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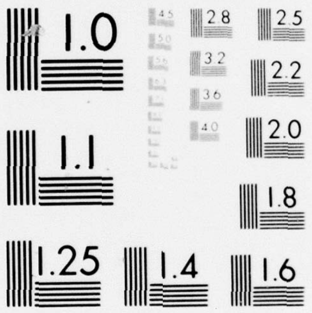

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Research and Development Technical Report

ECOM-4509

ANALYSIS TECHNIQUES AND INSTRUMENTATION FOR BLAST LOADED PARABOLIC ANTENNAS

James W. Jeter, Jr.

Research & Development Technical Support Activity

July 1977

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

In this report, a physical model and blast analysis techniques are developed for a solid surface parabolic antenna, using the NASTRAN structural analysis program The antenna considered is the US Army Satellite Communication Agency Antenna, consisting of a center section and four petal sections, all of which have the structural configuration of stressed skin over reinforcing ribs. The antenna is modelled as a network of flat membrane plates, except at connection points, where appropriate bending stresses are accounted for. An alternate model makes it possible to consider, to some extent, bending stresses in the skin.

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13. Abstract Con'd

A simplifying assumption of symmetrical behavior of the reflector reduces analysis costs considerably. When analysis of the center section alone is necessary, removal of a minimal number of computer cards from the complete model results in a model of the center section. Computer programs are described which translate the blast parameters and antenna geometry into concentrated dynamic loads at NASTRAN grid points. The analysis procedure for dynamic loads is outlined. Instrumentation and maximum overpressure loads for a shock tube test are recommended, based on available information. This task was supported financially by the Scientific Services Program of the US Army Research Office.

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ILLUSTRATIONS

INTRODUCTION

The purpose of this study is to develop analysis techniques for blast loaded parabolic antennas using existing structural codes, such as NASTRAN. The analysis techniques are for application to a US Army Satellite Communications Agency (SATCOM) Antenna to determine its behavior when subjected to air blasts. The antenna consists of a five piece monocoque reflector, lightweight reflector backup castings for the gimbal and actuator attachment points, a cross elevation axis of rotation with linear actuator drive, a tubular elevation/cross elevation gimbal assembly, an elevation axis of rotation with linear actuator drive, and a double tripod supporting the elevation axis. The problem is simplified and streamlined wherever possible to avoid excessive computer running costs. Computer programs are described which reduce the blast parameters and antennas geometry to concentrated loads at the NASTRAN grid points. Provisions were made to account for nonlinearities related to resistance to certain grid point displacements.

The objective of this study was to determine gauge locations and a nondestructive load range for the SATCOM antenna when subjected to frontal shock tube blasts. The conclusions stated here will be based on the geometry of the antenna, a NASTRAN static analysis of a model of the reflector, and a report by Tasker Industries on finite element studies for nuclear hardness of: a) the antenna on its shelter, and b) the antenna center section dismounted from the shelter.

DISCUSSION - Analysis of a Blast Loaded Parabolic Antenna

Although the antenna system is not structurally symmetric, the relatively high stiffness of the support in comparison to the reflector makes it possible to conservatively analyze the reflector as if it were fixed at its connection points to the supports and, therefore, symmetric about a horizontal axis. This assumption is expected to reduce the computer running time considerably, but has the disadvantage of restricting the model to the study of symmetric loads. It should be noted that available analyses indicate that a head-on (symmetric) blast loading will be the most critical. The NASTRAN model for the reflector is shown in Figure 1 through 3. Membrane plates were used to model the skin and ribs of the petals and center section, except at connection points, where membrane-bending plates were used. An alternate model using all membrane-bending plates makes it possible to study the flexual stresses to some extent. Elastic springs were used to model the rim latches, the petal-petal latches, and the petal-center section latches. Nonlinearities exist where the petals join together and where the petals join with the center section. When the joining parts are pressed together, a resisting force is developed; when these points move apart, no resisting force develops. An approach was devised using nonlinear springs to account for this behavior in the transient analysis only.

The mechanics of this approach is explained in Appendix A. It is recommended that the nonlinear springs be omitted unless there is an indication that the nonlinear effect will be significant. The support points and most of the latches on the reflector are cast aluminum. These were not modelled precisely because accurate dimensions were not available and existing analyses indicated a precise model was not necessary.

However, changes were made in the reflector model in the vicinity of latches and supports to approximate their influence on the rest of the structure. Details of the reflector model in the vicinity of the petal-petal latches and in the vicinity of the petal-center latches are shown in Figure 4. Details of the reflector supports for the symmetric model are shown in Figure 5. The cross elevation actuator is included in the model and is assumed to be pinned at its support areas, while the gimbal support is constrained for all motion except rotation about a vertical axis. It was convenient in most cases to define grid point locations and movements in terms of a cylindrical coordinate system with origin at the center of the back panel. Plates were generally defined so that outputted stress directions would be in the meridional-tangential directions for elements on the two faces, in the meridional-axial directions for ribs, and in the axial-tangential directions for edge elements. If an analysis is desired for the center section alone, all grid points, elements and load cards related to the petals and all elastic springs must be removed. Also, the case control deck and the bulk data deck must be purged of all nonlinear loads and multipoint constraints which refer to the petals.

NASTRAN has two possible formats for describing transient loads. One is defined by the conditions $P(t)=0 \quad (\bar{t} < 0 \text{ or } \bar{t} > T2-T1)$

$$P(t)=A\bar{t}^{B} e^{ct} \cos(2\pi F\bar{t}+G) \quad (o \leq t \leq T2-T1)$$

where

$P(t)$=the time dependent load at a point for a degree of freedom
$t=t-T1-\tau$
t=elapsed time
τ=time delay
B,C,F,G,T2,T1 are constants defined by the user.

The other NASTRAN loading format is of the form

$P(t)=A\,F(t-\tau)$ where $P(t)$, t, and τ are as defined previously
$F(t-\tau)$ is a tabulated function of time that is linearly interpolated between entries and A is a tabulated coefficient which may be different for each loaded degree of freedom.

The formula approach was considered first because of its apparant simplicity, but was rejected because of inconveniences it engenders when a change in the pressure-time relationship is desired. The tabular approach is applied to the antenna as follows: a pre-processor program generates the tabular information defining the pressure on the surface. Only a few of these points will generally be needed to define the time-pressure curve accurately in the NASTRAN table. This program is described in Appendix B. The tabulated coefficient, A, accounts for the area associated with a uniform pressure load on the reflector surface, and for the geometry of that surface. A FORTRAN IV computer program was written which reads the cards defining the front or back surface of the reflector and punches the NASTRAN DAREA cards which define the constant, A, for each loaded degree of freedom. Use of this program is detailed in Appendix C. The approach used in splitting up the area is the same as that used by NASTRAN for static pressure loads. For triangles, one third of the total area is associated with each corner. Each diagonal of a quadrangle is used to split the quadrangle into two triangles. The triangle areas are distributed as described above and the area associated with a corner of the quadrangle is the sum of the triangle areas associated with that corner divided by six.

For the transient analysis of the reflector, either the NASTRAN direct or the NASTRAN modal approach could be used. The direct approach is recommended here, primarily for its ability to handle nonlinearities. It is suggested that a static analysis and a normal mode analysis be executed before the more expensive dynamic analysis to check for weaknesses in the model. These preliminary analyses may also provide insight on use of the Guyen Reduction, which can reduce processor time by decreasing the number of points given inertia properties. The time increment size can be roughly determined by the equation:

$$\Delta t = \frac{1}{20f}$$

where Δt= time increment (secs)
f= highest frequency expected to influence solution significantly (cycles/sec)

The Tasker report describes a modal transient analysis, using the STARDYNE finite element program. Computer processor time was in excess of three hours for the analysis of the antenna on the shelter, so several measures were taken to increase the efficiency of the analysis. One such measure involved minimizing the number of monitored points, to the extent that only latches and two rib plates were monitored on the reflector. Presumably these points were found to be critical in a less expensive static analysis. The transient analysis considered only elastic behavior of the structure; since time dependent effects on material properties were either unknown or not accounted for, the Tasker report defined failure in terms of the ultimate strength, i.e., the stress at which separation of molecules occurs in a static situation. A failure factor, determined by dividing the maximum stress on a member by the ultimate stress, was used to indicate the severity of stress. Five monitored antenna elements "failed" in this test. These elements and their failure factors are shown in Table 1.

TABLE 1

Summary of Antenna Failures

MEMBER	FAILURE FACTOR
Latch Casting	6.1
X-Elevation Actuator	3.6
Elevation Actuator	7.2
Gimbal Tube	1.6
Rear Leg	1.4

The high stress level in the latch casting is indicative of the stresses in the unmonitored portion of the reflector, where it is likely that failure occurred. The possibility of a buckling failure is high, but is not reflected in Table 1. For this analysis, the shelter was available to absorb considerable energy and, thus, reduce the blast effect on the antenna. The antenna will be ground mounted for the shock tube test.

In the second analysis, the center section was ground mounted and subjected to the same blast. The smaller model allowed for more points on the antenna to be monitored. The monitored elements which "failed" and their failure factors are given in Table 2.

TABLE 2

Summary of Center Section Failures

MEMBER	FAILURE FACTOR
Actuator trailing arm	2.6
Rear leg	1.2
Reflector skin (worst case)	6.4

The report indicates that every reflector plate element monitored experienced stresses exceeding the allowable buckling load in the center section test.

A study of the geometry and the static NASTRAN solution, as well as the Tasker report, indicated that the upper portion of the reflector away from the cross elevation support is where the largest stresses are likely to occur. This is because the stiffness is lower and because fewer paths are available for removal of energy from this area.

CONCLUSIONS

Analysis of a Blast Loaded Parabolic Antenna

A physical model and blast analysis techniques have been developed for a solid surface parabolic antenna, using the NASTRAN structural analysis program. Pre-processer programs were developed to define the blast pressure load in terms acceptable to NASTRAN. A method was developed for dealing with nonlinear deformations of the reflector. It is expected that the model will give reasonable results for the overall behavior of the reflector. If information concerning localized effects is desired, a separate detailed local analysis, based on the solution for the total reflector, can be made. This separate analysis would be approximate, but should be sufficiently accurate to describe the localized behavior. Application of the Guyen Reduction is recommended for subsequent runs once the general dynamic behavior of the antenna has been established.

Instrumentation for SATCOM Antenna Shock Tube Test

The Tasker analysis were done for a specified nuclear blast. Failure factors are given for some of the members which failed, presumably the most serious failures. A gross estimate of the maximum nondestructive overpressure could be had by dividing the Tasker overpressure by the largest failure factor. This method ignores plasticity and buckling, but these phenomena may have reduced significance due to the high strain rate and the short load duration. This approach does not account for the energy absorbing effect of the shelter which was included in the Tasker analysis. It is conservative in assuming a linear relationship between stress and overpressure rather than stress and impulse, since the duration of the nuclear blast is probably much higher than that of the shock tube blast. At any rate, the estimated overpressure should be used as an indicator only.

Instrumentation was concentrated on the top of the antenna away from the cross elevation support. These locations are tabulated in Table 3. Location codes 1, 2, 3, 4, 5, 7, 9, 12 and 16 indicate points where high stresses are expected. The other points are monitored primarily to gain information about the behavior of the antenna.

TABLE 3. SENSOR SELECTIONS AND LOCATIONS ON ANTENNA FOR SHOCK TUBE TEST

Test W/Petals Location Code	Test W/O Petals Location Code	Sensor Type	Channels Required	Location
1		Linear Strain	1	Upper center latch, left petal (on single piece center selection)
2		Rosette Strain	3	On front of petal, vicinity of #1
3		Linear Strain	1	On shaft of elevation actuator (two gages in series, one on each side) SEE NOTE 1
4		Linear Strain	1	Rear leg, left side (two gages in series, one on each side) SEE NOTE 1
5		Linear Strain	1	Gimbal tube, upper left side (two gages in series, one on each side) SEE NOTE 1
6		Linear Strain	1	Left petal rim, near rim latch connecting to upper petal
7	7	Rosette Strain	3	Between ribs in center section at left of top centerline
8		Accelerometer	1	Upper petal rim, near rim latch connecting to left petal
9		Linear Strain	1	On shaft of cross-elevation actuator SEE NOTE 1
10		Rosette Strain	3	On rear of petal, vicinity of #1
11		Rosette Strain	3	On front of left petal, vicinity of upper to left (petal to petal) latch

Test W/Petals Location Code	Test W/O Petals Location Code	Sensor Type	Channels Required	Location
12		Rosette Strain	3	On rib on upper side of left petal
13	13	Linear Strain	1	On front left side of center section over and perpendicular to rib
14		Accelerometers	2	On front of both sides of upper petal to left petal joint, away from petal to petal latch
15		Accelerometers	2	Both sides of petal to center section joint on upper part of left petal
	16	Rosette Strain	3	On front of center section, Vicinity of #1
	17	Rosette Strain	3	On rear of center section, Vicinity of #1
	18	Accelerometer	1	On front edge of center section, near petal to petal joint
	19	Rosette Strain	3	Physically on edge of center section, between petal to center section latches

NOTE 1: Location #3, 4, 5 & 9 are to be installed on structural and mechanical members which support and position this antenna. Directions as to their exact locations will be supplied at the test site

APPENDIX A

NASTRAN Model of Nonlinear Behavior of Surfaces in Contact

The following model of the nonlinear behavior of surfaces in contact for the reflector should be used only when this behavior will have a significant effect on the problem. For the present model, a minimum of thirty eight (38) transfer functions and seventy six (76) nonlinear loads must be developed if the nonlinearity is to be handled automatically by NASTRAN. The procedure is as follows:

1) Define extra points for each pair of points in contact, using EPOINT cards.

2) Relate the extra points to the points in contact through transfer functions, using TF cards. The transfer function is:

$(1)\mu_D + (1)\mu_1 + (-1)\mu_2 = 0$ where μ_D is the extra point. For petal to petal contact surfaces μ_1 is the tangential deflection of the first of the contact points encountered when traversing the reflector in the tangential direction and μ_2 is the tangential deflection of the second of the contact points. For petal to center section contact surfaces, μ_1 is the radial deflection of the first of the contact points encountered when traversing the reflector in the radial direction and μ_2 is the radial deflection of the second of the contact points. The presence of a transfer function must be indicated in the case control deck.

3) Apply the negative power function nonlinear load to both points in contact using NOLIN4 cards. The two loads are defined, respectively, by the equations: $P_1(t) = -S_1 (-\mu_D (t))^1$, $P_2 (t) = -S_2(-\mu_D (t))^1, \mu_D (t) < 0$

$$P_1(t) = P_2(t) = 0 , \mu_D(t) \geq 0$$

where S_1= const - arbitrarily taken to be the same as used in the elastic springs and $S_2 = -S_1$. The presence of a nonlinear load system must be indicated in the case control deck.

APPENDIX B

COMPUTER PROGRAM FOR PRESSURE TIME HISTORY OF BLAST LOAD ON THE REFLECTOR SURFACES

For load definition purposes, the reflector can be compared to a closed rectangular box, a shape which has been subjected to extensive study. The empirical formulas presented by Gladstone[1] for the rectangular box were used in a short computer program[2] written for use on the Hewlett-Packard 9830 Calculator to provide the average pressure-time history of the blast load on each face of the reflector. Data is inputted by the following statement:

9000 DATA A, B, C, D, E, F where

A = Surface indicator (1 = front 2 = side 3 = back)

B = Positive phase duration (seconds)

C = Time increment for calculating pressure (seconds)

D = Peak overpressure (psi)

E = Length of Reflector (ft)

F = Heighth of "rectangle" or half of width of "rectangle", whichever is smaller (ft) (For reflector, F = radius, in ft)

The output for this program is a printout of the pressure for each time step and a plot of pressure vs. time. The plot is used to determine how many of the printout values are sufficient to accurately define the load history. Appropriate data can then be selected from the printout to describe the load on NASTRAN TABLED cards.

Formulas for load-history descriptions from other sources can be substituted for the Gladstone formulas in the program.

---

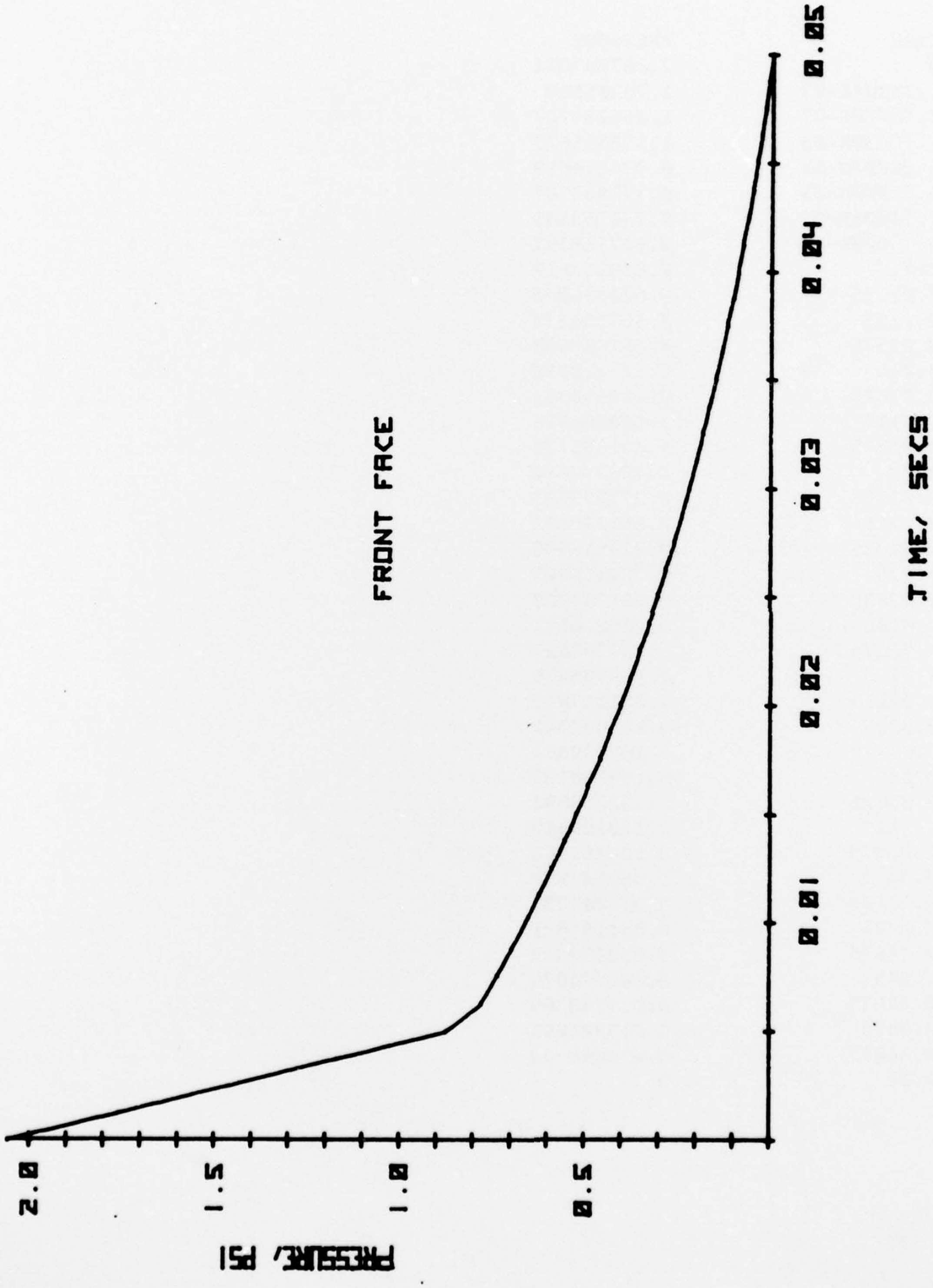
[1] The Effect of Nuclear Weapons, Samuel Gladstone, US Atomic Energy Commision, Washington, DC, April 1962

[2] Computer program and plot appear on following pages

```
10  READ A,X1,D1,P0,L,S
20  R=2*P0*(102.9+4*P0)/(102.9+P0)
30  U=1117*(1+6*P0/7/14.7) (1/2)
40  SCALE 0,X1*7/6,0,0,R*6/5
50  OFFSET X1/8.5,R/5
60  XAXIS 0,0.005,0,X1
70  YAXIS 0,0.1,0,R
80  LABEL (*,1.5,1.7,0,1)
81  PLOT X1/2,R/2,1
82  IF A#1 THEN 85
83  LABEL (*) "FRONT FACE"
84  GOTO 90
85  IF A#2 THEN 88
86  LABEL (*) "SIDE FACE"
87  GOTO 90
88  LABEL (*) "BACK FACE"
90  FOR Y=0.5 TO R STEP 0.5
100  PLOT 0,Y,1
110  CPLOT -5,-0.3
120  LABEL (170)Y
130  NEXT Y
140  PLOT -7,R/2,1
150  CPLOT -7,-0.3
160  LABEL (*,1.5,1.7,PI/2,1) "PRESSURE, PSI"
170  FORMAT F4.1
180  LABEL (*,1.5,1.7,0,1)
190  FOR X=0.01 TO X1 STEP 0.01
200  PLOT X,0,1
210  CPLOT -3,-2
220  LABEL (240)X
230  NEXT X
231  PLOT X1/2,-4,1
232  CPLOT -5,-0.3
233  LABEL (*) "TIME, SECS"
240  FORMAT F6.2
250  Q=14.7*5/14*(P0/14.7)↑2/(1+1/7*P0/14.7)
260  IF A#1 THEN 310
270  X2=3*S/U
280  Y2=Q*(1-X2/X1) 2*EXP(-2*X2/X1)+P0*(1-X2/X1)*EXP(-X2/X1)
290  L1=X1
300  GOTO 400
320  X2=L/U
330  Y2=-0.4*Q*(1-X2/X1/2)↑2 EXP(-2*X2/X1/2)+P0*(1-X2/X1/2)*EXP(-X2/X1/2)
340  L1=X1+X2/2
350  X3=(L+4*S)/U
360  X2=L/U
370  Y2=-0.4*Q*(1-(X3-X2)/X1)↑2*EXP(-2*(X3-X2)/X1)
380  Y2=Y2+P0*(1-(X3-X2)/X1)*EXP(-(X3-X2)/X1)
```

```
390  L1=X1+X2
400  D=X1/D1
410  PRINT "TIME", "PRESSURE"
420  FOR X=0 TO L1 STEP D
430  GOSUB A OF 470,540,620
440  NEXT X
450  PEN
460  STOP
470  Y=0.4*Q*(1-X/X1)↑2*EXP(-2*X/X1)+P0*(1-X/X1)*EXP(-X/X1)
480  IF X2 D THEN 510
490  IF X >= X2 THEN 510
500  Y=R*(1-X/X2)+Y2*X/X2
510  PLOT X,Y
520  PRINT X,Y
530  RETURN
540  N=0,4*Q*(1-(X-X2/2)/X1) 2*EXP(-2*(X-X2/2)/X1)
550  Y=N+P0*(1-(X-X2/2)/X1)*EXP(-(X-X2/2)/X1)
560  IF X2 D THEN 590
570  IF X >= X2 THEN 590
580  Y=Y2*X/X2
590  PLOT X,Y
600  PRINT X,Y
610  RETURN
620  Y=0.4*Q*(1-(X-X2)/X1) 2*EXP(-2*(X-X2)/X1)+PO*(1-(X-X2)/X1)*EXP(-(X-X2)
     /X1)
630  IF X3 D THEN 680
640  IF X >= X3 THEN 680
650  Y=0
660  IF X<X2 THEN 680
670  Y=(X-X2)/(X3-X2)*Y2
680  PLOT X,Y
690  PRINT X,Y
700  RETURN
9000   DATA 1,0.05,40,1,0.5,2
9990   END
```

```
TIME                PRESSURE
0                   2.057747834
1.25000E-03         1.76201578
2.50000E-03         1.466283727
3.75000E-03         1.170551673
5.00000E-03         0.874819619
6.25000E-03         0.777923667
7.50000E-03         0.736753283
8.75000E-03         0.697168292
0.01                0.659113619
0.01125             0.622536070
0.0125              0.587384259
0.01375             0.553608550
0.015               0.521160990
0.01625             0.489995253
0.0175              0.460066578
0.01875             0.431331720
0.02                0.403748894
0.02125             0.377277723
0.0225              0.351879192
0.02375             0.327515598
0.025               0.304150507
0.02625             0.281748709
0.0275              0.260276177
0.02875             0.239700027
0.03                0.219988476
0.03125             0.201110810
0.0325              0.183037342
0.03375             0.165739381
0.035               0.149189198
0.03625             0.133359992
0.0375              0.118225860
0.03875             0.103761768
0.04                0.089943520
0.04125             0.076747731
0.0425              0.064151801
0.04375             0.052133885
0.045               0.040672875
0.04625             0.029748369
0.0475              0.019340650
0.04875             9.43066E-03
0.05                0
```


FRONT FACE
PRESSURE, PSI
2.0
1.5
1.0
0.5
TIME, SECS
0.01
0.02
0.03
0.04
0.05

APPENDIX C

Computer Program for Generation of NASTRAN-DAREA Cards for Loaded Grid Points

A FORTRAN program (LOAD), for use on the Burroughs B5700 was devised to generate the NASTRAN DAREA cards for a uniform time-dependent pressure on the front or back surface of the reflector. The program reads as input the GRID cards and connection member cards for trianglular or quadrangular plates on the surface. These are preceded by a data card with three integers on it, separated by commas. The first integer is a flag which equals one (1) for a load on the front face. The second integer indicates the number of grid points to be read, while the third indicates the number of plates. The GRID cards follow in any order and the connecting member cards follow the grid cards in any order. A listing of the program appears on the following pages.

```
ONSITE
FILE  13=HERB, UNIT=READER
REAL RI,R(200),TI,T(200),ZI,Z(200),K,HI,KI,H4,AA,AB,AC,AD,L
REAL CA,CB,CD,CC,LR(200),LZ(200)
REAL LE
INTEGER NG,GR,G(200),NPL,A,B,C,D,A1,B1,C1,D1
INTEGER LARRY(8),BARRY(8),HARRY(8),GARRY(8)
READ (13,/)PJ,NG,NPL
PRINT 51,PJ,NG,NPL
DO 600 I=1,NG
READ(13,800)LARRY,RI,TI,ZI
51 FORMAT(3I3)
PRINT 800,LARRY,RI,TI,ZI
CALL HAROLD (LARRY,GR)
G(I)=GR
R(G(I))=RI
T(G(I))=TI*3.141593/180
600 Z(G(I))=ZI
800 FORMAT (8X,8A1,8X,3F8.3)
801 FORMAT (24X,4(8A1))
802 FORMAT ("CHECK GEOMETRY")
DO 604 I=1,NPL
READ(13,801)LARRY,BARRY,HARRY,GARRY
PRINT 801,LARRY,BARRY,HARRY,GARRY
CALL HAROLD (LARRY,A1)
CALL HAROLD (BARRY,B1)
CALL HAROLD (HARRY,C1)
CALL HAROLD (GARRY,D1)
IF (D1.NF.0) GO TO 603
D1=A1
603 IF (R(A1).EQ.R(D1)) GO TO 606
IF (R(C1).EQ.R(B1) ) GO TO 602
PRINT 802
STOP
602 IF (T(A1).NE.T(B1)) GO TO 605
A=B1
B=A1
C=D1
D=C1
GO TO 601
605 A=C1
B=D1
C=A1
D=B1
GO TO 601
606 IF (T(A1).NE.T(B1)) GO TO 607
A=A1
```

```
 340  B=B1
 350  C=C1
 360  D=D1
 370  GO TO 601
 380  607 A=D1
 390  B=C1
 400  C=B1
 410  D=A1
 420  601 K=(R(B)-R(A))*COS((T(D)-T(A))/2)
 430  HI=(K**2+(Z(B)-Z(A))**2)**.5
 440  KI=(R(C)-R(D))*COS((T(D)-T(A))/2)
 450  H4=(KI**2+(Z(C)-Z(A))**2)**.5
 460  AA=R(A)*SIN((T(D)-T(A))/2)*HI
 470  AD=R(A)*SIN((T(D)-T(A))/2)*H4
 480  AB=R(C)*SIN((T(C)-T(A))/2)*HI
 490  L=(R(B)-R(C))*(R(A)*SIN((T(D)-T(A))/2)/(R(B)-R(A)))
 500  AC-HI*(R(C)*SIN((T(C)-T(A))/2)-L)
 501  AA-ABS(AA)
 502  AB=ABS(AB)
 503  AC=ABS(AC)
 504  AD=ABS(AD)
 510  CA=(AA+AB+AD)/6
 520  CB=(AA+AB+AC)/6
 530  CC=(AB+AC+AD)/6
 540  CD=(AC+AD+AA)/6
 546  K=ABS(K)
 547  HI=ABS(HI)
 550  608 LR(A)=LR(A)+CA+K/HI
 560  LR(B)=LR(B)+CB*K/HI
 570  LR(C)=LR(C)+CC*K/HI
 580  LR(D)=LR(D)+CD*K/HI
 590  LZ(A)=LZ(A)+CA*LE
 600  LZ(B)=LZ(B)+CB*LE
 610  LZ(C)=LZ(C)+CC*LE
 620  LZ(D)=LZ(D)+CD*LE
 630  604 CONTINUE
 650  804 FORMAT ("DAREA   ",2I8,3X,"1",4X,F8.3.I8,3X,"3",4X,F8.3)
 670  DO 609 I=1,NG
 671  IF (PJ.EQ.2) GO TO 610
 672  LR(G(I))=-LR(G(I))
 673  GO TO 609
 674  610 LZ(G(I))=-LZ(G(I))
 675  PRINT 804,PJ,G(I),LZ(G(I)),G(I),LR(G(I))
 680  609 PUNCH 804,PJ,G(I),LZ(G(I)),G(I),LR(G(I))
 690  STOP
 999  END
2000  SUBROUTINE HR(NAME,Q)
```

```
2010  DIMENSION Q(8)
2020  QS="00000"
2030  DO 1 I=1,8
2040  QT=CONCAT(O,Q(I),42,12,6)
2050  IF(QT.EQ.QS)GO TO 1
2070  NAME=NAME*10+QT
2080  1 CONTINUE
2090  RETURN
2100  END
10090 SUBROUTINE HARDOL(LETTER,IVAL)
10100 INTEGER LETTER(8),NUMS(10),BLANK
10110 DATA NUMS/1HO,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/,BLANK/1H/
10120 IVAL=0
10122 DO 10 I=1,8
10124 IF(LETTER(I).NE.BLANK) GO TO 1000
10126 10 CONTINUE
10128 RETURN
10130 1000 IF(LETTER(8).NE.BLANK)GO TO 2500
10140 LSAVE=LETTER(8)
10150 DO1800 I=1,7
10160 1800LETTER(9-I)=LETTER(8-I)
10170 LETTER(1)=SAVE
10180 GO TO 1000
10190 2500 IDEC=0
10200 2600 IF(LETTER(8-IDEC).LT.NUMS(1))GO TO 3500
10205 IF(LETTER(8-IDEC).GT.NUMS(10))GO TO 3500
10210 DO 100 I=1,10
10220 IF(LETTER(8-IDEC).EQ.NUMS(I))GO TO 3000
10230 100CONTINUE
10240 3000 IVAL=IVAL+(I-1)*10**IDEC
10250 IDEC=IDEC+1
10260 GO TO 2600
10270 3500 IF(LETTER(8-IDEC).EQ.BLANK)RETURN
10280 PUNCH 200
10290 200 FORMAT(17H0NVALID CHARACTER)
10300 RETURN
10310 END
```

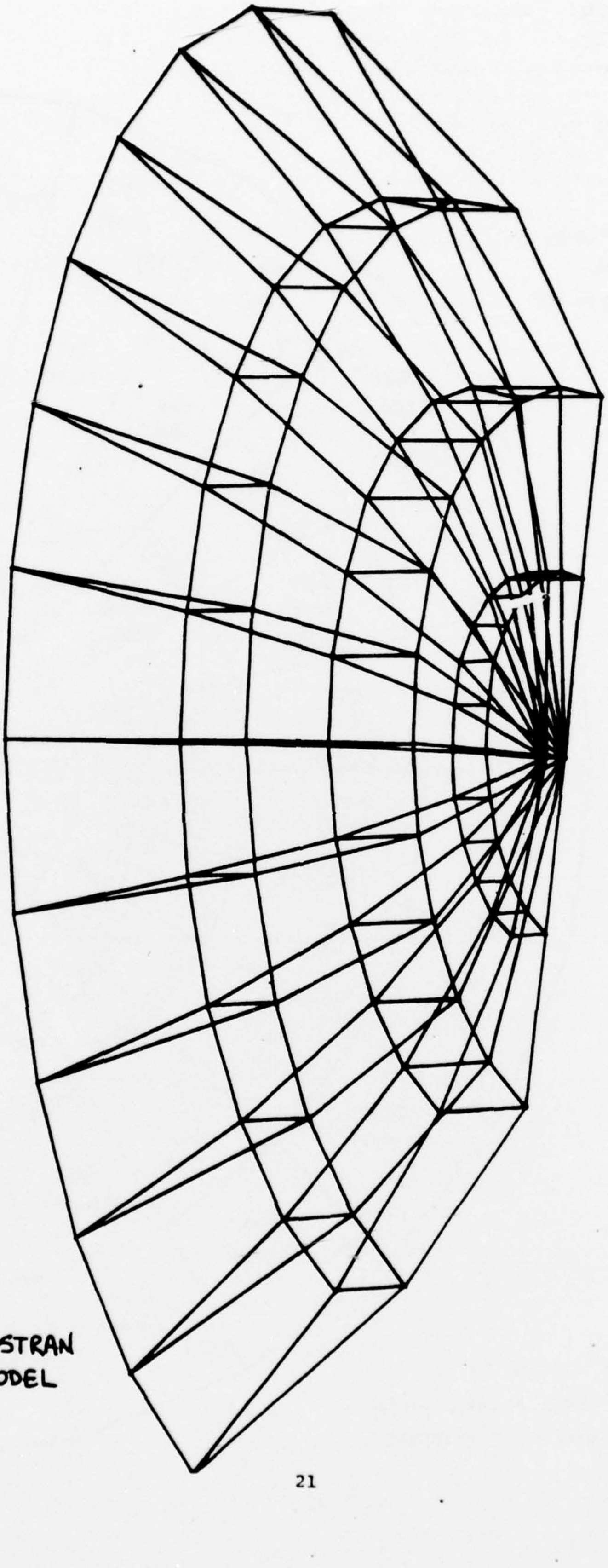


FIGURE 1. NASTRAN MODEL

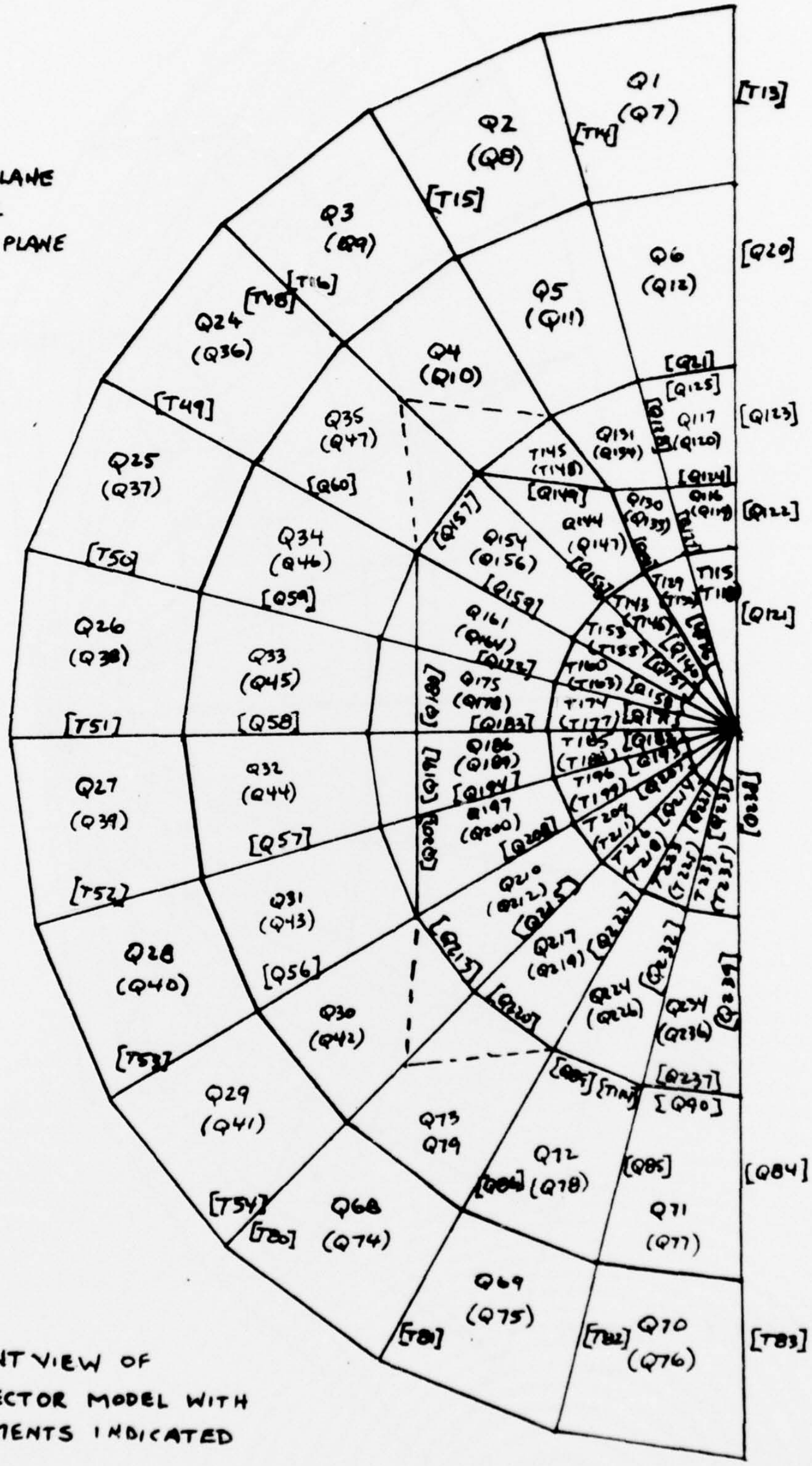
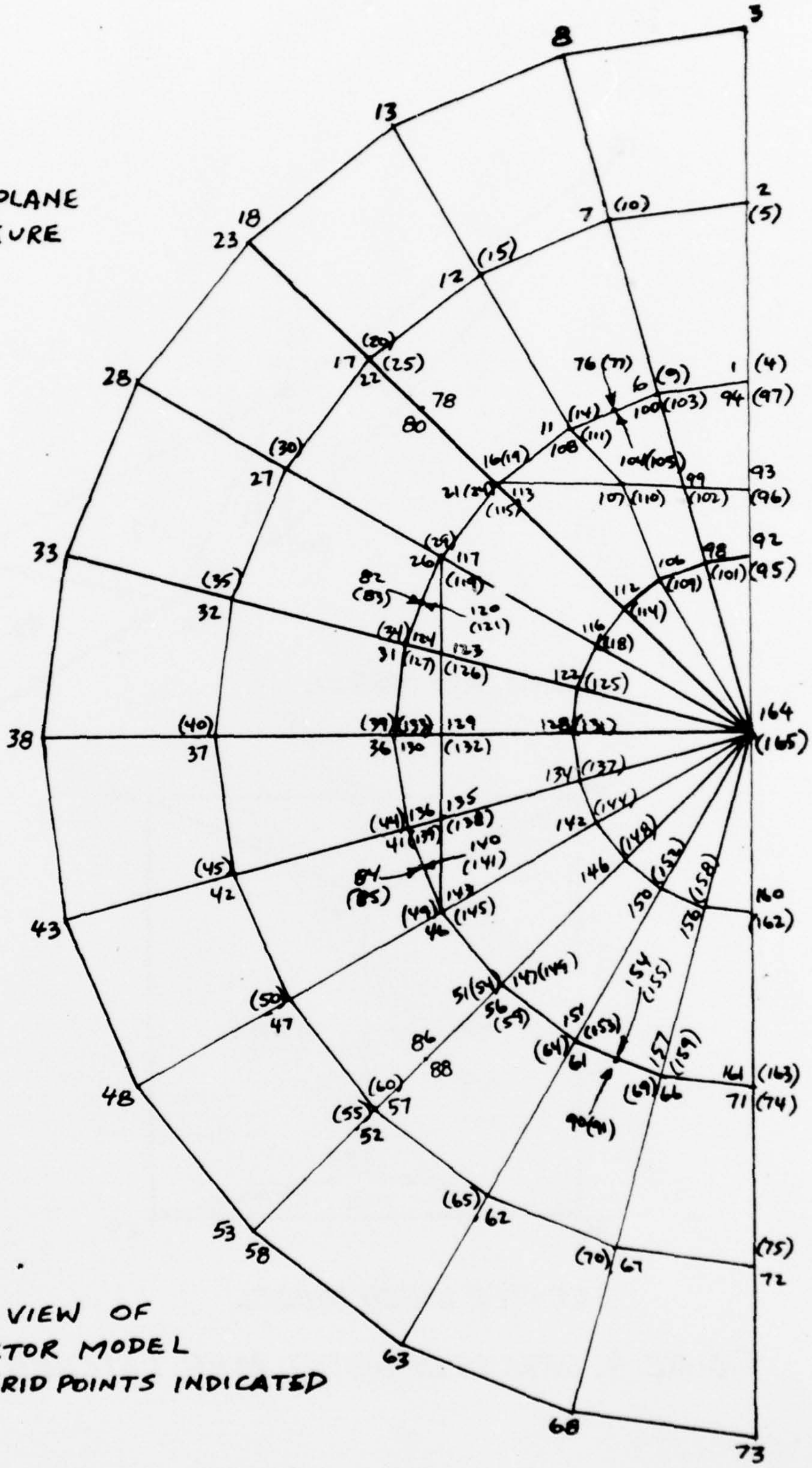


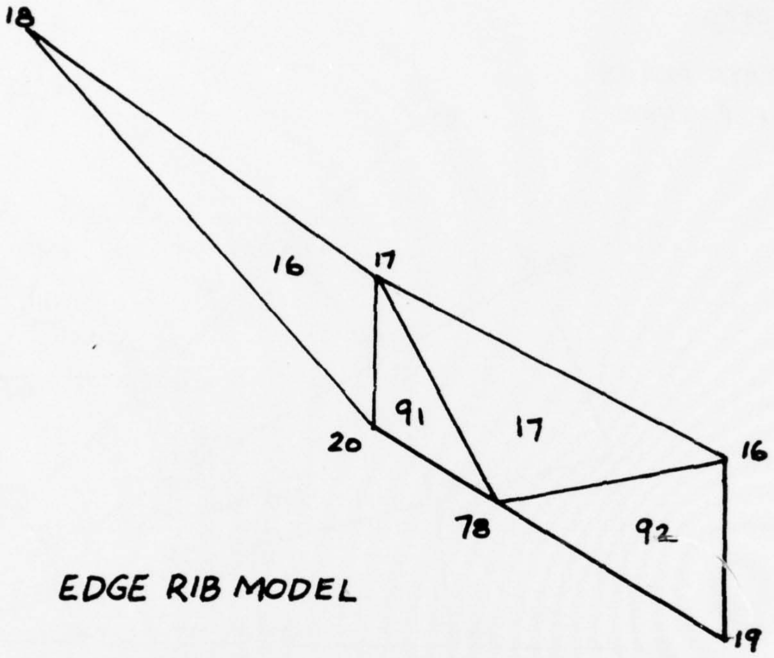
FIGURE 2. FRONT VIEW OF REFLECTOR MODEL WITH ELEMENTS INDICATED



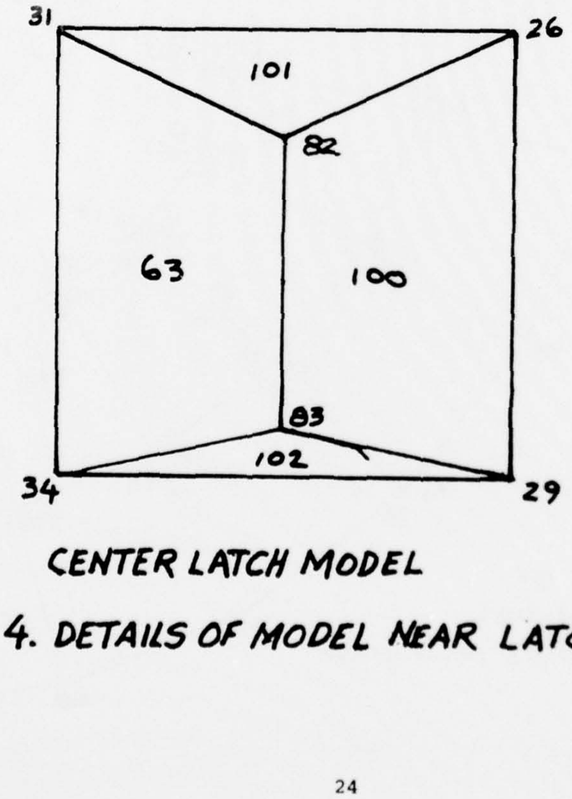
GRID POINTS

( ) BENEATH PLANE
OF FIGURE

FIGURE 3. FRONT VIEW OF
REFLECTOR MODEL
WITH GRID POINTS INDICATED

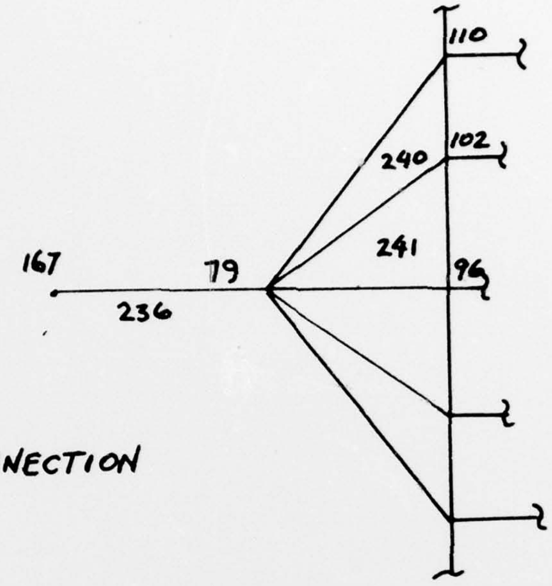


EDGE RIB MODEL

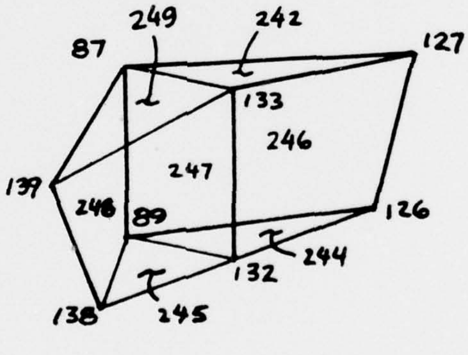


CENTER LATCH MODEL

FIGURE 4. DETAILS OF MODEL NEAR LATCHES



SIDE CONNECTION



BOTTOM CONNECTION

FIGURE 5. DETAILS OF MODEL CONNECTIONS