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North American Aviation, Inc.

NA-59-1736

(U) SUMMARY OF XB-70 FLUTTER MODEL

TESTS FROM 1 MARCH 1958 TO 20 MAY 1960

NAA DESIGNATION NA-267

AF DESIGNATION XB-70

CONTRACT AF 33(600)-38669

International Airport, Los Angeles 45, California

LOS ANGELES DIVISION

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Serial No. 9

File No.

Report No. NA-59-1736

NORTH AMERICAN AVIATION, INC.

INTERNATIONAL AIRPORT
LOS ANGELES 45, CALIFORNIA

ENGINEERING DEPARTMENT

SUMMARY OF XB-70 FLUTTER MODEL TESTS FROM 1 MARCH 1958 TO 20 MAY 1960

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No. of Pages 63

Date 30 June 1960

REVISIONS

DATE	REV. BY	PAGES AFFECTED	REMARKS

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DECLASSIFIED AFTER 12 YEARS
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ED-337, REV. 1-52

62-ASRS-1736

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LIST OF FIGURES (Cont.)

ABSTRACT

Model characteristics, flutter speeds, frequencies, test conditions and other data pertinent to flutter evaluation of the B-70 configurations under consideration are herein presented. The data accumulated have been used to specify stiffness levels required to prevent flutter of the XB-70 Air Vehicle.

FOREWORD

The data presented in this report were compiled during March 1, 1958 to May 20, 1960 as a part of flutter development under Contract No. AF 33(600)-38669. This flutter model test analysis report is submitted in accordance with page 23, item 6, paragraph 4 of Appendix C of Contract AF 33(600)-38669. This report was prepared by R. W. Deckman and H. K. Arnold.

H. R. Sweet, Supervisor
Vibration, Flutter, & Acoustics

SUMMARY

Analyses of, and conclusions reached, from all XB-70 flutter model tests conducted during the period 1 March 1958 through 20 May 1960 are presented. The unusually low sea level mass ratios of the XB-70 A/V necessitated extensive use of low density styrofoam in the model fabrication. These low mass ratios also lead to problems with oscillatory flow characteristics of the North American Low Speed Tunnel (NAAL) and showed the necessity of tunnel modifications to improve the flow prior to further tests of complete XB-70 models.

A flutter boundary through the subsonic and transonic range has been obtained for the vertical stabilizer and the results used to specify hinge point, actuator and vertical stabilizer stiffness requirements. Low speed flutter model data on the canard have shown that the most critical condition is with the flaps unlocked; the test results have been used to specify flap actuator stiffness and flap stiffnesses (both locked and unlocked conditions), canard root stiffness, canard stiffness, and to specify the requirement for a flaps locked indication to the pilot. Subsonic and transonic test data of the wing have been used to specify wing stiffness and wing fold stiffness requirement; the test results show that for the stiffness specified the minimum flutter margins are to be expected at sea level transonic speeds.

SUSPENSION SYSTEM AND .03 SCALE COMPLETE MODEL

The purpose of this test was to evaluate a new spring suspension system designed for testing complete flutter models. The results of fourteen runs varying the elastic axis of the suspension system with respect to c.g. of the model indicated that the suspension system would adequately perform the desired function.

The suspension system was designed on the following assumptions:

translation	=	1.7 cps
rotation	=	2.12 cps
roll		no requirement

The model mass parameters assumed were as follows:

$M = .0334$ lb-in^{-1}sec.^{2}

$I_{pitch} = 5.63$ lb-in-sec.^{2}

$I_{yaw} = 6.38$ lb-in-sec.^{2}

$I_{roll} = .863$ lb-in-sec.^{2}

The suspension system stiffness requirements were then:

$K_{translation}$ 3.77 lb/in.

$C_{rotation}$ 1000 in-lb/rad.

To meet the above stiffness requirements six springs with a spring constant of 5.38 lbs/in. were selected. A diagram of the suspension system set-up is shown in Figure 1.

The .03 scale complete model represented external geometry, mass, c.g., and inertia about three axis of a "rigid" -127 configuration at sea level. The measured frequencies of model rigid body modes are as follows:

SUSPENSION SYSTEM AND .03 SCALE COMPLETE MODEL (Con't)

$f_{pitch} = 2.4$ cps
$f_{yaw} = 2.17$ cps
$f_{roll} \cong 2.85$ cps

$f_{vertical\ translation} = 1.75$ cps
$f_{side\ translation} = 1.78$ cps
$f_{fore\ \&\ aft\ translation} = 4.0$ cps

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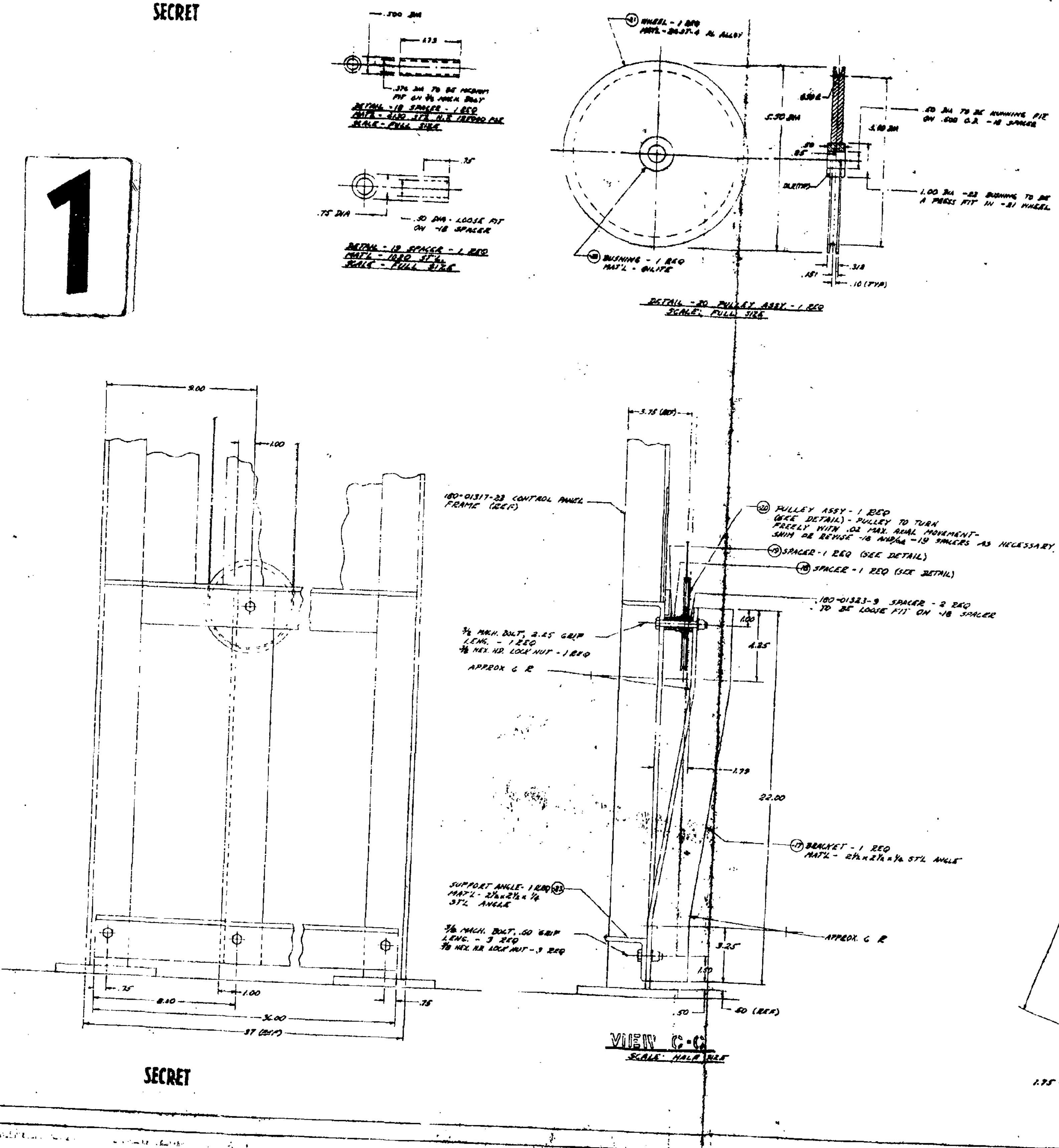

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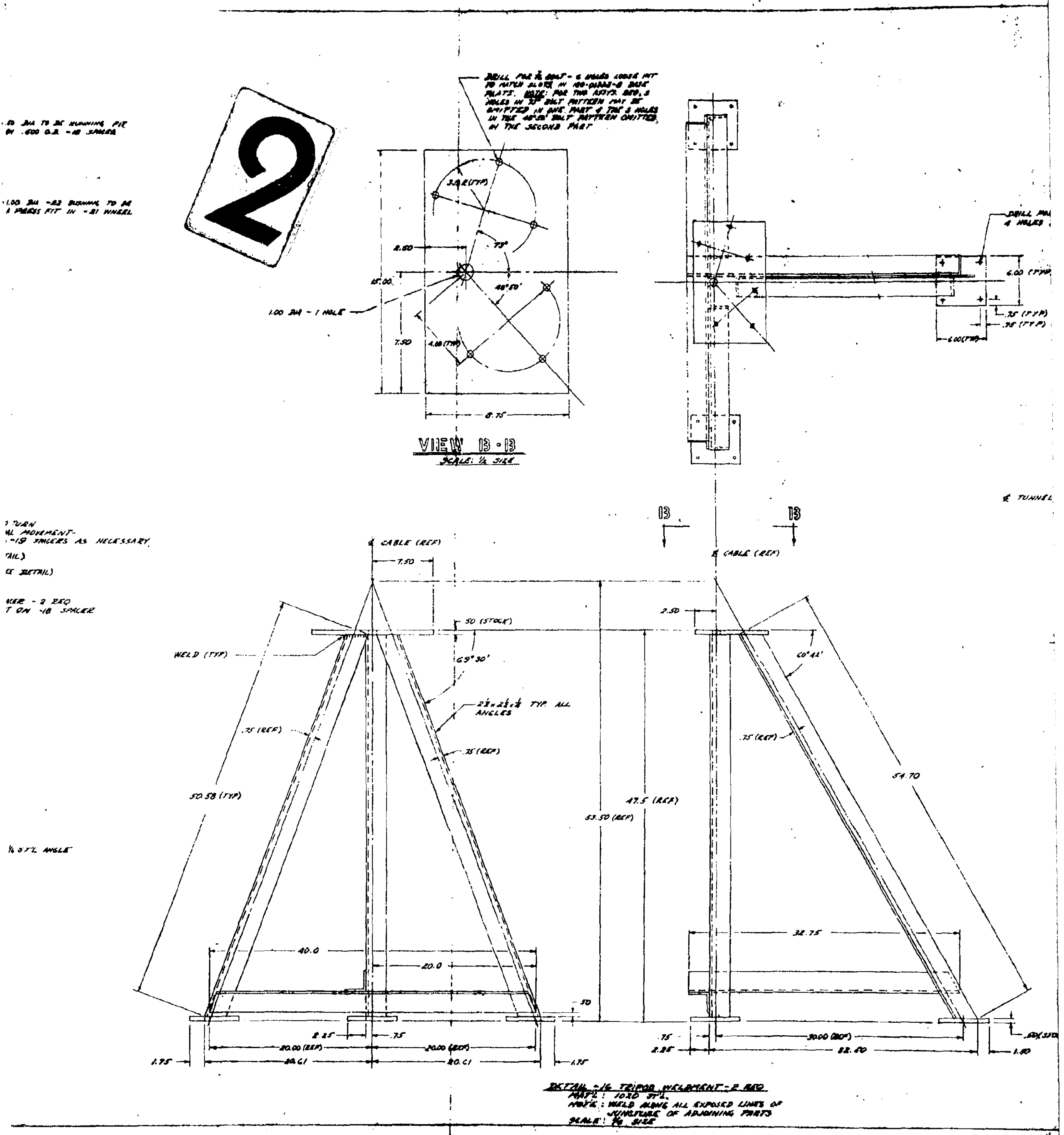
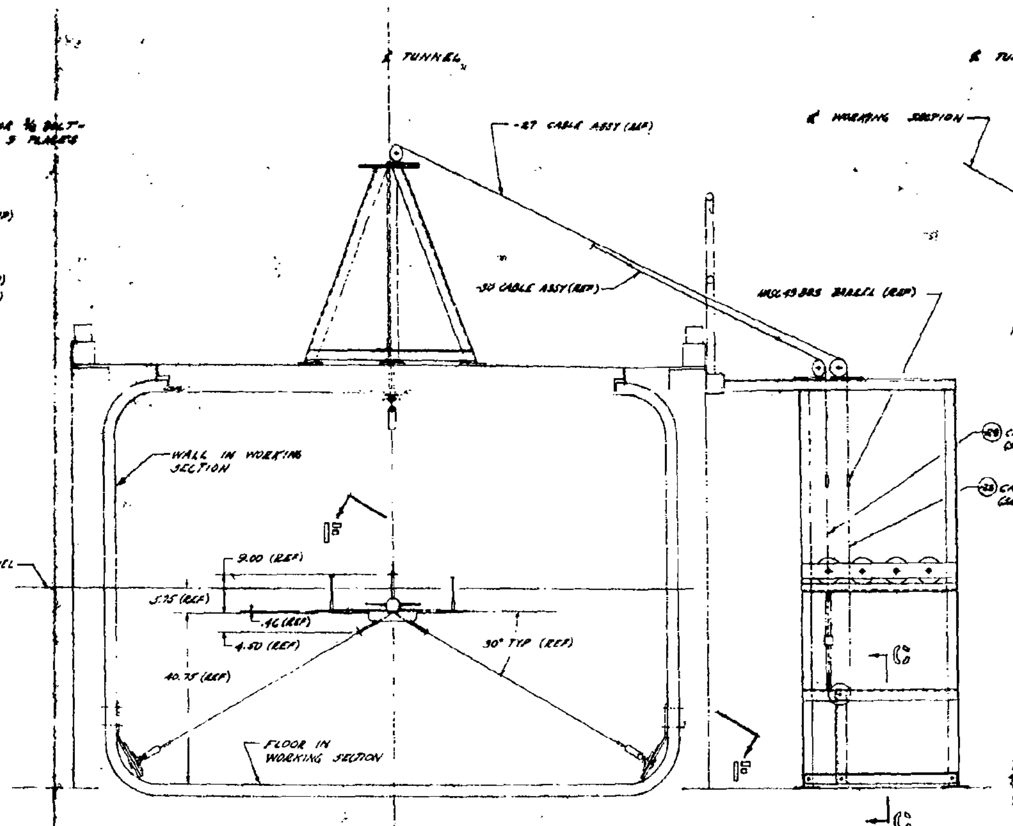
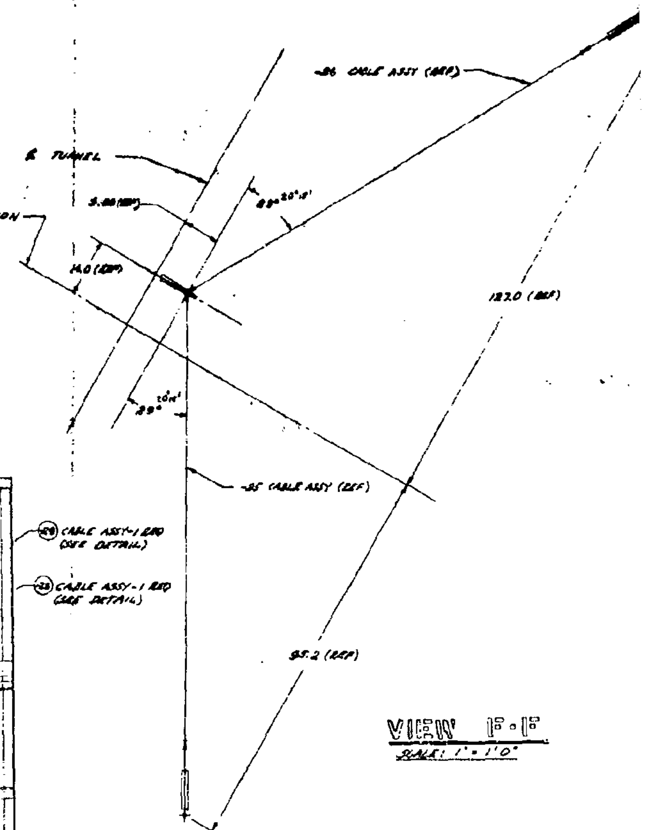


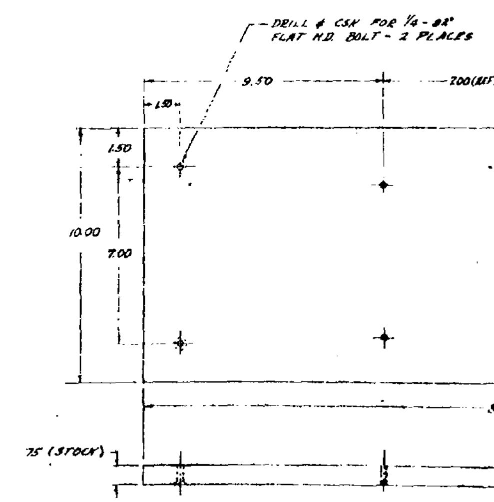
2
DRILL FOR 3/4 BOLT - 6 HOLES LOOSE FIT TO MATCH SLOTS IN ... BASE PLATS. NOTE: FOR THE ASSYS. REQ, 3 HOLES IN 33° BOLT PATTERN MAY BE OMITTED IN ONE PART & THE 3 HOLES IN THE 48°50' BOLT PATTERN OMITTED IN THE SECOND PART
3.0 R (TYP)
73°
2.50
15.00
48°50'
1.00 DIA - 1 HOLE
4.88 (TYP)
7.50
8.75
VIEW B-B
SCALE: 1/2 SIZE
DRILL FOR
4 HOLES
6.00 (TYP)
.75 (TYP)
.75 (TYP)
6.00 (TYP)
℄ TUNNEL
B
B
℄ CABLE (REF)
7.50
.50 (STOCK)
WELD (TYP)
69°30'
2 1/2 x 2 1/2 x 1/4 TYP. ALL ANGLES
.75 (REF)
.75 (REF)
50.58 (TYP)
47.5 (REF)
53.50 (REF)
40.0
20.0
.50
2.25
.75
20.00 (REF)
20.00 (REF)
1.75
40.61
40.61
1.75
℄ CABLE (REF)
2.50
60°42'
.75 (REF)
54.70
32.75
.75
2.25
30.00 (REF)
32.50
.50 (STOCK)
1.50
DETAIL -16 TRIPOD WELDMENT - 2 REQ
MAT'L: 1020 ST'L.
NOTE: WELD ALONG ALL EXPOSED LINES OF JUNCTURE OF ADJOINING PARTS
SCALE: 1/10 SIZE



VIEW D-D
SCALE: 1" = 1'0"

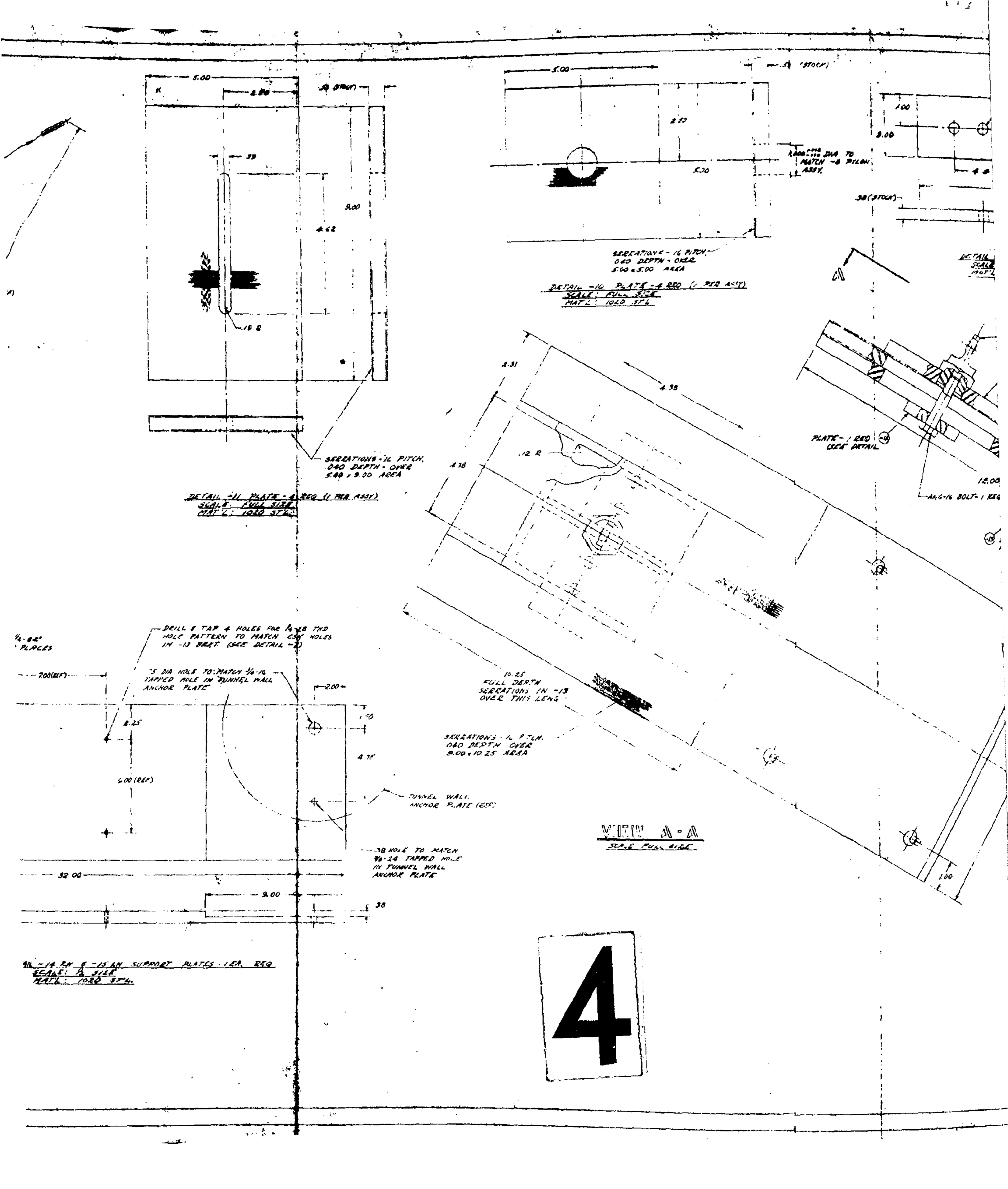


VIEW F-F
SCALE: 1" = 1'0"

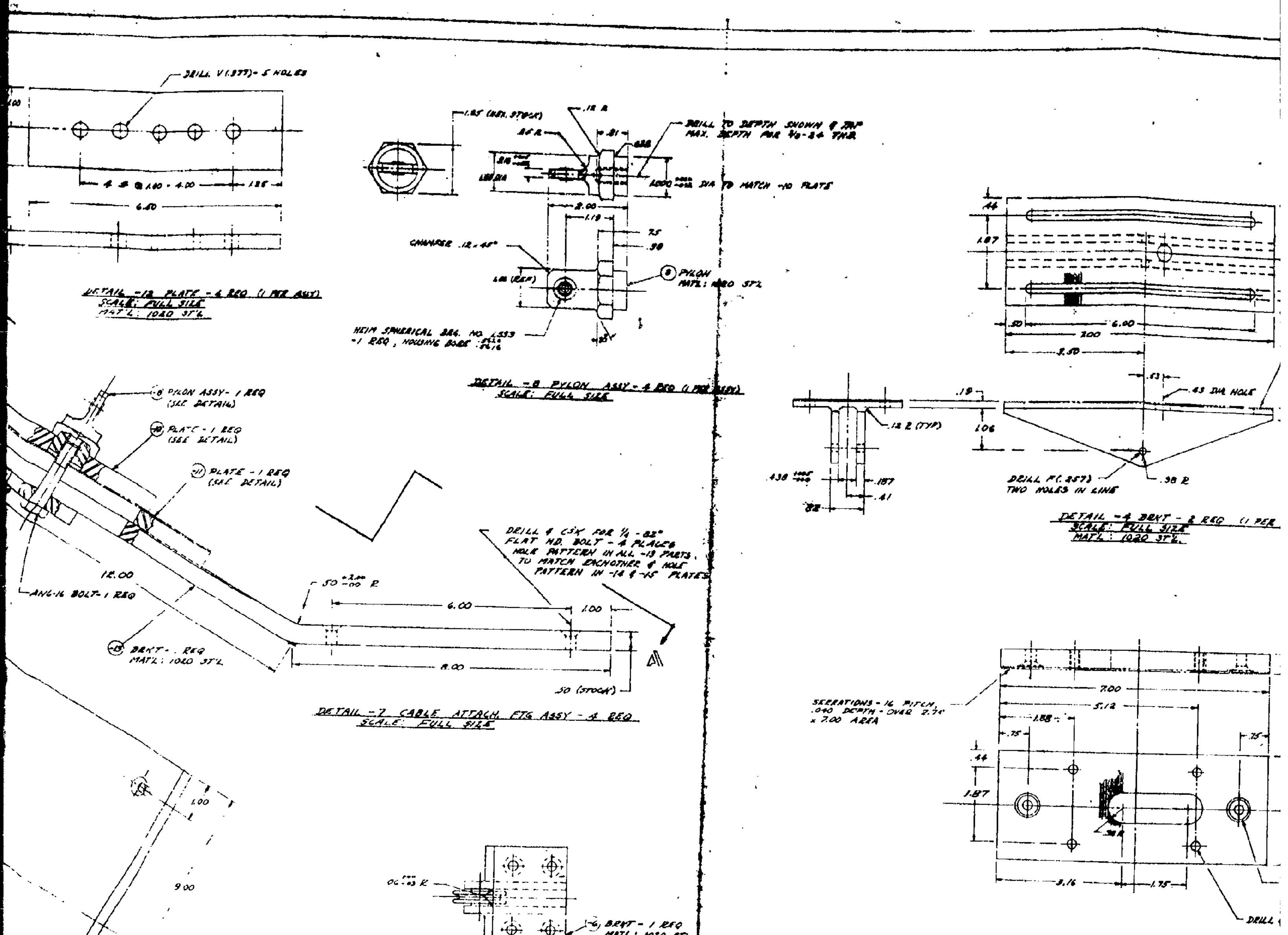


DETAIL -14

3

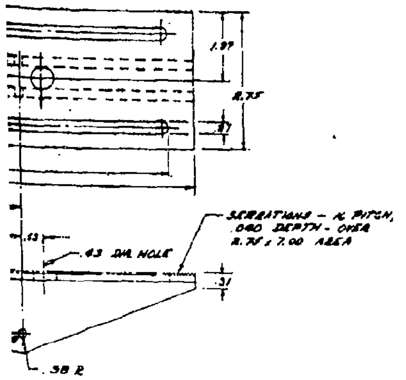


DETAIL -11 PLATE - 4 REQ (1 PER ASSY)
SCALE: FULL SIZE
MAT'L: 1020 STL.
SERRATIONS - 16 PITCH, .040 DEPTH - OVER 5.00 x 9.00 AREA
DETAIL -16 PLATE - 4 REQ (1 PER ASSY)
SCALE: FULL SIZE
MAT'L: 1020 STL.
SERRATIONS - 16 PITCH, .040 DEPTH - OVER 5.00 x 5.00 AREA
DIA TO MATCH -8 PYLON ASSY.
PLATE - 1 REQ (SEE DETAIL)
AN6-16 BOLT - 1 REQ
DRILL & TAP 4 HOLES FOR 1/4-28 THD HOLE PATTERN TO MATCH CSK HOLES IN -13 BRKT. (SEE DETAIL -2)
.75 DIA HOLE TO MATCH 1/2-16 TAPPED HOLE IN TUNNEL WALL ANCHOR PLATE
10.25 FULL DEPTH SERRATIONS IN -13 OVER THIS LENG
SERRATIONS - 16 PITCH, .040 DEPTH OVER 9.00 x 10.25 AREA
TUNNEL WALL ANCHOR PLATE (REF)
.38 HOLE TO MATCH 3/8-24 TAPPED HOLE IN TUNNEL WALL ANCHOR PLATE
VIEW A-A
SCALE FULL SIZE
-14 RH & -15 LH SUPPORT PLATES - 1 EA. REQ
SCALE: 1/2 SIZE
MAT'L: 1020 STL.
4

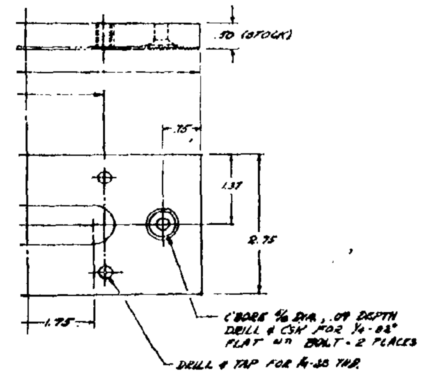


DETAIL -12 PLATE - 4 REQ (1 PER ASSY)
SCALE: FULL SIZE
MAT'L: 1020 ST'L
DETAIL -8 PYLON ASSY - 4 REQ (1 PER ASSY)
SCALE: FULL SIZE
HEIM SPHERICAL BRG.
CHAMFER .12 x 45°
PYLON ASSY - 1 REQ (SEE DETAIL)
PLATE - 1 REQ (SEE DETAIL)
BRKT - REQ
MATL: 1020 ST'L
DRILL & CSK FOR 1/4 - 82° FLAT HD. BOLT - 4 PLACES HOLE PATTERN IN ALL -13 PARTS TO MATCH EACH OTHER & HOLE PATTERN IN -14 & -15 PLATES
DETAIL -7 CABLE ATTACH. FTG ASSY - 4 REQ
SCALE: FULL SIZE
DETAIL -4 BRKT - 2 REQ
SCALE: FULL SIZE
MAT'L: 1020 ST'L
DRILL F(.257) TWO HOLES IN LINE
.43 DIA HOLE
SERRATIONS - 16 PITCH, .040 DEPTH - OVER 2.75 x 7.00 AREA
DETAIL -3 PLATE - 2 REQ
SCALE: FULL SIZE
MATL: 1020 STL
BRKT - 1 REQ
MATL: 1020 STL
AN219A1 PULLEY - 1 REQ
1/4-28 MACH. BOLT, .75 GRIP LENG. - 1 REQ
1/4-28 HEX. HD. LOCKNUT - 1 REQ
DETAIL -5 PULLEY BRKT ASSY - 1 REQ
SCALE: FULL SIZE
DETAIL -2 PULLEY BRKT ASSY
SCALE: FULL SIZE

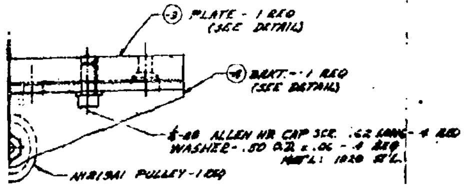
5



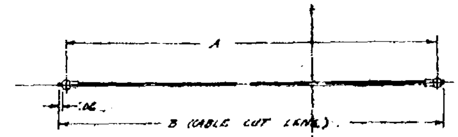
BRKT - 2 REQ (1 PER ASSY)
ULL SIZE
20 STL



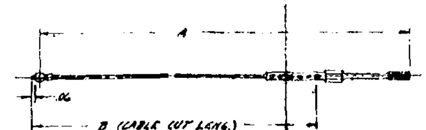
-3 PLATE - 2 REQ (1 PER ASSY)
LE: FULL SIZE
'L: 1020 STL



PULLEY BRKT ASSY - 2 REQ
LE: FULL SIZE



TYPE "B" CABLE ASSY
SCALE: FULL SIZE



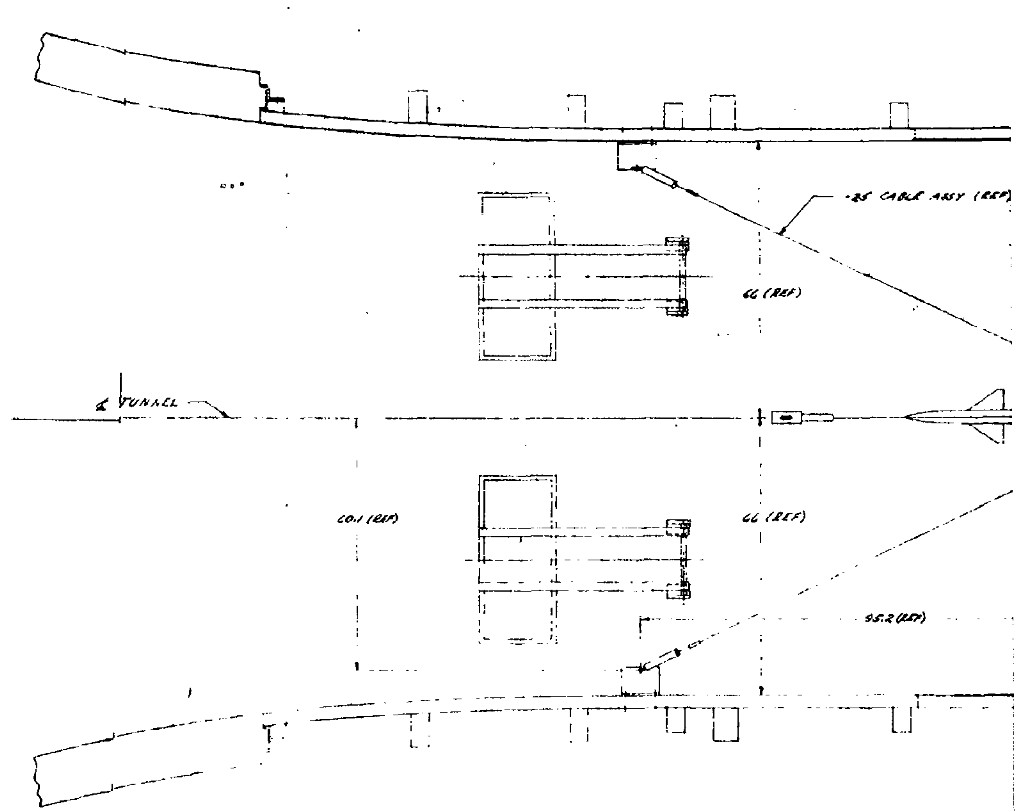
TYPE "A" CABLE ASSY
SCALE: FULL SIZE

CABLE ASSY DASH NO.	NO. REQ.	TYPE	APPROX. LENGTH "A"	APPROX. LENGTH "B"	END FITTINGS - 1 EA. REQ/ASSY		LOCATION OF CALL-OUT
					LEFT END	RIGHT END	
-24	4	A	7.4	5.7	AN664C2	MS650-S2R	SIDE VIEW
-25	2	A	107.5	105.8	AN664C2	MS650-S2L	
-26	2	A	111.9	110.2	AN664C2	MS650-S2L	
-27	1	A	250.0	248.8	AN664C2	MS650-S2R	
-28	1	A	83.0	81.3	AN664C2	MS650-S2L	VIEW D-D
-29	1	A	27.0	25.3	AN664C2	MS650-S2R	
-30	1	A	240.0	238.3	AN664C2	MS650-S2L	SIDE VIEW
-31	1	B	73.3	72.0	AN664C2	AN664C2	
-32	1	B	75.1	74.0	AN664C2	AN664C2	

DETAIL OF CABLE ASSYS

NOTES:
1. USE ⅛ DIA CARBON STEEL CABLE, SPEC. MIL-C-1511, FOR ALL ASSYS.
2. SWAGE TERMINALS PER MIL-T-6117 (FAC-1).
3. TEST ALL ASSYS. AT 800 LBS PER MIL-C-5688 (FAC-1).
4. IDENTIFY ALL ASSYS WITH TAG AFTER FABRICATION.

6

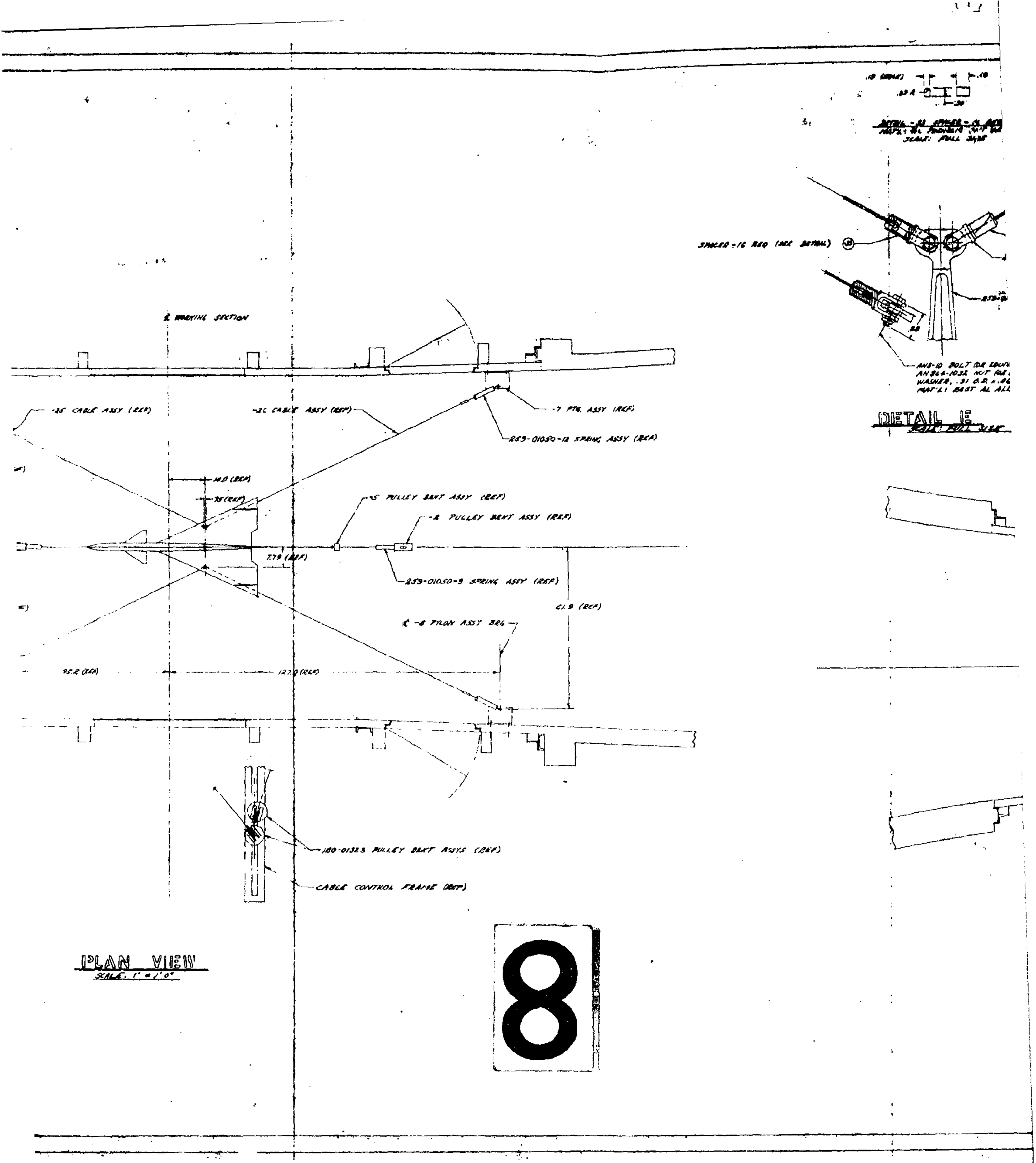


REQ/ASSY AND	LOCATION OF CALL-OUT
-52R	SIDE VIEW
-52L	
-52L	
-52R	
-52L	VIEW D-D
-52R	
-52L	SIDE VIEW
CR	
CR	

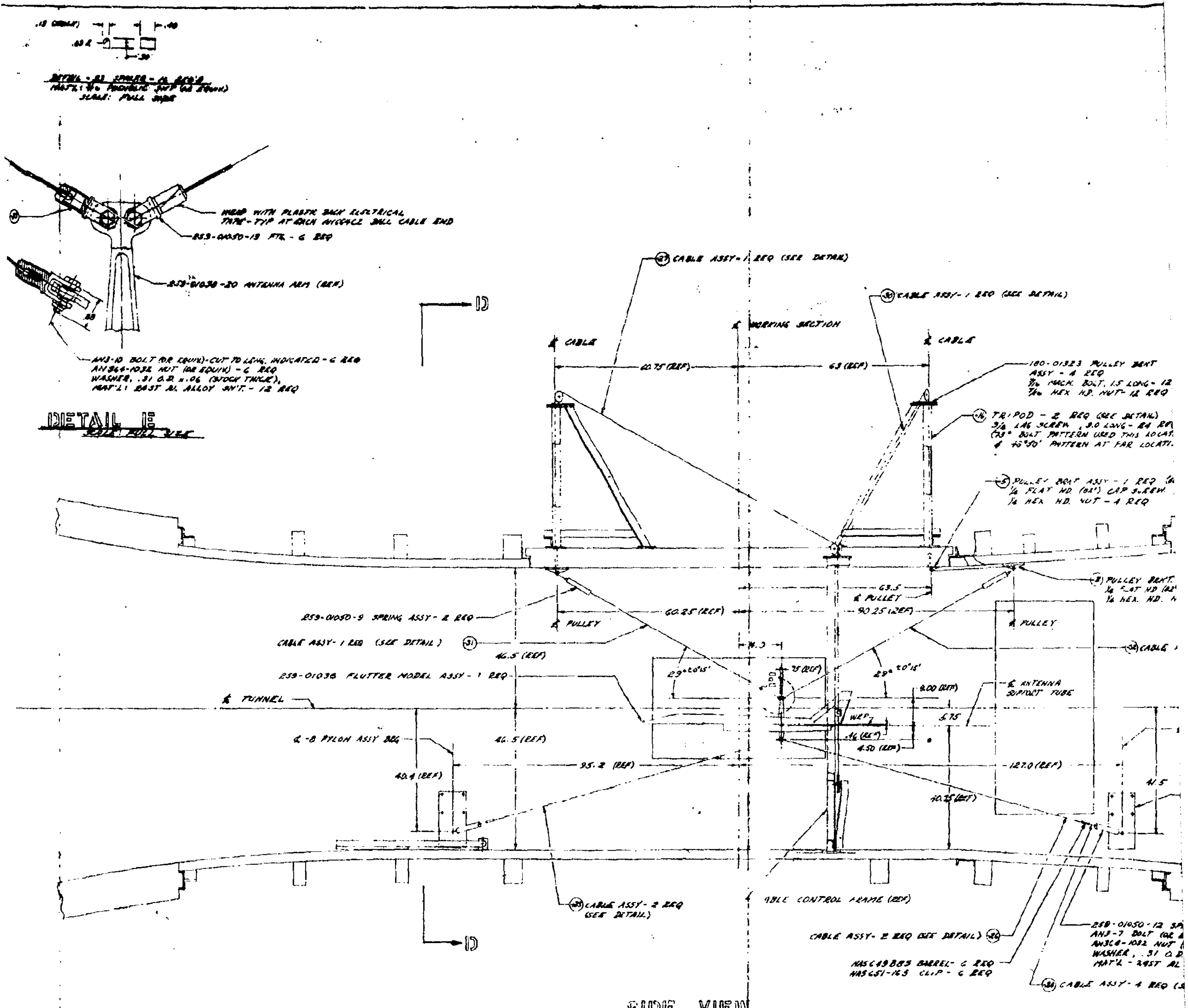
PLAN

SCALE: 1" =

7



PLAN VIEW
SCALE: 1" = 1'0"



SIDE VIEW
SCALE: 1" = 1'0"

NOTE:
SEE VIEW F-F FOR RIG ANGLE OF LOWER CABLES

9

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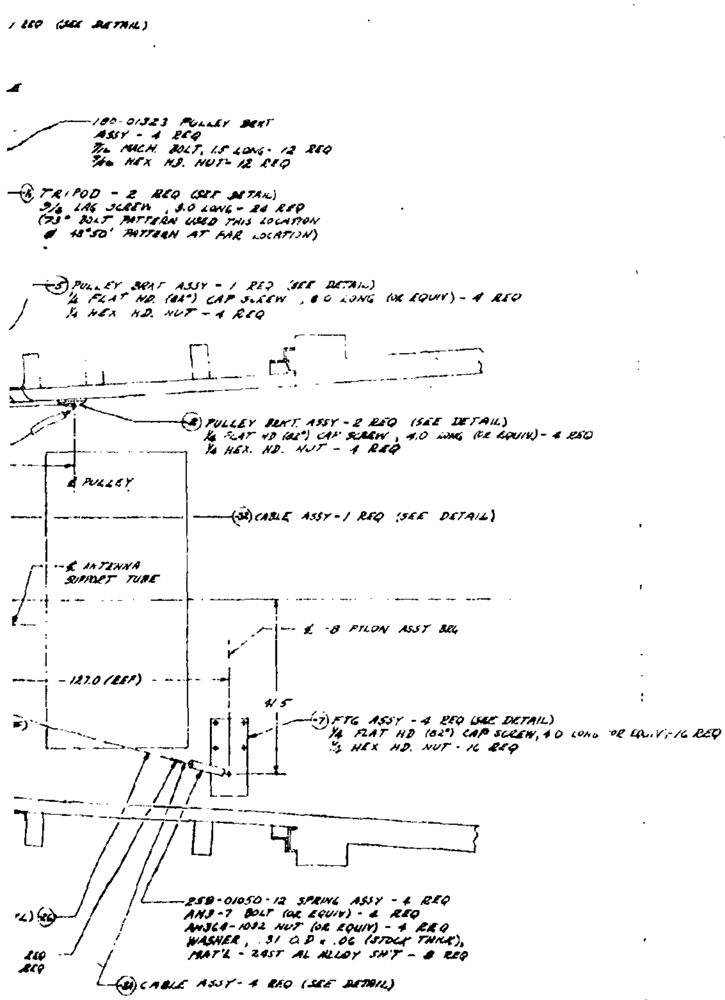
FIG 1



GENERAL NOTES

1. PARTS -14 & -15 NOT USED FOR THIS INSTALLATION. PARTS WILL BE USED ON 257 CONTRACT INSTALLATION

10

259-01043

259-01043

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REL #3

DATE 3-14-58

CO 259-96

AMERICAN AVIATION, INC.

MODEL GROUP

SUSPENSION SYSTEM - FLUTTER MODEL

259-01043

.10 SCALE SUBSONIC VERTICAL STABILIZER

Various root stiffness magnitudes were investigated using a .10 scale spindle type vertical tail for the -172 configuration at sea level.

The model was constructed of solid styrofoam whose thickness at any point in the planform simulated full scale bending stiffness. The model was ballasted for sea level conditions.

The root stiffness in pitch and roll were simulated over a range of stiffnesses by means of springs. The roll spring consisted of a square shaft attached at one end to the lower portion of the vertical tail and free to be clamped at the other end so that the effective length of the spring could be varied. The yaw springs were sets of two coil springs, each set of the same spring constant, which attached to the lower part of the vertical tail.

The results of the flutter test and shake test are shown on Figure 2. For any given roll stiffness, an increase in pitch stiffness gave an increase in flutter speed; for a constant pitch stiffness, an increase in roll stiffness gave an increase in flutter speed. The pitch stiffness affects the flutter speed to a larger degree than the roll stiffness. For this vertical stabilizer configuration, a pitch stiffness greater than 20,200 in-lb/rad and a roll stiffness greater than 22,600 in-lb/rad are required to give a sufficiently high flutter speed.

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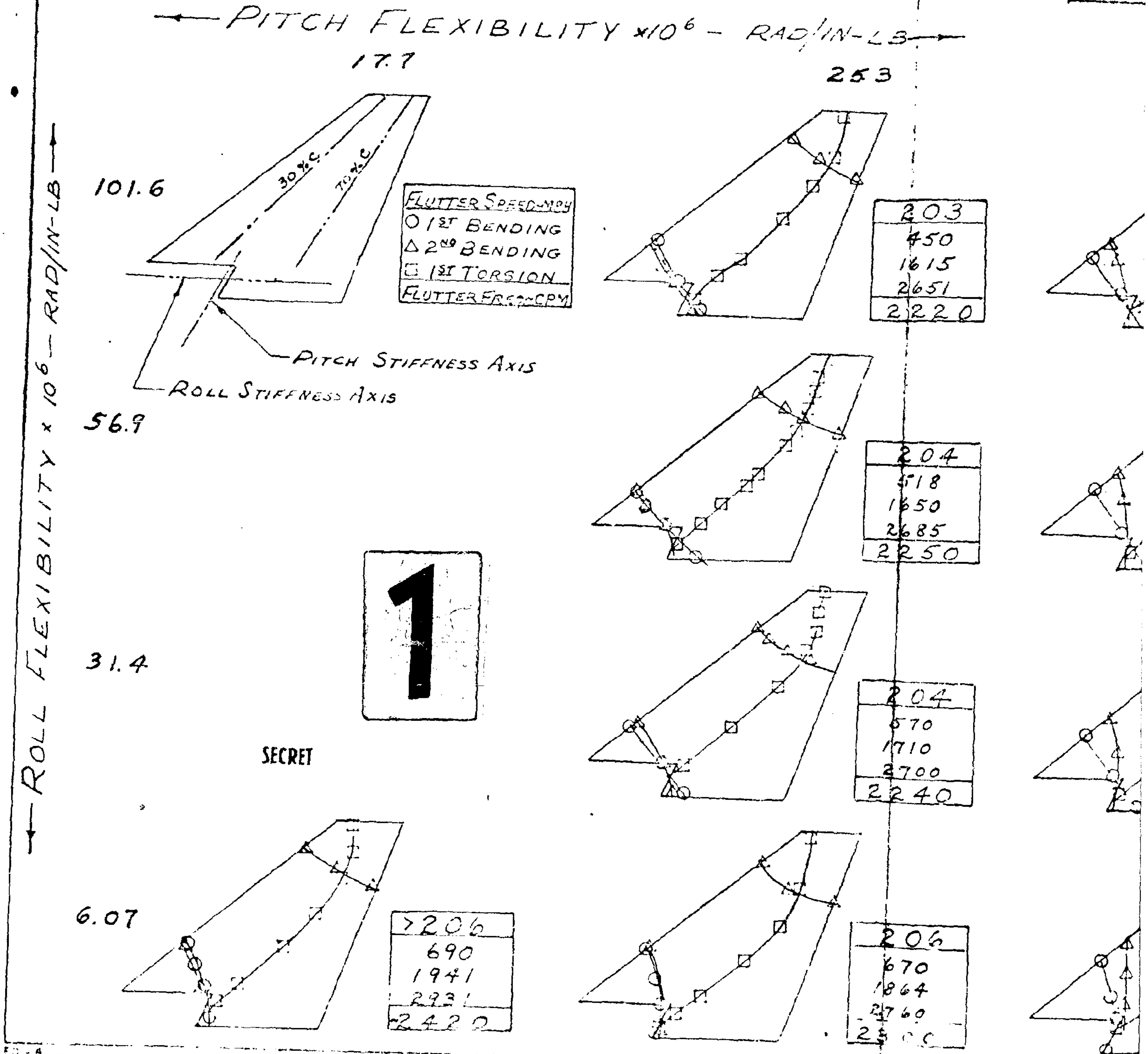

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DATE: 9-18-58	.10 ℄ VERTICAL	MODEL NO XB-70

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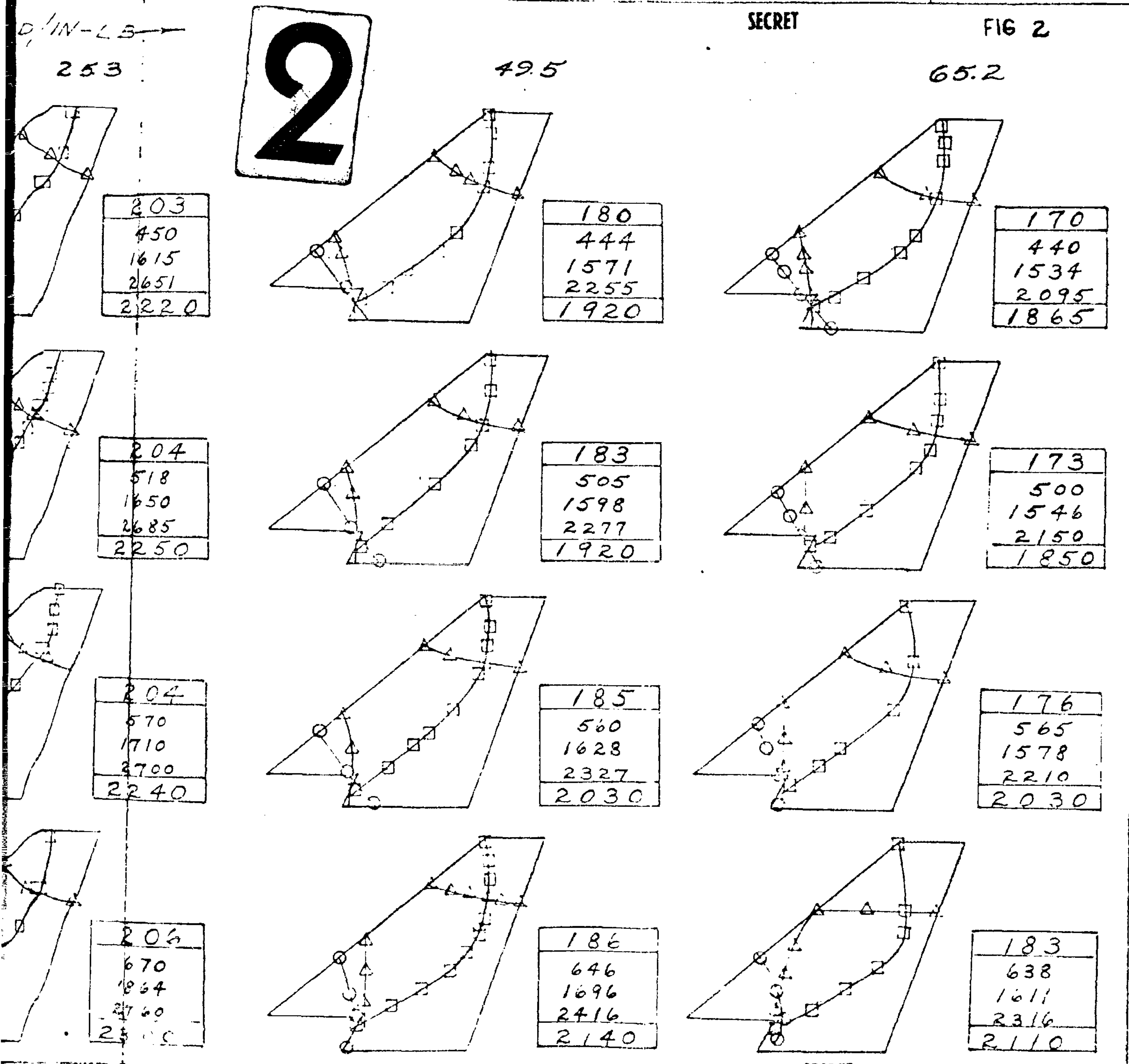
FIG 2



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.06 SCALE SUBSONIC VERTICAL STABILIZER

A styrofoam, .06 geometric scale and .233 speed scale, cantilevered model of the -172 configuration of the outboard vertical stabilizer was flutter tested in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel. Shake test and flutter test results are shown on Figure 3.

No root flexibilities were simulated in the model. However, the flutter point obtained provided useful information on non-dimensional stiffness requirements for the planform.

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DATE 9

OUTBOARD VERTICAL STABILIZER

.06 SCALE MODEL

MODE	FREQUENCY	NODE LINES
1ST BENDING	f = 25.9 CPS	—
2ND BENDING	f = 73.3 CPS	△
1ST TORSION	f = 89.7 CPS	□

MAX. TUNNEL SPEED = 204 MPH (CLOSE TO SUSTAINED FLUTTER)

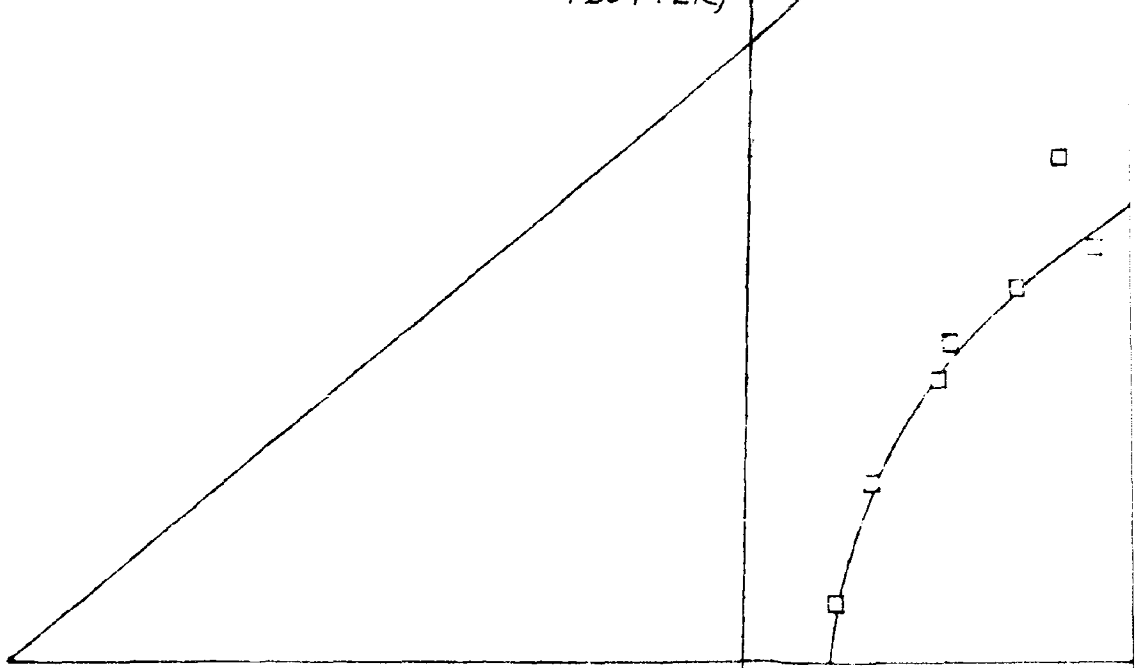

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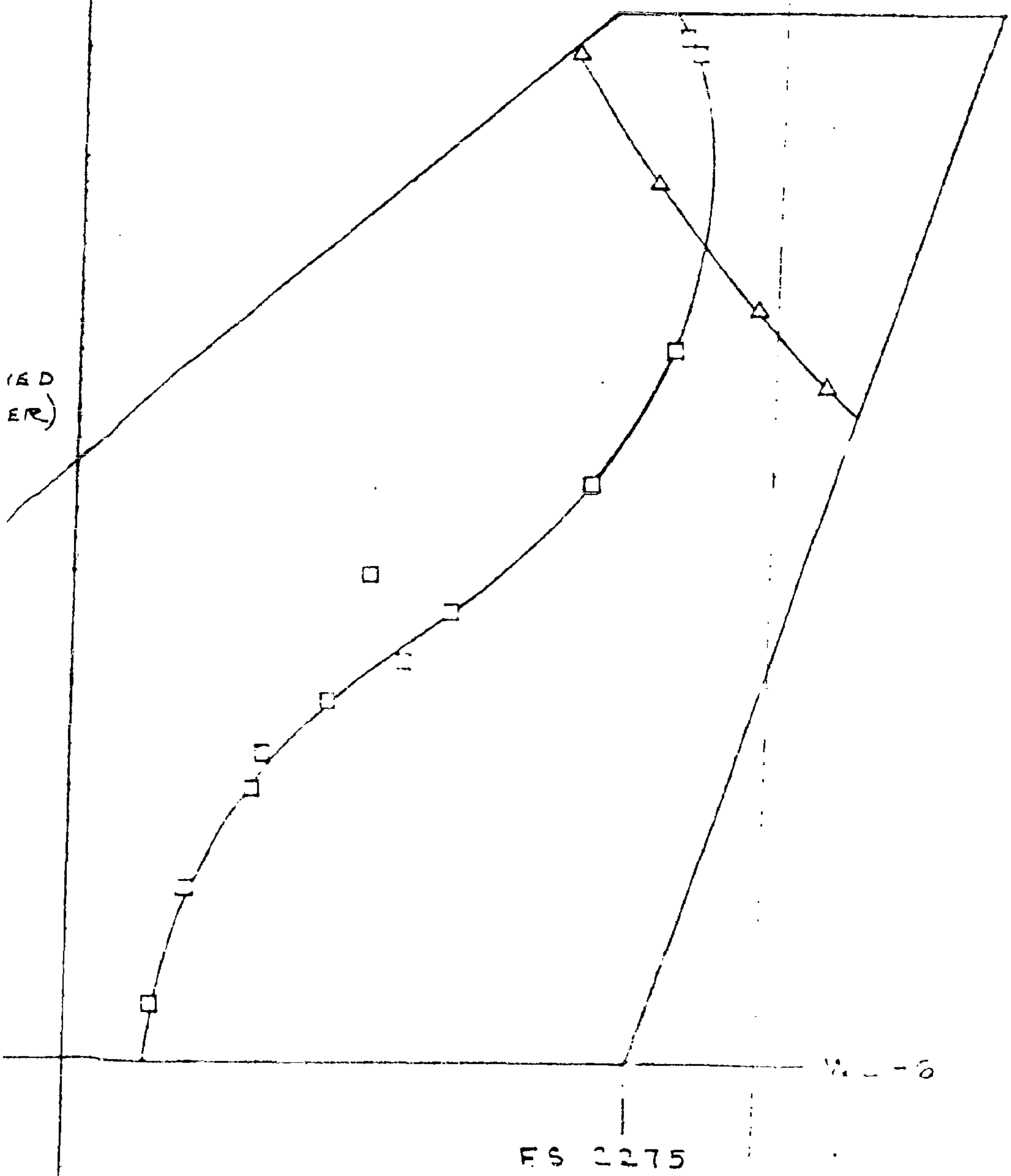
FIG 3



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SCALE

.06 SCALE SUBSONIC WING II WITH OUTBOARD VERTICAL

To investigate the interaction of wing and the vertical tail, a model simulating the -172 configuration was flutter tested in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel.

The cantilever mounted styrofoam model of .06 geometric scale and a speed scale .233, was tested with the wing empty and full of fuel. Before each of the actual flutter tests, a shake test was conducted to determine natural frequencies and node lines. The results of these tests are shown on Figure 4 through Figure 8. From the flutter tests of the model, it may be concluded that the empty wing has a lower flutter speed than the full wing. Comparing the results of this test with those on the vertical stabilizer only, the flutter mode encountered was primarily a wing mode rather than a vertical stabilizer mode.

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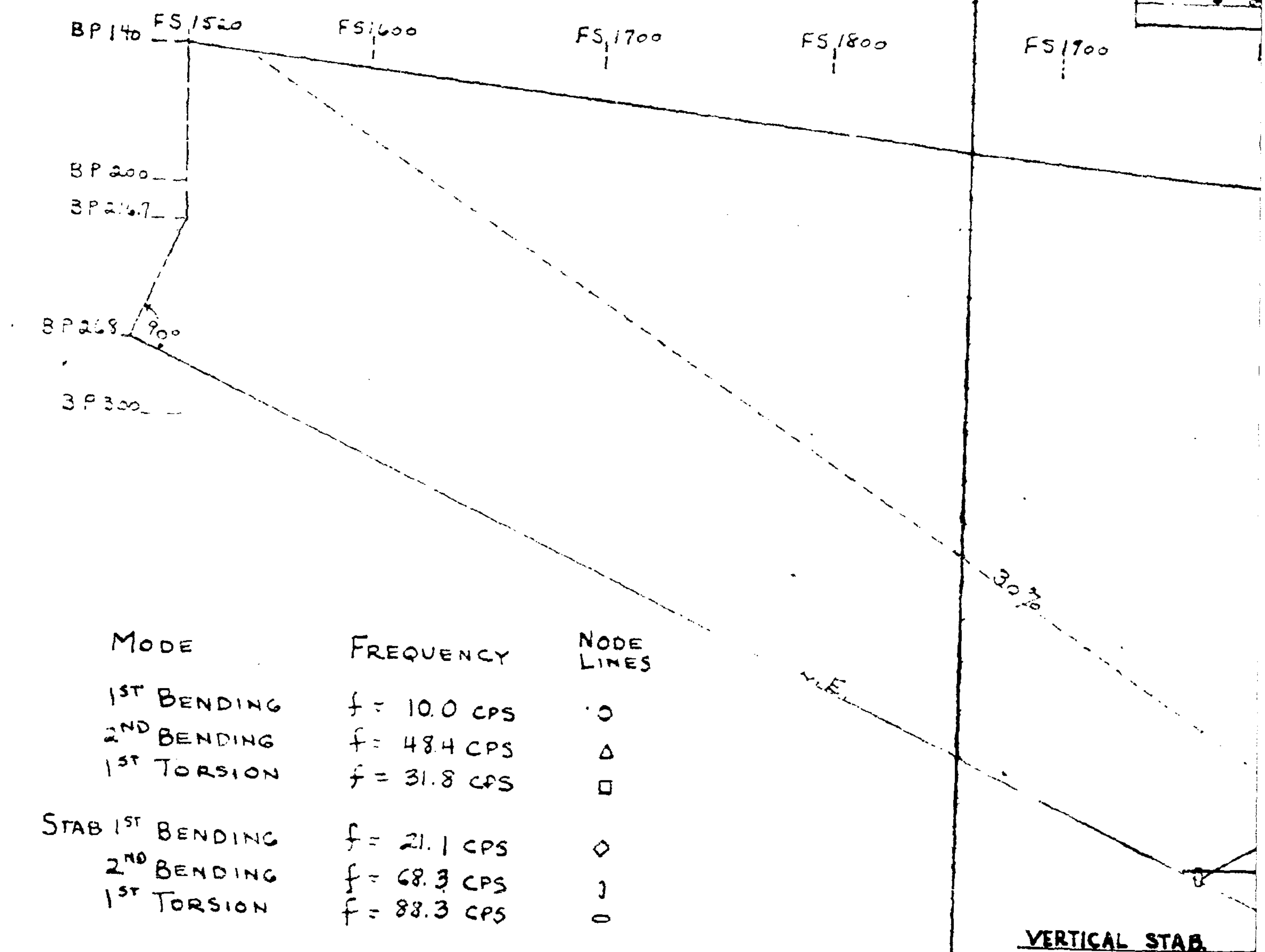

MODE	FREQUENCY	NODE LINES
1ST BENDING	f = 10.0 CPS	○
2ND BENDING	f = 48.4 CPS	△
1ST TORSION	f = 31.8 CPS	□
STAB 1ST BENDING	f = 21.1 CPS	◇
2ND BENDING	f = 68.3 CPS	)
1ST TORSION	f = 88.3 CPS	⊖

MAX TUNNEL SPEED = 185 MPH (CLOSE TO SUSTAINED FLUTTER)

SCALE 1/100

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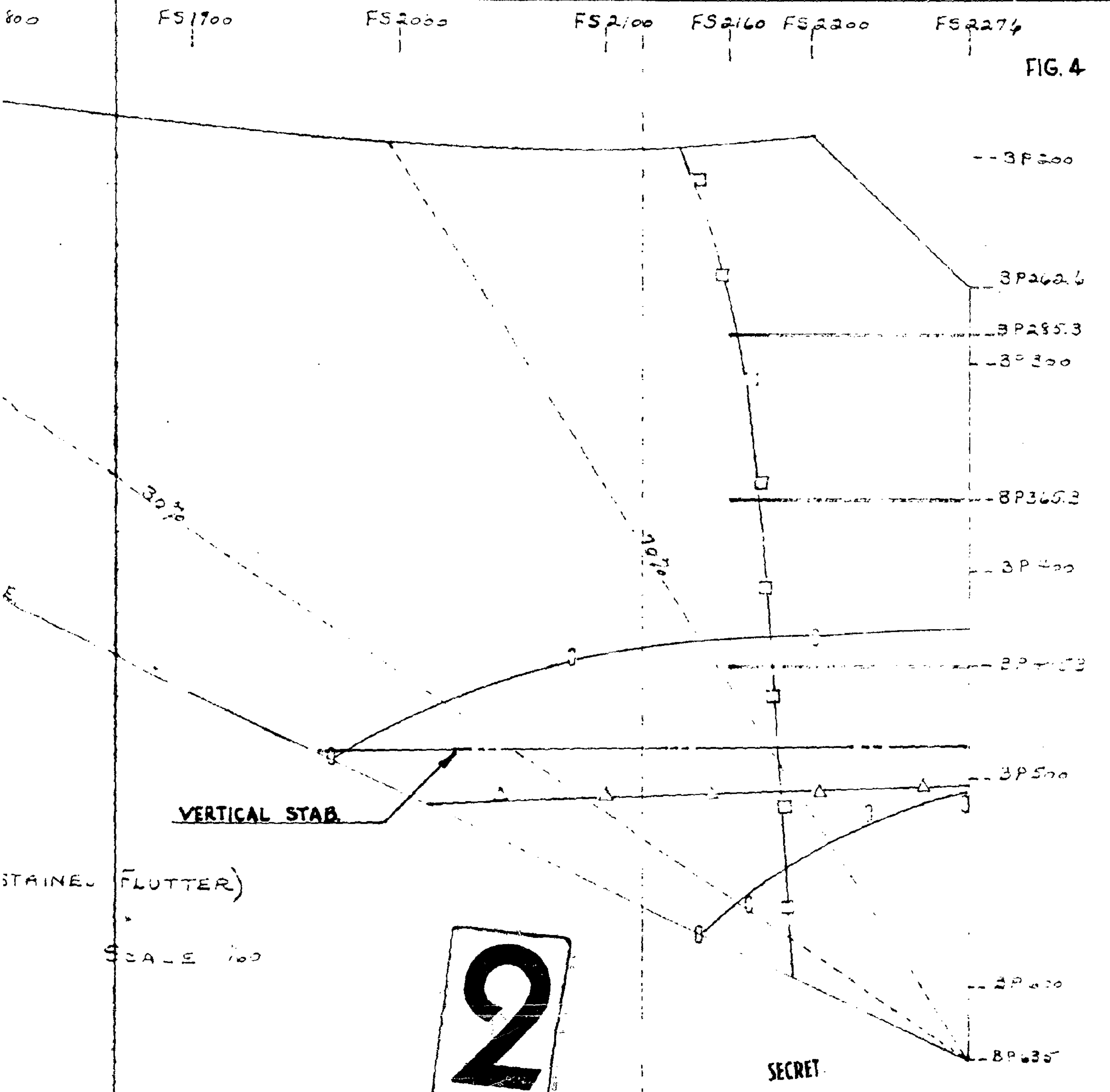
CHECKED BY J.R.S.	SHAKE TEST RESULTS	NA-59-1736 REPORT NO.
DATE 5-2?-59	.06 WING #2 WITH OUTB'D VERT	MODEL NO. XB-70
	EMPTY FUEL	

FIG. 4



STRAINED FLUTTER)

SCALE 1/60

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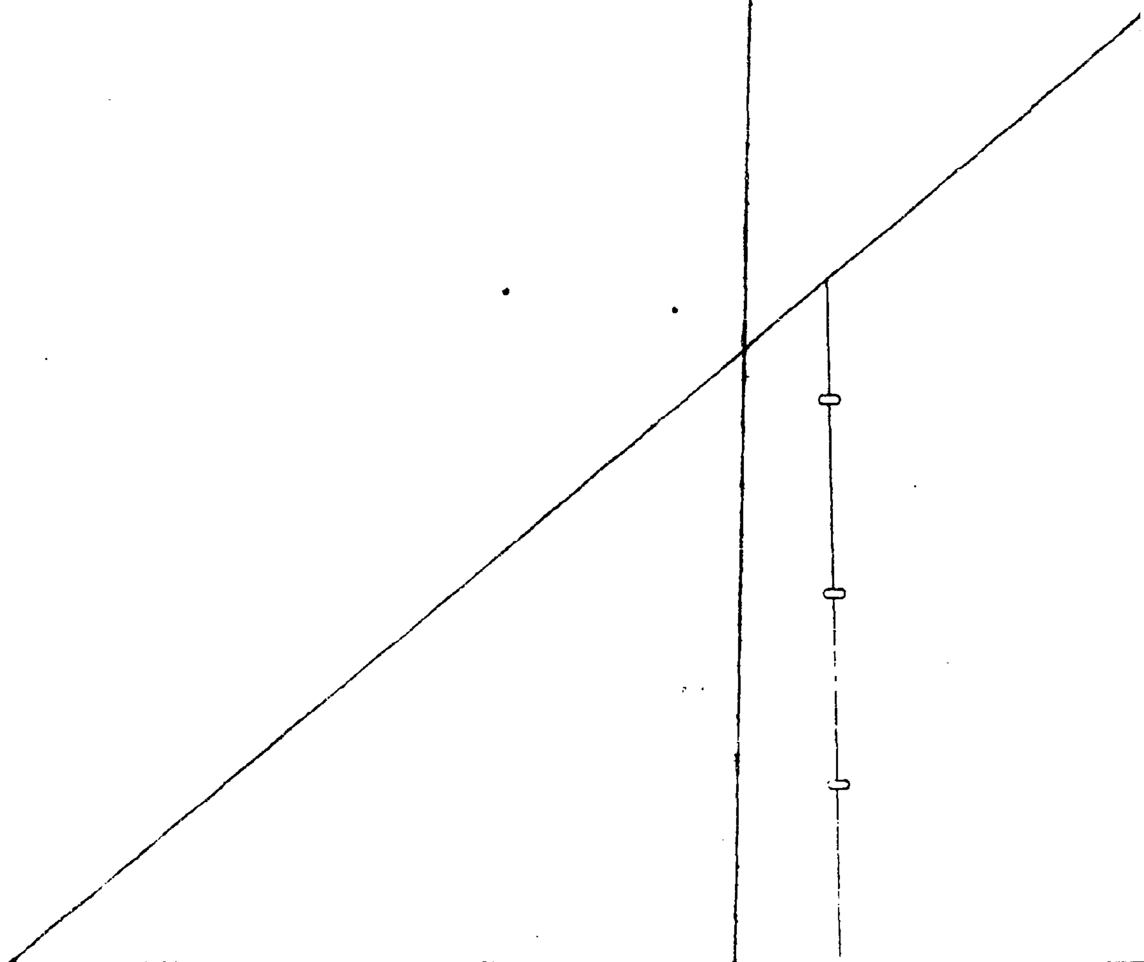
9-1



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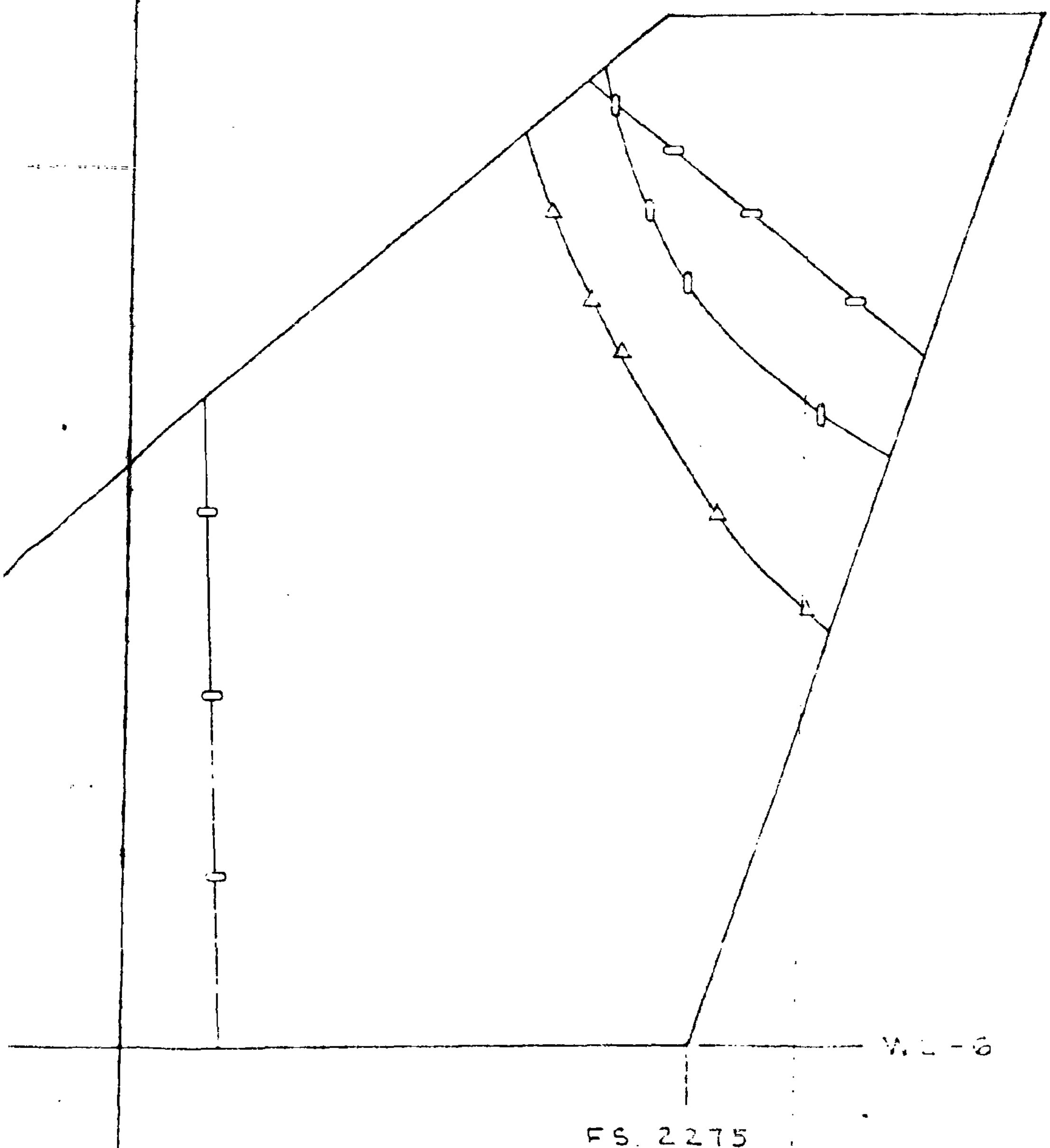
DATE 9-19-58	.06 WING *2 W/ OUTBOARD VERT. STAB. EMPTY WING FUEL	XB-70

FIG 5



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1/40 SCALE

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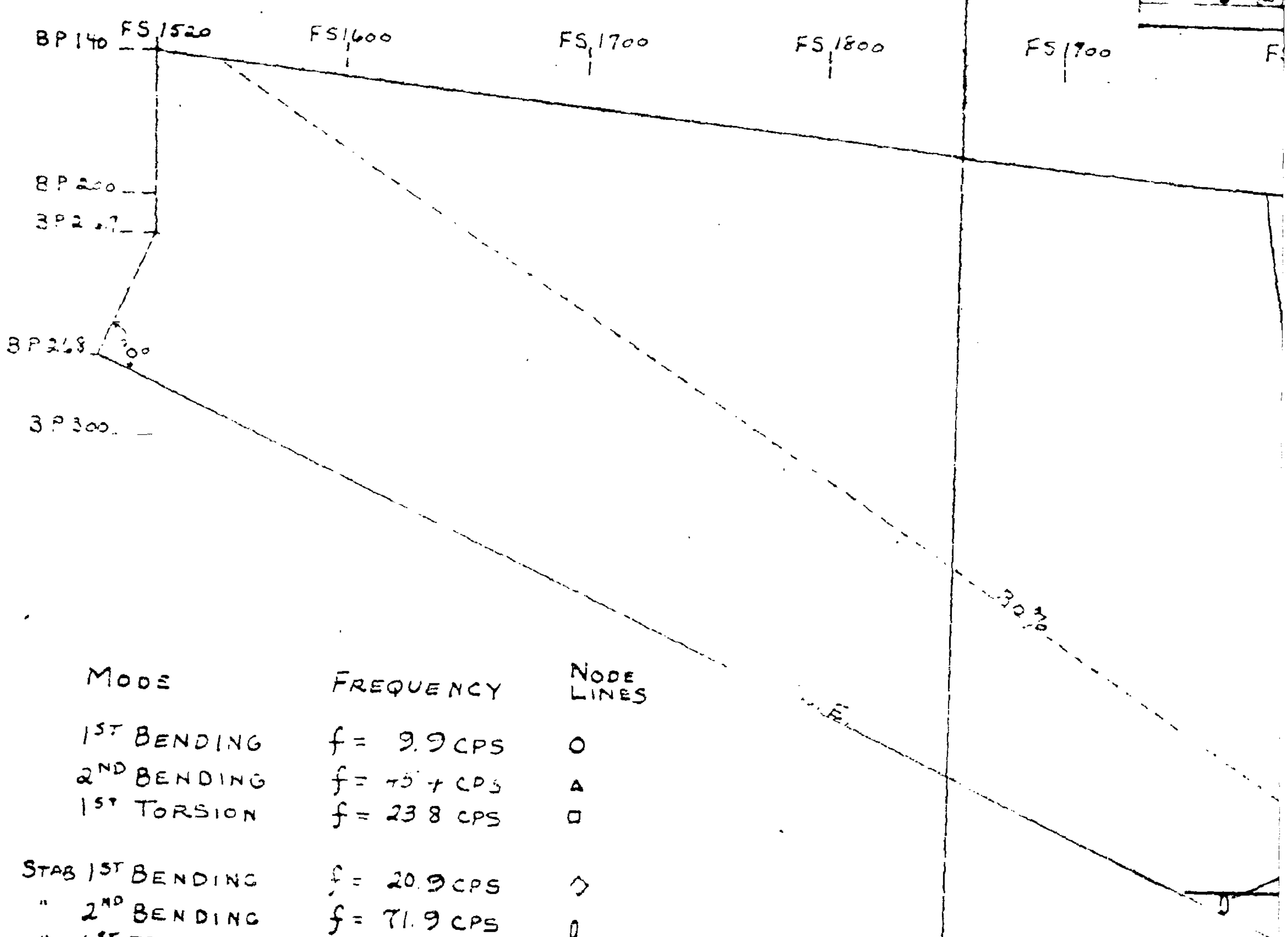

MODE	FREQUENCY	NODE LINES
1^{ST} BENDING	f = 9.9 CPS	○
2^{ND} BENDING	f = 45.4 CPS	△
1^{ST} TORSION	f = 23.8 CPS	□
STAB 1^{ST} BENDING	f = 20.9 CPS	◇
" 2^{ND} BENDING	f = 71.9 CPS	0
" 1^{ST} TORSION	f = 84.9 CPS	⊖

MAX. TUNNEL SPEED = 192 MPH (CLOSE TO SUSTAINED FLUTTER)

SCALE 1/20

1

WING L.E. INTERSECTS B.P. ... FS ...

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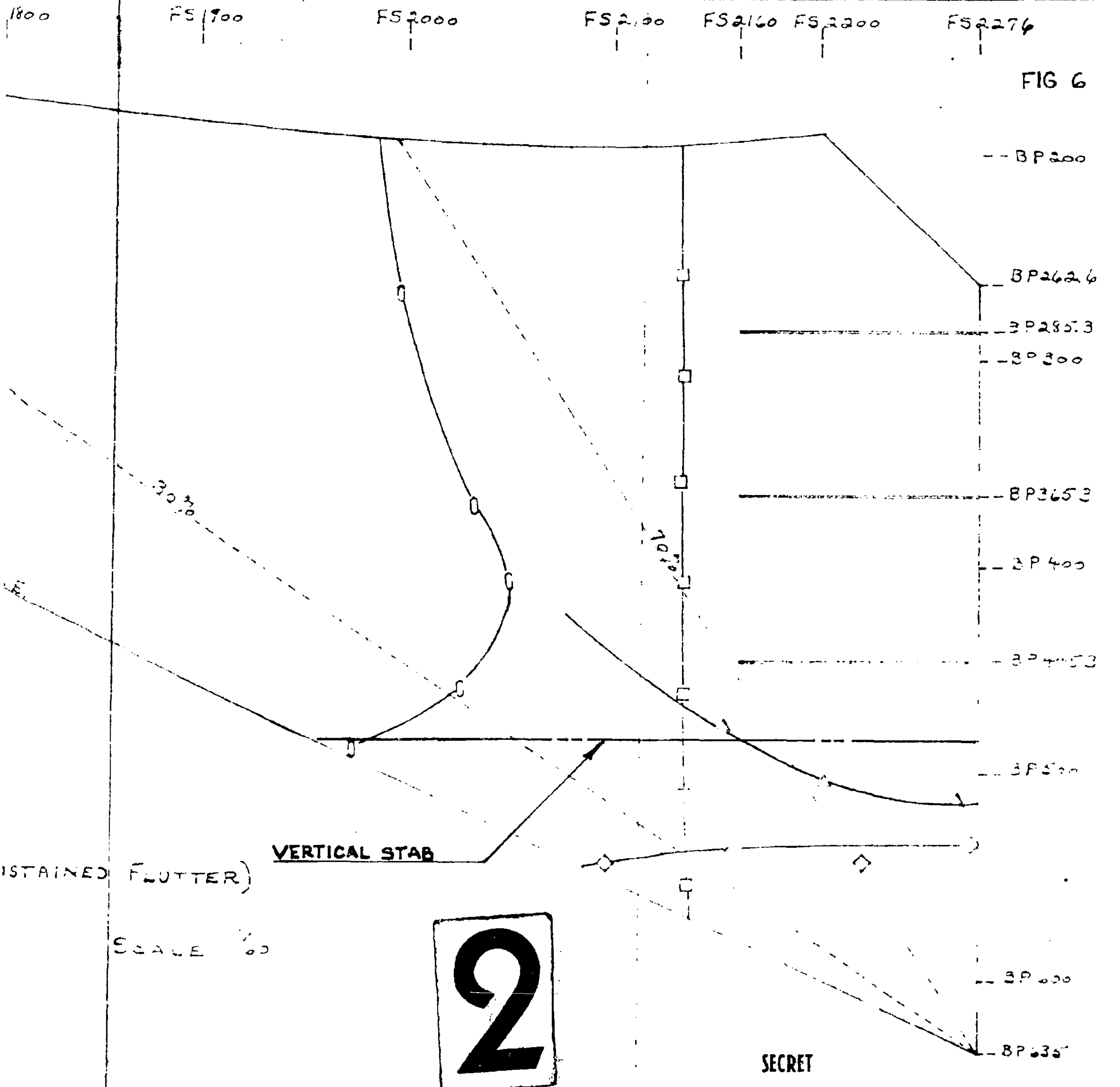
PREPARED BY: V.L.S.	NORTH AMERICAN AVIATION, INC.	PAGE NO. 12 OF 63
CHECKED BY: J.R.S.	SHAKE TEST RESULTS	REP. NO. NA-59-1736
DATE: 5-2[illegible]-59	.06 WING #2 WITH OUTB'D VERT FULL FUEL	MODEL NO. XB 70

FIG 6



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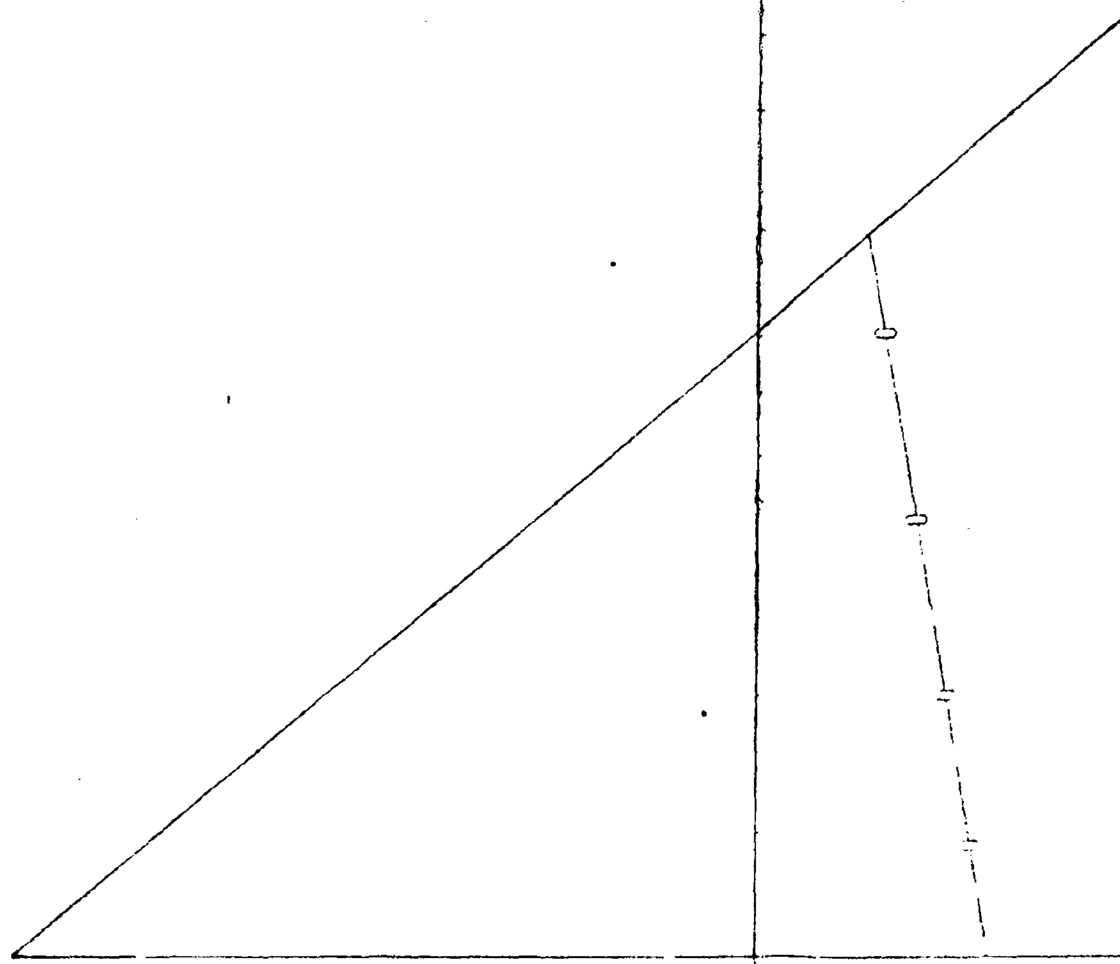
9-



1

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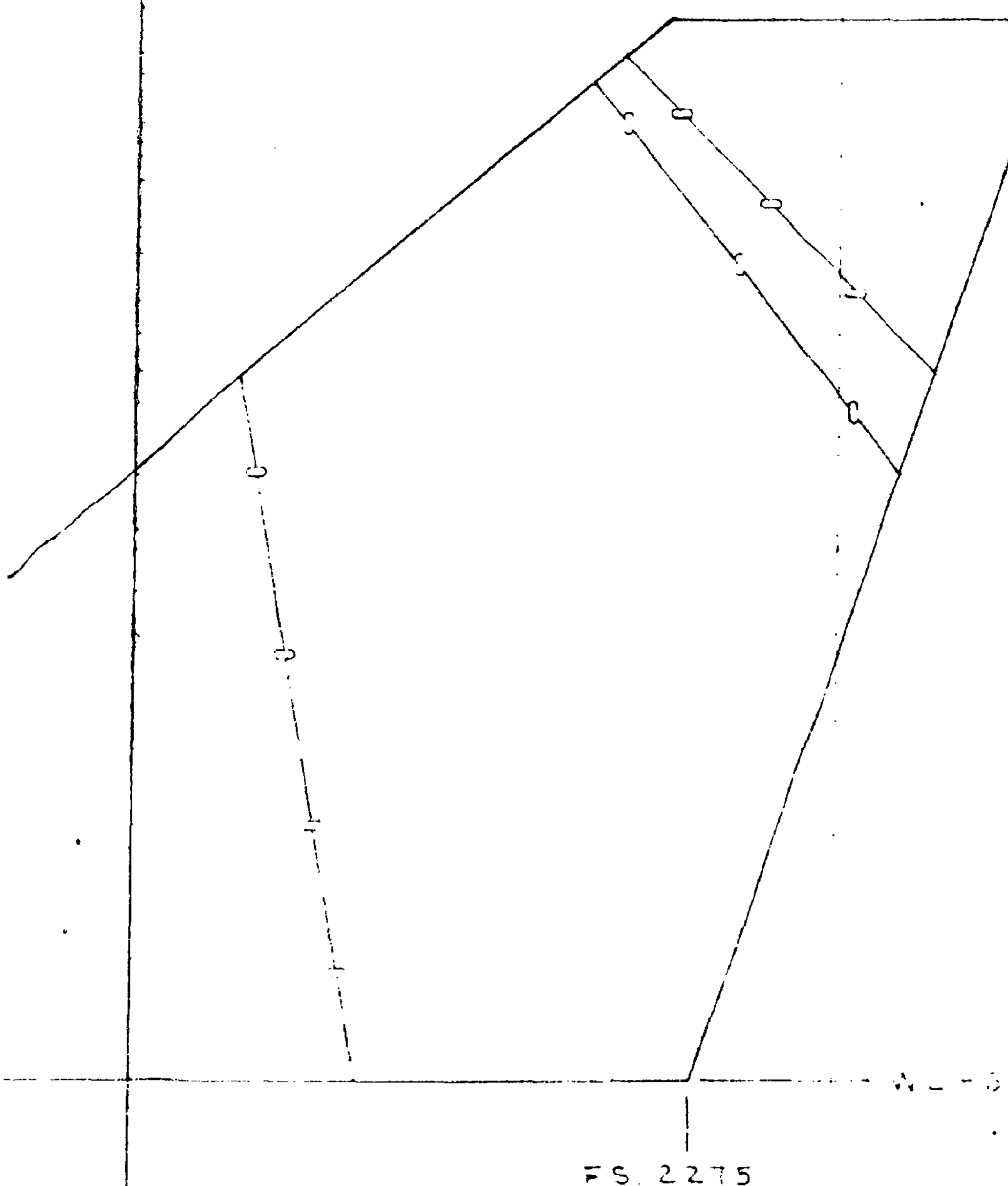
ED-423

SECRET

MGH	AVIATION INC.	13 / 63
J.R.S.	SHAKE TEST RESULTS	NA-59-1736
9-19-58	.06 WING #2 WITH OUTBOARD VERT. STAB. FULL WING FUEL	XB-70

FIG. 7



1/45 SCALE

2

SECRET

FIG 8

FLUTTER SPEED COMPARISON
WING #2 WITH AND WITHOUT VERT.

FLUTTER SPEED—MPH			
WITH VERT. STAB		WITHOUT VERT STAB	
FUEL LOADING		FUEL LOADING	
EMPTY	FULL	EMPTY	FULL
185	192	181	

.06 SCALE SUBSONIC WING I

Various fuel and ballast loadings were investigated using a .06 scale model of the wing cantilever mounted. The fuel loadings tested were; level, forward, aft, outboard, and inboard for 0, 25, 50, 75 and 100 per cent of full fuel load.

The model was constructed of solid styrofoam scaled to a .06 geometric scale and a .233 speed scale. Holes were drilled into the styrofoam so that the weights appropriate to the loading condition could be inserted. The model was cantilevered from the floor of the WSC 7 3/4 x 11 foot, low speed, atmospheric wind tunnel. A shake test of each condition was conducted prior to flutter testing.

After the flutter test was completed on all loading conditions of interest attempts were made to obtain destructive flutter for the critical points. The tip of the model was broken off in the empty condition while raising the flutter speed from 175 to 182 mph. The flutter was primarily of second bending type. These tests show a general trend of the flutter speed to increase with increase in fuel loading.

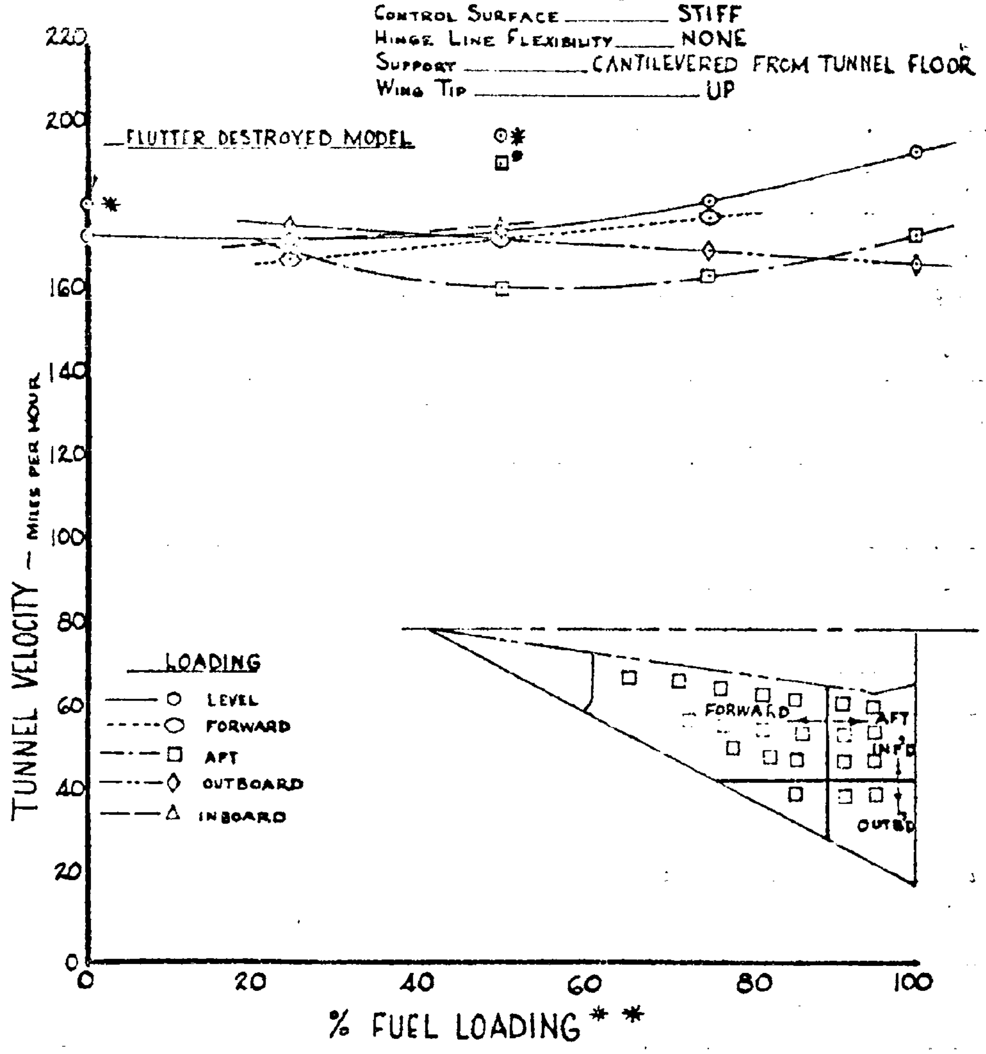
FIG 9

FLUTTER SPEED vs WING FUEL LOADING

B-70 WING #1 NAAL TEST #429

MODEL CHARACTERISTICS:

Geometric Scale .06
Material SOLID STYROFOAM
Speed Scale .233
Altitude SEA LEVEL
Control Surface STIFF
Hinge Line Flexibility NONE
Support CANTILEVERED FROM TUNNEL FLOOR
Wing Tip UP



* ATTEMPTS TO OBTAIN DESTRUCTIVE FLUTTER. ALL OTHER POINTS APPEARED VERY CLOSE TO SUSTAINED FLUTTER.

* * PER CENT OF FUEL LOADING REFERS TO % OF FULL FUEL LOAD FOR LEVEL FUEL LOADING IN AREAS DEFINED BY SKETCH.

PREPARED BY: R.W.D.	NORTH AMERICAN AVIATION, INC.	PAGE NO 17 OF 63
CHECKED BY: J.R.S.	SECRET	NA-59-1736 REPORT NO.
DATE: 11-30-59		MODEL NO. XB-70

B-70 WING NAAL TEST #429

FIG 10

MODEL CHARACTERISTICS

GEOMETRIC SCALE .... .06
SPEED SCALE .... .233
MATERIAL .... STYROFOAM
ALTITUDE .... SEA LEVEL
CONTROL SURFACE .... STIFF
HINGE LINE FLEXIBILITY .... NONE
SUPPORT ..... CANT. FROM TUNNEL FLOOR
WING TIP .... UP
FUEL LOADING .... VARIABLE

SUMMARY OF TEST RESULTS

RUN NO	FUEL	LOADING: LEVEL	FORWARD	AFT	OUTB'D	INB'D	MAX TUNNEL SPEED MPH	SHAKE TEST FREQUENCIES ~CPS: f_1	f_2	f_3	f_4
1	EMPTY	✓					168	12.8	32.0	45.8	72.8
2	FULL	✓					192	12.4	23.9	37.5	49.6
3&4	FULL		✓			✓	181	13.0	29.8	39.1	68.0
5	FULL			✓			175	12.3	25.9	44.5	69.2
6	3/4			✓			165	13.2	29.6	48.5	74.9
7&8	3/4	✓					180	11.8	26.8	42.3	54.8
9	1/2	✓					176	13.4	29.0	44.2	69.3
10	1/2			✓			162	13.2	30.8	48.7	75.3
11	1/4			✓			171	13.8	32.9	49.1	76.6
12	1/4	✓					174	12.7	29.3	43.5	64.5
13	FULL				✓		168	12.1	25.8	41.7	60.2
14	3/4				✓		171	13.6	29.6	46.6	67.3
15	1/4		✓				169	13.8	34.1	47.9	72.3
16*	1/2			✓			165	11.7	27.8	44	68.3
17	1/2	✓	[ONE WT LOCATION HAD			3/4 WT]	177	12.6	26.4	41.1	66.8
18	3/4		✓				179	12.6	29.0	39.8	49.6
19	1/2		✓				174	12.1	30.2	41.6	63.7
20	1/2					✓	177	12.1	29.8	42.5	63.3
21	1/4					✓	173	12.1	30.7	44.2	66.0
22	1/4				✓		177	13.3	33.3	48.9	74.4
23*	1/2			✓			173	12.3	27.8	43.5	65.2
24*	1/2			✓			181	12.2	27.6	43.9	66.4
25*	1/2			✓			178	12.1	27.1	43.2	68.2
26**	1/2			✓			192	SAME AS RUN #10			
27**	1/2	✓					199	SAME AS RUN #9			
28**	EMPTY	✓					182	SAME AS RUN #1			

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* 64 LBS. BALLAST ADDED ** ATTEMPTS TO OBTAIN [illegible]

.06 SCALE SUBSONIC WING II

Required stiffness levels were investigated at sea level, 15,000 feet, and 30,000 feet for various hinge rotational stiffness levels at 60% and 79% wing semi-span.

The .06 geometric scale model with a speed scale of .233 was constructed of solid styrofoam. At the 60% and 79% semi-span positions, rotational springs of the following stiffnesses were installed:

Stiffness in in-lb/rad x 10^{-4}

	10%	25%	50%	75%	100%
60% Fold Line	.311	.781	1.561	2.342	3.112
79% Fold Line		.1201	.2401	.3602	.4802

The model was ballasted for the empty sea level condition. To simulate altitude, incremental ballast was added to the empty sea level model. While the stiffness was being investigated at one hinge position, the other hinge was maintained at the 100% stiffness level. The 100% stiffness level corresponds to that existing if the structure were continuous across the hinge.

The natural frequencies and node lines of the first three or four modes were determined before actual flutter testing the model in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel at sea level density. The flutter margin was shown to be adequate in all runs, with the flutter speed being relatively insensitive to fold stiffness, fold position, or tip deflection, and increasing with altitude more rapidly than a constant q.

B-70 WING NAAL TEST #430

FIG 11

MODEL CHARACTERISTICS

GEOMETRIC SCALE ...... .06
SPEED SCALE .... .233
MATERIAL .... STYROFOAM
ALTITUDE .... VARIABLE

CONTRAL SURFACE .... STIFF
HINGE LINE STIFFNESS ......VARIABLE
SUPPORT...CANT. FROM TUNNEL FLOOR
WING TIP DEFLECTION.....VARIABLE
FUEL LOADING .... EMPTY

SUMMARY OF TEST RESULTS

RUN NO	ALT. FT.	STIFF. LEVEL % 60% b/2	STIFF. LEVEL % 79% b/2	DEFLECT~° 60% b/2	DEFLECT~° 79% b/2	MAX TUNNEL SPEED MPH	SHAKE TEST FREQUENCIES ~ CPS f_1	f_2	f_3	f_4
1	S.L.	100	100	0	0	169	10.5	31.3	47.0	—
2	S.L.	100	100	0	45	190	9.8	30.2	44.2	60.7
3	S.L.	100	100	0	75	200	11.0	33.3	47.4	66.8
4	S.L.	100	100	25	0	196	9.9	29.7	40.6	59.0
5	S.L.	100	100	52	0	202	11.5	29.0	39.4	61.3
6	S.L.	100	75	0	0	204	9.8	28.5	41.5	58.8
7	S.L.	100	50	0	0	198	9.8	31.3	45.0	64.4
8	S.L.	100	25	0	0	185	10.7	30.6	44.5	65.1
9*	S.L.	100	100	0	0	181	10.5	31.3	47.0	—
10	S.L.	75	100	0	0	199	10.6	31.6	46.2	65.4
11	S.L.	50	100	0	0	192	9.5	29.3	42.6	60.1
12	S.L.	25	100	0	0	180	9.4	28.8	41.2	58.7
13	S.L.	25	100	25	0	188	10.8	32.8	42.8	64.1
14	S.L.	25	100	52	0	184	10.3	25.8	35.1	54.8
15	15,000	100	100	0	0	203	7.6	23.3	33.4	48.5
16	15,000	25	100	0	0	202	8.2	25.4	36.2	52.0
17	30,000	25	100	0	0	202	6.3	19.7	28.0	—
18	30,000	100	100	0	0	205	6.3	19.6	28.2	—

* RERUN #1

SECRET

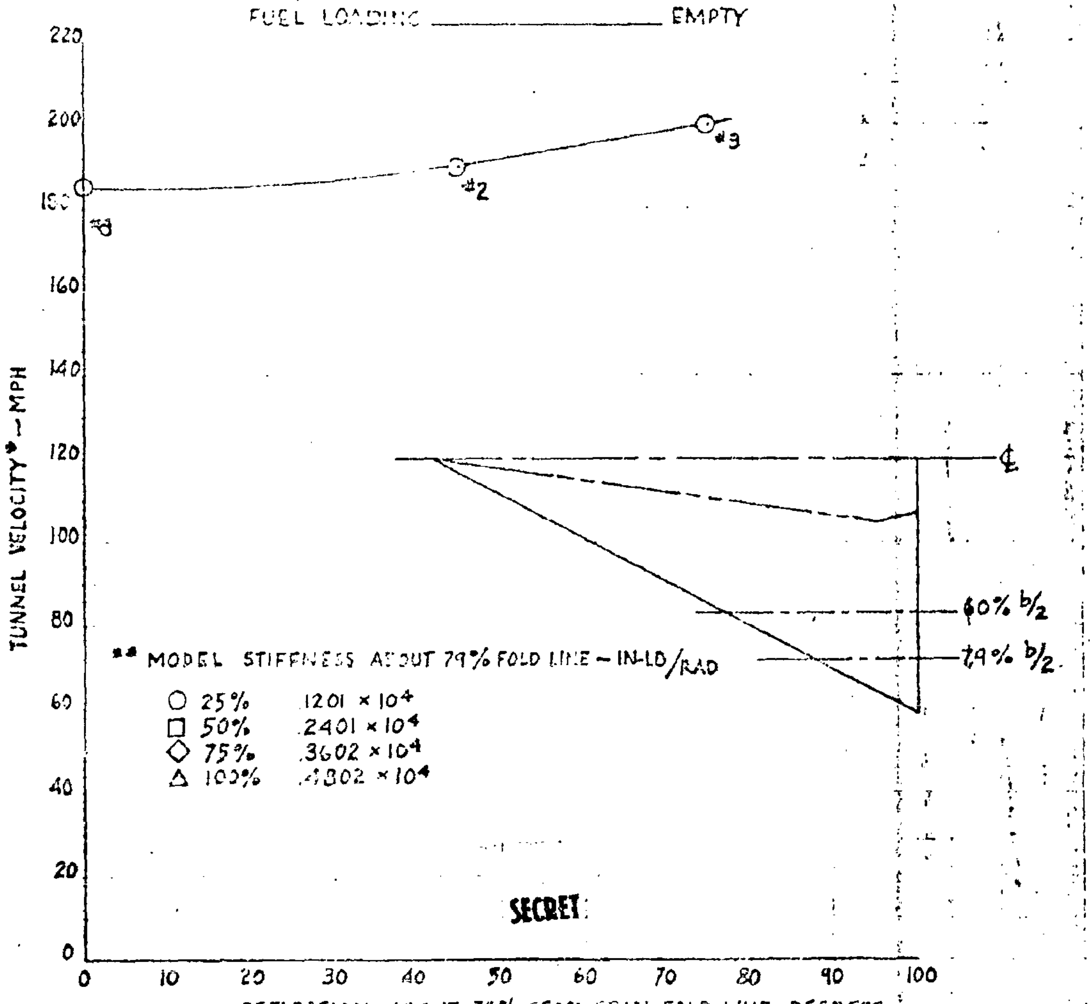
FIG 12

VARIATION OF FLUTTER SPEED WITH DEFLECTION ABOUT 75% SEMI-SPAN FOLD LINE

B-70 WING #2 NAAL TEST #430

MODEL CHARACTERISTICS:

GEOMETRIC SCALE —— .06
MATERIAL —— SOLID STYROFOAM
SPEED SCALE —— .233
ALTITUDE —— SEA LEVEL
CONTROL SURFACE —— STIFF
HINGE LINE STIFFNESS —— **
SUPPORT —— CANTILEVERED FROM TUNNEL FLOOR
WING TIP DEFLECTION —— SEE PLOT
FUEL LOADING —— EMPTY



*ALL POINTS APPEARED CLOSE TO SUSTAINED FLUTTER, EXCEPT WHERE TUNNEL BRAKES REMOVED.
NUMBERS ADJACENT TO CIRCLED POINTS INDICATE NAAL TEST RUN NUMBERS.
STIFFNESS ABOUT 60% LINE MAINTAINED AT 100% OR 3.112×10^4 IN-LB/RAD.

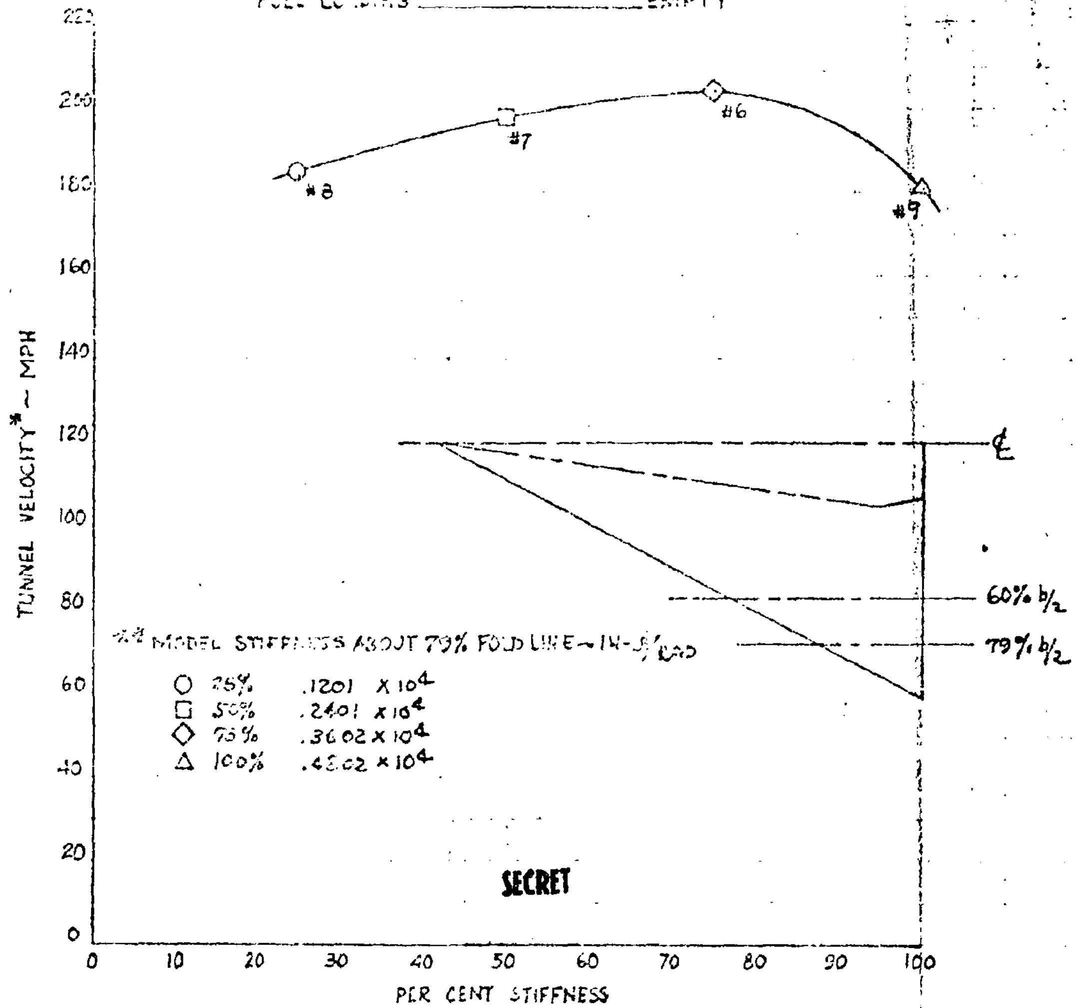
FIG 13

VARIATION OF FLUTTER SPEED WITH STIFFNESS ABOUT 79% SEMI-SPAN FOLD LINE

B-70 WING #2 NAAL TEST #430

MODEL CHARACTERISTICS:

- GEOMETRIC SCALE ——— .06
- MATERIAL ——— SOLID STYROFOAM
- SPEED SCALE ——— .233
- ALTITUDE ——— SEA LEVEL
- CONTROL SURFACE ——— STIFF
- HINGE LINE STIFFNESS ——— **
- SUPPORT ——— CANTILEVERED FROM TUNNEL FLOOR
- WING TIP DEFLECTION ——— 0°
- FUEL LOADING ——— EMPTY



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*ALL POINTS APPEARED CLOSE TO SUSTAINED FLUTTER EXCEPT WHERE TUNNEL BRAKES REMOVED.
NUMBERS ADJACENT TO CIRCLED POINTS INDICATE NAAL TEST RUN NUMBERS.
STIFFNESS ABOUT 60% LINE MAINTAINED AT 100% OR 3.112×10^4 IN-LB/RAD.

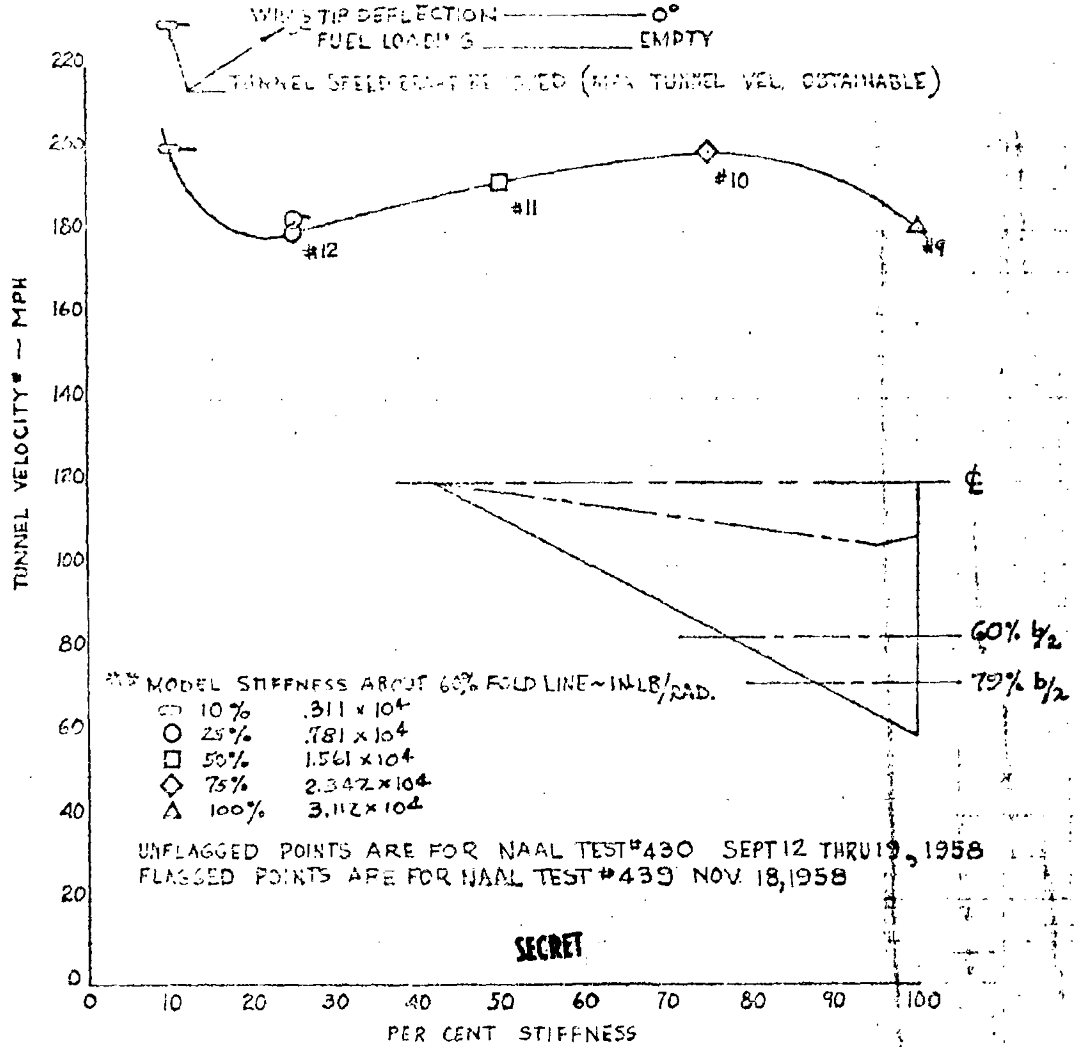
FIG 14

VARIATION OF FLUTTER SPEED WITH STIFFNESS ABOUT 60% SEMI-SPAN FOLD LINE

B-70 WING #2 NAAL TEST #430 & 439

MODEL CHARACTERISTICS:

- GEOMETRIC SCALE — .06
- MATERIAL — SOLID STYROFOAM
- SPEED SCALE — .233
- ALTITUDE — SEA LEVEL
- CONTROL SURFACE — STIFF
- HINGE LINE STIFFNESS — **
- SUPPORT — CANTILEVERED FROM TUNNEL FLOOR
- WING TIP DEFLECTION — 0°
- FUEL LOADING — EMPTY



*ALL POINTS APPEARED CLOSE TO SUSTAINED FLUTTER, EXCEPT WHERE TUNNEL BRAKES REMOVED
NUMBERS ADJACENT TO CIRCLED POINTS INDICATE NAAL TEST RUN NUMBERS.
STIFFNESS ABOUT 79% LINE MAINTAINED AT 100% OR $.4802 \times 10^4$ IN-LB/RAD.

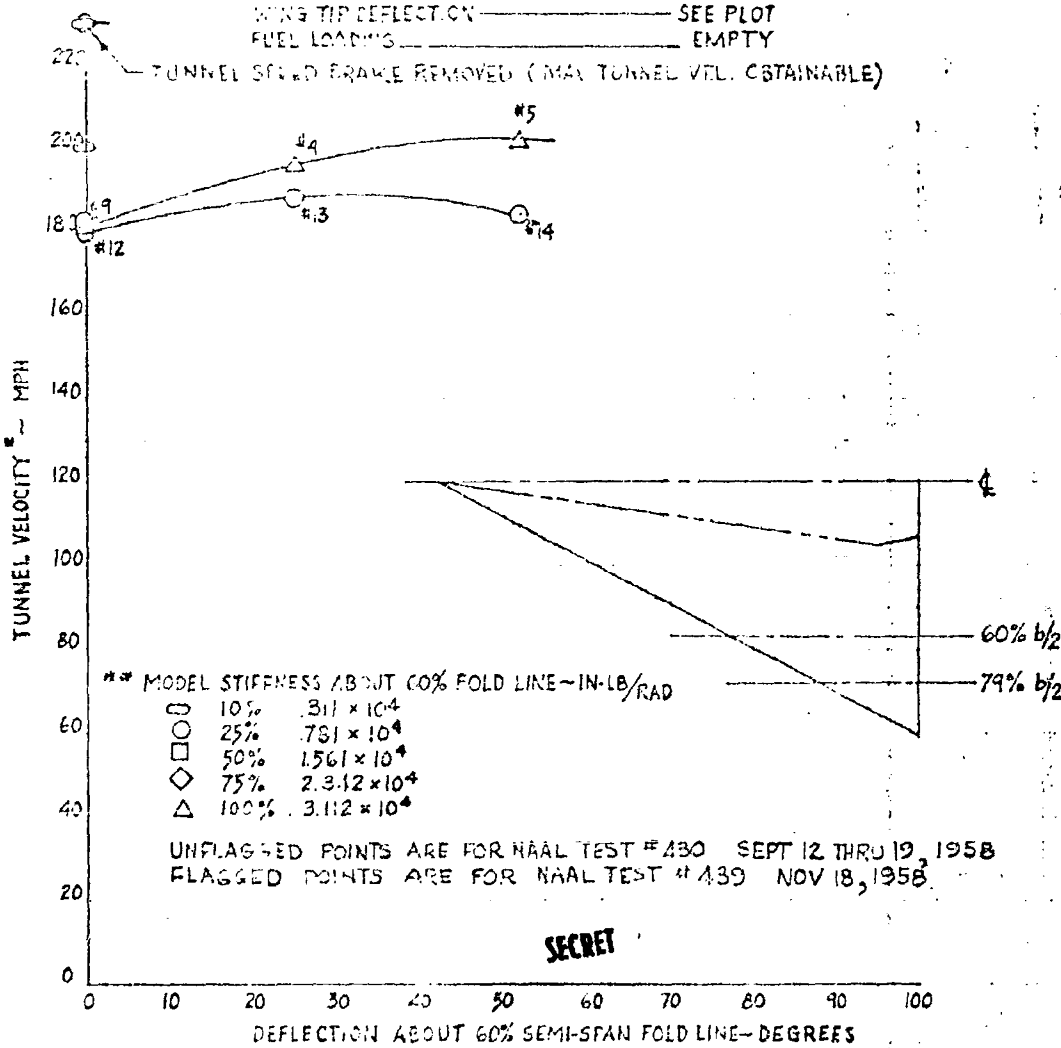
FIG 15

VARIATION OF FLUTTER SPEED WITH DEFLECTION ABOUT 60% SEMI-SPAN FOLD LINE

B-70 WING #2 NAAL TEST #430 & 439

MODEL CHARACTERISTICS:

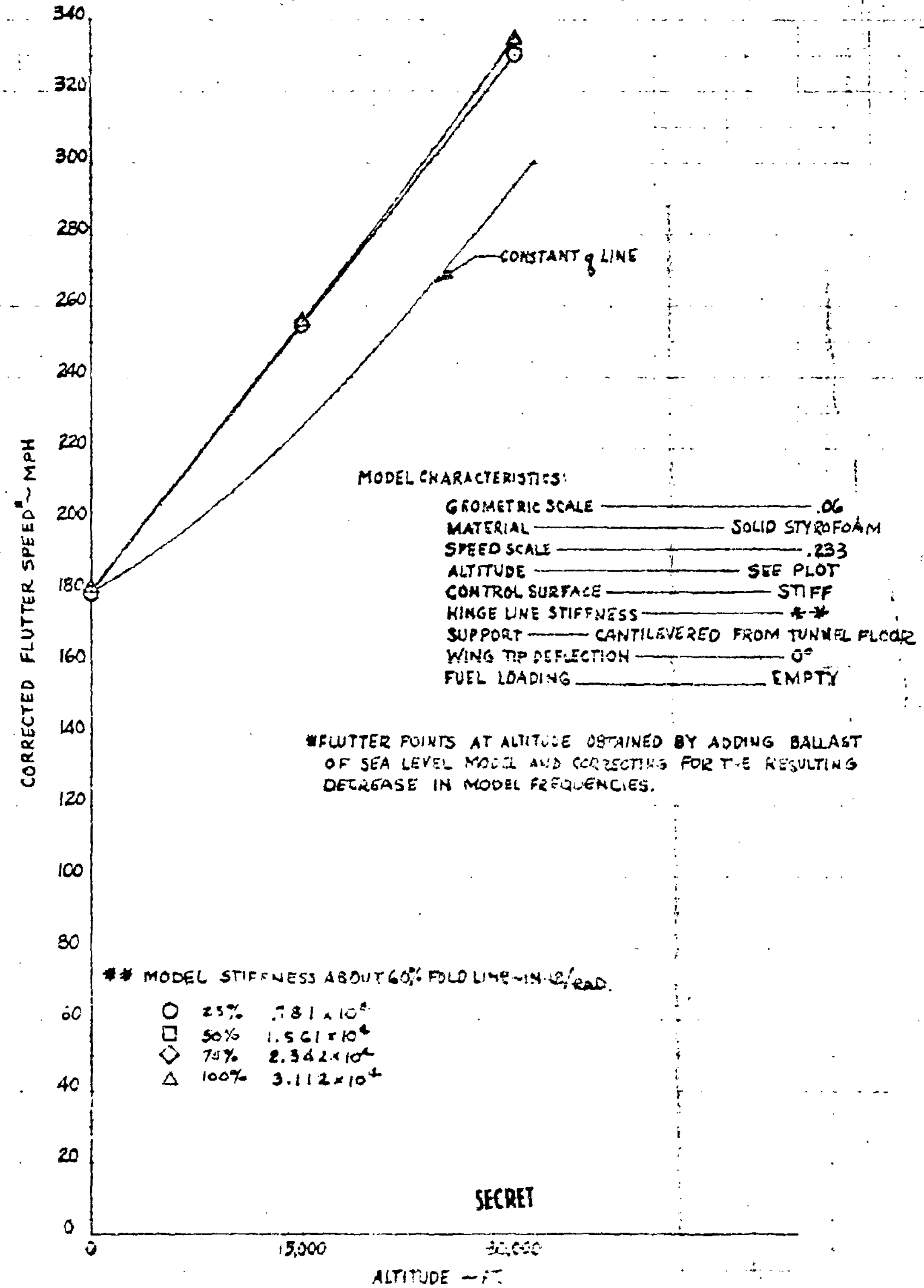
GEOMETRIC SCALE ———— .06
MATERIAL ———— SOLID STYROFOAM
SPEED SCALE ———— 233
ALTITUDE ———— SEA LEVEL
CONTROL SURFACE ———— STIFF
HINGE LINE STIFFNESS ———— **
SUPPORT ———— CANTILEVERED FROM TUNNEL FLOOR
WING TIP DEFLECTION ———— SEE PLOT
FUEL LOADING ———— EMPTY



*ALL POINTS APPEARED CLOSE TO SUSTAINED FLUTTER, EXCEPT WHERE TUNNEL BRAKES REMOVED.
NUMBERS ADJACENT TO CIRCLED POINTS INDICATE NAAL TEST RUN NUMBERS.
STIFFNESS ABOUT 79% LINE MAINTAINED AT 100% OR .4802 × 10^4 IN-LB/RAD.

VARIATION OF FLUTTER SPEED WITH ALTITUDE

FIG 16



.10 SCALE TRANSONIC WING

This transonic flutter model test was conducted to demonstrate an adequate flutter margin at M = .95.

The cantilevered 1/10 model of the -127 configuration was constructed with 4.5 lbs/ft^3 styrofoam filler between isowood spars and covered with thin sheets of aluminum. The control surfaces were not free to rotate. The model was ballasted to simulate full scale empty weight distribution. A shake test of the model was conducted to determine natural frequencies and node lines of the first three modes.

Flutter was not obtained but the model trailing edge was damaged due to flow reversal at tunnel shutdown. After repairing the model, and eliminating flow reversal by allowing the valve to remain open until all of the pressurized air was expended, very large margins were demonstrated without encountering flutter.

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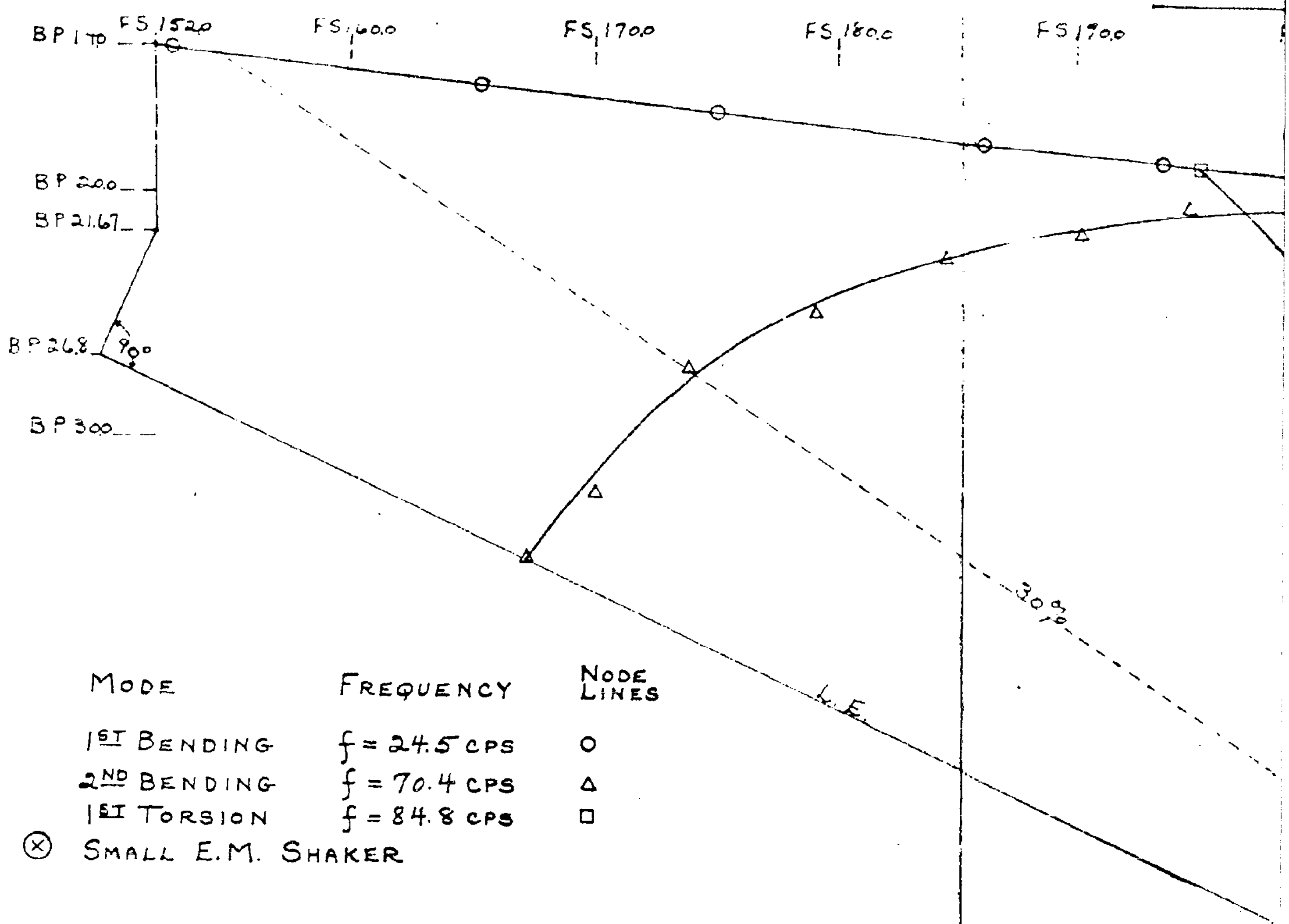


Mode	Frequency	Node Lines
1ST Bending	$f = 24.5$ cps	○
2ND Bending	$f = 70.4$ cps	△
1ST Torsion	$f = 84.8$ cps	□

⊗ Small E.M. Shaker

Design Flutter q = 1800 PSF

Maximum Test q = 2050 PSF
No Flutter

SECRET

Wing L.E. Intersects H/P ℄ @ FS 92.6

1

Scale 1/60

ED-423

PREPARED BY	NORTH AMERICAN AVIATION INC.	PAGE NO. 26 OF 63
CHECKED BY J.R.S.	SHAKE TEST RESULTS	REPORT NO. NA-59-1736
DATE 5-20-52	1/10 SCALE M=.95 MODEL SERIES	MODEL NO. XB-70

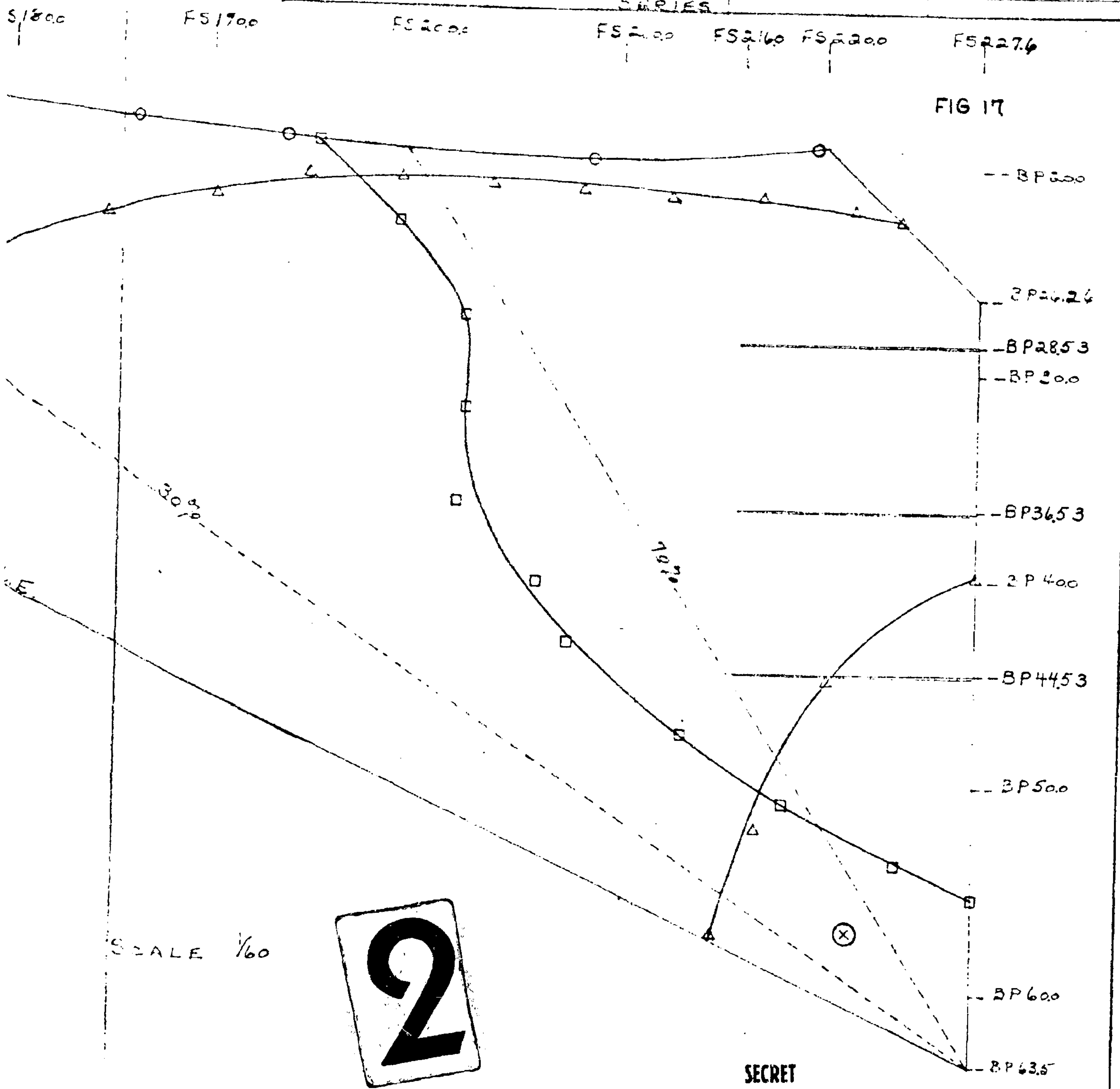


FIG 17

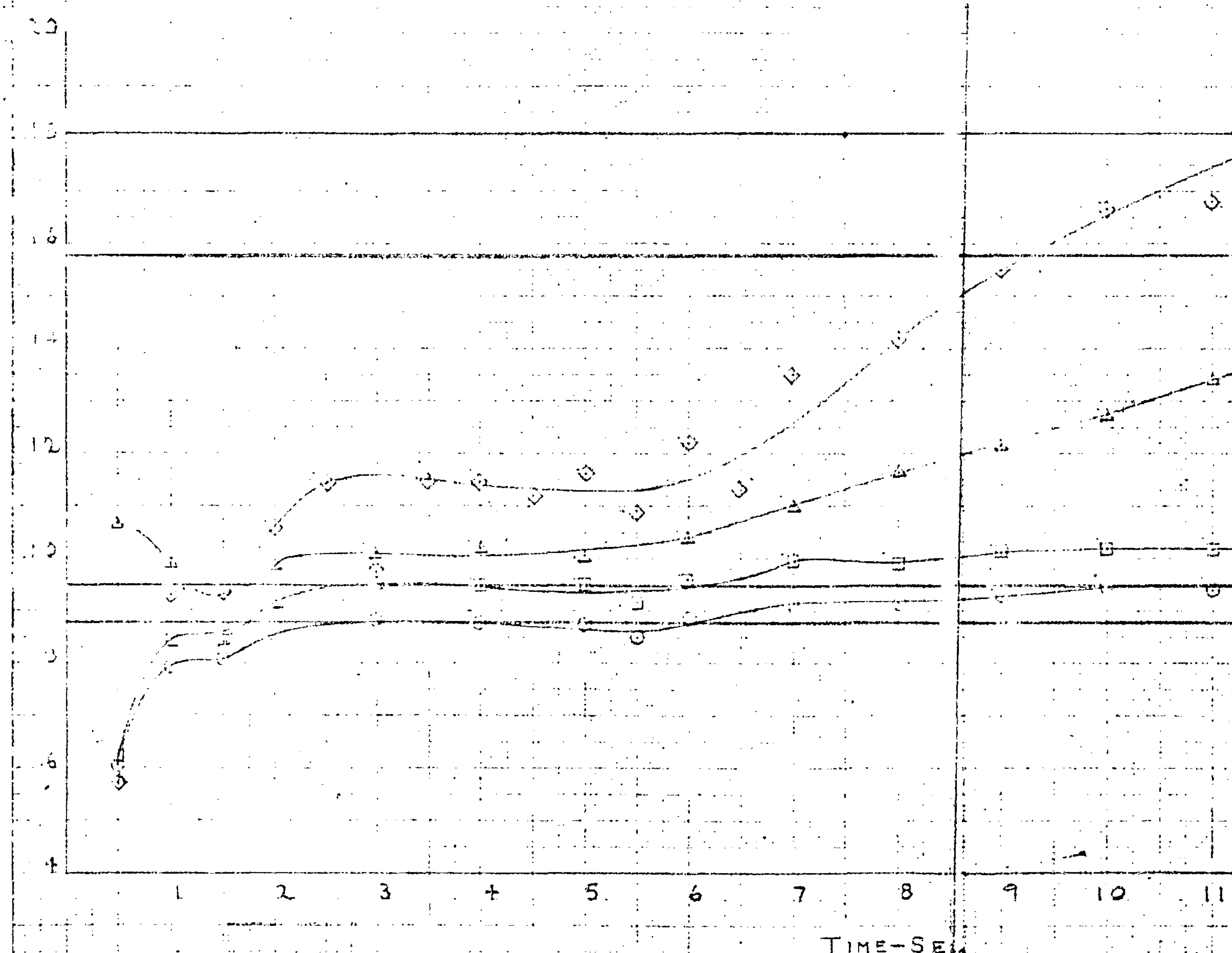
1

SECRET

PREPARED BY:	BAK
CHECKED BY:	J.R.S.
DATE	7-30-58

WIND TUNNEL TEST CONDITIONS FOR ASM MODEL

VARIATION OF q, P/P_c, T/T_{so} AND M VS. TIME



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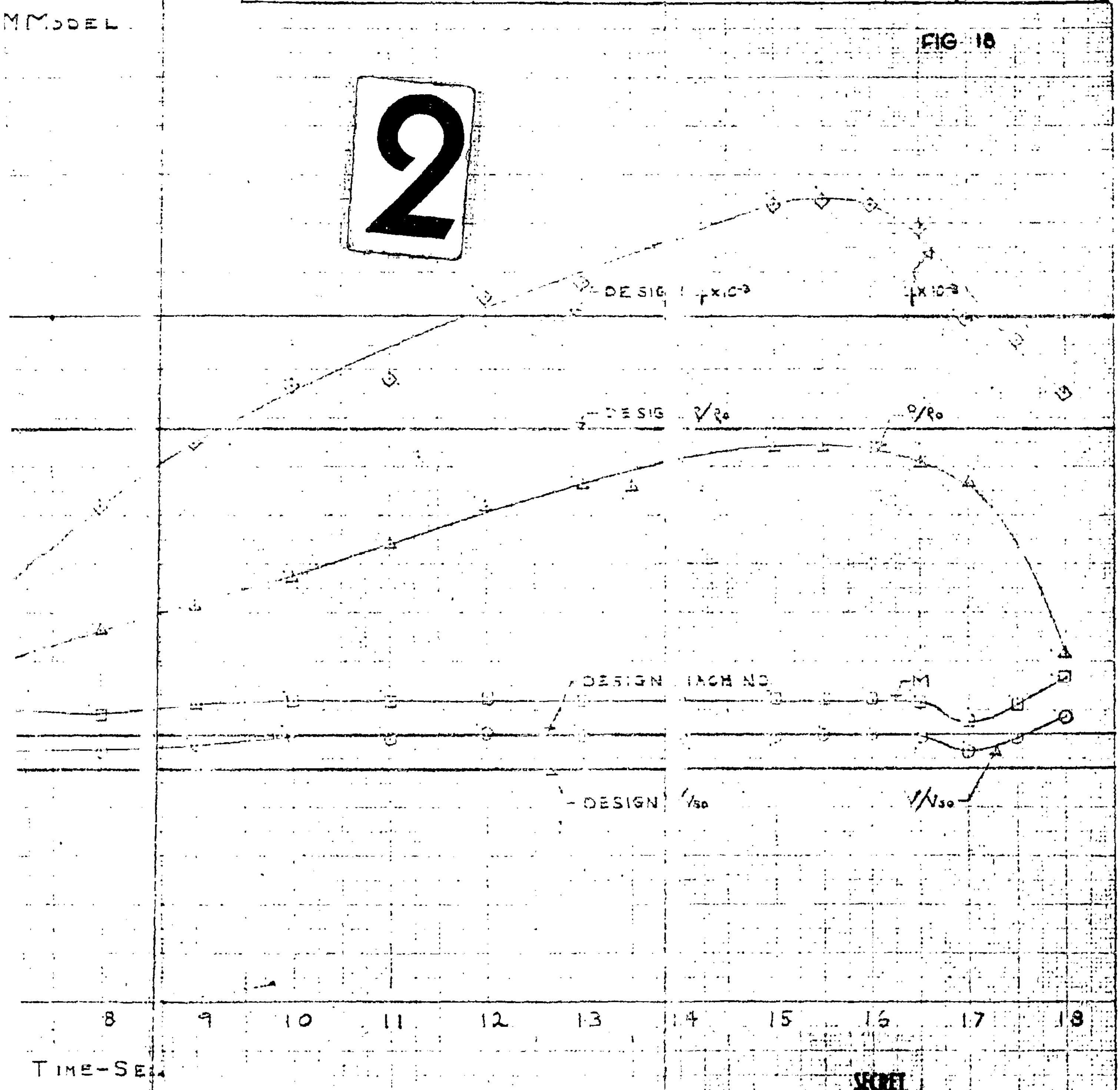
FORM ED-214

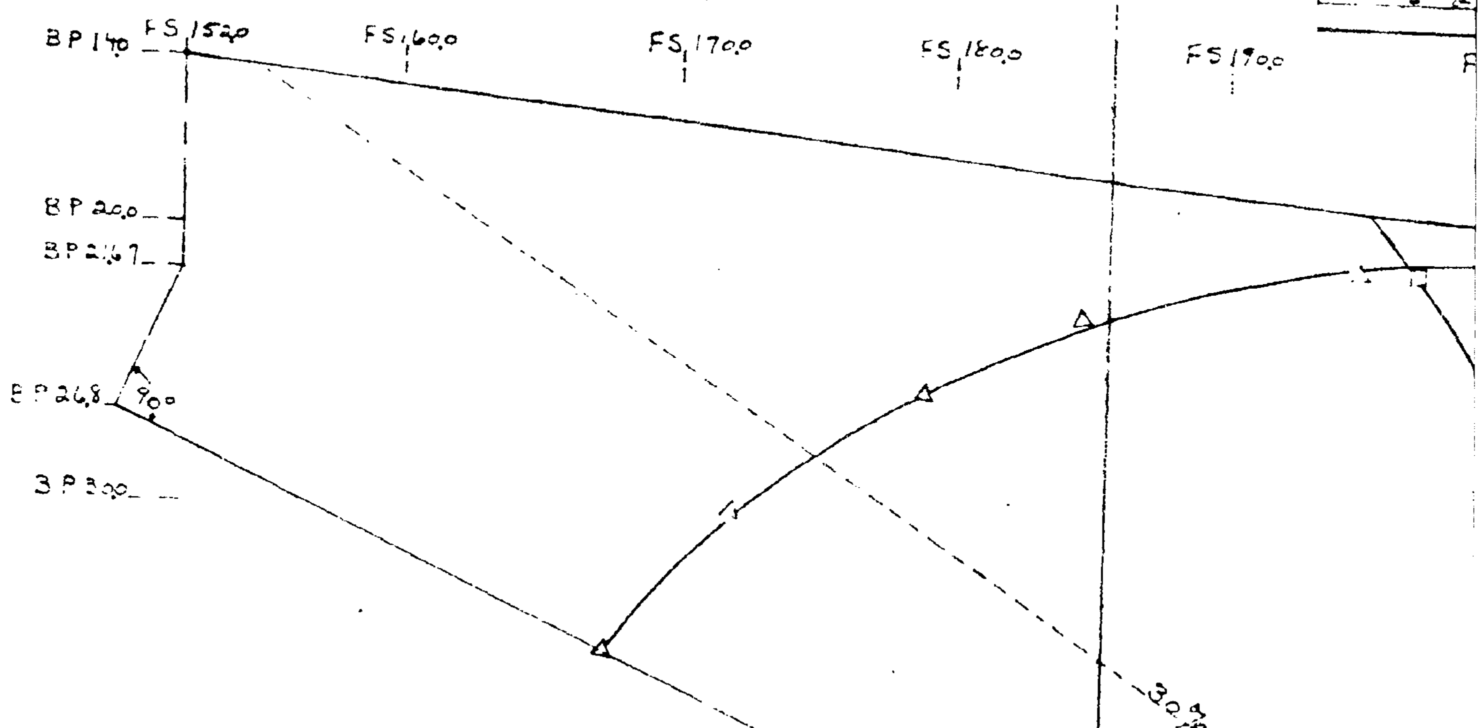
PREPARED BY: BAK	NORTH AMERICAN AVIATION, INC.	PAGE NO. 27 OF 63
CHECKED BY: J.R.S.	SERIES I SECRET	REPORT NO NA-59-1736
DATE 7-30-58		MODEL NO XB-70

FIG 18



SECRET

PREPARED BY
CHECKED BY J
DATE



MODE	FREQUENCY	NODE LINES
1ST BENDING	$f = 26.5$ CPS	○
2ND BENDING	$f = 78.1$ CPS	△
1ST TORSION	$f = 90.4$ CPS	□

DESIGN FLUTTER $\frac{q}{\delta}$ = 1800 PSF

MAXIMUM TEST $\frac{q}{\delta}$ = 2750 PSF
NO FLUTTER

1

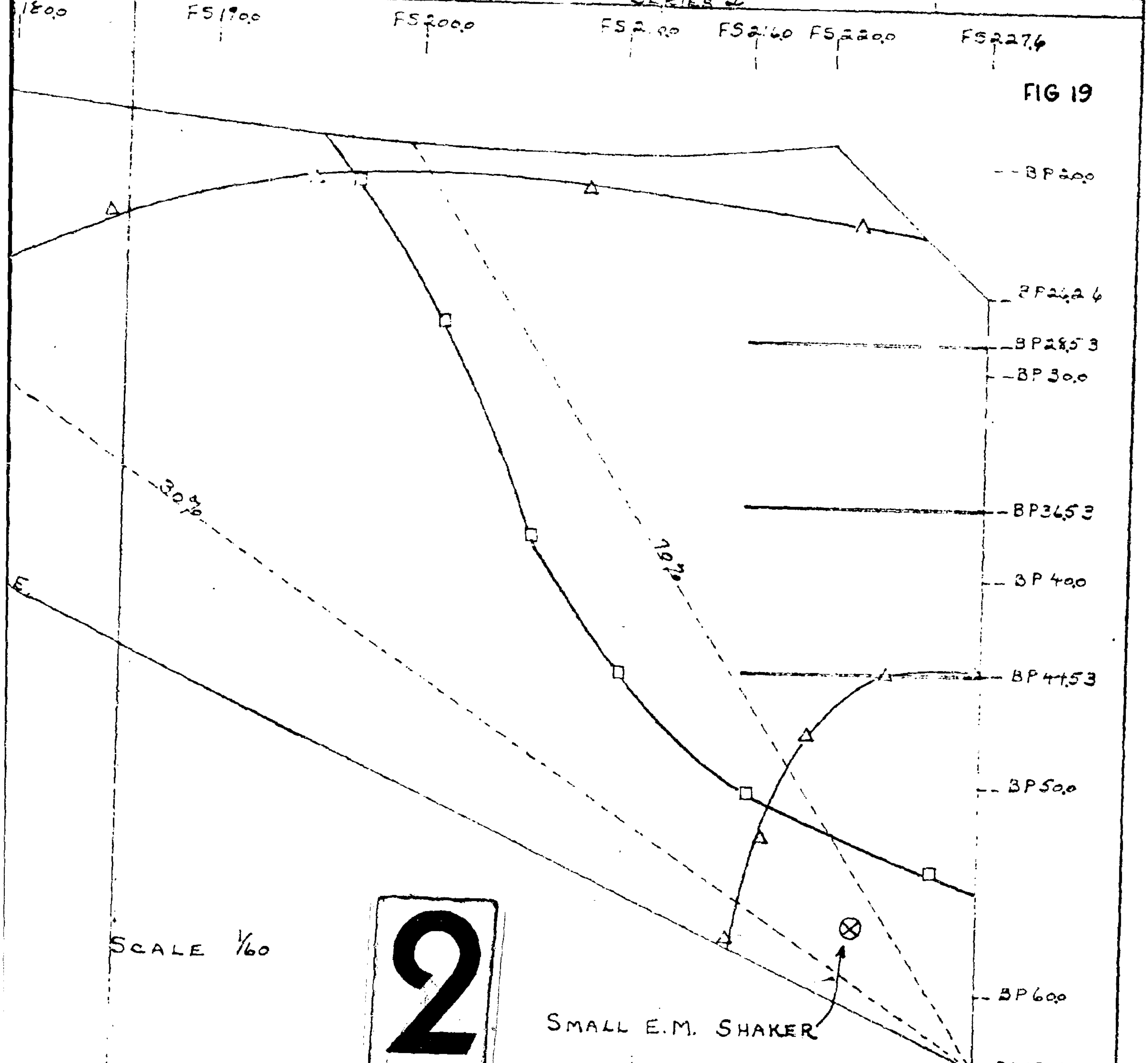
SCALE 1/60

WING L E INTERSECTS A/P ℄ @ FS 92.6

SECRET

PREPARED BY: V.L.S.	NORTH AMERICAN AVIATION, INC.	PAGE NO. 28 OF 65
CHECKED BY: J.R.S.	SHAKE TEST RESULTS	NA-59-1736 REPORT NO.
DATE: 5-21-5?	REPAIRED 1/40 SCALE M=.95 MODEL	MODEL NO. XB-70
	SERIES 2	

FIG 19



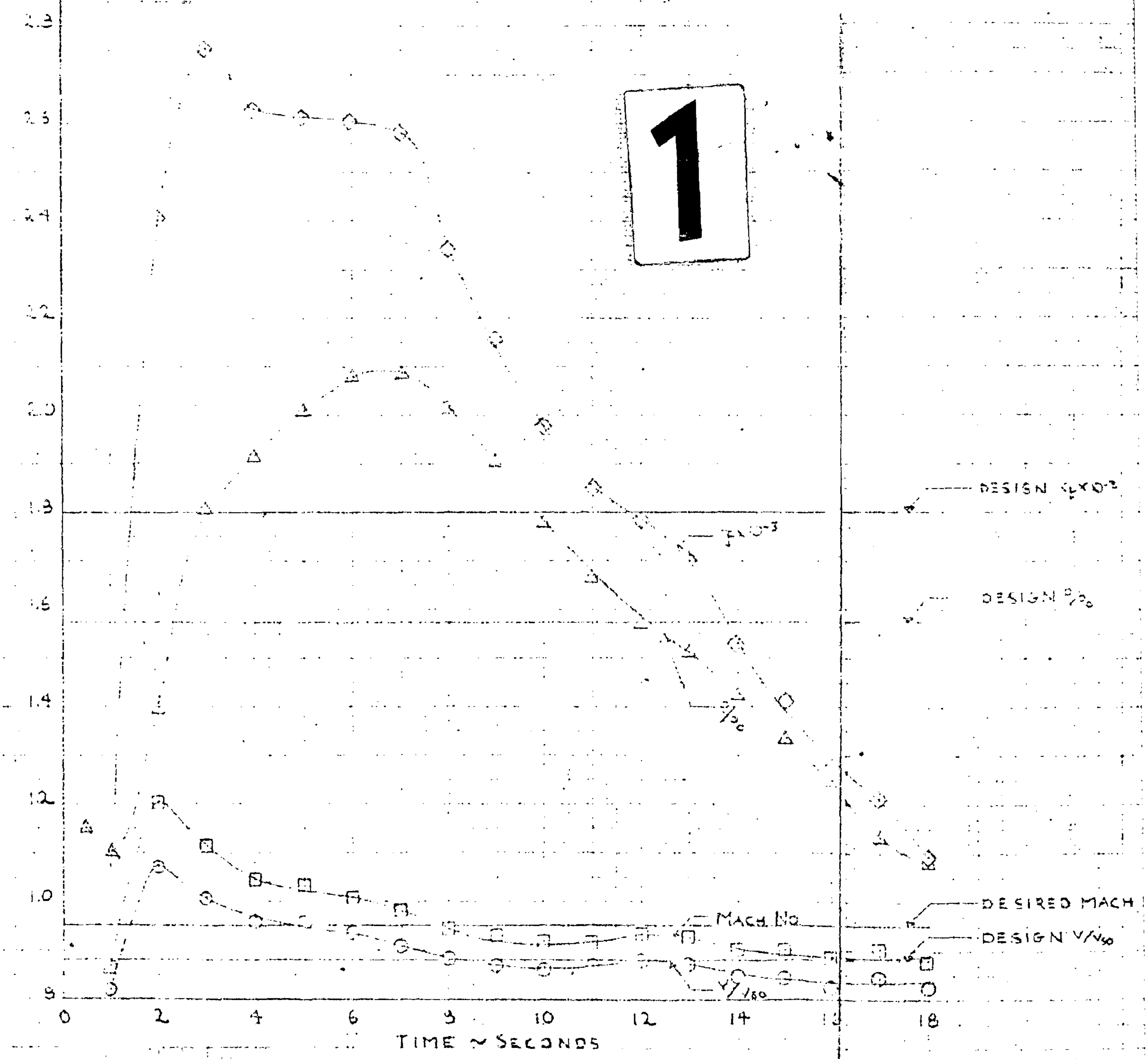
SECRET

PREPARED BY:	BAK
CHECKED BY	RWD
DATE	9-18-59

WIND TUNNEL TEST CONDITIONS FOR .95M MODEL

SECRET

VARIATION OF q, P/Po, V/V50 AND M VS TIME

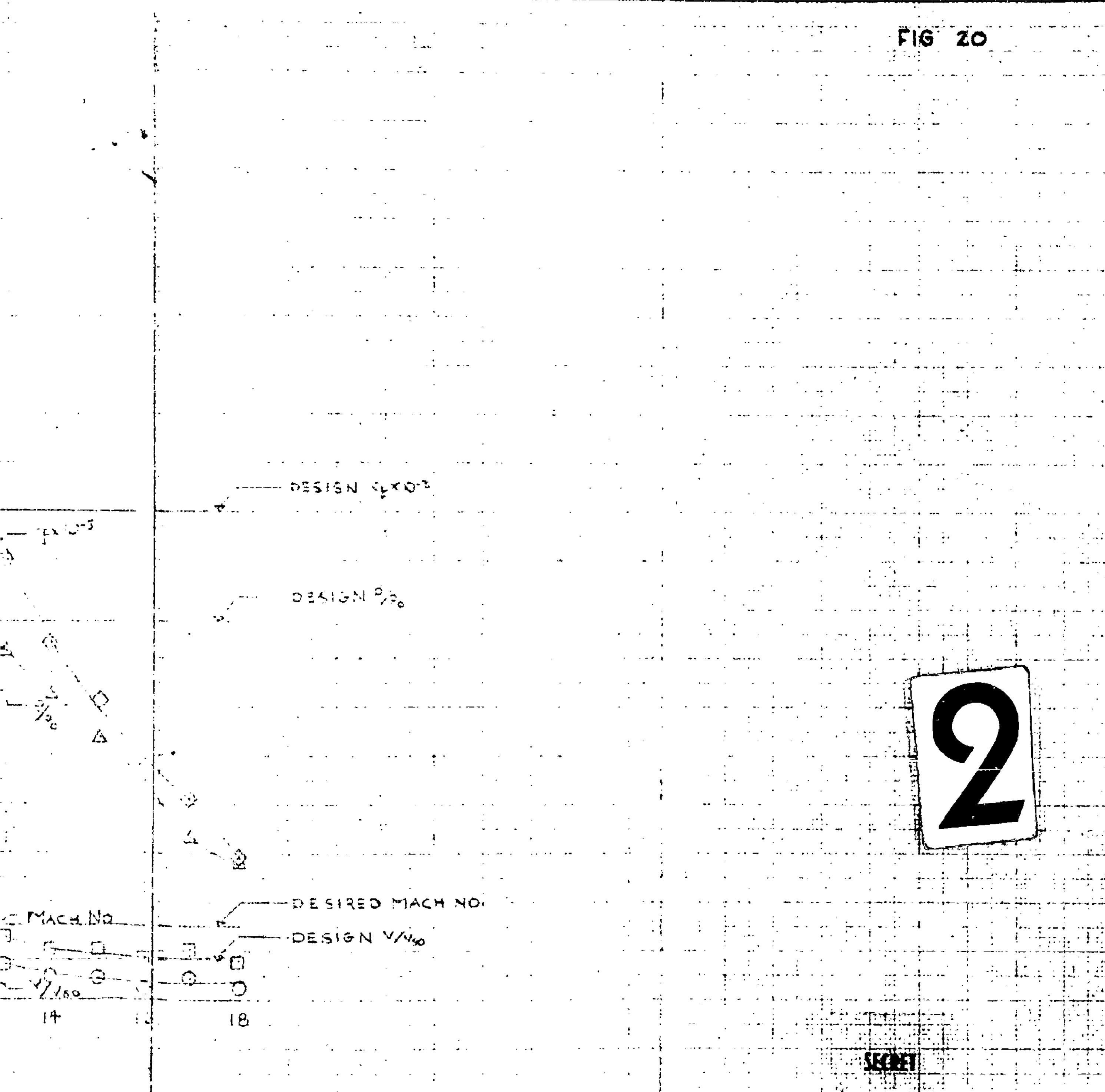


SECRET

FORM ED-216

PREPARED BY: BAK	NORTH AMERICAN AVIATION, INC.	PAGE NO 29 OF 63
CHECKED BY RWD	SECRET	NA-59-1736 REPORT NO.
DATE 9-18-59		MODEL NO XB-70

FIG 20



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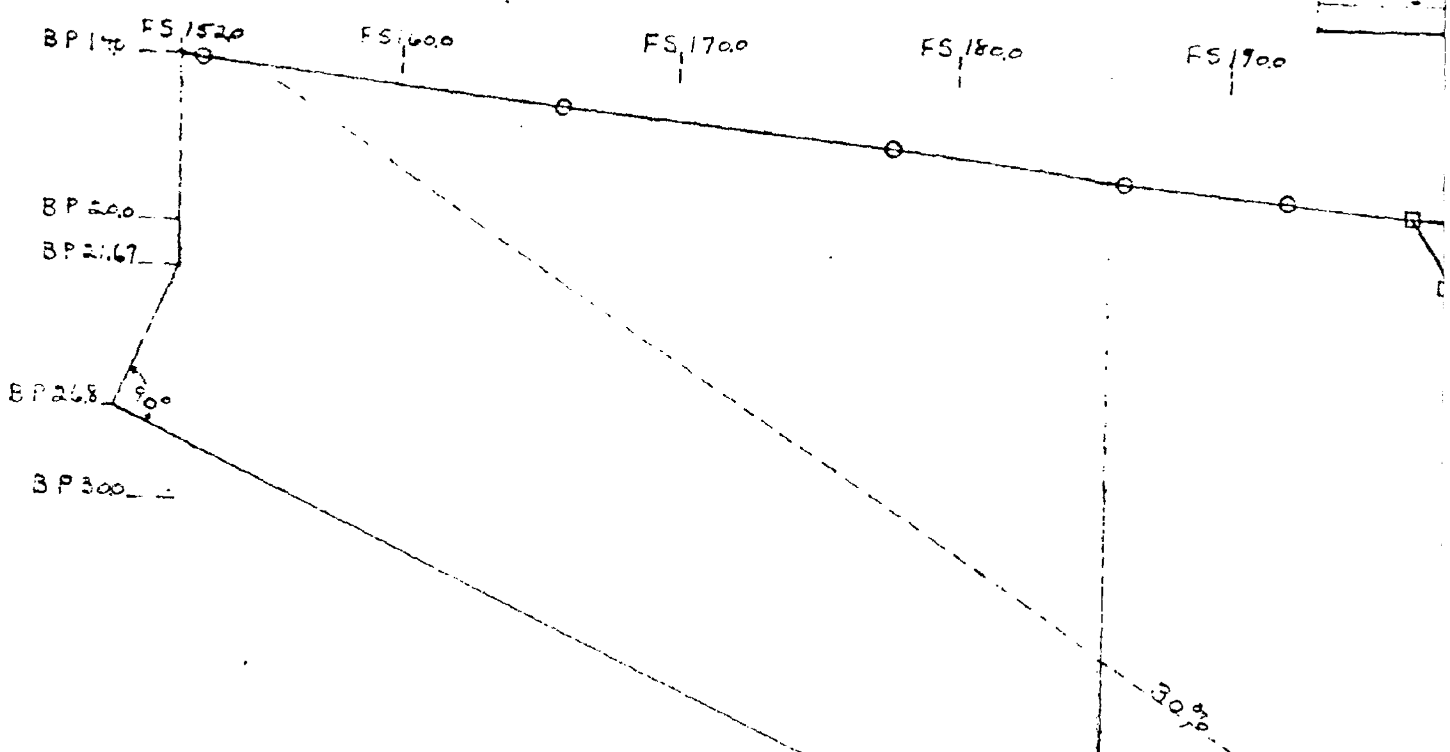
.10 SCALE SUPERSONIC WING

This high speed flutter model test was conducted to demonstrate an adequate flutter margin at M = 3.0.

The cantilevered 1/10 model of the -127 configuration was constructed with 3 lbs/ft^3 styrofoam filler between isowood spars and covered with thin aluminum sheets. The model was ballasted to simulate the full scale empty weight distribution. The control surfaces were not free to rotate. A shake test of the model was made to determine natural frequencies and node lines of the first three modes.

Flutter was not obtained but the model was destroyed as a result of tunnel starting loads.

SECRET



MODE	FREQUENCY	NODE LINES
1ST BENDING	f = 18.0 CPS	○
2ND BENDING	f = 48.3 CPS	△
1ST TORSION	f = 63.1 CPS	□

⊗ SMALL E.M. SHAKER

DESIGN FLUTTER q = 1994 PSF

MAXIMUM TEST q = 2990 PSF

NO FLUTTER - MODEL DESTROYED BY STARTING LOADS

SCALE 1/60

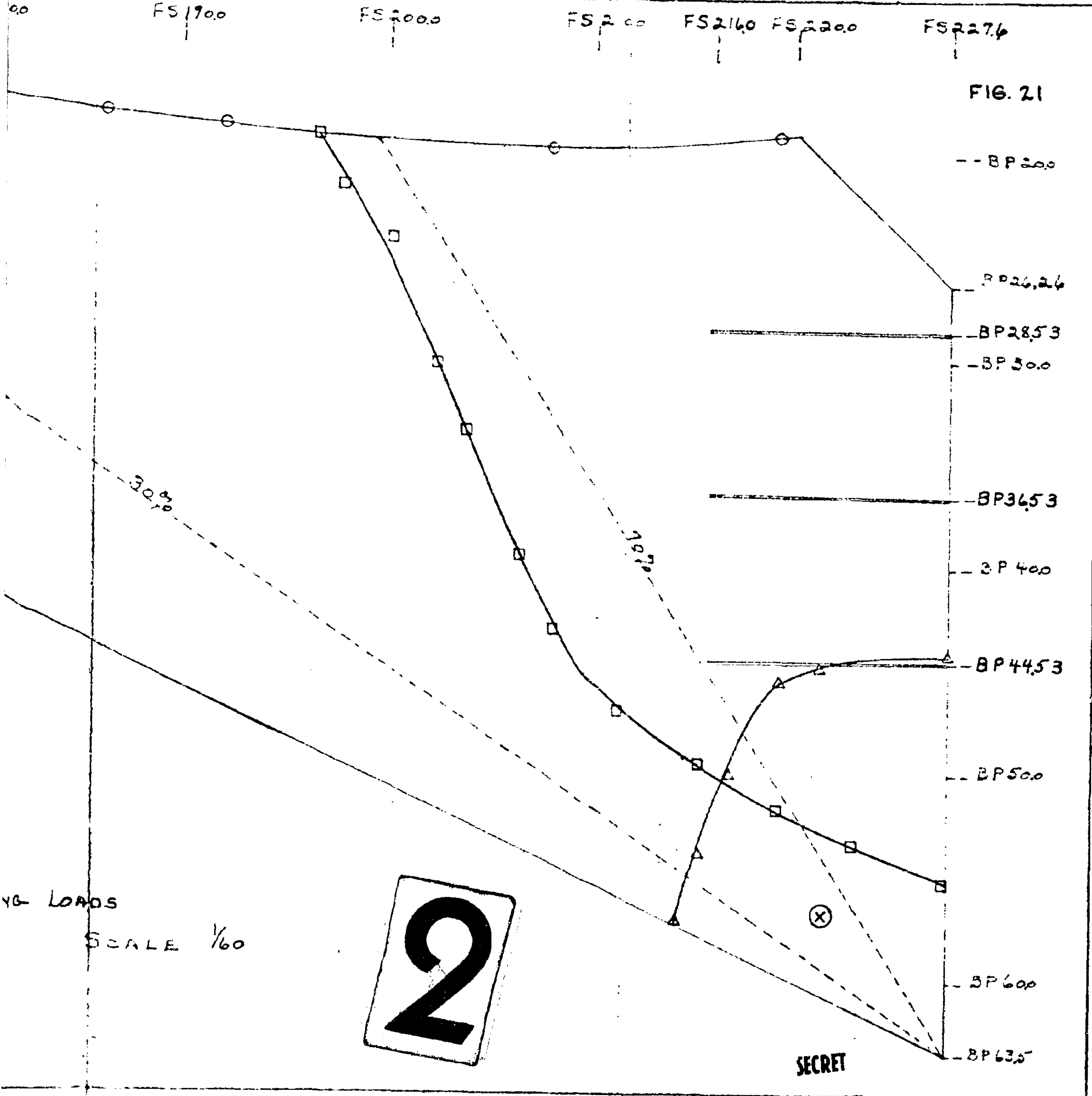
WING L.E. INTERSECTS A/P ℄ @ FS 92.6

1

SECRET

ED - 423

PREPARED BY V.L.S.	NORTH AMERICAN AVIATION, INC.	PAGE NO. 31 OF 63
CHECKED BY J.R.S.	SHAKE TEST RESULTS	NA-59-1736
DATE 5-22-59	.10 SCALE M_1 = 3.0 MODEL SERIES	MODEL NO. XB 70



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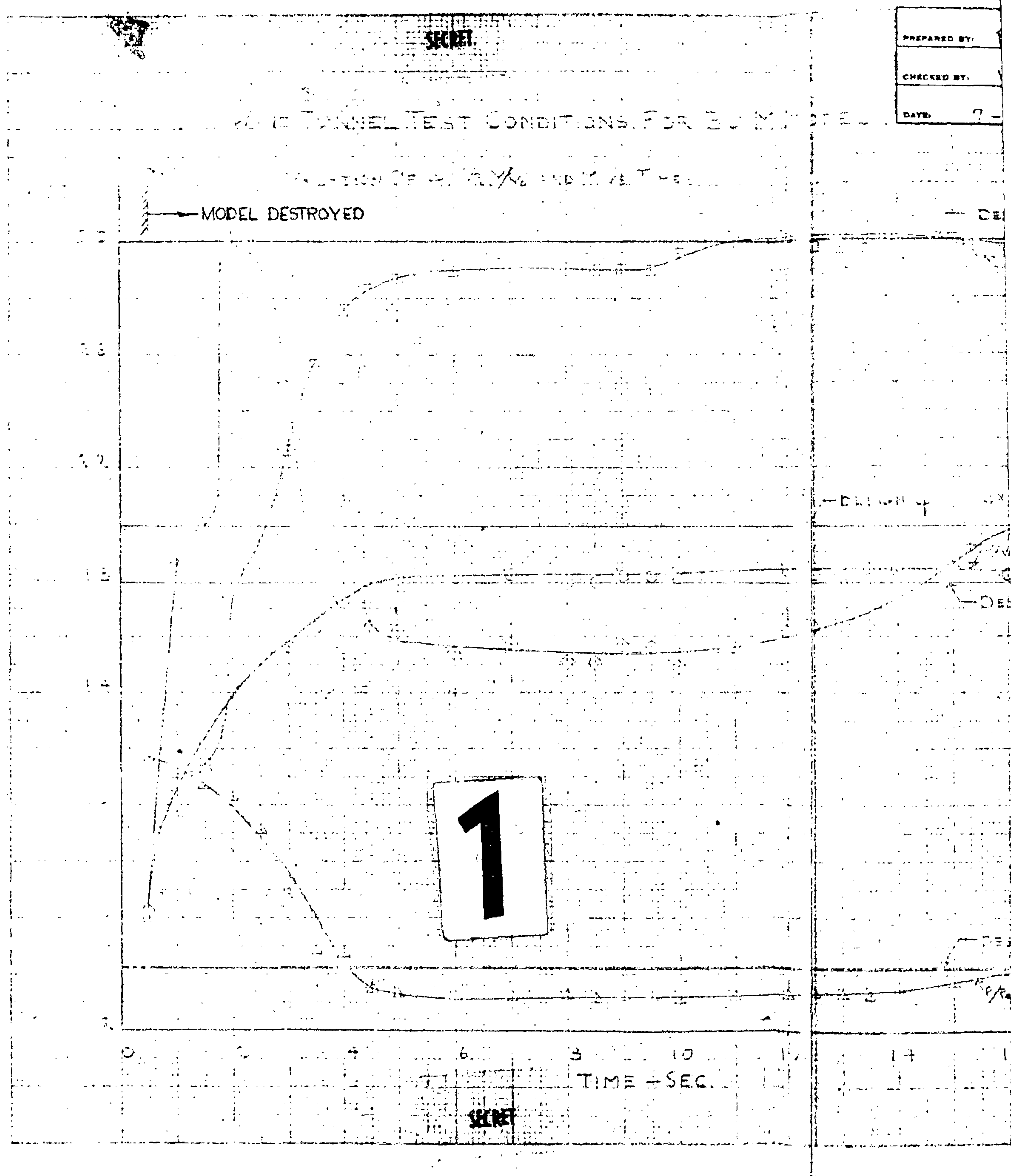
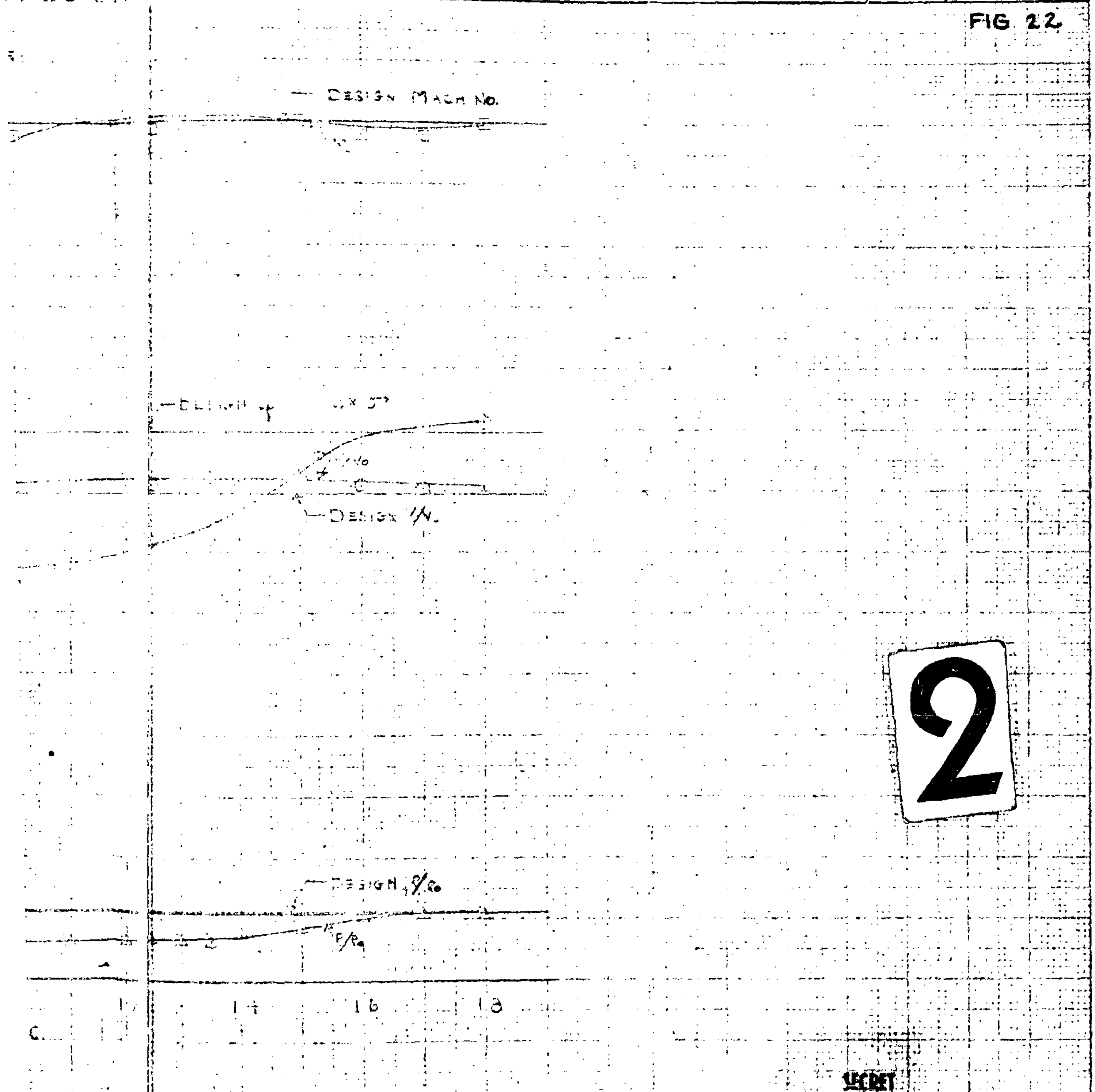

SECRET
PREPARED BY:
CHECKED BY:
DATE:
TUNNEL TEST CONDITIONS FOR
MODEL DESTROYED
0
2
4
6
8
10
14
TIME — SEC.
1
SECRET

PREPARED BY: BK	NORTH AMERICAN AVIATION, INC.	PAGE NO 32 OF 63
CHECKED: VLS	SERIES I SECRET	NA-59-1736 REPORT NO.
DATE: 7-30-58		MODEL NO. XB-70

FIG. 22



SECRET

.10 SCALE SUBSONIC WING

This low speed flutter model test was conducted to investigate the variation of flutter speed with the following parameters: stiffness about the 60% semi-span fold line; fuel loading; and tip deflection about the 60% semi-span fold line.

The solid styrofoam model of .1 geometric scale and .166 speed scale, was cantilever mounted in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel at sea level density. A shake test was conducted to determine natural frequencies and node lines of the first three modes prior to the actual flutter test.

The range of wing tip rotational stiffness levels tested had negligible effect on the flutter speed. A wing tip deflection of 50° and empty fuel loading gave the lowest flutter speed. In general flutter speed increased with increased fuel loading, increased rotational stiffness at the hinge, and decrease in tip deflection. In any configuration, the minimum flutter margin obtained was approximately 40%.

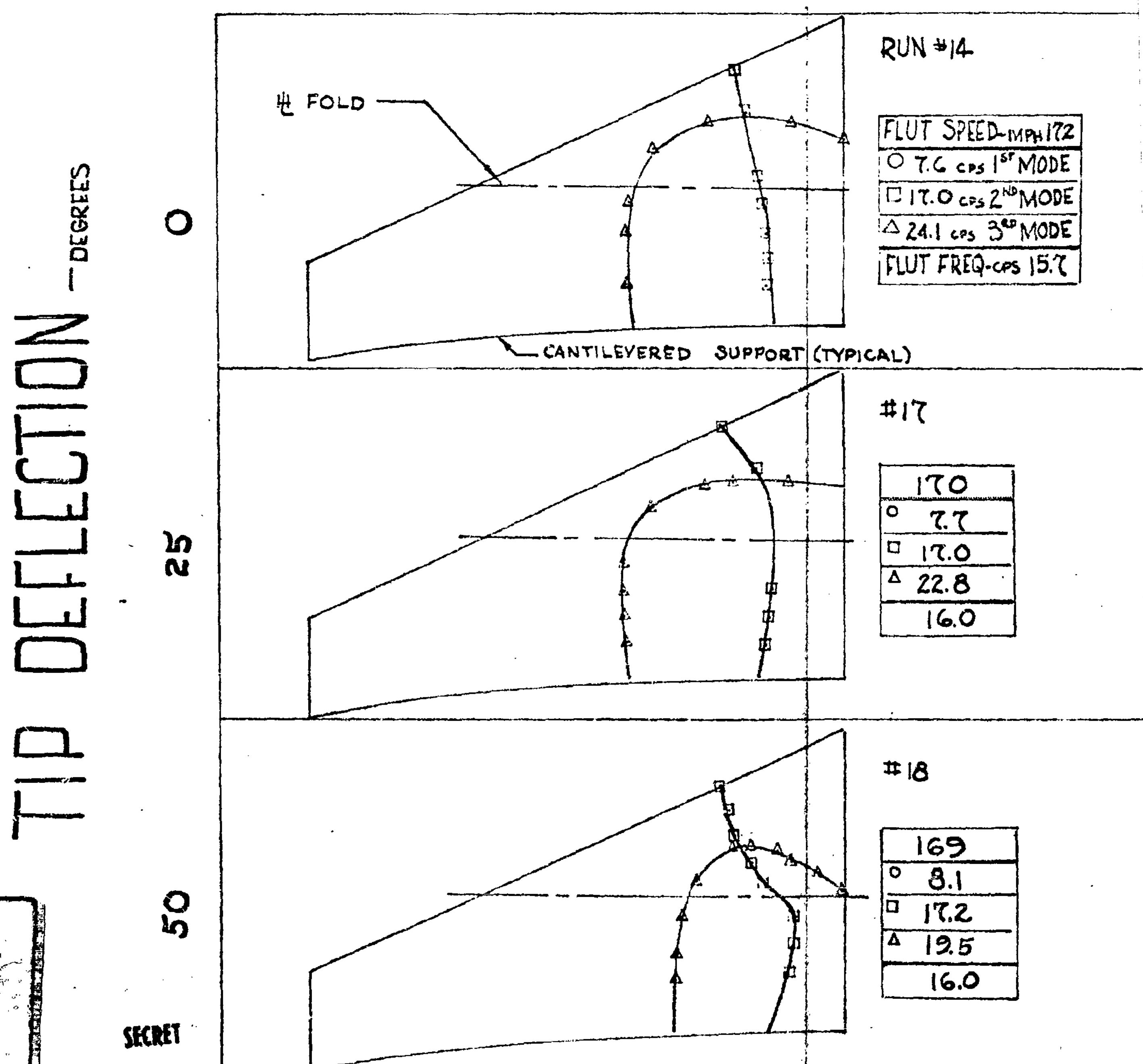
MODEL CHARACTERISTICS:

MATERIAL ________ SOLID STYROFOAM
SPEED SCALE ________ 1/6
ALTITUDE ________ SEA LEVEL
CONTROL SURFACE ________ STIFF

SECRET

✳ 100 % STIFFNESS EQUALS 74,140 IN-LB/RAD.

10 %



1

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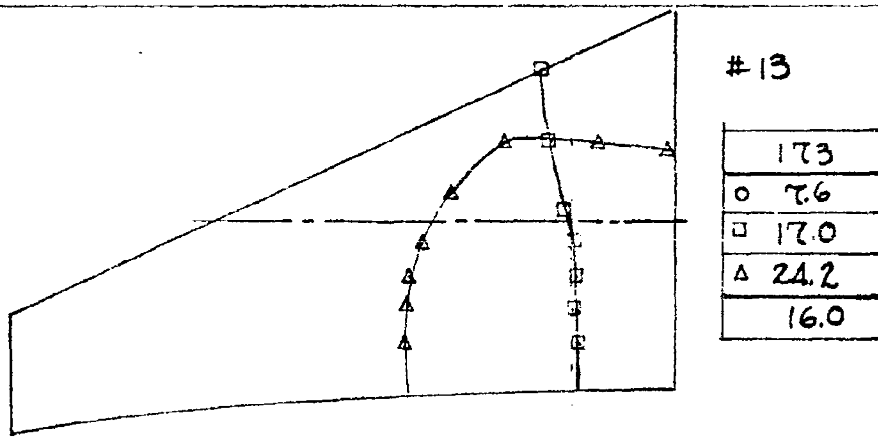
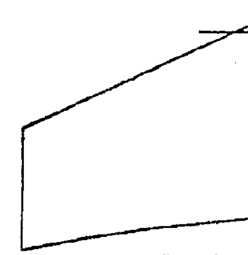
HINGE STIFFNESS

EMPTY FUEL LOADING

20%





2

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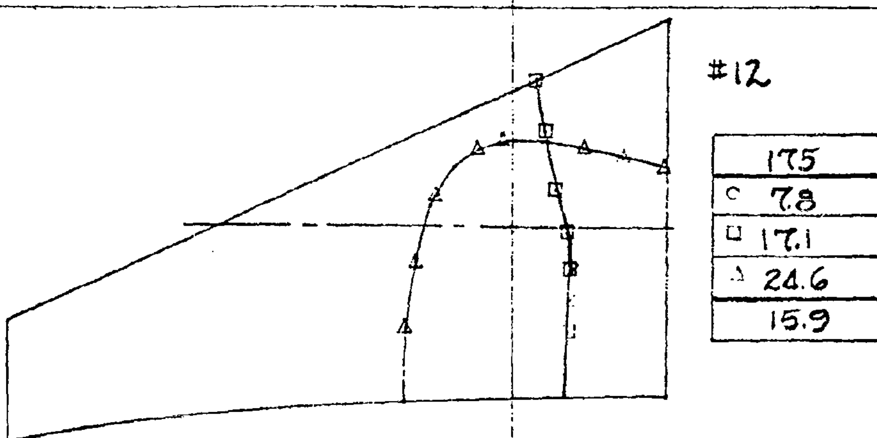
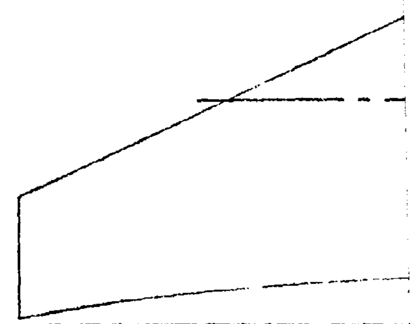
FLUTTER
1/10 SCALE
N

FFNFSS — PER CENT *

LOADING

40 %





3

R.W.D. NA-59-1736 34 63

AJE 44C

FLUTTER AND SHAKE TEST RESULTS XB-70

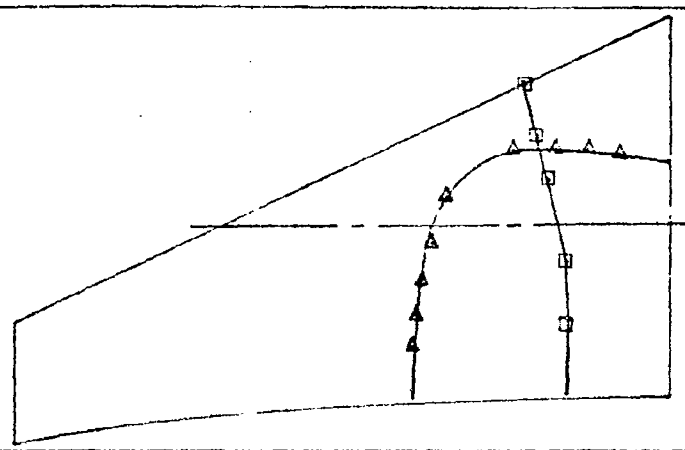
SCALE WING MODEL

NAAL TEST # 439 FIG 23

80 %

#12

175
○ 7.8
□ 17.1
△ 24.6
15.9



#11

175
○ 7.7
□ 17.1
△ 23.7
16.0

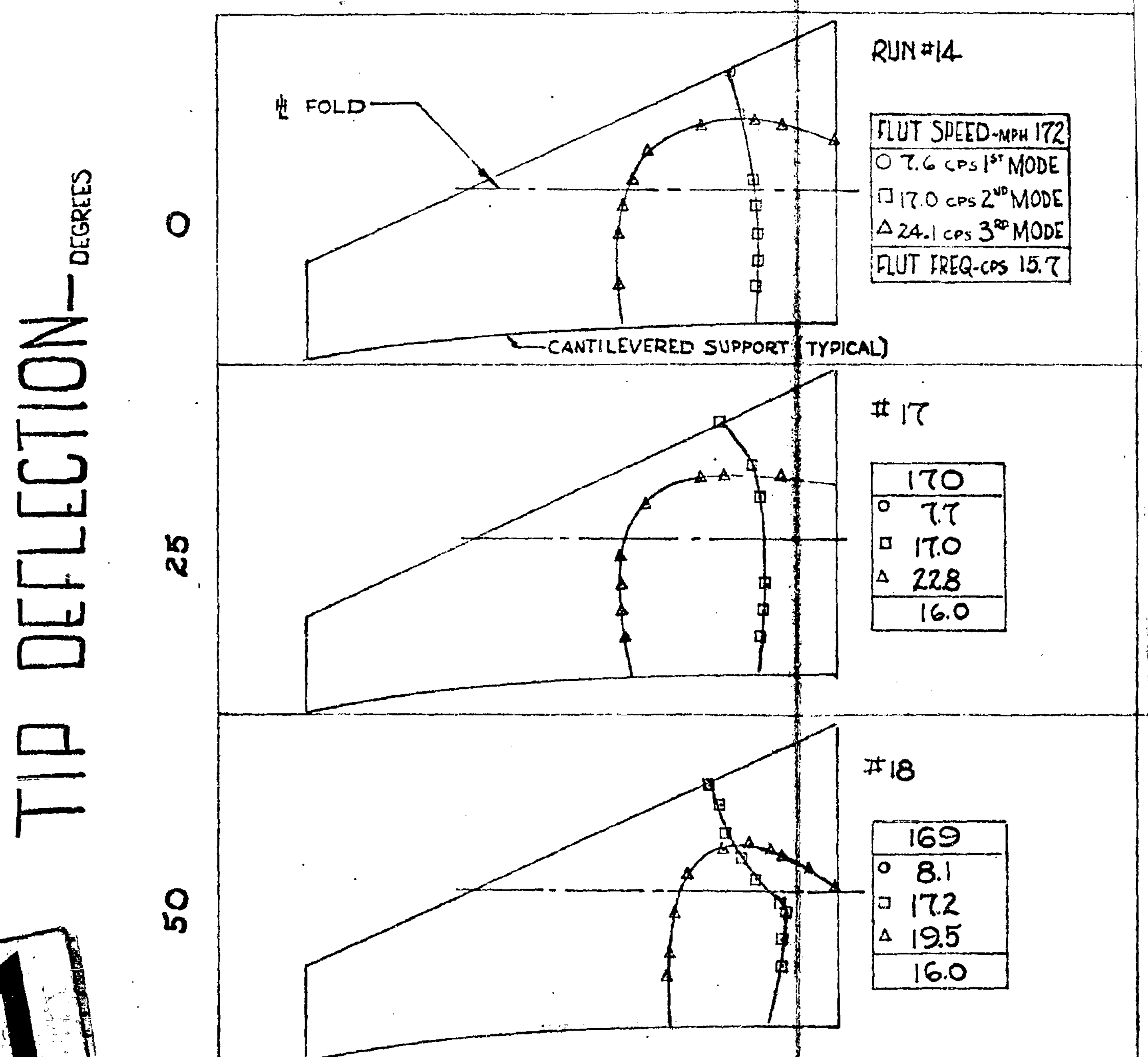
4

MODEL CHARACTERISTICS:

SECRET

MATERIAL	SOLID STYROFOAM
SPEED SCALE	1/6
ALTITUDE	SEA LEVEL
CONTROL SURFACE	STIFF
HINGE LINE STIFFNESS AT FOLD	7,414 IN-LB/RAD (10%)

EMPTY

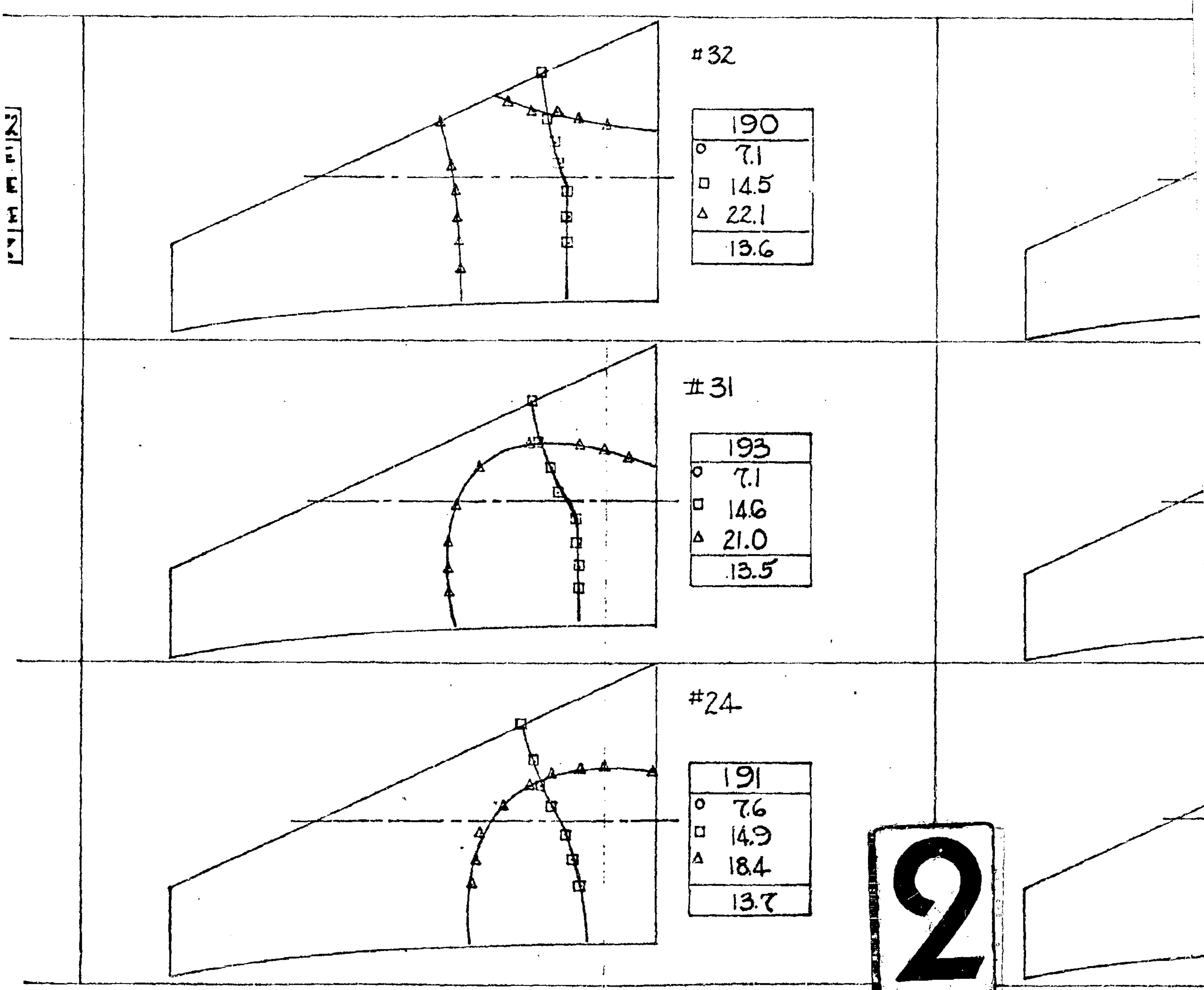


SECRET

1

FUEL LOADING

1/4 LEVEL



ADING

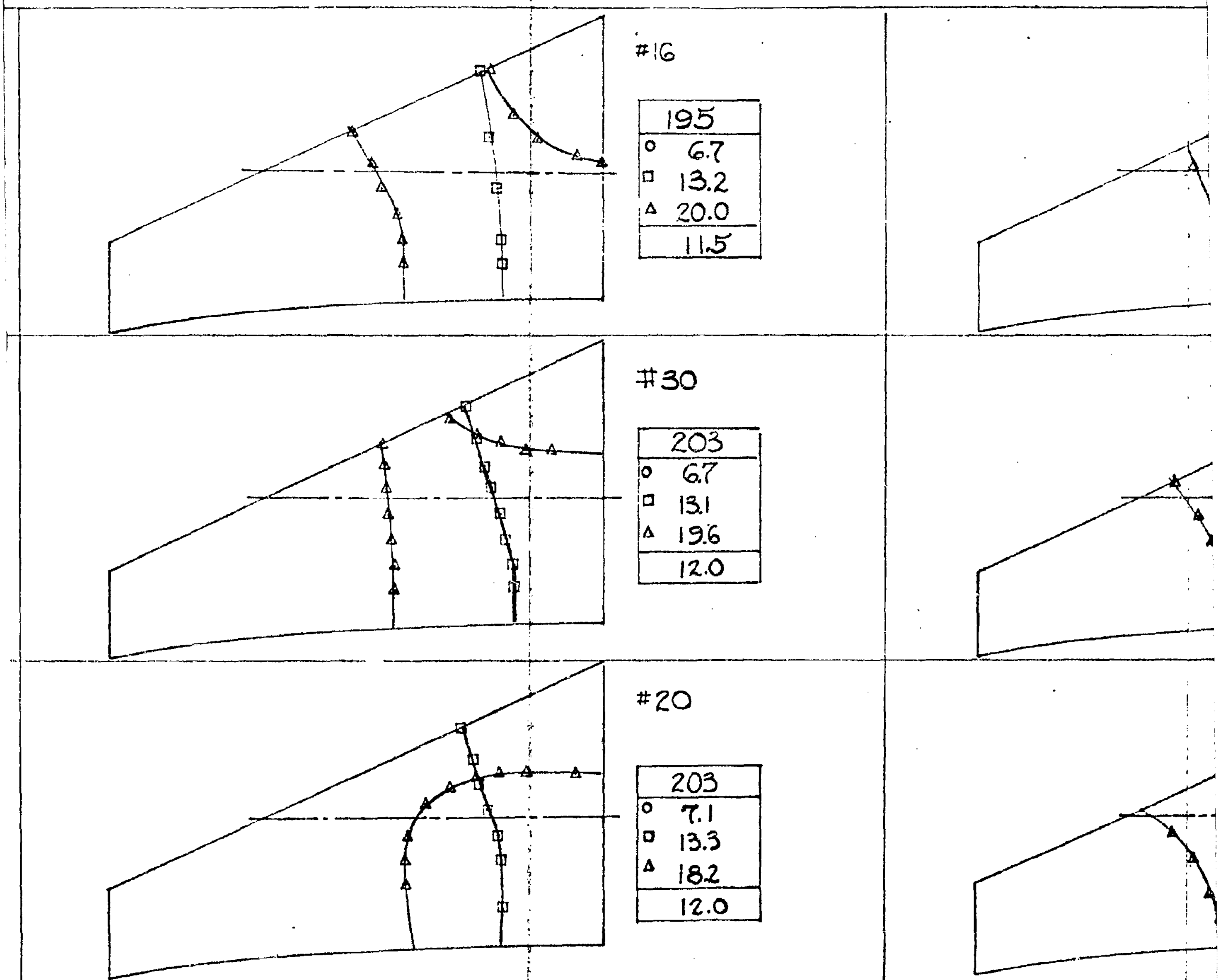
3

R.W.D.

AJE

FLU
1/10

½ LEVEL



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AJE

35 63
NA-59-1736

FLUTTER AND SHAKE TEST RESULTS

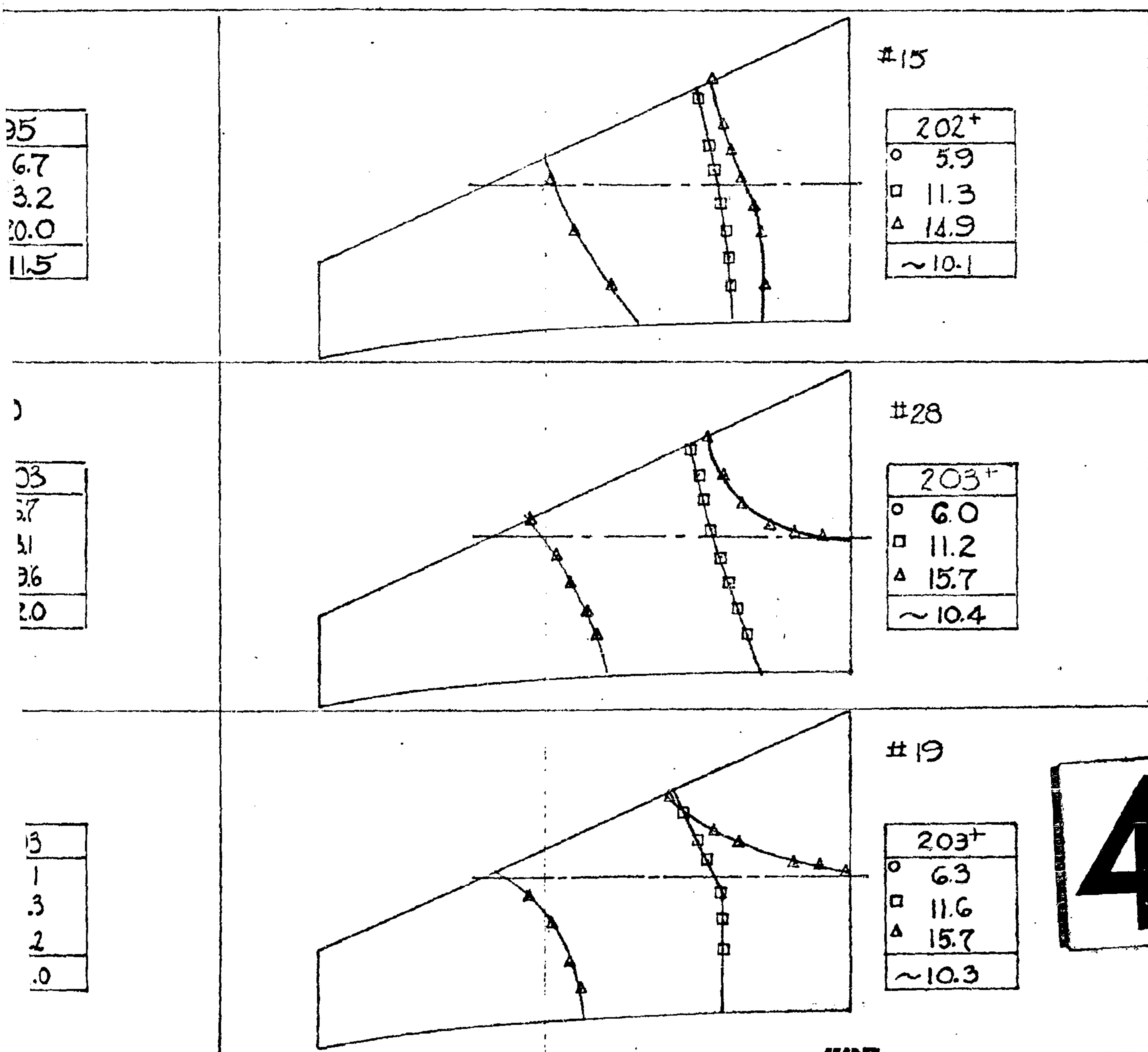
XB-70

1/10 SCALE WING MODEL

NAAL TEST #439

FIG 24

FULL

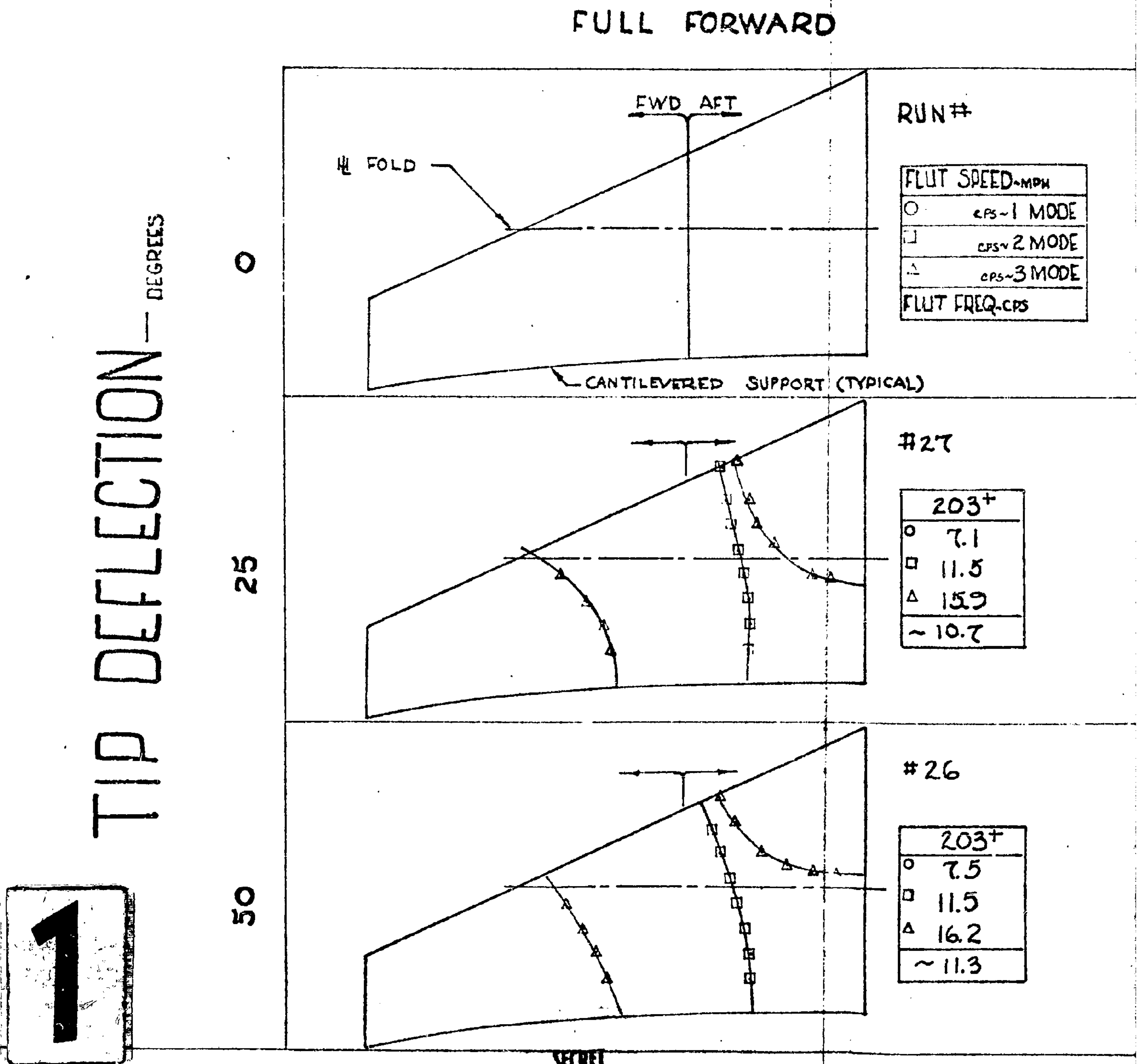


4

SECRET

MODEL CHARACTERISTICS:

MATERIAL ———— SOLID STYROFOAM
SPEED SCALE ———— 1/6
ALTITUDE ———— SEA LEVEL
CONTROL SURFACE ———— STIFF
HINGE LINE STIFF AT FOLD ———— 7,414 IN-LB/RAD (10%)

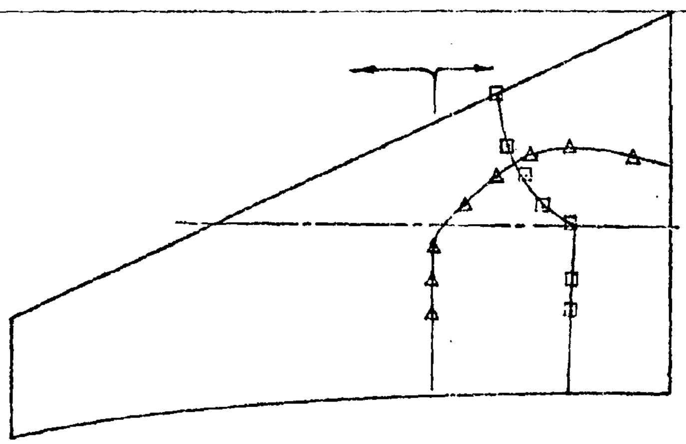


SECRET

2

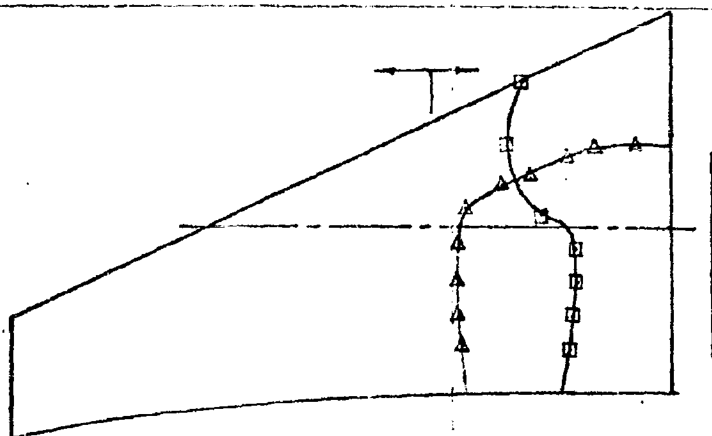
FULL AFT

TIP E



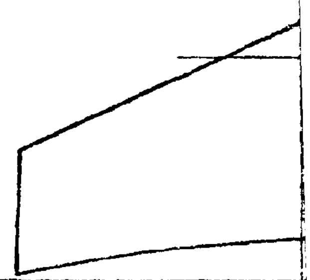
#29

	203
○	6.2
□	15.3
△	20.5
	14.1



#25

	203+
○	6.8
□	15.3
△	18.2
	~13.3

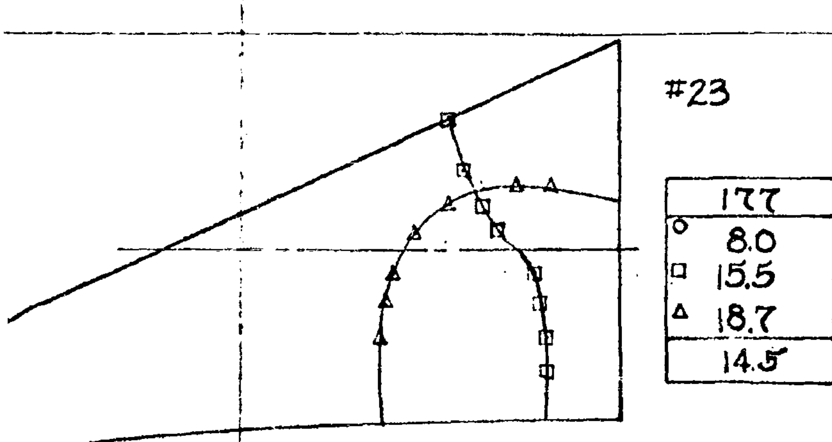


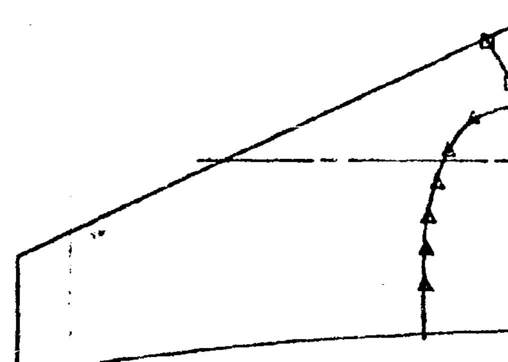
FUEL LOADING

TIP EMPTY INBOARD 1/4 LEVEL

TIP EMPTY INBO

3





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FLUTTER AND SHAKE T

1/10 SCALE WING

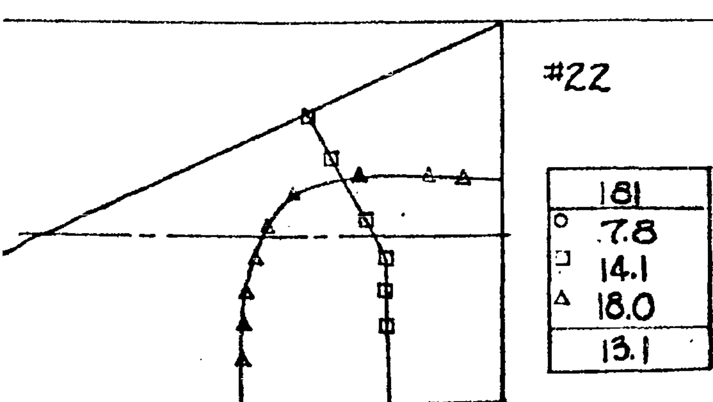
NAAL TEST #43

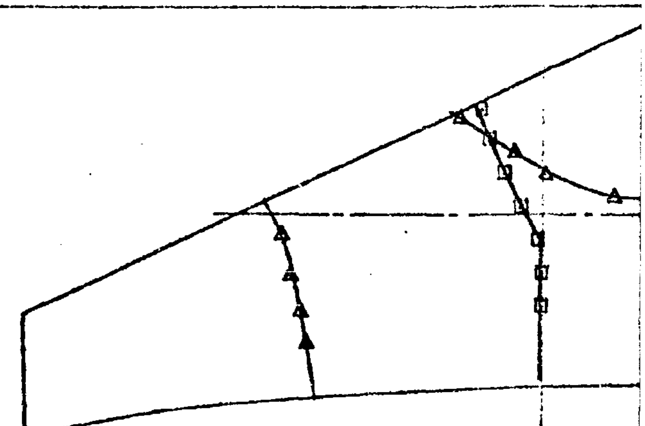
P EMPTY INBOARD 1/2 LEVEL

TIP EMPTY INBOARD

3

#22





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FLUTTER AND SHAKE TEST RESULTS

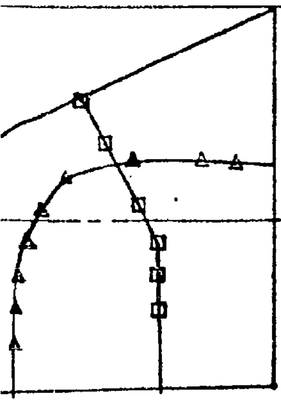
1/10 SCALE WING MODEL

NAAL TEST # 439

INBOARD 1/2 LEVEL

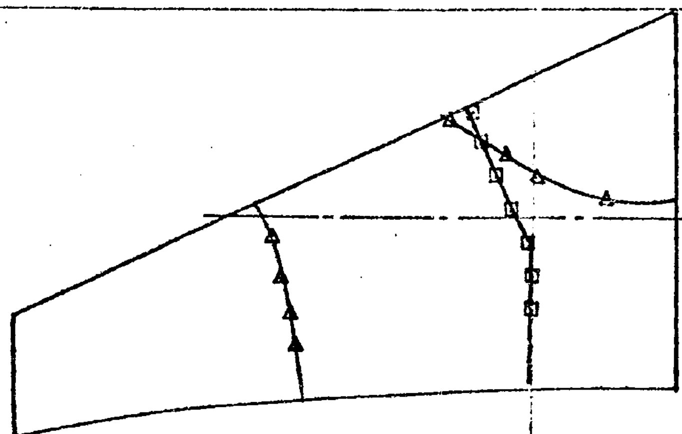
TIP EMPTY INBOARD FULL

4



#22

	181
○	7.8
□	14.1
△	18.0
	13.1



21

	200+
○	7.7
□	12.2
△	16.3
	~11.4

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36 63

NA-59-1736 -44C

FLUTTER AND SHAKE TEST RESULTS

1/10 SCALE WING MODEL

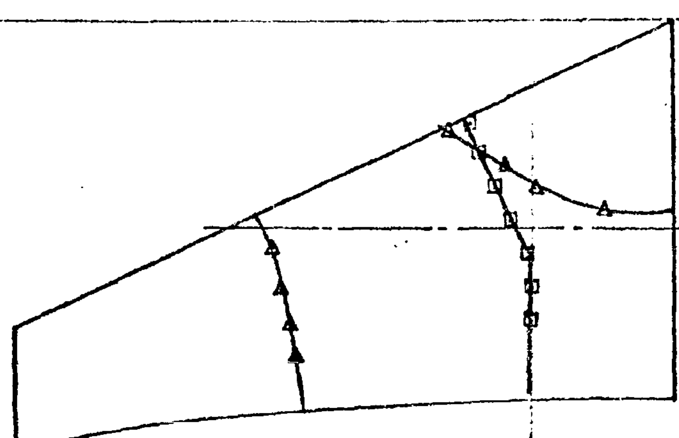
NAAL TEST # 439

X6-70

FIG 25

TIP EMPTY INBOARD FULL

5



21

200+
○ 7.7
□ 12.2
△ 16.3
~11.4

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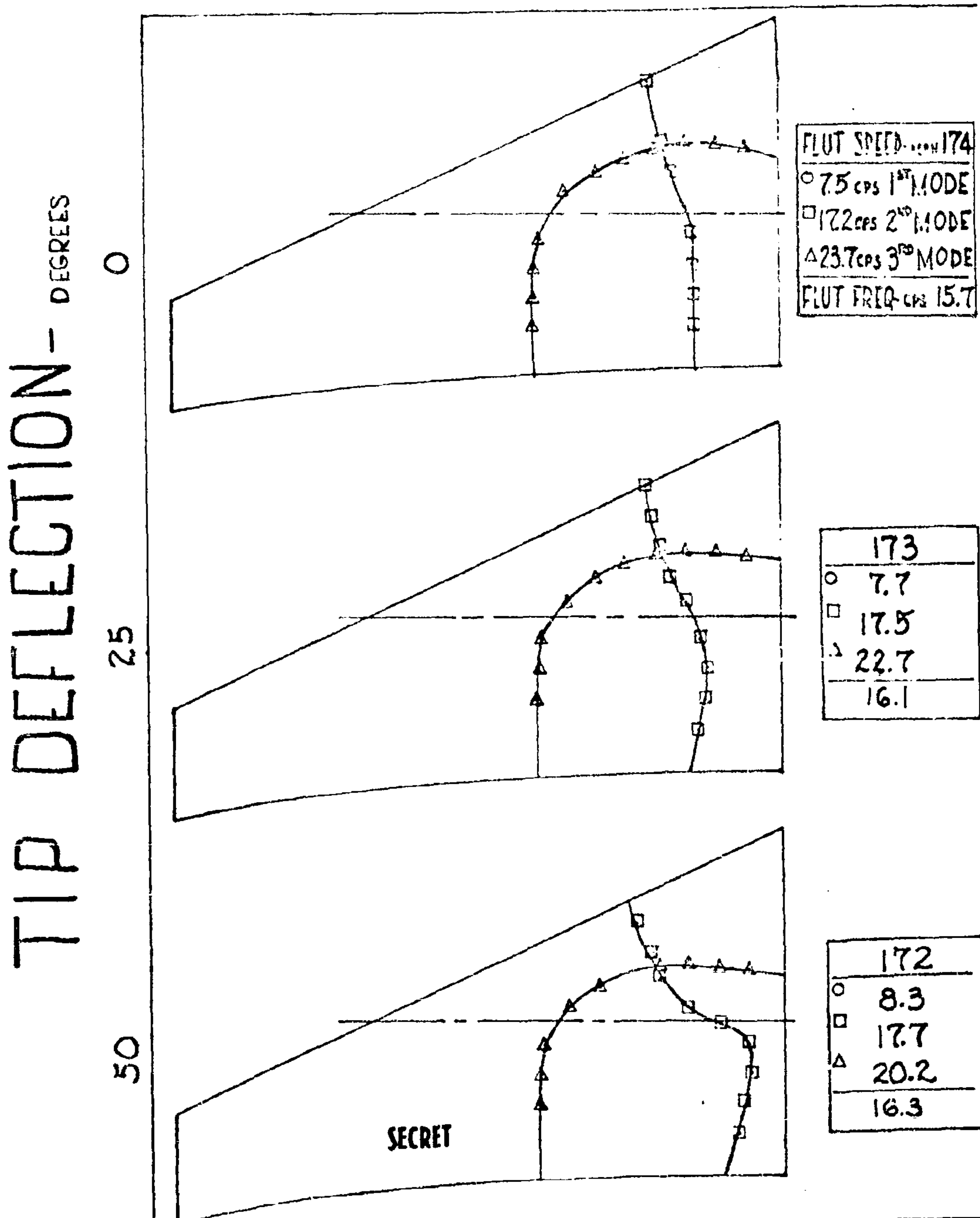
CHECKED BY: A J E	SECRET	NA-59-1736 REPORT NO
DATE:	FLUTTER AND SHAKE TEST RESULTS 1/15 SCALE WING MODEL	MODEL NO XB-70 -440

FIG 26

5° LEADING EDGE DROOP
FUEL LOADING
EMPTY



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B-70 WING NAAL TEST # 439 FIG 27

DEC. 9, 1958 TO DEC. 17, 1958

MODEL CHARACTERISTICS:

GEOMETRIC SCALE .1
SPEED SCALE .166
MATERIAL SOLID STYROFOAM

ALTITUDE S.L.
CONTROL SURFACE STIFF
SUPPORT CANT. FROM FLOOR

TABULAR SUMMARY FLUTTER TEST RESULTS

HINGE STIFFNESS	MODEL FLUTTER SPEED ~ M.P.H. LEVEL FUEL LOADING FULL	3/4	1/2	1/4	EMPTY	VARIED FUEL LOADING **FWD FULL	*AFT FULL	TIP DEFLECTN 0°	25°	50°	RUN NO.	OSCIL RECORD NO.	SHAKE TEST RESULTS ω_1 CPS	ω_2 CPS	ω_3 CPS	FLUT. FREQ. ω_4 CPS
80					175			✓			11	413 19 -	7.7	17.1	23.7	16.0
40					175			✓			12	1921	7.8	17.1	24.6	15.9
20					173			✓			13	1922 1923	7.6	17.0	24.2	16.0
10					172			✓			14	1924	7.6	17.0	24.1	15.7
10	>202							✓			15	1926	5.9	11.3	14.9	~10.1
10			195					✓			16	1927	6.7	13.2	20.0	11.5
10					170				✓		17	1928	7.7	17.0	22.8	16.0
10					169					✓	18	1929	8.1	17.2	19.5	16.0
10	>203									✓	19	1931	6.3	11.6	15.7	~10.3
10			203							✓	20	1932	7.1	13.3	18.2	12.0
10	INB'D >200				TIP >200					✓	21	1933	7.7	12.2	16.3	~11.4
10			INB'D 181		TIP 181					✓	22	1934	7.8	14.1	18.0	13.1
10				INB'D 177	TIP 177					✓	23	1936	8.0	15.5	18.7	14.5
10				191						✓	24	1937	7.6	14.9	18.4	13.7
10							>203			✓	25	1938	6.8	15.3	18.2	~13.3
10						>203				✓	26	1939	7.5	11.5	16.2	~11.3
10						>203			✓		27	1941	7.1	11.5	15.9	~10.7
10	>203								✓		28	1942	6.0	11.2	15.7	~10.4
10							203		✓		29	1943	6.2	15.3	20.5	14.1
10			203						✓		30	1944	6.7	13.1	19.6	12.0
10				193					✓		31	1945 1946	7.1	14.6	21.0	13.5
10				190				✓			32	1949	7.1	14.5	22.1	13.6
5° LEADING EDGE DROOP																
10					174			✓			33	2021	7.5	17.2	23.7	15.7
10					173	SECRET			✓		34	2022	7.7	17.5	22.7	16.1
10					172					✓	35	2023	8.3	17.7	20.2	16.3

* WTS #5, 6, 12, 13, 19, 20 & 25 ** WTS #1, 2, 3, 4, 9, 10, 11, 17, 18 & 24

.15 SCALE SUBSONIC VERTICAL TAIL

Various root support stiffness magnitudes and distributions were investigated using a .15 scale model of the canted hinge configuration of the vertical tail.

The model was constructed of 4.5lbs/ft^3 density solid styrofoam whose thickness at any point in the planform simulated full scale bending stiffness. The mass distribution of the model simulated full scale total mass at sea level conditions. In some sections near the root, the model was slightly overweight but the effects on flutter speed should be very small. The model was built to a .15 geometric scale and a .2 speed scale.

Lateral stiffness of the upper and lower hinges and the actuator point were simulated by small cantilevered beams. These springs were calibrated dynamically by attaching a known mass on the spring and recording the free vibration on an oscillograph to allow accurate determination of the spring constants. Root spring constants simulated were as follows:

LOCATION	MODEL SCALE ~LBS/IN			FULL SCALE ~ LBS/IN		
Upper Hinge	498.5	236.8	85.5	84,083	38,467	14,250
Lower Hinge	986	637.9		164,333	106,317	
Actuator	63.1	19.9		10,517	3,317	

Prior to the actual flutter test of each configuration, a shake test was conducted to determine natural frequencies and node lines of the first three modes. The flutter tests were conducted in the WSC 7 3/4 x 11 foot,low speed,atmospheric wind tunnel at sea level density.

The flutter tests showed that actuator stiffness is relatively unimportant. Decreasing the actuator stiffness improved bending-torsion frequency ratios slightly resulting in a small increase in flutter speed . It further showed that the largest increments in flutter speed were obtained by increasing the stiffness of the upper hinge point. In all configurations tested but one, the flutter frequency fell between the zero air speed frequencies for second bending and first torsion.

PREPARED BY:	R.
CHECKED BY:	J.
DATE:	12-

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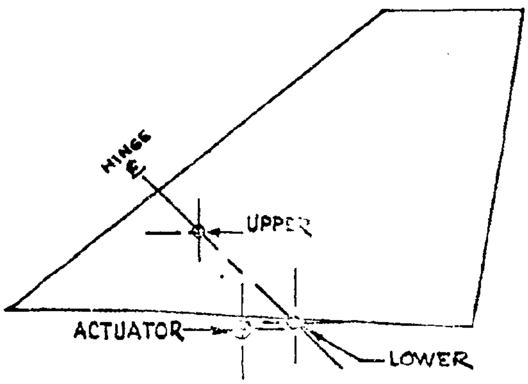
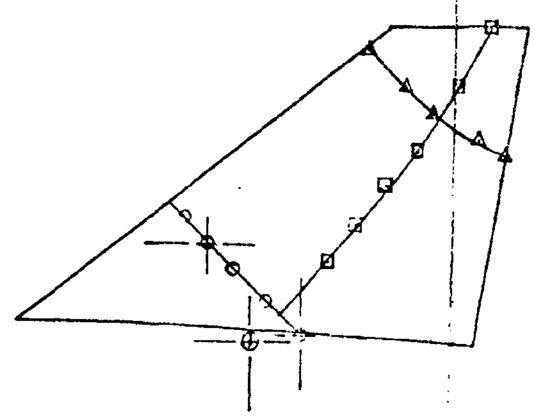


UPPER	LOWER	ACTUATOR
STIFFNESS		
FLUTTER SPEED-MPH		
○ 1ST BENDING ~CPS		
△ 2ND BENDING ~CPS		
□ 1ST TORSION ~CPS		
FLUTTER FREQ-CPS		

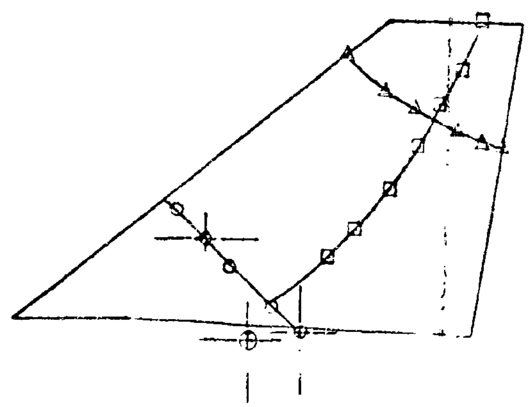
SPRING CONSTANT ~ K- LB/IN		
UPPER	LOWER	ACTUATOR
236.8	986	63.1
85.5	637.9	19.9



U STIFF	L STIFF	A STIFF
	165.5	
	3.6	
	24.3	
	34.0	
	25.0	

MODEL CHARACTERISTICS:

GEOMETRIC SCALE .... .15
MATERIAL .... SOLID STYROFOAM
SPEED SCALE .... .20
ALTITUDE .... SEA LEVEL
HINGE STIFFNESS .... VARIES
SUPPORT .... HINGES



U STIFF	L FLEX	A FLEX
	166.5	
	2.0	
	23.7	
	33.1	
	25.0	

1

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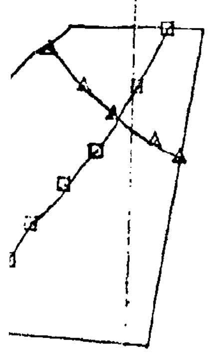
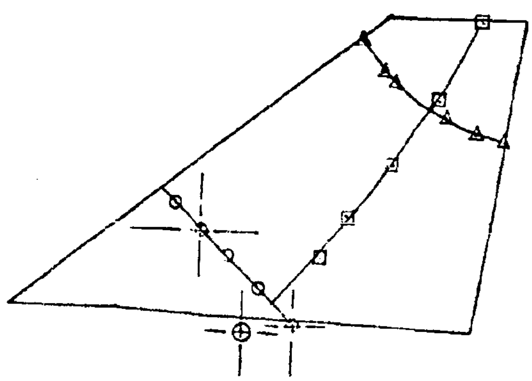
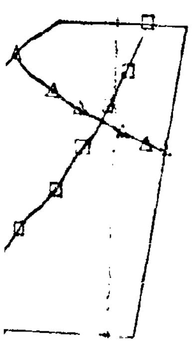
FIG 28



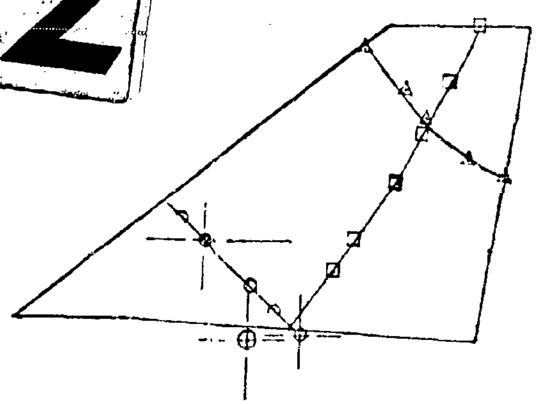
U STIFF	L STIFF	A STIFF
	165.5	
	3.6	
	24.3	
	34.0	
	25.0	



U STIFF	L FLEX	A STIFF
	165	
	3.6	
	24.2	
	33.2	
	24.5	



U STIFF	L FLEX	A FLEX
	166.5	
	2.0	
	23.7	
	33.1	
	25.0	



U FLEX	L FLEX	A FLEX
	133	
	2.0	
	23.7	
	26.1	
	21.9	

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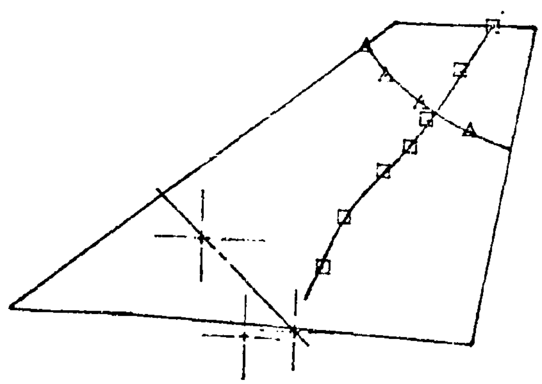
FIG 29

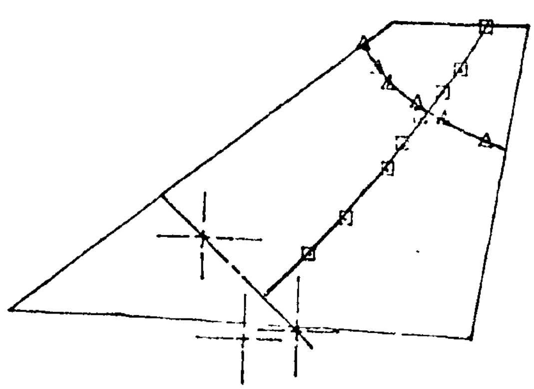
MODEL CHARACTERISTICS:

GEOMETRIC SCALE ______ .15
MATERIAL ______ SOLID STYROFOAM
SPEED SCALE ______ .20
ALTITUDE ______ SEA LEVEL
HINGE STIFFNESS ______ VARIES
SUPPORT ______ HINGES

SPRING CONSTANT ~ K- LB/IN		
UPPER	LOWER	ACTUATOR
236.8	986	63.1
85.5	637.9	19.9
498.5		



U EXTRA STIFF	L STIFF	A STIFF
179		
3.7 24.7 36.1		



U EXTRA STIFF	L FLEX	A STIFF
178		
3.7 24.7 35.7		
25.3		

.06 SCALE STIFF WING WITH FLEXIBLE ELEVONS AND .20 SCALE STIFF CANARD WITH FLEXIBLE FLAPS

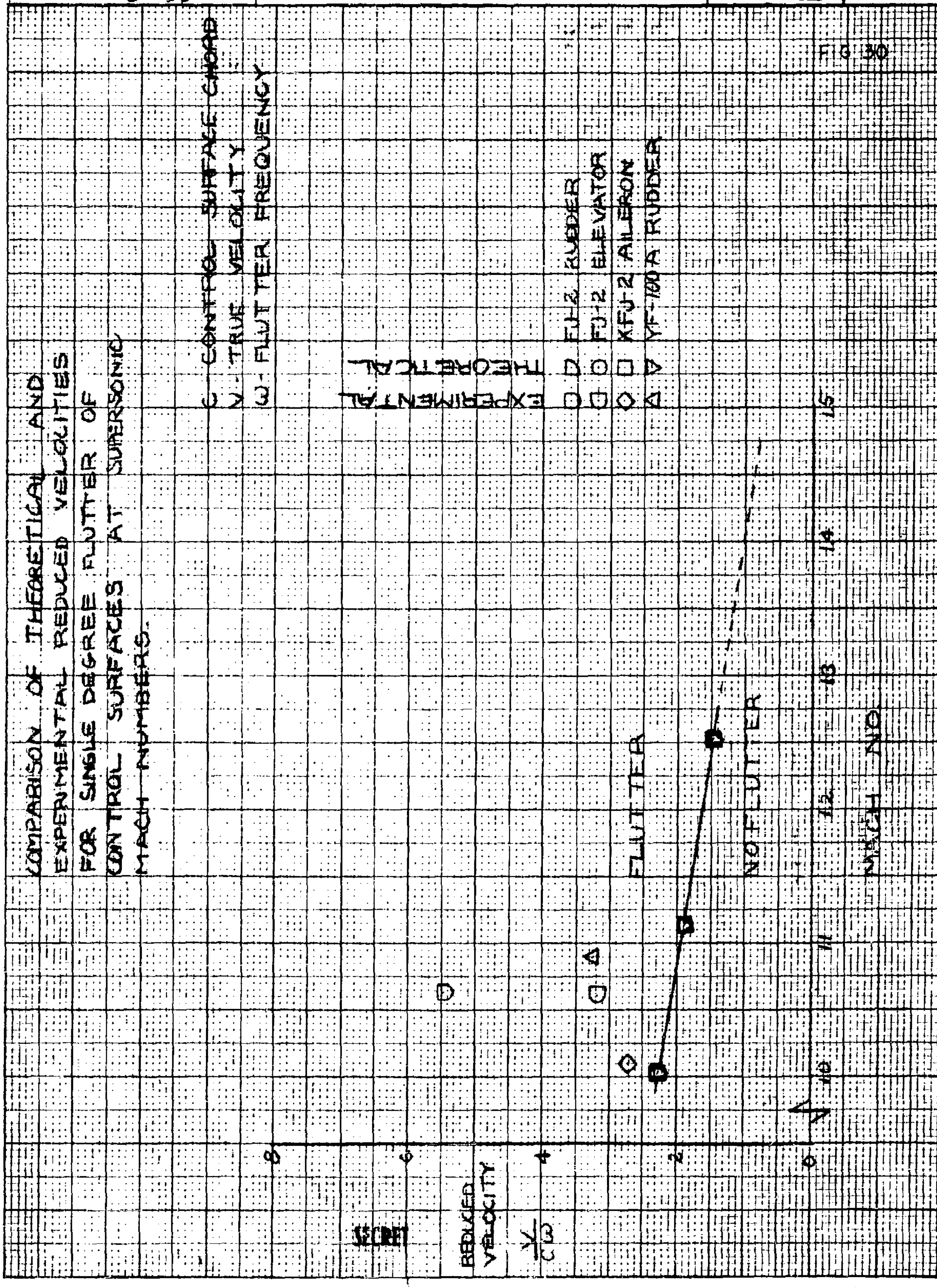
The purpose of these models was to check required elevon and flap rotational frequencies to prevent single-degree control surface rotational flutter at low supersonic speeds. The tests were conducted in TWT on 2 February 1959 through 4 February 1959 for 48.2 test hours for the elevons and on 4 February 1959 through 8 February 1959 for 34.0 test hours for the flaps.

On the basis of two-dimensional supersonic linearized oscillatory aerodynamic theory it can be shown that singe-degree supersonic control surface rotation flutter is independent of the percent chord location of the hinge line. This leads to a theoretical flutter boundary in a plot of $\frac{V}{c\omega}$ versus Mach number which is applicable to all hinged control surfaces in two-dimensional linearized flow. Figure 30 shows this boundary and some experimental flutter points obtained in flight tests. Since the theory indicates that instability occurs when the flutter frequency is below a certain critical value (depending somewhat on the Mach number) it can be seen that this type of flutter becomes more critical as the altitude is increased as a result of decreased flutter frequencies due to decreased aerodynamic stiffness.

Test conditions were selected in accordance with the theoretical predictions in that the control surface mass ratio was chosen so that the tunnel density range corresponded to an area in the flight envelope extending downward from the upper boundary over the range of Mach numbers from 1.0 to 1.5 and hinge flexures were tuned to provide several rotational frequencies ranging downward from the theoretical requirement. Conditions covered are shown in Figures 31 and 32.

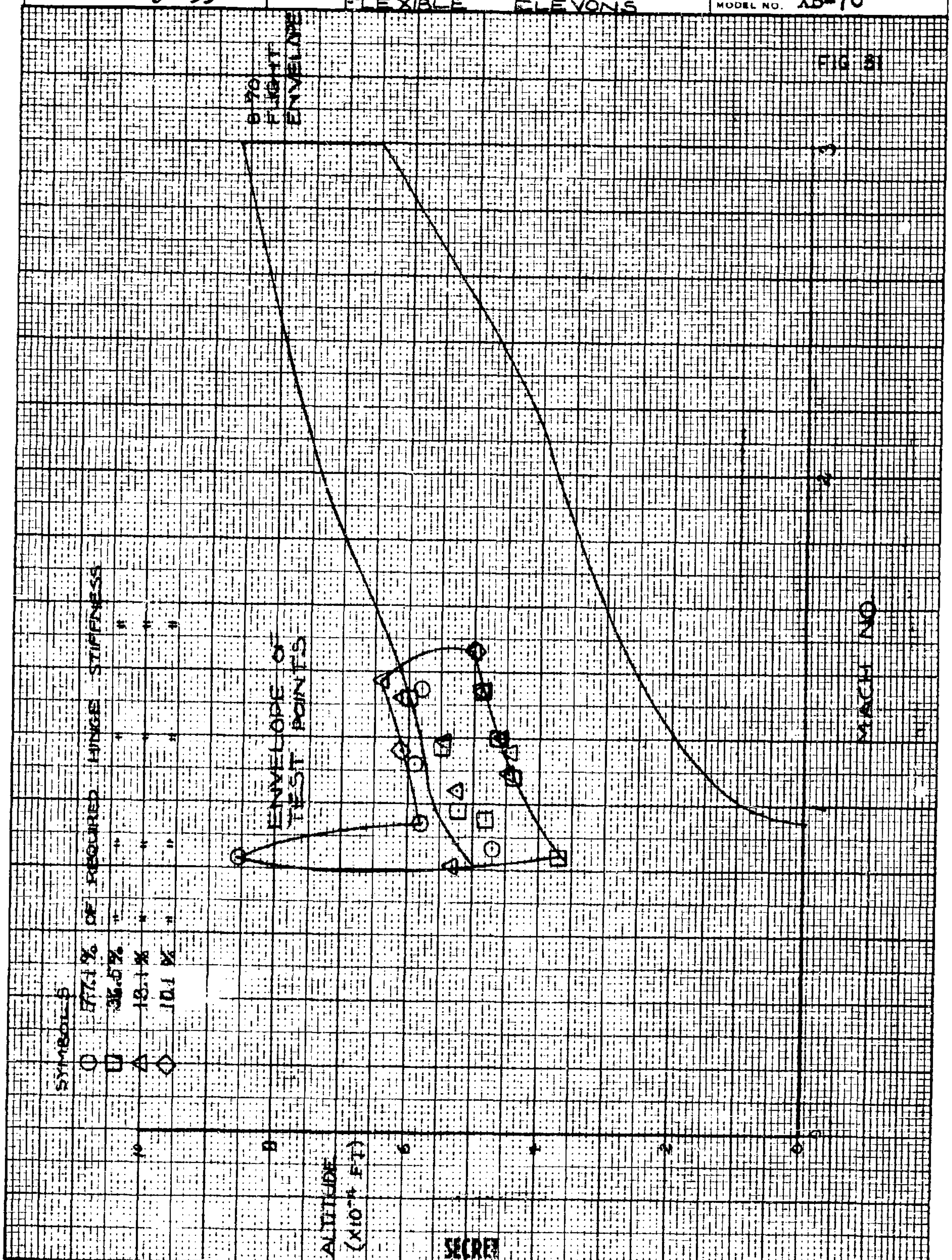
Flutter was not obtained for any stiffness value tested even though the most flexible configuration should have had a flutter frequency approximately equal to 40% of the theoretically required value for neutral stability on the basis of a detailed flutter analysis for the elevons, and an even lower percentage for the flaps. These results are not considered conclusive in view of the instabilities obtained in actual flight tests of earlier airplanes. This discrepancy between model and full scale test results may be due to relatively low model Reynolds numbers, shocks reflected from the porous walls of the test section or even to the possibility that the full scale phenomenon may have been transonic buzz dependent on shock and boundary layer conditions. Regardless of the explanation, B-70 elevons and flaps will continue to be designed to the theoretically required stiffness since no weight penalty is involved for reasonable configurations and a fairly high level of stiffness is required to prevent coupled flutter involving the control surfaces.

PREPARED BY HKA	NORTH AMERICAN AVIATION, INC	PAGE NO. 44 OF 63
CHECKED BY J.R.S.	SECRET	REPORT NO. NA-59-1736
DATE 11-30-59		MODEL NO. XB-70



FORM 1002-X (FORMERLY ED147)

PREPARED BY HKA	NORTH AMERICAN AVIATION, INC.	PAGE NO. 45 OF 63
CHECKED BY J.R.S.	SECRET .06 SCALE STIFF WING WITH	NA-59-1736 REPORT NO
DATE 11-30-59	FLEXIBLE ELEVONS	MODEL NO. XB-70



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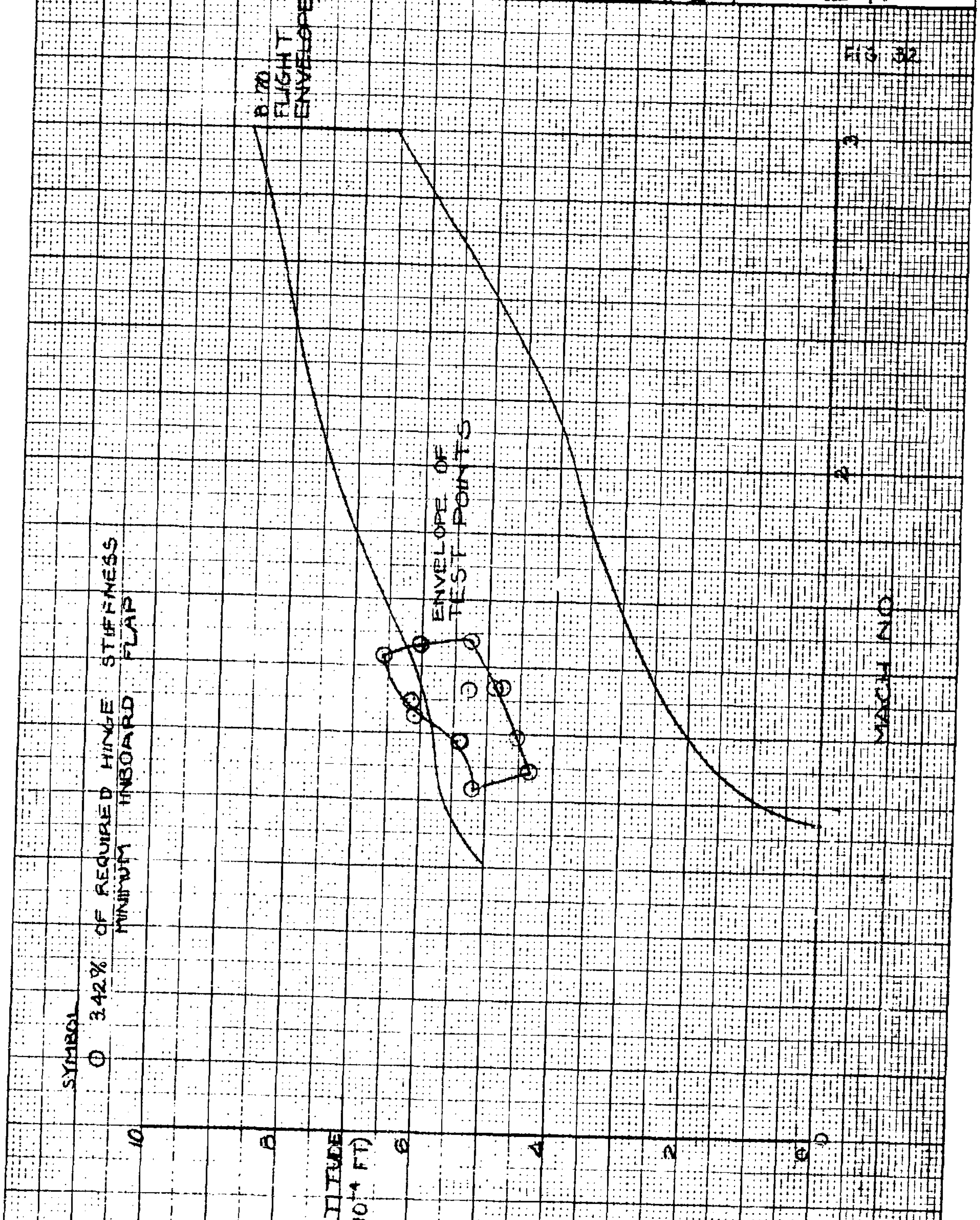
FORM 1002-X (FORMERLY ED14?)

NORTH AMERICAN AVIATION, INC.

SECRET

PREPARED BY HKA	.20 SCALE STIFF CANARD WITH FLEXIBLE FLAPS	PAGE NO. 48 OF 63	
CHECKED BY J.R.S.		REPORT NO. NA-59-1736	
DATE 11-30-59		MODEL NO. XB-70	



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CHECKED BY:	
DATE:	11/2

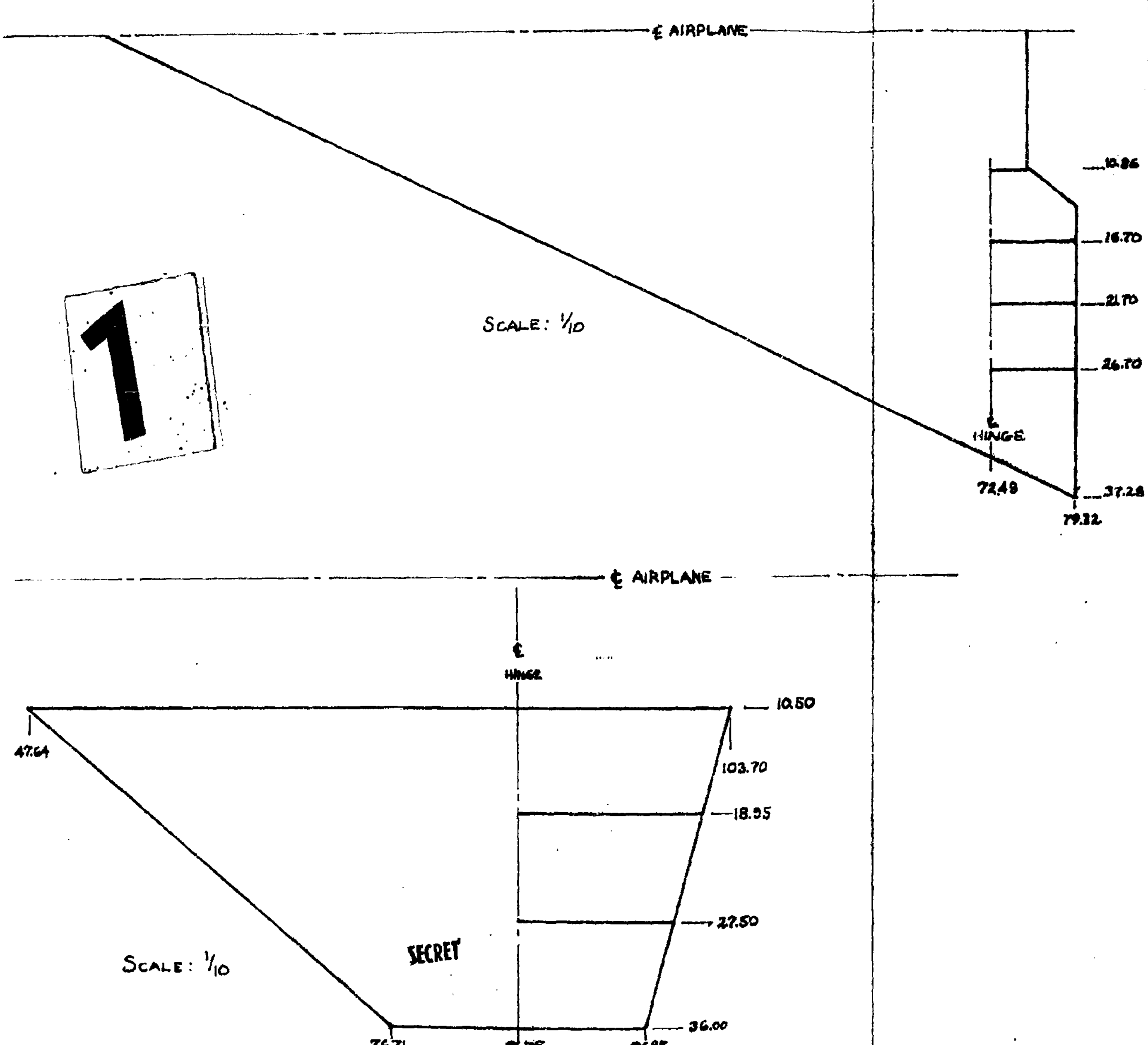

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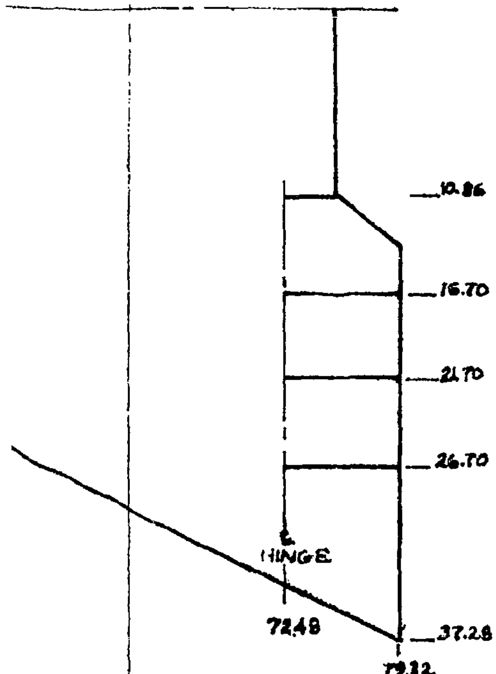
FIG. 33

SUMMARY OF MODEL DATA

.06 WING WITH FLEXIBLE ELEVONS
.20 CANARD WITH FLEXIBLE FLAPS



ELEVONS

LOCATION	INERTIA ABOUT ℄ LB-IN-SEC²		ZERO AIRSPEED ROTATION FREQ. CPS			
	MODEL	REQ'D	STIFF	MED	FLEX	REQ'D
INBOARD	.00943	.00926	206	139	84	267
CENTER	.01236	.01245	205	145	84	267
OUTBOARD	.01202	.01245	200	136	85	267

150

2

FLAPS

LOCATION	INERTIA ABOUT ℄ LB-IN-SEC²		ZERO AIRSPEED ROTATION FREQ CPS	
	MODEL	REQ'D	FLEX	REQ'D
INBOARD	.584	.513	26	115.0
CENTER	.496	.320	30	135.4
OUTBOARD	.289	.292	37	161.2

COMPLETE MODEL TEST

Flutter trends were established by means of thirteen runs of the B-70 complete airplane configuration with variations in fuel loading and tip deflection about the 79% semi-span fold line.

The model was constructed of styrofoam and isowood. The wings were made of solid styrofoam with the thickness at any point in the planform scaled to simulate full scale bending stiffness. The fuselage was constructed of styrofoam and isowood; isowood was used as a stiffener in areas where styrofoam alone would become to thick to maintain the goemetric shape. The vertical tail did not simulate stiffness but was of the correct geometric shape. The complete airplane model was constructed to a .06 geometric scale and a 1/6 speed scale.

These tests were conducted in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel at sea level density.

A shake test was conducted to determine natural frequencies and node line locations of the first four or five symmetric and anti-symmetric modes before flutter testing the configurations. Due to the static divergence tendency induced by the suspension system, the horizontal stabilizer was removed and replaced with an equivalent weight. In cases where flutter was obtained, the flutter frequency fell near the zero air speed frequencies for fuselage vertical bending or wing bending indicating the importance of these modes in determing the flutter speeds.

These tests were conducted on the -44C configuration. Subsequent to these tests the -70A configuration has evolved with a shortened and stiffer forward fuselage.

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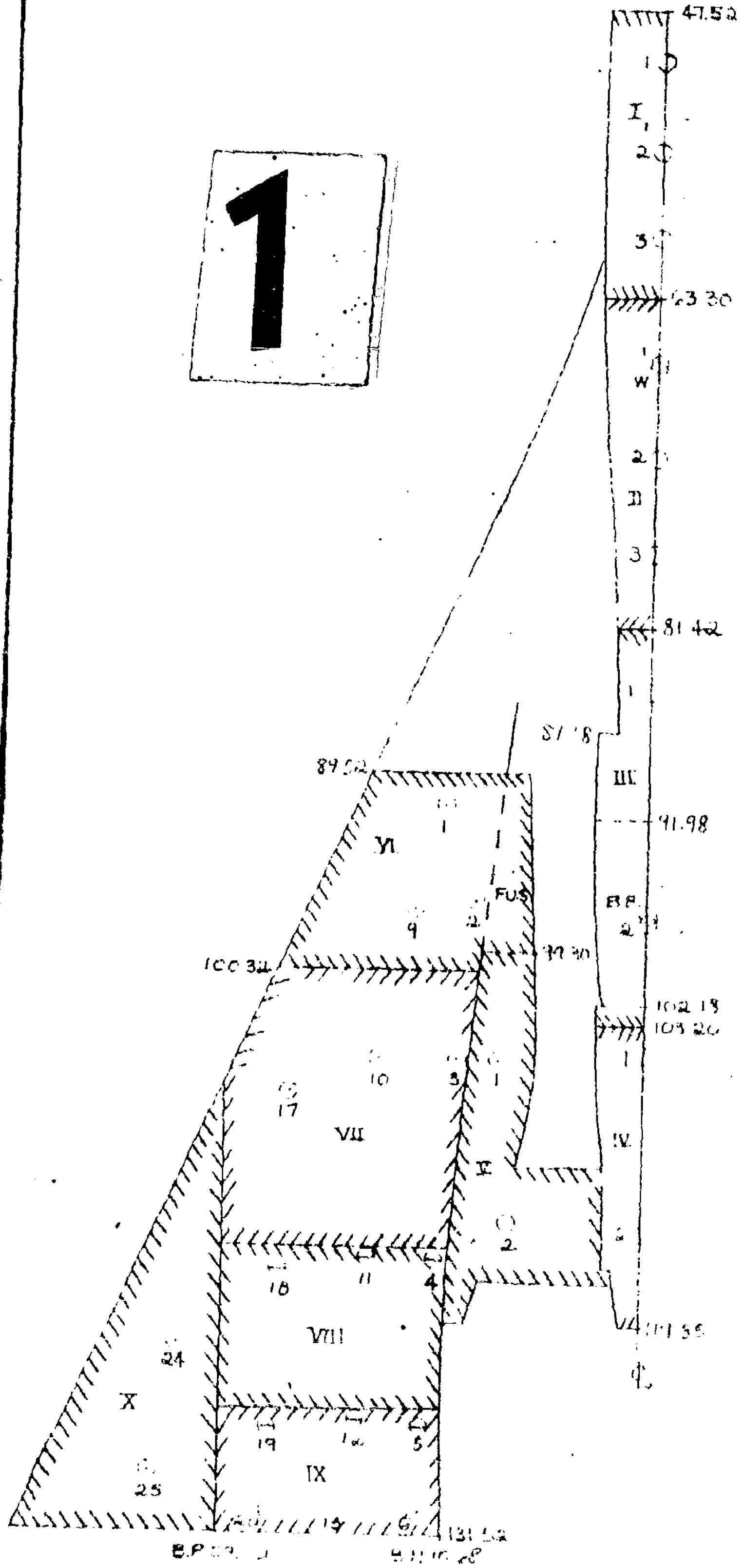
PREPARED BY:
CHECKED BY:
DATE 5-13

1



FULL SCALE		MODEL SCALE						
WEIGHT LBS.	C.G. OF AIR VEHICLE INS.	ORDER OF SEQ'NCE	TANK NO.	WEIGHT NO.	AMOUNT OF BALLAST REM'D.	BALLAST C.G. F.S. INS.	BALLAST C.G. B.P. INS.	WEIGHT LBS.
536,810.3	1602.5	← FULL CONDITION →						115.95
			X	24	ALL	121.188	25.500	
527,430.3	1593.9	A		25	ALL	128.142	26.754	113.92
510,431.6	[illegible]	B	I	1	ALL	50.244	–	110.25
			VI	FUS.	ALL	94.866	7.380	
				1	ALL	91.152	11.058	
				2	ALL	96.510	9.366	
474,385.6	1621.7	C		9	ALL	96.888	12.648	102.47
			VII	3	ALL	105.270	10.236	
				10	ALL	105.210	14.550	
				17	ALL	107.100	19.440	
				4	½	116.364	11.298	
				11	½	116.190	15.018	
438,000.3	1604.2	D		18	½	116.844	19.944	94.61
421,001.6	1631.9	E	I	2	ALL	55.032	–	90.94
			VIII	4	½	116.364	11.298	
				11	½	116.190	15.018	
				18	½	116.844	19.144	
				5	½	125.556	11.874	
				12	½	125.100	15.360	
395,717.4	1608.3	F		19	½	125.670	20.130	85.48

ARMAMENT TO BE DROPPED AT PILOT'S

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PREPARED BY: AJE	NORTH AMERICAN AVIATION, INC.	PAGE NO. 49 OF 63
CHECKED BY: V.L.C.	ORDER OF FUEL SEQUENCING	NA-59-1736 -44C
DATE 5-13-59	.06 NAAL COMPLETE MODEL (REVISION OF DATA RELEASED 2-5-59)	MODEL NO. XB-70

MODEL SCALE							FULL SCALE		MODEL SCALE							
TANK NO.	WEIGHT NO.	AMOUNT OF BALLAST REM'D.	BALLAST C.G. F.S. INS.	BALLAST C.G. B.P. INS.	WEIGHT LBS.	C.G. OF AIR VEHICLE INS.	WEIGHT LBS.	C.G. OF AIR VEHICLE INS.	ORDER OF SEQNCE	TANK NO.	WEIGHT NO.	AMOUNT OF BALLAST REM'D.	BALLAST C.G. F.S. INS.	BALLAST C.G. B.P. INS.	WEIGHT LBS.	C.G. OF AIR VEHICLE INS.
FULL CONDITION →					115.95	96.15	378,718.7	1635.7	G	I	3	ALL	59.820	–	81.80	98.14
X	24	ALL	121.188	25.500						IX	5	½	125.556	11.874		
	25	ALL	128.142	26.754	113.92	95.64					12	½	125.100	15.360		
I	1	ALL	50.244	–	110.25	97.15					19	½	125.670	20.130		
VI	FUS.	ALL	94.866	7.380							6	ALL	130.296	11.880		
	1	ALL	91.152	11.058							13	ALL	130.296	15.414		
	2	ALL	96.510	9.366			363,426.0	1615.5	[illegible]		20	ALL	130.260	20.178	78.50	96.93
	9	ALL	96.888	12.648	102.47	97.30	348,506.7	1637.0	I	II	1	ALL	66.810	–	75.28	98.22
VII	3	ALL	105.270	10.236						V	1	ALL	105.300	8.040		
	10	ALL	105.210	14.550			312,709.7	1610.6	J		2	ALL	114.240	7.416	67.55	96.64
	17	ALL	107.100	19.440						II	2	ALL	72.048	–		
	4	½	116.364	11.298							3	ALL	77.286	–		
	11	½	116.190	15.018						IV	1	ALL	104.382	–		
	18	½	116.844	19.944	94.61	96.25	247,347.1	1623.2	K		2	ALL	114.242	–	53.43	97.39
I	2	ALL	55.032	–	90.94	97.92	222,964.1	1623.8	L	B.B.	–	ALL	97.080	–	48.16	97.43
VIII	4	½	116.364	11.298						III	1	ALL	[illegible]	–		
	11	½	116.190	15.018							2	ALL	97.494	–		
	18	½	116.844	19.144						WATER		ALL	66.900	–		
	5	½	125.556	11.874			137,161.1	1638.7	← EMPTY CONDITION →						42.59	98.32
	12	½	125.100	15.360												
	19	½	125.670	20.130	85.48	96.50										

ARMAMENT TO BE DROPPED AT PILOT'S DISCRETION

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FIG 35

COMPLETE MODEL-TEST RESULTS

NAAL TEST # 443

RUN NO	CONFIGURATION: FUEL LOADING CONDITION	TIP DEFL. 0°	TIP DEFL. 50°	FLUTTER TEST RESULTS: FLUTTER YES	NO	FLUTTER FREQ CPS	PHASE	SHAKE TEST FREQUENCIES ~ CPS: SYMMETRIC f_1	f_2	f_3	f_4	f_5	ANTI-SYMMETRIC f_1	f_2	f_3	f_4	f_5
1*																	
2*																	
3	EMPTY	✓		✓		5.6	SYM	6.3	12.0	14.1	21.4	28.7	6.0	13.5	20.7	25.5	—
4*																	
5	SEQ L-H_2O	✓			✓	12.5 [illegible]	SYM	5.5	11.8	13.8	20.0	26.9	5.9	12.9	20.3	24.7	—
6	SEQ A (FULL)	✓		[illegible]		8.9	SYM	4.6	8.5	11.1	14.8	20.5	4.4	8.9	17.3	18.3	—
7	SEQ B	✓			✓			4.7	8.6	11.3	15.0	21.0	4.4	9.1	18.5	19.5	21.5
8	SEQ D	✓			✓			4.9	9.2	11.3	16.0	21.8	4.4	9.7	10.7	19.6	22.3
9	SEQ E	✓			✓			4.9	9.5	11.9	17.2	22.7	4.5	11.6	18.9	20.5	23.1
10	SEQ G	✓			✓			5.0	10.0	12.4	19.2	24.9	4.7	12.1	19.5	21.8	23.5
11	SEQ K+[illegible]	✓			✓			5.2	11.1	12.7	20.3	25.6	5.2	12.7	20.6	24.8	—
12	EMPTY		✓	[illegible]		~6.3	SYM	6.3	12.9	14.1	21.5	30.8	6.4	13.5	20.4	27.3	—
13	SEQ A		✓		✓			4.7	8.7	10.3	15.1	21.0	4.4	9.0	16.4	17.5	—
14**	EMPTY	✓		[illegible]		[illegible]	SYM	[illegible]	12.2	15.6	22.3	27.0	—	—	—	—	—
15***	EMPTY	✓		[illegible]		[illegible]	SYM	6.6	12.2	15.2	22.9	27.4	—	—	—	—	—
16****	SEQ A	✓		✓		9.4	SYM	4.8	8.9	10.4	15.6	—	—	—	—	—	—

MODEL CHARACTERISTICS

GEOMETRIC SCALE ...... .06
SPEED SCALE 1/6
MATERIAL .... STYRO & ISO
ALTITUDE .... SEA LEVEL
TIP DEFLECTION .... VARIABLE
CONTROL SURF. .... STIFF
SUPPORT. .... SUSPENSION SYST
HINGE FOLD STIFF. ..... 10% ~
HORIZ STAB INCIDENCE ... NONE
FUEL LOADING .... VARIABLE

* THESE RUNS WERE MADE TO ORIENT THE MODEL, NO TEST DATA OBTAINED. SUBSEQUENT RUNS WERE MADE WITH NO HORIZONTAL STABILIZER.
** STIFFNESS INCREASED 100%-150% FROM ANTENNA TO REAR.
*** STIFFNESS 1/2 OF RUN # 14 FROM ANTENNA TO REAR.
**** STIFFNESS SAME AS RUN # 15

.10 SCALE TRANSONIC WING

This model simulated the -44 C configuration. Three identical cantilever models were constructed with 0° tip deflection.

The stiffness of the wings was scaled to simulate a Mach number of 1.05 at sea level, with the stiffness reduced by a factor 1/1.32, so that in the event flutter occurred at conditions corresponding to the flight boundary, the required margin would be demonstrated at the correct mass ratio.

The models were constructed of a styrofoam core covered with aluminum skins of various thicknesses, consistent with full scale construction. The joints of the skins were overlapped and secured with glue. Subsequent tests of this glue showed it to be flexible which was indicated by the shake test frequencies being too low by 23%.

This test was conducted at TWT on 3/2/59 through 3/3/59 for seven test hours.

The purpose of the test was to determine the variation of flutter characteristics with Mach number in the transonic region. Flutter was not obtained and large margins were demonstrated.

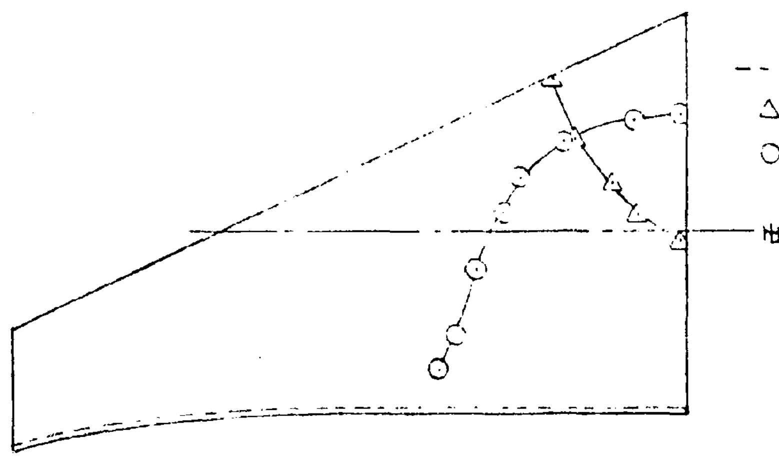
FIG. 36

44C CONFIGURATION

MODEL SCALE	.10
MATERIAL	STYROFOAM CORE ALUMINUM SKIN
SUPPORT	CANTILEVER FLOOR MOUNT
HINGE STIFFNESS	67544 IN-LB/RAD
FUEL LOADING	EMPTY
TIP DEFLECTION	0°

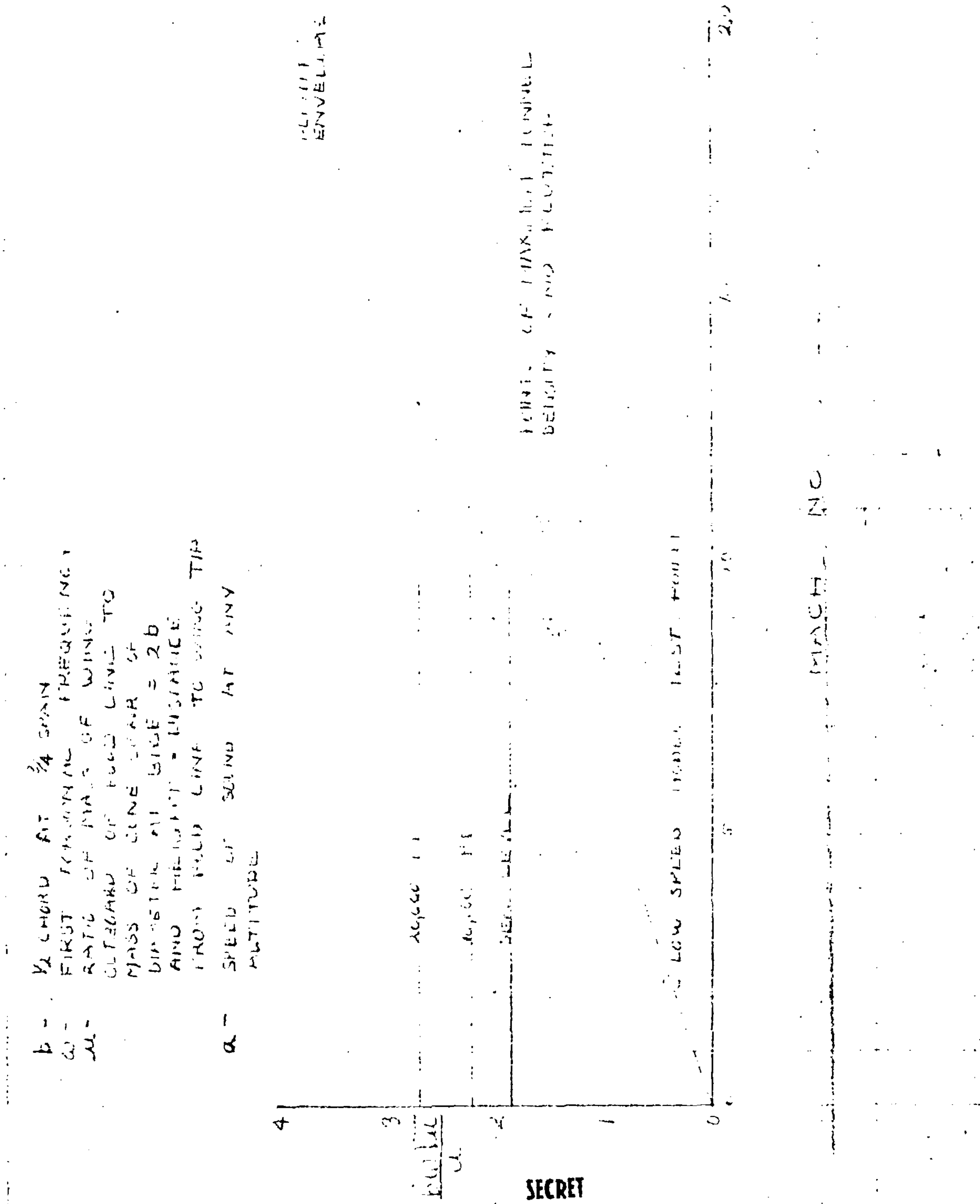
SHAKE TEST RESULTS

---	ω_1	22.5 CPS
△	ω_2	70.9 CPS
○	ω_3	88.3 CPS



NOMINAL MACH NUMBERS TESTED: .95
1.05
1.10

FIG 37



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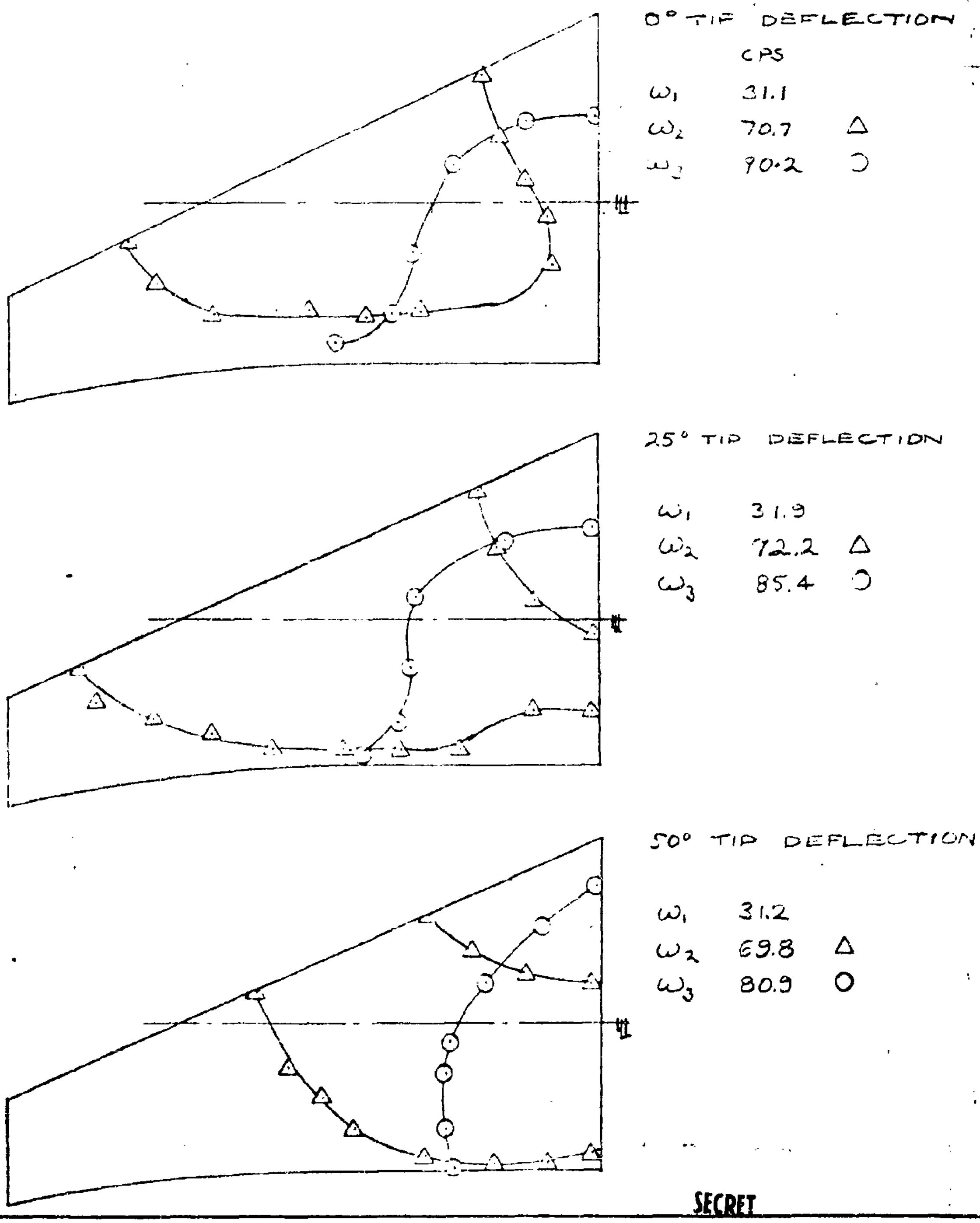
.10 SCALE TRANSONIC WING

These models are the same as the previous .10 scale transonic wings except as modified to incorporate 25° and 50° wing tip deflection. The purpose of the tests was to investigate the effect of wing tip deflection on flutter speeds at a low supersonic Mach number. Tests were conducted at M = 1.10 with variable tunnel density in TWT on 4/21/59 through 4/23/59 for 33 test hours. Static air loads destroyed the model with 50° tip deflection and flutter was not encountered for either the 0° or 25° tip deflection models. From indications of the approach to flutter for 0° deflection it may be concluded that 25° deflection causes no appreciable reduction in flutter speed. Very large margins were demonstrated.

PREPARED BY: HKA	NORTH AMERICAN AVIATION, INC.	PAGE NO. 55 OF 63
CHECKED BY: J.R.S.	1/10 SCALE TRANSONIC	NA-59-1736 REPORT NO.
DATE: 11/12/59	WING SECRET	MODEL NO. XB-70

FIG. 38

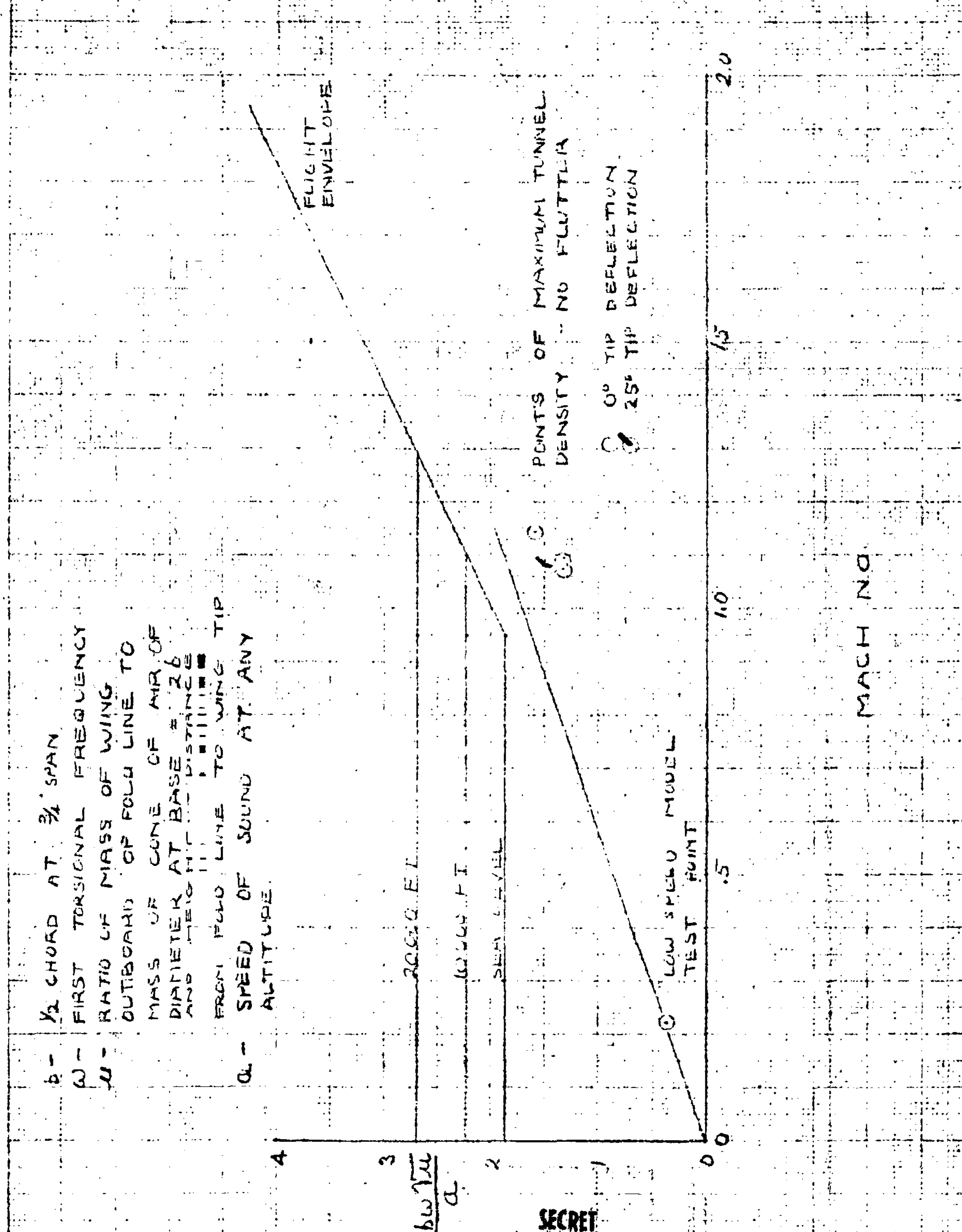
SHAKE TEST RESULTS



SECRET

PREPARED BY: HKA	NORTH AMERICAN AVIATION, INC.	PAGE NO. 56 OF 63
CHECKED BY: J.R.S.	SECRET .10 SCALE TRANSONIC	NA-59-1736 REPORT NO.
DATE: 11/12/59	WING	MODEL NO. XB-70

FIG. 38



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.20 SCALE TRANSONIC VERTICAL TAIL

Three identical models of the vertical tail were constructed simulating the -44C configuration including root flexibility.

The model was constructed of a styrofoam core with aluminum skins, the same type of construction as was used for the .10 scale transonic wings. Comparison of shake test results and other vertical stabilizer models has indicated that these models were too flexible, i.e., the frequencies were lower than required by design model factors by approximately 14-1/2 per cent as a result of excessive glue joint flexibility. Since mass parameters were correct, this lower stiffness level still provides full usable data.

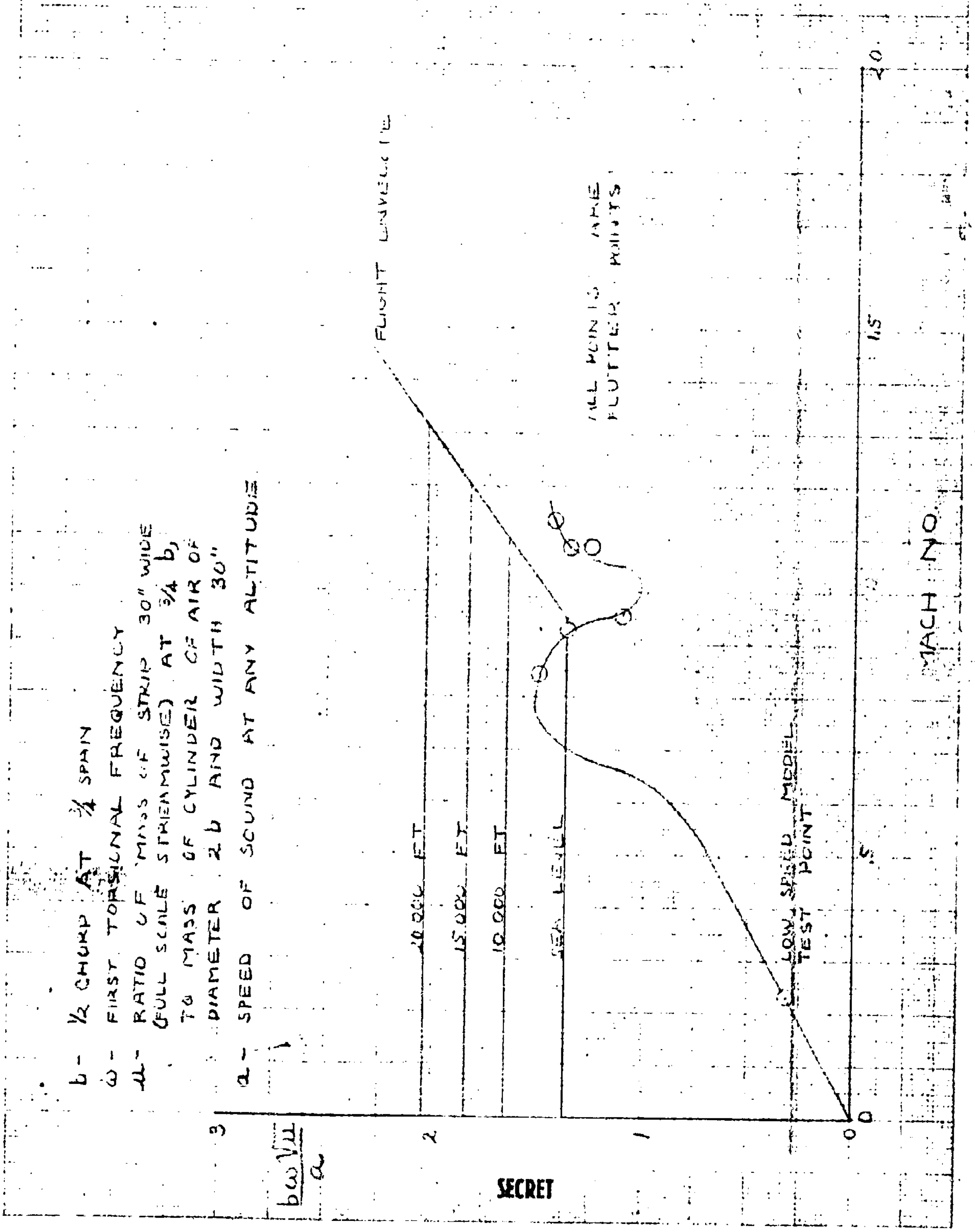
Six flutter points were obtained during the test. As observed with high speed motion picture photography, the flutter mode was first bending-first torsion with a large torsion component.

The shapes of the flutter boundary curve and the T.W.T. operation characteristic curve led to flutter at several points during a blow. The changing tunnel conditions removed the model from a flutter range before model damage occurred. The maximum density flutter point obtained in each case then caused model damage.

The test was conducted in TWT from 3/4/59 through 3/3/59 for 30 test hours.

From this test it was concluded that, for the configuration tested, an increase of 10% in torsion stiffness would be required in the midspan region in order to provide the required margin of safety.

FIG 41


b - 1/2 CHORD AT 3/4 SPAN
ω - FIRST TORSIONAL FREQUENCY
μ - RATIO OF MASS OF STRIP 30" WIDE (FULL SCALE STREAMWISE) AT 3/4 b, TO MASS OF CYLINDER OF AIR OF DIAMETER 2b AND WIDTH 30"
a - SPEED OF SOUND AT ANY ALTITUDE
FLIGHT ENVELOPE
ALL POINTS ARE FLUTTER POINTS
20,000 FT
15,000 FT
10,000 FT
SEA LEVEL
LOW SPEED MODEL TEST POINT
MACH NO
0
.5
1.5
2.0
3
2
1
0
bω√μ / a

HORIZONTAL STABILIZER

Flutter trends were established by means of a total of twenty-four runs of the B-70 horizontal stabilizer with variation in pitch and yaw stiffness, flap locked and unlocked, and angle of incidence.

The 1/5 geometric scale model with a 1/6 velocity scale, was constructed of solid styrofoam with the thickness at any point in the planform scaled to simulate full scale bending stiffness. The flap was free to rotate about its hinge line hinges which were constructed so that the flap could be locked in position also. Flap actuator stiffness was simulated by a pair of springs attached to a wheel-type ring at the end of a cylindrical tube. The model mass simulated full scale mass data.

Pitch stiffness and yaw stiffness was simulated by small cantilevered beam springs. The springs were calibrated dynamically by attaching a known mass on the spring and recording the free vibration on an oscillograph record for each length of spring.

A shake test was conducted to determine natural frequencies and node lines of the first four symmetric and anti-symmetric modes prior to the actual flutter test of each configuration. These tests were conducted in the WSC 7 3/4 x 11 foot low speed atmospheric wind tunnel at sea level density.

These tests demonstrated adequate margin for all configurations except those including unlocked flaps and indicated that further study was required to optimize the design for adequate margin with respect to the 300 KIAS limit speed for the flaps unlocked case.

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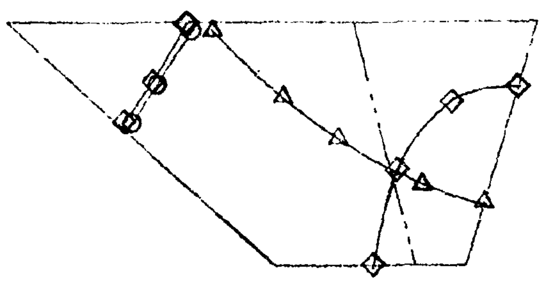
B-70 HORIZONTAL STABIL
NAAL TEST 445
MODEL CHARACTERISTI

GEOMETRIC SCALE $1/5$
SPEED SCALE $1/6$
MATERIAL SOLID STYROFOAM
SPRING CONSTANTS PITCH
YAW
FLAP INERTIA ABOUT H_L

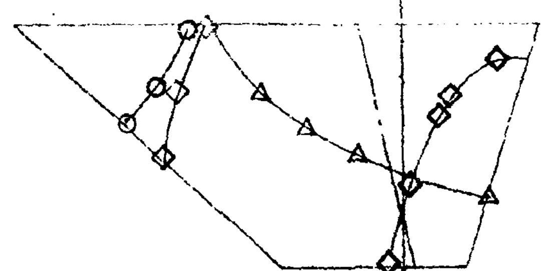
ALTITUDE
CONTROL SUR
SUPPORT
STIFF
FLEXIBLE
STIFF
FLEXIBLE

FLAP RESTRAINT	LOCKED		
PITCH STIFFNESS	STIFF	STIFF	F
YAW STIFFNESS	STIFF	FLEX	F

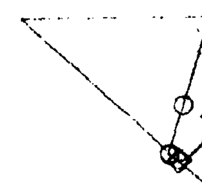
SYMMETRIC MODES



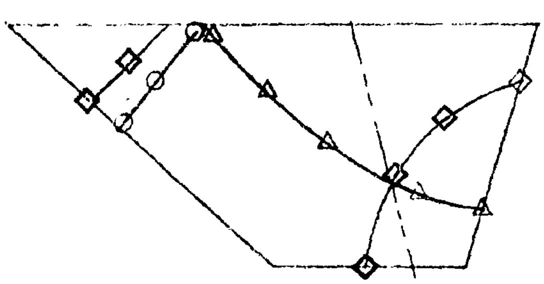
MODE	FREQ-CPS	
1	9.5	○
2	15.3	
3	20.2	△
4	29.2	◇
5		



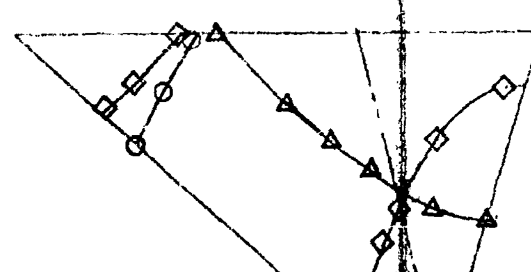
MODE	FREQ-CPS	
1	9.2	○
2	13.7	
3	20.4	△
4	29.3	◇
5		



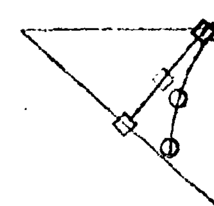
ANTI-SYMMETRIC MODES



MODE	FREQ-CPS	
1	9.7	○
2	16.8	
3	19.7	△
4	27.6	◇
5		



MODE	FREQ-CPS	
1	9.8	○
2	15.8	
3	20.[illegible]	△
4	27.6	◇
5		



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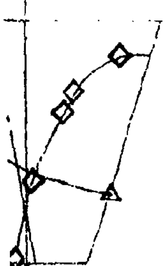
ORIZONTAL STABILIZER
NAAL TEST 445
DEL CHARACTERISTICS

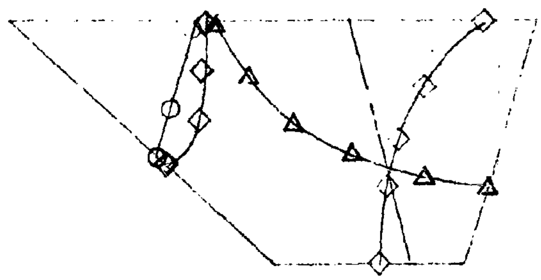
1/5	ALTITUDE	SEA LEVEL	
1/6	CONTROL SURFACE	VARIABLE	
RGFOAM	SUPPORT	SPECIAL MOUNT	
PITCH	STIFF	42,850	IN.LBS/RAD
	FLEXIBLE	18,585	IN.LBS/RAD
YAW	STIFF	32,150	IN.LBS/RAD
	FLEXIBLE	22,950	IN.LBS/RAD
		.04455	IN-LBS-SEC^2

PREPARED BY:
CHECKED BY: J.R.
DATE

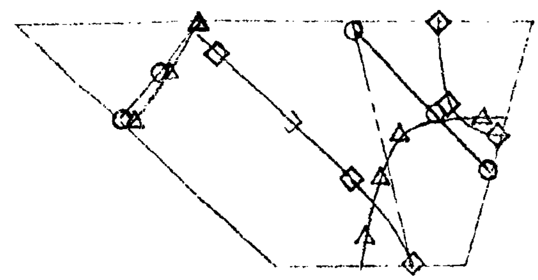
	FLEX	STIFF	STI
	FLEX	STIFF	FL

LO

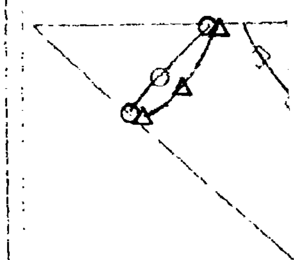


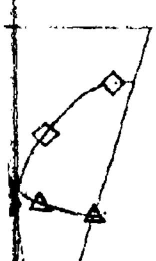


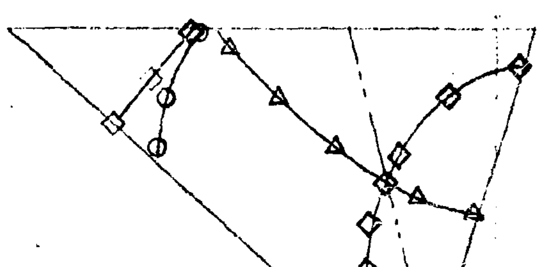
MODE	FREQ~CPS	
1	8.4	○
2	13.7	
3	19.5	△
4	28.0	◇
5		



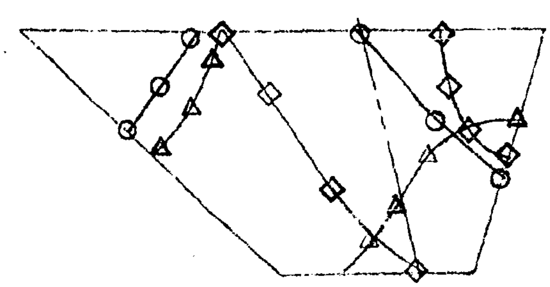
MODE	FREQ-CPS	
1	11.3	○
2	16.9	
3	25.9	△
4	33.7	◇
FLAP	4.8	



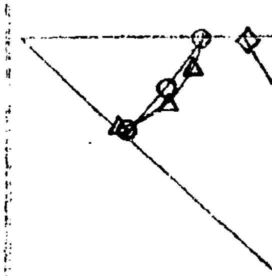




MODE	FREQ-CPS	
1	8.6	○
2	15.8	
3	19.6	△
4	26.8	◇
5		



MODE	FREQ-CPS	
1	11.6	○
2	17.4	
3	26.0	△
4	34.4	◇
FLAP	4.8	



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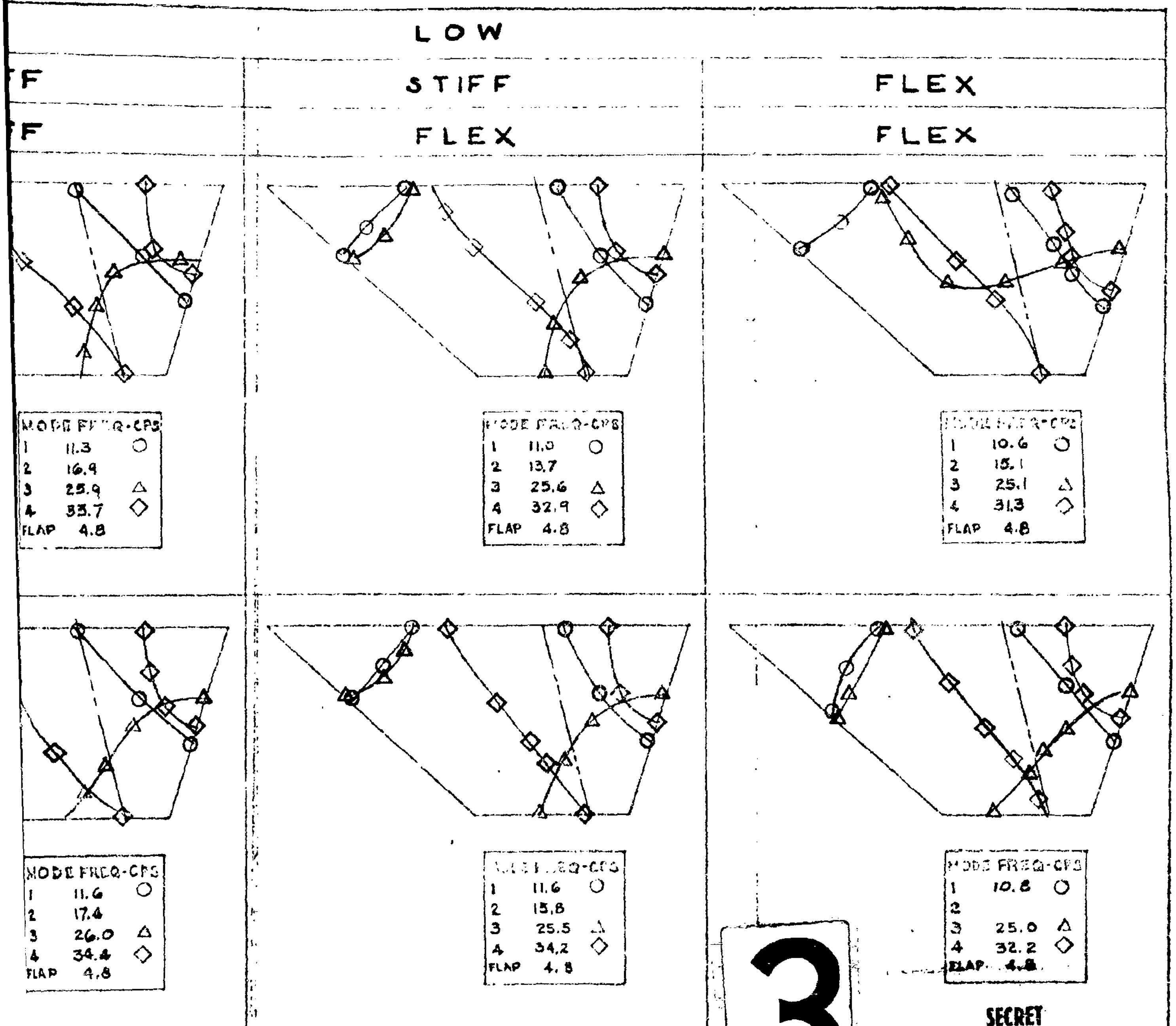
CHECKED BY J.R.S	INTERNATIONAL AIRPORT LOS ANGELES 45, CALIFORNIA	NA-59-1736 REPORT NO
DATE	SHAKE TEST RESULTS – HORIZ STAB	MODEL NO XB-70

FIG 42

SECRET



SECRET

3

R.W.D.
H.R.S.
11-30-59

SECRET

NA-59-1736
XB-70

F[illegible] SPAN MODEL OF CANARD
LOW SPEED 1/15 SCALE

FIG 43

TEST CONFIGURATIONS

MAXIMUM SPEED AND FLUTTER FREQ.

FLAP			LOCKED			LOAD			FREE		
ANGLE			0°	3°	6°	0°	3°	6°	0°	3°	6°
YAW	PITCH										
STIFF	STIFF	V_{max} MPH	172			67	68.5	[illegible]	[illegible]	71	73.5
		f_F CPS	—			11.1	[illegible]	[illegible]	10.47	10.71	10.57
	MED	V_{max} MPH									
		f_F CPS									
	FLEX	V_{max} MPH									
		f_F CPS									
MEDIUM	STIFF	V_{max} MPH									
		f_F CPS									
	MED	V_{max} MPH									
		f_F CPS									
	FLEX	V_{max} MPH									
		f_F CPS									
FLEXIBLE	STIFF	V_{max} MPH	175			65.5	66	73	65.5	68.5	74
		f_F CPS	—			10.71	10.69	10.89	10.4	10.5	10.5
	MED	V_{max} MPH									
		f_F CPS									
	FLEX	V_{max} MPH	160	145		60	60	61.5	57	59	62
		f_F CPS	—	—		10.00	10.08	10.19	9.48	9.47	9.64

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HORIZONTAL STABILIZER
NAAL TEST NO. 445

MODEL CHARACTERISTICS

ALTITUDE — SEA LEVEL
CONTROL SURFACE — VARIABLE
SUPPORT — SPECIAL MOUNT

RUN NO.	PITCH SPRING			YAW SPRING			FLAP			INCIDENCE			OSCIL. REC. NO.	MAX SPEED MPH	FLUTTER		FLUTTER MOTION PHASE	f_1
	STIFF	MED	FLEX	STIFF	MED	FLEX	LOCK	LOW	FREE	0°	3°	6°			YES	NO		
1 SEE RUN NO. 8			✓			✓	✓			✓								7.4
2			✓			✓		✓		✓			2607	60	✓		SYM	10.6
3			✓			✓		✓			✓		2608	60	✓			
4			✓			✓		✓				✓	2609	61.5	✓			
5			✓			✓			✓			✓	2610	62	✓			
6			✓			✓			✓		✓		2611	59	✓			
7			✓			✓			✓	✓			2612	57	✓			
8			✓			✓	✓			✓			2614	160		MARG.		8.4
9 SEE RUN			✓			✓	✓				✓		2621	124		✓		
10	✓					✓		✓		✓			2622	65.5	✓			11.0
11	✓					✓		✓			✓		2623	66		MARG.		
12	✓					✓		✓				✓	2624	73	✓			
13	✓					✓			✓			✓	2628	74	✓			
14	✓					✓			✓		✓		2629	68.5	✓			
15	✓					✓			✓	✓			2630	65.5	✓			
16	✓					✓	✓			✓			2635	175		✓		9.2
17	✓			✓				✓		✓			2637	67	✓			11.3
18	✓			✓				✓			✓		2638	68.5	✓			
19	✓			✓				✓				✓	2639	73	✓			
20	✓			✓					✓			✓	2641	73.5	✓			
21	✓			✓					✓		✓		2642	71	✓			
22	✓			✓					✓	✓			2643	67	✓		ANTI-SYM.	
23	✓			✓			✓			✓			2645	172		✓	SYM.	9.5
24			✓			✓	✓				✓		2653	145		✓		8.4

SECRET

PREPARED BY [illegible]	NORTH AMERICAN AVIATION, INC
CHECKED BY JRS	[illegible]
DATE	

...IZER

FIG 44

SEA LEVEL
[illegible] VARIABLE
SPECIAL MOUNT

OSCIL. REC. NO.	MAX SPEED MPH	FLUTTER YES	FLUTTER NO	FLUTTER MOTION PHASE	SHAKE TEST F[illegible] SYMMETRIC f_1	f_2	f_3	f_4	f_5	A[illegible] f_1	f_2	f_3	f_4	f_5	FLUTTER FREQ [illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]			
2607	[illegible]	✓		SYM	10.6	15.1	25.1	[illegible]		[illegible]		[illegible]	[illegible]		[illegible]	
2608	60	✓													10.09	
2609	61.5	✓													10.19	
2610	62	✓													[illegible]	[illegible]
2611	59	✓													9.47	
2612	57	✓			↓	↓	↓	↓		↓		↓	↓		9.48	↓
2614	160		MARG.		8.4	13.7	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	
2621	124		✓		↓	↓	↓	↓		↓	↓	↓	↓			
2622	65.5	✓			11.0	13.7	25.6	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		10.71	
2623	66		MARG.												10.69	
2624	73	✓													[illegible]	
2628	74	✓													10.5	[illegible]
2629	68.5	✓													10.5	
2630	65.5	✓			↓	↓	↓	↓		↓	↓	↓	↓		10.4	↓
2635	75		✓		9.2	13.7	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]			
2637	67	✓			11.3	16.9	25.9	[illegible]		11.6	17.4	[illegible]	[illegible]		11.1	
2638	68.5	✓													11.11	
2639	73	✓													11.11	
2641	73.5	✓													10.97	[illegible]
2642	71	✓		↓											10.71	
2643	67	✓		ANTI-SYM.	↓	↓	↓	↓		↓	↓	↓	↓		10.47	↓
2645	172		✓	SYM.	9.5	15.3	[illegible]	29.2		[illegible]	[illegible]	[illegible]	27.6			
2653	145		✓	↓	8.4	13.7	19.5	[illegible]		8.6	15.8	19.6	26.8			

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