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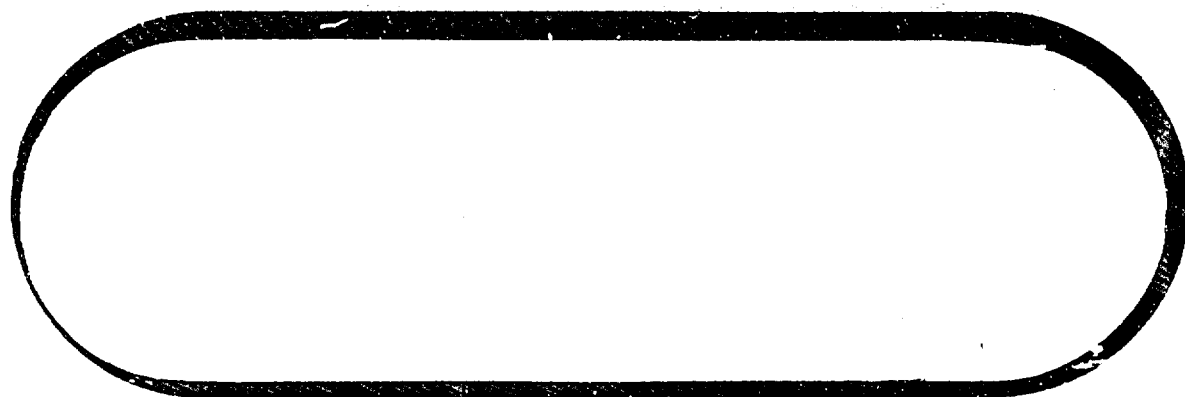
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BOEING



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SECOND PROGRESS REPORT

For Period Ending 15 June 1973

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Office of Naval Research

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Arbitration No. 22217

VARIABLE CAMBER WING

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Contract No. N00014-73-C-0244

The Boeing Aerospace Co.

June 1973

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1.0 SUMMARY

1. The first series of wind tunnel tests were completed on June 15 and the second series is scheduled to begin on June 25.
2. Preliminary force and moment data indicate that large improvements in performance were achieved relative to the basic F-8.
3. Several alternative leading edge concepts permitting increased deflection have been designed.
4. Approximate weight increments for the boiler plate technology demonstrator prototype have been determined.

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2.0 TECHNICAL STATUS

WIND TUNNEL TEST PROGRAM

The initial series of wind tunnel tests which were designed to demonstrate the aerodynamic advantages of an advanced technology variable camber wing have been completed. These tests were conducted during twenty-four shifts of occupancy time at the NASA Ames 14-foot transonic wind tunnel between May 21 and June 15, 1973.

The configurations tested consisted of the basic F-8, the F-8 with an advanced technology wing, the advanced wing with simple hinged leading and trailing edge flaps and various combinations of smooth, curved variable camber flaps. A summary of the test configurations and test conditions is presented in Figure 1.

Examination of preliminary force and moment data indicates that very substantial performance improvements over the basic F-8 were obtained, however, the magnitude of these improvements will not be determined until final data are available from NASA in early July.

The wind tunnel model of the ATVCW was equipped with two streamwise rows of pressure taps at 24% and 64% semispan respectively. Preliminary test results indicate fairly good agreement between theory and experiment for approximately similar conditions.

FIGURE 1 TEST SUMMARY - Ames 14' Transonic Wind Tunnel

CONFIGURATION	RUN NUMBER	MACH NUMBER	ANGLE OF ATTACK	YAW ANGLE	L.E. DEFLECTION	INBOARD T.E. DEFLECTION	OUTBOARD T.E. DEFLECTION	HORIZONTAL TAIL INCIDENCE
BASIC F-8 (Inverted) (Upright)	1-5	.7,.9,.925 .95,1.15	-5° to 5°	0	0	0	0	OFF
	6-13	.7,.9,.925 .95,1.15	-2° to max.	0	0	0	0	OFF, 0°
	14-18	.7,.9,1.15	-2° to max.	5°	0	0	0	0°
ADVANCED TECHNOLOGY WING	21-34,* 99-102*	.7,.9,.925 .95, 1.15	-2° to max.	0	0	0	0	OFF, 0° -5°, -10°
	19,20	.7,.9	-2° to max.	5°	0	0	0	0°
ATUCH + SIMPLE HINGED FLAPS	86-91*	.7,.9,1.15	-2° to max.	0	0	-2S	-2S	OFF, 0°
	35-37	.7,.9,1.15	"	"	10S	0	0	OFF
	48,49	.7,.9	"	"	20S	0	0	OFF
	38,39*	"	"	"	10S	5S	5S	OFF
	40-43	"	"	"	20S	5S	5S	OFF, -5°
	44-47	"	"	"	20S	10S	10S	OFF, -5°

* PRESSURE DATA OBTAINED

FIGURE 11 TEST SUMMARY - ARES 14' TRANSONIC WIND TUNNEL (Continued).

CONFIGURATION	RUN NUMBER	MACH NUMBER	ANGLE OF ATTACK	YAW ANGLE	L.E. DEFLECTION	INBOARD T.E. DEFLECTION	OUTBOARD T.E. DEFLECTION	HORIZONTAL TAIL INCIDENCE
ATVCM + CONFORMAL FLAPS	53-56, 82*, 83*	.7, .9	-2° to max.	0	7.5C, 15C 30C	0	0	OFF
	50-52*	.7, .9, 1.15	"	"	22.5C	0	0	"
	84, 85	.7, .9	"	"	15C	10C	10C	"
	57-60*	"	"	"	30C	5C	5C	OFF, 0°
	61-66*	"	"	"	"	10C	10C	OFF, 0°, -5°
	67-70	"	"	"	"	18C	18C	OFF, -5°
ATVCM + MIXED CONFORMAL AND SIMPLE HINGED FLAPS	71, 72	.7, .9	-2° to max.	0	30C	10S	18C	OFF
	73, 74	"	"	"	"	"	10S	"
LATERAL CONTROL	92, 93, 94	.7, .9, 1.15	-2° to max.	0	0°	Left+5S Right-5S	0	0°
	97, 98	.7, .9	"	"	"	Left 0 Right-15S	"	"
	95, 96	"	"	"	"	Left+25S Right-15S	"	"
	77, 78	"	"	"	30C	Left+10S Right-5S	10C	"
	75, 76	"	"	"	"	Left+25S Right-15S	"	"

NOTE: S = SIMPLE HINGED C = CONFORMAL

Figure 2 shows a comparison of the theoretical and experimental pressure distributions at the inboard wing station. The experimental pressure distribution has a slightly higher peak at the leading edge. At the rear an expected decambering effect takes place due to viscous effects. The outboard wing (Figure 3) shows good agreement of the peak pressures, but a slightly lower overall C_p -level on the upper surface. Boundary layer buildup again causes a decambering effect towards the trailing edge.

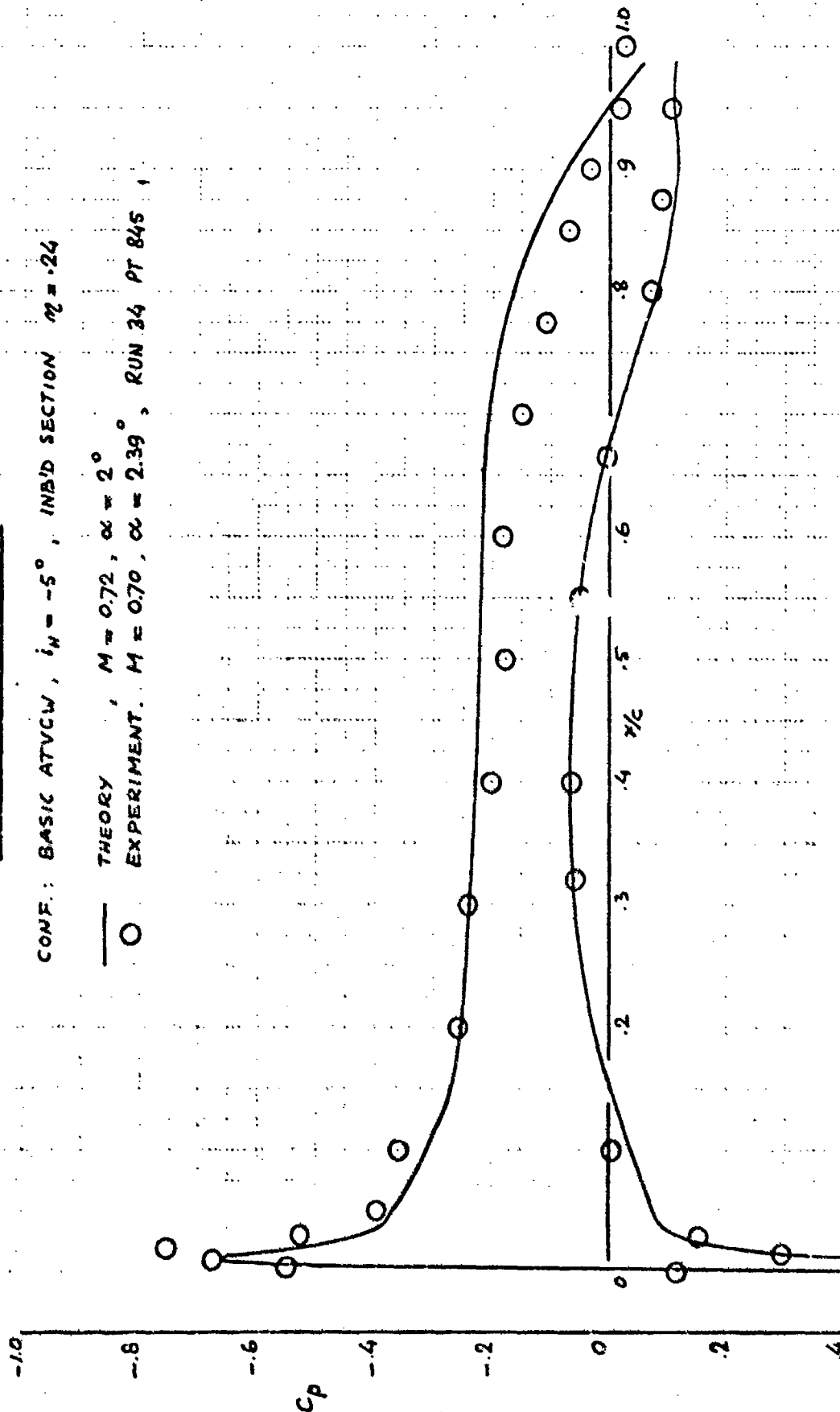
The next series of wind tunnel tests is scheduled to begin on June 25 in the NASA Ames 9 x 7 supersonic wind tunnel. These will be followed directly by low speed tests during the next week in the Ames 12-foot pressure wind tunnel.

COMPARISON OF THEORETICAL AND EXPERIMENTAL
PRESSURE DISTRIBUTIONS

CONF.: BASIC ATVCW, $i_H = -5^\circ$, INBD SECTION $\eta = .24$

— THEORY, $M = 0.72$, $\alpha = 2^\circ$

○ EXPERIMENT, $M = 0.70$, $\alpha = 2.39^\circ$, RUN 34 PT 845



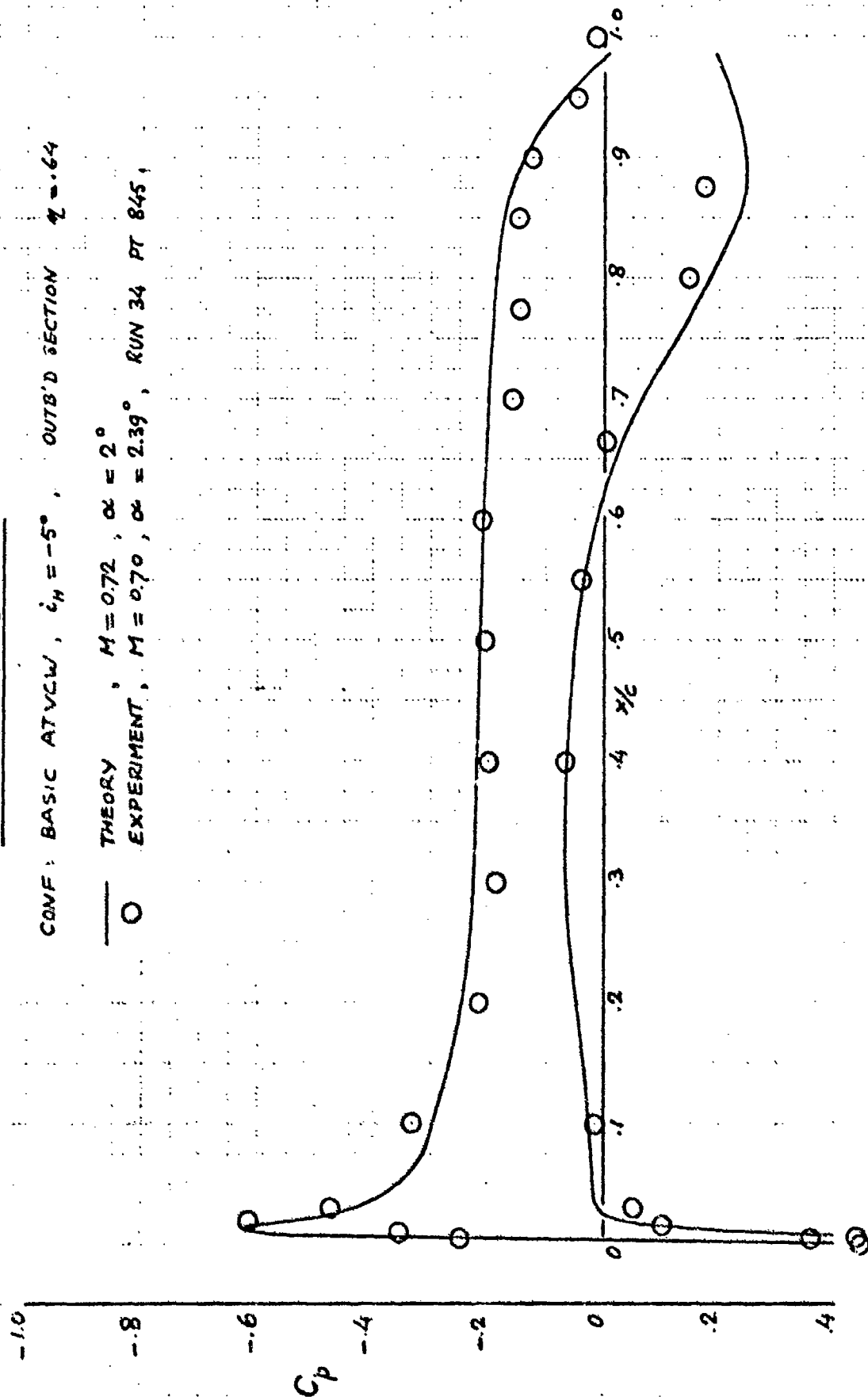
CALL	KASCHIPPERS 6-19-78	DATE	
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Fig 2

COMPARISON OF THEORETICAL AND EXPERIMENTAL
PRESSURE DISTRIBUTIONS

CONF: BASIC ATVCW, $i_n = -5^\circ$, OUTB'D SECTION $\eta = .64$

— THEORY, $M = 0.72$, $\alpha = 2^\circ$
 O EXPERIMENT, $M = 0.70$, $\alpha = 2.39^\circ$, RUN 34 PT 845,

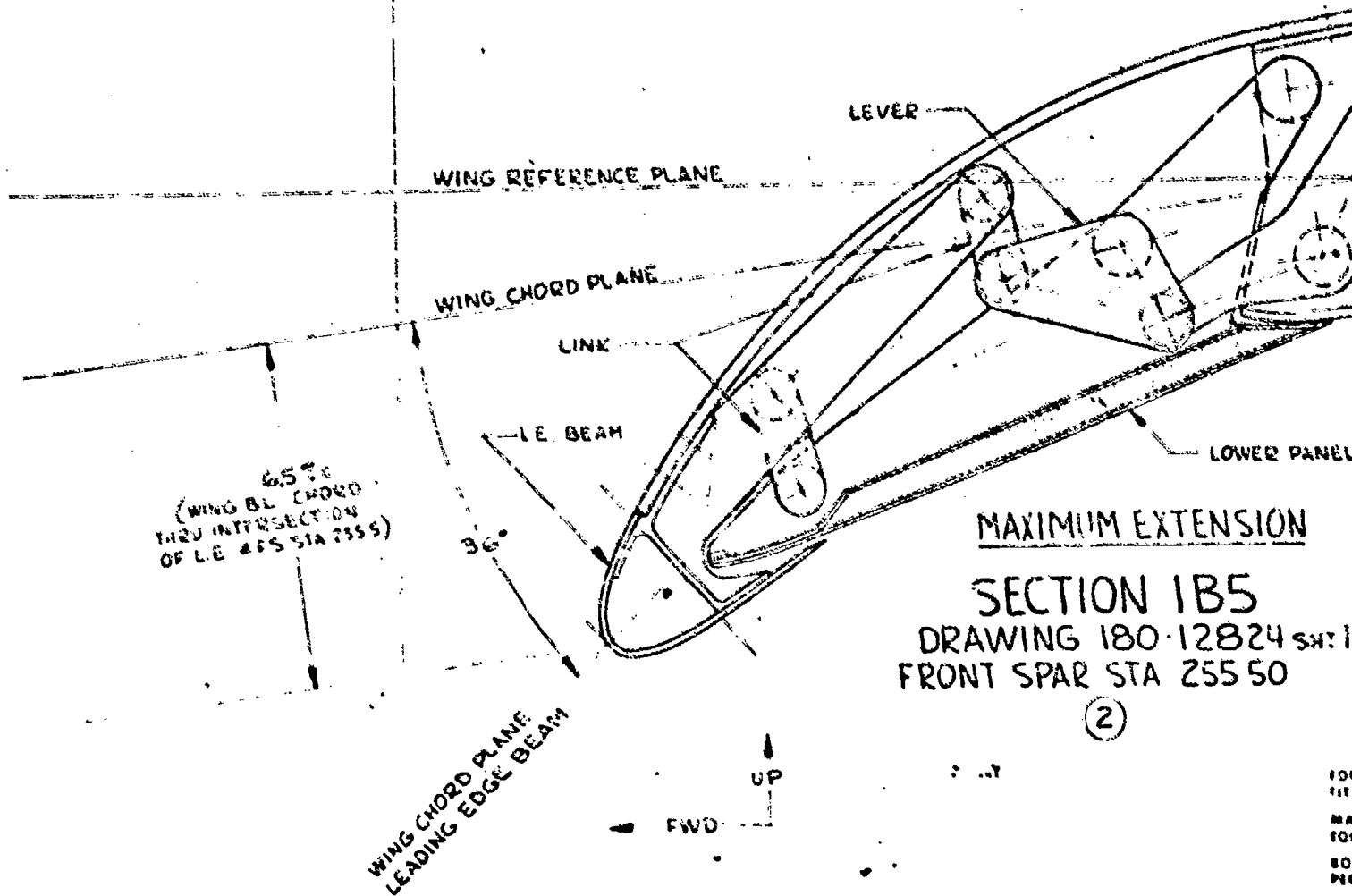
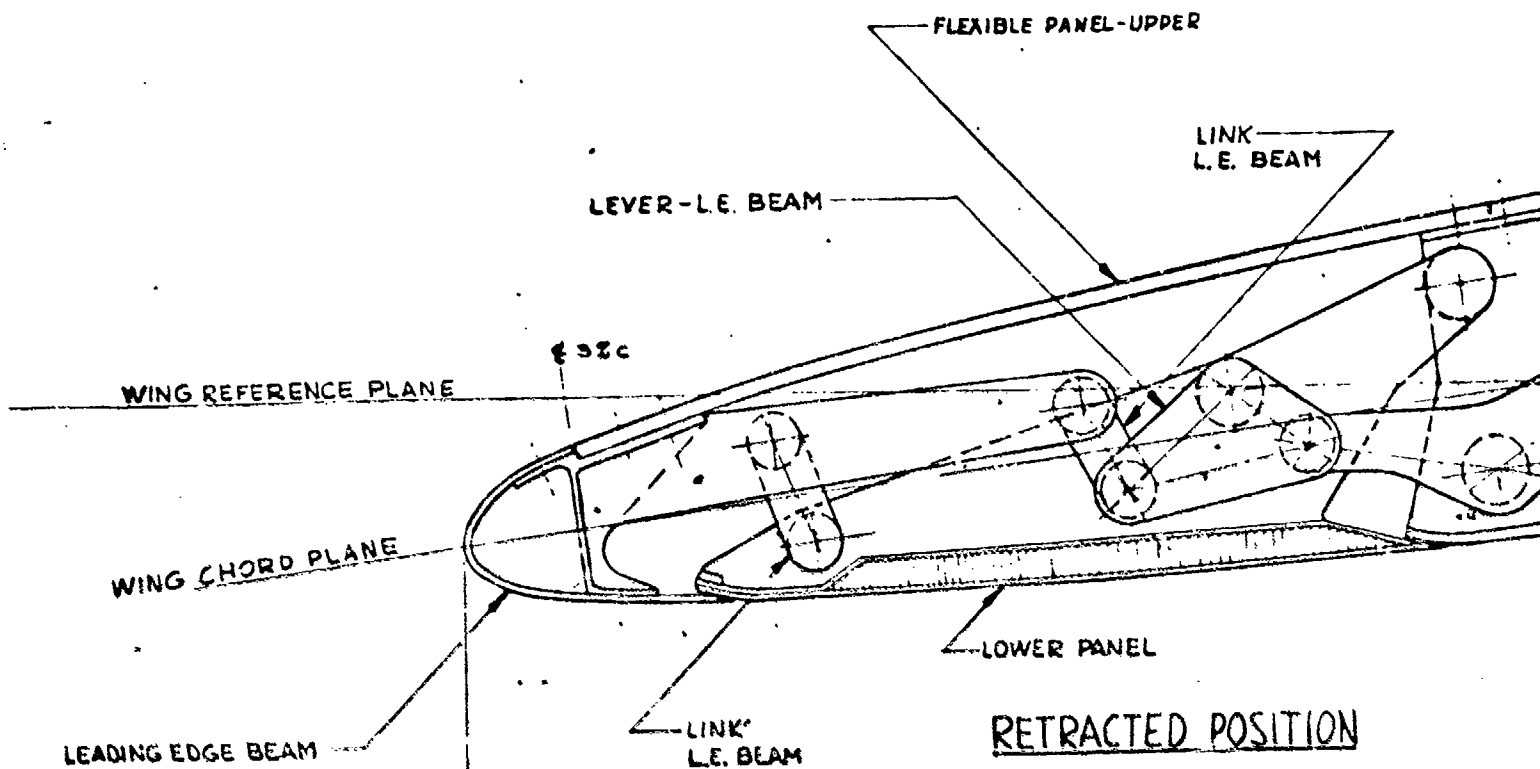


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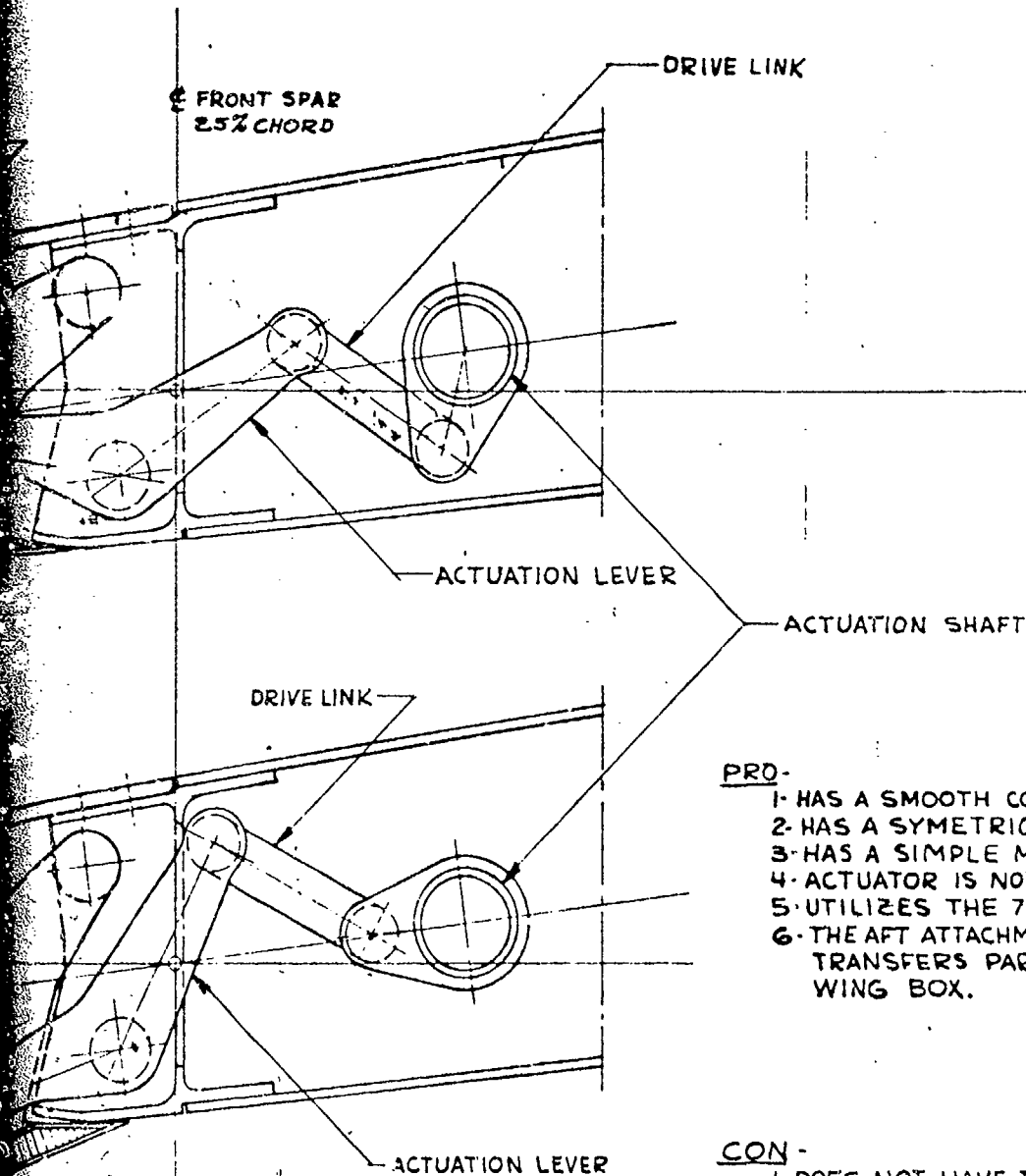
STRUCTURAL DESIGN TRADES

A number of variable camber leading edge concepts have been designed in an attempt to improve on the original concept described in Reference 1 and shown in Figure 4. The design trades included consideration of concepts to achieve greater deflections and no reduction in lifting surface area with deflection. Several of these concepts are shown in Figures 5 through 7. Figure 8 presents a comparison of the relative shapes and extensions of the leading edge flap systems for both the high speed maneuver and low speed takeoff and landing conditions. A simple hinge flap is included for comparison.

Reference 1: Ishimitsu, K. K.; "Mechanization and Utilization of Variable Camber in Fighter and Attack Airplanes"; Boeing Document D180-15377-1, January 1973.



REVISIONS			
SYM	ZONE	DESCRIPTION	DATE
A		REDRAWN TO INCREASE C.E. DEFLECTION	5/8/75



PRO -

- 1- HAS A SMOOTH CONTOUR AT ALL ANGLES OF EXTENSION
- 2- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK-UP.
- 3- HAS A SIMPLE MECHANISM.
- 4- ACTUATOR IS NOT IN THE PRIMARY STRUCTURAL LOAD PATH
- 5- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLOGY
- 6- THE AFT ATTACHMENT OF THE FLEXIBLE LEADING EDGE TRANSFERS PART OF THE AIR LOAD DIRECTLY INTO THE WING BOX.

CON -

- 1- DOES NOT HAVE THE REQUIRED LEADING EDGE EXTENSION FOR LANDING AND TAKE-OFF. (FOR THIS PROGRAM)
- 2- HAS A SIGNIFICANT WING AREA REDUCTION AT MAXIMUM EXTENSION.
- 3- HAS TWO SLIP JOINTS IN THE LOWER SURFACE.
- 4- WING BOX BENDING STRESSES ARE TRANSFERRED DIRECTLY INTO THE FLEXIBLE PANEL. (FLIGHT OPERATING STRESSES ARE DIFFICULT TO DETERMINE IN THE FLEXIBLE PANEL.)
- 5- REQUIRES A DEVELOPMENT PROGRAM.

FORM, PUNCH, STRAIGHTEN & FIT METAL PARTS PER BAC 300

MATERIAL SUBSTITUTION & EQUIVALENTS PER BAC 3005

BOLT & NUT INSTALLATION PER BAC 3009

PART MARKING PER BAC 3007

RIVET INSTL & SYM PER BAC 3004

SEE BAC 2097 FOR SURFACE ROUGHNESS

FOR FINISH CODE SEE DOCUMENT D2-5000

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES

ANGLES ± DECIMALS ±

RIVET & BOLT EDGE MARGINS ±.05

SHEET METAL CORNER RADI ROUTED PARTS ONLY

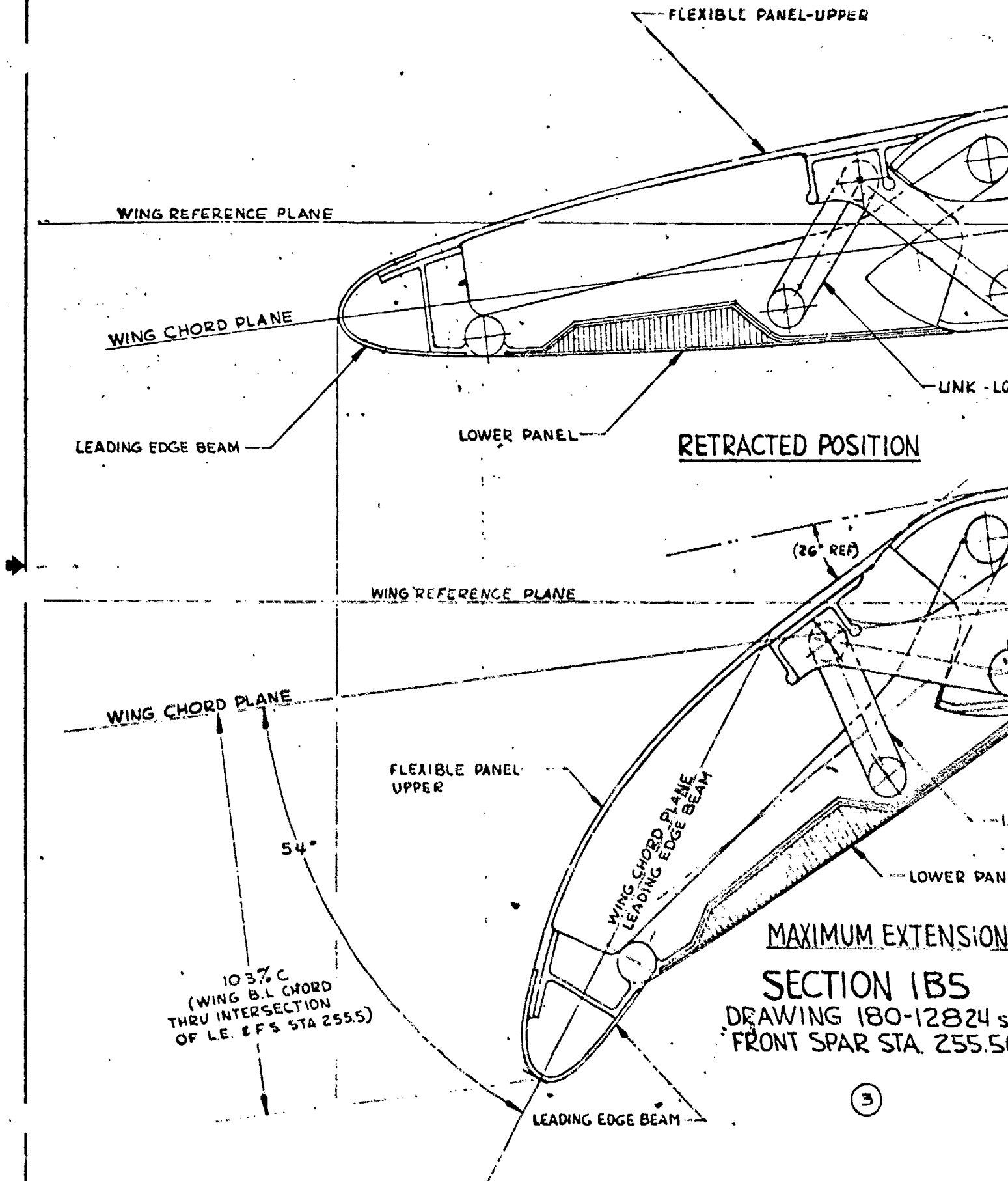
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EXTERNAL 22 00

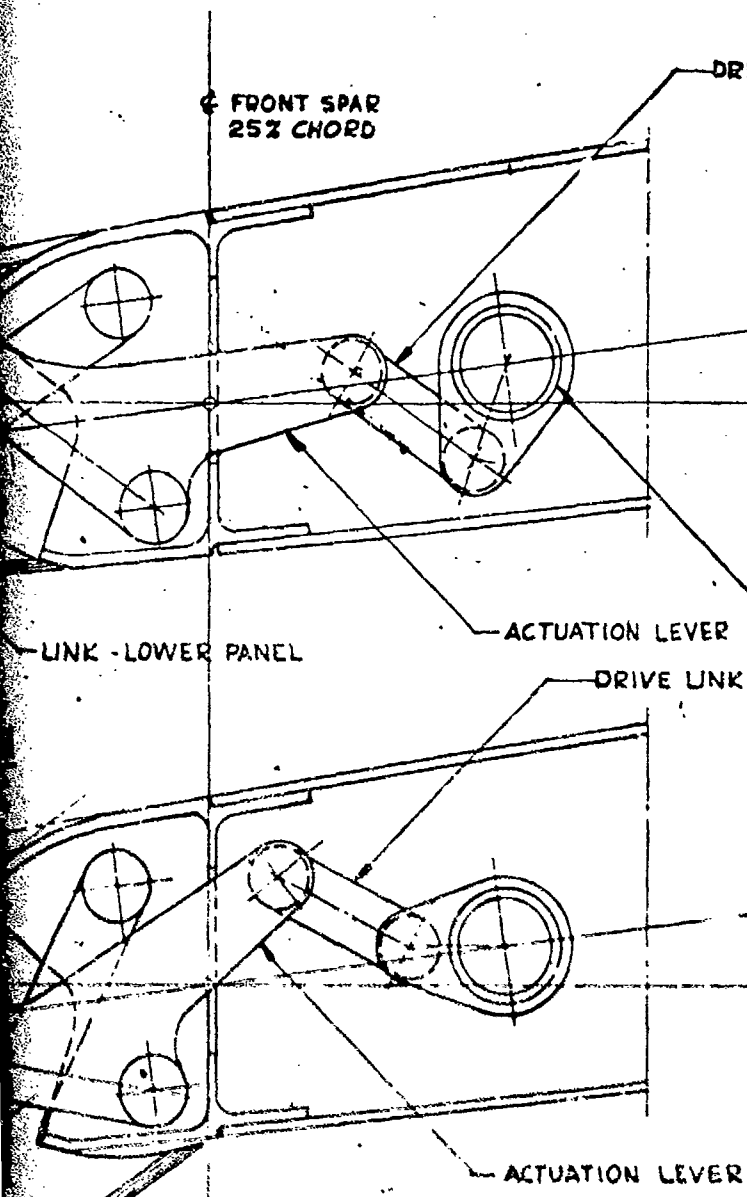
BEND RADIUS
± 0' ON .01 & .06
± .03 ON .07 & GREATER

SEE SHEET 1 ON PL FOR LIST OF MATERIAL USAGE AND

USED ON	DRAWN	DATE	THE BOEING COMPANY	
	M. M. K. ANDY	5-7-75	TACTICAL CONCEPT PLANE PROJECT	
	CHECKED		LEADING EDGE FLAP	
	STRESS		VARIABLE CAMBER WING	
SECT NO	ENGR	6-1-75	F-8 FLIGHT DEMONSTRATION	
CHG NO	GROUP		CODE IDENT NO	SIZE
GROUP ORG	PROJ		81205	D
			SCALE FULL	1/4" 2

180-12824





PRO -

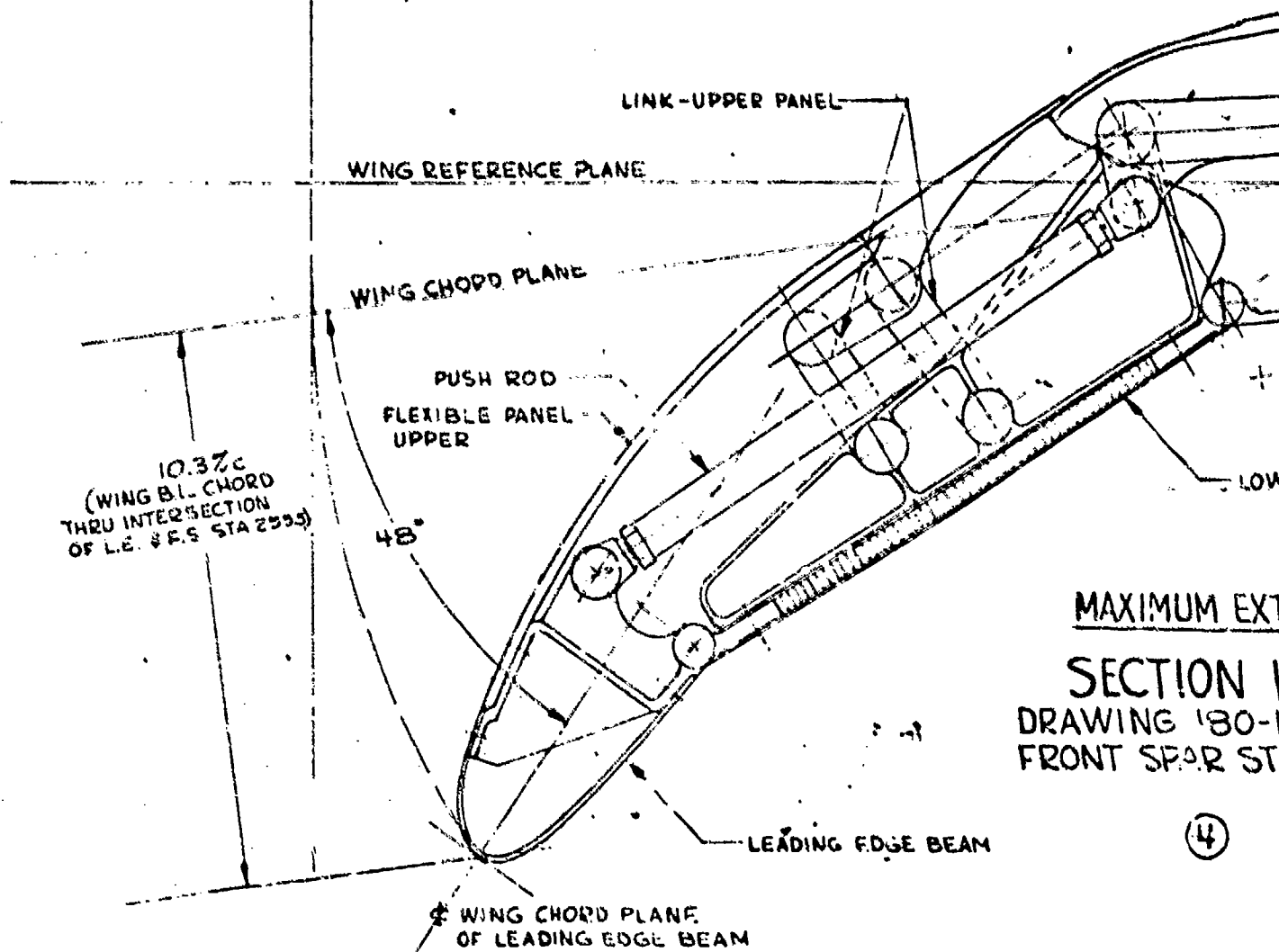
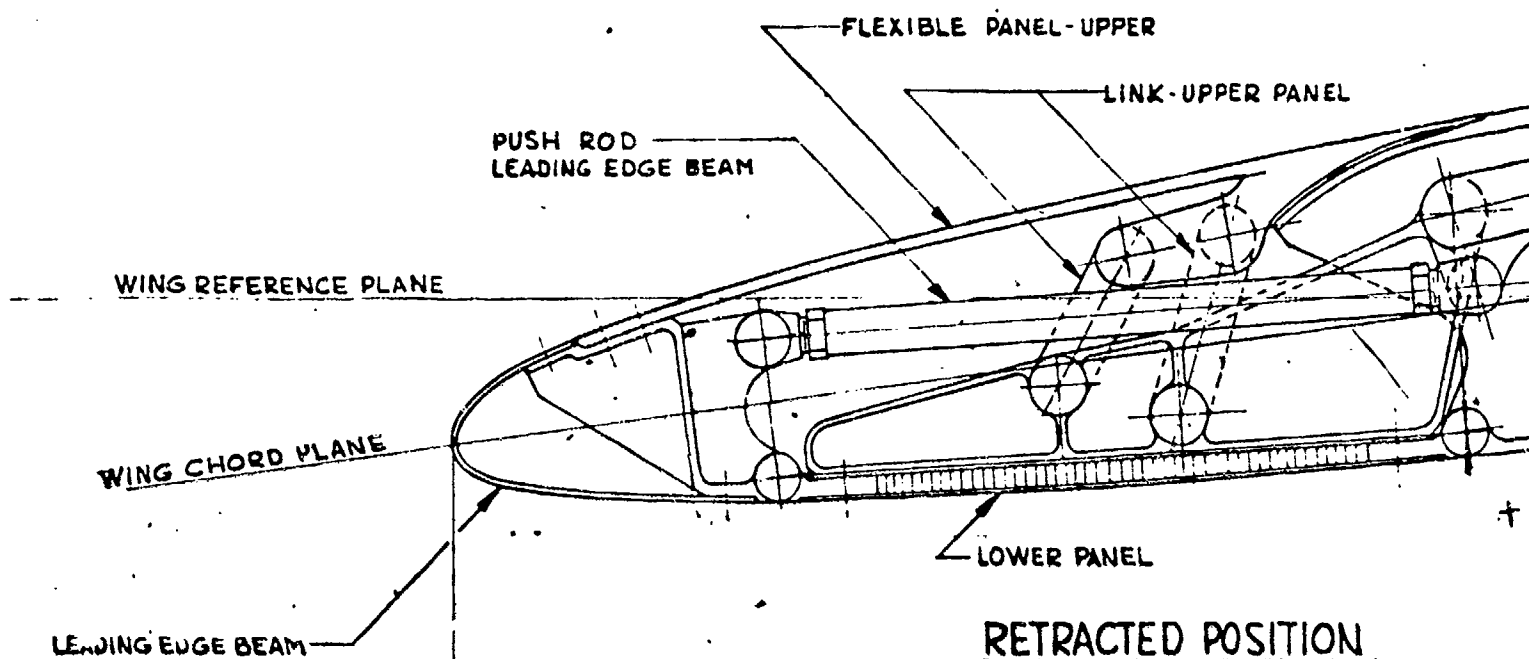
- 1-HAS THE REQUIRED LEADING EDGE EXTENSION FOR LANDING AND TAKE-OFF.
- 2-HAS SMOOTH CONTOUR AT SMALL ANGLES OF EXTENSION. (HIGH SPEED MANEUVER)
- 3- DOES NOT TRANSFER THE WING BOX STRESSES DIRECTLY INTO THE FLEXIBLE PANEL.
- 4- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK
- 5- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLOGY
- 6- HAS A SIMPLE MECHANISM.
- 7- ACTUATOR IS NOT IN THE PRIMARY STRUCTURAL LOAD PATH.

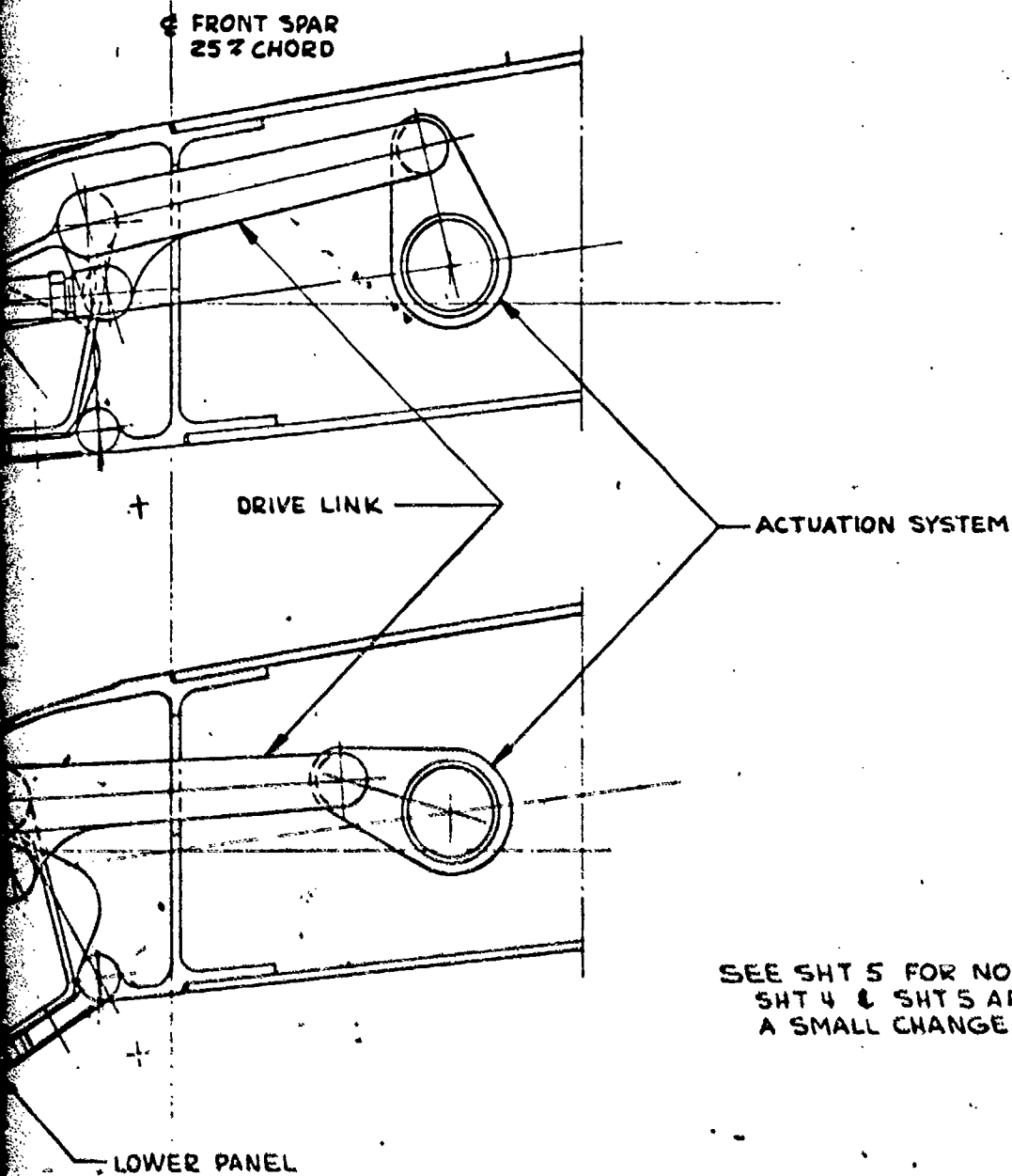
CON -

- 1-HAS A FLAT SPOT IN THE CONTOUR AT HIGH ANGLES OF EXTENSION. (LANDING AND TAKE-OFF)
- 2-REQUIRES A DEVELOPMENT PROGRAM.
- 3-HAS TWO SLIP JOINTS. (ONE UPPER, ONE LOWER)
- 4-UTILIZES THE FLEXIBLE SKIN AS A PUSH ROD IN THE MECHANISM TO LOCATE THE LEADING EDGE BEAM.
5. AT LARGE LEADING EDGE DEFLECTIONS THE AIRFOIL RADIUS ON THE UPPER SURFACE IS THE SAME AS SIMPLE HINGED LEADING EDGE.

LOWER PANEL
EXTENSION
35
2824 SHT 1
255.50

USED ON		DATE		THE BOEING COMPANY SEATTLE, WASHINGTON	
BY		DATE		LEADING EDGE FLAP VARIABLE CAMBER WING F-8 FLIGHT DEMONSTRATION	
M. M. KILGUS		5/11/73			
SEC. NO.		STRUCT.		D	
1405		5/11/73			
CIR. NO.		P. NO.		CODE IDENT NO.	
1405		1		81205	
PART. NO.		P. NO.		180-12821	
1405		1		PAGE FULL	





SEE SHT 5 FOR NOTBS
SHT 4 & SHT 5 ARE THE SAME EXCEPT FOR
A SMALL CHANGE IN LEADING EDGE ANGLE.

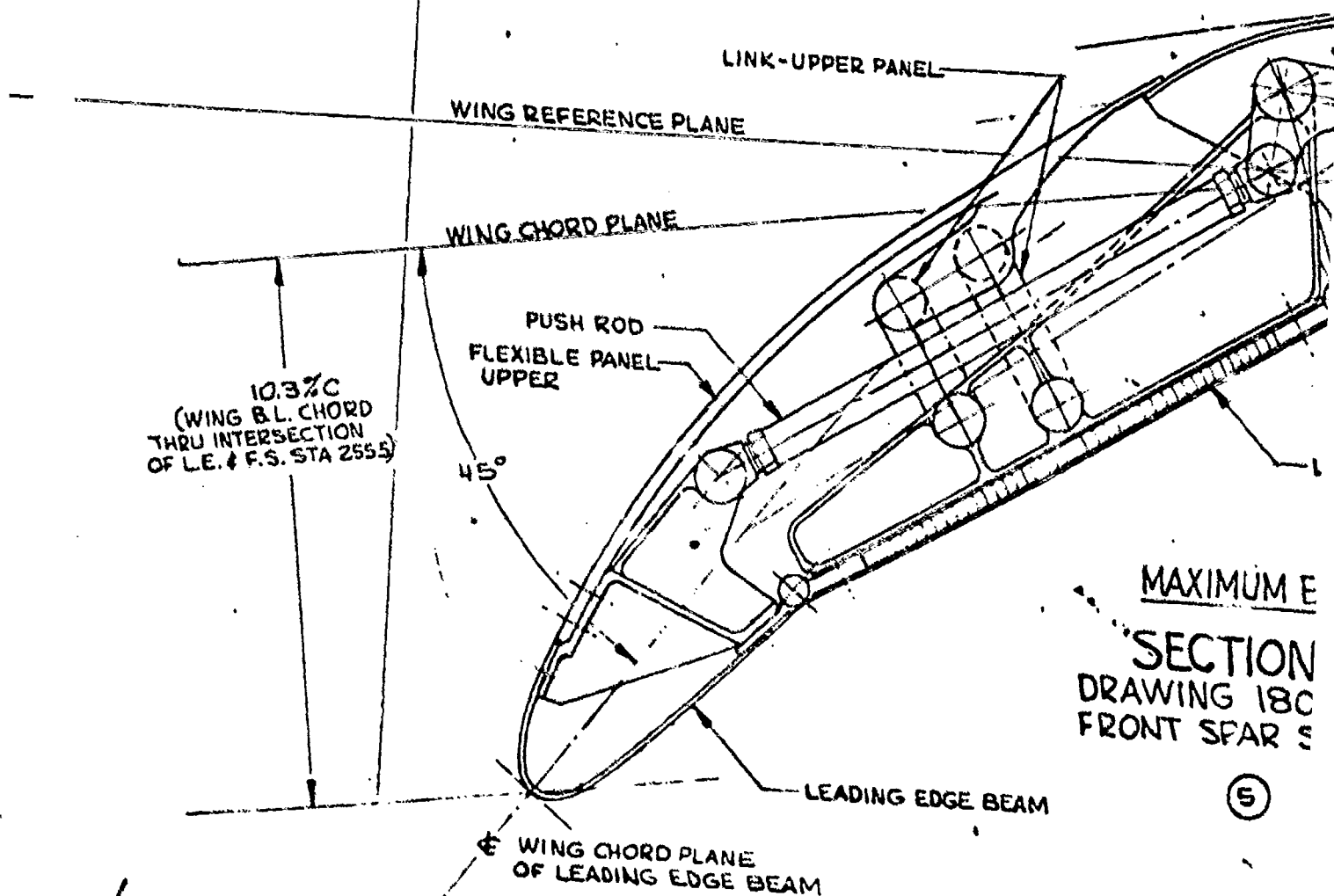
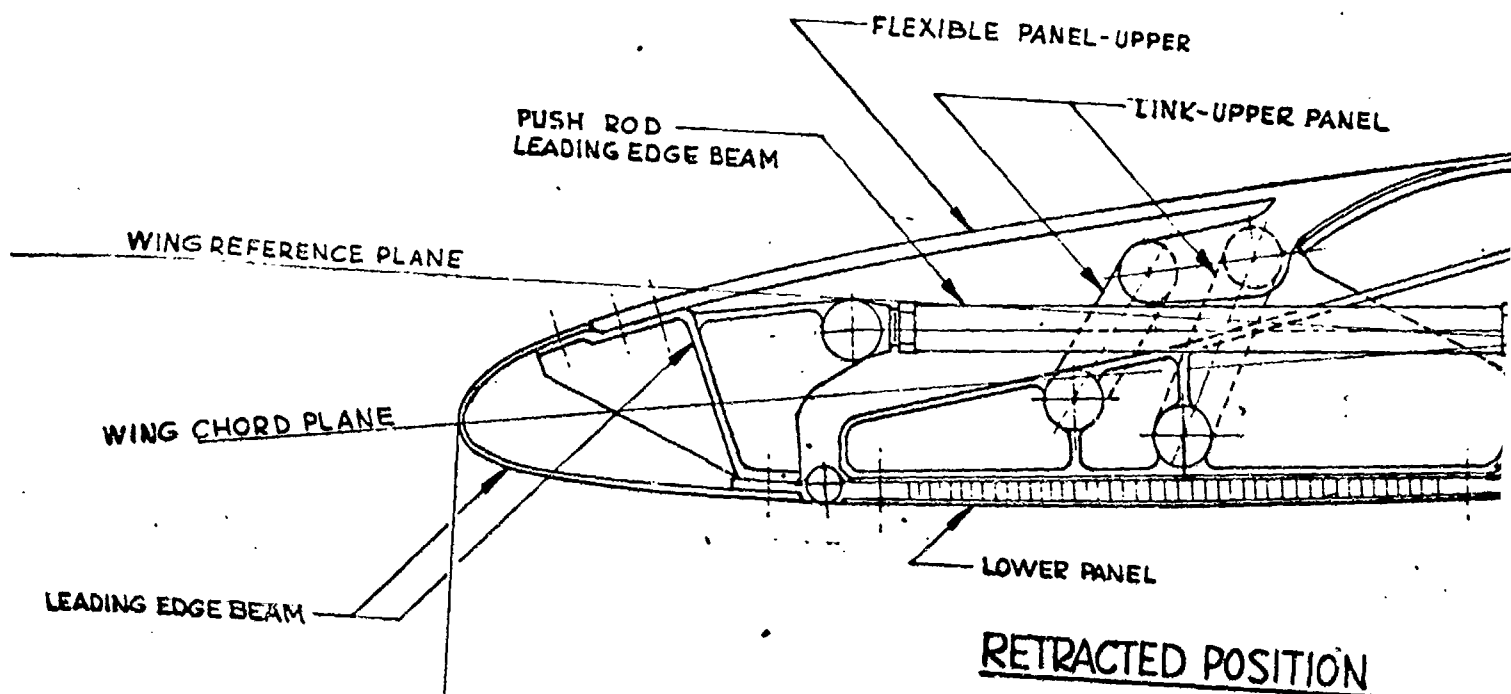
MINIMUM EXTENSION

SECTION 1B5
WING 180-12824 SHT 1
SPAR STA 255.50

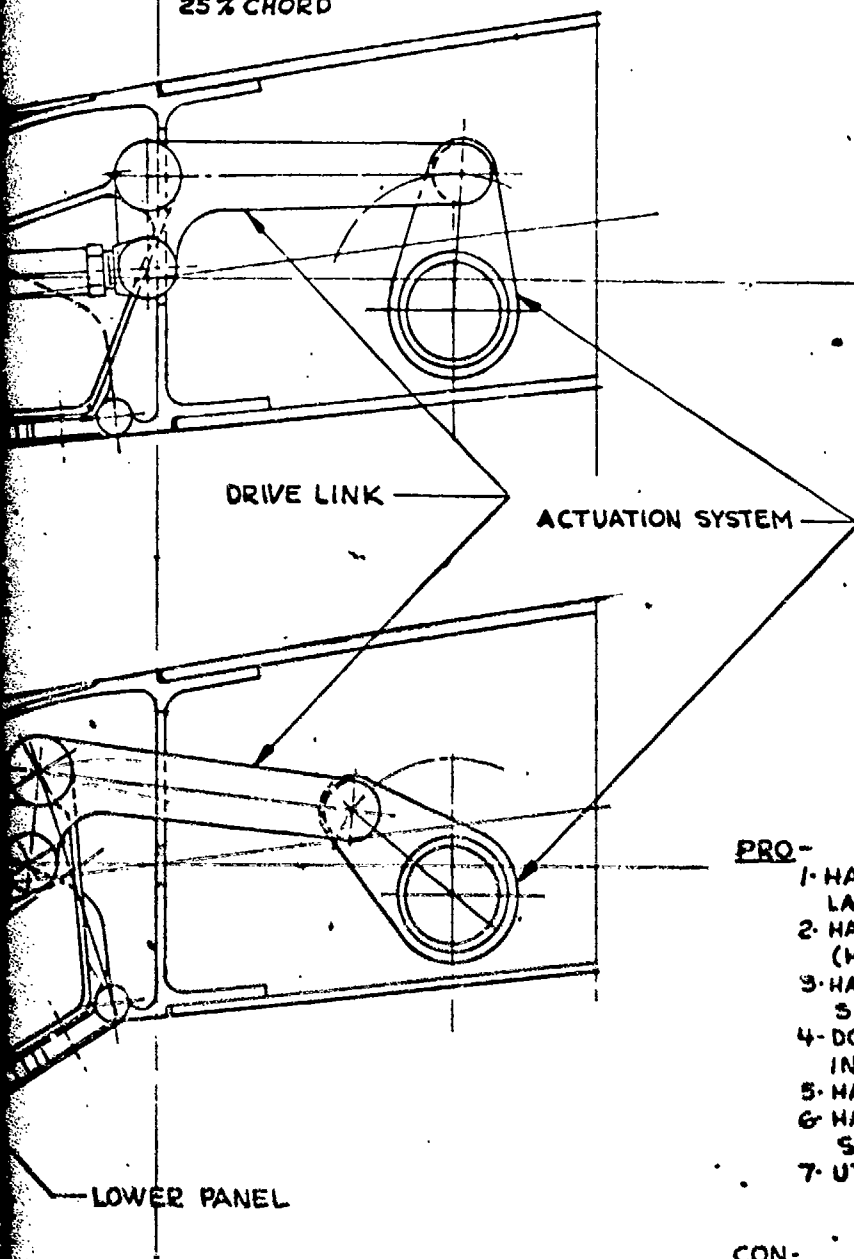
4

SEE SHEET 1 FOR LIST OF MATERIAL AND NOTES

USED ON	DATE	BY	THE BOEING CO.
		M. M. KINNEY	SEATTLE, WASHINGTON
SECTION	DATE	5-18-78	LEADING EDGE FLAP
CHG. NO.	DATE	5-18-78	VARIABLE CAMBER WING
			F-8 FLIGHT DEMONSTRATOR
			180-12824



♀ FRONT SPAR
25% CHORD



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PRO-

- 1- HAS THE REQUIRED LEADING EDGE EXTENSION FOR LANDING AND TAKE-OFF.
- 2- HAS A SMOOTH CONTOUR AT SMALL ANGLES OF EXTENSION. (HIGH SPEED MANEUVER)
- 3- HAS A MINIMUM WING AREA REDUCTION. (SAME AS A SIMPLE HINGE LEADING EDGE)
- 4- DOES NOT TRANSFER THE WING BOX STRESSES DIRECTLY INTO THE FLEXIBLE PANEL
- 5- HAS A SYMETRICAL DOUBLE SHEAR LINKAGE STACK-UP.
- 6- HAS A MINIMUM NUMBER OF SLIP JOINTS (ONE IN UPPER SURFACE)
- 7- UTILIZES THE 747 VARIABLE CAMBER FLAP TECHNOLOGY.

CON-

- 1- HAS A FLAT SPOT IN THE CONTOUR AT HIGH ANGLES OF EXTENSION. (LANDING AND TAKE-OFF)
- 2- DIFFICULT TO FABRICATE AND ADJUST
- 3- MECHANISM IS MORE COMPLICATED THAN BASELINE DESIGN.
- 4- REQUIRES A DEVELOPMENT PROGRAM.

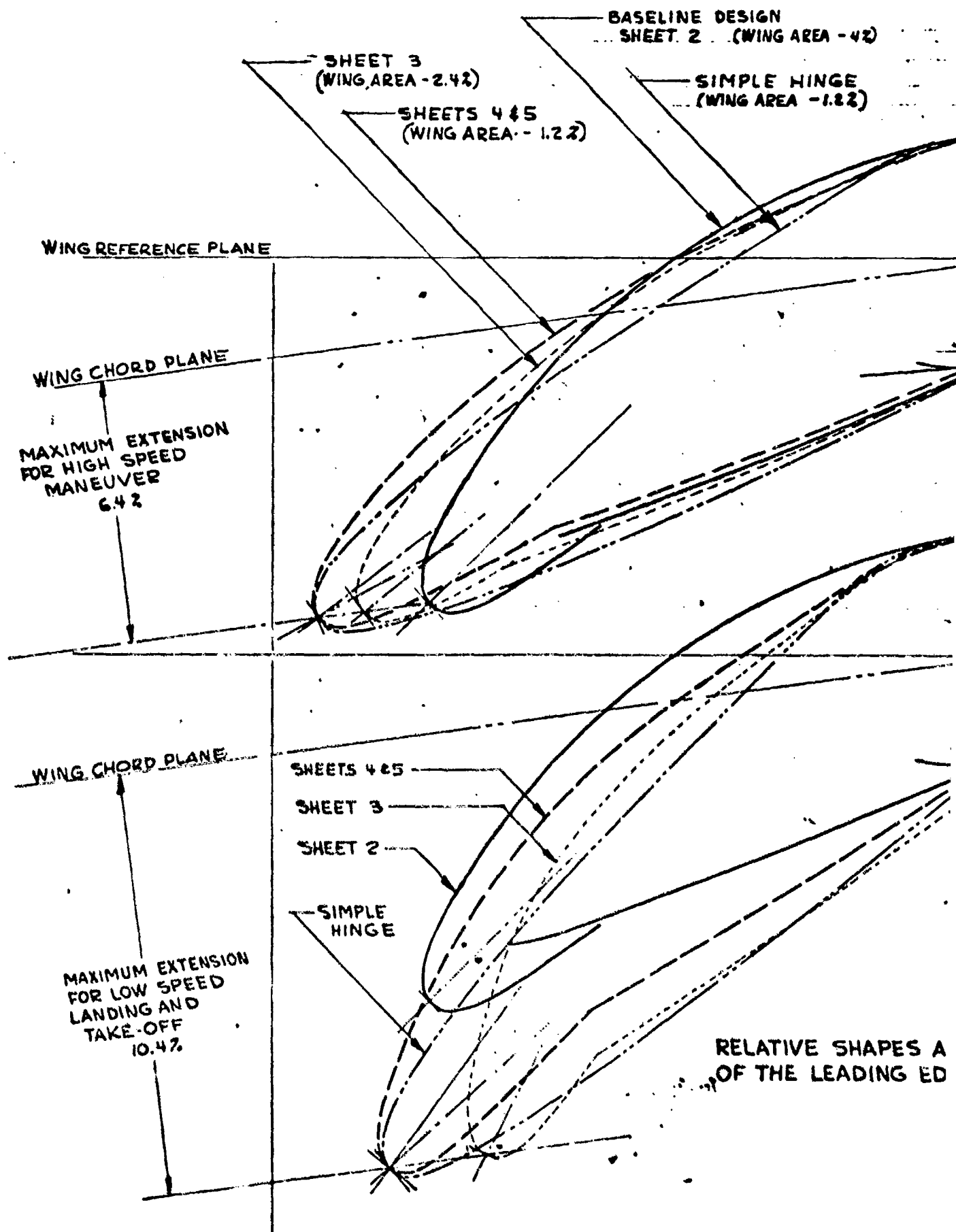
NUM EXTENSION

ION 1B5

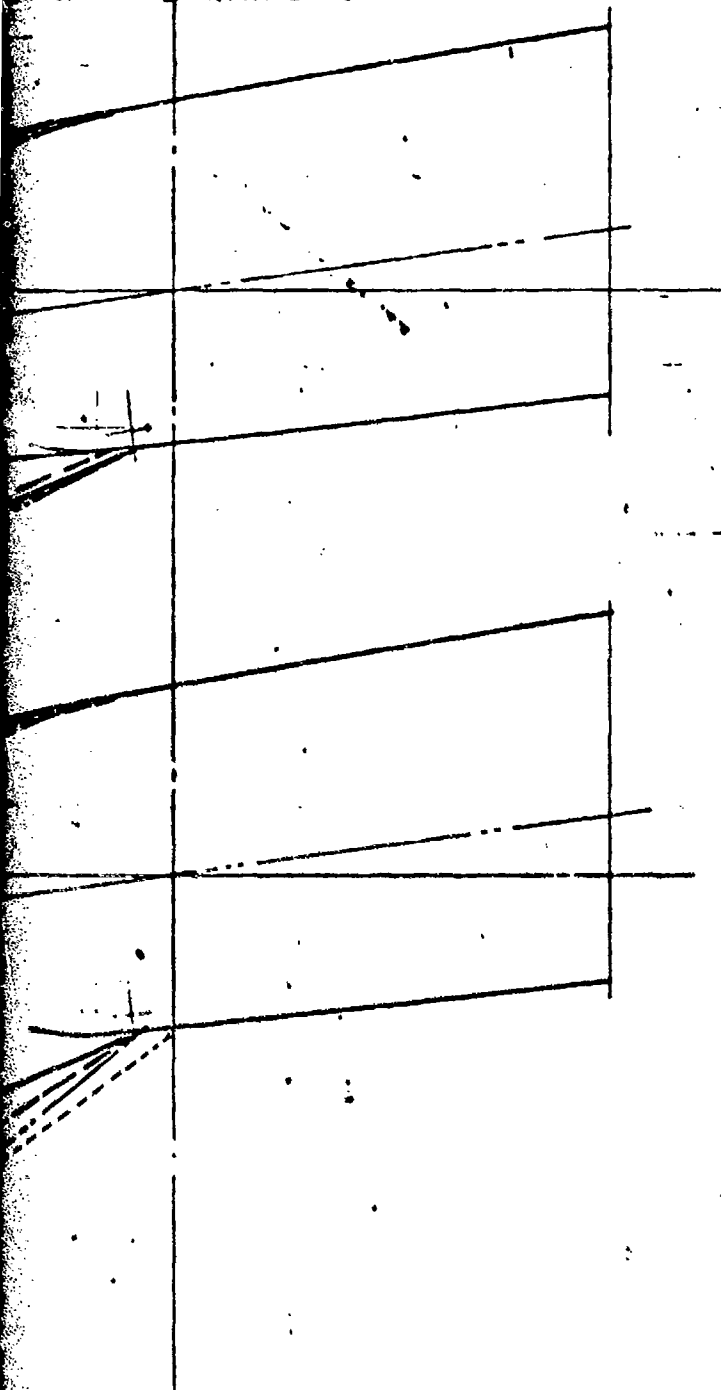
180-12824 SHT 1
PAR STA. 255.50

5

USED ON	C-73		THE DOEING COMPANY	
	BY M. McKinney	5-27-73	SEATTLE WASHINGTON	
SERIAL NO			LEADING EDGE FLAP VARIABLE CAMBER WING F-8 FLIGHT DEMONSTRATOR	
CHAS NO			180-12824	
DATE	5-27-73		D	
DATE OF NEXT			58205	
			5	



FRONT SPAR



ES AND EXTENSIONS
EDGE FLAP SYSTEMS

SEE SHEET 1 FOR LIST OF MATERIAL AND NOTES.

USED ON	CONTR		THE BOEING COMP
	DR M. McKINNEY	5-28-79	
SECT NO.	STRUCT		LEADING EDGE FLAP VARIABLE CAMBER WING F8 FLIGHT DEMONSTRAT
	ENG A. Adams	5-28-79	
ENG NO	GPR		SIZE D CORR IDENT NO 180-1282U
	PNO		

STRUCTURES

The main wing structural box has been sized and weighed. Leading edges based on the original design concept have also been sized.

Input data for the flutter analysis has been generated and results will be available during the coming month.

Potential flow theoretical pressures have been computed for the basic wing and with the leading edges drooped 30 degrees. They confirm the assumption that leading edge upper surface pressures approach a vacuum at buffet lift coefficients.

3.0 NEXT REPORT PERIOD PROJECTION

During the next report period the principal effort will involve conduct of the wind tunnel tests at NASA Ames Research Laboratory and analysis of the data from the initial series of tests.

The structural design trades will continue and the loads, stress, flutter and weights analyses will near completion.

Safety and failure mode analyses of the control systems will be conducted.

4.0 EXPENDITURE STATUS

As of mid-June 1973, the program expenditures are within the revised forecast.