}{V} \right)^2 - \left( \frac{\omega_i b_o}{V} \right) (1 + ig_i) (1 + ig) \right] q_i + \sum_{j=1}^n \frac{\frac{1}{2} \rho b_o^3 \bar{A}_{ij}}{M_i} q_j = 0$$

Noting that  $\frac{\omega b_o}{V} = k$ , the reduced frequency, and letting

$$\Omega = \left( \frac{\omega_o b_o}{V} \right)^2 (1 + ig) \quad (4)$$

where the reference frequency,  $\omega_o$ , is usually taken to be the modal frequency,  $\omega_i$ , of the mode that the user estimates to be nearest the flutter frequency,

*0-2*

one then obtains

$$\sum_{j=1}^n (C_{ij} - \delta_{ij}\Omega)q_j = 0 \quad i = 1(1)n \quad (5)$$

where

$$C_{ij} = \left(\frac{\omega_o}{\omega_i}\right)^2 \frac{1}{(1 + ig_i)} \left( \frac{\frac{1}{2}\rho b_o^3 \bar{A}_{ij}}{M_i} + \delta_{ij}k^2 \right) \quad (6)$$

Equation (5), above, is solved by a matrix eigenvalue routine. The results,  $\Omega$ , are presented as plots of incremental damping,  $g$ , versus flutter speed index,  $F$ , where

$$F = \frac{V}{\omega_o b_o \sqrt{\mu}}$$

The mass ratio,  $\mu$ , is given by

$$\mu = \frac{M_o}{\bar{v} b_o^3 \rho} \quad (7)$$

where  $M_o$  is any convenient reference mass and is usually

$$M_o = \iint_{\bar{v}} m(x,y) dx dy \quad (8)$$

the mass of the lifting surface, and where  $\bar{v}$  is a dimensionless reference volume usually given by

$$\bar{v} = \frac{1}{b_o^3} \int_{\text{span}} \pi b^2(y) dy \quad (9)$$

but can be set to 1.0 if desired. In equation (9), span is the full or semispan consistent with  $W$ , usually the semispan.

## Data Setup

Program FLUTDET reads the flutter parameters from the INPUT file and the aerodynamic forces from binary file GENF. The INPUT file will be described and followed by a brief description of GENF (which has been described in the document of program GENFLU).

Description of the INPUT file.— The INPUT file consists of a case identification card followed by several variables read in a NAMELIST format. The single case identification card is read into an 8-word array, IDFL, in an 8A10 format. The NAMELIST name is NAME1. Note that some of the variables are preset to default values and need not be read unless values other than default are desired.

The variables in NAME1, their definitions and their default values, if any, are as follows.

- IGAIN     the gain of the interpolation formula. The  $\bar{A}_{ij}$ 's from GENF are interpolated versus  $k$  such that there are IGAIN-1 interpolated  $\bar{A}_{ij}$  values between every adjacent pair of  $\bar{A}_{ij}$  from GENF. Default = 20, maximum = 40, minimum = 2
- ITER     the number of Laguerre iterations used in solving for the eigenvalues from equation 5. If ITER is too small, discontinuities will appear on the V-g plots.  
Default = 1.0
- BREF     reference length,  $b_0$   
Default = 1.0
- VOLUME   the dimensionless volume,  $\bar{v}$  (see equation 9). If omitted, the value read from GENF will be used. If included, the value read by the NAMELIST overrides the value read from GENF.  
No Default
- NMP     number of vibration modes to be processed. If NMP = 0, it is set to NDF. This parameter permits the use of only the first NMP modes from the input files.  
Default = 0, maximum = NDF
- (GMASS(I), I=1, NMP)     the generalized mass array ( $M_i$  is defined by equation 2).  
Default = 16\*1.0
- REFMASS   the reference mass used in the calculation of mass ratio and flutter speed index (see equations 7-8). If REFMASS = 0, it is set to 4.\*GMASS(1).  
Default = 1.0

(FREQ(I),I=1,NMP) array of modal vibration frequencies ( $\omega_i$  in equation 6).  
Ascending order is recommended. Zero values (rigid body modes) must precede all nonzero values.  
No default values

NEM unused parameter

MPS parameter for unimplemented option. Must be .FALSE.  
Default = .F.

REFREQ reference frequency ( $\omega_0$  in equation 6). If REFREQ = 0., it is set to the third nonzero value of FREQ.  
Default = 1.0

(G(I),I=1, NMP) array of modal damping coefficients ( $g_i$  in equation 6).  
Default = 16\*0.0.

NA number of altitudes or density values to be calculated.  
Default = 1, maximum = 40

(ALT(I),I=1,NA) array of altitudes or densities. If CONV(2) = 0, ALT(I) is the density value. If CONV(2)  $\neq$  0, the ALT(I) is the geometric altitude in physical units (usually meters).  
Default is ALT(1) = 0. (sea level) and ALT(2) through ALT(10) = the discontinuities of the temperature scale in meters; ALT(11) - ALT(40) are not defaulted.

(CONV(I),I=1,4) a four-word array of unit conversion factors, CONV(1) is a multiplicative factor that converts the user's generalized aerodynamic forces to the  $\bar{A}_{ij}$ 's of equation 3. That is  $\bar{A}_{ij} = \text{CONV}(1) * A_{ij,u}$ . Default = 1.0.

CONV(2) is the factor by which the values of ALT(I) must be divided to give the altitude in feet for entry into the standard atmosphere subroutine, AT62. If CONV(2) = 0, ALT(I) is taken to be the value of density.  
Default = 0.3048.

CONV(3) is the factor by which the density output from the atmospheric subroutine in slugs/ft<sup>3</sup> must be multiplied to give a density ( $\rho$ ) consistent with the units of  $b_0$  and  $M_i$  in equation 6. If CONV(2) = 0, then CONV(3) applies to the value of density supplied in ALT(I).  
Default = 515.379

CONV(4) is the factor by which the speed of sound output from the atmospheric subroutine in ft/sec must be multiplied to give units consistent with  $b_o$ .

Default = 0.3048

Examples: If  $b_o$  is in meters and  $M_i$  is in kilograms, default values for CONV(2) through CONV(4) should be used. If  $b_o$  is in feet and  $M_i$  is in slugs, CONV(2) through CONV(4) should be set to 1.0.

The following six NAMELIST parameters are used for scaling the  $g$  vs  $V$  (flutter speed index) plot.

GMIN        the minimum value of  $g$  (incremental damping) to be plotted.  
Default = 0.7

GMAX        the maximum value of  $g$  to be plotted.  
Default = 0.3

YSPAN       the length of the  $Y$  (or  $g$ ) axis of the plot in inches.  
Default = 10.0

FMIN        the minimum value of  $F$  (flutter speed index) to be plotted.  
Default = 0., minimum = 0.0

FMAX        the maximum value of  $F$  to be plotted.  
Default = 3.0

XSPAN       the length of the  $x$  (or  $F$ ) axis in inches.  
Default = 15.0

GTK and FTK are unused parameters.

Description of file GENF.— The aerodynamic force file GENF consists of a single binary file of NRF + 1 records. The first record contains 21 words: (IDA(I), I=1,8), (IDS(I), I=1,8), EM, BREF, VOLUME, NDF, NRF, where IDA is the aerodynamic identification card (passed from SUBCMAT), IDS is the structural mode identification card (passed from MPROC), EM is the Mach number, VOLUME is the dimensionless reference volume, NDF is number of vibration modes, and NRF is the number of reduced frequencies. The next NRF records contain  $1+2*NDF**2$  words, RF, ((A(I,J), I=1,NDF), J=1,NDF) where RF is the reduced frequency  $k$  and A(I,J) is the complex  $\bar{A}_{ij}$  for the value of RF. The reduced frequencies RF must be monotonic (monotonically decreasing preferred).



### Program Limits

The limits on the various integer input quantities are summarized below

IGAIN	2 through 40
ITER	1 or more
NA	1 through 40
NDF	1 through 16
NK	3 or more
NMP	1 through NDF

### Program Output

Program FLUTDET prints the flutter results on the OUTPUT file. The plot vector file for the V-g plots is placed in file SAVPLT (declared by subroutine PSEUDO) for later postprocessing.

The OUTPUT file contains the heading information followed by a reflection of the input data. The flutter results for each altitude are listed in order of decreasing reduced frequency. The column labeled mode refers to the branch of the V-g curve in essentially the order of the modes at the highest value of  $k$ . The headings for the velocities is listed as meters/sec but will be in the units the user employs. The units for altitude are listed as meters but are those appropriate for altitude, except that the density is listed if CONV(2) = 0.0 (density values supplied by the user). The quantities DG/DRF and DFSI/DG are the derivatives  $dg/dk$  and  $dF/dk$  determined by differencing. They provide the user an indication of the slope of the flutter crossing without reference to the plots. The scales on the V-g plots are not labeled and should be chosen to permit easy scaling with a ruler (1 unit per inch of plot, etc.). The value for altitude listed on the plot is also density if CONV(2) = 0.

Divergence calculations are made with FLUTDET providing the aerodynamics are given for  $k = 0$ , since the eigenvalue problem has been formulated such that it is valid for  $k = 0$ . However, the interpolation for the divergence crossings is erratic and the divergence results may or may not be printed as a flutter crossing of essentially zero value of  $k$  (this situation can be alleviated, however, by setting  $g_1$  to a small negative value such as  $-.001$ ). The divergence condition will appear on the V-g plot as a branch of the plot that approaches the  $g = 0$  line as  $k$  approaches zero.

Listing of Sample INPUT Data

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FLUTTER CHECK RUN FOR NOMINAL CASE USING SUBCMAT WITH CONVERSION FACTOR INCLUDED  
SNAME1 REFFREQ= 97.955, FREQ(1)=46.935, 97.955, 144.827, 154.629, 240.081,  
272.062, 288.147, 302.535, 364.865,  
GMASS(1)=.10529, .03349, .07298, .04934, .12916, .05619, .02405, .17267, .09901,  
REFMASS= 1.862,  
CONV(2)=0., 1., 0., IGAIN=40., BREF=2.89208,  
FMAX= 1.0, XSPAN=10., GMIN=.5, GMAX=.3, YSPAN=8.,  
NMP=9,  
NA=6, ALT(1)= .005000, .003851, .002569, .001795, .001020, .000500\$



NEM = 0,  
 MPS = F,  
 REFFREQ = .97955E+02,  
 G = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  
 NA = 6,  
 ALT = .5E+02, .3851E+02, .2569E+02, .1795E+02, .102E+02, .5E+03, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  
 0.0,  
 0.0, 0.0, 0.0, 0.0,  
 CONY = .1E+01, 0.0, .1E+01, 0.0,  
 GMIN = .5E+00,  
 GMAX = .3E+00,  
 YSPAN = .8E+01,  
 GTK = .1E+00,  
 FMIN = 0.0,  
 FMAX = .1E+01,  
 XSPAN = .1E+02,  
 FTK = .1E+01,  
 SEND

MODE	REDUCED FREQUENCY	FLUTTER SPEED INDEX	FREQUENCY (RAD/SEC)	FLUTTER SPEED (METERS/SEC)	AIR SPEED (METERS/SEC)	DG/DMF	DFBI/DG	ALTITUDE (METERS)	MASS RATIO
7	1.23558	.708385	256.146	599.593		I =.428332	1.46257	.500000E=02	8.92572
9	1.20526	.882206	311.170	746.670		I =.120503	4.47980	.500000E=02	8.92572
8	1.16252	.881439	299.875	746.020		I =.203708E=01	37.5920	.500000E=02	8.92572
9	1.09030	.944443	301.348	799.345		I =.674531	=1.02779	.500000E=02	8.92572
6	1.07147	.955808	174.282	470.417		I =.403224	.936618	.500000E=02	8.92572
8	1.00491	.994897	242.586	842.047		I =.451448	=1.43327	.500000E=02	8.92572
2	.830405	.302608	73.5393	256.118		I =1.66442	.180291	.500000E=02	8.92572
6	.495063	.931605	134.971	188.479		I =.782800	=.808924	.500000E=02	8.92572
5	.423643	1.50173	186.183	1271.02		I =7.40140	.764589E=01	.500000E=02	8.92572
9	.358364	2.85909	299.848	2419.84		I =.274540E=01	293.970	.500000E=02	8.92572
8	.280946	3.06436	251.948	2593.57		I =4.50225	1.92025	.500000E=02	8.92572
9	.213103	4.77375	297.713	4040.34		I =1.35198E=01	=1655.57	.500000E=02	8.92572
7	.197728	2.47633	143.293	2095.88		I =8.79728	=.715390	.500000E=02	8.92572
8	.173678	4.44946	225.949	3762.49		I =.823051E=01	=245.359	.500000E=02	8.92572
8	.117476	5.83928	200.751	4942.17		I =.833949E=01	347.430	.500000E=02	8.92572
8	.742089E=08	7.32311	.159038E=04	6198.04		I =.240909	7.96362	.500000E=02	8.92572
7	.232902E=08	5.77639	.593712E			I =1.17074	=2.01655	.500000E=02	8.92572
8	.146621E=14	.645079	.276795E=12	545.975		I =-1.84466	=.173639E=01	.500000E=02	8.92572
5	.444347E=13	1.74074	.226363E=10	1473.31		I =.527360	=.241611	.500000E=02	8.92572

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OF POOR QUALITY

9	1.14865	.827098	316.805	797.653	I	.111529	5.08311	.385100E=02	11.5888
7	1.12488	.684631	256.809	660.258	I	.502104	1.24739	.385100E=02	11.5888
8	1.06897	.841377	299.918	811.423	I	.159450E=01	49.3917	.385100E=02	11.5888
6	1.02378	.524028	178.900	505.372	I	.440209	.860861	.385100E=02	11.5888
9	.964072	.940040	302.205	906.574	I	.517469	=1.40172	.385100E=02	11.5888
8	.890446	.993922	295.125	958.537	I	.482343	=1.79242	.385100E=02	11.5888
2	.743810	.295861	73.3832	285.328	I	=2.09639	.138633	.385100E=02	11.5888
6	.431089	.940127	155.145	906.658	I	.848279	=.864206	.385100E=02	11.5888
5	.373458	1.50026	186.834	1446.85	I	=7.20289	=.206139	.385100E=02	11.5888
9	.315006	2.85453	299.846	2752.90	I	=.286162E=01	319.047	.385100E=02	11.5888
8	.247980	3.05072	252.270	2942.11	I	=5.87288	2.12662	.385100E=02	11.5888
9	.187582	4.75960	297.721	4590.15	I	.110562E=01	=2261.42	.385100E=02	11.5888
7	.174144	2.47313	143.616	2385.09	I	=10.3313	=.798158	.385100E=02	11.5888
8	.150814	4.48297	225.451	4323.37	I	.744895E=01	=312.320	.385100E=02	11.5888
8	.103837	5.81632	201.395	5609.25	I	=.807150E=01	403.922	.385100E=02	11.5888
8	.150899E=07	7.32311	.368491E=04	7062.40	I	.241694	10.6297	.385100E=02	11.5888
7	.519624E=08	5.77639	.100090E=04	5970.75	I	1.78112	=2.66241	.385100E=02	11.5888
6	.865130E=14	.645079	.570318E=12	622.113	I	=1.84466	=.178766E=01	.385100E=02	11.5888
5	.142995E=13	1.74074	.830045E=11	1678.77	I	.527397	=.245479	.385100E=02	11.5888
9	1.07003	.743108	324.636	877.432	I	.111800	5.20523	.256900E=02	17.3720
7	.951382	.667443	259.251	788.089	I	=.583188	1.17422	.256900E=02	17.3720
6	.934106	.482831	184.138	570.107	I	=.546067	.696426	.256900E=02	17.3720
8	.923921	.795377	300.026	939.149	I	=.127818E=01	67.1821	.256900E=02	17.3720
9	.784447	.946040	302.987	1117.05	I	.540116	=1.82842	.256900E=02	17.3720
8	.713465	1.01845	296.664	1202.55	I	.468568	=2.76894	.256900E=02	17.3720
2	.620464	.288563	73.0984	340.723	I	=2.91893	.963744E=01	.256900E=02	17.3720
6	.348368	.950965	135.255	1122.86	I	.929424	=.982251	.256900E=02	17.3720
5	.306405	1.50026	167.678	1771.45	I	=11.0561	=.369592E=01	.256900E=02	17.3720
9	.258159	2.84485	299.846	3359.08	I	=.275063E=01	404.461	.256900E=02	17.3720
8	.203755	3.03488	252.464	3583.46	I	=7.21470	1.39193	.256900E=02	17.3720
9	.193613	4.74694	297.711	5609.00	I	.128702E=01	=2397.37	.256900E=02	17.3720
7	.142892	2.46926	144.054	2915.60	I	=11.2487	=1.09395	.256900E=02	17.3720
8	.121375	4.55542	224.749	5355.24	I	.659595E=01	=438.394	.256900E=02	17.3720
8	.856016E=01	5.78521	202.186	6830.94	I	=.748220E=01	534.989	.256900E=02	17.3720
8	.416495E=07	7.32311	.124525E=03	8848.84	I	.243336	16.2796	.256900E=02	17.3720
7	.178358E=07	5.77639	.420630E=04	6820.53	I	1.78634	=4.05464	.256900E=02	17.3720
6	.626516E=14	.645079	.165005E=11	761.683	I	=1.84466	=.189901E=01	.256900E=02	17.3720
5	.335772E=14	1.74074	.238633E=11	2055.40	I	.527479	=.253875	.256900E=02	17.3720
9	.992536	.681249	330.258	962.315	I	.111049	5.36137	.179500E=02	24.8627
6	.836182	.437890	187.009	646.803	I	=.654399	.587449	.179500E=02	24.8627
7	.810941	.661345	261.950	934.199	I	.549866	1.31098	.179500E=02	24.8627
8	.799102	.768956	300.127	1086.21	I	=.112233E=01	89.4241	.179500E=02	24.8627
9	.645049	.964027	303.726	1361.76	I	.468018	=2.75329	.179500E=02	24.8627
8	.575656	1.05783	297.428	1494.27	I	.458549	=3.80952	.179500E=02	24.8627
2	.524960	.283768	72.7597	400.844	I	=5.95629	.701585E=01	.179500E=02	24.8627
6	.289038	.958217	135.276	1353.55	I	.987065	=1.10990	.179500E=02	24.8627
5	.256818	1.49592	187.619	2112.81	I	=6.92656	=.652041	.179500E=02	24.8627
9	.216374	2.83724	299.850	4007.82	I	=.297055E=01	441.978	.179500E=02	24.8627
8	.171050	3.02159	252.441	4276.13	I	=.42848	1.26009	.179500E=02	24.8627
9	.128692	4.73641	297.717	5690.53	I	.112938E=01	=3216.89	.179500E=02	24.8627
7	.119779	2.46576	144.255	3483.07	I	=9.99750	=1.57158	.179500E=02	24.8627
8	.100569	4.56711	224.339	6451.38	I	.573092E=01	=605.075	.179500E=02	24.8627
8	.719926E=01	5.78471	202.706	8143.08	I	=.722037E=01	658.589	.179500E=02	24.8627
8	.918257E=07	7.32311	.328444E=03	10584.4	I	.245344	23.3602	.179500E=02	24.8627
7	.526636E=07	5.77640	.144583E=03	8159.59	I	1.79520	=5.83728	.179500E=02	24.8627
6	.127381E=13	.645079	.401345E=11	911.221	I	=1.84466	=.204325E=01	.179500E=02	24.8627
5	.140932E=12	1.74074	.119824E=09	2458.93	I	.527586	=.264739	.179500E=02	24.8627

9	.861825	.604393	337,499	1132,56	I =,980730E=01	6,37090	.102000E=02	43,7535
5	.670631	.435427	189,205	815,942	I =,813049	.500502	.102000E=02	43,7535
7	.621611	.697314	264,743	1231,73	I =,516544	1,67400	.102000E=02	43,7535
8	.617130	.750852	300,237	1407,01	I =,101384E=01	119,346	.102000E=02	43,7535
9	.472716	.995827	305,012	1866,07	I =,449682	=3,93377	.102000E=02	43,7535
8	.413098	1,11321	297,962	2086,02	I =,462858	=5,56838	.102000E=02	43,7535
2	.400874	.277863	72,1724	520,683	I =6,39003	.169572E=01	.102000E=02	43,7535
5	.216047	.966081	135,237	1810,33	I 1,05769	=1,35604	.102000E=02	43,7535
6	.194839	1,50553	190,063	2821,19	I =15,3979	=,311501	.102000E=02	43,7535
9	.163625	2,82830	299,854	5299,92	I =,304359E=01	566,609	.102000E=02	43,7535
8	.129739	3,00905	252,948	5638,61	I =6,13697	5,73157	.102000E=02	43,7535
9	.972775E=01	4,72371	297,734	8851,70	I =,153153E=01	=3208,81	.102000E=02	43,7535
7	.903979E=01	2,46005	144,091	4609,86	I =8,12870	=2,47162	.102000E=02	43,7535
8	.748560E=01	4,61154	223,669	8641,51	I =,615823E=01	=769,888	.102000E=02	43,7535
8	.546669E=01	5,73919	203,286	10754,6	I =,675711E=01	935,363	.102000E=02	43,7535
8	.234728E=06	7,32311	.111377E=02	13722,7	I =,249861	40,1360	.102000E=02	43,7535
7	.285333E=06	5,77641	.106793E=02	10824,3	I 1,81093	=10,2317	.102000E=02	43,7535
6	.207400E=11	1,74074	.233924E=08	3261,95	I =,527854	=,292087	.102000E=02	43,7535
5	.185592E=13	.645079	.775719E=11	1208,80	I =1,84463	=,240712E=01	.102000E=02	43,7535
9	.695469	.534825	344,222	1431,43	I =,668447E=01	10,4083	.500000E=03	89,2572
5	.485681	.422471	189,888	1130,72	I =1,02794	.457004	.500000E=03	89,2572
7	.438213	.656792	266,355	1757,87	I =,500089	2,37178	.500000E=03	89,2572
8	.435038	.745905	300,303	1996,37	I =,108100E=01	158,277	.500000E=03	89,2572
9	.324646	1,01874	306,071	2726,61	I =,403714	=6,08150	.500000E=03	89,2572
9	.304878	1,06758	301,213	2857,32	I =2,68713	.127127	.500000E=03	89,2572
8	.305941	1,06264	300,864	2844,09	I 2,99383	=2,00841	.500000E=03	89,2572
2	.283456	.272218	71,4087	728,577	I =12,0665	.832270E=02	.500000E=03	89,2572
9	.278945	1,15500	298,159	3091,29	I =,666216	=5,75476	.500000E=03	89,2572
7	.150250	.971857	135,134	2601,12	I 1,10320	=1,85170	.500000E=03	89,2572
6	.136567	1,50660	190,411	4032,34	I =26,1812	=,132265	.500000E=03	89,2572
8	.114841	2,82143	299,858	7551,40	I =,317459E=01	768,878	.500000E=03	89,2572
9	.924192E=01	2,93047	250,639	7843,25	I =12,7346	3,40132	.500000E=03	89,2572
8	.680083E=01	4,72933	297,652	12657,8	I =,116756E=01	=5901,11	.500000E=03	89,2572
5	.638665E=01	2,46468	145,674	6596,59	I =9,41144	=3,36082	.500000E=03	89,2572
9	.520250E=01	4,63788	223,296	12413,0	I =,482516E=01	=1390,51	.500000E=03	89,2572
9	.384882E=01	5,71930	203,713	15307,4	I =,676919E=01	1304,99	.500000E=03	89,2572
9	.401973E=06	7,32309	.272420E=02	19594,9	I =,258091	75,5420	.500000E=03	89,2572
7	.857971E=13	.645079	.512193E=10	1726,52	I =1,84460	=,528413E=01	.500000E=03	89,2572
6	.235798E=10	1,74074	.379859E=07	4659,00	I =,524500	=,357667	.500000E=03	89,2572
5	.220276E=05	5,77645	.117754E=01	15460,4	I 1,85414	=20,2665	.500000E=03	89,2572

THE PLOT CONTROL CARD IMAGE IS,

PLOT,CALPOST,FB(FSH=28,,FSV=14.)  
//PAPER 12, LEROY PEN SIZE .5, MULTIPLE MODE//

FRAME	X0	Y0	XM	YM	CAL. POS
1	0.	0.	1.000000E+00	1.000000E+00	0.
2	0.	0.	1.000000E+00	1.000000E+00	0.
3	0.	0.	1.000000E+00	1.000000E+00	0.
4	0.	0.	1.000000E+00	1.000000E+00	0.
5	0.	0.	1.000000E+00	1.000000E+00	0.
6	0.	0.	1.000000E+00	1.000000E+00	0.

JOB NAME == 4AFQBDL  
DELIVERY == B648 RB R M BENNETT/EXT2661

THE PLOT CONTROL CARD IMAGE IS,

PLOT,CALPOST,FB(FSH=28,,FSV=14.)  
//PAPER 12, LEROY PEN SIZE .5, MULTIPLE MODE//

OPERATIONS CONTROL MESSAGES.

SET BLKNO 2\*\*\*  
PLEASE CHANGE PAPER

SET BLKNO 3\*\*\*  
PLEASE CHANGE PAPER

SET BLKNO 4\*\*\*  
PLEASE CHANGE PAPER

SET BLKNO 5\*\*\*  
PLEASE CHANGE PAPER

SET BLKNO 6\*\*\*  
PLEASE CHANGE PAPER

THIS FILE CONTAINS 6 FRAMES.  
12 PLOTS.  
17279 POINTS.  
ESTIMATED PLOTTING TIME 0 HR8 17 MINS.  
ESTIMATED PLOTTING 5.5 FEET  
AVERAGE POS 0. PERCENT

PLOT TAPE NO. PLT021 UN CALCOMP PLATNER.  
DATE = 78/05/08. TIME = 15.13.20.

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13.06.34.FLUTDET,T0600,CM060000.
13.06.34.8648 RB R M BENNETT/EXT2661 29
13.06.34.USER,052061N,.
13.06.34.CHARGE,100652,LRC,
13.06.35.GET,GENF=BGENF,
13.06.35.GET,FLUTDET/UN=052061N,PW#
13.07.21.FLUTDET,
13.07.22. ++ INPUT1 .185 .095
13.07.31. ++INTERPS 3.365 3.180
13.09.09. ++FLUTTER 103.600 100.235
13.09.10. ++ INPUT1 103.605 .005
13.09.20. ++ PLOTVG 111.355 7.750
13.09.20. END FLUTDET
13.09.20. 111.285 CP SECONDS EXECUTION TIME
13.09.20.ATTACH,PLOT/UN=LIBRARY,
13.09.35.PLOT,CALPOST,FB(FSH=28,,FSV=14.)
13.10.00.CONT, //PAPER 12, LEROY PEN SIZE .5, MULT
13.10.00.IPLE MODE//
13.10.00. THIS JOB HAS ***** PLOT ***** OUTPUT
13.10.57. CFD. PLT021.
13.13.10.MT25, ASSIGNED TO CALTPE , VSN=PLT021.
13.13.21. ***** PLOT OUTPUT COMPLETED *****
13.13.22.UEAD, 0.003KUNS,
13.13.22.UEPF, 0.178KUNS,
13.13.22.UEMT, 0.273KUNS,
13.13.22.UEMS, 13.090KUNS,
13.13.22. 175 CPU SEC = UECP/5
13.13.22.UECP, 143.995SECS,
13.13.22.AESR, 216.819UNTS,

```



#### REFERENCES

1. Harder, Robert T.; and Desmarais, Robert N.: Interpolation Using Surface Splines. *J. Aircraft*, Vol. 9, No. 2, Feb. 1972, pp. 189-191.
2. Watkins, Charles E.; Woolston, Donald S.; and Cunningham, Herbert J.: A Systematic Kernel Function Procedure for Determining Aerodynamic Forces on Oscillating or Steady Finite Wings at Subsonic Speeds. NASA TR R-48, 1959.
3. Wilkinson, J. H. and Reinsch, J.: Linear Algebra. Handbook for Automatic Computation, Vol. II, F. L. Bauer, ed. Springer-Verlag, New York, 1971.
4. Desmarais, Robert N.; and Bennett, Robert M.: An Automated Procedure for Computing Flutter Eigenvalues. *J. Aircraft*, Vol. II, No. 2, Feb. 1974, pp. 75-80.

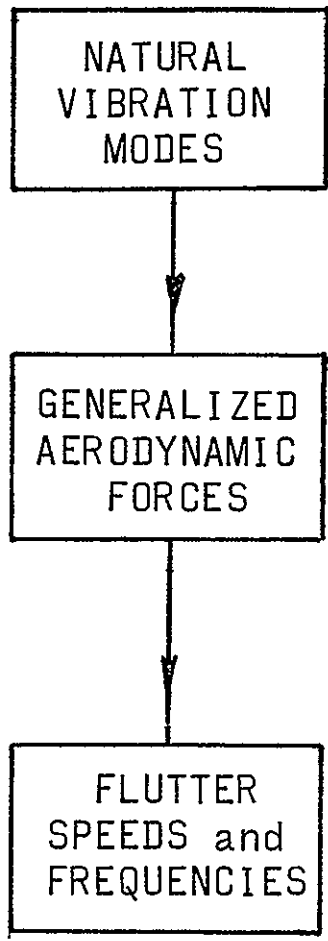


Figure 1. - Overall block diagram of flutter analysis.

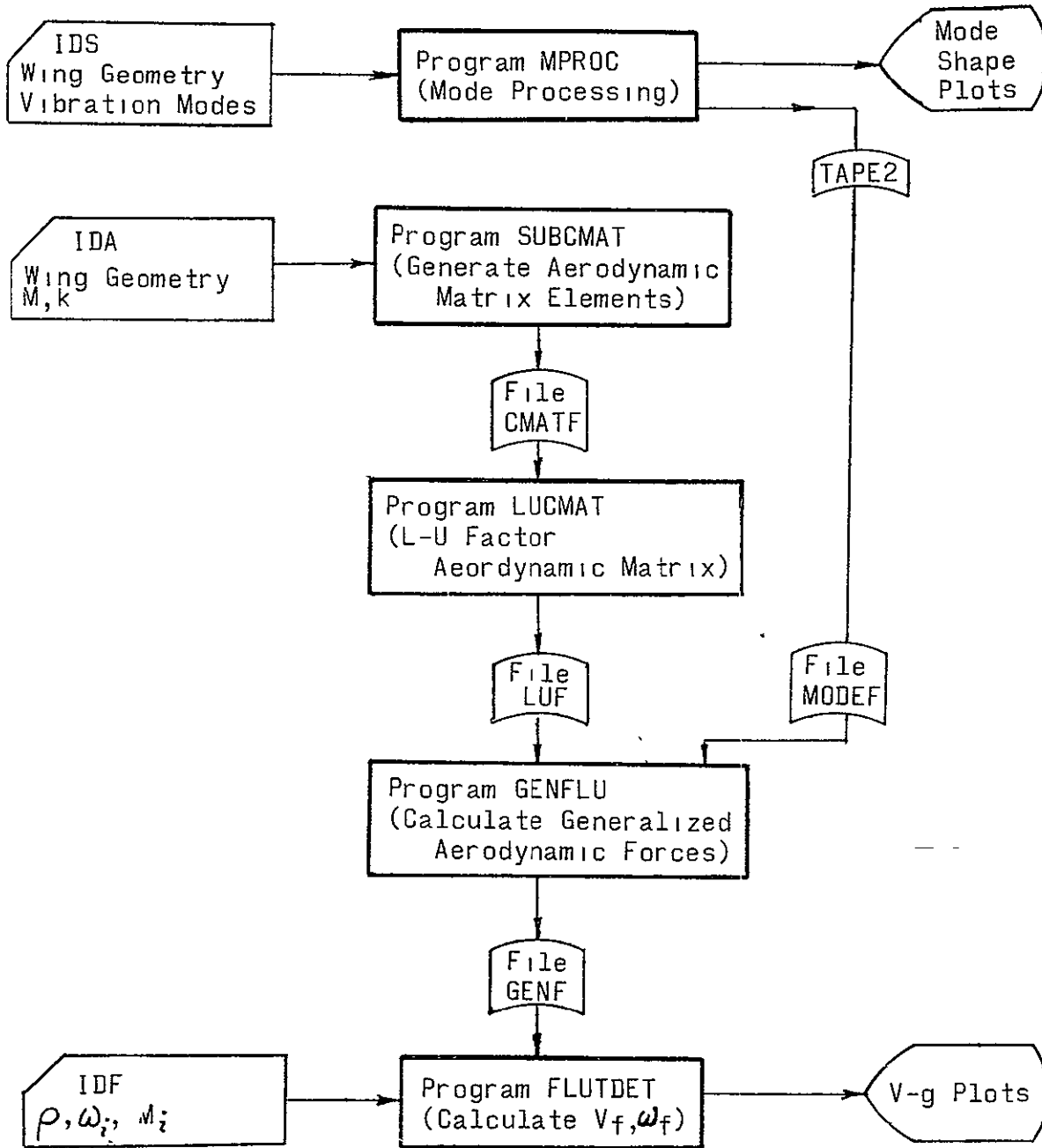


Figure 2. - Block diagram of FAST Version 1.0.

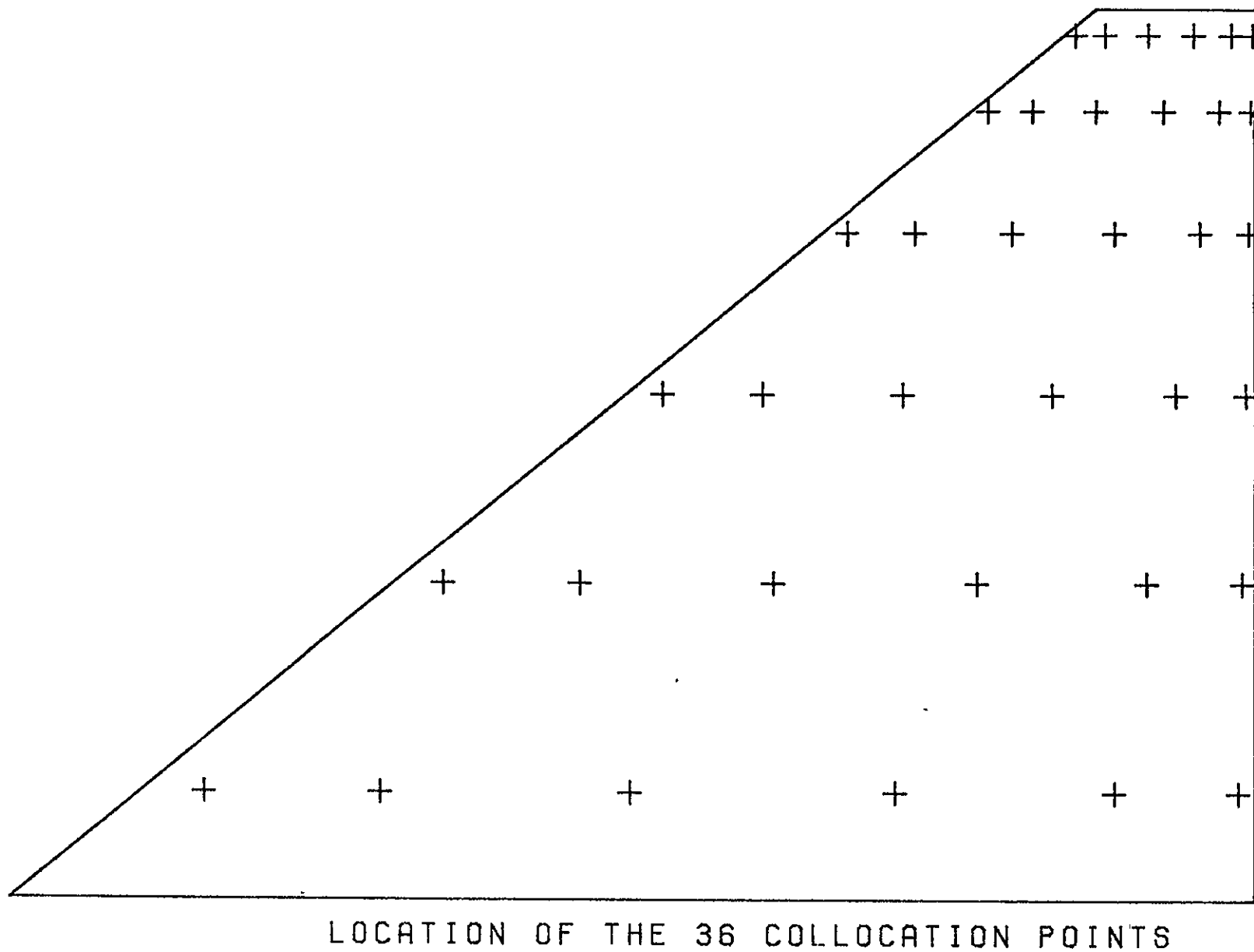


Figure 3. - Plots for sample case generated by MPROC.

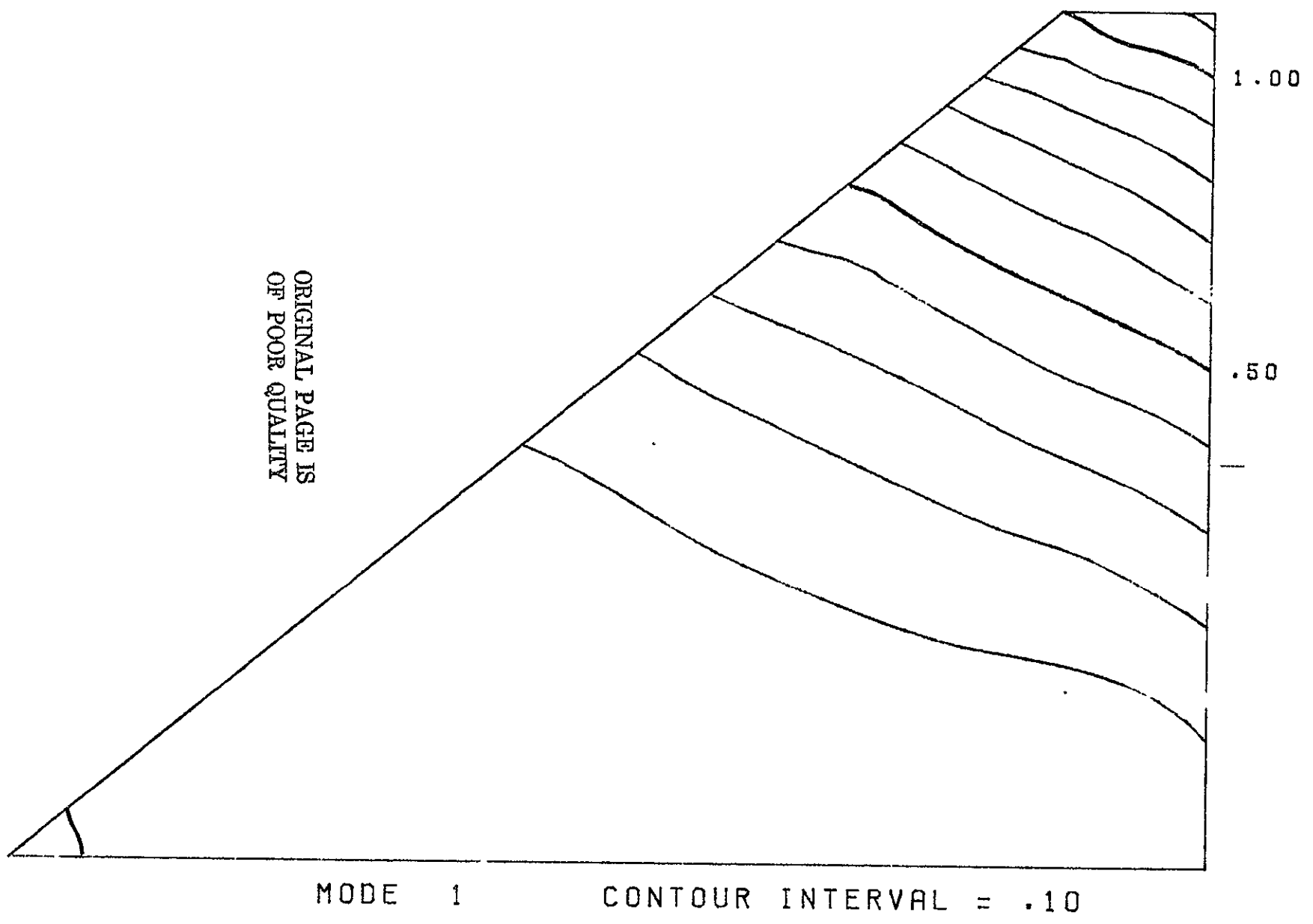
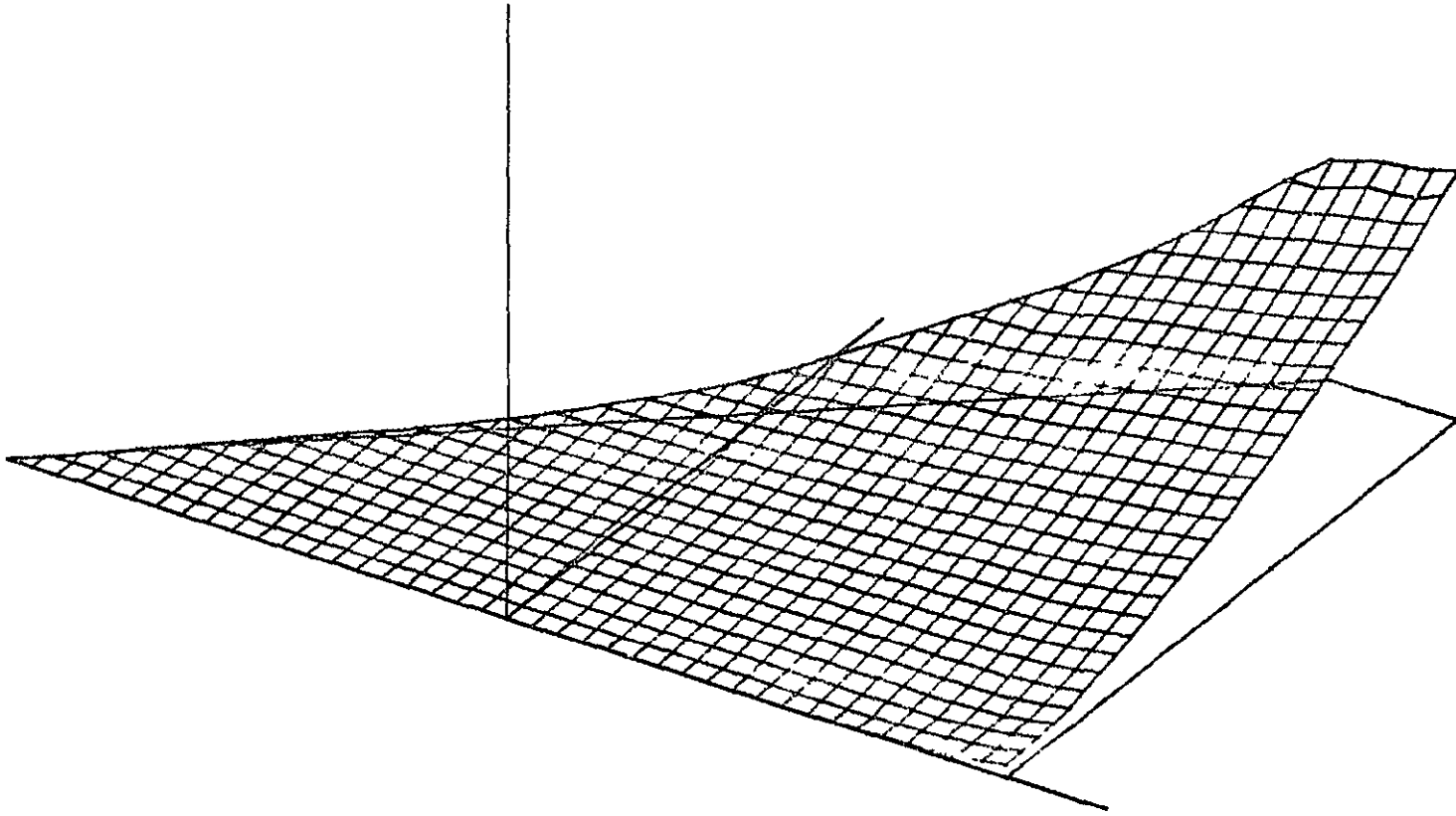


Figure 3. - Continued.



MODE 1      OBLIQUE PROJECTION

Figure 3. - Continued.



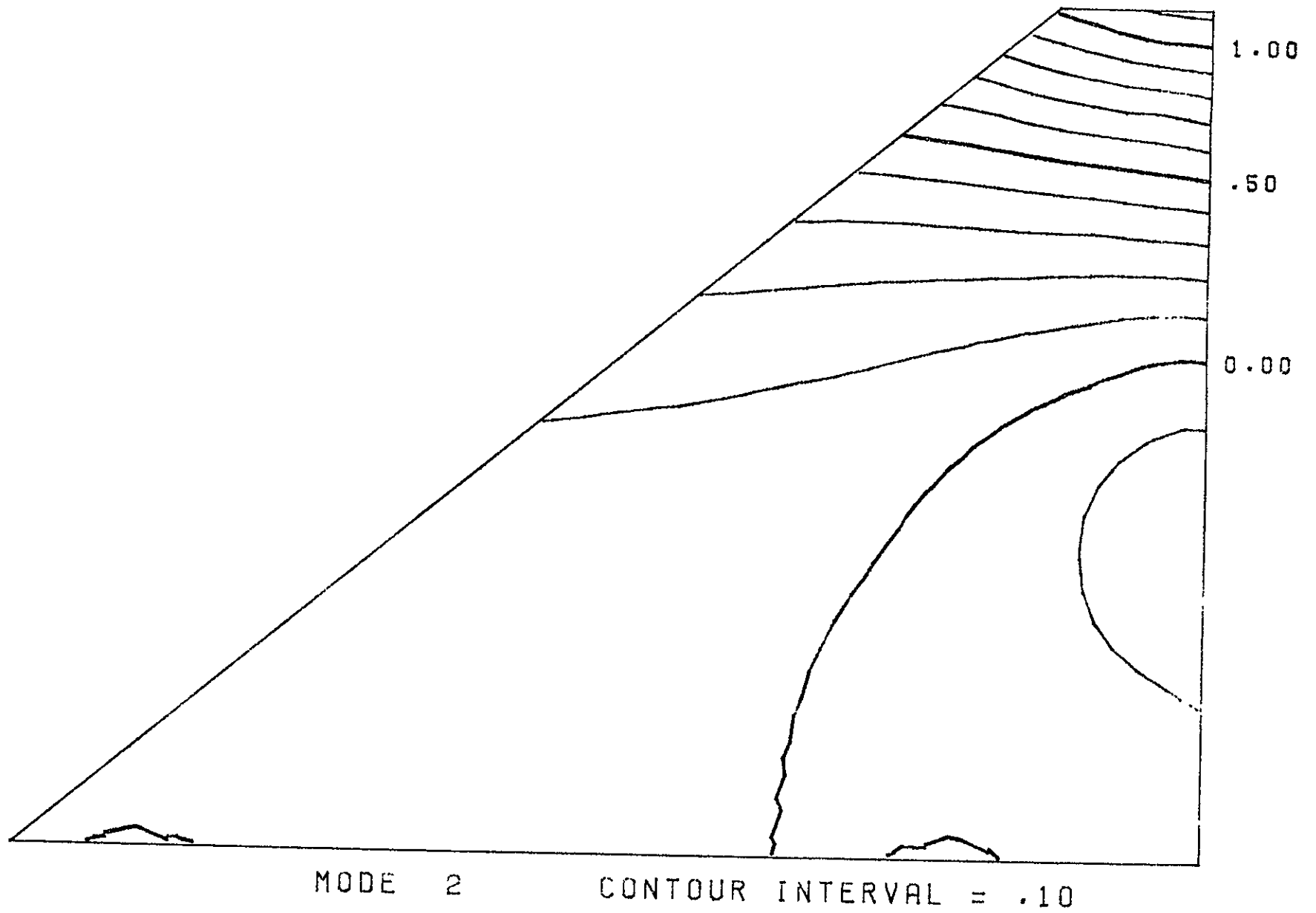
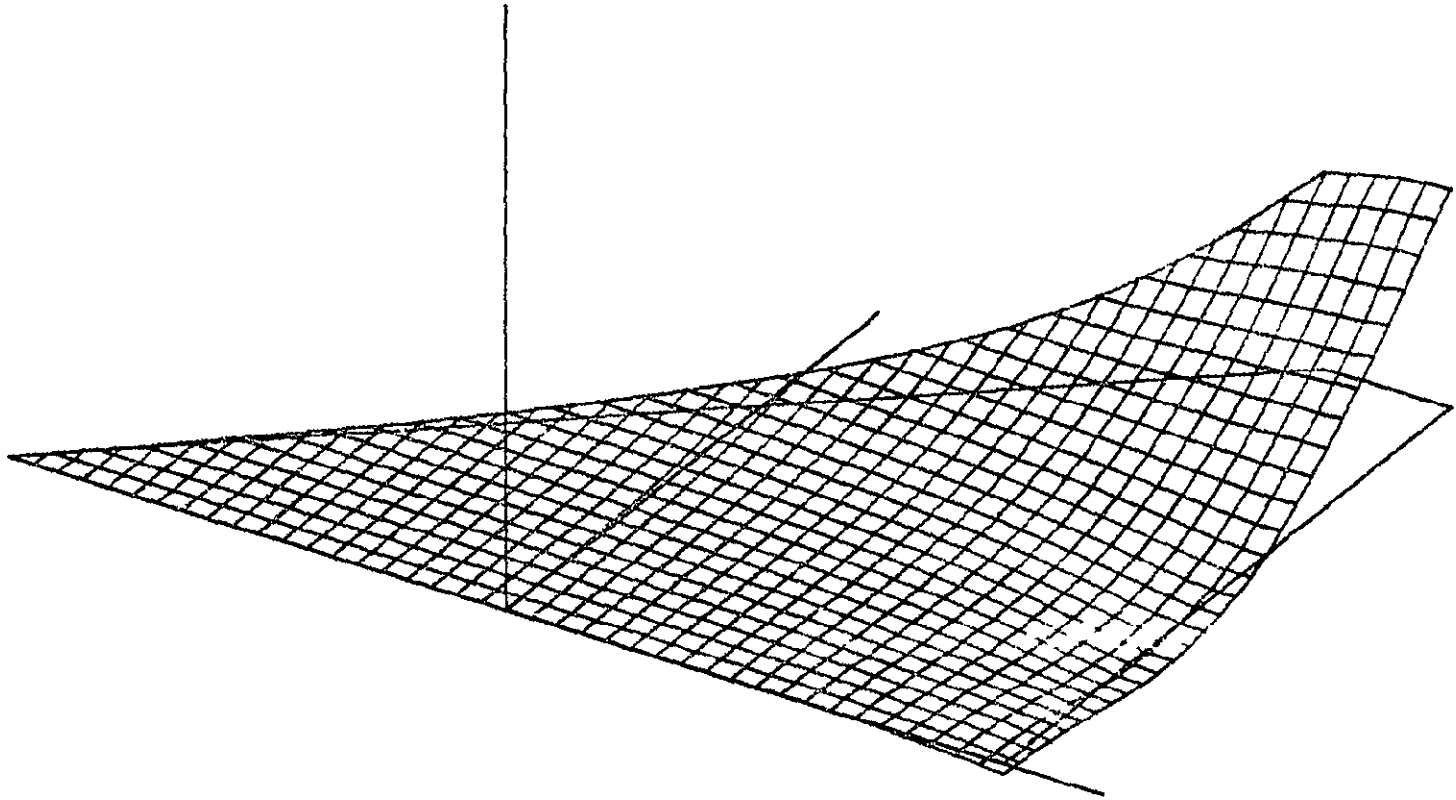


Figure 3. - Continued.





MODE 2            OBLIQUE PROJECTION

Figure 3. - Continued.

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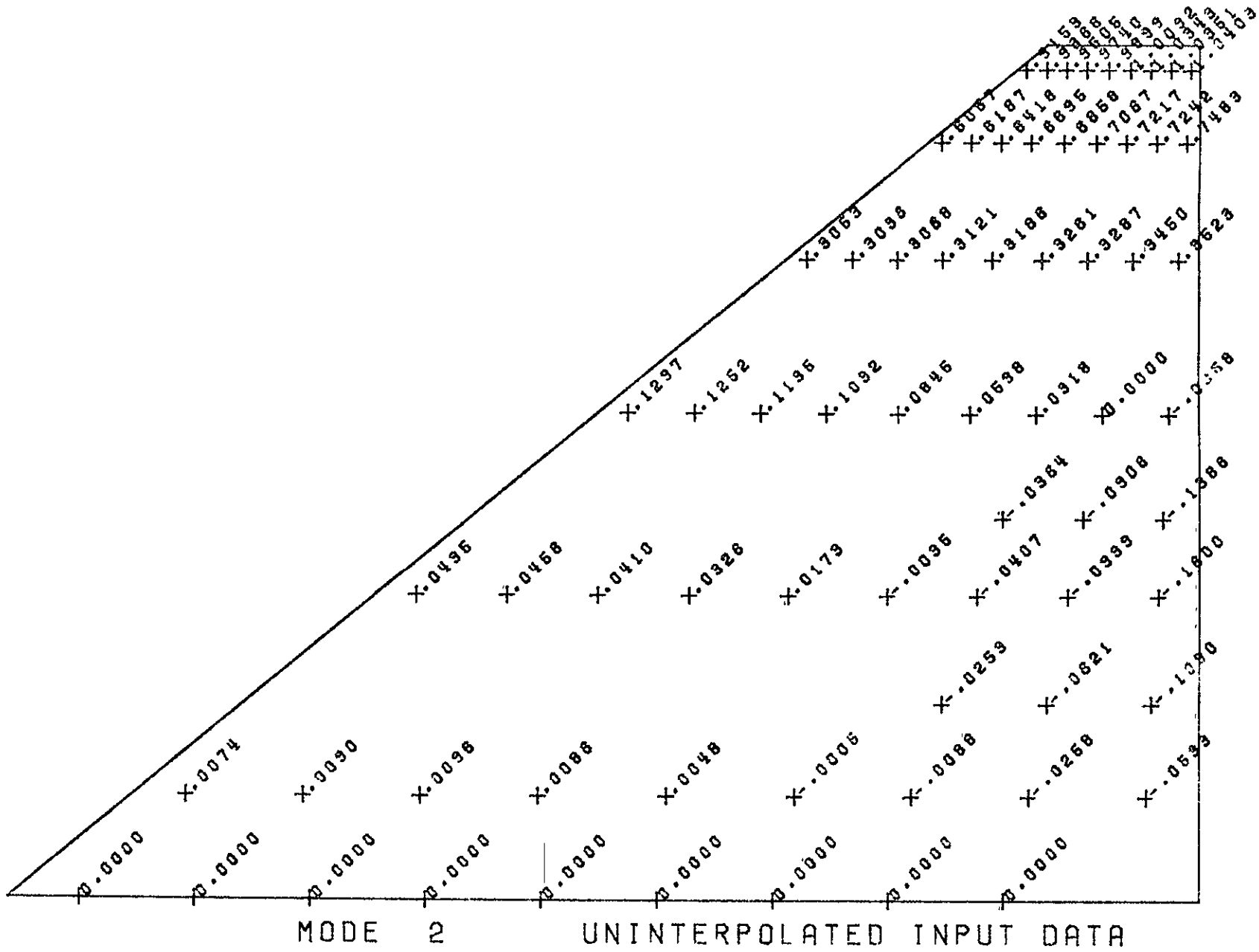


Figure 3. - Continued.

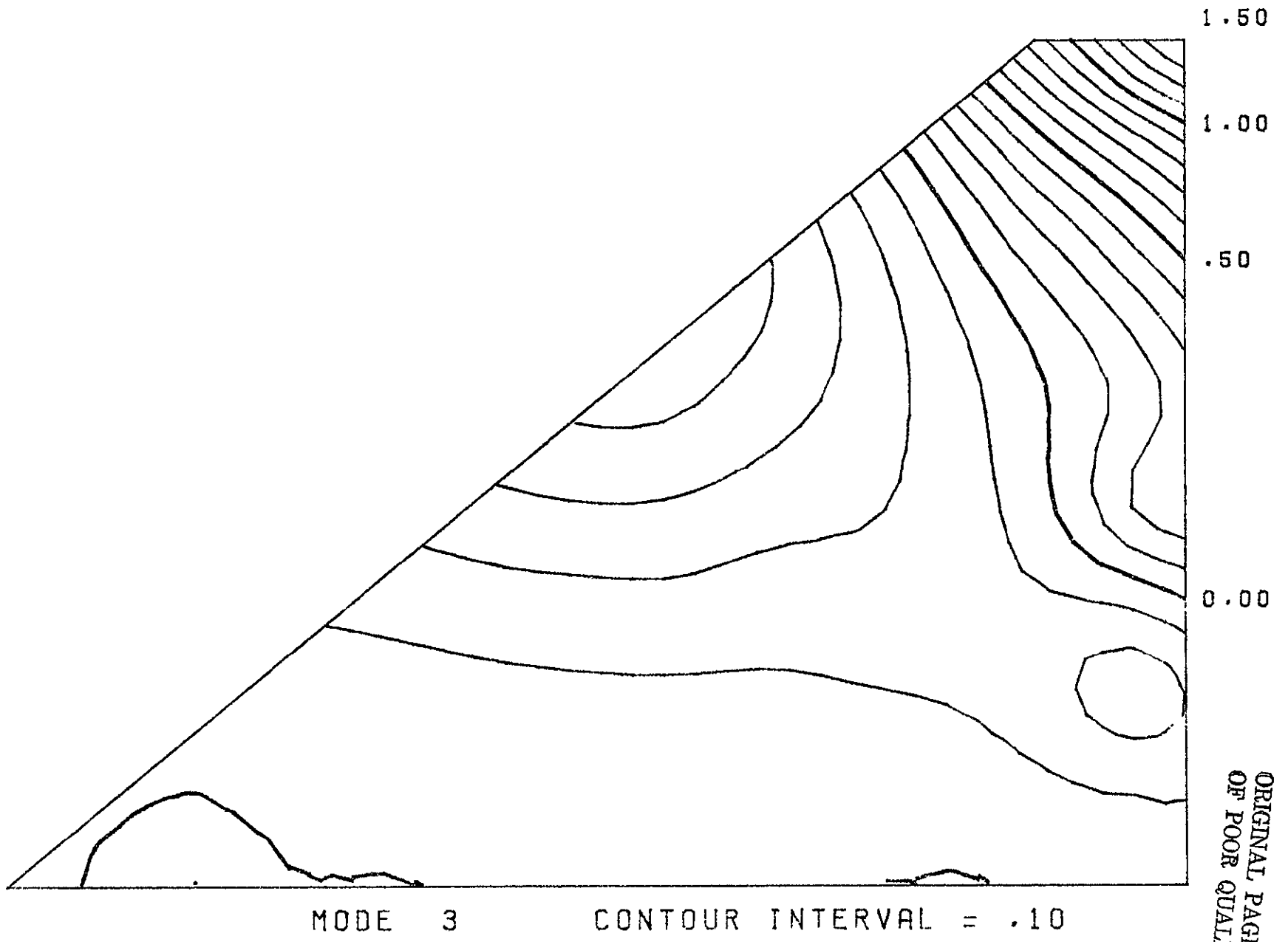
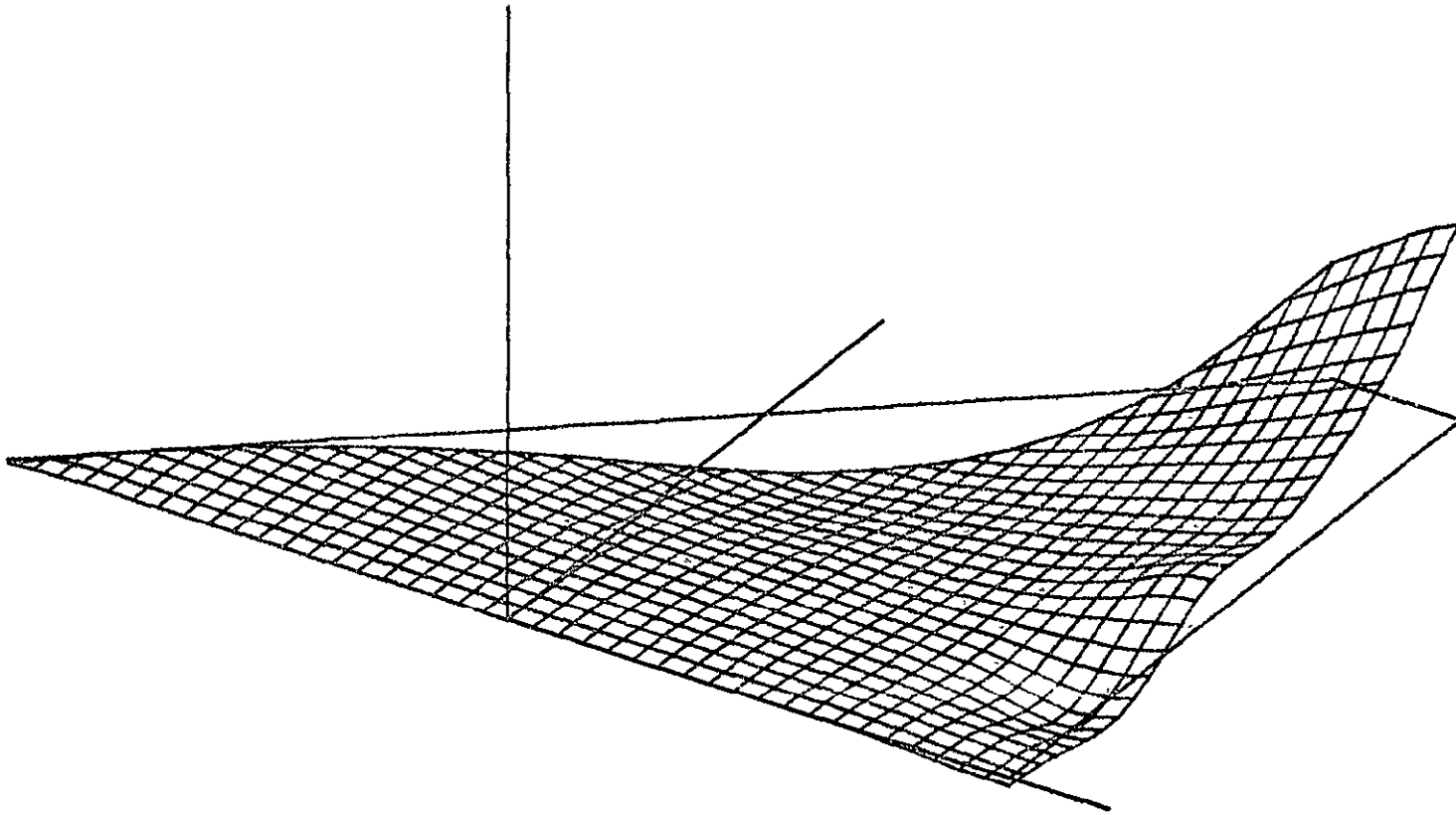


Figure 3. - Continued.



MODE 3 OBLIQUE PROJECTION

Figure 3. - Continued.

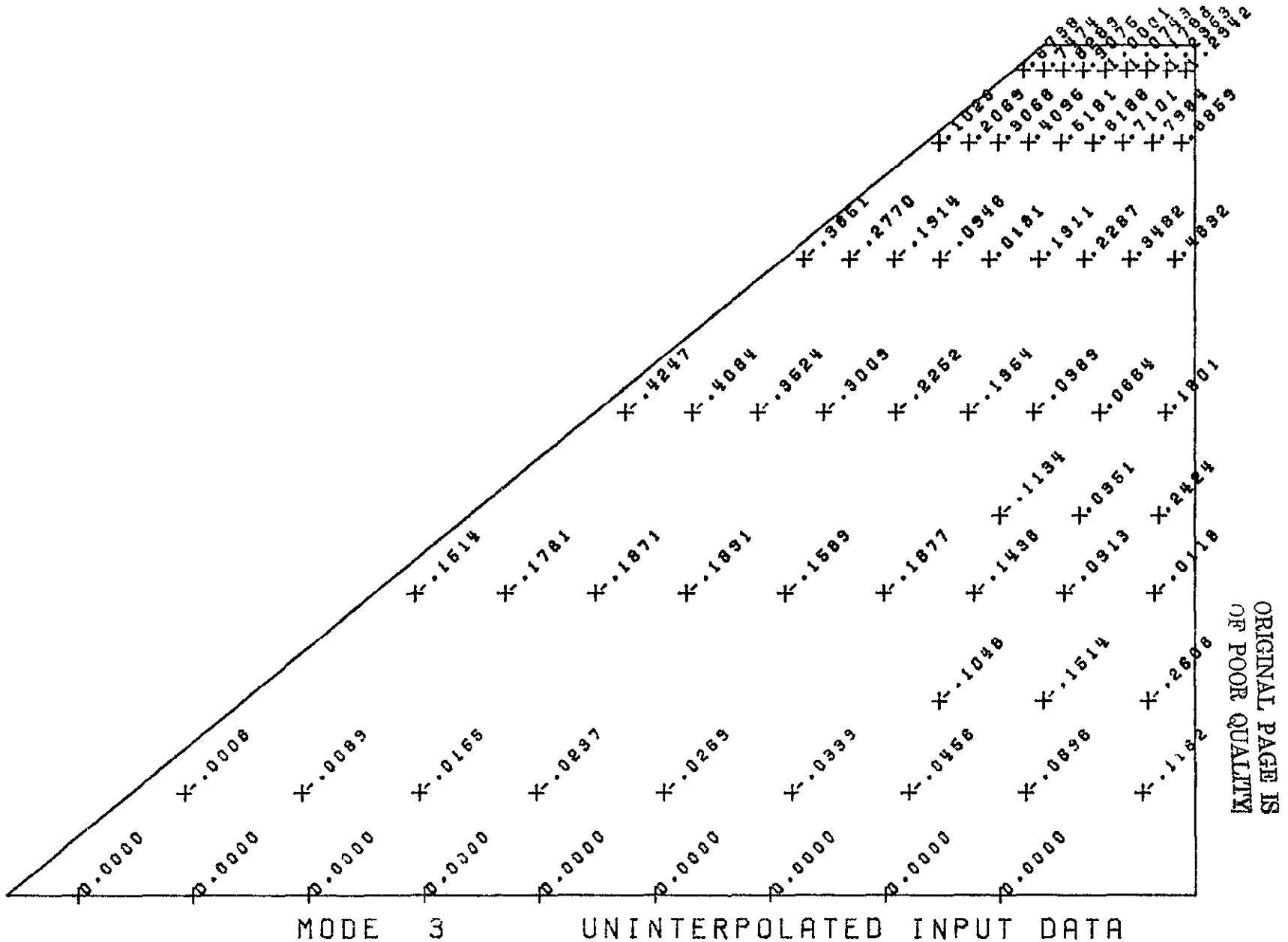


Figure 3. - Continued.

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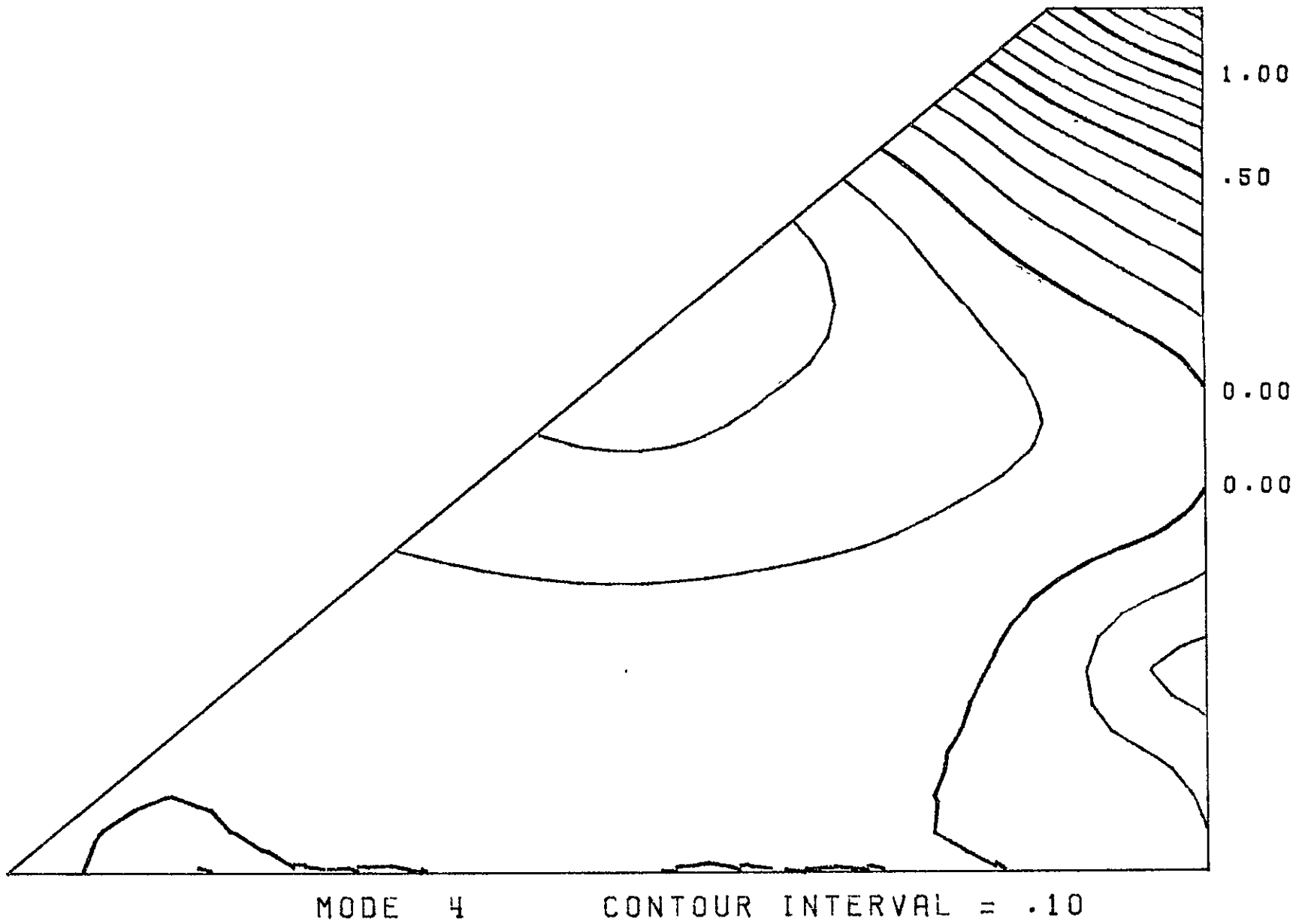
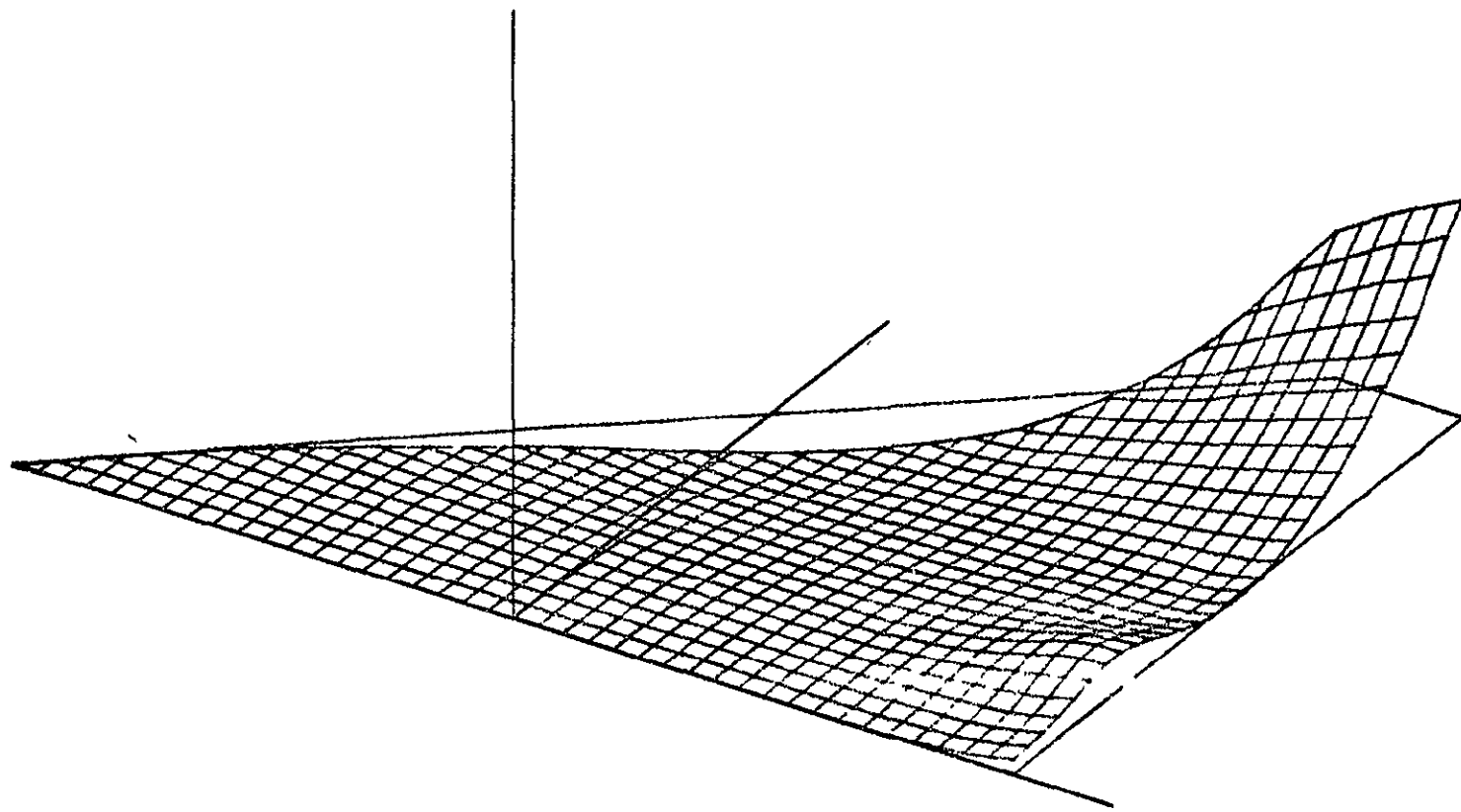


Figure 3. - Continued.



MODE 4

OBLIQUE PROJECTION

Figure 3. - Continued.

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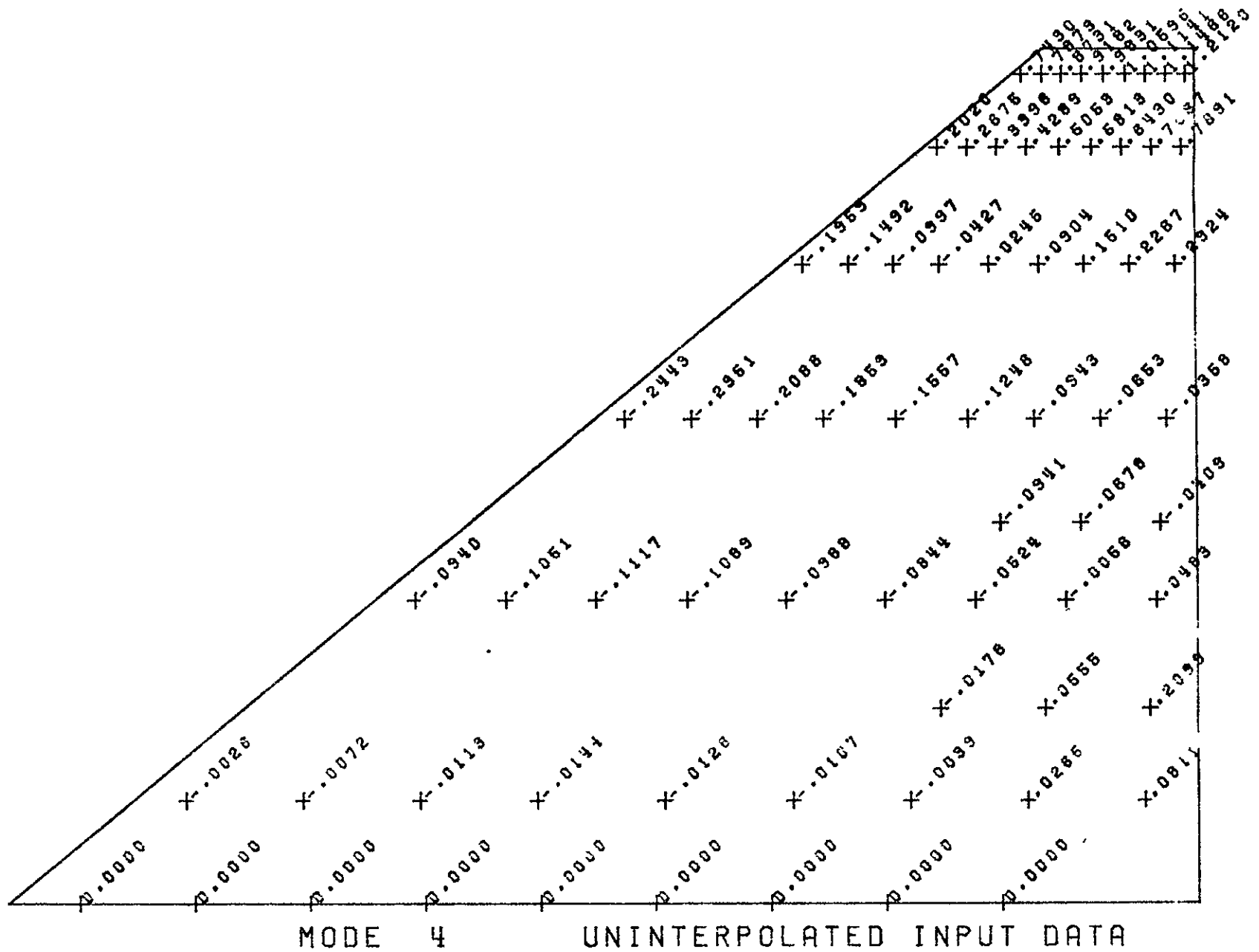


Figure 3. - Continued.



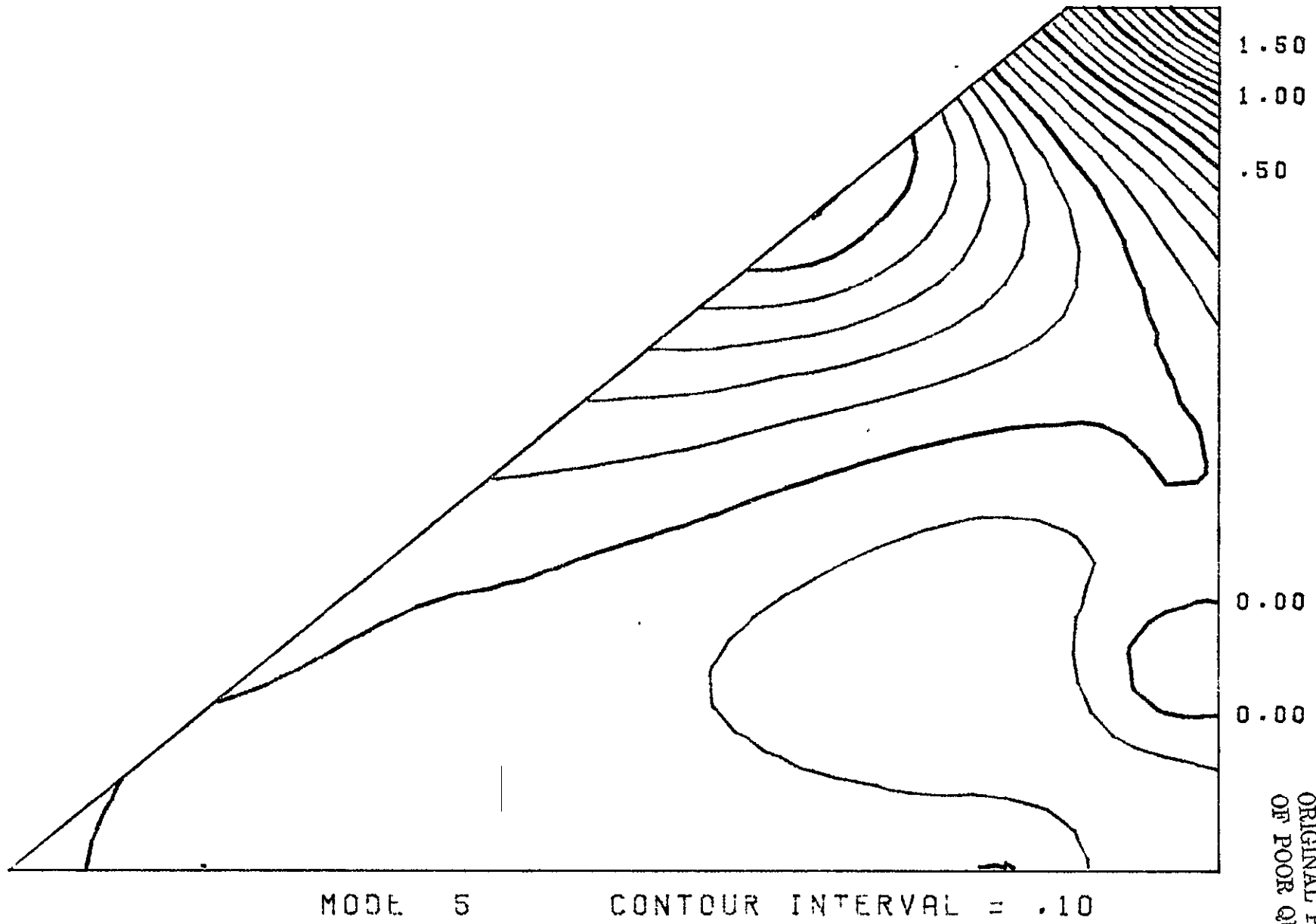
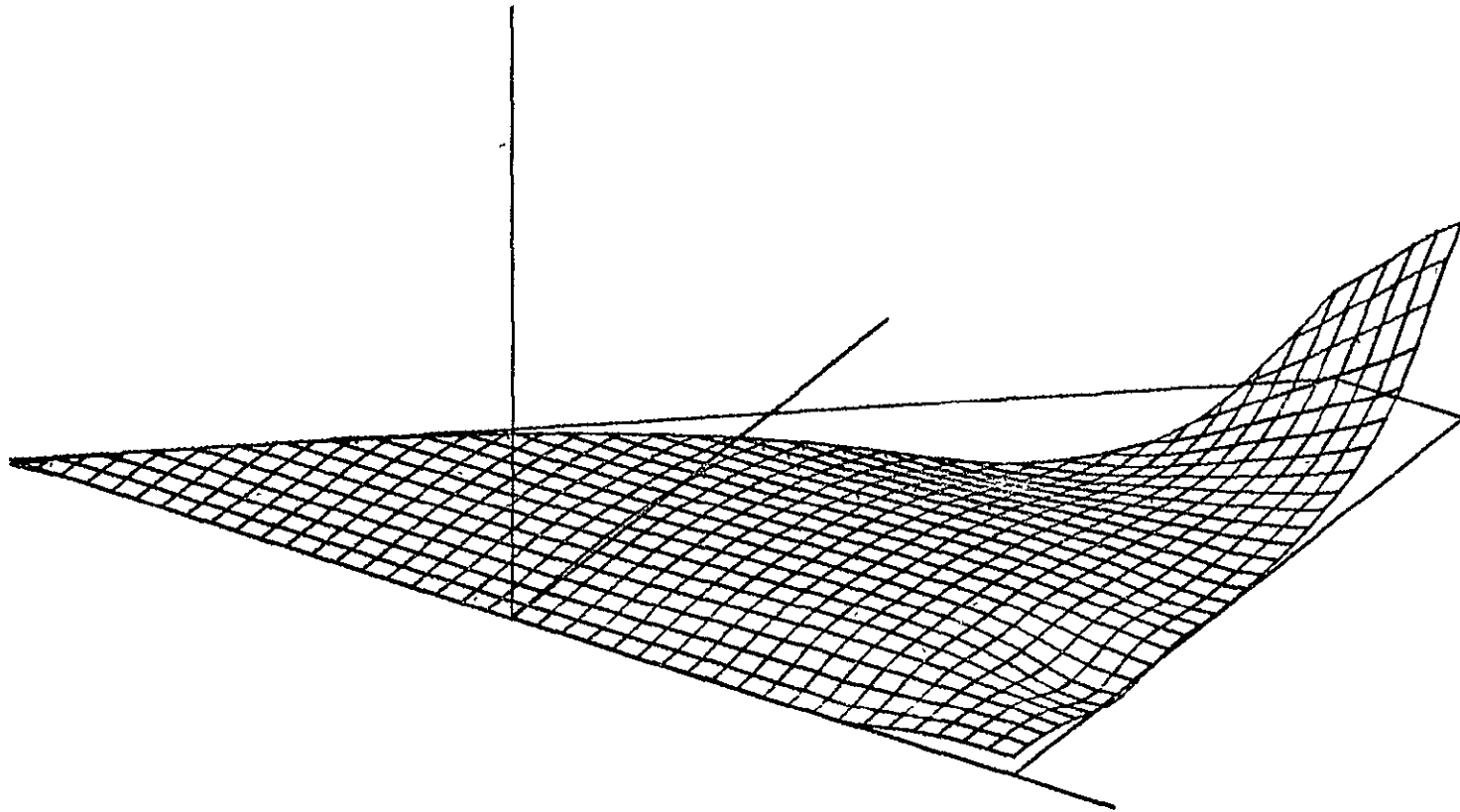


Figure 3. - Continued.



MODE 5 OBLIQUE PROJECTION

Figure 3. - Continued.

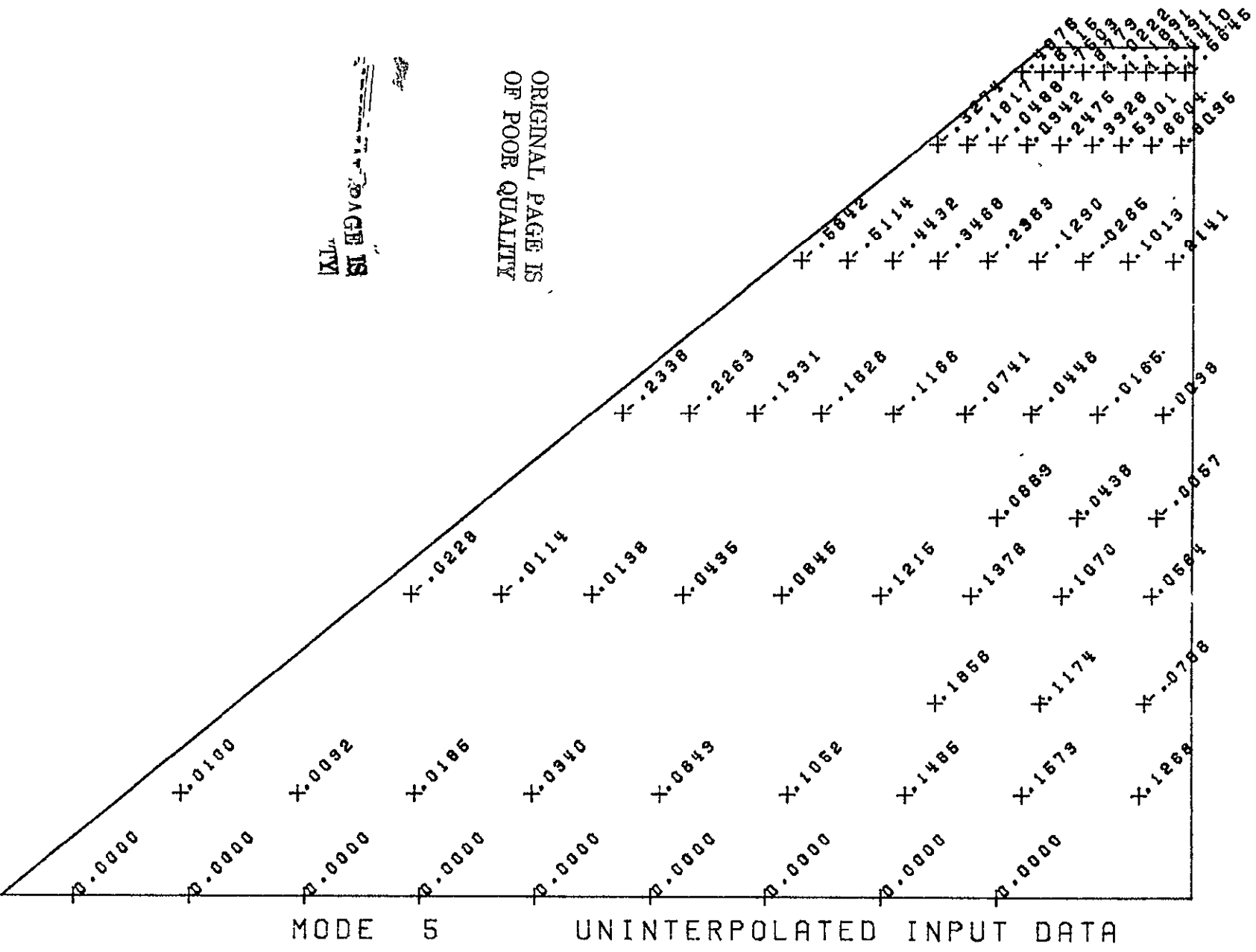


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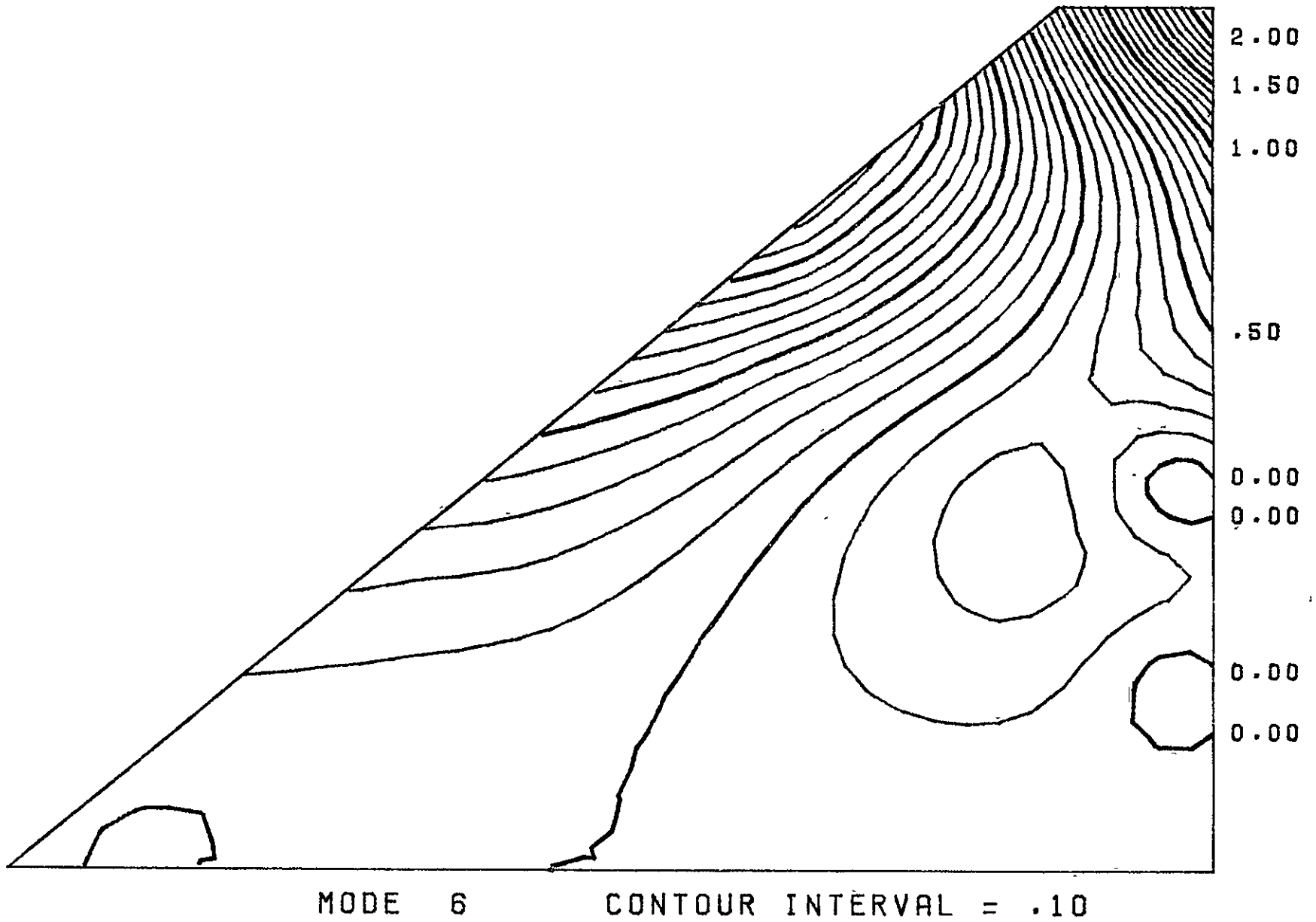
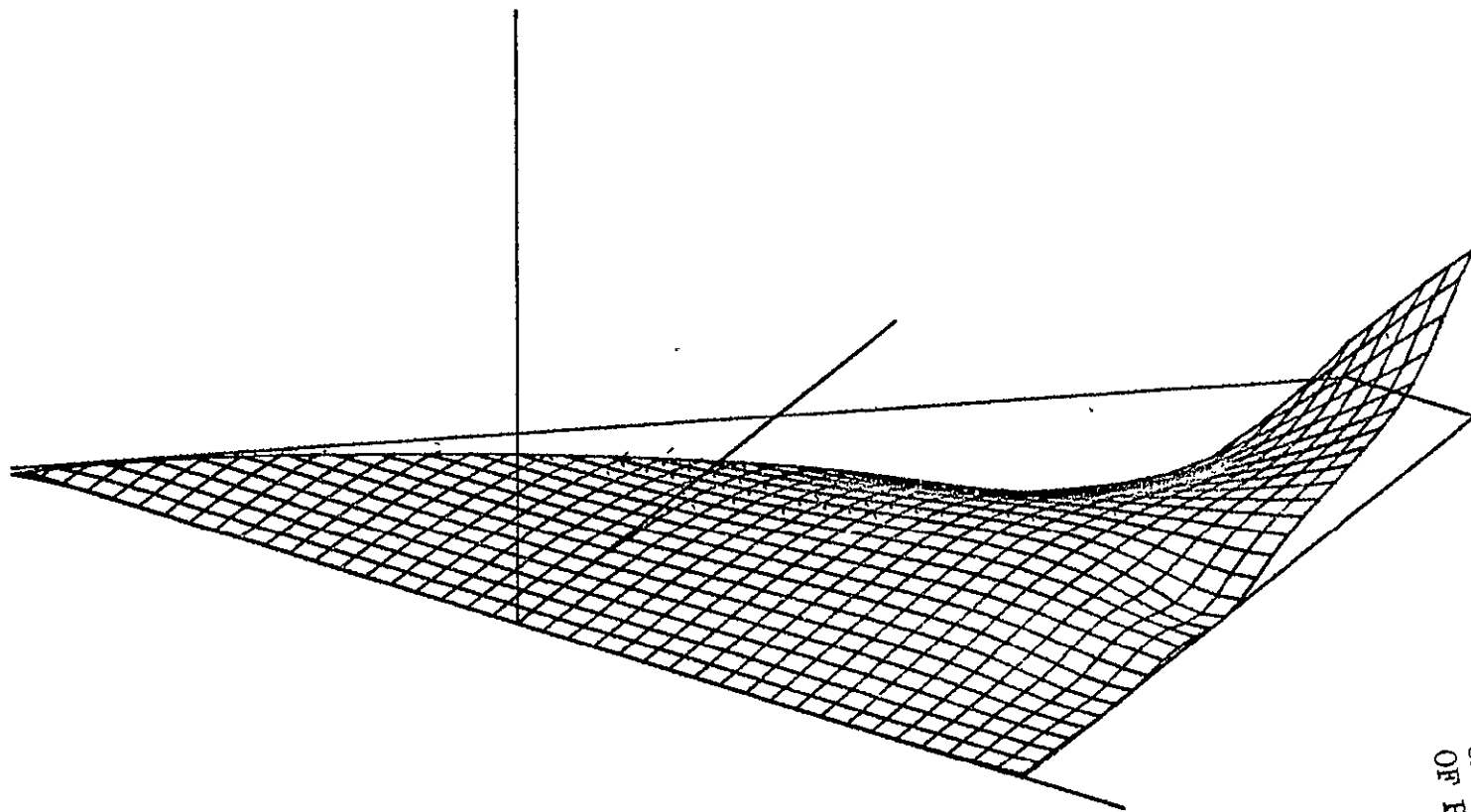


Figure 3. - Continued.



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MODE 6 OBLIQUE PROJECTION

Figure 3. - Continued.

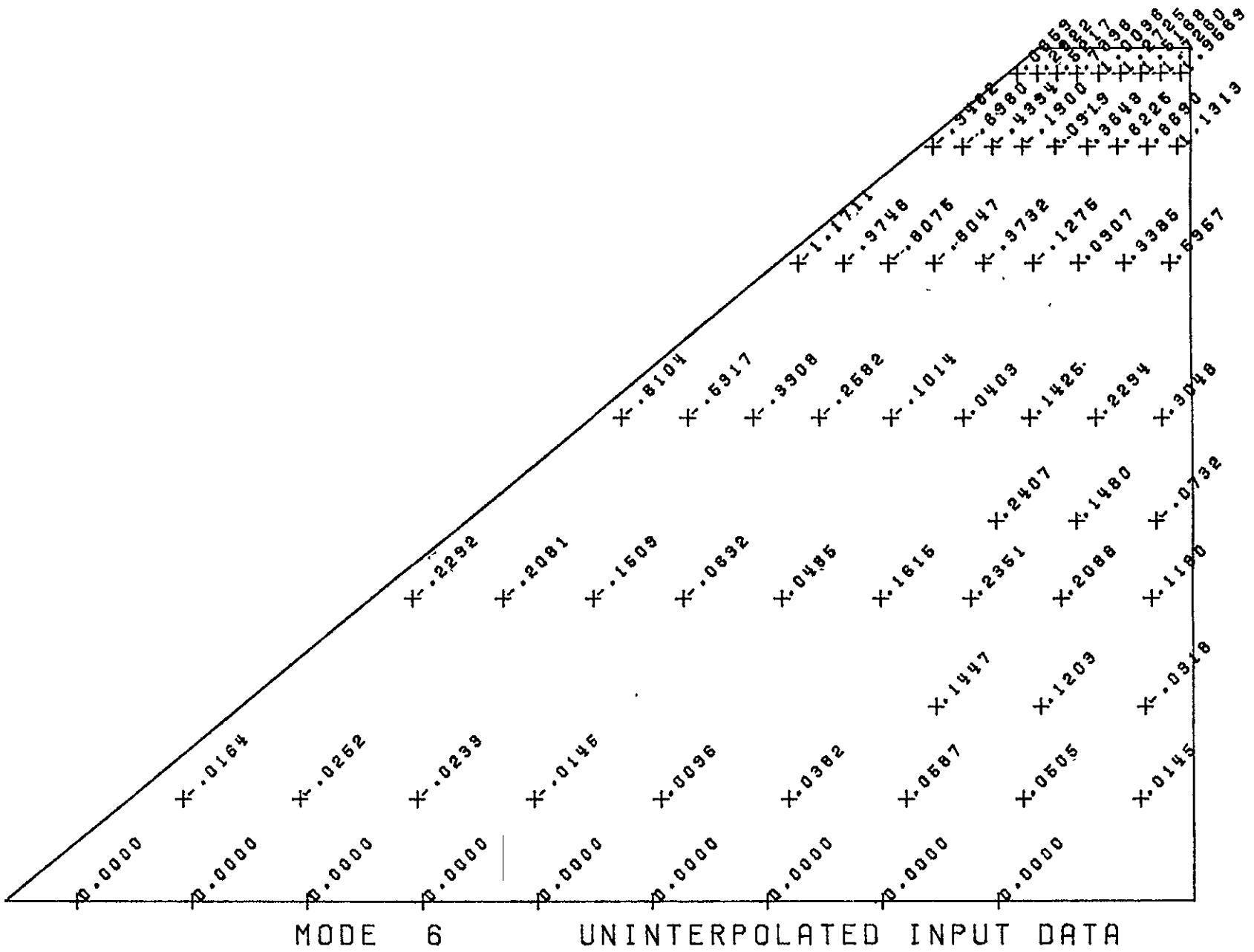


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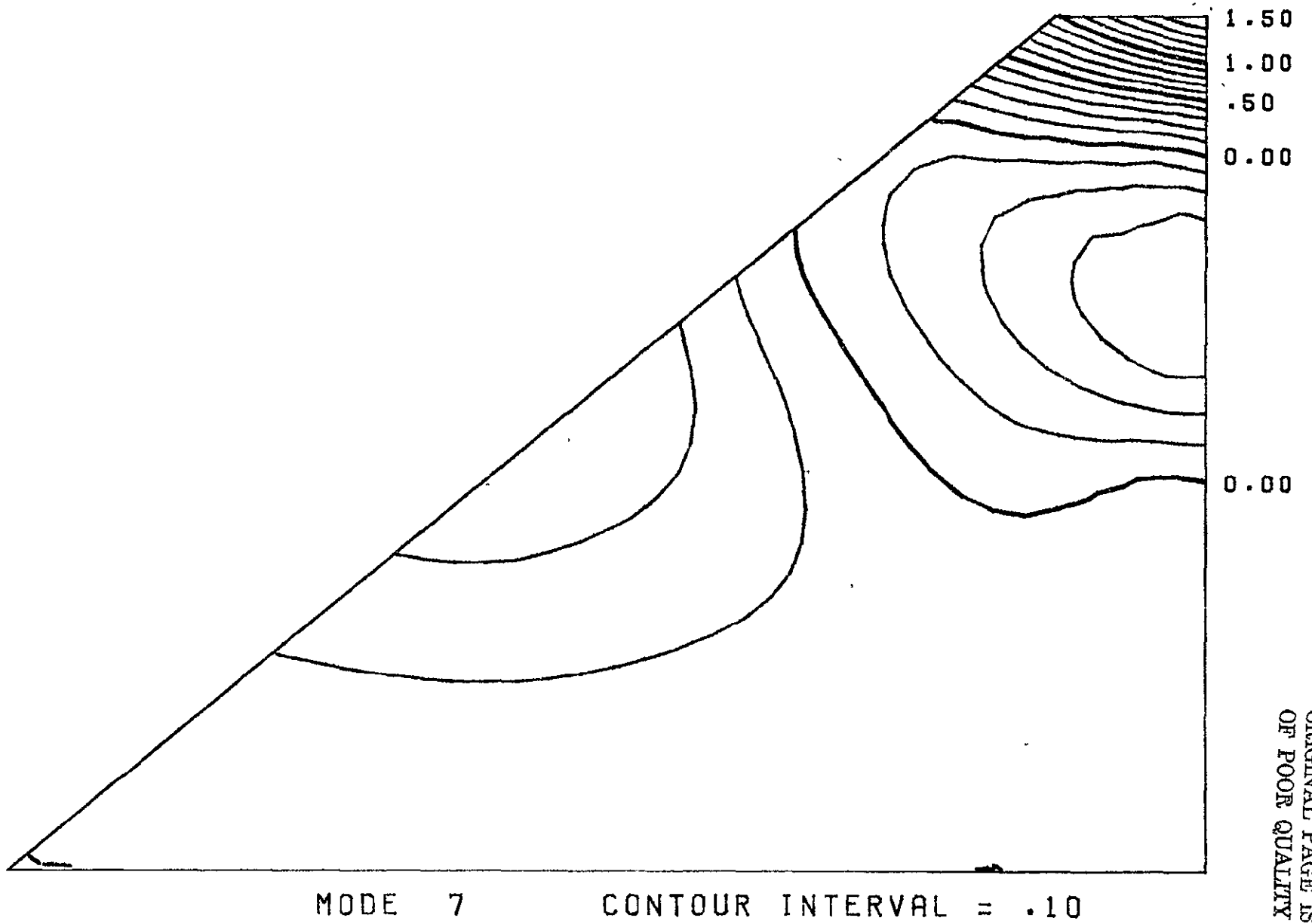
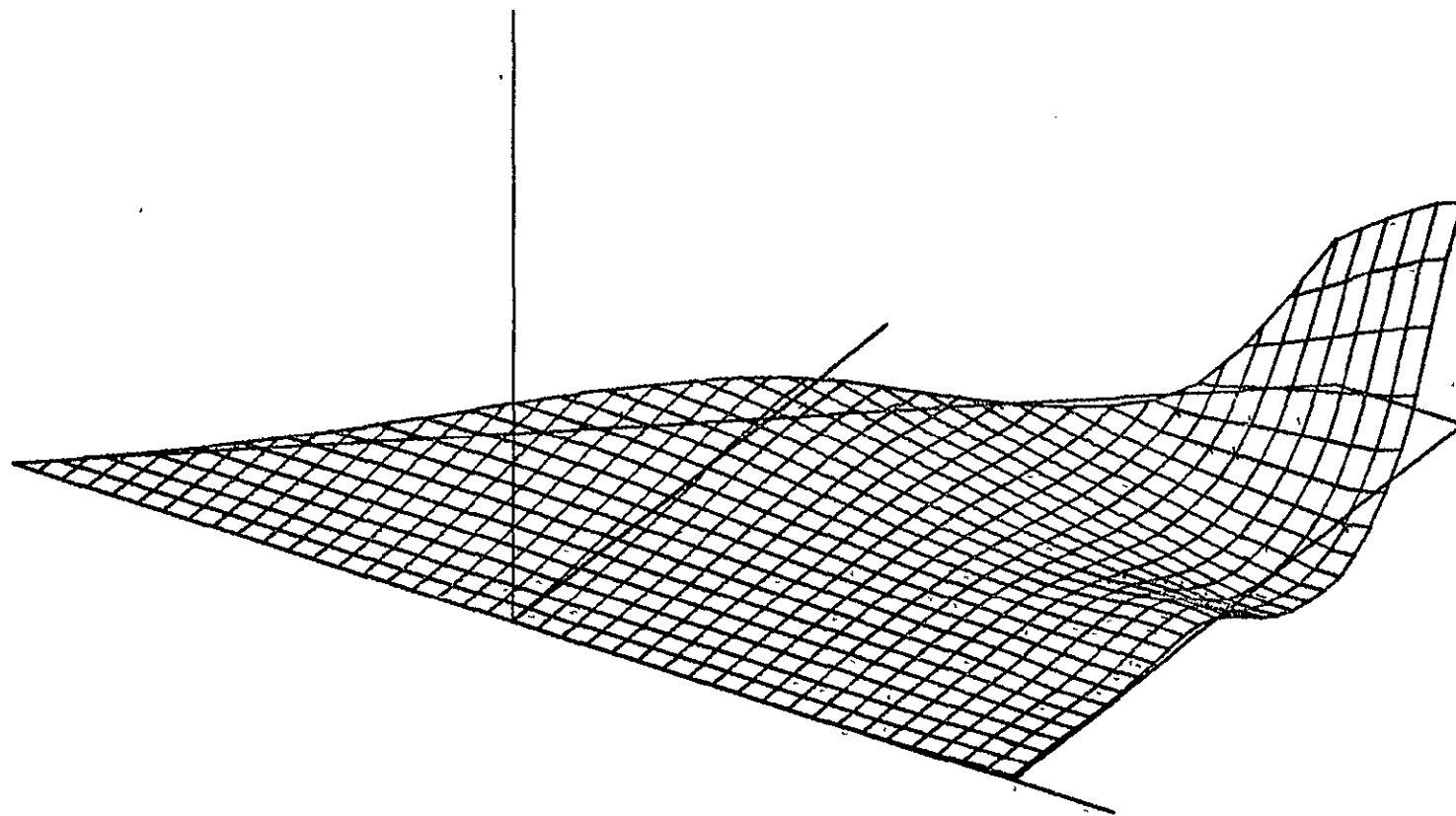


Figure 3. - Continued.



MODE 7

OBLIQUE PROJECTION

Figure 3. - Continued.



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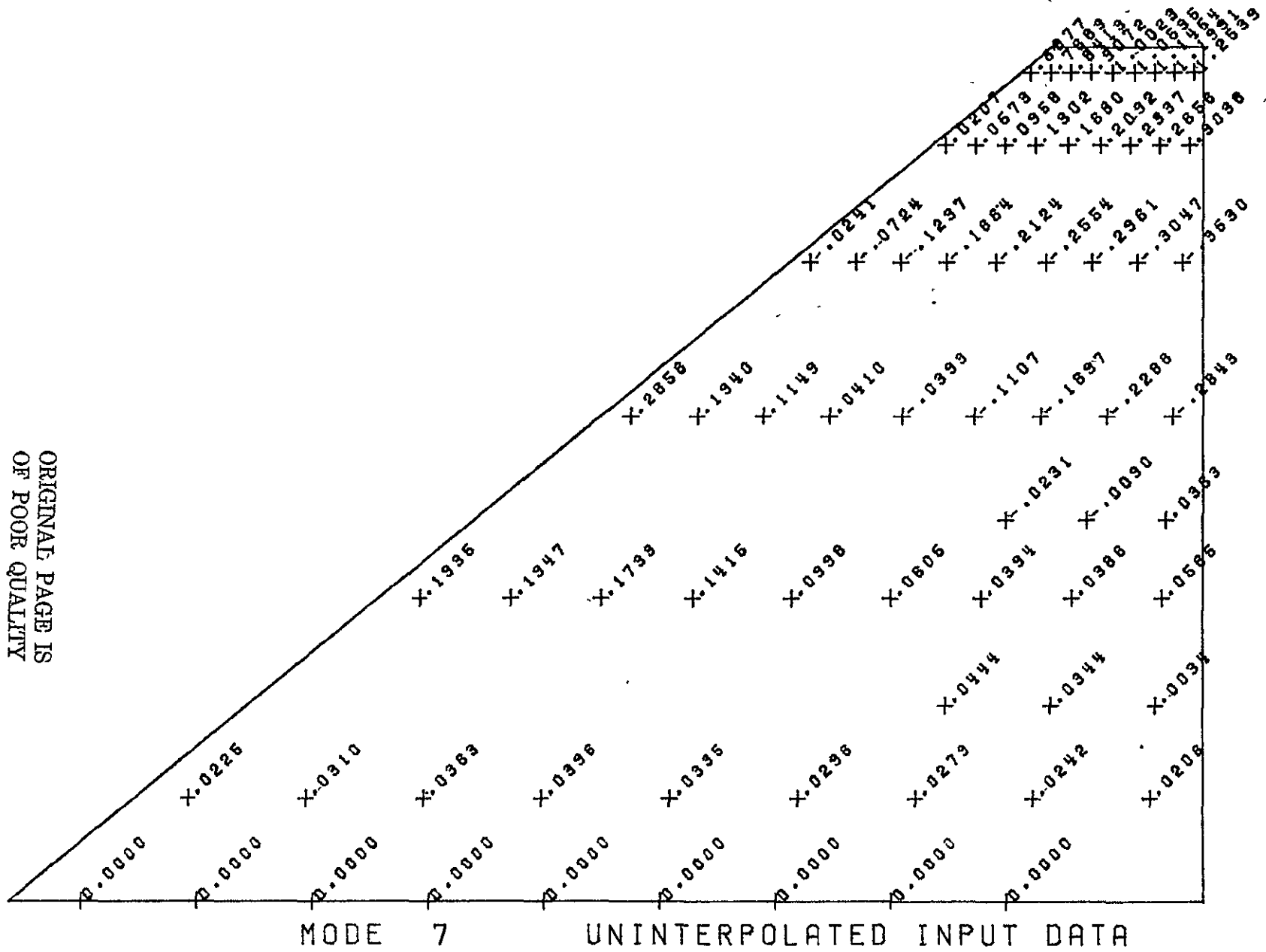


Figure 3. - Continued.

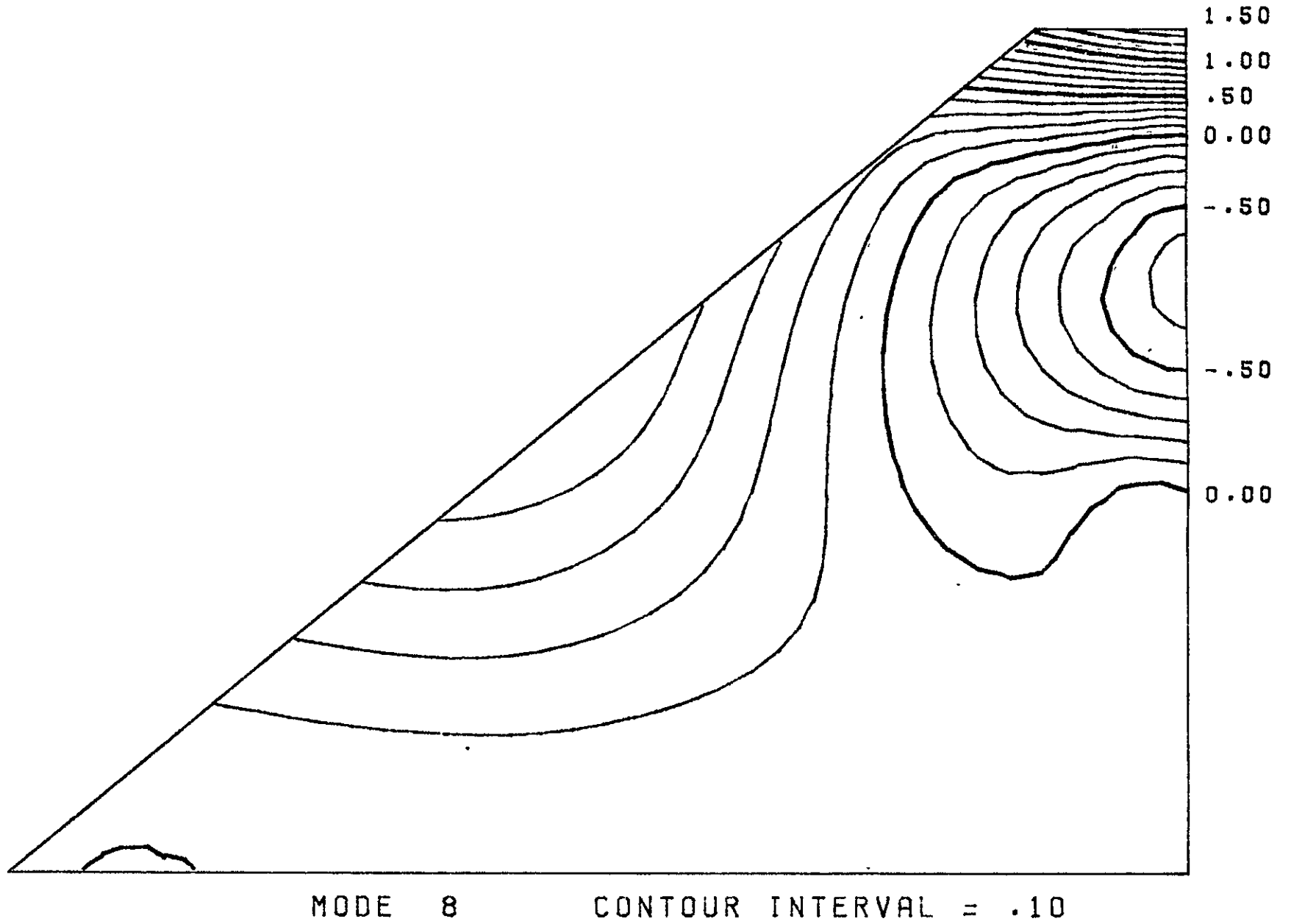
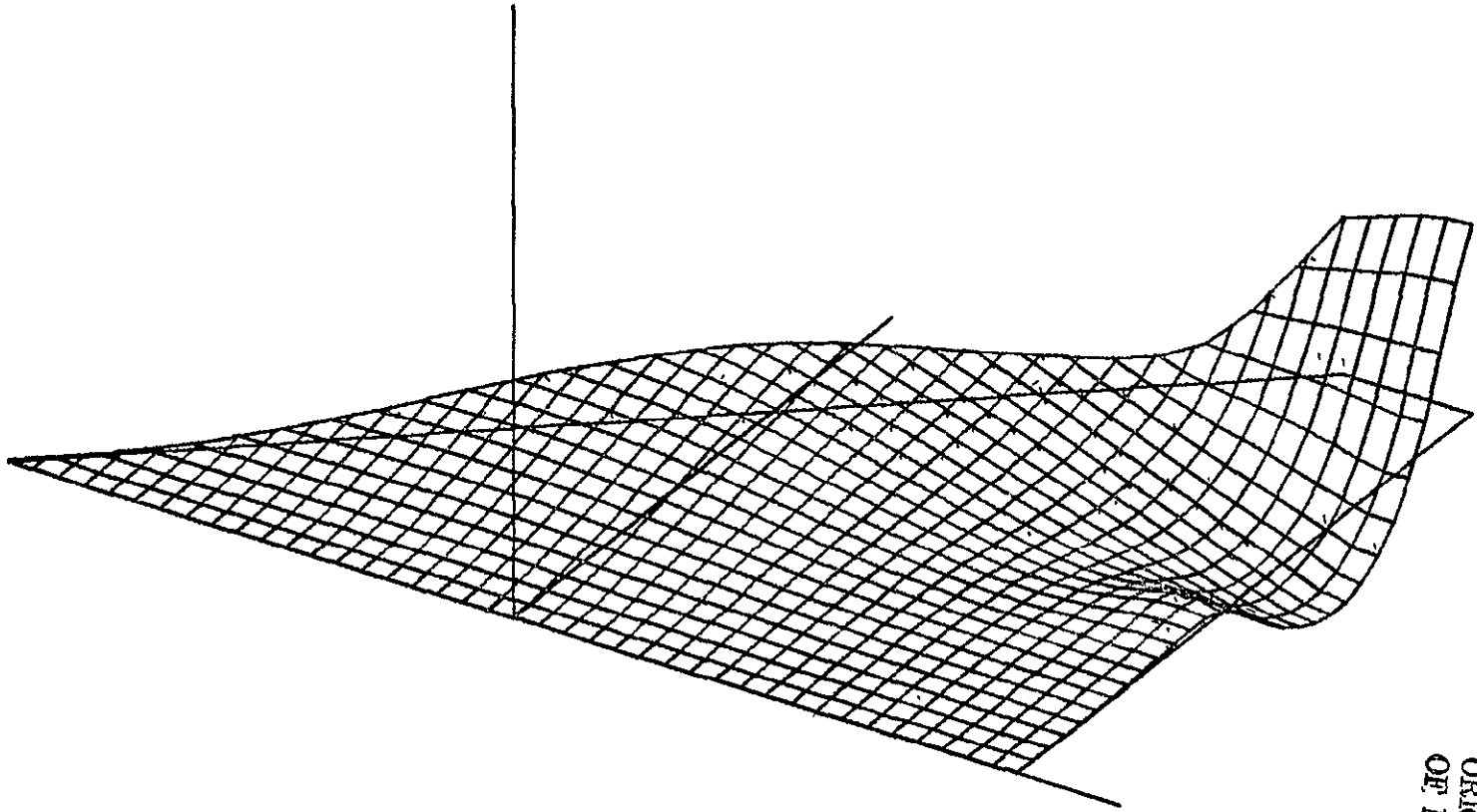


Figure 3. - Continued.



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MODE 8 OBLIQUE PROJECTION

Figure 3. - Continued.

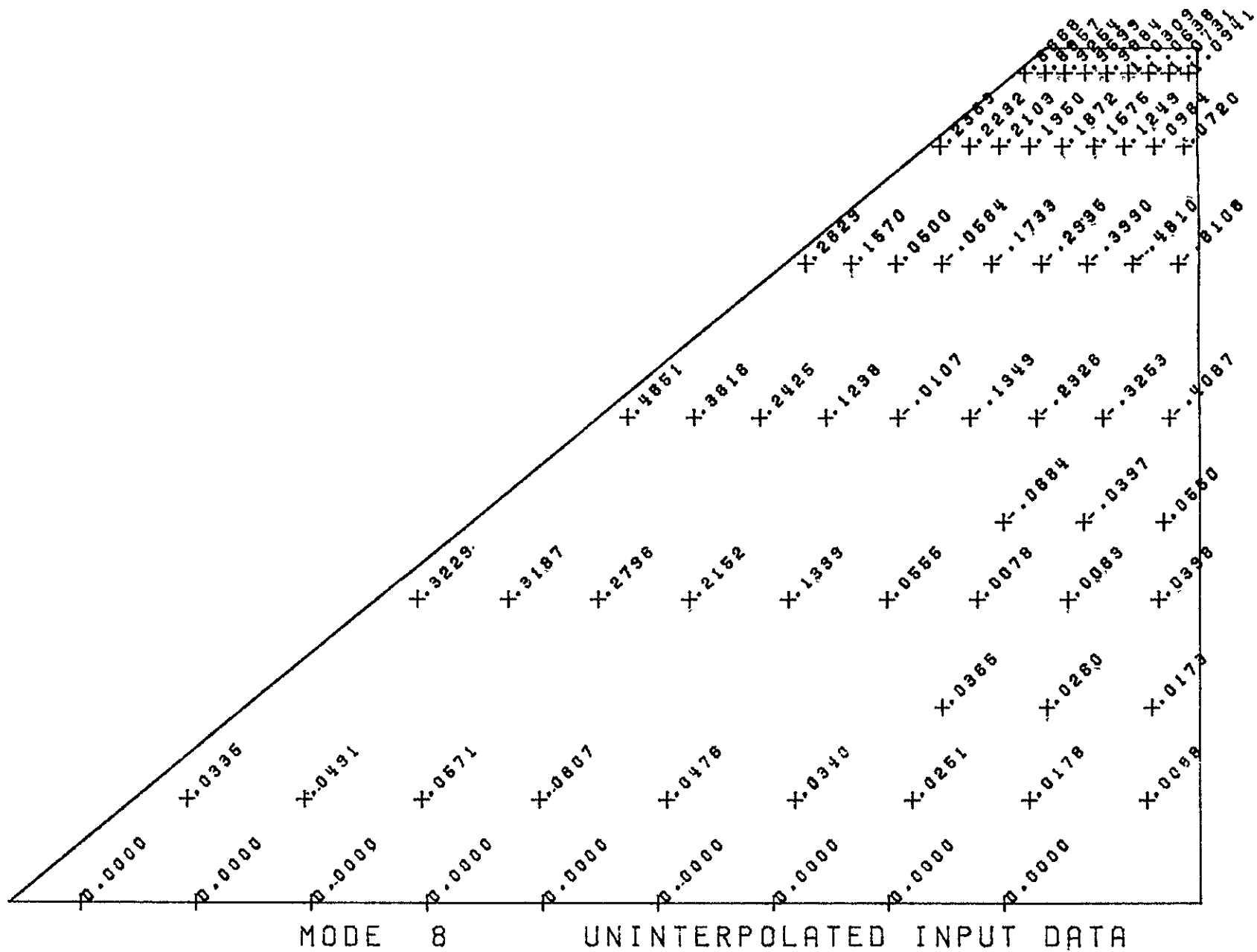


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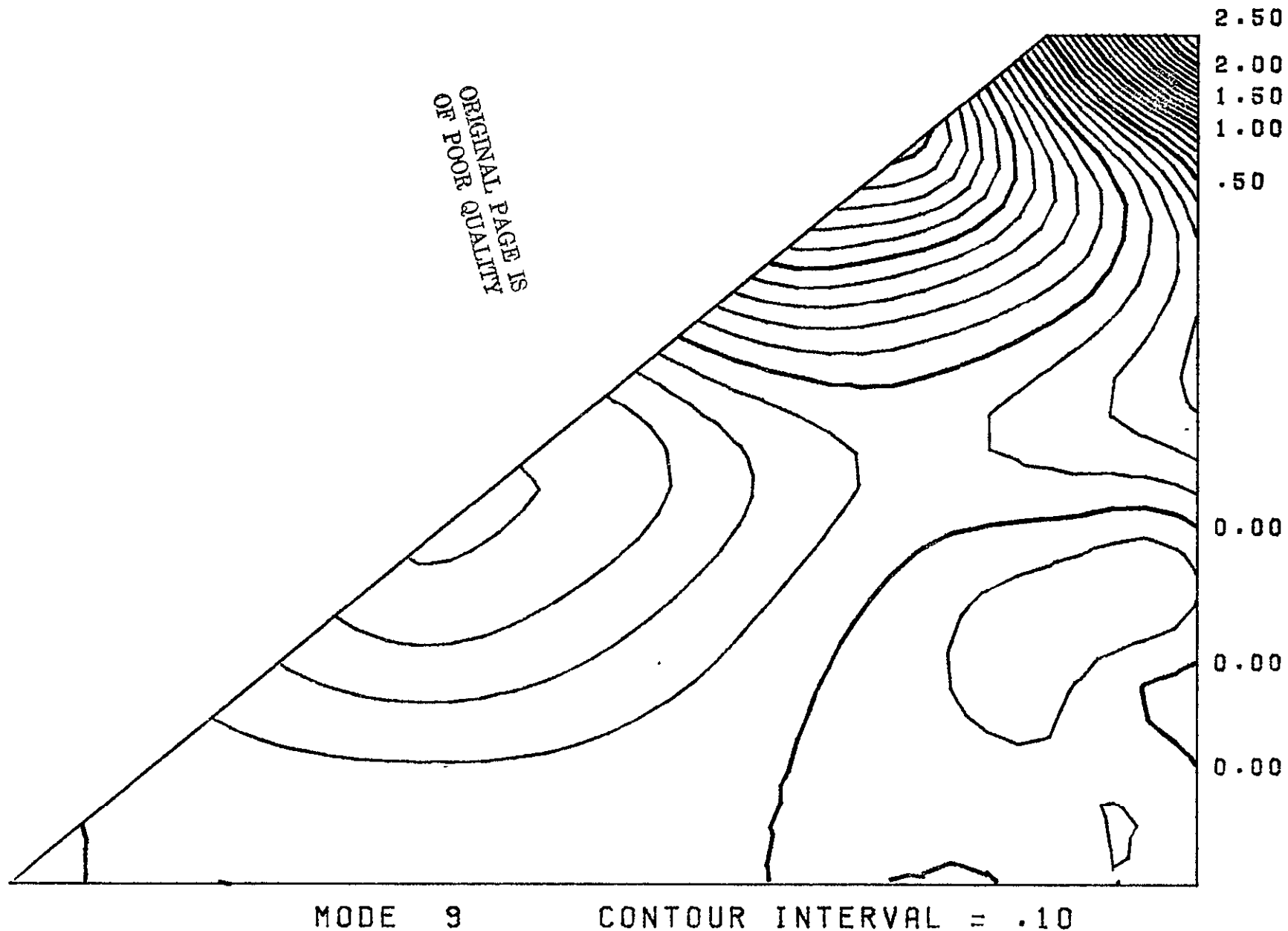
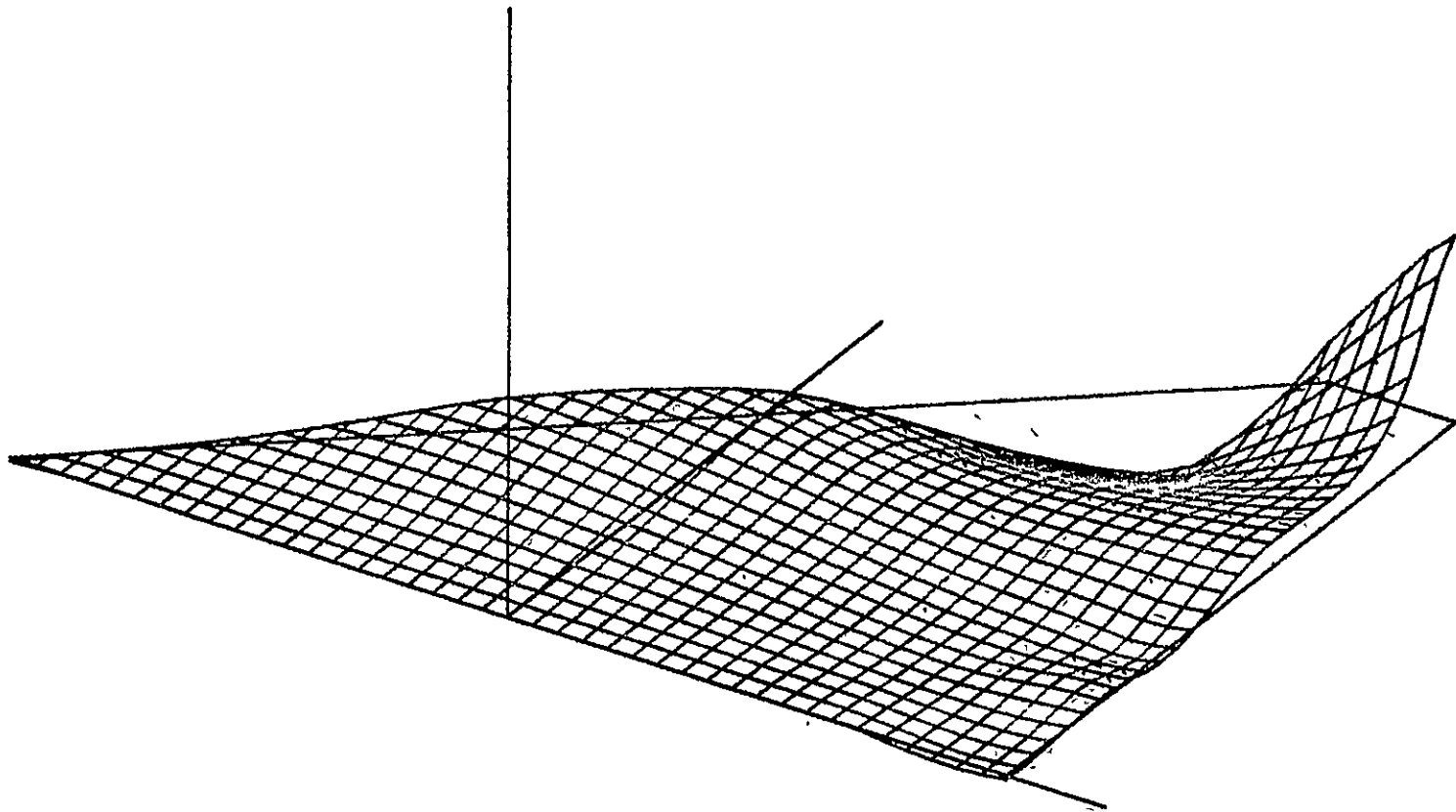
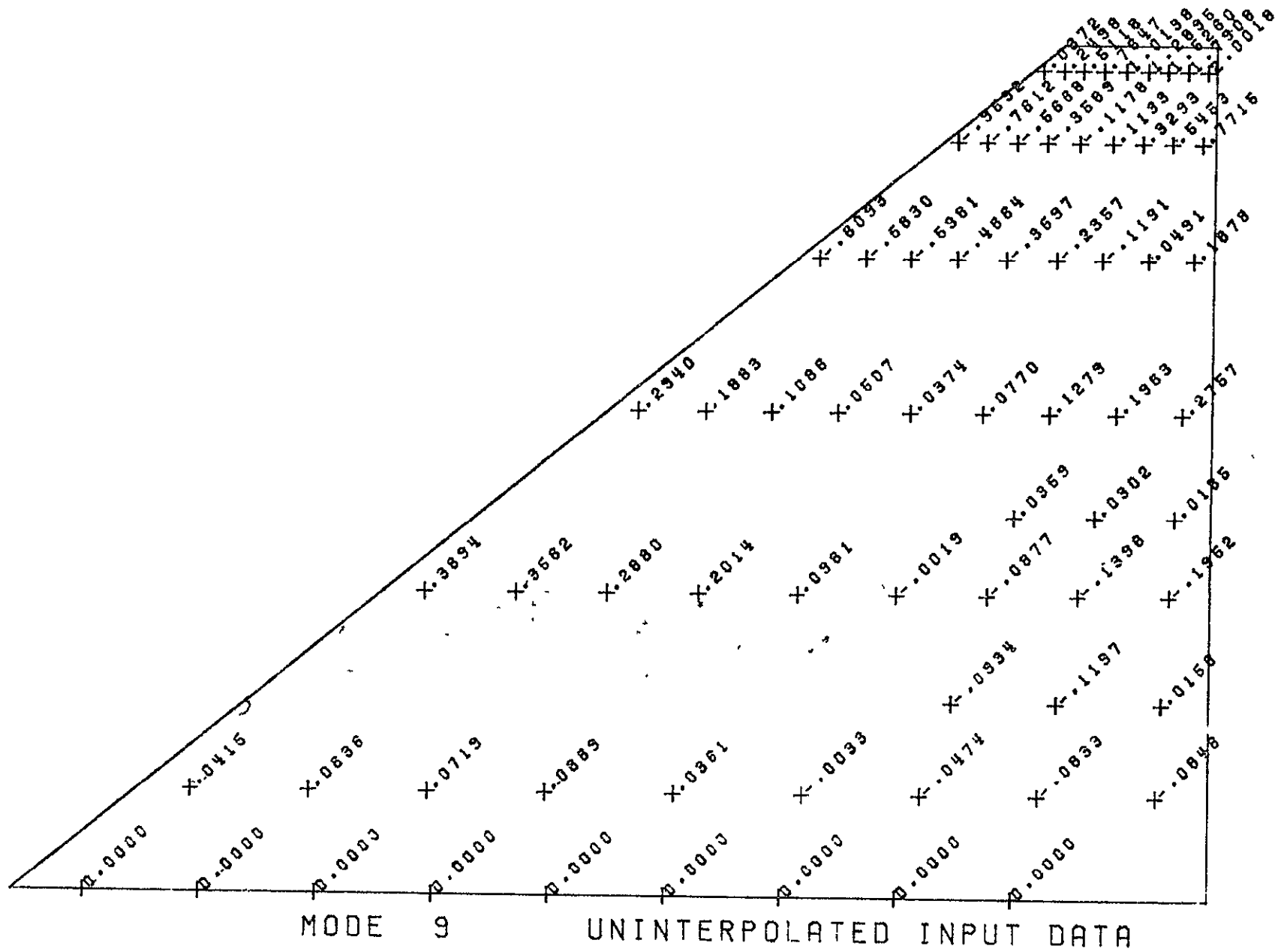


Figure 3. - Continued.



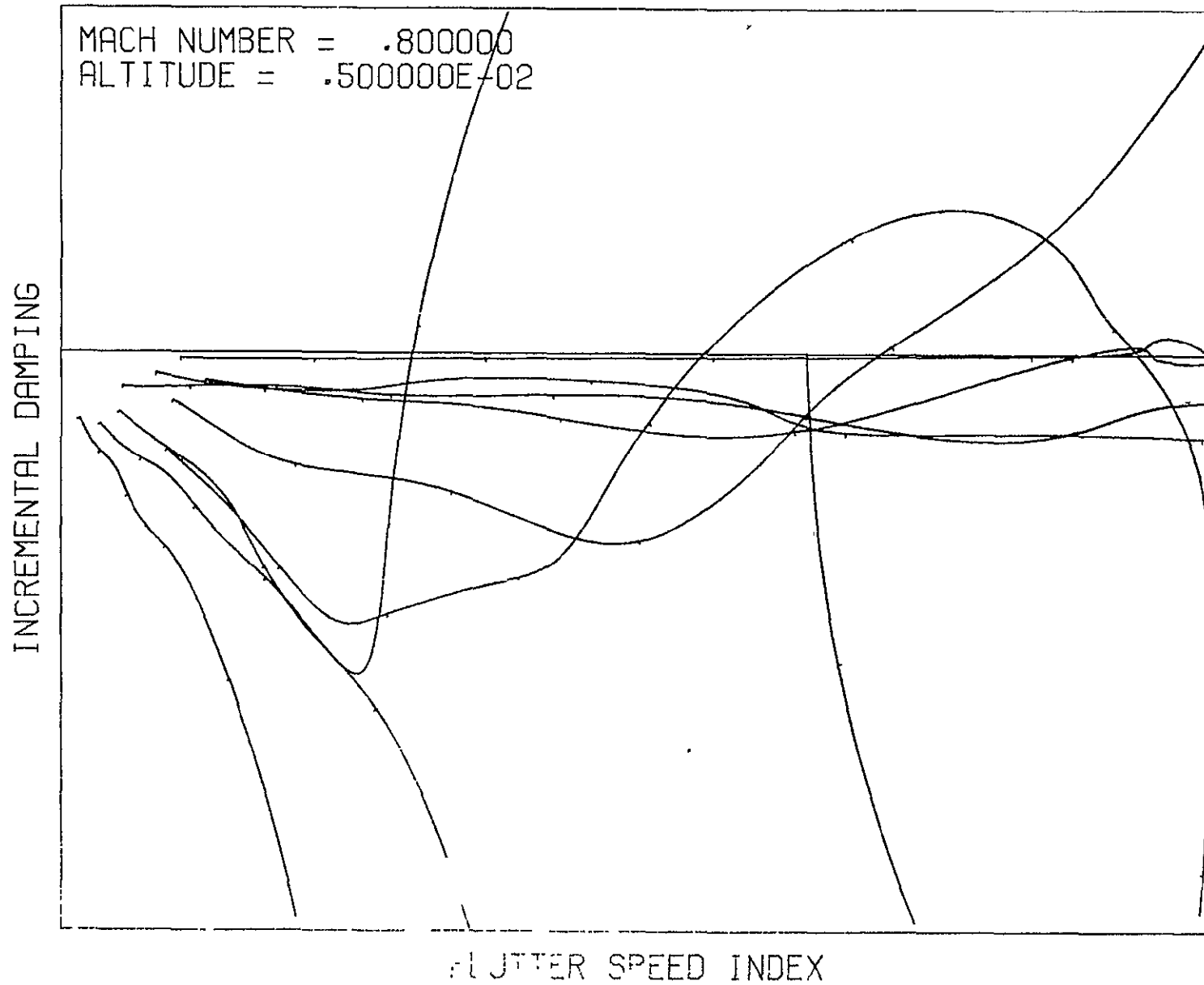
MODE 9 OBLIQUE PROJECTION

Figure 3. - Continued.



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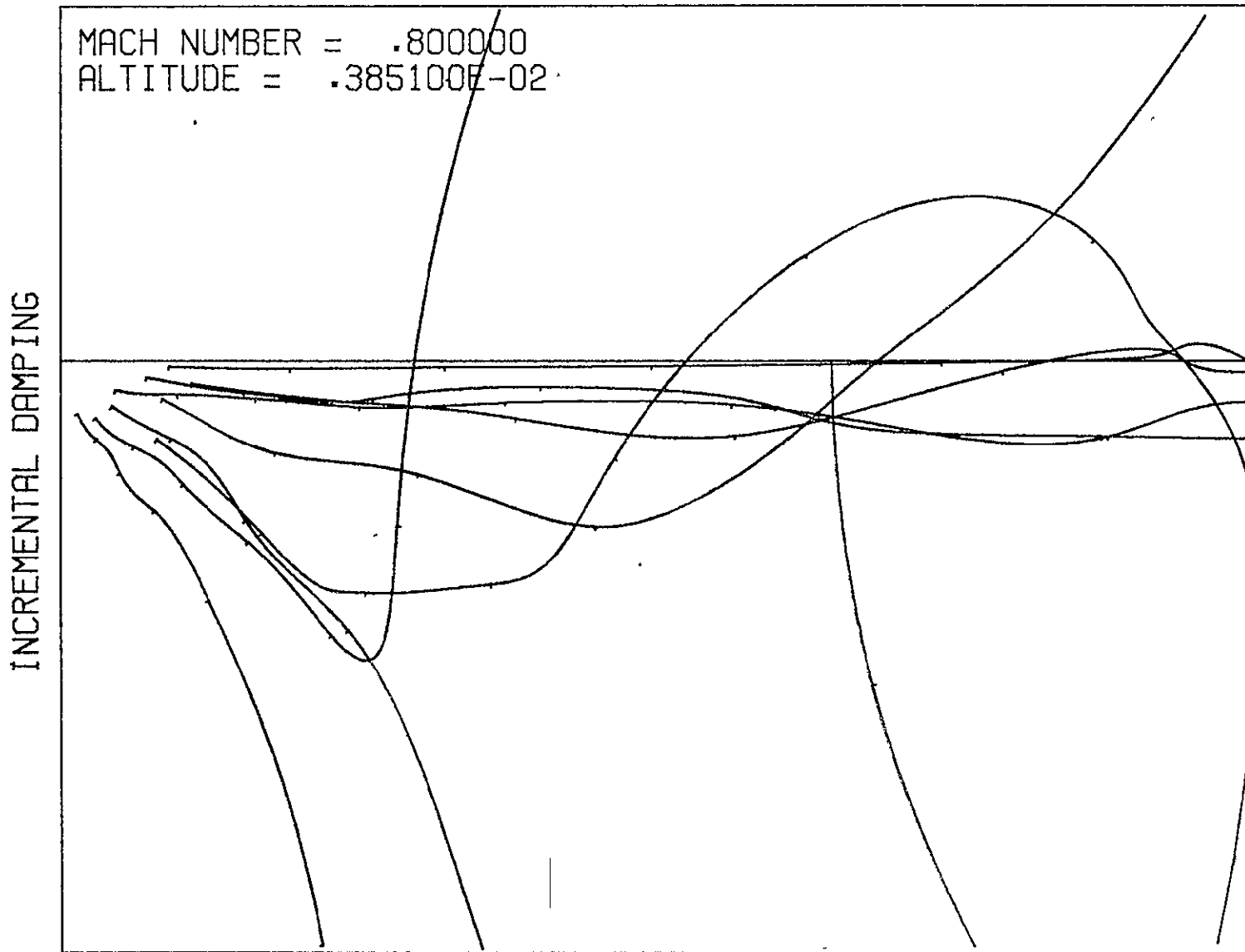
Figure 3. - Concluded.



(a) Density = .005000.

Figure 4. - V-g plots for the sample case generated by FLUTDET.





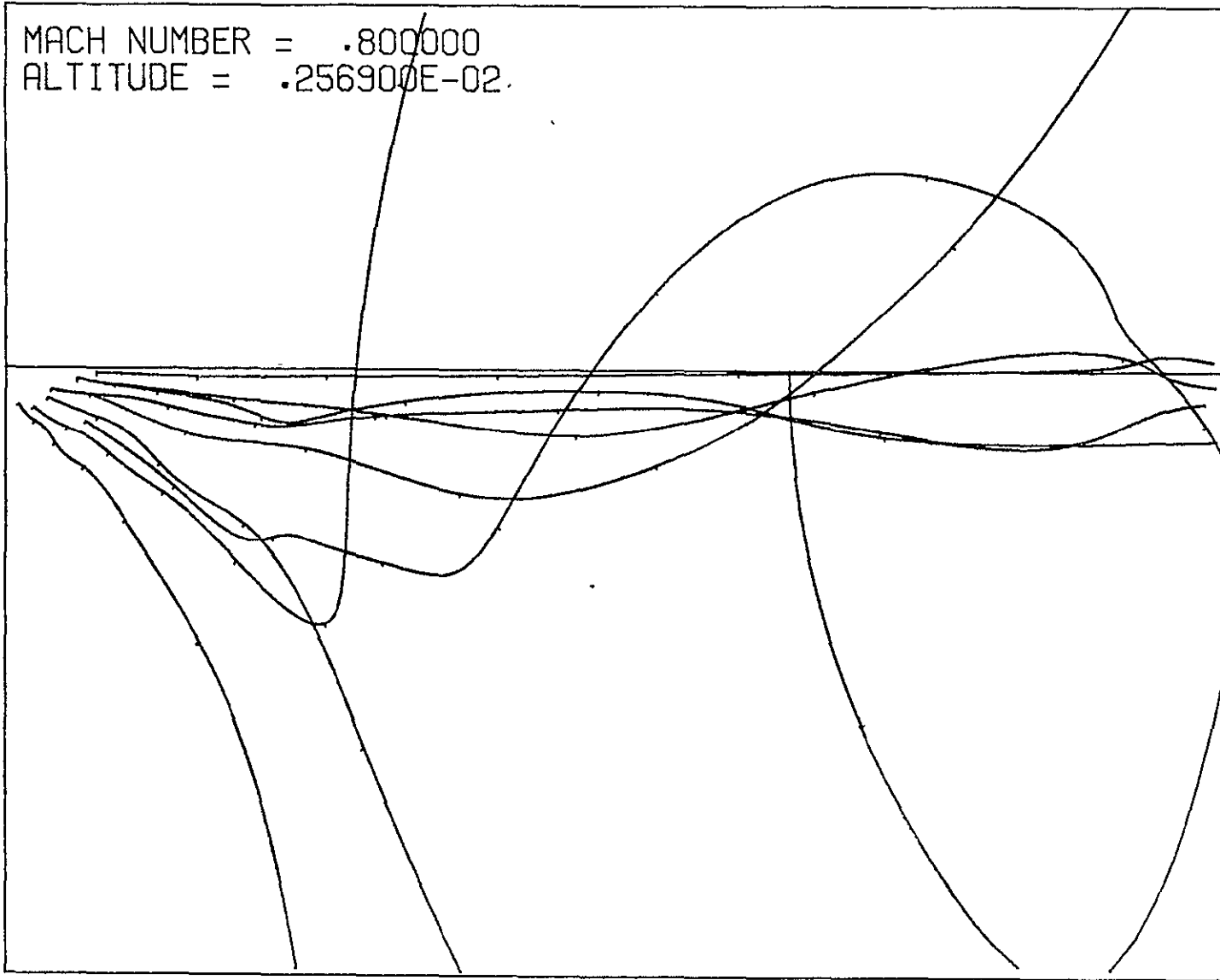
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FLUTTER SPEED INDEX

(b) Density = .003851.

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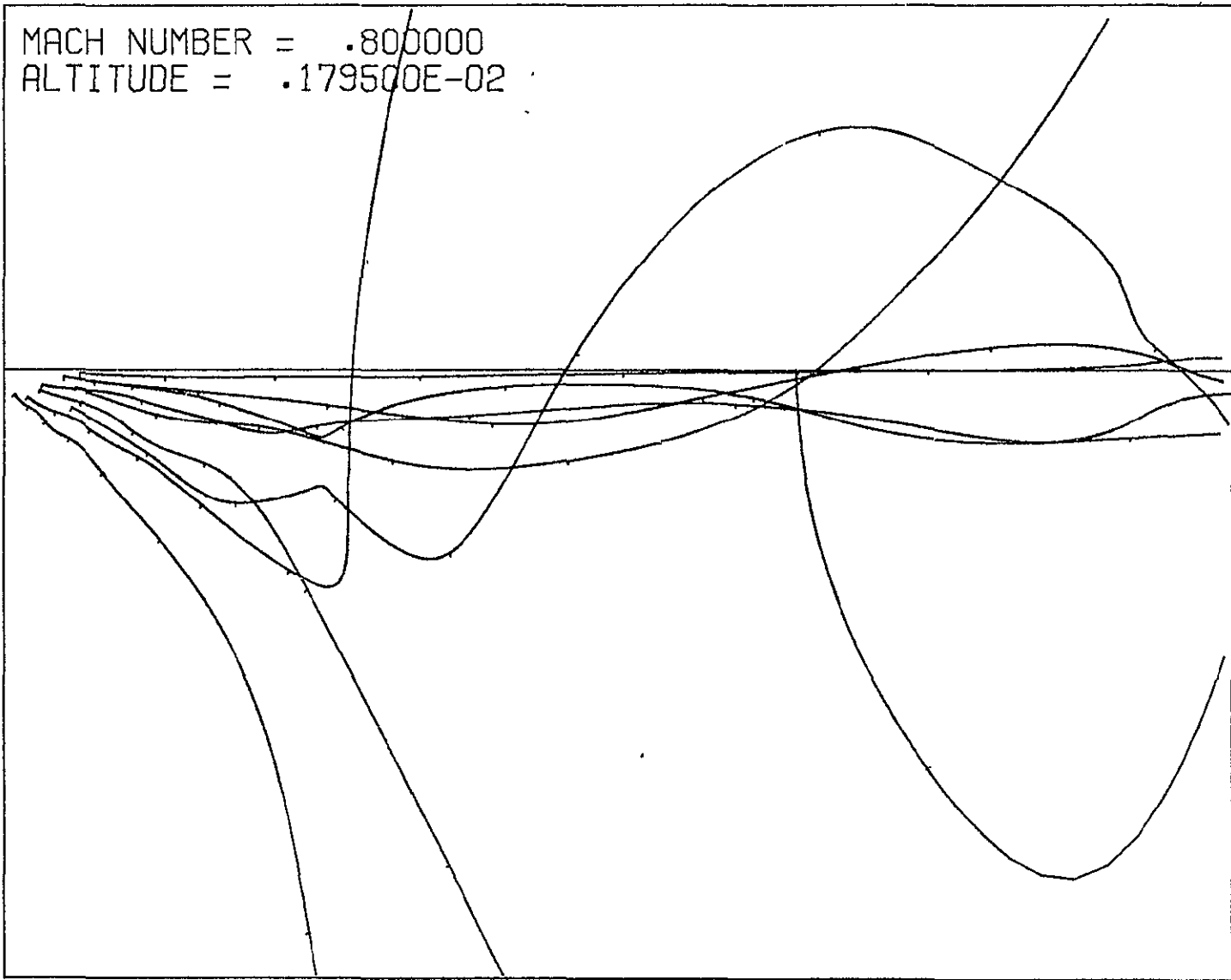
INCREMENTAL DAMPING



FLUTTER SPEED INDEX

(c) Density = .002569.

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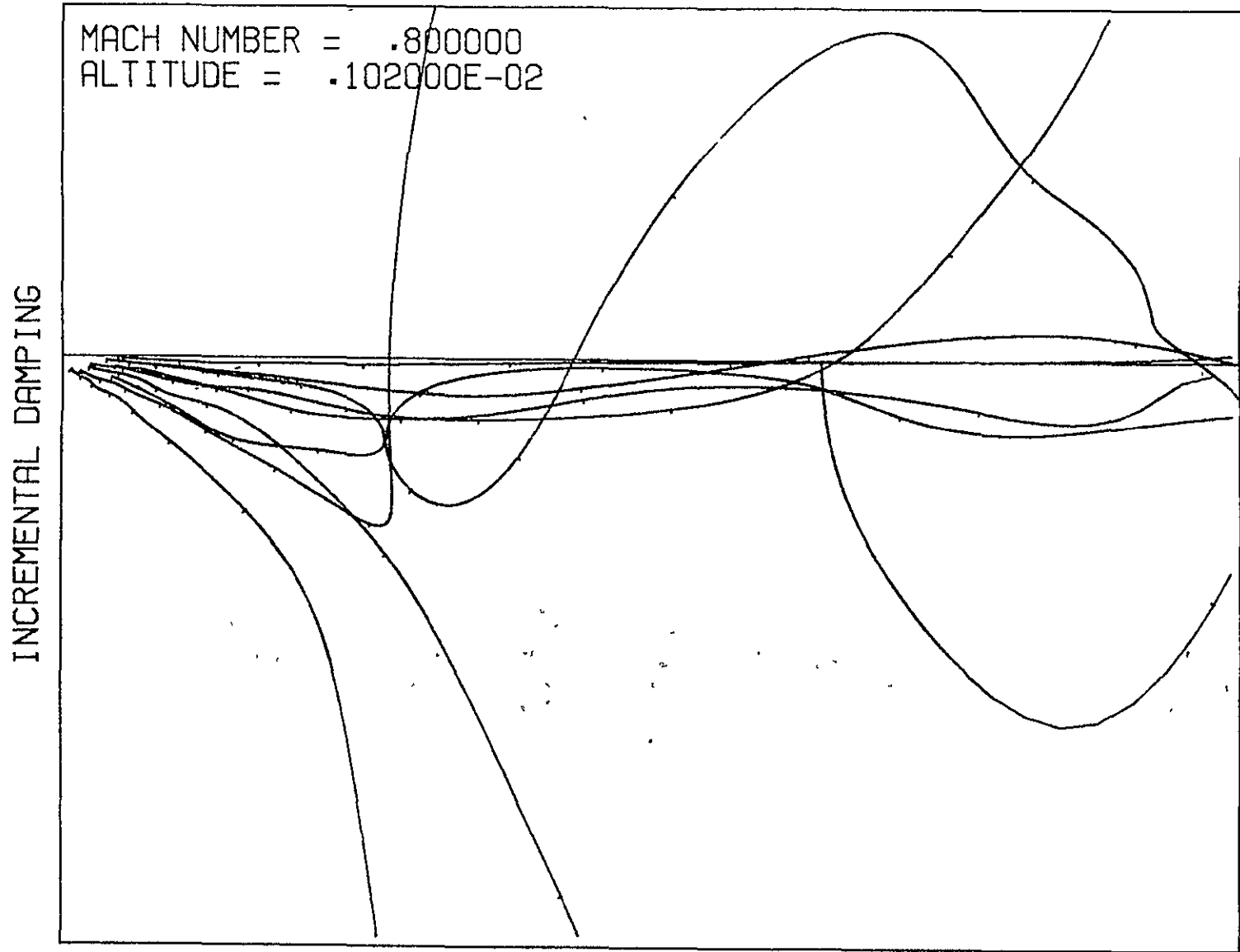


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FLUTTER SPEED INDEX

(d) Density = .001795.

Figure 4. - Continued.



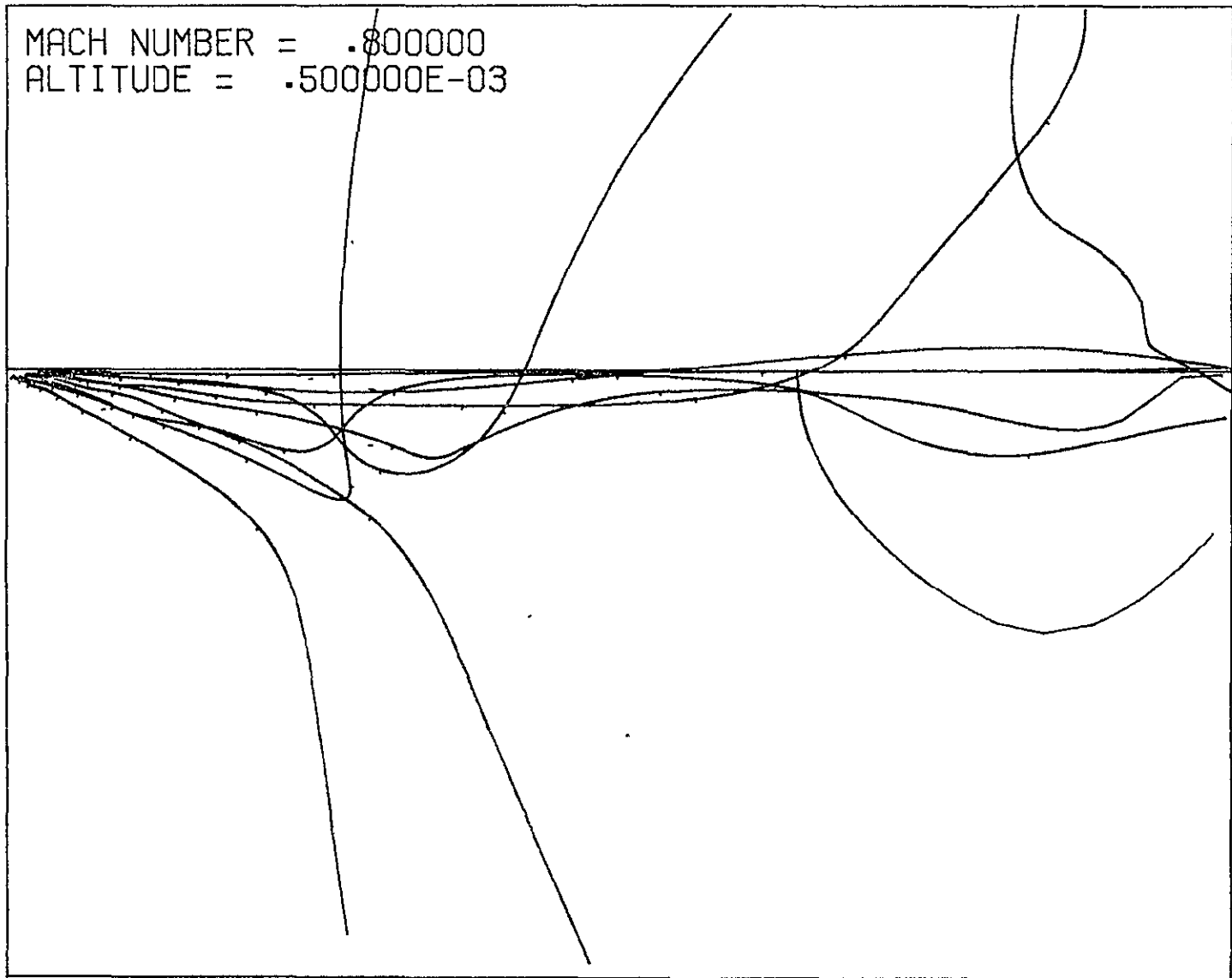
FLUTTER SPEED INDEX

(e) Density = .001020.

Figure 4. - Continued.

MACH NUMBER = .800000  
ALTITUDE = .500000E-03

INCREMENTAL DAMPING



FLUTTER SPEED INDEX

(f) Density = .000500.

Figure 4. - Concluded.

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