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TITLE

Feasibility Study, XC-142A Modified For Open Ocean Operation

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ABSTRACT

A study has been performed to determine the feasibility of developing a seaplane version of the Model XC-142A airplane. A STOL seaplane version and a VTOL seaplane version of the Model XC-142A airplane, both fitted with inflatable vertical floats, were studied, and the feasibility of developing both of these airplanes was established. As a result of this feasibility study, it is recommended that further engineering work be done to establish the validity of the assumptions used in this study.

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1. PURPOSE

Many methods of antisubmarine warfare are being studied to cope with the quiet, deep running, nuclear submarine threat. One promising method involves the use of an airplane capable of sitting on the ocean surface with its engines shut down. Such a system is capable of staying on station for long time periods (days rather than hours), and it is also very quiet while sitting on the water. The conduct of ASW sonar search in such a quiet environment improves the sensitivity of the sonar equipment and the alertness of the crew, and the system is much less likely to be detected by a submarine than would be a hovering helicopter.

Previous experiences have shown conventional seaplanes unable to operate from open ocean areas except under relatively calm sea conditions. These experiences have also uncovered severe problems due to the crews getting motion sickness. The advent of the V/STOL airplane and its ability to land with little or no forward speed offers the potential of avoiding the severe water impact loads encountered by the conventional seaplanes landing in rough seas. The recent development of the inflatable vertical float concept offers a means of making the airplane sitting on the open ocean surface a more stable platform thus alleviating the crew motion sickness problem and further improving the sonar performance by reducing noise transmitted by the airplane into the water. The purpose of this study is to determine feasibility of developing a V/STOL airplane capable of operating from open ocean areas with surface conditions up to a sea state four. This feasibility has been determined by studying problems associated with modifying a Model XC-142A airplane to operate from open ocean areas. The Model XC-142A airplanes modified to operate from open ocean areas are hereafter referred to as Model V-464 airplanes.

The Model XC-142A airplane is a V/STOL transport airplane being developed under contract to the U. S. Air Force as management agency for the Department of Defense. Five prototype airplanes are being built and tested for operational suitability by all three military services. The Model XC-142A airplane is a high wing transport airplane, powered by four T64-GE-1 turboshaft engines driving four propellers through an interconnected transmission system, and using the tilt-wing-deflected slipstream concept to attain the V/STOL capability. It made its first flight in September of 1964.

The approach used in this study has been to develop a VTOL and a STOL V-464 airplane configuration, and to evaluate the technical problems, risks and weight penalties associated with each of these configurations. From this evaluation it was reasoned that feasibility of development could be established and major technical problems defined.

The following study ground rules were selected in conjunction with personnel of Code RA-5 of BuWeps:

- The STOL V-464 is to have a seaplane hull and the buoyancy of the hull is to be sufficient to give the propeller tip and/or the wing flap trailing edge, with the wing at its most critical operational tilt angles, a three-foot clearance above the static water line. The STOL V-464 airplane is to be fitted with auxiliary wing tip floats which provide lateral buoyant stability.
- Both the VTOL and STOL V-464 airplanes will sit in the open ocean on inflatable vertical floats which will make the V-464 a stable platform for on-the-water operations. These floats will be sized to keep the bottom of the hull (or fuselage) at

least seven feet above the static water line. The inflatable vertical floats should be designed to withstand loads caused by a five knot movement through the water.

- The configurations of both the VTOL and STOL Model V-464 airplanes will deviate as little as possible from that of the Model XC-142A airplane.

The concept of open ocean operation for the VTOL V-464 airplane is to take off vertically, retract the inflatable vertical floats, and transition to conventional flight. For landing, the transition to hover is made, the inflatable vertical floats are extended while the airplane hovers, and then it is set down on the open ocean vertically.

The concept of open ocean operation for the STOL V-464 airplane is to tilt its wing to 40° (flap deflected to 30°) and takeoff in a STOL mode after a very short water run. The transition to conventional flight is made after the airplane becomes airborne. For the landing cycle, the airplane makes a transition to the landing configuration (40° wing incidence and 60° of flap deflection) and lands on the water at a low airspeed (approximately 30 knots). Once the airplane is at rest on the water, it "jacks" itself up on the inflatable vertical floats. Prior to taking off, the inflatable vertical floats are retracted. For this study, the VTOL airplane takeoff weight was selected as 37,500 pounds and the STOL airplane weight was selected as 45,000 pounds.

The structural characteristics of the inflatable vertical floats have been given to LTV Vought Aeronautics for this study by Goodyear Aerospace Corp., and Mr. E. H. Handler, BuWeps, RAAD-343, has guided LTV in selecting the hydrodynamic configurations of the STOL V-464 airplane and of the inflatable vertical floats.

2. <u>GENERAL DATA</u>

a. REFERENCES

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(21) Locke, F. W. S., Jr., "A Graphical Method for Interpolation of Hydrodynamic Characteristics of Specific Flying Boats from Collapsed Results of General Tests of Flying Boat-Hull Models," NACA TN 1259, January 1948.

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(23) Blakeslee, D. J., Johnson, R. P., and Skandahl, H., "A General Representation of the Subsonic Lift-Drag Relation for an Arbitrary Airplane Configuration," Rand Corp., RM-1593.

(24) "Martin Model M-270, Water Loads Investigation," Martin Report ER-7516, November, 1955.

(25) "Estimated Weight and Balance, Model XC-142A," LTV Report No. 2-53460/2R-45, May 1962.

(26) "MIL-HDBK-5 Metallic Materials and Elements for Flight Vehicle Structures," August 1962.

(27) Cox, J. W., "Structural Behavior of Seaplane Hull Bottom Plating," I.A.S. Preprint No. 586, January 1956.

b. FORMULAE

(1) STOL V-464 Hull Impact Loads

The following criteria was used to determine hull impact loads in a sea state four for the STOL V-464 airplane. The Martin Company Report ER 7516 "Martin Model M-270, Water Loads Investigation; Hull Bottom Pressures and Impact Loads," November 1955, reports that the load equations specified in MIL-A-8629 (AER) and ANC-3 were obtained from the impact theory of Milwitzky's investigation, which is reported in NACA TN No. 1516, with simplifying assumptions applied to give satisfactory results for hulls of conventional design. The application of Milwitzky's work for shallow impacts at the lower trims was recognized by Schmitzer and reported in NACA TR No. 1152, which is a report on the theory and procedure for solving impact loads on chine-immersed bodies.

By preliminary calculations for hull step landing of the STOL V-464 seaplane, it was found that the chines do not immerse at maximum acceleration. Therefore, the formulae, symbols, and procedure of Milwitzky's work were applied to the STOL V-464 range of parameters. The equation

$$Niw_{max} = \frac{\ddot{y}}{g} = \frac{C_{1_{max}} \dot{Y}o^2 \left(\frac{\alpha g}{w}\right)^{1/3} \phi\ (A) = 1}{32.2}$$

where Niw_{max} is the maximum load factor

$\ddot{y}$ = maximum acceleration - ft./sec.^{2}

g = 32.2 ft./sec.^{2} (gravity)

$C_{1_{max}}$ = maximum load factor coefficient

$\dot{Y}o$ = effective initial sink speed - ft./sec.

$\left(\frac{\alpha \zeta g}{w}\right)^{1/3}$ = scale factor (see figure 13)

and $\Phi(A) = 1$ Aspect-ratio reduction factor provides results that are considered sufficient for this phase of the study.

(2) Inflatable Vertical Float Loads

The following analysis is a determination of the loads on the inflatable vertical floats during VTOL water landings and sea sitting conditions. The condition of the water surface was assumed to correspond to that described by sea state four.

The results, determined for the described loading conditions, include the drag and bouyant forces on the floats and the resulting loads transmitted to the float attachment fittings on the fuselage and wing tips (or auxiliary floats).

(a) Design Parameters

The loads analysis is based on the following operating conditions, design parameters, and limiting assumptions.

1. Float Dimensions

Figure I illustrates the position of the floats, their size and spacing. The float dimensions used for the preliminary loads analysis are listed in Table I for the 37,500 lb. VTOL V-464 airplane with conventional fuselage and for the 45,000 lb. STOL V-464 airplane with a sea-plane type hull and auxiliary pontoon floats.

2. Sea State

A sea state four condition was interpreted to be described by waves of maximum height of eight ft. (through to crest) and minimum length to height ratio of 20. The speed of advance of such a wave is approximately 20 knots for a fully developed sea. The relative drift rate between airplane and water during landings and sea sitting operations is assumed to have a maximum value of five knots.

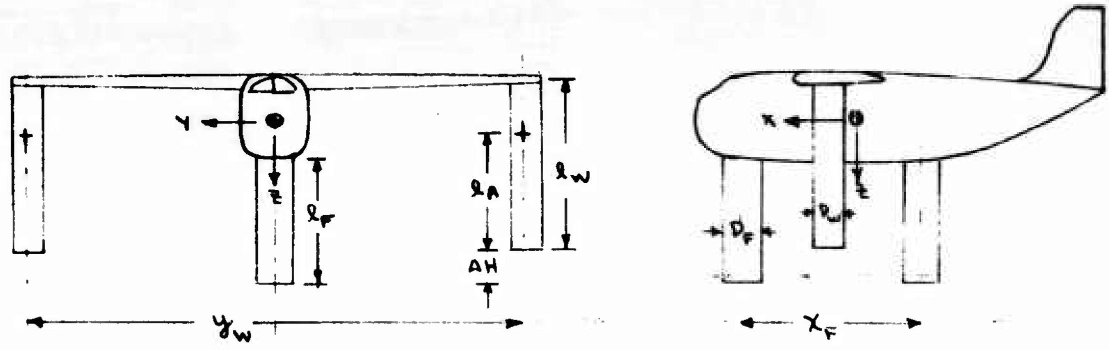
3. VTOL Landing Conditions

A range of impact sink speeds between four and 16 fps, combined with an initial drift rate of five knots was considered for the landing analysis.

In order to determine critical loads, it was necessary to study the variation in the loads caused by impact at different prints of a typical sea state four wave form. This assumes that the wave shape remains constant during the short period of time considered and that the horizontal position of the wave form with respect to the airplane is also unchanged in this period of time.

FIGURE 1'

FLOAT DIMENSIONS



Y-Z PLANE

X-Z PLANE

FIGURE 2'

INFLATABLE FLOAT APPLIED LOADS

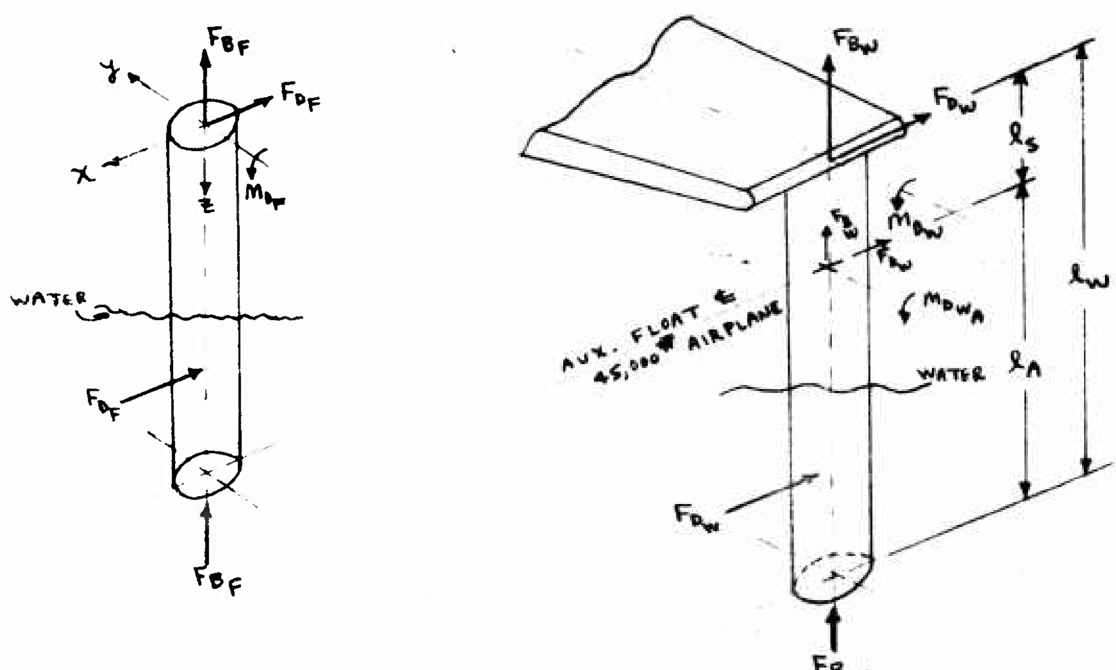
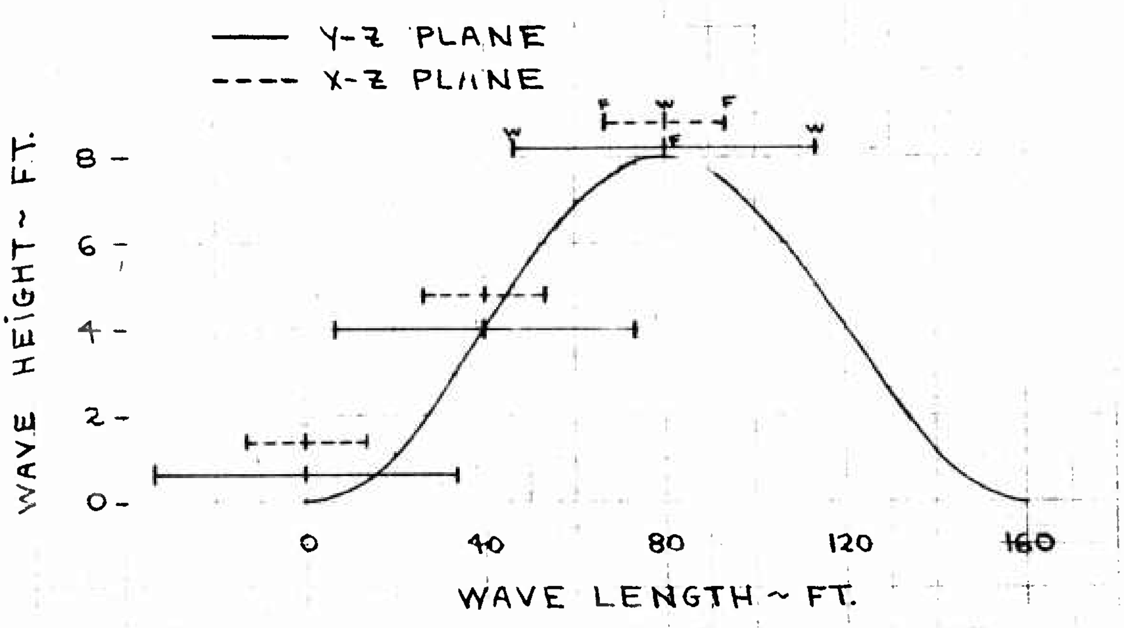


Figure 3' shows the relative position between the floats and a wave form having the dimensions previously described. Three possible landing positions are shown: crest, trough, and maximum slope point on the wave. In figure 3', the solid lines represent the relative position for superposition of the Y-Z plane of the airplane on the wave form. The dotted lines represent superposition of the X-Z plane. Figure 1' and Table 1 give the float dimensions.

FIGURE 3'

SUPERPOSITION OF FLOAT POSITIONS ON SEA STATE 4 WAVE FORM



The relative water penetration into the wave form of the fuselage and wing floats can be scaled off of the figure. The fuselage floats are longer than the wing floats and strike the water first. The impact analysis has two parts: (1) fuselage float penetration up to the point where wing floats touch and (2) motion after all floats submerge.

Table 2 is a listing of the incremental immersion of the fuselage floats as scaled from figure 3. This method is based on the further assumption that pitching or rolling motion is negligible during the short period of time considered. The critical load conditions for the fuselage and wing floats are selected from the possible wave impact cases of Table 2. For the preliminary loads, this will be the condition that produces maximum float immersion, since the drift rate is assumed constant and the vertical drag force on the floats is small compared to the float bouyant forces.

4. Sea Sitting Condition

During the sea sitting condition, the airplane is subjected to translational, rolling, and pitching motion. Here again, in order to simplify analysis, it is assumed that the effects of pitching or rolling are small compared to a vertical heaving motion produced by a passing wave. It will be assumed that the airplane is accelerated vertically from a float sea static position by a passing wave having the dimensions previously described. The passage of a wave of this size, at a speed of advance of 20 knots, produces vertical wave motion at a velocity of approximately four fps. This value is used in the analysis of sea sitting conditions. The relative drift rate between the airplane and the water is assumed to be five knots.

TABLE 2

IMMERSION DEPTH OF FUSELAGE FLOATS PRIOR TO WATER CONTACT OF WING FLOATS

	Impact Point	(a) Y-Z Plane	(b) X-Z Plane
1.	Wave Crest	7 ft.	3.5 ft.
2.	Wave Trough	1	4.5
3.	Flat Sea (ref.)	4	4
4.	Wave Maximum Slope	0 8	6

(b) Dynamic Model of Airplane

The dynamic model used to represent the airplane and the inflated floats is shown in figure 4A. The figure illustrates a rigid airplane that has translational motion only. The positive Z motion is directed downward to correspond to the direction in which the airplane is sinking on landing. The motion in the X or Y coordinate, depending upon direction of lateral drift, is at a constant velocity of five knots for the preliminary loads analysis.

The floats are assumed to be sufficiently rigid to prevent significant bending or other distortion during landing impact.

Figure 4B indicates the forces acting on the airplane during motion of the dynamic model of figure 4A. As the floats penetrate the water, the vertical force on each float is a function of the sinking rate, the total immersion, and the drag characteristics of each float.

The vertical float forces are then represented as:

Fuselage Float

$$\text{Bouyant Force} = F_{BF} = K_{BF}Z \quad (1)$$

where K_{BF} = bouyant force per ft. of water penetration

Z = total immersion of fuselage float.

$$\text{Vertical Drag Force} = F_{CF} = Q_{FZ}S_{FZ} = (1/2\rho_w \dot{Z}^2 C_{DZ})\, A_{FZ} \quad (2)$$

where A_{FZ} = float cross-sectional area in X-Y plane.

The total force on the fuselage is then:

$$F_{ZF} = F_{BF} + F_{CF} = K_{BF}Z + 1/2\rho_w \dot{Z}^2 C_{DZ}A_{FZ} \quad (3)$$

Wing Float

$$\text{Bouyant Force} = F_{BW} = J_{BW}\,(Z-\Delta H) \quad (4)$$

where ΔH = fuselage float immersion prior to contact of wing floats.

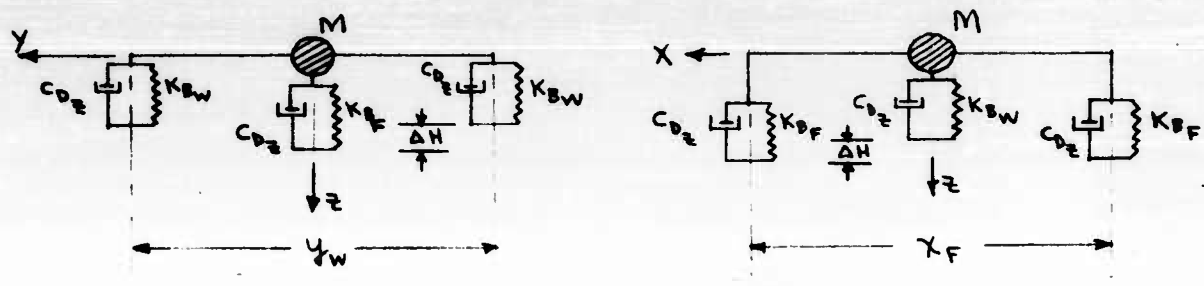
$$\text{Vertical Drag Force} = F_{CW} = Q_{WZ}\, S_{WZ} = (1/2\rho_w \dot{Z}^2\, C_{DZ})\, A_{WZ} \quad (5)$$

and

FIGURE 4'

DYNAMIC MODEL FOR WATER LANDING

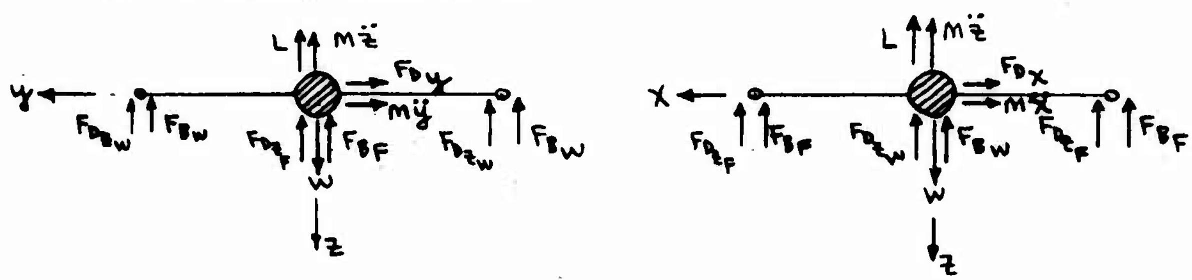
A. SPRING-MASS-DAMPER MODEL



Y-Z PLANE

X-Z PLANE

B. FORCE DIAGRAM



Y-Z PLANE

X-Z PLANE

$$F_{ZW} = F_{BW} + F_{CW} = K_{BW}\,(Z - \Delta H) + 1/2\,\rho_w\,\dot{Z}^2$$

$$C_{DZ}\,A_{ZW} \qquad (6)$$

It is assumed that all floats have the same vertical drag coefficient, C_{DZ}.

Summing up all of the forces, the differential equation representing the Z motion of the airplane is

$$M\ddot{Z} + 2\,F_{ZF} + 2\,F_{ZW} = W - L \qquad (7)$$

where L = Aerodynamic lift, plus Engine thrust

or

$$M\ddot{Z} + 2(K_{BF}Z + 1/2\,\rho_w\,\dot{Z}^2\,C_{DZ}\,A_{FZ}) +$$

$$2\left\{K_{BW}(Z - \Delta H) + 1/2\,\rho_w\,\dot{Z}^2\,C_{DZ}\,A_{WZ}\right\} = W - L \qquad (8)$$

where for a VTOL landing, $L = 2/3\,W$.

For lateral drift motion, it has been assumed that the floats are relatively inflexible, so the lateral forces are a function only of the drift rate.

<u>Fuselage Float</u>

$$\text{Drag Force} = F_{DFX} = Q_{FX}\,S_{FX} = (1/2\,\rho_w\,\dot{X}^2\,C_{DX})A_{FX}$$

$$= (1/2\,\rho_w\,\dot{X}^2\,C_{DX})\,D_W(Z- \quad H)$$

$$(\ ) \ (\ - \ ) \qquad (9)$$

<u>Wing Float</u>

$$\text{Drag Force} = F_{DWX} = Q_{WX}\,S_{WX} = (1/2\ \ w\,\dot{X}^2\,C_{DX})\,A_{WX}$$

$$= (1/2\,\rho_w\,\dot{X}^2\,C_{DX}) \quad (D_W)\,(Z - \Delta H) \qquad (10)$$

and

$$F_{DX} = 2\,F_{DFX} + 2\,F_{DW}$$

$$= 2\left\{(1/2\,\rho_w\,C_{DX}\,D_F)\,\dot{X}^2 Z + (1/2\,\rho_w\,C_{DX}D_W)\,\dot{X}^2\right.$$

$$\left.(Z - \Delta H)\right\} \qquad (11)$$

The applied loads on the floats are illustrated in figure 2. The vertical drag forces F_{CF} and F_{CW} are not shown because they are assumed negligible for the preliminary loads analysis. The lateral drag forces F_{DF} and F_{DW} are shown with one axial orientation, but in analysis of loads at the fuselage and wing tips all possible axial orientations are considered.

The drag moments generated are:

$$M_{DF} = F_{DF} \left(l_F - \frac{Z}{2} \right) \tag{12}$$

$$M_{DW} = F_{DW} \left[l_W - \frac{(Z - \Delta H)}{2} \right] \tag{13}$$

The longitudinal of buckling stress produced in the float fabric can be expressed as

$$\sigma_{LF} = 1/12 \left[\frac{4M_{DF}}{\pi D_F^2} + \frac{F_{BF}}{\pi D_F} \right]$$ lbs. per inch of fuselage float fabric thickness (14)

$$\sigma_{LF} = 1/12 \left[\frac{4M_{DW}}{\pi D_W^2} + \frac{F_{BW}}{\pi D_W} \right]$$ for the wing float (15)

In the case where vertical drag force is significant, the bouyant forces in the equations would be replaced by $F_{ZF} = F_{BF} + F_{CF}$ and $F_{ZW} = F_{BW} + F_{CW}$.

The stress equations as written here correspond to those derived by Goodyear Aerospace Corp. for the V-464 for various float dimensions and recommended operating pressures. However, the required operating pressures are modified to correspond to fabric tension as derived from equations (14) and (15) from which M_{DW} and F_{BW} are determined.

The required float operating pressure and total weight of the fabric in one "sea leg" are obtained from the following formulae.

$$\sigma_L = \frac{pD}{4} \quad \text{or} \quad p = \frac{4\sigma_L}{D} \qquad (16)$$

where σ_L = longitudinal inflation stress in pounds per inch of circumference times unit inch of thickness of fabric.

p = internal pressure, psi

D = diameter of "sea leg," inches

$W_{Total} = 144 \times 10^{-6} p \, V_T$, an empirical formula

where W_{Total} = total weight of the fabric in one "sealeg," pounds

p = internal pressure in psf

V_T = inflated volume in cubic ft.

c. SYMBOLS

(1) Notation

A	Area
b	Width of a section
C_D	Drag coefficient
D	Diameter
F	Force
F	Primary stress
g	Acceleration of gravity
FH	Froude number
H	Cylinder length
ΔH	Fuselage float immersion prior to wing float
I/C	Section Modulus
i	Wing incidence angle
K	Constant
l	Length
l/r	Slenderness ratio
L	Moment about the X axis
M	Airplane mass
M	Moment about the Y axis
N	Moment about the Z axis
P	Total applied load
Q	Flow pressure
q	Shear flow
R	Reaction load
S	Flow area
s	Shear force

T	Applied torsional moment
t	Time
t	Thickness
W	Airplane weight
X	Dimension in the longitudinal direction
Y	Dimension in the lateral direction
Z	Dimension in the vertical direction
ρ	Density
ω	Harmonic frequency
σ_L	Longitudinal stress

(2) Subscripts

A	Auxiliary float
A	STOL airplane auxiliary float
B	Buoyant
b	Bending
c	Compression
D	Drag
F	Fuselage
O	Initial
s	Shear
t	Tension
W	Wing
X	Longitudinal
Y	Lateral
Z	Vertical

d. SPECIAL PROCEDURES

(1) Wing Load Distribution

The wing load distributions and unit solutions for the XC-142A wing and as reported in LTV Report Numbers 2-53420/4R-916, 2-53420/4R-902, and 2-53420/4R-915 were used for comparison with the V-464 loads. This approach provided a means of rapidly evaluating the extent and significance of the latter critical design loads.

(2) Wing Stress Analysis

The wing stress analysis performed to establish the required wing "beef up" uses data from LTV Report Numbers 2-53420/2R-800 and 2-53420/4R-908 to compare with stress analysis data for the V-464. This comparison is used to rapidly develop the extent of the required "beef up" of the wing structure.

3. DETAIL DATA

a. CONFIGURATION, AIRFRAME, AND SYSTEMS DESIGN

(1) STOL V-464

(a) Configuration

The configuration for the STOL V-464 airplane is determined by using the existing XC-142A fuselage lines, adding a seaplane hull below Z 100, incorporating rotating auxiliary floats at the wing tips, redesigning the main and nose alighting gear, removing the cargo ramp and associated fairings and increasing the size of the front entry door to allow for cargo loading and unloading. These changes permit seaplane operations. The addition of inflatable vertical floats to the basic amphibian configuration provide a table platform for water operation in rough seas up to sea state four.

The seaplane hull configuration is determined by using data furnished in reference (1) for Model No. 339-22, designation 5.07-7-20. The 105 inch beam and 20 degree deadrise angle are in agreement with the Stevens Institute model. A rounded forebody keel arrangement similar to that described in reference (24) was studied for the STOL V-464, but with the slow landing speeds of this airplane, little advantage for this shape was found. A clearance of 36 inches of the flap trailing edge in conjunction with a 40 degree wing incidence and 60 degree flap deflection is used to establish the static waterline for the hull displacement. The floats were located vertically such that they are below the static water line, thus providing lateral stability for the airplane in the water. Inflatable vertical floats are located in the hull and within the auxiliary floats. The inflatable vertical float static waterline is established by requiring seven foot clearance below the bottom of the hull. The general arrangement of the STOL V-464 airplane is shown in figure 1 for the hull with the 20° deadrise angle and in figure 2 for the hull with the rounded forebody.

(b) Airframe

Airframe construction is consistent with the requirements set forth in references (2), (3), (4), and (5).

1. Fuselage

The use of existing structural components of the XC-142A is considered feasible for fuselage structure above Z 100, while structure below this point will require complete redesign and analysis with the exceptions of the cargo floor. A 60 x 72 in. cargo door is added by increasing the size of the present front door and becomes the prime cargo loading/unloading opening. Removal of the rear cargo ramp, ramp doors and fairing are replaced with fixed structure designed for airloads above Z 100 and water loads below this point.

All structure in contact with the water and subject to water spray is of corrosion resistant materials.

2. Wing

Wing structure will remain essentially intact with the exception of local reinforcement to the wing torque box outboard of the inboard nacelle. STOL landing loads on the auxiliary floats were small when compared to inflatable vertical float loads which are large enough to require wing structural reinforcement. This reinforcement consists of additional stiffeners, greater front and rear beam cap area and increased skin gauges.

Rotation of the auxiliary float pylon is required to provide the flexibility of either STOL or VTOL operation. A four degree angle of attack on the auxiliary float is used during the landing operation. Rotational motion is provided by restraining a pylon shaft in a bearing housing installed between the front and rear beam of the wing torque box. Actuation and structural description of the rotation mechanism for the auxiliary float pylon is similar to the rotational mechanism for the wing mounted inflatable vertical floats and is described in that section of this report.

3. Vertical and Horizontal Tail

Additional vertical tail area is required to keep the directional stability of the STOL V-464 equal to that of the XC-142A. Flight tests have not at yet established the directional stability characteristics of the XC-142A sufficiently accurate that it can be said that its level of directional stability is needed; therefore, the general arrangement drawings of the STOL V-464 airplane show only the XC-142A vertical tail.

The horizontal tail size is not expected to change.

4. Auxiliary Float and Pylon

Amphibian transverse stability is provided by a rotating auxiliary float at each wing tip. Auxiliary float-pylon rotation permits the float to remain level for various positions of wing incidence in addition to permitting the vertical extension of the inflatable floats in the water. The pylon is fixed to an aerodynamic fairing housing a pivoting shaft. Auxiliary float displacement volume is determined by the emperical formula of reference (2). Standard float construction and design is used with the exception of adding storage and structural provisions for the inflatable floats, reel, reel actuation mechanism, inflatable float doors with actuaters and provisions for float structural restraint.

(c) Systems

The STOL V-464 systems will remain essentially the same as those of the XC-142A with the following exceptions.

1. Alighting Gear

Alighting gear redesign to the nose and main gear is required by the change of ground lines, contours, maximum gross weight and operational field requirements. Addition of a seaplane hull required a deeper fuselage and longer gear struts with attendant changes in gear geometry. The retaining of the same XC-142A turnover angle increased the main gear tread while the nose gear was moved forward to clear the forward fuselage inflatable float. A 36 x 11 Type VII single wheel main gear, UCI of 32 and 20 x 5.5 Type VII dual wheel nose gear UCI of 30 will permit minimum runway operation from flexible pavement and landing mats. The alighting gear is designed to withstand seawater corrosion and the gear wells are designed as water-tight compartments.

2. Inflatable Vertical Floats

The inflatable vertical float system consists of four inflatable, elastomer impregnated fabric floats capable of extension and retraction from reel gear box driven and powered by a hydraulic motor. The structural attachment of the floats to the airframe structure is subject to further analysis although preliminary work shows the landing and sitting loads are within acceptable limits. Several unknown factors dictate prototype fabrication and testing and only an approximation to the actual proposed operational system was investigated. In each of the four floats, a hydraulic motor-gear box combination is used to power the retraction mechanism which draws the fabric material up the center of the float and on to the spool of the reel. Extension is accomplished by unreeling the fabric and applying air pressure to the float. Enough space is allocated within the reel to account for wrinkles, folds and uneven retraction on the spool with a volume three times greater than the volume of the float material. Two methods of inflatable vertical float fabrication have been studied. One is by a standard sewing technique and the second by filament winding. Filament winding would produce a seamless float structure compatible with pressure vessel design. The filament wound float is shown in the fuselage floats of figures (1) and (2).

Fuselage float support structure includes pressure bulkheads forward and aft of the reel, a circular frame to carry float loads to fuselage, gearbox bulkhead supports, and the inflatable float doors with their actuating mechanisms. Additional work remains to be done in sufficient detail to establish the mechanical tie of the float fabric to the airframe structure in order to provide a pressure tight joint as well as a sound structural attachment.

Tests conducted by the Convair Division of General Dynamics on a 1/20 scale model of the PBM-5 seaplane configured with vertical floats, indicate the desirability of attaching damping plates at the base of the vertical floats. A 108 inch diameter plate is used on all four floats of the V-464 airplane. Goodyear Aerospace Corp. has suggested constructing the damping plates using an airmat under pressure, and formed to shape by a large number of restraining fibers attached to the upper and lower mat surfaces throughout the mat. The use of fiber restraint to form a predetermined shape in flexible structures is a concept that has been proven by Goodyear.

3. Other Systems

The definition of changes to the control and stabilization, hydraulic, fuel and engine, pneumatic, environmental, electrical, power transmission, avionic, and cockpit systems is assumed to be only those changes required within the addition of the seaplane hull, rotating auxiliary floats, inflatable floats, alighting gear and the removal of the cargo ramp and actuators.

Control and stabilization will require further analysis to determine changes for seaplane operation. Hydraulic system changes are primarily the addition of inflatable float door actuators, extension-retraction motors and the removal of the cargo ramp actuators. The fuel system requirements will not change with the exception of the fueling-defueling relocation from the main gear fairing to the main gear well within the hull. Water spray protection of the engine air inlet is considered the major modification to the engine system requiring further study.

The XC-142A APU is replaced with a turbine air compressor mounted in the cargo compartment to furnish compressed air to the four inflatable floats and function as the airplane auxiliary power unit. No major changes are anticipated to the environmental and the electrical systems. The power transmission system will require review in methods of corrosion protection of the magnesium transmission system gearcases. Avionic and cockpit systems are assumed to remain unchanged.

(2) VTOL V-464

(a) Configuration

The VTOL V-464 airplane configuration is configured around the XC-142A aircraft with only those modifications pertinent to the installation of the vertical inflatable floats. Principal changes are to the lower fuselage and cargo floor and the wing tip and wing torque box outboard of the inboard nacelle. An inflatable vertical float housing, shaped to give good aerodynamic flow characteristics, is designed to rotate at the wing tips for VTOL operation at wing incidence angles from 0° to 98°. A clearance of seven feet between the bottom of the fuselage and the inflatable float static waterline is maintained under a displacement of 37,500 lbs. The general arrangement of the VTOL V-464 airplane is shown in figure 3.

(b) Airframe

The airframe is essentially the XC-142A airframe with modifications consistent with the installation of inflatable vertical floats in the fuselage and on each wing tip.

1. Fuselage

The fuselage structural integrity is maintained by redistribution of inflatable float loads at X 165 and X 415. Openings of 70 inches in diameter for the 60 inch diameter floats are made and reinforced by adding a cylinderical float support structure, a bulkhead for mounting the extension - retraction gear box and motor, gussets around the circumference of the opening to support the filament wound float, reel support fittings and door hinges with actuators. Float loads are redistributed to the cargo floor, local frames and bulkheads and the fuselage skin. The remaining fuselage structure is assumed to remain intact.

2. Wing

The wing revisions consist of local reinforcement of the wing torque box outboard of the inboard nacelle and torque box modification to the front and rear beam, the upper and lower skins and the skin stringers outboard of the outboard nacelle. Installation of a bearing housing between the front and rear beam will transmit wing inflatable vertical float loads to the torque box through the same angle as the wing of 98° to permit the inflatable vertical float to maintain a perpendicular attitude with the sea surface.

3. Vertical and Horizontal Tail

The vertical and horizontal tail are identical to the surfaces of the XC-142A.

4. Wing Mounted Inflatable Vertical Float Fairing

A faired housing is used to store the float and to transmit the float landing and sitting loads to the wing torque box. The inflatable vertical float is extended and retracted by means of a hydraulic motor driven gear box through a reel supported at two pressure bulkheads. A plenum chamber is formed between the pressure bulkheads during the float extension cycle. The resulting plenum chamber is sealed at the float housing shaft and transmits compressor air to the floats while extended. A circumferencial structural ring is used to attach the float fabric to the fairing and pressure bulkheads which in turn transmit the float loads to the shaft. The shaft is supported at the wing by a bearing housing capable of sustaining axial as well as bending loads.

The inboard end of the shaft is splined to retain the shaft drive gear and a splined lock sleeve. Sleeve actuation is through two hydraulic cylinders used to engage-disengage the splines and therefore provide torsional restraint to the shaft. Shaft rotation is through a splined drive gear powered by a gearbox-hydraulic motor drive. Hydraulic actuators operate doors to close the retracted float opening. The smallest frontal area compatible with the stored float housing is shown in figure 4.

(c) Systems

1. Alighting Gear

The alighting gear for the VTOL V-464 airplane is identical to the XC-142A alighting gear.

2. Inflatable Vertical Floats

The inflatable vertical float design considerations are the same as for the STOL V-464 with the exception of material thickness and float lengths.

3. Other Systems

The control and stabilization system is the same as for the XC-142A. The fuel system requires no modification, while the engine system requires further study to determine the effect of water ingestion on the inlet ducts, engines, and accessories. Provisions for removal of the auxiliary power unit and addition of turbines with the combined functions of air compressors and auxiliary power units are made.

Modifications to the environmental, electrical, avionic, and cockpit systems are consistent with the addition of the inflatable vertical floats and are considered minor changes. The use of magnesium in the power transmission system for the integral and tee gear cases and pillow blocks will require further investigation for corrosion protection and/or replacement with non-corrosive materials.

b. STRUCTURAL LOADS AND ANALYSES

(1) STOL V-464 Hull Impact Load Factor Design Parameters

(a) Design Conditions for Sea State Four

Airplane strength and rigidity requirements for the XC-142A airplane are contained in a series of military specifications of which the water load requirements are in reference 7, which specifies that the range of design sinking speed relative to horizon shall be from a minimum of three feet per second (FPS) to a design of 10 FPS. From figure 5 the vertical wave particle velocity is 4.5 FPS. Hence, the effective initial sink speed range of 7.5 FPS to 14.5 FPS was used.

The range of initial forward speeds was 30 to 40 knots, or an equivalent of approximately 50 to 67 FPS, respectively. Consequently, the range of effective initial flight-path angles is set between six (6°) and 16 degrees.

The design condition for landing maximum impact was taken on the wave flank at maximum slope, and the effective trim was limited to seven degrees at which time the afterbody contacts the water surface. Weight of the STOL V-464 seaplane is 45,000 lb., and the dead rise angle at the step is 20°.

(b) Solution for Design Parameters

Using these initial conditions, the motion of the seaplane is approximated by rotating the axes relative to the wave surface, figure 6, and the coefficients unique to the STOL V-464 are solved to plot an envelope of design parameters vs. maximum impact load factor.

There is a single approach parameter, a function of trim and the initial flight-path angle and its variation is presented in figure 7. The approach parameter design range for this study is shown in figure 8.

Figure 9 provides the variation of the scale factor, or ratio of virtual mass to the mass of the float, with the design range of trim angle.

For a given effective initial sink speed (vertical velocity) and the initial forward velocity, the effective initial flight-path angle in degrees can be determined. For a given trim angle in degrees, the approach parameter can be obtained from figure 8, and for the scale factor at $\phi(A)=1$ from figure 9. Figures 10 and 11 or 12 through 15 can then be used to obtain the coefficients for maximum load-factor, vertical-velocity ratio, draft and time respectively as plotted on the "at maximum acceleration" curves. All terms being accounted for, the values of maximum impact load factor, vertical velocity, draft and time at instant of maximum acceleration are solved by substitution in their respective equations shown along the ordinate scales. In this manner, the parametric envelopes were determined and are plotted in figure 16.

Figure 17 is a plot of recommended design parameters for the hull impact loads for the STOL V-464 seaplane upon landing. The requirement of reference 8 is superposed also, and it can be noted in reference 9 that the experimental accelerations for zero trim are 10% to 20% less than for accelerations for three degree trim.

(2) **Analysis for STOL and VTOL V-464, Inflatable Vertical Float Loads**

(a) **Analysis of Loads**

1. VTOL Landing

A solution to the differential equation for vertical motion, equation 7, is based on the particular wave impact condition considered.

Since a two-phase analysis is required because of the difference in impact time for the fuselage and wing inflatable vertical floats, the equations of motion are derived for each phase.

For the preliminary loads analysis, the vertical drag force on the floats has been assumed negligible. The validity of this assumption is checked out elsewhere in the analysis. Also, during phase (1) of the motion, there are no force contributions from the fuselage floats, so equation (8) can be reduced to

$$M\ddot{Z}_1 = 2\,K_{BF}\,Z_1 = W-L = W/3 \qquad (16)$$

let

$$\omega_1 = \sqrt{\frac{2K_{BF}}{M}}$$

Substituting this into equation (16) =

$$\ddot{Z}_1 + \omega_1^2\,Z = \frac{W}{3M} \qquad (17)$$

For initial conditions at water impact of $Z = 9$ and $\dot{Z}_0 =$ some sink speed, equation (17) has a solution of the form:

$$Z_1 = \frac{\dot{Z}_0}{\omega_1}\sin\omega_1 t + \frac{W}{3M\omega_1^2}(1 - \cos\omega_1 t) \qquad (18)$$

The resulting expressions for velocity and acceleration are:

$$\dot{Z}_1 = \dot{Z}_0 \cos\omega_1 t + \frac{W}{3M\omega_1} \sin\omega_1 t \tag{19}$$

$$\ddot{Z}_1 = -\dot{Z}_0 \omega_1 \sin\omega_1 t + \frac{W}{3M} \cos\omega_1 t \tag{20}$$

After the wing floats have contacted the water, the differential equation for phase (2) is

$$M\ddot{Z}_2 + 2 (K_{BF} + K_{BW}) Z_2 = W/3 \tag{21}$$

letting $\omega_2 = \frac{2(K_{BF} + K_{BW})}{M}$

equation (21) becomes

$$\ddot{Z}_2 + \omega_2^2 Z_2 = \frac{W}{3M} \tag{22$$

The solution is

$$Z_2 = \frac{\dot{Z}_{20}}{2} \sin\omega_2 t + \frac{W}{3M\omega_2^2}(1 - \cos\omega_2 t) + Z_{20} \tag{23}$$

where the inertial velocity, $\dot{Z}_{20}$, is the velocity at the end of phase (1) and is calculated with the use of equation (19). This is the velocity at the instant of time at which a plot of equation (18) indicates that the fuselage float has penetrated to the depth, H. The figure, ΔH, was established and tabulated in Table 2 for the various impact conditions.

Then $Z_{20} = \Delta H$ in equation (23). The velocity and acceleration expressions are

$$\dot{Z}_2 = \dot{Z}_{20} \cos\omega_2 t + \frac{W}{3MW_2} \sin\omega_2 t \tag{24}$$

$$\ddot{Z}_2 = -\dot{Z}_{20} \cos\omega_2 t + \frac{W}{3M} \cos\omega_2 t \tag{25}$$

The maximum fuselage float immersion occurs at the point where $\dot{Z}_2 = 0$. So, solving equation (24) for this condition

$$\tan \omega_2 t = - \frac{\dot{Z}_{20}}{W/3M \omega_2} = - \frac{3M \omega_2^2 Z_{20}}{W} \qquad (26)$$

Solving for t in equation (26) and substituting into equation (23), the maximum displacement of the fuselage float is obtained. The equivalent wing float immersion is then $Z - \Delta H$.

The critical load cases for the fuselage and wing floats are then determined by solving the equations of motion for the various impact cases of Table 2.

Most of the values of the parameters needed for solution of the preceeding equations are given in Table 1 for the 37,500 pound airplane.

The bucyant forces for the floats are calculated to be

$$K_{BF} = \rho_W A_{FZ} = 1.988 \left[\frac{3.14}{4} (5)^2\right] = 1{,}260 \text{ lbs/ft}$$

$$K_{BW} = \rho_W A_{WZ} = 1.988 \left[\frac{3.14}{4} (4)^2\right] = 793 \text{ lbs/ft}$$

Landing analysis was carried out for three specific sink speeds: $\dot{Z}_0$ = four, ten and 16 fps. All curves are plotted for this sink speed range.

Since for the preliminary loads analysis the drift rate is assumed constant, the drag forces for phases (1) and (2) are represented as

Phase (1)

$$F_{DX} = 2\,F_{DFX} = 2\left\{1/2\ \rho_w C_{DX} D_F \dot{X}_O^{\,2}\right\} Z \qquad (27)$$

Phase (2)

$$F_{DX} = 2\,F_{DX} + F_{DW}$$

$$= 2\left\{1/2\ \rho_w C_{DX} D_F \dot{X}_O^{\,2}\right\} Z + 2\left\{1/2\ \rho_w C_{DX} D_W \dot{X}_O^{\,2}\right\}(Z-\Delta H) \qquad (28)$$

The maximum vertical acceleration, for small vertical drag, occurs at the maximum immersion point and can be expressed from equation (25) in terms of "g" loading as

$$g_Z = \frac{\ddot{Z}_2}{g} = \frac{1}{g}\left[-\dot{Z}_{20}\,\omega_2 \sin \omega_2 t + \frac{W}{3M} \cos \omega_2 t\right] \qquad (29)$$

The calculated maximum fuselage float immersions are plotted in figure 19 as a function of airplane sink speed. This is for impact on different points of sea state four size wave. A plot is also included, for reference, of the immersion on a calm sea.

Figures 20 and 21 show the resulting maximum loads calculated for the fuselage floats and wing floats, respectively. These are based on the immersion data of figure 19.

In all cases, the wing float immersion is $Z_W = Z - \Delta H$.

These results are based on the maximum loads obtained from analyzing all cases described in table 2. For the fuselage float the maximum loads are produced by case 1a, $\Delta H = 7$. For the wing float, case 4a is found critical.

The drag and drift parameters are:

$C_{DZ} = 0$

$C_{DX} = 1.0$

$\dot{X} = \text{Const} = 5$ knots

Figure 22 is a plot of the airplane maximum acceleration, based on the buoyant forces of figures 20 and 21.

2. Sea Sitting Condition

The airplane is assumed to be initially in a static, calm sea position, except for the five knot relative drift. From this reference point, the airplane is heaved upward by a wave whose dimensions are illustrated in figure 3. The wave form imparts an initial upward velocity of approximately 4 fps to the airplane. For the float dimensions described in table 1, the static immersions for the two airplane configurations are:

	VTOL 37,500 lbs.	STOL 45,000 lbs.
Fus. Float	10.4 ft.	12.5
Wing Float	7.1 ft.	8.5

Since all floats are in the water at the beginning of the analysis, the magnitude of the parameters will be similar to those used for phase (2) of the water landing analysis. The only difference will be the initial conditions.

Referring to equations (23), (24) and (25):

$$Z_2 = \frac{\dot{Z}_0}{\omega_2} \sin \omega_2 t + \frac{F}{M \omega_2^2} (1 - \cos \omega_2 t) + Z_0 \qquad (30)$$

$$\dot{Z}_2 = \dot{Z}_0 \cos \omega_2 t + \frac{F}{M \omega_2^2} \sin \omega_2 t \qquad (31)$$

$$\ddot{Z}_2 = -\dot{Z}_0 \omega_2^2 \sin \omega_2 t + \frac{F}{M} \cos \omega_2 t \qquad (32)$$

where Z_0 = static immersion of fuselage float

$\dot{Z}_0$ = 4 fps wave vertical velocity

In the second term of each equation, $F = 2 (\Delta H) K_{BW}$. This is a correction term to take into account the fact that the fuselage floats have a different immersion as a reference point.

The wave form is assumed to rise so that the airplane C. G. can be either approximately at the crest of the wave or at the point of wave maximum slope.

The float forces and moments are determined by the same procedure previously described.

Table 3 is a listing of the loads obtained for the STOL and VTOL V-464 airplanes for the sea sitting condition. For the 37,500 pound VTOL airplane, the wing float moment is at the wing tip. For the 45,000 pound STOL airplane, the moments are listed for both the wing tip point and at the water level of the auxiliary float.

3. Towing of Airplane

Two possible conditions are assumed for towing: (1) five knot velocity on calm water and (2) five knot velocity in water described by sea state four conditions.

The second condition is the same as the sea sitting condition previously described, since both are at a relative drift velocity of five knots between airplane and water.

The calm sea towing condition is at the normal static immersion depts for the floats. The float forces are:

Fuselage Float

$$F_{BF} = K_{BF} \; Z_{FO} \tag{33}$$

$$F_{DF} = 1/2 \, \rho \, \dot{X}_O^{\,2} \, C_{DX} \, A_{FX} \tag{34}$$

Wing Float

$$F_{BW} = K_{BW} \; Z_{WO} \tag{35}$$

$$F_{DF} = 1/2 \, \rho \, \dot{X}_O^{\,2} \, C_{DX} A_{WX} \tag{36}$$

Table 4 is a listing of the loads for towing on a calm water surface at a five knot drift rate. The loads for towing through sea state four waves is the same as those shown in Table 3 for the sea sitting condition. This is true because the same five knot relative velocity between airplane and water is used.

4. Vertical Float Drag

In the preliminary loads analysis the vertical float drag was assumed to be small enough to neglect in the analysis. If the drag is considered in the transient solution of airplane motion, the differential equation of motion for phase (1) is:

$$M\ddot{Z} + 2 \left\{ K_{BF} \, Z + 1/2 \, \rho_W \dot{Z}^2 \, C_{DZ} \, A_{FZ} \right\} = W-L \tag{37}$$

and for phase (2) is:

$$M\ddot{Z} + 2 \left\{ K_{BF} \, Z + 1/2 \, \rho_W \dot{Z}^2 \, C_{DZ} A_{FZ} \right\} + 2 \left\{ K_{BW} \, (Z - \; H) + 1/2 \, \rho_W Z^2 \, C_{DZ} \, A_{WZ} \right\} = W-L \tag{38}$$

Because of the non-linear drag forces occurring in the equations, the solutions to the equations is accomplished with a high speed digital computer program. A brief description of this program is given in APPENDIX A.

The expression for time varying loads, based on the computer solution for Z versus time are:

Fuselage Float

$$F_{ZF} = F_{BF} + F_{CF} = K_{BZ} + 1/2\, \rho_W \dot{Z}^2\, C_{DZ}\, A_{FZ} \tag{39}$$

$$M_{DF} = F_{ZF} \left(l_F - \frac{Z}{2} \right) \tag{40}$$

$$\sigma_{LF} = 1/12 \left[\frac{\Delta M_{DF}}{\pi D^2} + \frac{F_{ZF}}{\pi D_F} \right] \tag{41}$$

Wing Float

$$F_{ZW} = F_{BW} + F_{CW} = K_{BW} (Z - \Delta H) + 1/2\, \rho_W \dot{Z}^2\, C_{DZ} A_{WZ} \tag{42}$$

$$M_{DW} = F_{ZW} \left[l_F - \frac{(Z - \Delta H)}{2} \right] \tag{43}$$

$$_{LW} = 1/12 \left[\frac{4 M_{DW}}{\pi D_W^2} + \frac{F_{ZW}}{\pi D_W} \right] \tag{44}$$

The drift rate ($\dot{X}$) is assumed constant for this analysis.

Figure 18 shows a comparison of float immersion as a function of time for float vertical drag coefficients of $C_{DZ} = 0.0$ and $C_{DZ} = 0.2$. This latter drag value was estimated, with the aid of reference 10, chapter 3, to be the maximum drag coefficient that could be expected for flow against the end of a cylinder having a slightly rounded end.

A digital computer was used for a numerical solution of the two cases. The results, obtained for sink speeds of four 10 and 16 fps, indicate that the original assumption of negligible vertical drag effects does not cause an appreciable error in the calculated float immersions.

5. Lateral Float Drag

An investigation of lateral float drag was made with the use of reference 10. Figure 27 of chapter 10 of this reference is a plot of the drag coefficient (for flow perpendicular to a cylinder partially immersed in water) as a function of Froude Number. This is expressed as

$$F_H = \frac{V}{\sqrt{gH}} \tag{45}$$

where V = relative velocity between water and cylinder

H = length of immersed cylinder

For a relative velocity of five knots, this becomes

$$F_H = \frac{5(1.689)}{\sqrt{32.2H}} = \frac{1.485}{\sqrt{H}} \tag{46}$$

When the cylinder first penetrates the water, theoretically F_H approaches an infinite value. From the reference, figure 27, $C_D \cong 0.5$ for large values of F_H. For the maximum immersion depths reached by the floats, $F_H \cong 0.350$. This number gives a drag coefficient, $C_D \cong 0.75$.

Since the maximum loads (at H = max.) are the ones of greatest concern, the higher value, $C_D \cong 0.75$ appears to be the smallest practical number to be used in any loads revision.

Figures 24 and 25 show the calculated loads for the case where the float lateral drag coefficients were reduced to $C_{DX} = 0.75$. The reasoning behind the assumption of this value has been previously discussed in the report.

The buoyant forces, F_{BF} and F_{BW}, are not plotted on the figures, since their magnitudes are unchanged from those shown in figures 20 and 21.

6. Variation in Drift Rate

All preliminary loads were determined using a constant drift rate of five knots. If it is assumed that the water is slowing the airplane down from an initial drift rate of five knots, the differential equation of motion for lateral drift is expressed for the two phases as

Phase (1)

$$M\ddot{X} + 2\left\{1/2\, \rho_W C_{DX}\, D_F\right\} Z\dot{X}^2 = W-L$$

Phase (2)

$$MX + 2\left\{1/2\, \rho_W C_{DX}\, D_F\right\} Z\dot{X}^2 + 2\left\{1/2\, C_{DX}\, D_W\right\}$$

$$(Z - \quad H)\, \dot{X}^2 = W-L \qquad (48)$$

The vertical motion is assumed to be described by the same equations outlined for the preliminary loads analysis.

The computer program used for this two degree-of-freedom analysis is described in Appendix A.

Figure 23 indicates the change in lateral velocity (drift rate) with time if the airplane impacts the water at five knots (8.445 fps) and slows down due to lateral lateral float drag. The results indicate that the airplane slows down to a drift rate from 3.3 to 3.6 fps for a sink speed range between four and 16 fps. at the time that the floats reach maximum immersion.

The impact point used was the crest of a wave, but the drift rate dows not change significantly for impact on the side of a wave.

Figures 26 and 27 are plots of the maximum drag forces, moments, and longitudinal stresses determined during the immersion. The peak loads occurred before maximum immersion was reached.

Figures 30 and 31 are comparisons of the drag force and drag moment on the floats for the constant drift case and the variable drift case. Shown as horizontal dotted lines on the left side of the plots are the drag forces and moments calculated for the towing condition and previously recorded in Tables 3 and 4.

I. Shorter Floats

The float lengths used for preliminary loads analysis were assumed to be the same for both the STOL and VTOL V-464 airplanes and were based on selected water clearance requirements for the 45,000 pound STOL airplane. For equal water clearance, the floats could be shortened for the 37,500 pound VTOL airplane.

For the same weight distribution to the floats that was established for the 45,000 pound STOL airplane, the static immersion depths for the VTOL airp. ane are

$Z_{FO} = 10.4$ ft.

$X_{WO} = 7.1$ ft.

With fuselage and wing water clearances of seven and 15 ft., respectively, the total revised float lengths would be

$F = 10.4 + 7 = 17.4$ or 17.5 ft.

$W = 7.1 + 15 = 22.1$ 22.0 ft.

Figures 28 and 29 show the calculated loads for the possible shorter floats on the 37,500 pound STOL airplane. Maximum loads for the constant drift case are compared with those for a variable drift rate. The lateral float drag coefficient used was $C_{DX} = 1.0$.

(3) **Structural Analysis**

(a) Design Loads

The limit design loads developed by the methods previously described are converted to ultimate design loads by increasing them by a factor of 1.5 as required by reference (7).

(b) Design Load Conditions

The STOL V-464 landing loads are not critical; therefore, this structural analysis is based on the ultimate load introduced by the inflatable vertical floats with a drift rate of five knots in a sea state four. The specific design load conditions analyzed are:

- Wing incidence of 40° with a drag force applied in the outboard direction to the wing tip mounted inflatable vertical float.
- Wing incidence of 40° with a drag force applied in the aft direction to the wing tip mounted inflatable vertical float.
- Wing incidence of zero with a drag force applied in the outboard direction to the wing tip mounted inflatable vertical float.

The VTOL V-464 is designed to land in a sea state four at a 12 foot per second sink speed and with a 5 knot drift rate on its inflatable vertical floats. The specific design load conditions analyzed are:

- A drag force applied in the aft direction to the wing tip mounted inflatable vertical float.

- A drag force applied in an outboard direction to the wing tip mounted inflatable vertical float.

(c) Analysis of Pivot-Pylon Structure

A preliminary analysis has been performed to define the structure required for the pivot pylon area. The general arrangement drawings (figures 1, 2 and 3) show the distance between the wing tip mounted inflatable vertical floats is 810 inches for the STOL V-464. The wing box ends at wing station 398. A preliminary structural arrangement drawing (figure 4) is shown for the wing tip inflatable vertical floats for the VTOL V-464. The structure that supports the auxiliary float pylon for the STOL V-464 is approximately the same. The analysis of this structure is presented in Appendix C.

(d) Analyses of Primary Wing Structure

The primary wing structure is analyzed by applying the XC-142A unit solutions to the V-464 distributed wing loads. The design load curves and are presented in figures 32 through 36 for the STOL V-464 and figures 37 through 41 for the VTOL V-464. The wing stress analysis results are presented in figures 42 through 44 for the STOL V-464.

In summary, the following comments are made:

1. STOL V-464

The wing tip housing structure requires approximately the same assembly as for the VTOL. The wing compression buckling skin-stringers at outermost fibers require an increase from zero at inboard engine to a maximum of over three times the basic areas outboard of the outboard engine. The extent of strengthening the rear beam shear web is approximately the same as for the VTOL.

2. VTOL V-464

The wing-tip housing structure requires 17-4 PH stainless steel weldment. Wing compression buckling skin-stringers at outermost fibers require an increase from zero at the wing pivot station 51 to a maximum of approximately 2.7 times the basic areas outboard of the outboard engine. The extent of strengthening the rear beam shear web is not as severe.

c. HYDRODYNAMICS AND AERODYNAMICS

In keeping with the desire to ascertain the feasibility of providing the XC-142A with an open ocean landing capability, the effort described in this section is restricted to effects considered to be of the first order. Certain aspects of the two configurations presented in this document have not been studied in detail on the assumption that such an effort will not provide a significant change in the results of this study. Two examples of such design simplifications are the use of a standard hull-form on the STOL V-464 and the scaling of the vertical float configuration from the recommendations of reference (20) on both the STOL and VTOL V-464.

(1) Hydrodynamic Characteristics

(a) STOL V-464 Configuration

Results of an extensive literature search indicate that reference (1) provides the most complete source of information pertaining to hull forms suitable for use with the XC-142A fuselage. The selected STOL V-464 hull is from this reference. The beam of the hull is the maximum width of the XC-142A fuselage. In the interest of minimizing fuselage height while providing acceptable hull impact landings and spray characteristics, a dead rise angle of 20° is used. The length-beam ratio of 5.07 is used, as the small gains of a larger ratio do not justify the complication of incorporating a longer hull. The use of the larger length-beam ratio with a smaller beam was discarded in light of the already large static load coefficient. The afterbody angle of 7 degrees gives a reasonable corridor between the upper and lower trim limits of stability during planing without excessive deterioration of the spray and resistance characteristics in the displacement regime. The hydrodynamic characteristics of the selected hull are shown on figure 48. Reynolds number corrections are not applied to the water resistance data, because of the negligible effect this correction would have on takeoff and landing distance. The configuration drawing, figure 1, reflects a change in the step and the chine as recommended by Mr. Handler, BuWeps, RAAD-343.

The wing tip floats were originally sized according to the expressions given in reference (2). Minor modifications to the tip float geometry have resulted in the present configuration exceeding the minimum requirement of reference (2) by twelve percent. A preliminary investigation of various loading conditions does not show any need for enlarging this float size.

The method of reference (21) is used to determine the water resistance for the takeoff maneuver. This method takes into account the change in lift forces during the takeoff run through the use of aerodynamic data overlays and collapsed, hull model test data. The transition from the displacement to planing regimes is taken, as usual, at the speed where the planing resistance is the same magnitude as the displacement resistance.

The determination of the water resistance for landing is simplified by assuming that thrust is reduced to zero one second after impact. The resulting low aerodynamic lift provides essentially a constant hull load coefficient as the aircraft decelerates, and the water resistance becomes a unique function of speed. The aircraft enters the displacement regime as soon as the thrust is reduced as a result of the low landing speed and the high hull loading.

(b) VTOL V-464 Configuration

The over-all size of the vertical floats is based on a static clearance of 7 feet between the water and the bottom of the fuselage, reasonable inflation pressures and moderate wing tip pod size. The relative sizing of the fuselage and wing vertical floats is the same as that recommended in reference (20). Damping plates similar to those proposed in reference (20) are also incorporated in this design. No problems peculiar to the XC-142A are anticipated due to the use of these floats.

(2) Aerodynamic Characteristics

The drag calculations for both V-464 configurations are based on the methods given in reference (5) for the XC-142A. Drag increments are computed for each airframe component that represents a change from the XC-142A. These increments are obtained by calculating the flat plate skin friction coefficient for each component and then applying a form drag correction factor. The equation below is used to compute the skin friction coefficient.

$$C_{f_{F.P.}} = \frac{0.455}{(\log_{10} R_e)^{2.58}}$$

where $C_{f_{F.P.}}$ = skin friction coefficient

R_e = Reynolds number

This equation assumes fully developed turbulent flow. The Reynolds Number (R_e) is based on the component representative length and a sea level speed of 250 knots. The form factors are obtained from references (10) and (23). Additional correction factors found in references (22) and (23) are applied to account for interference, roughness and leakage.

The change items in the drag build-up for both V-464 configurations are tabulated below. The corresponding values for the XC-142A are also shown.

	VTOL V-464		STOL V-464		XC-142A	
	f ft^2	C_{D_o}	f ft^2	C_{D_o}	f ft^2	C_{D_o}
Fuselage	5.79	0.0108	9.40	0.0176	5.79	0.0108
Floats & Pylons	----	------	2.27	0.0043	----	------
Wing Tip Pods	1.24	0.0023	----	------	----	------
Landing Gear Fairing	1.10	0.0021	----	------	1.10	0.0021
Identical Items	12.70	0.0238	12.70	0.0238	12.70	0.0238
Total Drag	20.83	0.0390	24.37	0.0457	19.59	0.0367

f = equivalent flat plate drag area

C_{D_o} = f/wing area

The XC-142A induced drag equation is used for both V-464 configurations, as follows:

$$C_{D_i} = 0.05\,(C_L - 0.045)^2$$

C_{D_i} = induced drag coefficient

C_L = lift coefficient

The XC-142A lift, drag, thrust and fuel flow have been utilized in the takeoff and landing calculations on the STOL V-464 airplane. This is a valid approximation since the thrust and resulting slipstream effects are predominant at the low speeds used during takeoff and landing. For all practical purposes, the modified portions of the fuselage are not exposed to the propeller slipstream. The effect of the proximity of the water (ground) surface is included in these characteristics.

(a) Performance

The mission profile used in the computation of mission performance for both V-464 configurations is:

- Five minute warm-up on normal-rated power.
- Climb on course to cruise altitude on military-rated power.
- Cruise to station at optimum altitude at speed for maximum range.
- Cruise on station at sea level at speed for maximum range.
- Climb on course to cruise altitude on military-rated power.
- Cruise to base at optimum altitude at speed for maximum range.
- Land at base with 10% of initial fuel.

1. STOL V-464

STOL V-464 payload versus time-on-station is presented in figure 49 for three radii of action. The mission is performed on a standard day at a takeoff weight of 45,000 pounds. A 7,379 pound payload for the STOL takeoff weight of 45,000 pounds represents the full internal fuel load of 9100 pounds.

Figure 50 presents STOL takeoff distance at sea level versus gross weight for both standard (59°F) and tropical (90°F) days. As a result of these calculations, it is noted that the large values of thrust available during takeoff make the water resistance of minor importance in computing takeoff distance. Removing the water resistance from the takeoff calculations only decreases takeoff distance by 4 percent. The fact that the STOL V-464 can take off in essentially the same distance as the VTOL V-464 on a standard day with a higher gross weight is a result of not having a large lift margin at lift-off for the STOL airplane. Of the various combinations of wing incidence and flap deflection analyzed, the minimum takeoff distance is obtained using the 40 degree wing incidence and the 60 degree flap deflection. The wing incidence is limited to 40 degrees for the STOL V-464 due to wing trailing edge water clearance.

Landing distance at sea level versus landing weight is shown in figure 51 for standard (59°F) and tropical (90°F) days. The relatively long landing distance is a result of not having a thrust reversal system on the STOL V-464. The approach speed is the trimmed equilibrium approach speed for a rate of sink equal to 200 ft/min. The approach configuration permitting minimum equilibrium speed, based on XC-142A data, is a wing incidence of 40 degrees and a flap deflection of 60 degrees. To account for pilot and thrust control reaction time, the approach speed is maintained for one second after impact. Zero thrust is assumed for the remainder of the landing maneuver. Realistic landing distances are obtained by terminating the landing maneuver at 4 knots.

2. VTOL V-464

Mission payload for the VTOL V-464 versus time-on-station for radii of action of 50 N.M., 150 N.M., and 250 N.M. is presented in figure 52. The mission is performed on a standard day at the V-464 design VTOL takeoff weight of 37,500 pounds. As noted, a payload of 1034 pounds represents a full internal fuel load of 9100 pounds. The VTOL design takeoff weight of 37,500 pounds represents a thrust-to-weight ratio of 1.18 on a standard (59°F) day at sea level. A thrust-to-weight ratio of 1.15 permits a takeoff weight increase to 38,700 pounds on a standard day. XC-142A propeller thrust and fuel flow data are used in the calculation of climb and cruise performance.

Takeoff and landing performance for the VTOL V-464 is that of the XC-142A in the VTOL mode. The STOL V-464 takeoff and landing distance is calculated by combining the hydrodynamic and aerodynamic lift and drag with the available thrust in a step-by-step integration.

(b) Stability and Control

The higher moments of inertia of both of the V-464 configurations and the higher flap settings used for the STOL takeoff maneuver requires minor increases in control power over the XC-142A during hover and low speed flight. Due to the questionable "state-of-the-art" in VTOL and STOL control power requirements, it is not known whether the present XC-142A system has sufficient margin to compensate for these increases. The upcoming low speed and hover portions of the XC-142A flight test program will provide the necessary information on this subject. Until this information is available, it will be assumed that the present control and stability augmentation systems are satisfactory for both of the V-464 airplanes in hover and low speed flight.

The XC-142A stabilizer and control surfaces are adequate for the VTOL V-464 in conventional flight.

Due to the greater de-stabilizing influence of the modified fuselage on the STOL V-464, the XC-142A vertical tail is increased by 30 percent to provide the same level of directional stability as the XC-142A. This increase is not reflected in the VTOL V-464 configuration drawing because it is not yet known whether this level of stability is desired.

d. PROPULSION

The tolerance of the V-464 propulsion system to a salt water environment is of primary importance in the successful conversion of the airplane to an amphibian. First efforts have been directed toward a definition of the engine operating environment resulting from downwash and recirculation in the STOL and VTOL configurations, the effects of sea water ingestion on the engine and configuration changes that could minimize the ingestion problem.

(1) Downwash and Recirculation

Downwash and recirculation operation of the V-464 in a near water mode-either STOL or VTOL configurations-results in spray producing propeller slipstream velocities at the water surface. A portion of the spray will be entrained in the flow of the propeller recirculation field and brought into proximity of the engine inlets.

Downwash direction and velocity are presented in figure 53 for the XC-142 operating in the hover configuration at normal takeoff gross weight and a propeller height to diameter ratio (H/D_p) of 1.0. The figure was generated by assuming that the velocity at any point in the flow field would equal the vector summation of the velocities developed by each lifting device at that point. References (11) and (12) were sources for the flow direction and velocity for each propeller. The information of figure 53 was developed for hover over the ground but also applies to water.

A literature search and a series of model tests over water have been made to augment the LTV downwash and recirculation predictions for the V-464. References (13) through (17) have been found applicable. Of most interest were the film reports of references (13) and (16). At disk loadings comparable to the V-464 in the VTOL configuration (54.2 lb/ft^2) the Curtis Wright X-19 appeared to recirculate little water through the propeller disks. A similar indication was reflected by the film report on the Piasecki VZ8P-A. Although the film reports visually indicated favorable recirculation effects in the propulsion configurations tested, the variation of the V-464 geometry in VTOL mode (four propellers on a tilt wing) and the inability to predict recirculation in the STOL configuration prompted a series of model tests to aid in the definition of the recirculation problem.

A 0.11 scale model of the XC-142A was tested over a twenty-four foot diameter tank of water with scale disk loadings representative of takeoff power and propeller - water surface relationships which will exist in the V-464. No wind or wave action was simulated. Figures 54 and 55 illustrate the test set up. Scaling methods of reference (13) which allow for water surface tension effects upon spray formation were used to develop model propeller disk loadings. A water pick up bar, "moisture meter", was devised to trap water passing through four radial stations of the left outboard propeller. Figures 56 and 57 illustrate the design of the moisture meter on the model. Color motion pictures were taken of the recirculation field of the propellers from horizontal and overhead vantage points. Water recirculation data and motion pictures were taken for a series of model heights above the water surface and propeller disk loadings in the VTOL configuration. STOL configuration data were limited to a H/D_p representative of the V-464 on the water ($H/D_p = 0.9$).

The quantities of water collected in the traps of the moisture meter during the STOL and VTOL configuration tests are plotted in figures 58 through 60 versus trap location for levels of propeller disk loading.

The water collection data in the STOL and VTOL configurations may be compared to one another for a relative indication of the water recirculation problem. The absolute quantities cannot be scaled to the full size V-464 with complete assurance of the validity of the data because the water drops formed during the model tests were not to scale and hence did not follow a scaled recirculation path. The water collection data do represent the best quantitative data available at this time for determining recirculated water quantities. On the basis of a "reasonable estimate" then the water collected in the model tests has been scaled to full size V-464 by applying full scale inlet area and the inverse root of the scale factor (1/0.332).

The model disk loading of 7.74 lb/ft^2 (54.2 lb/ft^2 full scale) represents a scaled 40,900 lb V-464 with military power on four T64-GE-1 engines. Downwash in the STOL configuration (40° wing tilt with flaps) caused much spray to be driven forward of the model into the air entering the propellers. Comparing the water quantities passing through the outboard propeller at the 7.74 lb/ft^2 disk loading (figures 58 and 59) for an H/D_p of 0.9, the STOL configuration is almost 3 times worse than the VTOL configuration. Assuming that these water quantities exist at the full scale inlet of the engine, 8.07 lb/min of water would be inducted by the 243 in^2 inlet. This quantity of water represents 0.56% of military rated airflow.

Water ingestion in the VTOL mode is less than 0.2% of military rated airflow at the H/D_p of 0.9 and a disk loading of 7.74 lb/ft^2. Increasing the model height ratio (H/D_p) to 1.64 (figure 60) reduces the water ingestion to an insignificant level. These test results reasonably substantiate the inference of the motion pictures of references (13) and (17) that small quantities of water will be carried in the recirculation field of the propellers. A short color motion picture of the STOL and VTOL configuration tests is available at a model disk loading of 7.74 lb/ft^2 for a range of H/D_p from 0.9 through 5.0.

(2) Sea Water Effects Upon the T64 Turboshaft Engine

A preliminary investigation has been made of the T64 engine to determine the problem areas which would be likely to appear if the engine were operated in a sea water environment. Based upon General Electric operating experience with the T58 engine in such an environment, the following modifications will be required to the T64:

(a) The magnesium components would be replaced with other materials.

(b) Some anti-corrosion features would be added. A titanium compressor is being developed for an advanced version of the T64 engine to improve corrosion resistance. Incorporating this compressor would also decrease engine weight by approximately 45 pounds.

(c) Hot sections of the engine may require corrosion resistant coatings.

The T64 engine will ingest water quantities to 6% of the military rated airflow with no immediate adverse effects on engine operation. Deposits will form upon the blading within the engine, however, which will cause a power loss. A fresh water washing procedure will be required similar to that which has been developed for the T58 engine.

There are no data available which will indicate the effects of a wave momentarily engulfing the engine tailpipe such as might occur in heavy seas.

(3) Configuration Changes

The estimated water quantities that will be ingested by the T64 engine in the V-464 are 0.56% and 0.2% of military rated airflow in STOL and VTOL configurations for normal gross weight with no wind or wave action. It is possible that these percentages are minimums and may increase significantly with more severe sea states. A separator is desirable to minimize the salt deposits upon the engine blading when operating in the VTOL or STOL configuration.

General Electric has a sand and dust separator under development for the T58 and T64 engines which operates on centrifugal principle. The device consists of a straight section of duct ahead of the engine face. Swirl vanes at the entrance impart rotation to the airflow causing the heavy sand and dust particles to gravitate to the duct wall. An annular trap collects the debris which is then ejected from the duct. Straightening vanes remove the swirl before the air enters the engine. General Electric quotes an expected engine performance degradation of three percent. Figure 61 is a sketch of the separator. This General Electric sand and dust separator configuration does not lend itself to application on the V-464 because of the geometry required for the present inlet. The centrifugal separation principle will perform satisfactorily with water drops however, and this principle can be applied through a suitably designed configuration for the V-464 inlet.

The configuration of the V-464 inlet incorporates abrupt turns to conform to propeller gearbox and engine placement within the nacelle. A study has been made to evaluate the centrifugal separation characteristics of the abrupt inlet turns on the water drop-air moisture entering the inlet. This study, which is presented in Appendix B, shows that with minor modifications for disposing of collected water the present inlet configuration will provide adequate water separation.

4. WEIGHT AND BALANCE CONTROL

a. WEIGHT CONTROL SUMMARY

The V-464 empty weights are derived from the specification XC-142A weight empty as presented in reference (25), with allowances made for the required incremental weights. Table 5 presents a summary of the empty, operating, and take-off weights for the XC-142A and V-464 airplanes. A group weight statement for the specification XC-142A plus the delta weights for both the VTOL V-464 and the STOL V-464 versions is shown in Table 6.

The overall balance is determined by calculating the effect of the various changes on the tilting and non-tilting components of the XC-142A. These changes are tabulated in Tables 7 and 8, and the center of gravity shift versus wing tilt was plotted for gross take-off weight and zero fuel conditions as shown in Figures 63 and 64. For comparative purposes, the appropriate XC-142A center of gravity positions are also shown.

b. WEIGHT ESTIMATION

The incremental weights required to develop a VTOL and STOL V-464 airplane were determined by analytical, statistical, and calculated methods and vendor quotes. A breakdown of the weight into these groups is shown below.

VTOL CONFIGURATION

Item	Analytical	Statistical	Calculated	Vendor Quote
Wing	290	14	105	-
Fuselage		300		
Vertical Floats	1000	1210	100	
Inflation System		166		325
Totals	1290	1690	205	325

STOL CONFIGURATION

Item	Analytical	Statistical	Calculated	Vendor Quote
Wing	168		113	
Tail		76		
Fuselage		1731		
Alighting Gear:				
Land Type		-30		
Water Type	276	596		
Vertical Floats	600	570	100	
Inflation System		166		325
Totals	1044	3109	213	325

The following sections describe in detail the development of these weight increments for each major component.

(1) Wing

(a) Description

The current XC-142A wing will not require any major redesign. However, additional bending and shear material will be required to carry the inflatable vertical float loads, resulting in a weight increase in the skins, stringers, spar caps, and webs. These increases were calculated from the revised stress levels in members for both the VTOL and STOL configuration.

In the VTOL configuration, the tip structure was extended 24 inches per side to give clearance between the basic wing structure and the inflatable vertical float pod during wing rotation. This tip extension is not required on the STOL configuration since the auxiliary float pylon provides the clearance. Both the VTOL and the STOL versions required a forged bearing housing at the wing tip to mount the inflatable vertical float housing and the auxiliary float pylon.

(b) Weight Summary

	XC-142A	ΔW from Col. (1)	VTOL	ΔW from Col. (1)	STOL
Skins, stringers and spar caps	1162	286	1448	162	1324
Spar webs	225	4	229	6	231
Wing tip fairing	6	14	20	0	6
Wing tip forging	0	105	105	113	113
Interspar ribs	317	0	317	0	317
Leading edge assembly	109	0	109	0	109
Trailing edge assembly	288	0	288	0	288
Fairings and fillets	36	0	36	0	36
Control surfaces	696	0	696	0	696
Total	2839	409	3248	281	3210

(c) Weight Derivation

1. Skins, Stringers, and Spar Caps

The compressive elemental areas at eight spanwise stations were increased to accommodate the change in stress levels for the critical conditions. Thus, the weight of additional material required in the compressive members was determined. The additional material required in the tensile elements was taken as 80 per cent of that determined for the compressive members. The following were the critical conditions used to determine the required bending material:

VTOL Condition 1

Elements affected 2 thru 13 and 62 thru 68

Wing Station From	Wing Station To	Bay Length (in.)	Average Area Increase ($in.^2$)	Volume Increase (in^3)
0	50.75	50.75	0	0
50.75	86.14	35.39	0.799	28.3
86.14	106.45	20.31	1.600	32.5
106.45	146.20	39.75	2.227	88.5
146.20	176.53	30.33	2.375	72.0
176.53	246.26	69.73	1.931	134.6
246.26	318.91	72.65	1.379	100.2
318.91	349.25	30.34	0.955	29.0
349.25	398.00	48.75	0.867	42.3

Volume Increase compressive elements	527.4
80% for tension elements increase	422.0
Total volume increase	949.4

Weight increase = (0.1 x 949.4) = 95 lb./side

VTOL Condition 2

Elements affected 2 thru 7 and 49 thru 68

Wing Station From	Wing Station To	Bay Length (in.)	Average Area Increase (in^2)	Volume Increase (in^3)
0	50.75	50.75	0	0
50.75	86.14	35.39	0.506	17.9
86.14	106.45	20.31	1.311	26.6
106.45	146.20	39.75	1.763	70.1
146.20	176.53	30.33	1.913	58.0
176.53	246.26	69.73	1.819	126.8
246.26	318.91	72.65	1.829	132.9
318.91	349.25	30.34	1.589	48.2
349.25	398.00	48.75	1.071	52.2
	Volume Increase compressive elements			532.7
	80% for tension elements increase			426.0
	Total Volume Increase			958.7

But elements amounting to 50% of this volume were included in Condition 1. Therefore,

Weight Increase = 0.5(0.1 x 948.7) = 48 lb./side

Increase in skin, stringers and spar caps for the VTOL configuration = 2(95 + 48) = 286 lbs. per airplane.

STOL Condition 3B

Elements affected 2 thru 24 and 66 and 68

Wing Station From	Wing Station To	Bay Length (in.)	Average Area Increase (in^2)	Volume Increase (in^3)
0	146.20	146.20	0	0
146.20	176.53	30.33	0.30	9.10
176.53	246.26	69.73	1.23	85.77
246.26	318.91	72.65	2.29	166.37
318.91	349.25	30.34	2.48	75.24
349.25	398.00	48.75	1.29	62.89
	Volume increase compressive elements			399.37
	Increase in tension elements - 80% of compressive			320.00
	Total Volume Increase			719.37

Weight Increase = (0.1 x 719) = 72 lb./side

STOL Condition 1B

Elements affected, in addition to those already covered by Condition 3B, only 62 and 64 require revision.

Wing Station From	to	Bay Length (in.)	Average Area Increase (in^2)	Volume Increase (in^3)
106.45	146.20	39.75	0.044	1.75
146.20	176.53	30.33	0.124	3.76
176.53	246.26	69.73	0.194	13.52
246.26	318.91	72.65	0.221	16.08
318.91	349.25	30.34	0.187	5.66
349.25	398.00	48.75	0.170	8.30
		Volume increase compressive elements		49.07
		Increase in tension elements - 80% of compressive		40.00
		Total Volume Increase		89.07

Weight Increase = 9 lb./side.

Therefore, increase in skin, stringers, and spar caps for the STOL configuration = 2(72 + 9) = 162 lbs. per airplane.

2. Spar Webs

The stress levels in the spar webs exceeded the XC-142 allowables only outboard of Station 320. The delta weight was determined in the same manner as for the bending material described previously and resulted in an increase of 4 lbs. for VTOL and 6 lbs. for STOL.

3. Wing Tip Fairing

For the VTOL configuration, a wing tip fairing is required between the end of the torque box and the float pod, the float loads being taken through the rotation shaft forging. The fairing plan area is 8 square feet and an allowance of 10 lbs. per wing was made.

For the STOL version, the fairing over the wing to pylon attachment would require the same amount of material as the current XC-142A wing tip fairing, thus involving no weight change.

4. Wing Tip Forging

This was calculated from a preliminary layout drawing sized for both VTOL and STOL.

Summary	VTOL	STOL
Bearing Housing Forging (2)	114	122
Bearings (4)	16	16
Structure Replaced 7.5 ft^2/side	-25	-25
Total	105	113

(2) Tail

(a) Description

There will be no change required from the current XC-142A to the VTOL V-464; however, the STOL V-464 airplane could possibly require a vertical tail that is larger by 40 square feet due to the deeper fuselage section. No other item in this group will be affected.

(b) Weight Summary

	XC-142A	W from Col. (1)	VTOL V-464	W from Col. (1)	STOL V-464
Vertical Tail	250	0	250	76	326

(c) Tail Derivation

The area of the fin and rudder on the XC-142A is 130 ft^2 or 1.92 lbs/ft^2. The revised area of the STOL airplane is 170 ft^2 and using the same weight per square foot results in:

Vertical Tail (STOL) = 170 x 1.92 = 326 lbs.

(3) Fuselage

(a) The VTOL V-464 airplane fuselage is changed only by the installation of the inflatable vertical floats. This installation involves cutting two 5-foot diameter holes through the cargo floor and outer skin, providing sufficient material around the holes to redistribute the existing loads plus the attachment of the floats and also strengthening of the fuselage locally to accommodate the loads transmitted by the vertical floats. Non-load-carrying mechanically operated doors will close the float bays off when the floats are retracted.

The STOL V-464 configuration incorporates the addition of a hull contour and a considerably deeper fuselage. This entailed redesigning a large portion of the structure. However, one advantage of the deeper hull section is that it will now contain the main landing gear, eliminating the need for a fairing. In the absence of current statistical data and as the scope of this phase of the study did not warrant a structural analysis, the method employed was to take the same weight per square foot for the dead rise plating as was used by a seaplane of similar gross weight from reference (27). This is considered to be conservative due to the relatively lower impact speed, and hence reduced plating pressure of a STOL V-464 versus a conventional seaplane. The structure above waterline 100 was left unchanged while that between waterline 100 and the dead rise was considered to vary linearly between these values.

Penalties for the vertical float installation were derived in a manner similar to the VTOL airplane and were kept separate from the conventional amphibian analysis.

(b) Weight Summary

VTOL V-464

XC-142A Fuselage Structure	4526 lbs.
Penalty for Vertical Float Installation	300 lbs.
TOTAL VTOL V-464 Fuselage Structure	4826 lbs.

STOL V-464

	XC-142A	Δ W	STOL V-464
Major Frames and Bulkheads	748	102	850
Skin, Stringers, and Minor Frames	1271	1519	2790
Longerons	185	-	185
Attachments - Wing	57	-	57
- Tail	46	-	46
Longitudinal Partitions	25	-	25
Flooring and Supports	688	-	688
TOTAL Basic Structure	3020	1621	4641

STOL V-464 (continued)

	XC-142A	ΔW	STOL V-464
TOTAL Basic Structure (brought fwd)	3020	1621	4641
Cockpit Enclosure	323	-	323
Windows	34	-	34
Flooring and Supports	55	-	55
Radome	27	-	27
Doors and Frames - Nose Gear	41	7	48
- Main Gear	74	41	115
- Escape	36	-	36
- Entrance and Cargo	418	-343	75
- Access	107	-	107
Fairing & Fillets- Miscellaneous	88	-	88
- Wing Ramp Fwd	67	-	67
- Wing Ramp Aft	53	-	53
- Dorsal	18	-	18
- Landing Gear	165	-165	-
Sealant	-	300	300
TOTAL Secondary Structure	1506	-160	1346
TOTAL Fuselage Structure (excluding Vertical Float provision)	4526	1461	5987
Penalty for Vertical Float Inst.	-	270	270
TOTAL STOL FUSELAGE STRUCTURE	4526	1731	6257

(c) Weight Derivation

VTOL V-464

Float Cutout (0.26 lbs/in circum)	100
Float Attachments	60
Distribution of float loads into structure $= \left(\frac{W_L \times N_L}{1000}\right)$ =	110
Cargo Floor Removed = (2.4 lb/sq.ft x 39.4 sq.ft.) =	-95
Outer Skin and Stringers Remover = (0.63 lb/sq.ft) x 39.4 sq.ft.) =	-25
Doors: Area = (19.7 sq.ft @ 3 lb/sq.ft. x 2) =	120
Door Mechanism and Actuators (2)	30
TOTAL	300

STOL V-464

Major Frames and Bulkheads are held proportional to wetted area

Weight $= (748 \times \frac{1910}{1687}$ sq.ft.$) =$ 850

Skin, Stringers, Light Frames, and Joints

	Area (sq.ft.)	t eff. (in.)	Lbs. per sq.ft.	Weight (lbs)
Forward of Step				
Dead Rise	210	0.250	3.60	756
W.L. 100 to Dead Rise	372	0.153	2.20	818
Above W.L. 100	338	0.049	0.71	240
Total Forward of Step	920	0.137	1.97	1814
Aft of Step				
Dead Rise	135	0.125	1.80	243
W.L. 100 to Dead Rise	351	0.087	1.25	439
Above W.L. 100	414	0.049	0.71	294
Total Aft of Step	900	0.075	1.08	976
TOTAL FORWARD AND AFT	1820	0.106	1.53	2790

Doors and Frames

Nose Gear Doors (11 sq. ft.)		48
Doors (3 lbs/sq.ft.)	33 lbs.	
Mechanism	12 lbs.	
Actuator	3 lbs.	
Main Gear Doors (25 sq.ft.)		115
Doors (3 lb/sq.ft.)	75 lbs.	
Mechanism	30 lbs.	
Actuators	10 lbs.	
Entrance & Cargo Doors (30 sq.ft.)		75
Door (2 lb/sq.ft.)	60 lbs.	
Mechanism	15 lbs.	
Fairings and Fillets		-165
Landing Gear deleted	-	
Sealant - Submerged wetted area	600 sq.ft.	
using 0.5 lb/sq.ft.		300

Penalty for Vertical Float Installation

Float Cutout (0.13 lb/in circumference)	50
Float attachments	60
Distribution of float loads into structure	55
Outer plating removed (19.7 sq.ft/float @ 3.6 lbs/sq.ft.)	-142
Doors (area = 19.7 sq.ft. @ 5 lbs/sq.ft.) (2)	197
Door Mechanism and Actuator (2)	50
TOTAL	270

(4) Alighting Gear - Land Type

(a) Description

No change is made to the landing gear group weight for the VTOL version.

For the STOL aircraft, the main gear strut will be lengthened due to the deeper fuselage section. This weight increase is compensated for by the use of a single wheel and tire working to a higher UCI.

(b) Weight Summary

	XC-142A	W	STOL V-464
Main Gear - Rolling	301	-150	151
- Structure	592	140	732
Nose Gear - Rolling	92	-20	72
- Structure	170	-	170
Controls	83	-	83
TOTAL	1238	-30	1208

(c) Weight Derivation

Main Gear - Rolling Assembly — -1501 lbs.
Delete one main wheel assembly per side

- Structure
Ratio shock strut + oil weight by length

i.e., $(420 \times \frac{160 \text{ in}}{120 \text{ in}}) - 420 =$ 140 lbs.

Nose Gear - Rolling Assembly
Reduction in weight of tires due to higher UCI — -20 lbs.

(5) Alighting Gear - Water Type

(a) Description

This sub group is comprised of the auxiliary float installation and is applicable to the STOL V-464 only.

(b) Weight Summary

Float	195
Pylon (including rotation mechanism)	241

Total Wing Tip Floats = 436 x 2 = 872 lbs.

(c) Weight Derivation

Float	Weight per Float
Shell (wetted area = 65 sq.ft.)	65
Dead Rise (area = 35 sq.ft.)	35
Bulkheads (2)	20
Longerons (120 in. long x 2)	15
Cutout for Ver. Float (4 ft dia)	15
Structure removed	-25
Ver. Float Doors (12.6 sq.ft.)	38
Door Mech. & Actuators	5
Misc. Attachments	12
Sealant	15
TOTAL Float	195 lbs/side

Pylon		
Primary Structure - est. assuming a steel tube 8 in. o/d w/thickness varying from 0.1 to 0.16 in.		100
Fairing (38 sq.ft.)		38
Rotation shaft - from preliminary layout		23
		80
Rotation System - Motor	25	
- Gearbox	20	
- Drive Gears	25	
- Actuation	10	
TOTAL Pylon (incl. rotating mech.)		241 lbs/side

(6) Inflatable Vertical Floats

(a) Description

The inflatable vertical floats will be inflated by air pressure which will be sufficient to keep the float skin in tension when immersed in the water under a specified side load.

A vertical fabric member, or curtain, is attached diametrically across the bottom of the float and fastened at the top of the retraction drum. When the drum revolves, the curtain is wound in, causing the float to be pulled up within itself and then, following the curtain, will be wound onto the drum.

The remainder of the installation includes an inflation system, which is accounted for separately, and a retraction mechanism.

For the VTOL configuration, a float pod has to be provided and is included in this group together with the required rotation mechanism.

(b) Weight Summary

	VTOL	STOL
Fuselage Installation	(770)	(770)
Floats	400	400
Retraction Mechanism	270	270
Pressure Dome and Sealing	100	100
Wing Installation	(1540)	(500)
Floats	600	200
Retraction Mechanism	250	250
Pressure Sealing	50	50
Float Pod	480	-
Rotation System	160	-
TOTAL Vertical Float Installation	2310	1270

(c) Weight Derivation

The weights for the inflatable vertical floats were derived from the empirical formula recommended by Goodyear Aerospace Corp.

$$W = \frac{2(3 \times p \times Vt \times n)}{K}$$

where:
- p is the internal pressure
- Vt is the bag volume
- n is the load factor
- K is a constant

VTOL V-464

Floats - using Goodyear equation

Fuselage p = 26.7 psi Vt = 382 ft.		
from equation weight = (200 lbs. x 2)	=	400 lbs.
Wing p = 48 psi Vt = 296 ft^3		
from equation weight = (300 lbs. x 2)	=	600 lbs.

Retraction Mechanism -

Fuselage

Motor and installation	20
Drum drive and clutch	20
Drum	41
Bearings and supports	5
Retraction curtain	30
Misc. Attachments	19
Total	135 lbs. x 2 = 270 lbs.

Wing

Motor and installation	20
Drum drive and clutch	20
Drum	35
Bearings and supports	5
Retraction curtain	30
Misc. Attachments	15
Total	125 lbs. x 2 = 250 lbs.

Pressure Dome and Sealing

Fuselage - semi sphere (5 ft dia.)	35
Cutouts, seals, etc.	15
Total	50 lbs. x 2 = 100 lbs.
Wing - Pressure sealing of drum compartment	25 lbs. x 2 = 50 lbs.

Wing Float Pod (wetted area 64.5

Shell	65
Bulkheads (2)	20
Float doors & mechanism	26
Pod rotation shaft	29
Shaft to pod forging	80
Misc. Attachments	20
Total	240 lbs. x 2 = 480 lbs.

Rotation System		
Motor	25	
Gearbox	20	
Drive gears	25	
Actuation	10	
Total	80 lbs. x 2	= 160 lbs.

STOL V-464

Fuselage Installation - same as VTOL = 770 lbs.

Wing Installation

Floats p = 27 psi Vt = 208 ft^3

from Goodyear equation weight	=	100 lbs/side
Retraction Mechanism - as VTOL	=	125 lbs/side
Pressure Sealing	=	25 lbs/side

TOTAL WING Installation 250 lbs x 2 = 500 lbs.

(7) Inflation System

(a) Description

The vertical floats will be inflated by bleed air supplied by two Air Research GTC 85's. When the floats are not being inflated, these units would perform the functions of the existing APU which is, therefore, removed.

The installation weight will be identical for both the VTOL and STOL airplane.

(b) Weight Summary

Inflation System Installation	600
Delete existing APU	-109
Total Inflation System Installation	491 lbs.

(c) Weight Derivation

Power Units (2 x GTC @ 217 lbs. ea.)	434
Air Induction	10
Exhaust	10
Sub Total (forward)	454

Weight Derivation (sub total forward) 454

Lubrication System	15
Fuel System	6
Controls	6
Starting System (incl. battery)	40
Supports	11
Fire Shielding	8
Piping - to wing floats	30
- to fuselage floats	20
Instruments, etc.	10
TOTAL	600 lbs.

5. CONCLUSIONS

- With the assumption that inflatable vertical floats can be made to perform as predicted by Goodyear Aerospace Corp., the development of the airframe of either the STOL V-464 or the VTOL V-464 is feasible.
- It appears that the VTOL and STOL V-464 can tolerate the sea water recirculated through the engine during takeoff or landing under calm sea conditions.
- The water ingested in the STOL mode as a result of recirculation is approximately three times that ingested in the VTOL mode.
- If sea water recirculation does not preclude STOL V-464 operations, it appears that the additional performance capabilities of the STOL V-464 are sufficient to compensate for its additional 1,172 pounds of airframe weight.
- The critical loading condition on the V-464 structure occurs when the airplane is sitting on the water on its inflatable vertical floats and is moving at a five knot speed relative to the water. This loading condition requires a considerable "beef up" of the basic XC-142A wing structure.
- A preliminary study of the growth potential of an airplane using a tilt wing, deflected slipstream concept and fitted with inflatable vertical floats (Appendix D) has developed a curve showing the payload that can be carried on a 1,000 n.m. radius of action mission as a function of the airplanes design gross weight (Figure 10).

PART II

1. RECOMMENDATIONS

Work is now in progress under a contract from BuWeps to General Dynamics (NOw 63-0793, Amendment 3) to confirm the structural integrity of inflatable vertical floats and to design an inflatable vertical float installation for the Model P5M aircraft. The following recommendations assume the structural integrity of these inflatable vertical floats is confirmed and that the details of tieing the inflatable vertical floats to the airplane structure are satisfactorily worked out.

These recommendations also assume that tests of engine propeller combinations operating over water will provide sufficient data to permit a correlation to be developed between the model tests and full scale.

a. PRELIMINARY DESIGN STUDY

The subject study of this report has concluded that it is feasible to modify a Model XC-142A airplane for open ocean operations. Many assumptions were made for this study, and the results of testing and design studies now in progress were not included. It is thus necessary that refinements to this feasibility study be made prior to the initiation of a program to design a Model V-464 airplane; and these refinements should include a review of the validity of each of the feasibility study assumptions, the incorporation of understanding gained from the General Dynamics tests and installation design studies and the model tests to establish structural loads (Item b below), and a check of the flutter and dynamic response characteristics of a Model V-464 airplane.

b. MODEL TESTS TO ESTABLISH STRUCTURAL LOADS

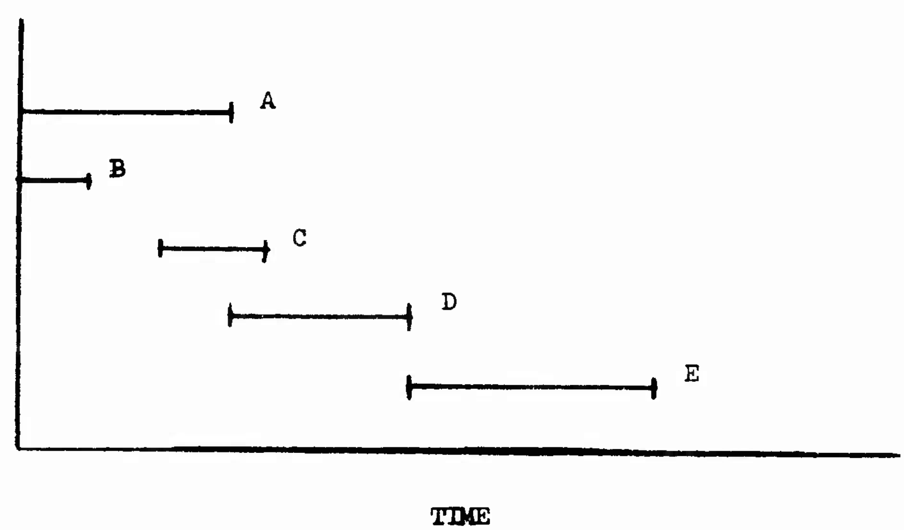
Model test work is required to confirm the critical load conditions analytically determined for the V-464 airplane. This should include a model having the scaled mass and inertia characteristics of the V-464 airplane, including the inflatable vertical floats, and tests to determine the VTOL landing loads on the inflatable vertical floats for various forward and/or lateral speeds and sink rates in various sea states.

c. FREE FLIGHT MODEL HOVER TESTS

A study should be made using the NASA XC-142A free flight model fitted with inflatable vertical floats to determine any adverse effects of these floats on the hover flying qualities of the V-464.

d. SCHEDULE

In order for the development of a seaplane version of the Model XC-142A airplane to proceed on a timely basis, and for the funding to be kept to a minimum until all areas of technical risk are analyzed and defined, it is recommended that this development proceed in accord with the schedule shown below:



A. Preliminary design study

B. Model test of structural loads

C. Free flight model hover tests

D. Detail design of inflatable vertical float installation for the Model V-464 airplane

E. Fabricate and test a seaplane version of the Model XC-142A airplane

PART III

TABLE I

INFLATABLE VERTICAL FLOAT DIMENSIONS

	Dimension (Ft.)	VTOL 37,500 Lb.	V-464 Airplane	STOL 45,000 Lb.
1.	l_F	17.5		17.5
2.	D_F	5		5
3.	X_F	27.5		27.5
4.	l_W	23.5		23.5
5.	l_A	--		16
6.	D_W	4		4
7.	Y_W	67.5		67.5
8.	ΔH	4		4

TABLE 3

MAXIMUM LOADS FOR SEA SITTING CONDITION

(AND TOWING, SEA STATE 4 AT 5 KNOTS)

V-464 AIRPLANE

	VTOL 37,500 #	STOL 45,000 #	
F_{D_F}	5,950	6,600	LBS.
M_{D_F}	66,000	66,700	Ft/LBS.
F_{B_F}	21,200	23,650	LBS.
σ_{L_F}	392	408.5	LBS./IN
F_{D_W}	4,280	4,750	LBS.
M_{D_W}	71,800	71,600	FT-LBS.
F_{B_W}	12,000	14,900	LBS.
σ_{L_W}	532	-	LBS/IN
	AUXILIARY FLOAT		
$M_{D_{W_A}}$	-	36,000	FT-LBS
$\sigma_{L_{W_A}}$	-	336.6	LBS/IN.

TABLE 4

TOWING LOADS
(Calm Sea at 5 Knots)

V-464 AIRPLANE

	VTOL 37,500#	STOL 45,000#	
F_{DF}	3,690	4,440	LBS
M_{DF}	52,750	58,800	FT/LBS
F_{BF}	13,100	15,750	LBS
σ_{LF}	125.4	146	LBS/IN
F_{DW}	2,020	2,410	LBS
M_{DW}	40,300	46,500	FT/LBS
F_{BW}	5,625	6,740	LBS
σ_{LW}	104.0		LBS/IN.
AUXILIARY FLOAT			
M_{DWA}		28,400	FT/LBS
σ_{LWA}		92	LBS/IN.

TABLE 5

GROSS WEIGHT SUMMARY

	XC-142A	V-464 VTOL	V-464 STOL
Weight Empty	23,045	26,555	27,736
Fixed Useful Load	785	785	785
Operating Weight Empty	23,830	27,340	28,521
VTOL Payload	8,000	4,490	-
VTOL Fuel (200 nm)	5,644	5,644	
VTOL Take-Off Gross Weight	37,474	37,474	-
STOL Payload	10,000	-	10,000
STOL Fuel	6,120	-	6,479
STOL Take-Off Gross Weight	39,950	-	45,000

TABLE 6

WEIGHT EMPTY SUMMARY

	WEIGHT				
	(1) SPEC XC-142A	(2) VTOL W from Col. (1)	(3) V-464 VTOL	(4) STOL W from Col. (1)	(5) V-474 STOL
Wing	2839	409	3248	281	3120
Tail	953	-	953	76	1029
Fuselage	4526	300	4826	1731	6257
Alighting Gear -					
Land Type	1238	-	1238	-30	1208
Water Type	-	-	-	872	872
Vertical Floats	-	2310	2310	1270	1270
Flight Controls	1593	-	1593	-	1593
Nacelles	1077	-	1077	-	1077
TOTAL STRUCTURE	12226	3019	15245	4200	16426
Engines	2872	-	2872	-	2872
Air Induction	117	-	117	-	117
Exhaust	-	-	-	-	-
Lubrication System	167	-	167	-	167
Fuel System	435	-	435	-	435
Engine Controls	97	-	97	-	97
Starting System	10	-	10	-	10
Propeller Installation	1656	-	1656	-	1656
Transmission	2362	-	2362	-	2362
TOTAL PROPULSION	7716	-	7716	-	7716
Auxiliary Power Unit	109	491	600	491	600
Instruments	299	-	299	-	299
Hydraulic System	47	-	47	-	47
Electrical System	533	-	533	-	533
Electronics	749	-	749	-	749
Armament	6	-	6	-	6
Furnishings	902	-	902	-	902
Air Conditioning & Anti-Ice	450	-	450	-	450
Auxiliary Gear	8	-	8	-	8
TOTAL FIXED EQUIPMENT	3103	491	3594	491	3594
WEIGHT EMPTY	23045	3510	26555	4691	27736

TABLE 7

BALANCE CALCULATIONS - STOL

ITEM	WEIGHT	X	WX	Z	WZ
XC-142A Specification Weight Empty - Tilting Component (Ref. 25)	12091	264.3	3,195,789	141.6	1,712,010
Add:					
Wing Structure	281	266.0	74,746	146.0	41,026
Alighting Gear - Water Type	160	290.0	46,400	146.0	23,360
Inflation System	30	275.0	825	146.0	438
TOTAL TILTING WEIGHT	12562	264.1	3,317,760	141.4	1,776,834
XC-142A Specification Weight Empty - Non-Tilting Component (Ref.)	10954	286.0	3,132,981	107.1	1,173,200
Add:					
Vertical Tail	76	544.5	41,382	229.8	17,465
Fuselage	1731	(197.0)	341,022	(8.3)	14,410
Alighting Gear - Land Type	-30	(155.5)	-4,665	(-151.7)	4,552
Alighting Gear - Water Type	712	300.0	213,600	82.6	58,811
Vertical Floats -					
Wing	500	308.0	154,000	66.0	33,000
Fuse	770	295.0	227,150	40.0	30,800
Inflation System	461	289.0	133,229	58.0	26,738
TOTAL NON-TILTING WEIGHT	15174	379.3	4,238,699	89.6	1,358,976
TOTAL WEIGHT EMPTY	27736	272.4	7,556,459	91.3	2,532,176
Add Useful Load:					
Pilot	400	63.0	25,200	121.0	48,400
Crew Chief	200	80.0	16,000	121.0	24,200
Unusable Fuel	35	270.0	9,450	148.0	5,180
Unusable Oil	70	255.0	17,850	142.4	9,970
Usable Fuel	6479	272.7	1,766,823	157.0	1,017,203
Usable Oil	80	255.0	20,400	142.5	11,400
Payload	10000	270.0	2,700,000	80.0	800,000
TAKE OFF GROSS WEIGHT	45000	269.2	12,112,182	98.9	4,448,529
TILTING COMPONENT	12712	264.0	3,356,010	141.5	1,798,204
NON-TILTING COMPONENT	32288	271.2	8,756,172	82.1	2,650,325
ZERO FUEL WEIGHT	28521	268.6	10,345,359	89.1	3,431,326
NON-TILTING COMPONENT (ZERO FUEL)	25809	270.8	6,989,349	63.3	1,633,122

TABLE 6

BALANCE CALCULATIONS - VTOL

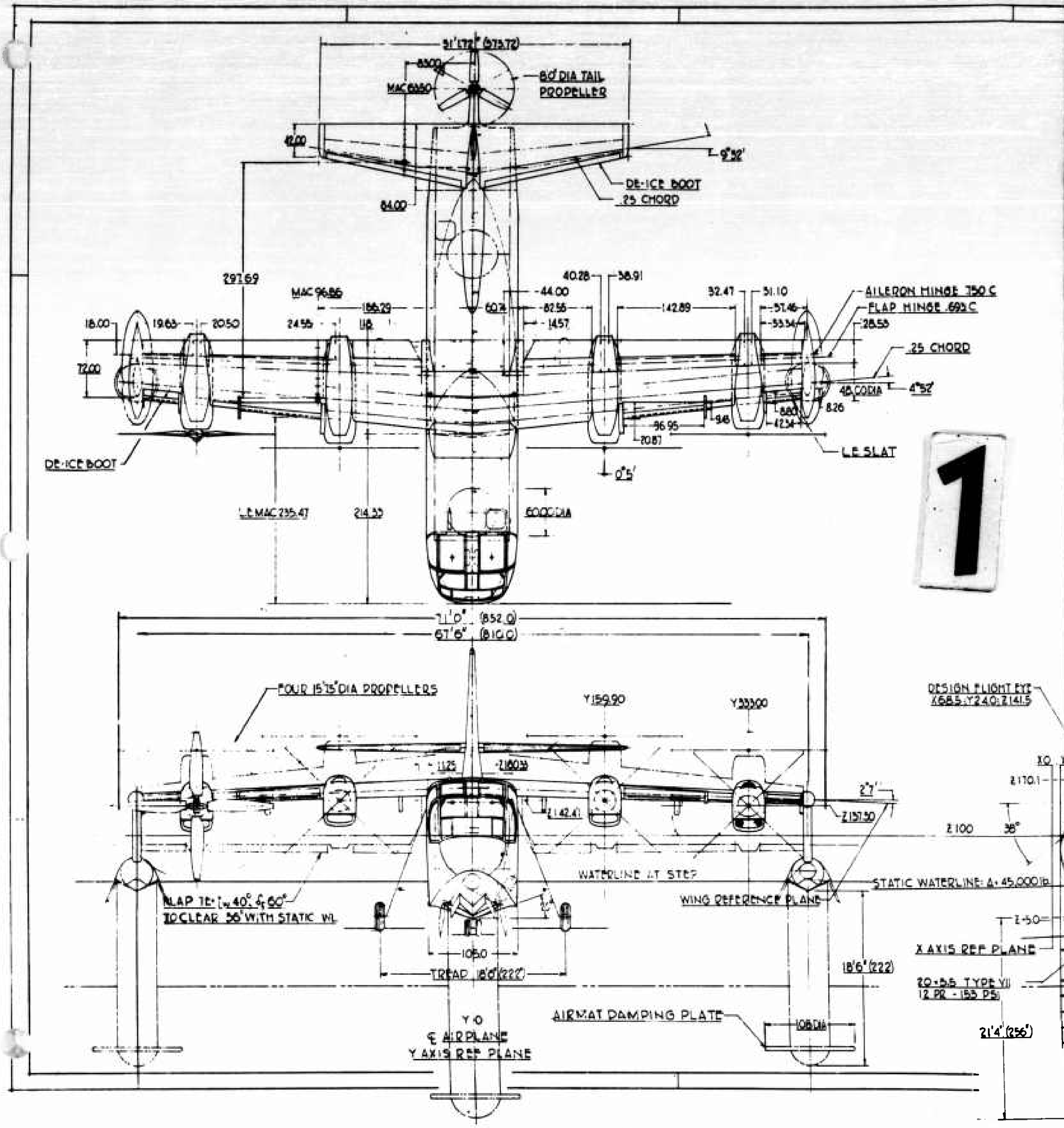
ITEM	WEIGHT	X	WX	Z	WZ
XC-142A Specification Weight Empty - Tilting Component (Ref.)	12091	264.3	3,195,789	141.6	1,712,010
Add:					
Wing Structure	409	266.0	[illegible]	146.0	59,714
Vertical Floats	160	290.0	46,400	146.0	23,360
Inflation System	30	275.0	825	146.0	438
TOTAL TILTING WEIGHT	12690	[illegible]	3,351,[illegible]	141.5	1,795,522
XC-142A Specification Weight Empty - Non-Tilting Component (Ref.)	[illegible]	[illegible]	[illegible]	[illegible]	1,173,200
Add:					
Fuselage Structure	300	[illegible]	[illegible]	[illegible]	18,000
Vertical Floats - Wing	[illegible]	304.[illegible]	419,520	150.0	207,000
Vertical Floats - Fuse	[illegible]	[illegible]	222,530	[illegible]	44,660
Inflation System	461	[illegible]	133,229	[illegible]	26,738
TOTAL NON-TILTING WEIGHT	13865	[illegible]	3,994,960	[illegible]	1,469,598
TOTAL WEIGHT EMPTY	26555	276.7	7,346,768	123.0	3,265,120
Add Useful Load:					
Pilot (2)	400	63.0	25,200	121.0	48,400
Crew Chief	200	80.0	16,000	121.0	24,200
Unusable Fuel	35	270.0	9,450	148.0	5,180
Unusable Oil	70	255.0	17,850	142.4	9,970
Usable Fuel (200 n.m.)	5644	265.7	1,499,680	157.1	886,420
Usable Oil	80	255.0	20,400	142.5	11,400
Payload	4490	270.0	1,212,300	80.0	359,200
TAKE OFF GROSS WEIGHT	37474	270.8	10,147,684	123.0	4,609,890
TILTING COMPONENT	12840	264.0	3,390,058	141.5	1,816,892
NON-TILTING COMPONENT	24634	274.3	6,757,626	113.4	2,792,998
ZERO FUEL WEIGHT	31830	271.7	8,648,004	117.0	3,723,470
NON-TILTING COMPONENT (ZERO FUEL)	18990	276.9	5,257,946	100.4	1,906,578

2. FIGURES

LIST OF FIGURES

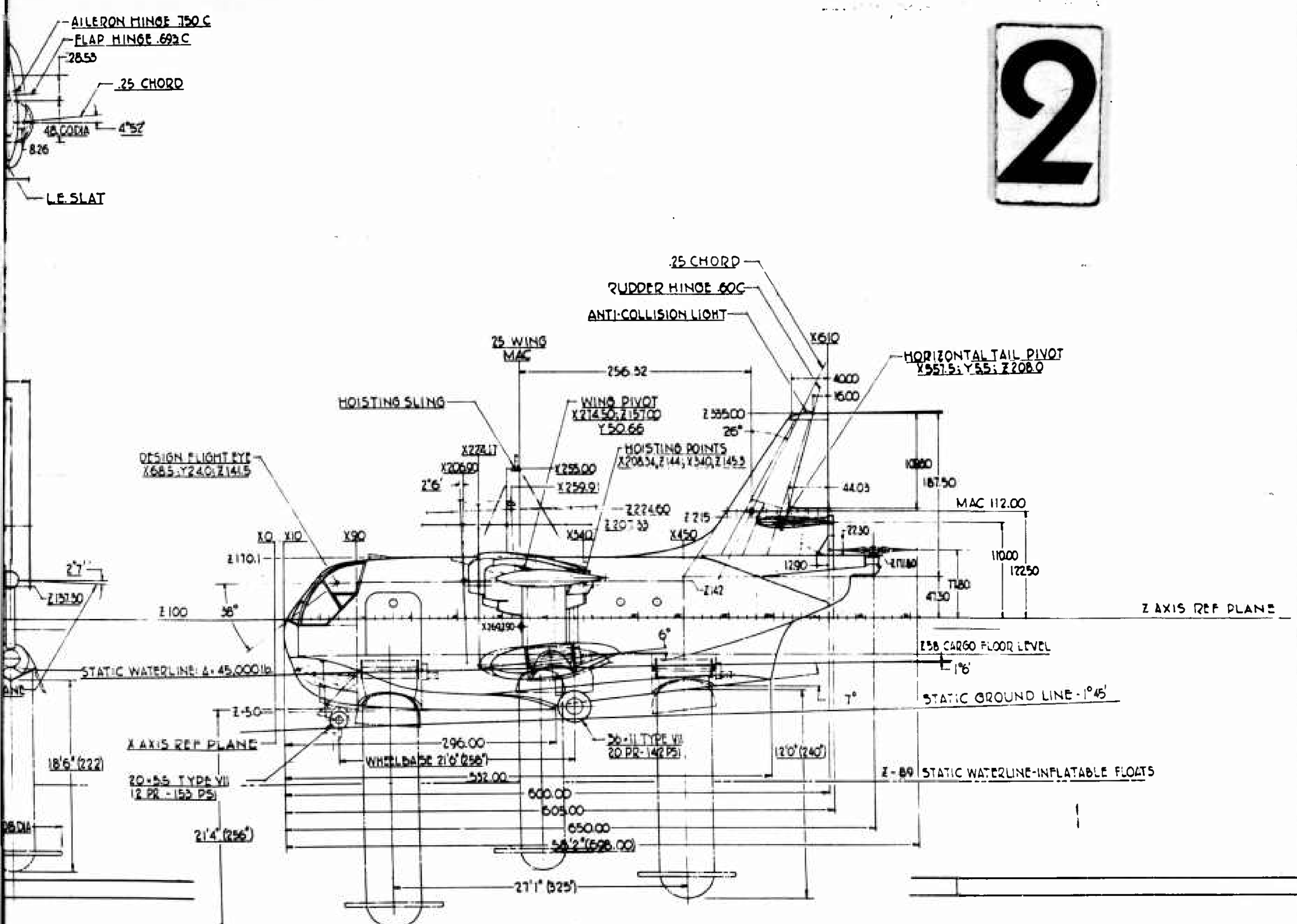
LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)



51'17.72" (673.72)
83.00
MAC 63.50
8.0' DIA TAIL PROPELLER
42.00
9°32'
DE-ICE BOOT
.25 CHORD
84.00
297.69
MAC 96.86
186.29
40.28
38.91
44.00
82.56
14.57
60.74
142.89
32.47
51.10
57.46
53.54
28.53
AILERON HINGE .750 C
FLAP HINGE .693 C
.25 CHORD
18.00
19.63
20.50
24.55
72.00
48.CODIA
4°52'
8.26
96.95
9.16
20.87
42.54
8.80
L.E. SLAT
DE-ICE BOOT
0°5'
L.E. MAC 235.47
214.35
60.00 DIA
71'0" (852.0)
67'6" (810.0)
1
FOUR 15'75" DIA PROPELLERS
Y159.90
Y333.00
DESIGN FLIGHT EYE X68.5 Y24.0 Z141.5
Z142.4
Z157.50
2°7'
Z170.1
Z100
38°
WATERLINE AT STEP
STATIC WATERLINE: A - 45,000 lb
FLAP TE - δ 40°, δ 60°
TO CLEAR 36" WITH STATIC WL
WING REFERENCE PLANE
Z+5.0
X AXIS REF PLANE
105.0
TREAD 18'6" (222")
18'6" (222)
20 - 5.5 TYPE VII
12 PR - 155 PSI
Y 0
℄ AIRPLANE
Y AXIS REF PLANE
AIRMAT DAMPING PLATE
108 DIA
21'4" (256")

2



AILERON HINGE .750 C
FLAP HINGE .692 C
28.55
.25 CHORD
4°52'
8.26
L.E. SLAT
.25 CHORD
RUDDER HINGE .60C
ANTI-COLLISION LIGHT
X610
HORIZONTAL TAIL PIVOT X557.5; Y55; Z208.0
25 WING MAC
256.52
40.00
16.00
HOISTING SLING
WING PIVOT X274.50; Z157.00 Y50.66
Z 555.00
26°
HOISTING POINTS X208.54, Z144; X340, Z145.5
X274.17
X255.00
X259.91
X206.90
2'6"
44.05
187.50
MAC 112.00
Z224.60
Z207.55
Z 215
X340
X450
Z230
X0
X10
X90
Z110.1
1290
110.00
122.50
47.30
71.80
Z137.50
Z 100
38°
Z 142
Z AXIS REF PLANE
6°
Z58 CARGO FLOOR LEVEL
1°6'
STATIC WATERLINE: △ 45,000 lb
7°
STATIC GROUND LINE - 1°45'
Z-50
X AXIS REF PLANE
296.00
56-11 TYPE VII 20 PR - 142 PSI
WHEELBASE 21'0" (258")
12'0" (240")
18'6" (222)
20-5.5 TYPE VII 12 PR - 153 PSI
552.00
Z - 89 STATIC WATERLINE-INFLATABLE FLOATS
600.00
605.00
650.00
21'4" (256")
58'2" (698.00)
27'1" (325")

GENERAL DATA

WING

AREA TOTAL, INCL. AILERON, FLAPS AND 87.50 SQ.FT OF FUSELAGE ____ 534.37 SQ.FT.
FLAP AREA TOTAL, VANE L.E. TO FLAP T.E. ____ 142.94 SQ.FT.
AILERON AREA TOTAL, AFT OF HINGE ____ 59.73 SQ.FT.
LEADING EDGE SLAT ____ 25.42 SQ.FT.
AIRFOIL SECTIONS ____ ROOT NACA 63-318 (MOD)
TIP NACA 63-318 (MOD)
INCIDENCE ____ LEVEL FLIGHT - ROOT 0 DEG
TIP 0 DEG
VTOL FLIGHT - 98 DEG

VERTICAL TAIL

AREA TOTAL, INCLUDING 6.57 SQ.FT. OF FUSELAGE AND EXCLUDING DORSAL ____ 130.00 SQ.FT.
RUDDER AFT OF HINGE ____ 22.82 SQ.FT.
AIRFOIL SECTIONS ____ ROOT NACA 0018
Z 171.80 t/c .178
Z 215.00 t/c .129
TIP NACA 0012

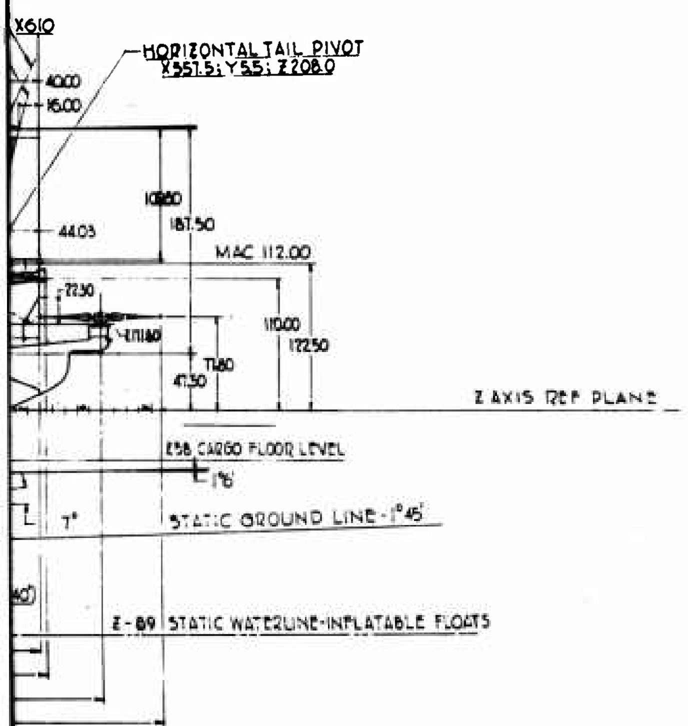
HORIZONTAL TAIL (ALL MOVEABLE)

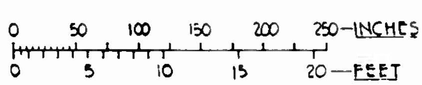
AREA TOTAL ____ 163.50 SQ.FT.
AIRFOIL SECTION ____ ROOT NACA 0015
TIP NACA 0012

CONTROL SURFACE MOVEMENT

AILERON ____ WING UP 50 DEG. FWD OR AFT
WING DN 15 DEG UP OR DN
FLAP (DOUBLE SLOTTED) ____ 60 DEG DOWN
RUDDER ____ 30 DEG R OR L
HORIZONTAL TAIL-LEADING EDGE ____ 39 DEG UP, 9 DEG DN

LANDING GEAR	TYPE	SIZE	PLY RATE	STATIC R	FLAT R	GROWN TIRE DIA	INFL. PRESS.
MAIN	III TUBELESS	11.00×12	8	12.5 IN.	8.6 IN.	32.80 IN	45 PSI
NOSE	III TUBELESS	8.50×10	10	10.2 IN.	6.8 IN.	26.10 IN.	61 PSI

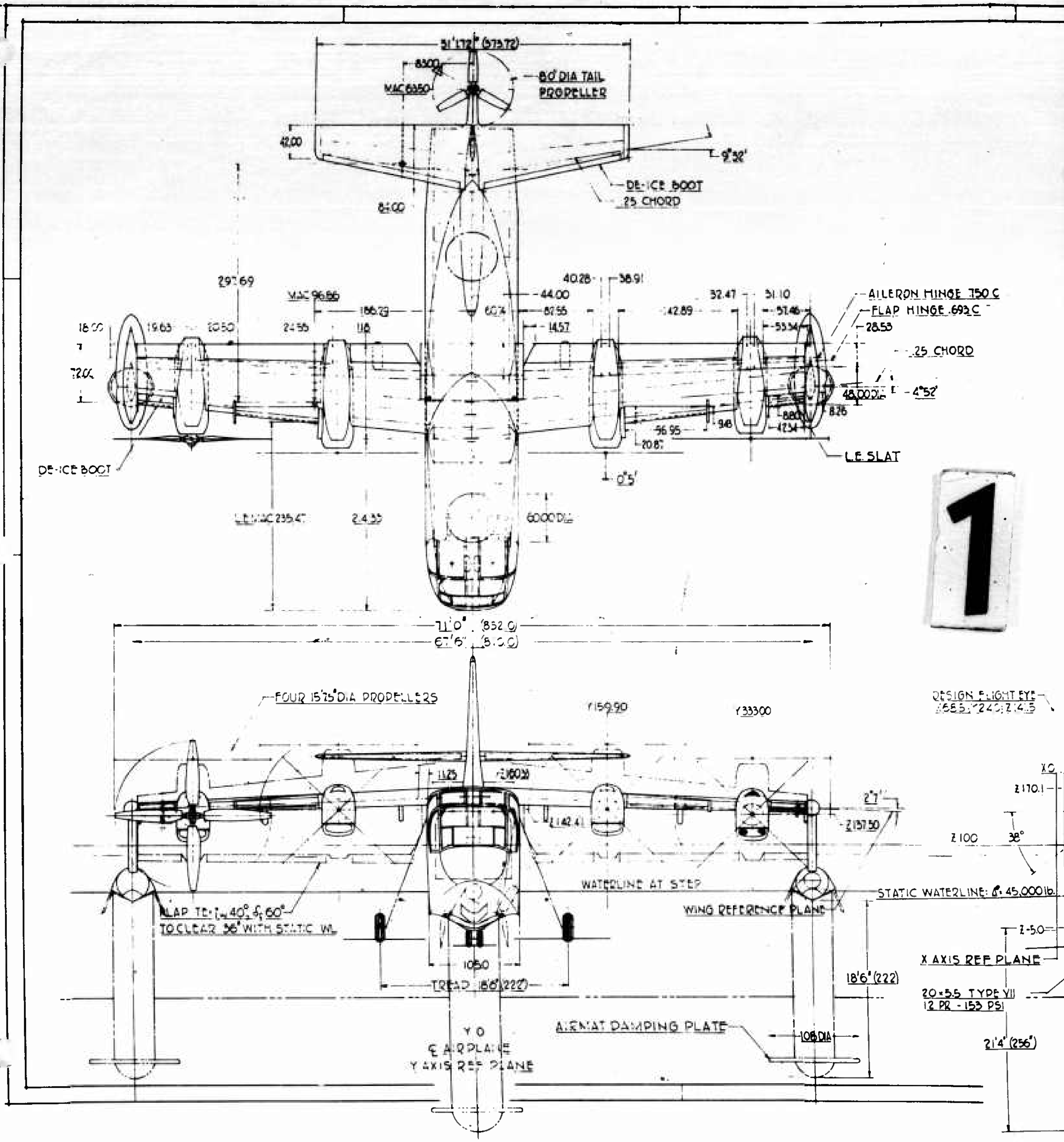




3

LTV VOUGHT AERONAUTICS DIVISION
GENERAL ARRANGEMENT
V464 STOL
80378
76-000298

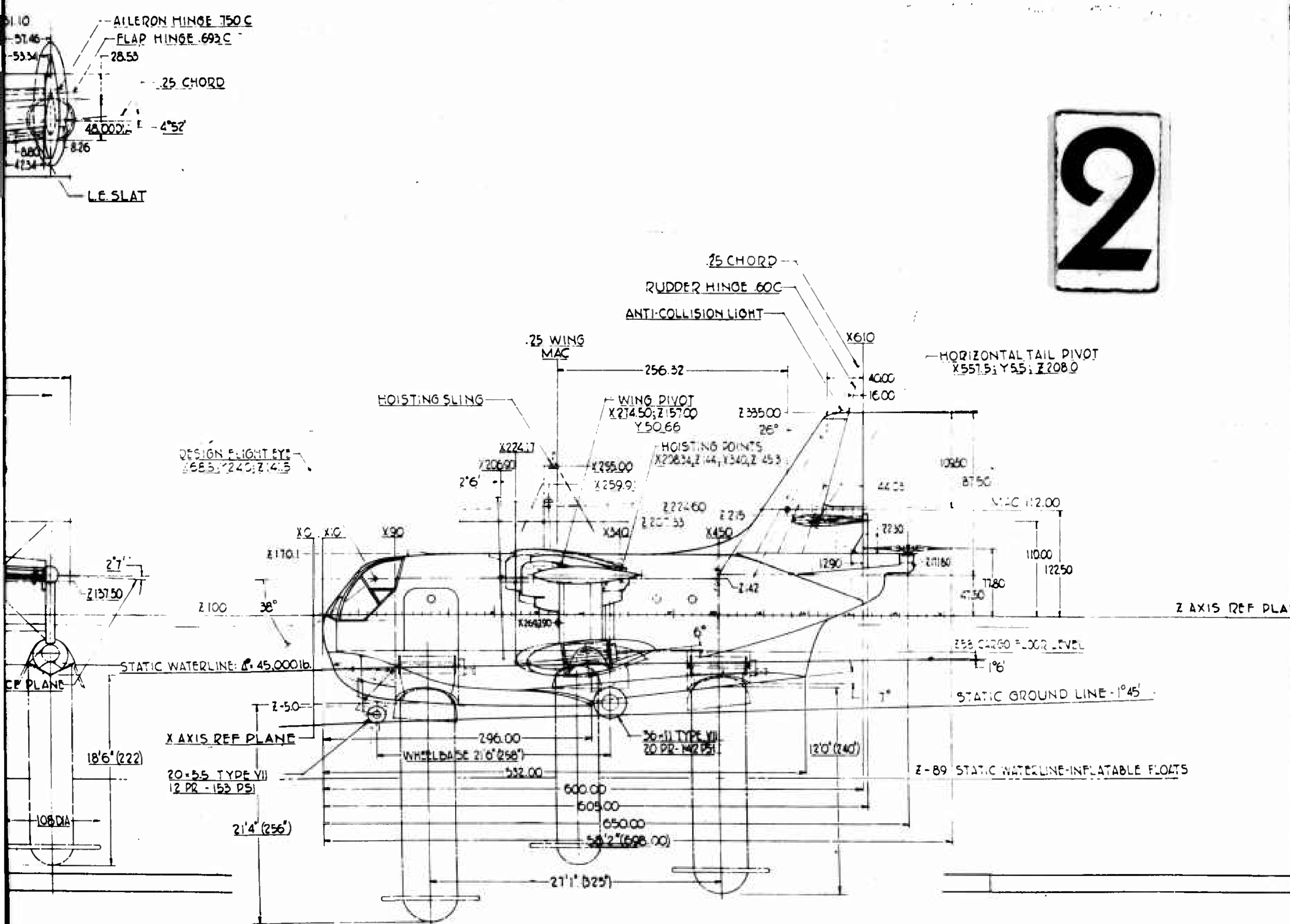
Figure 1 - General Arrangement, STOL V-464 - Vee Hull



51'1.72" (373.72)
8.0' DIA TAIL PROPELLER
DE-ICE BOOT
.25 CHORD
AILERON HINGE .750 C
FLAP HINGE .693 C
.25 CHORD
L.E. SLAT
DE-ICE BOOT
71'0" (852.0)
FOUR 15'75" DIA PROPELLERS
WATERLINE AT STEP
WING REFERENCE PLANE
STATIC WATERLINE @ 45,000 lb.
X AXIS REF PLANE
20 x 5.5 TYPE VII
12 PR - 153 PSI
TREAD 18'6" (222)
18'6" (222)
21'4" (256")
Y 0
℄ AIRPLANE
Y AXIS REF PLANE

1

2



AILERON HINGE .750 C
FLAP HINGE .693 C
.25 CHORD
4°52'
L.E. SLAT
.25 CHORD
RUDDER HINGE .60C
ANTI-COLLISION LIGHT
X610
.25 WING MAC
256.32
HORIZONTAL TAIL PIVOT X557.5; Y5.5; Z208.0
HOISTING SLING
WING PIVOT X274.50; Z157.00 Y50.66
HOISTING POINTS
DESIGN FLIGHT EYE
Z335.00
MAC 112.00
Z AXIS REF PLANE
Z58 CARGO FLOOR LEVEL
STATIC WATERLINE: @ 45,000 lb.
STATIC GROUND LINE - 1°45'
X AXIS REF PLANE
56×11 TYPE VII 20 PR - 142 PSI
WHEELBASE 21'6" (258")
20×5.5 TYPE VII 12 PR - 153 PSI
Z-89 STATIC WATERLINE-INFLATABLE FLOATS
18'6" (222)
108 DIA
21'4" (256")
12'0" (240")
296.00
532.00
600.00
605.00
650.00
58'2" (698.00)
27'1" (325")

GENERAL DATA

WING

AREA TOTAL, INCL. AILERON, FLAPS AND 87.50 SQ.FT. OF FUSELAGE		554.37 SQ.FT.
FLAP AREA TOTAL, VANE L.E. TO FLAP T.E.		142.94 SQ.FT.
AILERON AREA TOTAL, AFT OF HINGE		59.73 SQ.FT.
LEADING EDGE SLAT		25.42 SQ.FT.
AIRFOIL SECTIONS	ROOT	NACA 63-318 (MOD)
	TIP	NACA 63-318 (MOD)
INCIDENCE	LEVEL FLIGHT - ROOT	0 DEG
	TIP	0 DEG
	VTOL FLIGHT -	98 DEG

VERTICAL TAIL

AREA TOTAL, INCLUDING 6.87 SQ.FT. OF FUSELAGE AND EXCLUDING DORSAL		130.00 SQ.FT.
RUDDER AFT OF HINGE		22.82 SQ.FT.
AIRFOIL SECTIONS	ROOT	NACA 0018
	Z 171.80	t/c .178
	Z 215.00	t/c .129
	TIP	NACA 0012

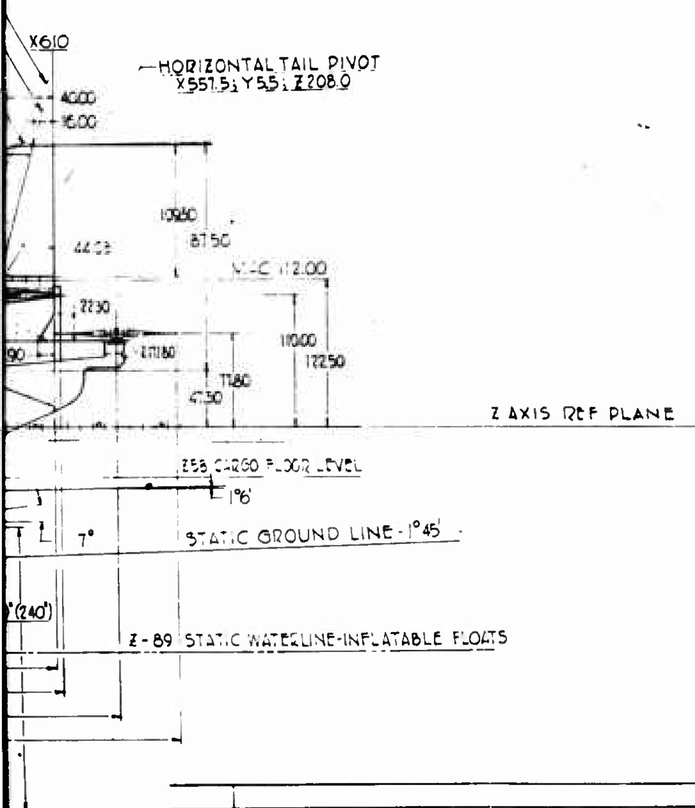
HORIZONTAL TAIL (ALL MOVEABLE)

AREA TOTAL		165.50 SQ.FT.
AIRFOIL SECTION	ROOT	NACA 0015
	TIP	NACA 0012

CONTROL SURFACE MOVEMENT

AILERON	WING UP	50 DEG. FWD OR AFT
	WING DN	15 DEG UP OR DN
FLAP (DOUBLE SLOTTED)		60 DEG DOWN
RUDDER		30 DEG R OR L
HORIZONTAL TAIL-LEADING EDGE		39 DEG UP, 9 DEG DN

LANDING GEAR	TYPE	SIZE	PLY RATE	STATIC R	FLAT R	GROWN TIRE DIA	INFL. PRESS.
MAIN	III TUBELESS	11.00×12	8	12.5 IN	8.6 IN.	32.80 IN	45 PSI
NOSE	III TUBELESS	8.50×10	10	10.2 IN.	6.8 IN.	26.10 IN	61 PSI



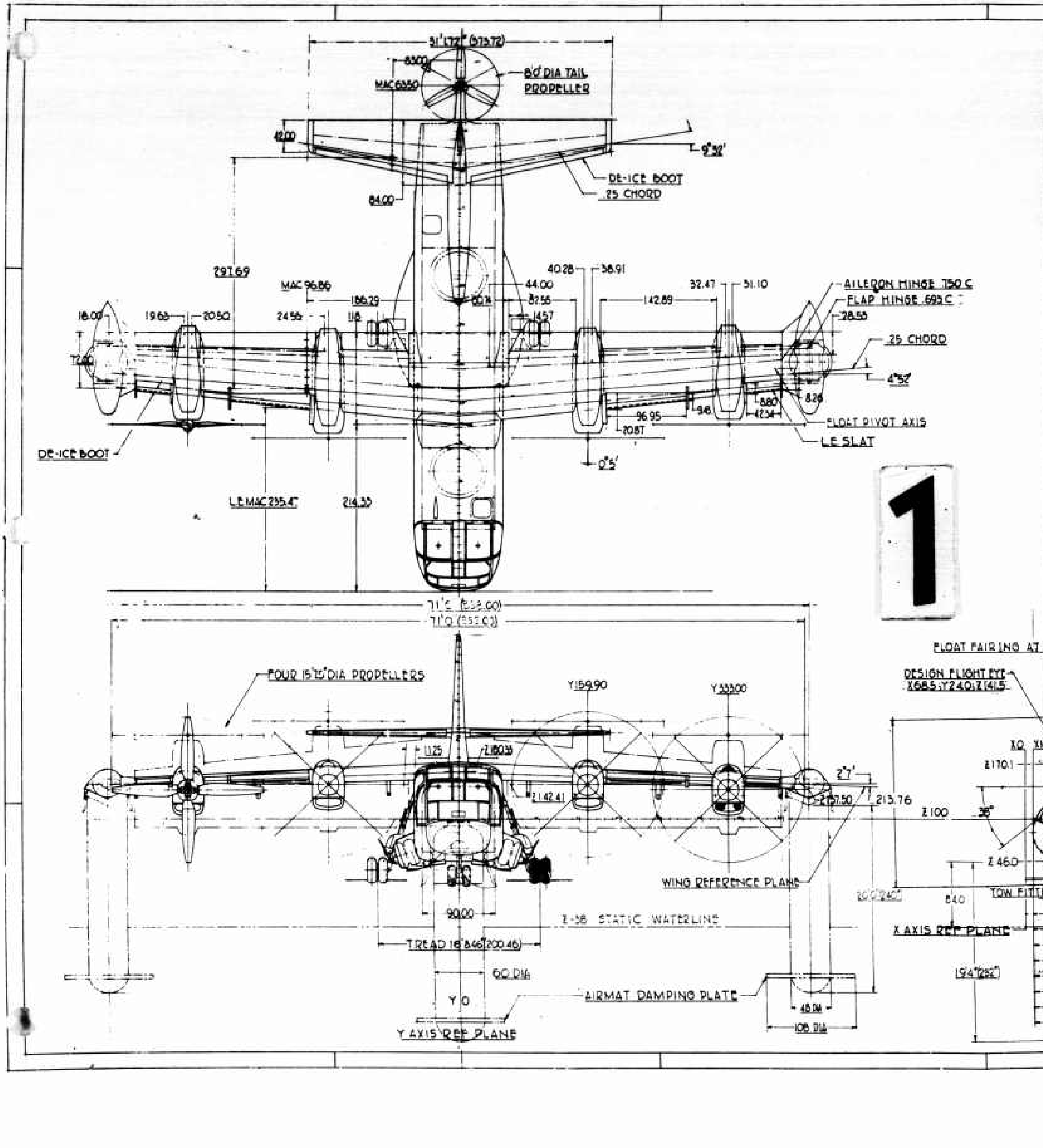
3

LTV VOUGHT AERONAUTICS DIVISION

GENERAL ARRANGEMENT
V464 STOL - ROUND HULL

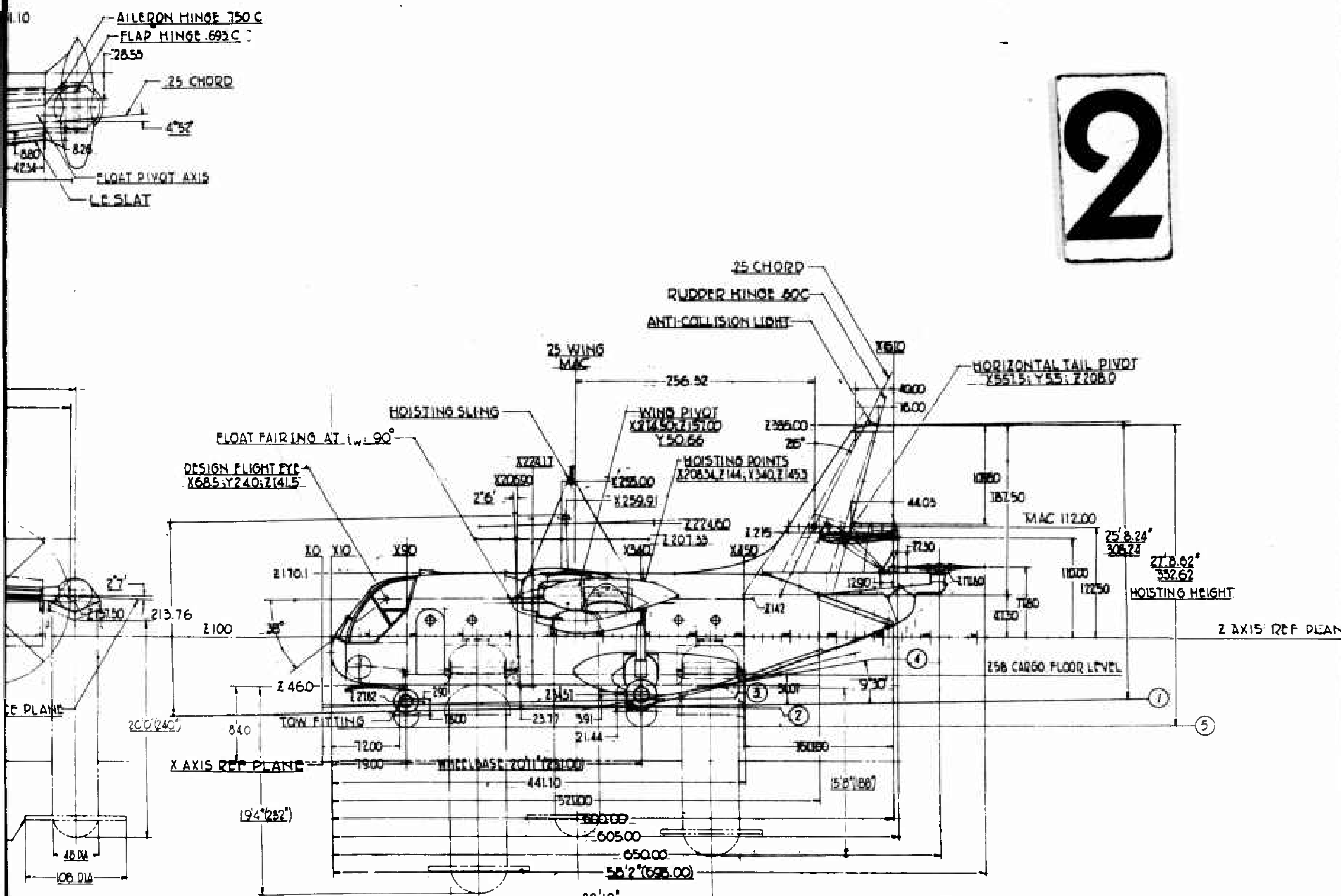
CODE IDENT NO 80378 — SIZE 80 — 76-000464 — SCALE 1/40

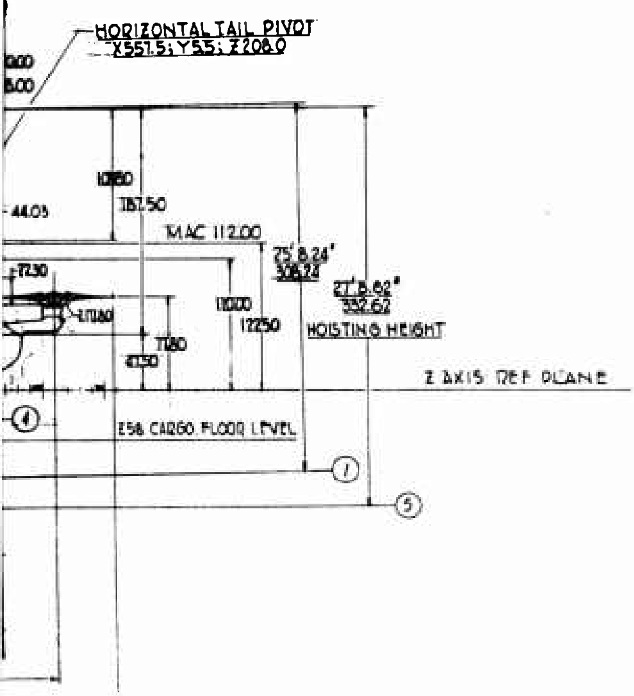
Figure 2 - General Arrangement, STOL V-464 - Rounded Hull



31'1.72" (373.72)
8'0" DIA TAIL PROPELLER
MAC 63.50
83.00
42.00
9°32'
DE-ICE BOOT
.25 CHORD
84.00
297.69
MAC 96.86
186.29
40.28
38.91
44.00
82.56
14.57
142.89
32.47
31.10
AILERON HINGE .750 C
FLAP HINGE .695 C
28.53
.25 CHORD
4°52'
8.26
FLOAT PIVOT AXIS
L.E. SLAT
96.95
20.87
18.00
19.68
20.50
24.55
72.00
DE-ICE BOOT
0°5'
L.E. MAC 235.4"
214.35
1
71'0" (853.00)
FOUR 15'15" DIA PROPELLERS
Y159.90
Y333.00
DESIGN FLIGHT EYE
X68.5; Y24.0; Z141.5
FLOAT FAIRING AT
1.125
Z180.35
Z142.41
2°7'
Z157.50
213.76
Z100
38°
Z46.0
Z170.1
WING REFERENCE PLANE
TOW FITTING
90.00
Z-38 STATIC WATERLINE
TREAD 16'8.46" (200.46)
X AXIS REF PLANE
60 DIA
Y0
AIRMAT DAMPING PLATE
48 DIA
108 DIA
Y AXIS REF PLANE

2


AILERON HINGE .750 C
FLAP HINGE .693 C
28.53
.25 CHORD
4°52'
.880
8.26
FLOAT PIVOT AXIS
L.E. SLAT
.25 CHORD
RUDDER HINGE .60C
ANTI-COLLISION LIGHT
.25 WING MAC
X610
HORIZONTAL TAIL PIVOT X551.5; Y55; Z208.0
256.52
40.00
18.00
HOISTING SLING
WING PIVOT X214.50; Z157.00 Y50.66
Z385.00
26°
FLOAT FAIRING AT i_w = 90°
HOISTING POINTS
X224.17
X206.90
X295.00
X259.91
DESIGN FLIGHT EYE X68.5; Y24.0; Z141.5
2'6"
44.05
187.50
MAC 112.00
Z224.60
Z207.33
Z215
X0
X10
X90
X340
X450
Z170.1
27'7"
Z157.50
213.76
Z100
36°
Z142
Z460
Z 218.2
Z145.1
25'8.24" 308.24
27'8.62" 332.62
HOISTING HEIGHT
Z AXIS REF PLANE
Z58 CARGO FLOOR LEVEL
9°30'
TOW FITTING
20'0"(240")
84.0
72.00
19.00
23.77
3.91
21.44
X AXIS REF PLANE
WHEELBASE 20'11" (251.00)
441.10
521.00
580.00
605.00
650.00
58'2"(698.00)
19'4"(232")
15'8"(188")
48 DIA
108 DIA
20'10"
CE PLANE



GENERAL DATA

WING

- AREA TOTAL, INCL. AILERON, FLAPS AND 87.50 SQ.FT. OF FUSELAGE ____ 534.37 SQ.FT.
- FLAP AREA TOTAL, VANE L.E. TO FLAP T.E. ____ 142.94 SQ.FT.
- AILERON AREA TOTAL, AFT OF HINGE ____ 59.75 SQ.FT.
- LEADING EDGE SLAT ____ 25.42 SQ.FT.
- AIRFOIL SECTIONS ____ ROOT NACA 63-318 (MOD); TIP NACA 63-318 (MOD)
- INCIDENCE ____ LEVEL FLIGHT - ROOT 0 DEG; TIP 0 DEG; VTOL FLIGHT - 98 DEG

VERTICAL TAIL

- AREA TOTAL, INCLUDING 63.37 SQ.FT. OF FUSELAGE AND EXCLUDING DORSAL ____ 130.00 SQ.FT.
- RUDDER AFT OF HINGE ____ 22.82 SQ.FT.
- AIRFOIL SECTIONS ____ ROOT NACA 0018; Z 171.80 t/c .178; Z 215.00 t/c .129; TIP NACA 0012

HORIZONTAL TAIL (ALL MOVEABLE)

- AREA TOTAL ____ 163.50 SQ.FT.
- AIRFOIL SECTION ____ ROOT NACA 0015; TIP NACA 0012

CONTROL SURFACE MOVEMENT

- AILERON ____ WING UP 50 DEG. FWD OR AFT; WING DN 15 DEG UP OR DN
- FLAP (DOUBLE SLOTTED) ____ 60 DEG DOWN
- RUDDER ____ 30 DEG R OR L
- HORIZONTAL TAIL-LEADING EDGE ____ 39 DEG UP, 9 DEG DN

LANDING GEAR	TYPE	SIZE	PLY RATE	STATIC R	FLAT R	GROWN TIRE DIA	INFL. PRESS.
MAIN	III TUBELESS	11.00×12	8	12.5 IN	8.6 IN.	32.80 IN.	45 PSI
NOSE	III TUBELESS	8.50×10	10	10.21N.	6.8 IN.	26.10 IN.	61 PSI

GROUND LINES

1. AIRPLANE IN NORMAL STATIC POSITION ____ 1°0' NOSE UP
2. AIRPLANE WITH M.G. SHOCK ABSORBERS & TIRES STATIC; N.G. SHOCK ABSORBERS FULLY COMPRESSED & TIRES FLAT ____ 0°27' NOSE DN
3. AIRPLANE WITH M.G. AND N.G. SHOCK ABSORBERS FULLY COMPR., ALL TIRES FLAT ____ 1°22' NOSE UP
4. AIRPLANE MAX TAIL DOWN WITH M.G. SHOCK-ABSORBER STRUT FULLY COMPRESSED TIRES FLAT ____ 9°30' NOSE UP
5. AIRPLANE WITH M.G. & N.G. FULLY EXTENDED, GROWN TIRE DIAMETER ____ 0°13' NOSE UP

3

0 50 100 150 200 250—INCHES
0 5 10 15 20—FEET

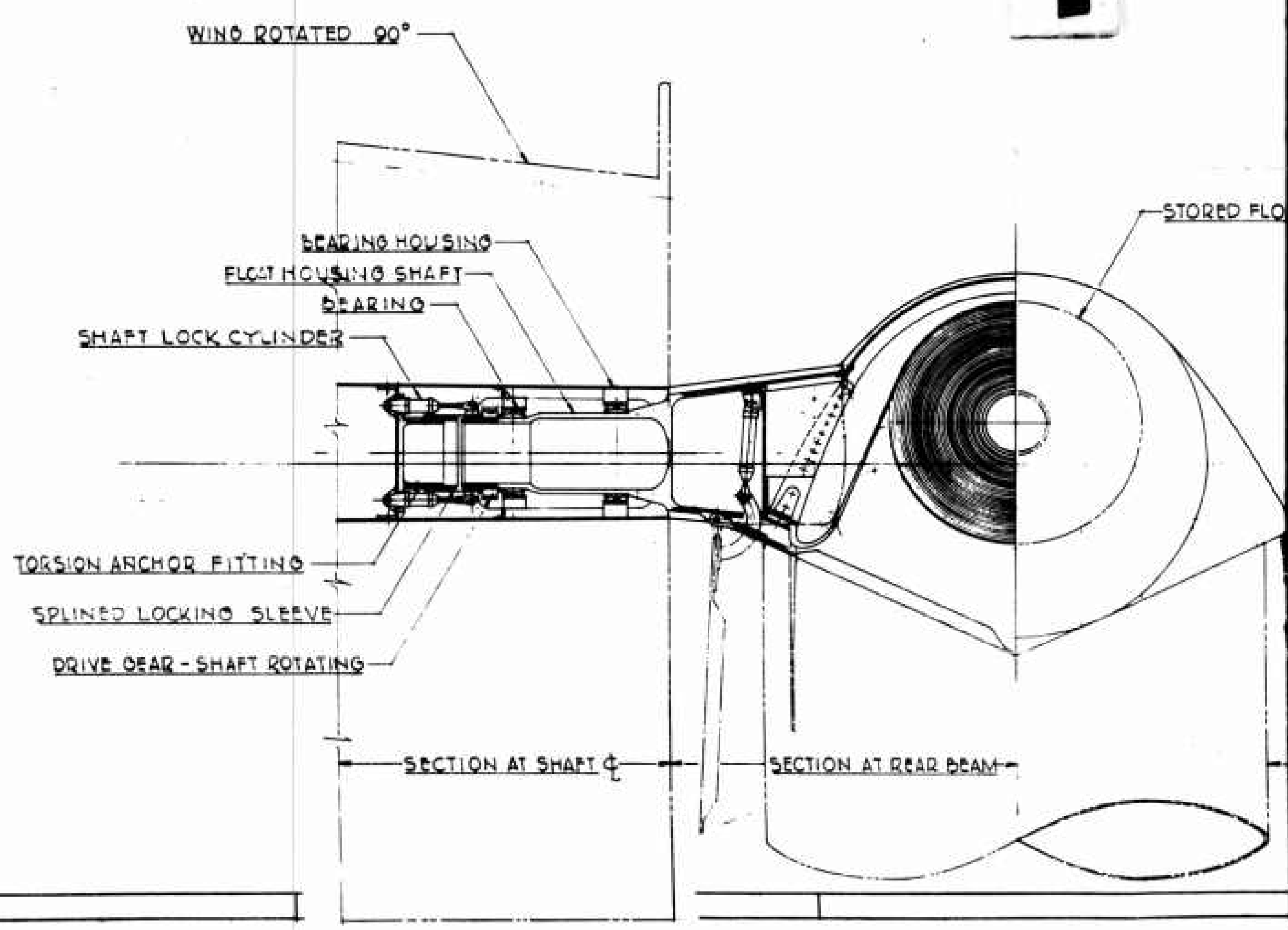
LTV VOUGHT AERONAUTICS DIVISION

GENERAL ARRANGEMENT
V464 VTOL

CODE IDENT NO 80378 — 76-000462

Figure 3 - General Arrangement, VTOL V-464

1


WING ROTATED 90°
STORED FLO
BEARING HOUSING
FLOAT HOUSING SHAFT
BEARING
SHAFT LOCK CYLINDER
TORSION ANCHOR FITTING
SPLINED LOCKING SLEEVE
DRIVE GEAR - SHAFT ROTATING
SECTION AT SHAFT ℄
SECTION AT REAR BEAM

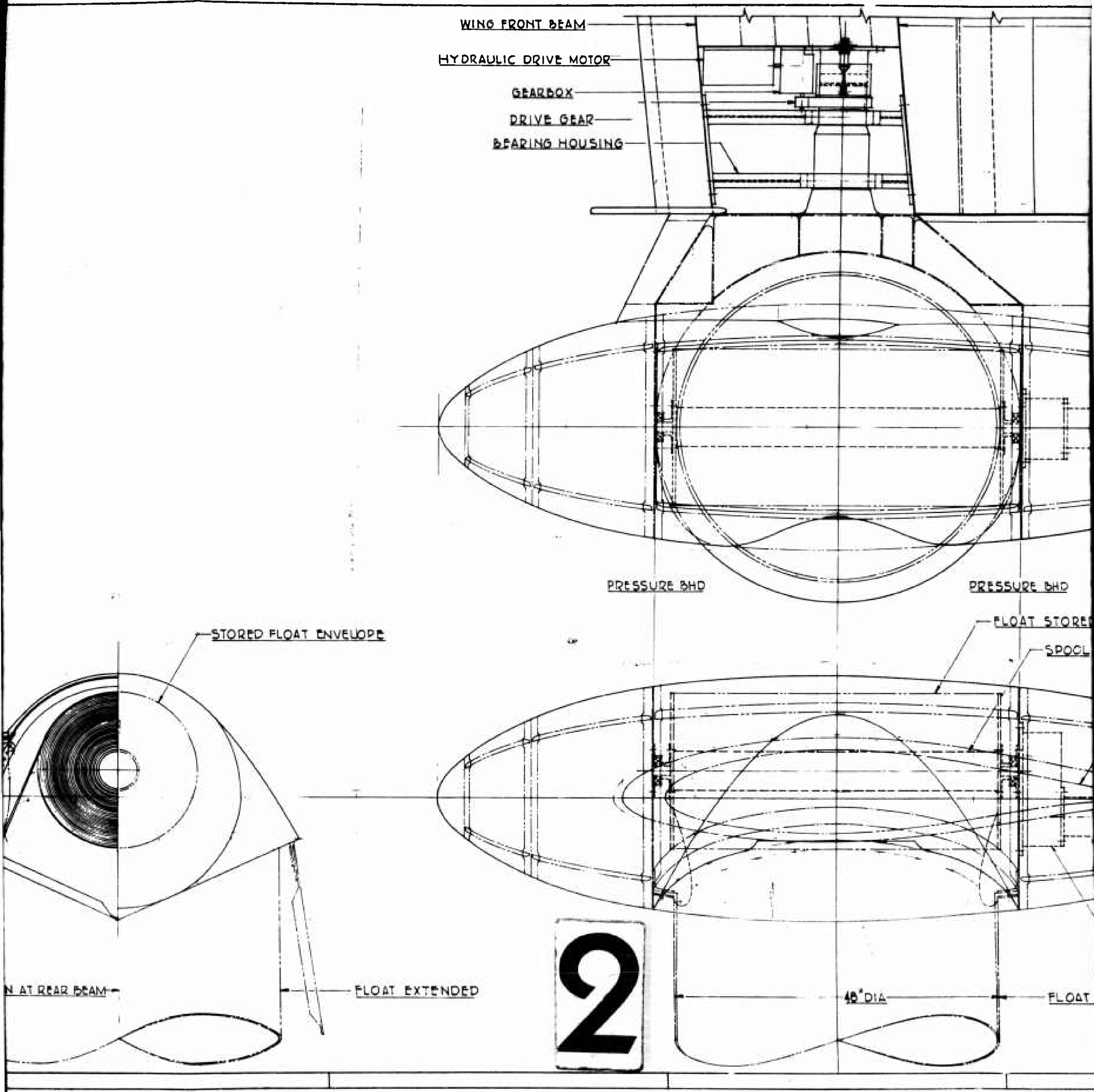


Figure 4 - Preliminary
Float, VTO

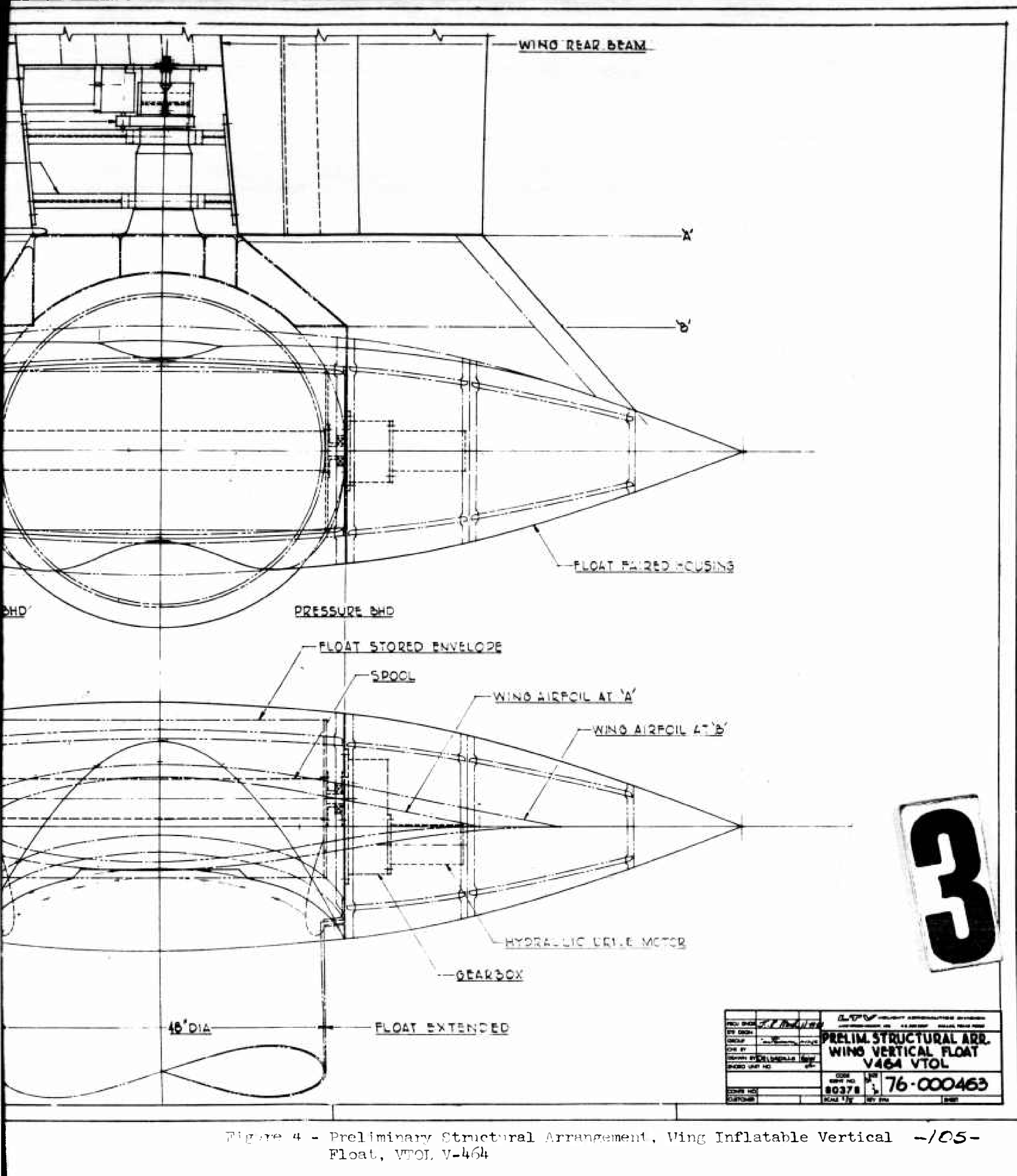


Figure 4 - Preliminary Structural Arrangement, Wing Inflatable Vertical Float, VTOL V-464

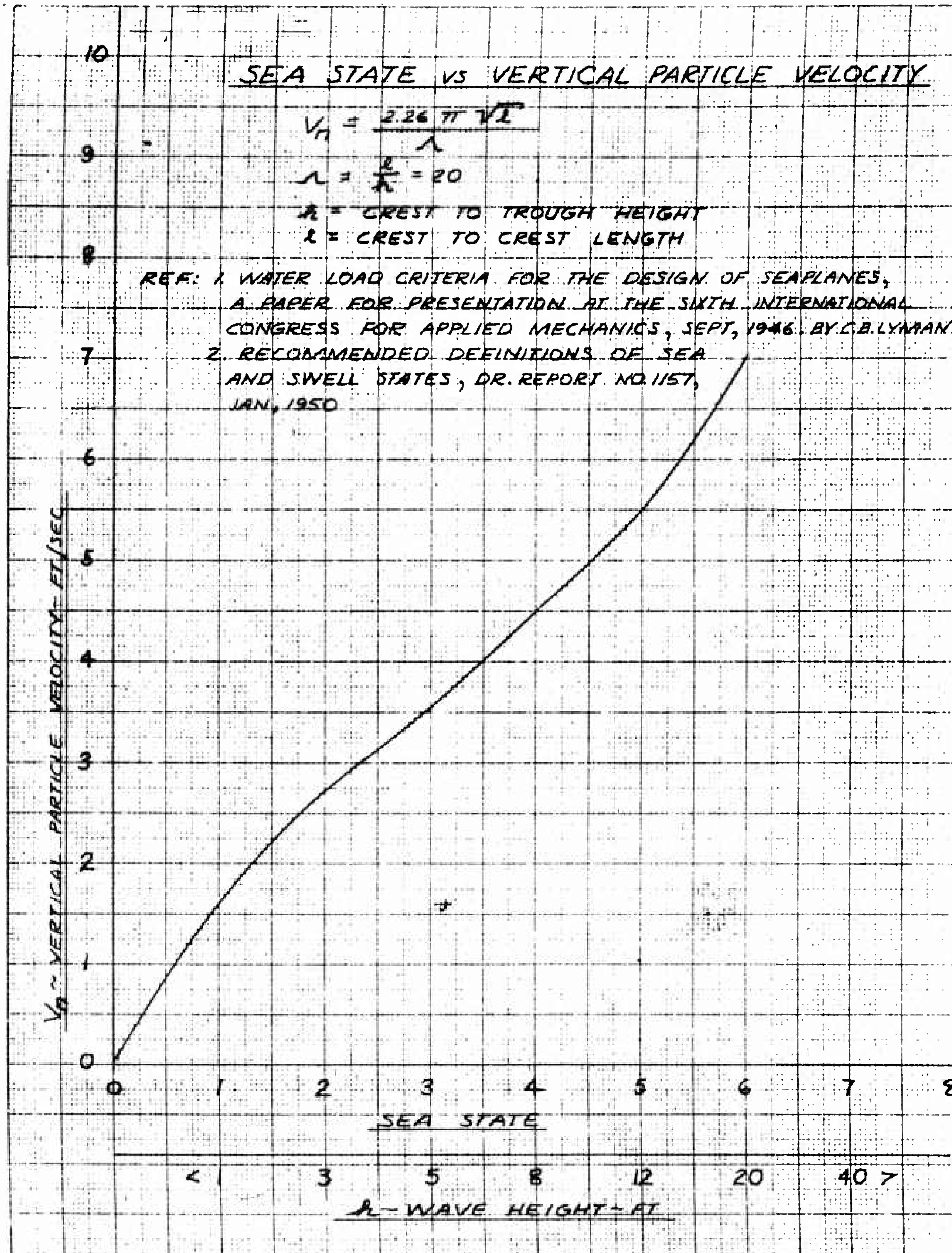


Figure 5 - STOL V-464 Hull impact;
Sea state vs. vertical particle velocity.

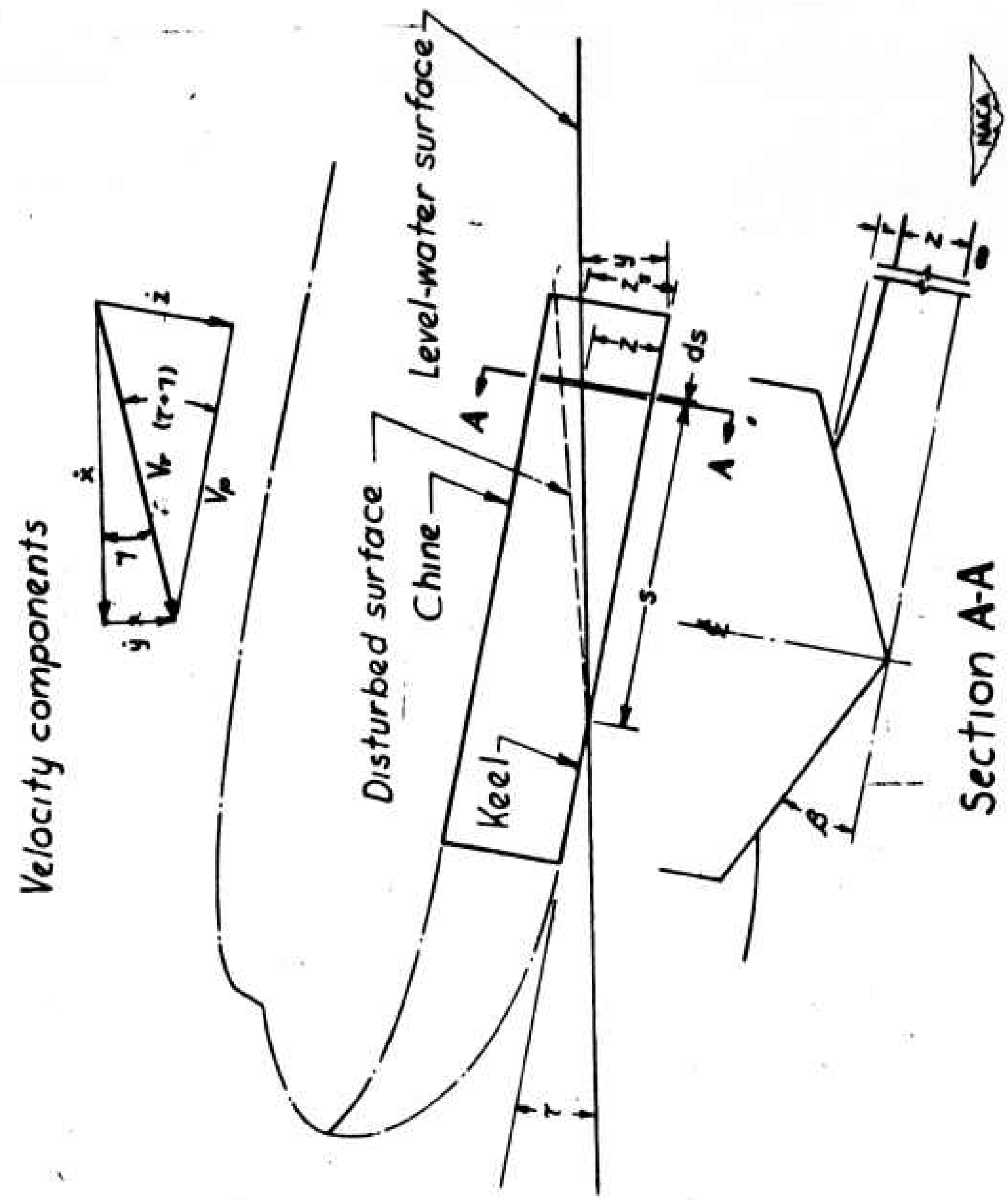


Figure 1.- Schematic representation of impact.

Figure 6 - STOL V-464 Hull impact;
schematic representation of impact.

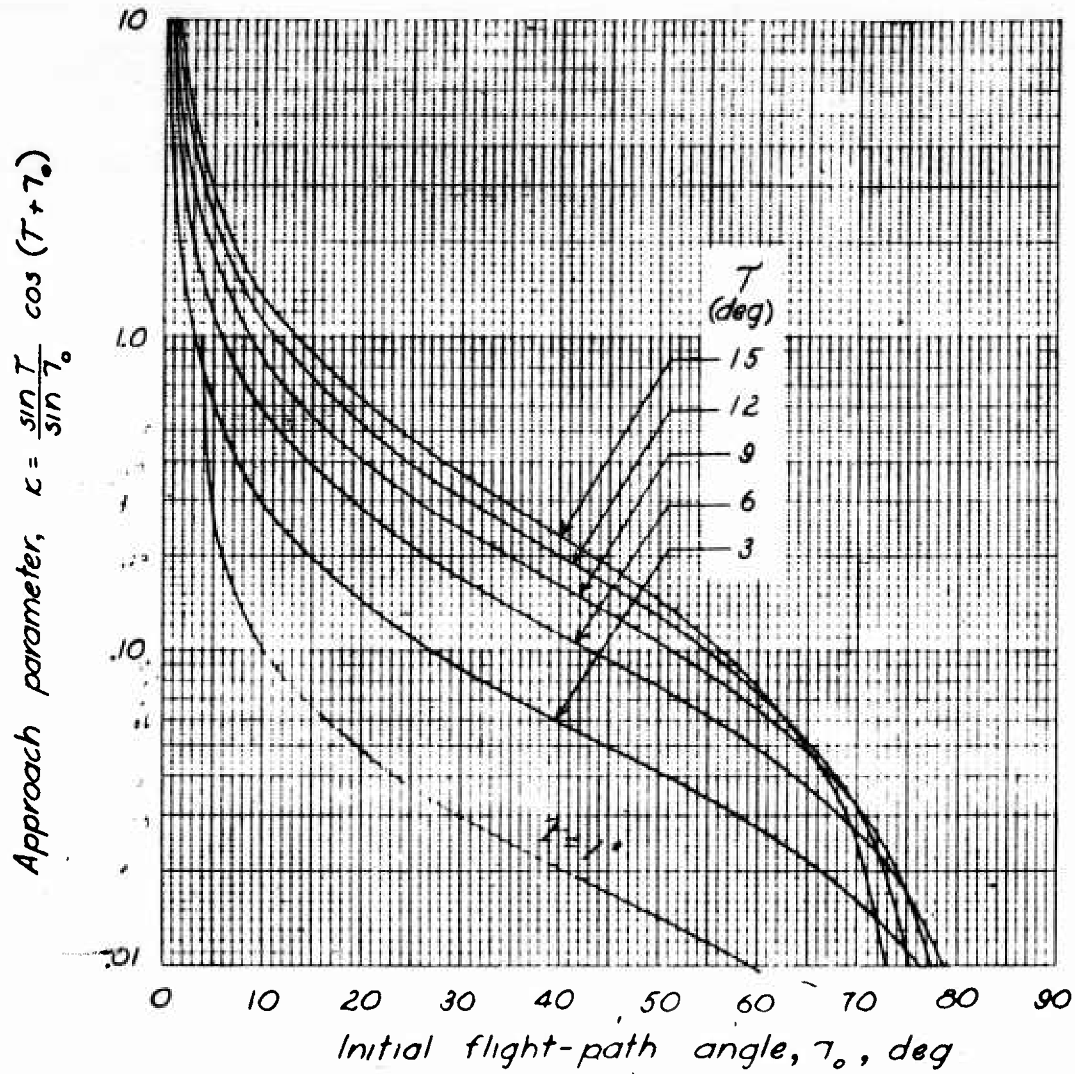


Figure 2.— Variation of approach parameter with trim and flight-path angle.

Figure 7 - STOL V-464 Hull impact ; Variation of approach parameter k.

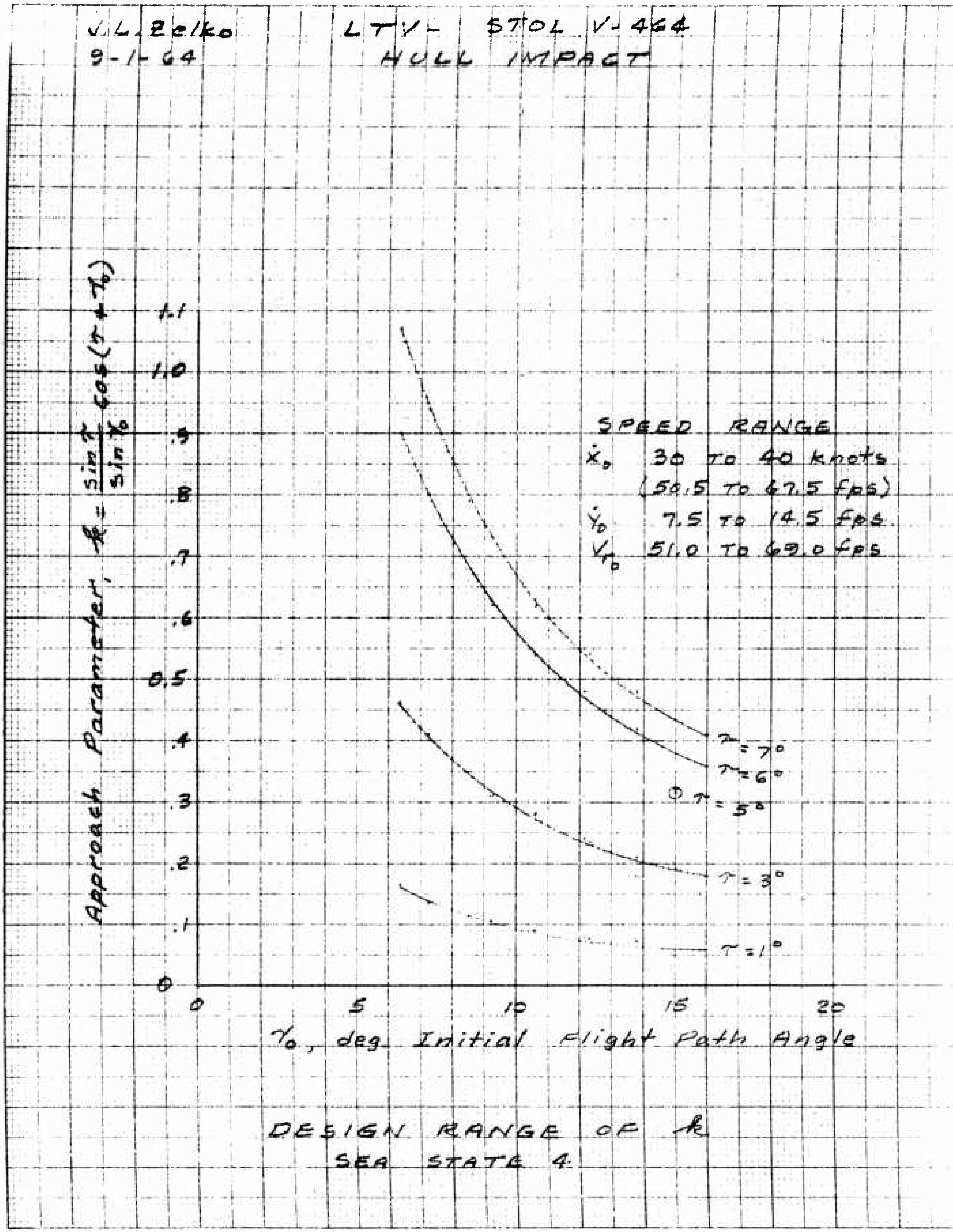


Figure 8 - STOL V-464 Hull impact; design range of k.

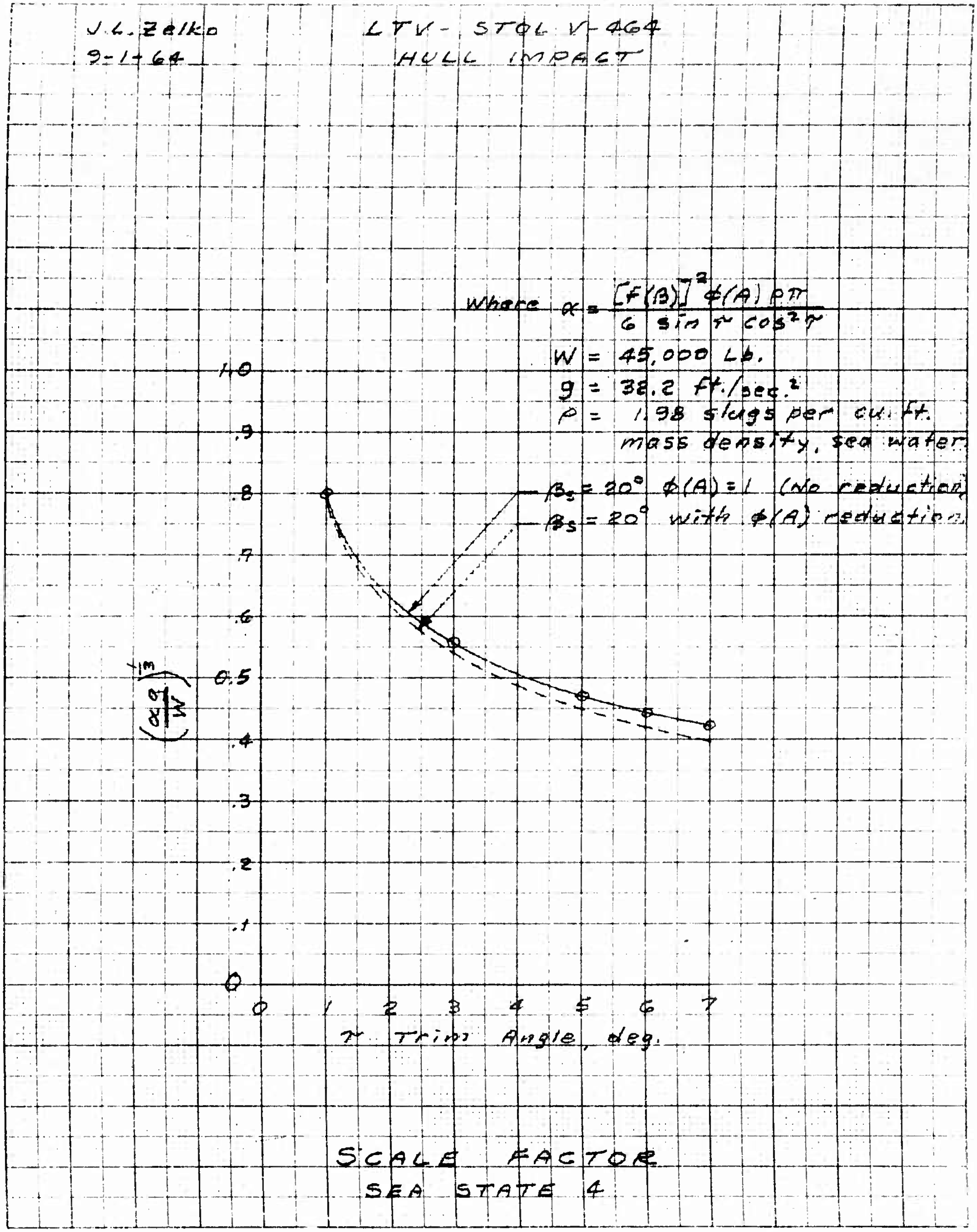
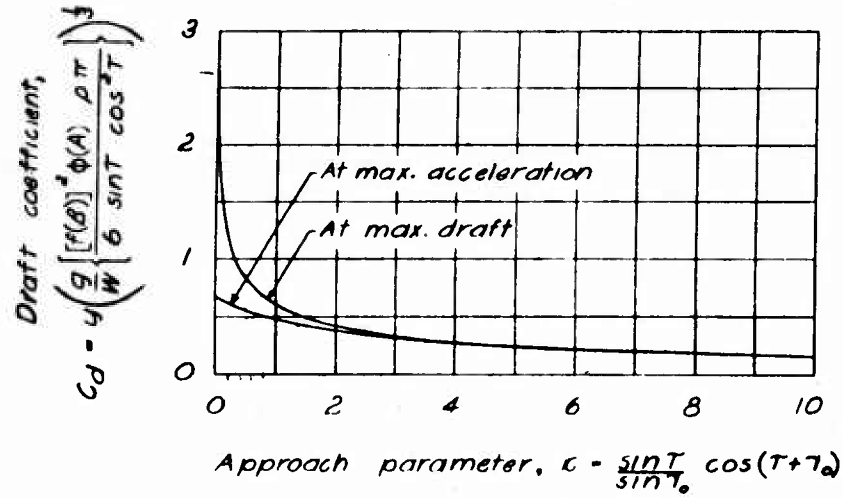
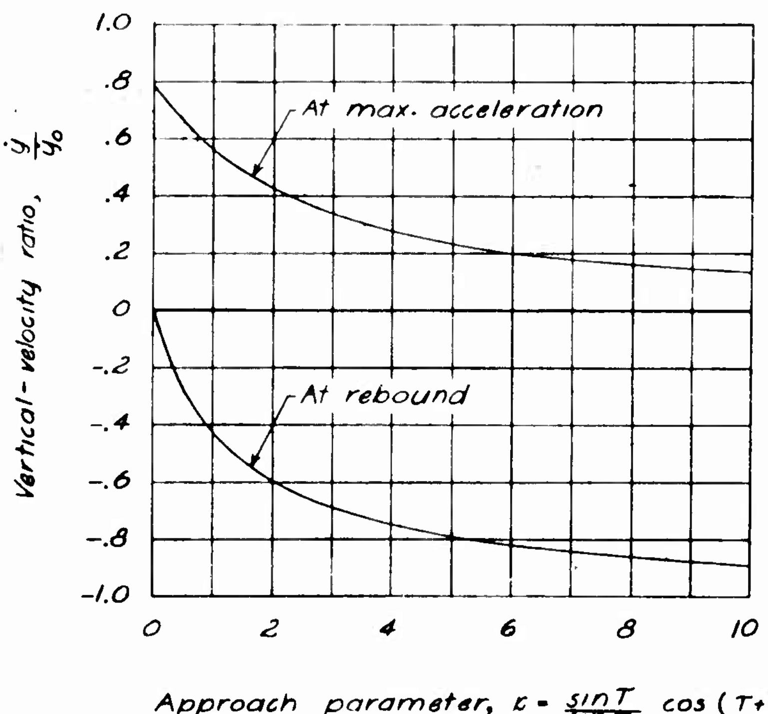


Figure 9 - STOL V-464 Hull impact; scale factor.



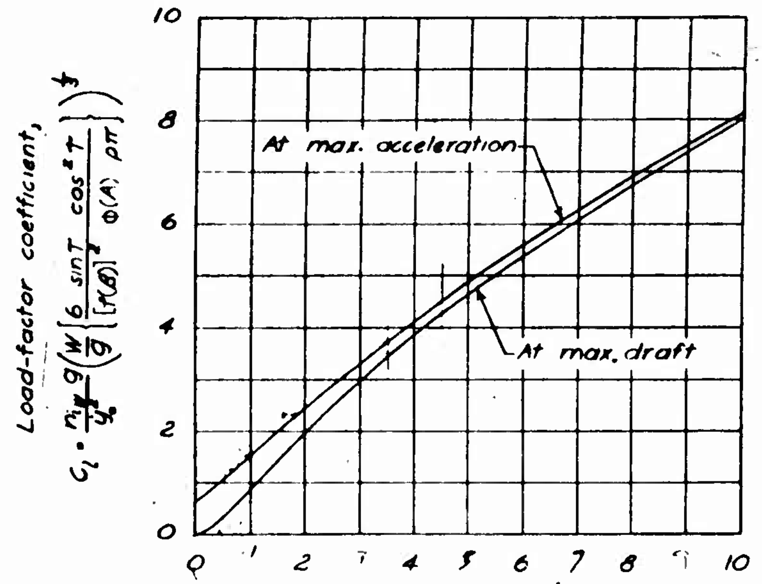
(a) Draft coefficient.



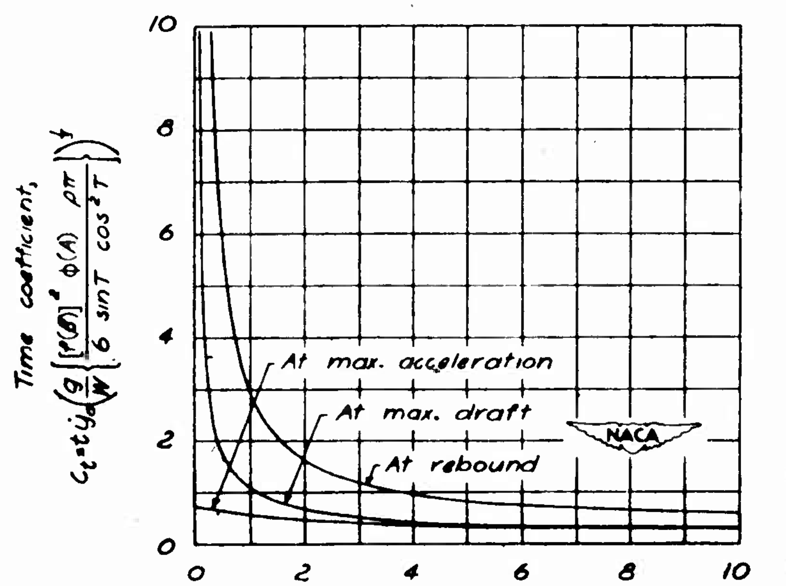
(b) Vertical-velocity ratio.

Figure 9.— Theoretical variation of the motion variables with approach parameter.

Figure 10 - STOL V-464 Hull impact; linear scale coefficients.



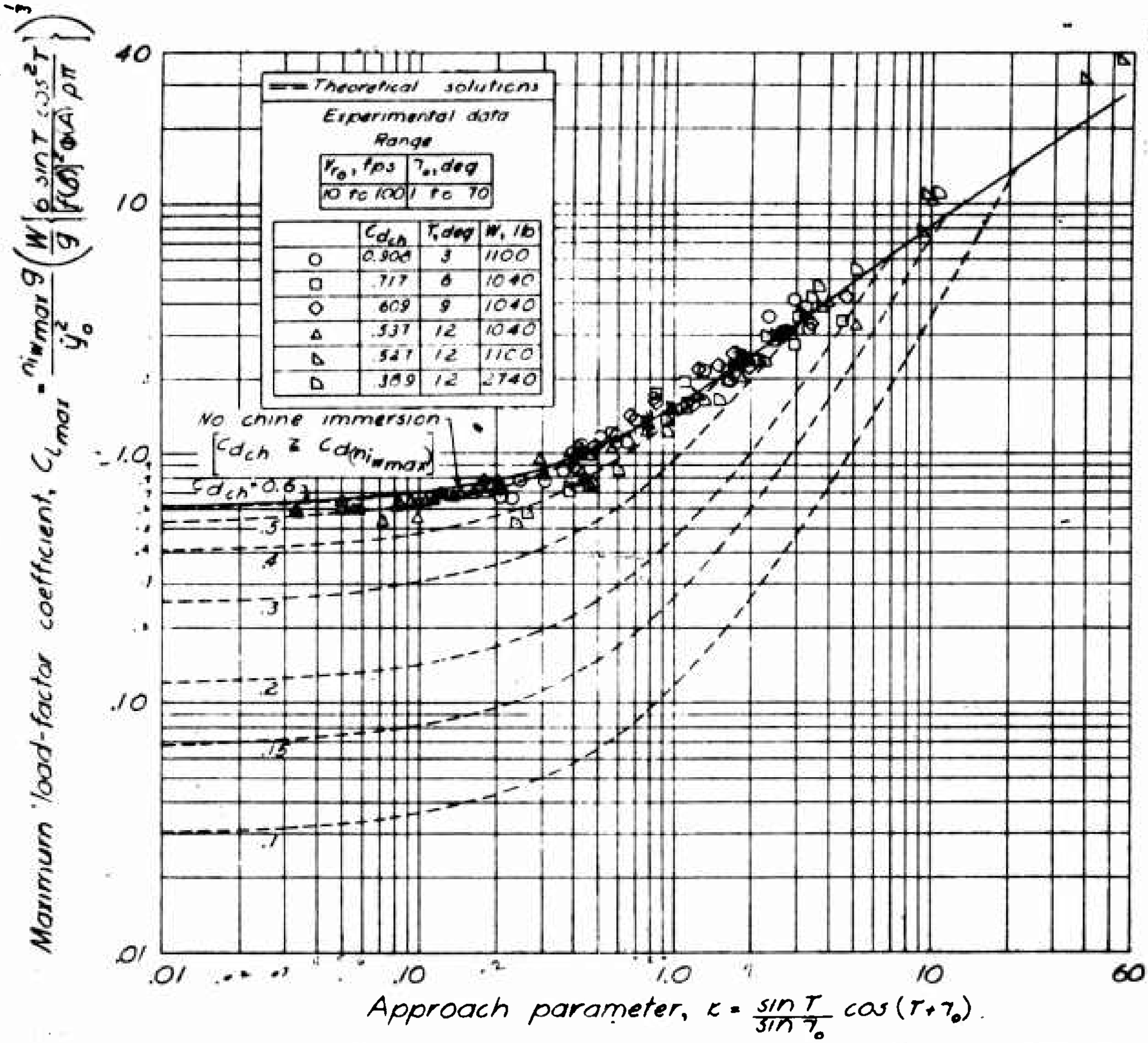
(c) Load-factor coefficient.



(d) Time coefficient.

Figure 9.— Concluded.

Figure 11 - STOL V-464 Hull impact; linear scale coefficients.



(a) Experimental data for $\beta = 22\frac{1}{2}°$.

Figure 10.— Comparison of theoretical and experimental variation of maximum load-factor coefficient with κ, including the effects of chine immersion.

Figure 12 - STOL, V-164 Hull impact; log scale coefficients.

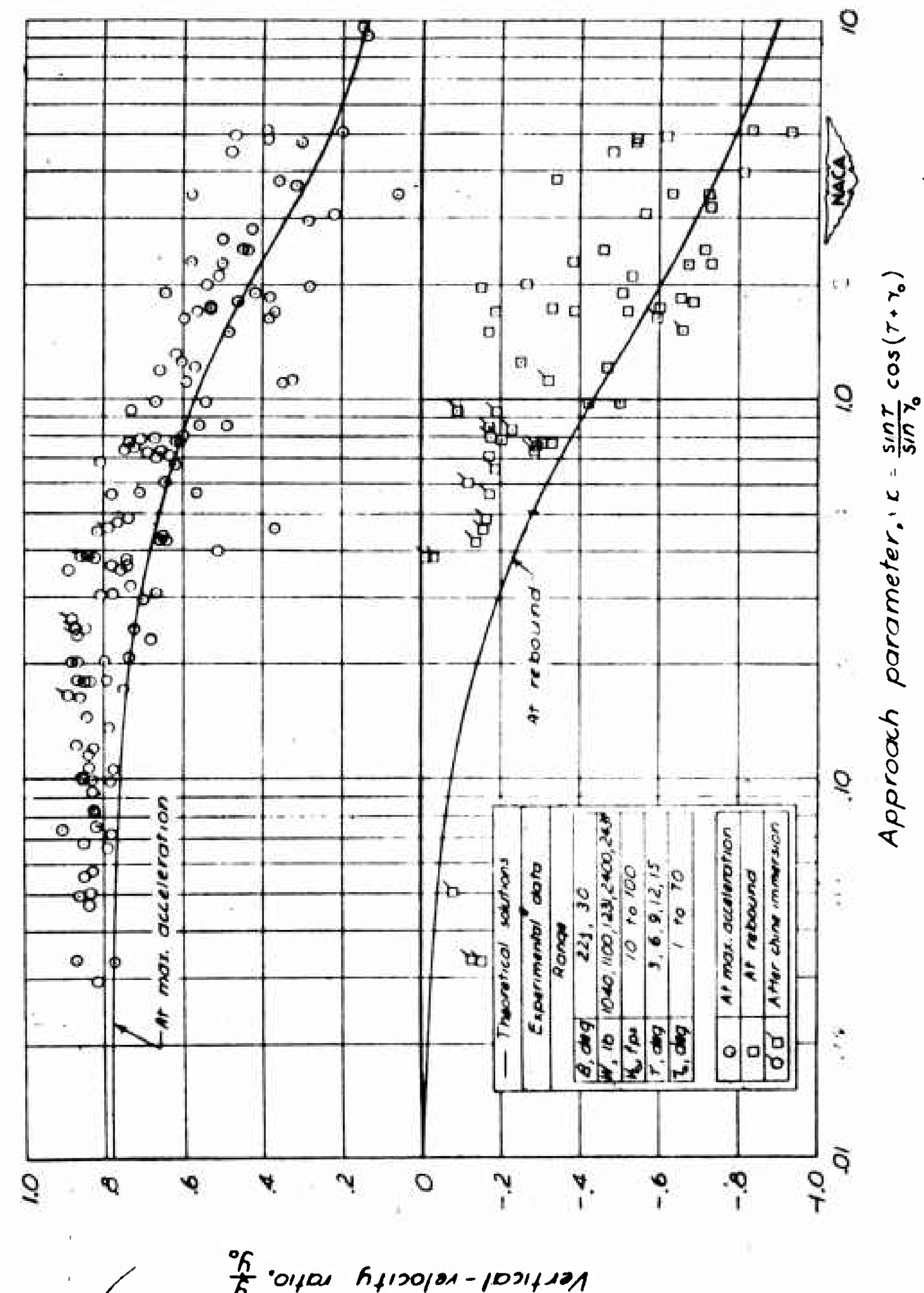


Figure 12. — Comparison between theoretical and experimental variation of vertical velocity with approach parameter.

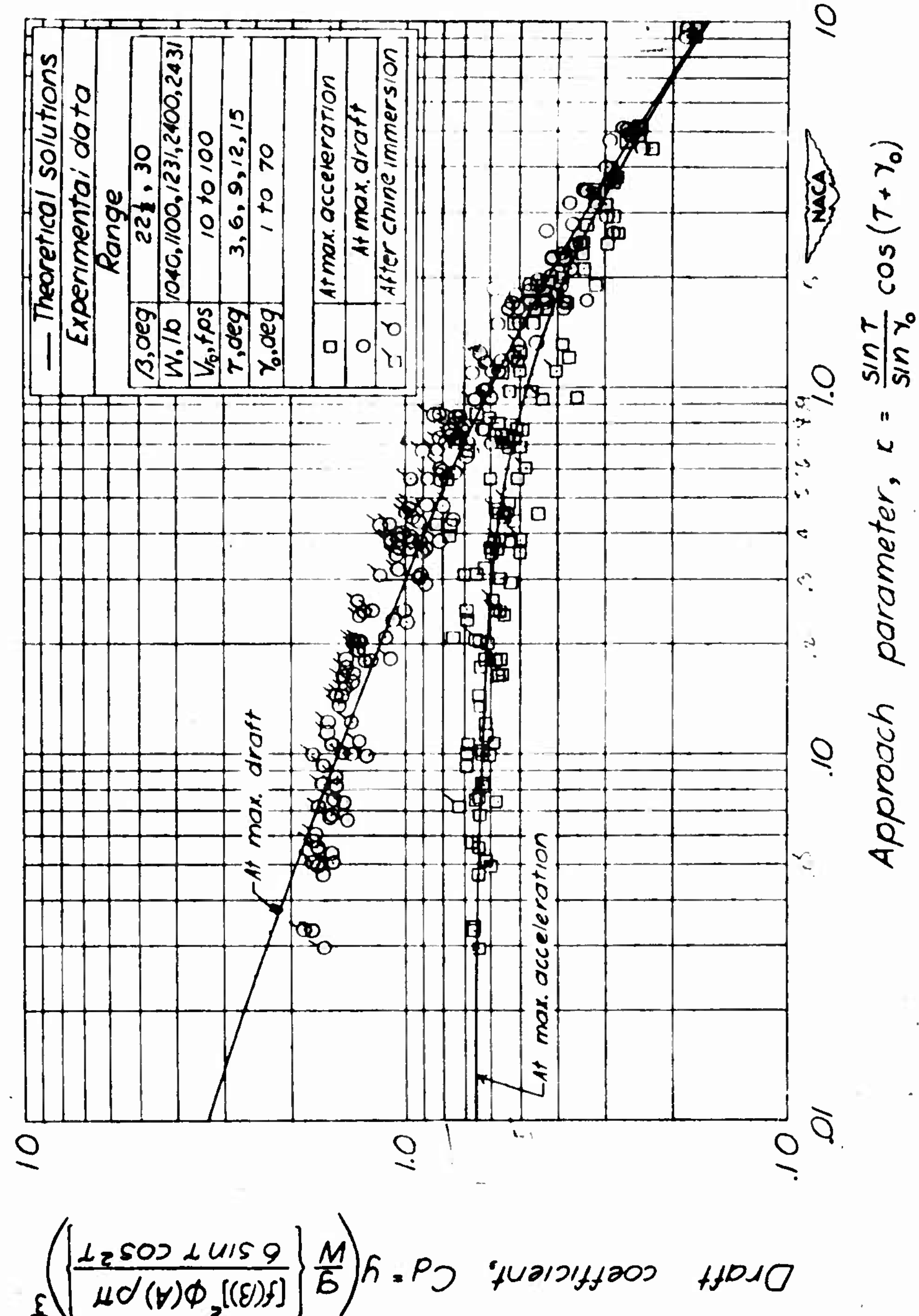


Figure 13.— Comparison between theoretical and experimental variation of draft with approach parameter.

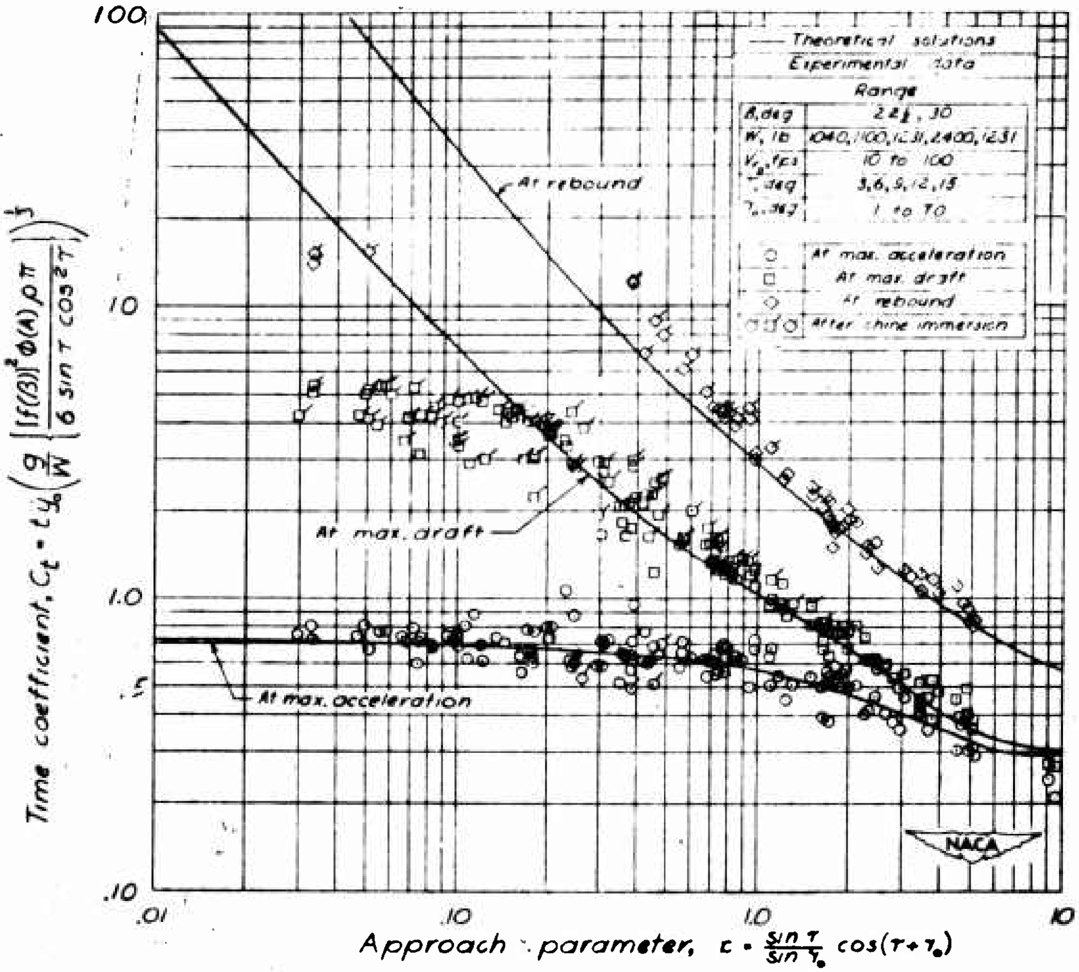


Figure 14.— Comparison between theoretical and experimental variation of time with approach parameter.

Figure 15 - STOL Y-464 Hull impact; log scale coefficients.

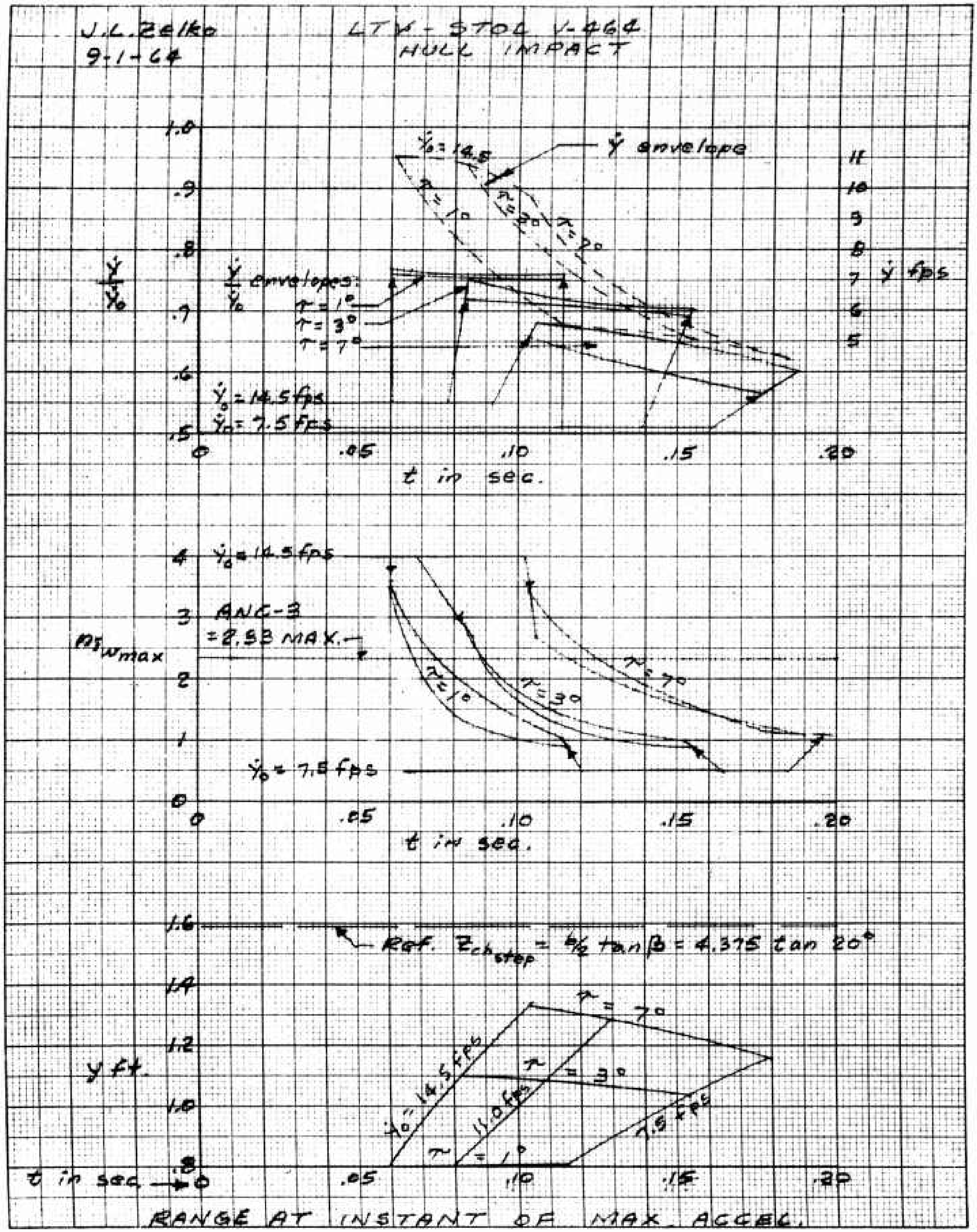
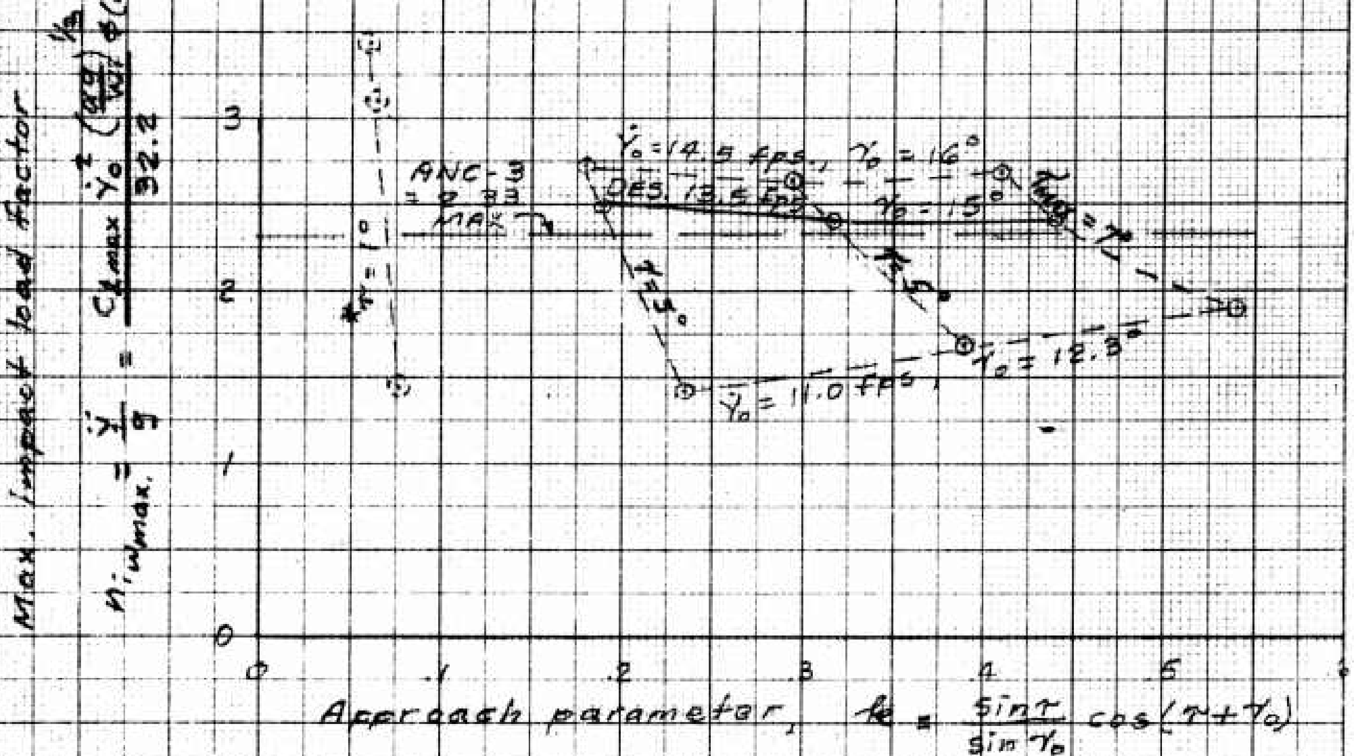


Figure 16 - STOL V-464 Hull Impact; **parametric envelopes.**

J. L. Zelka
31 Aug. 1964

LTV - STOL V-464

PLOT OF RECOMMENDED DESIGN PARAMETERS
FOR HULL IMPACT LOADS
FOR SEA STATE 4



*Note: Less critical per tests than trim τ of 3° per NACA TR810 (1945)

Initial forward velocity, $\dot{x}_0$	30 knots (50.5 fps)
Effective initial sink speed, $\dot{y}_0$	13.5 fps
" " flight path, γ_0	15°
" " trim, τ	0° to 7° max.
Dead rise angle at step, β_s	20°
Wt. of seaplane	45,000 lbs
Max. impact load factor, $n_{i_{w_{max}}}$	2.5

Figure 17 - STOL V-464 Hull impact; recommended design parameters.

c.a.
11/12/64

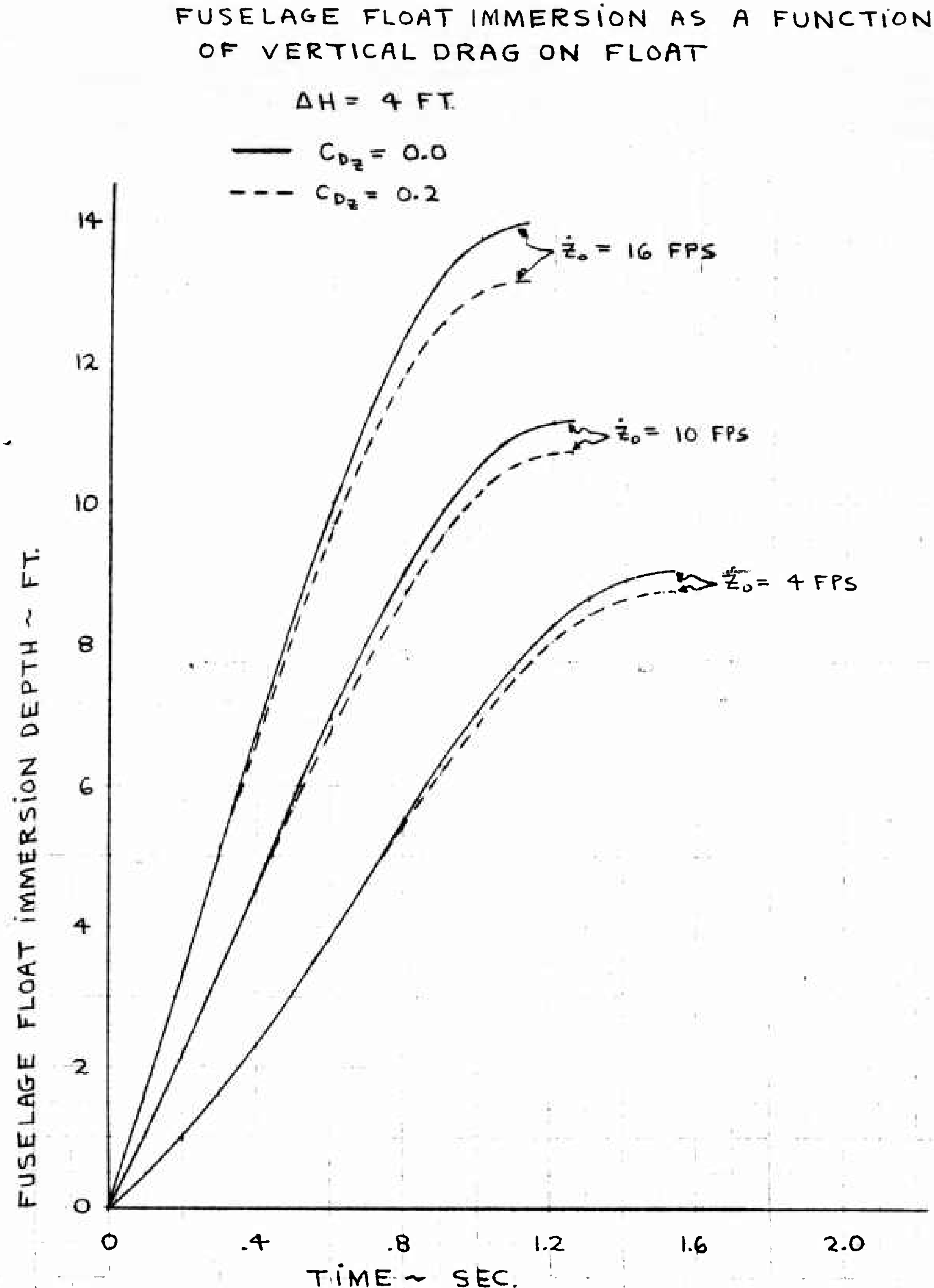


Figure 18 - Fuselage Float Immersion as a Function of Vertical Drag on Float

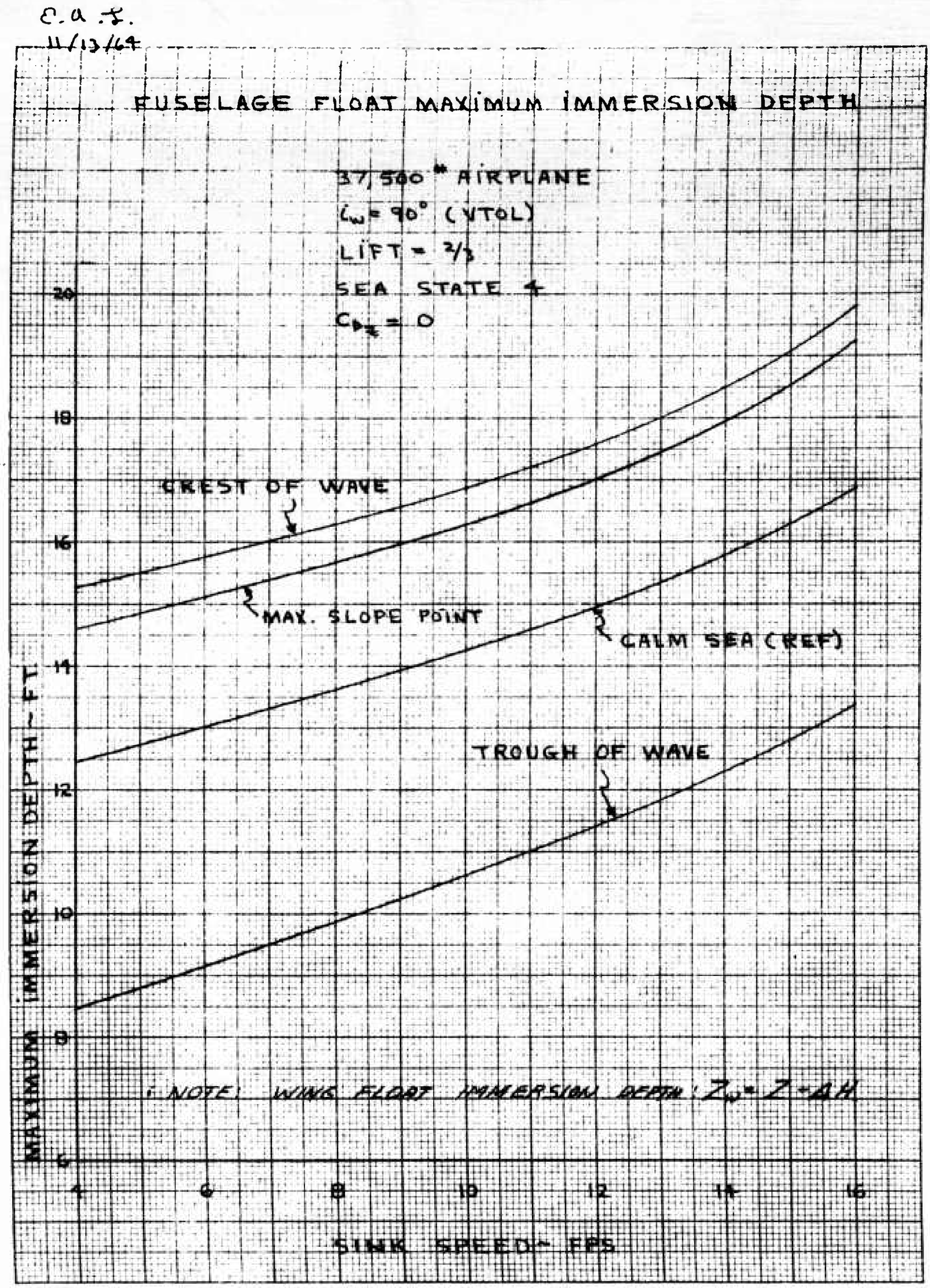


Figure 19 - Fuselage Float Maximum Immersion Depth

E.A.F.
11/13/64

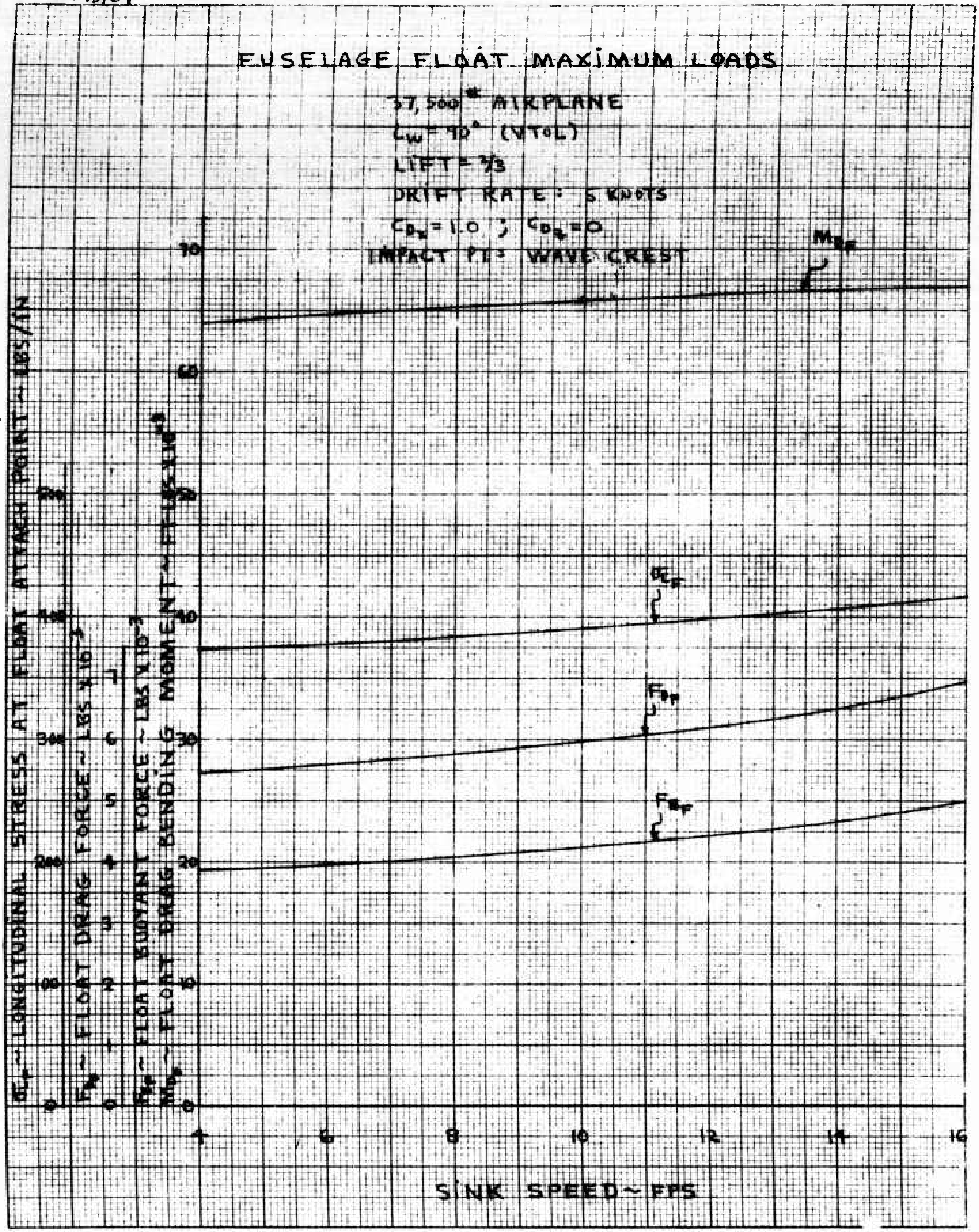


Figure 20 - Fuselage Float Maximum Loads

E.a.L.
11/13/64

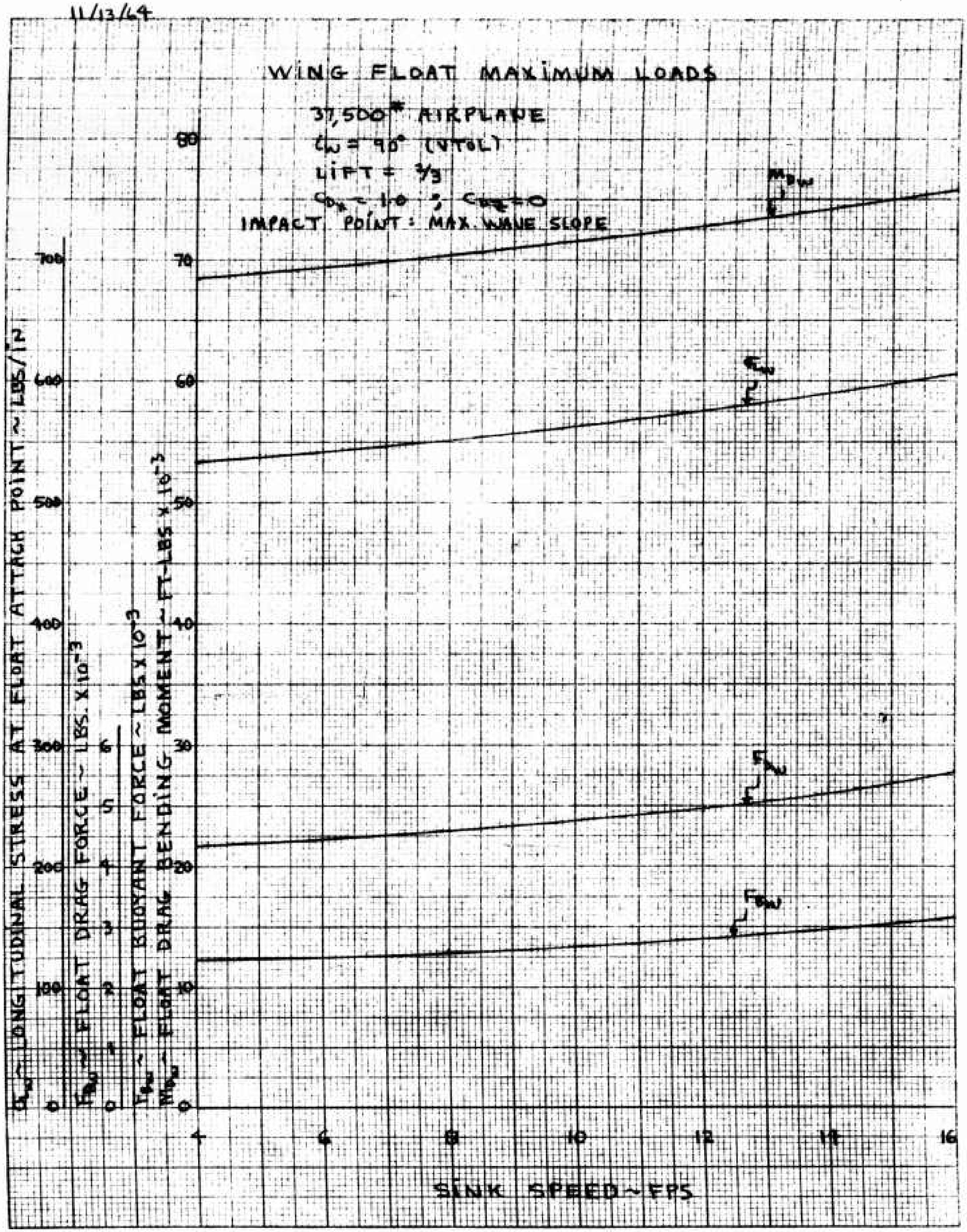


Figure 21 - Wing Float Maximum Loads

E.a.F.
11/12/64

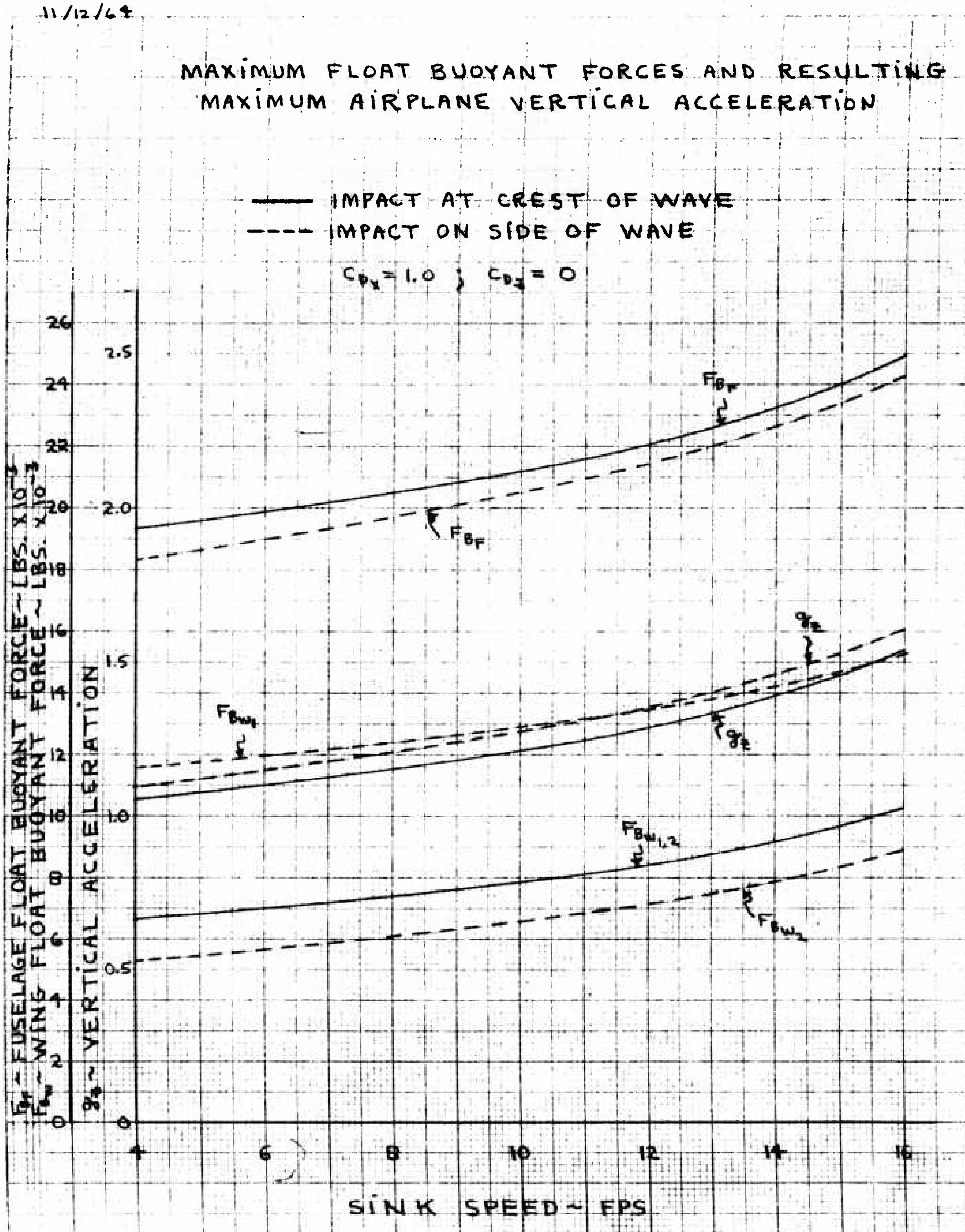


Figure 22 - Maximum Float Buoyant Forces and Resulting Maximum Airplane Vertical Acceleration

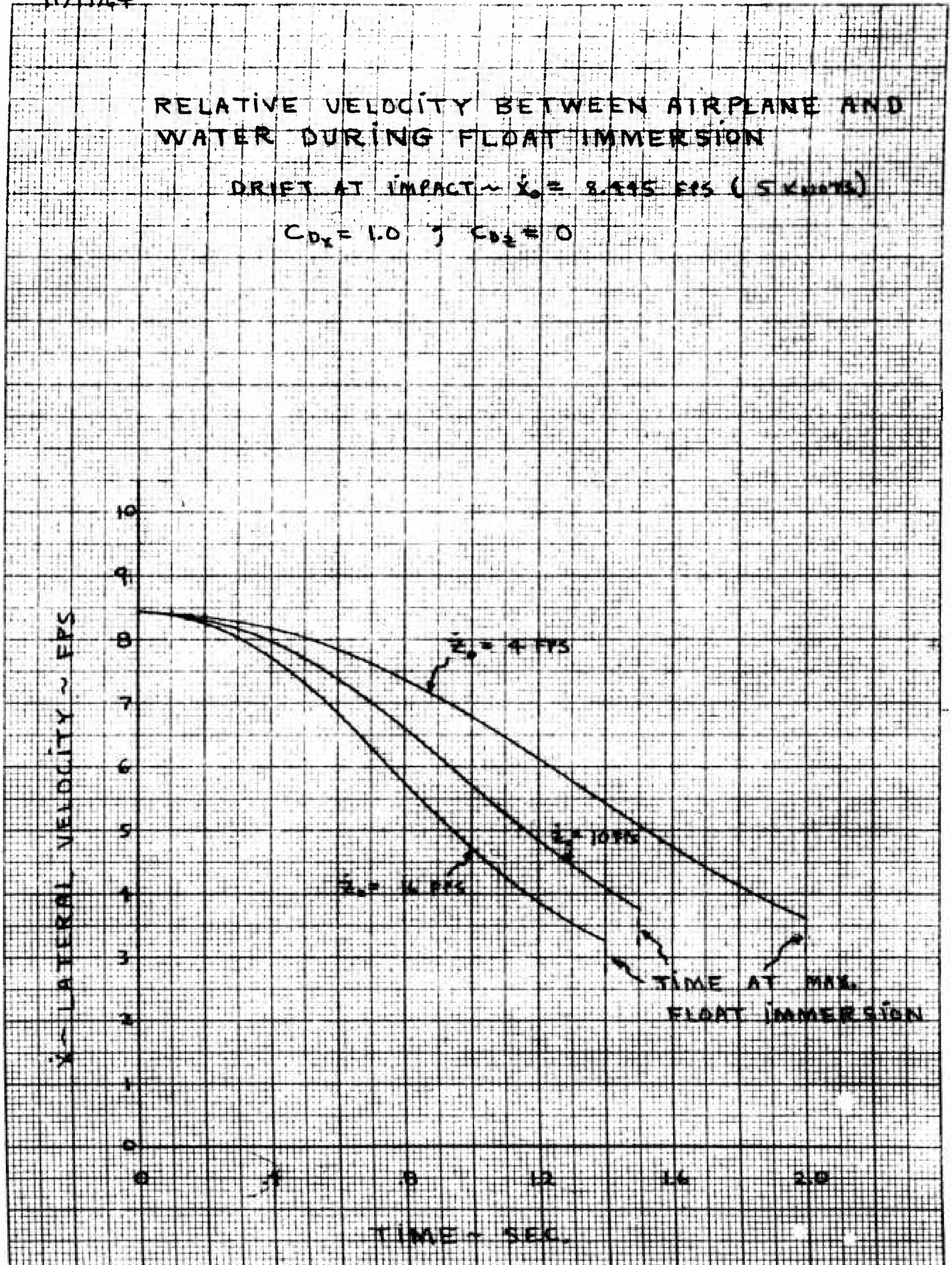


Figure 23 - Relative Velocity Between Airplane and Water During Float Immersion

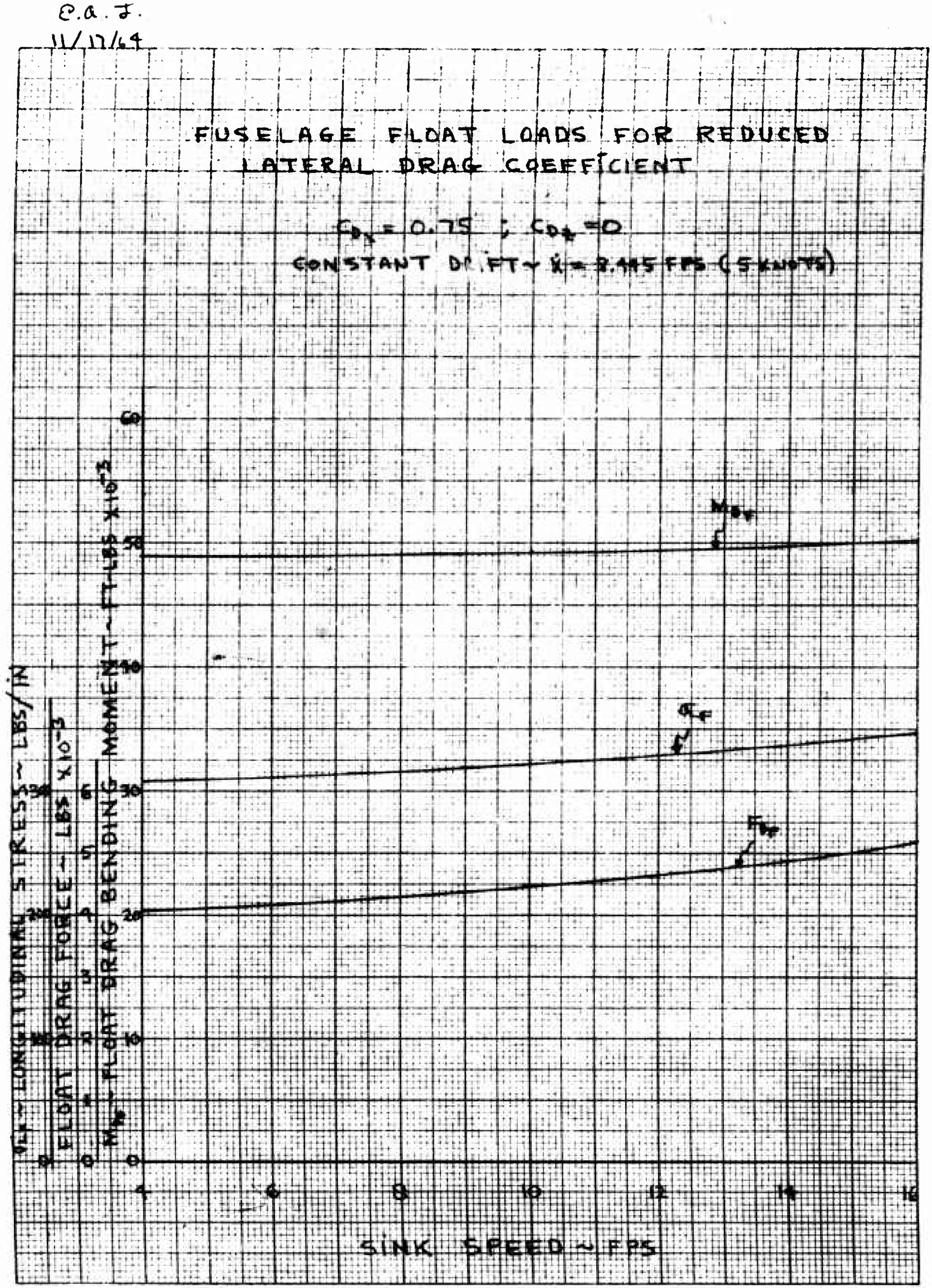


Figure 24 - Fuselage Float Loads for Reduced Lateral Drag Coefficient

E.a.L.
11/17/64

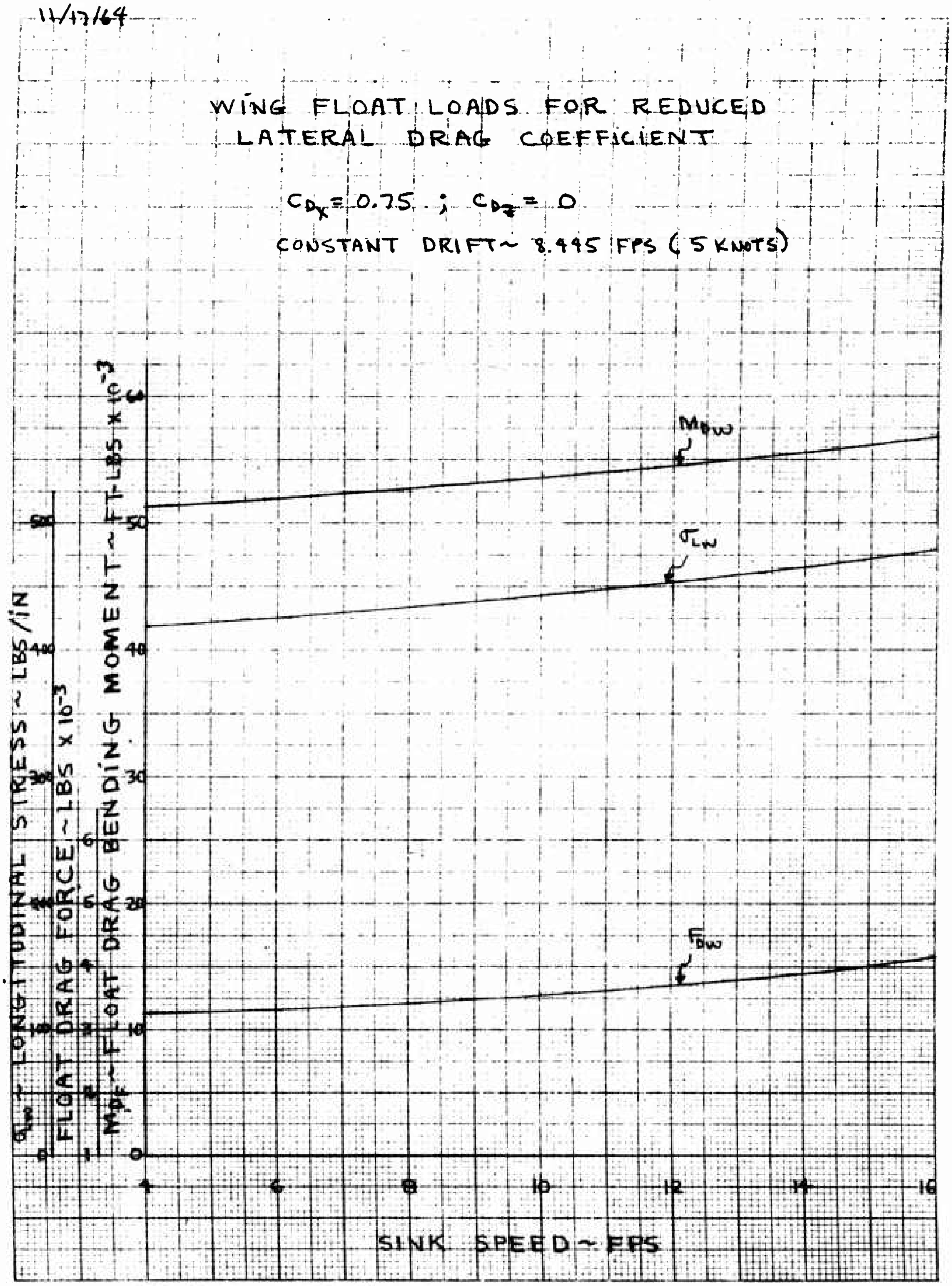


Figure 25 - Wing Float Loads for Reduced Lateral Drag Coefficient

E.a.F.
11/17/64

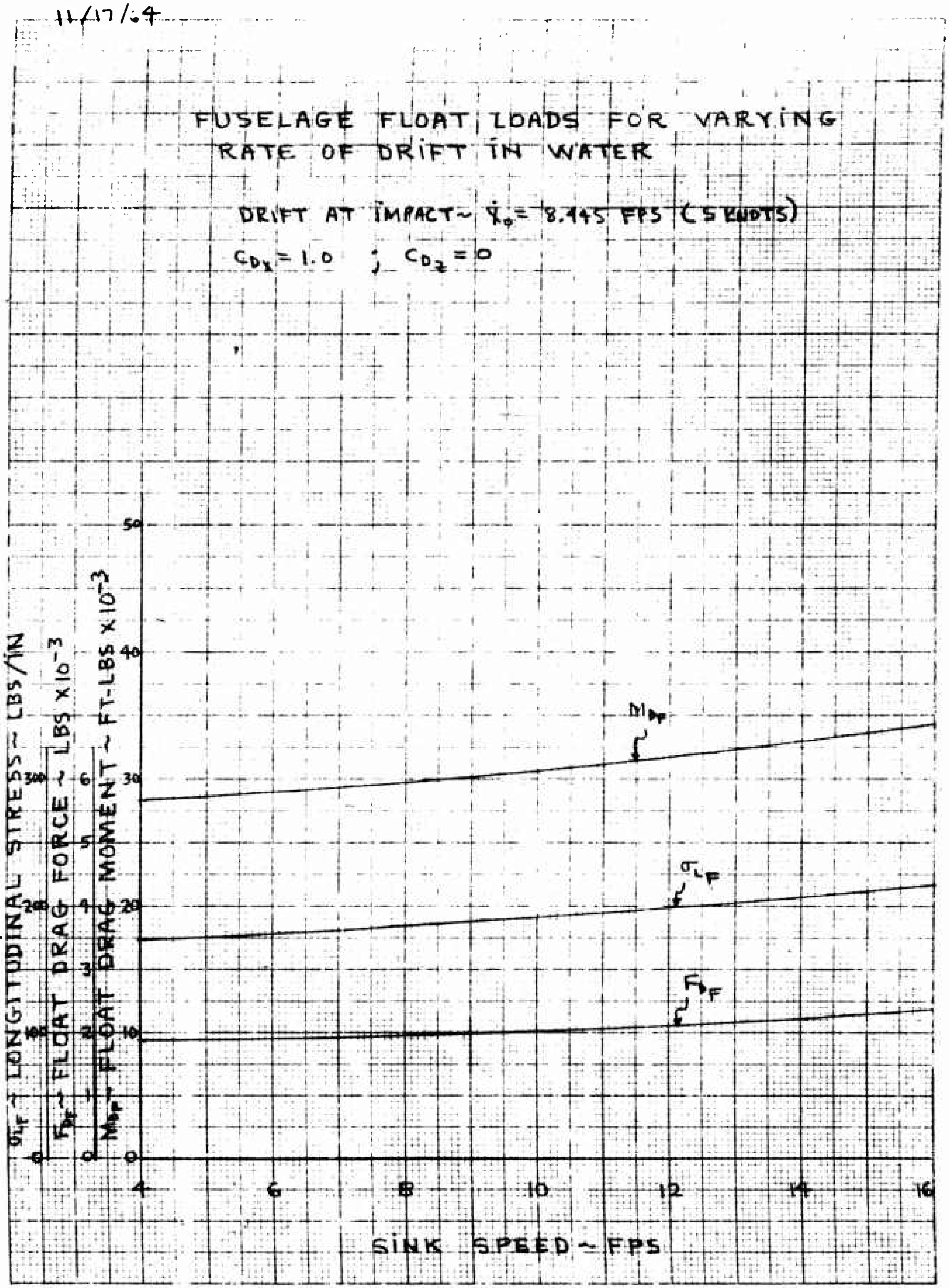


Figure 26 - Fuselage Float Loads for Varying Rate of Drift in Water

E.a.f.
11/17/64

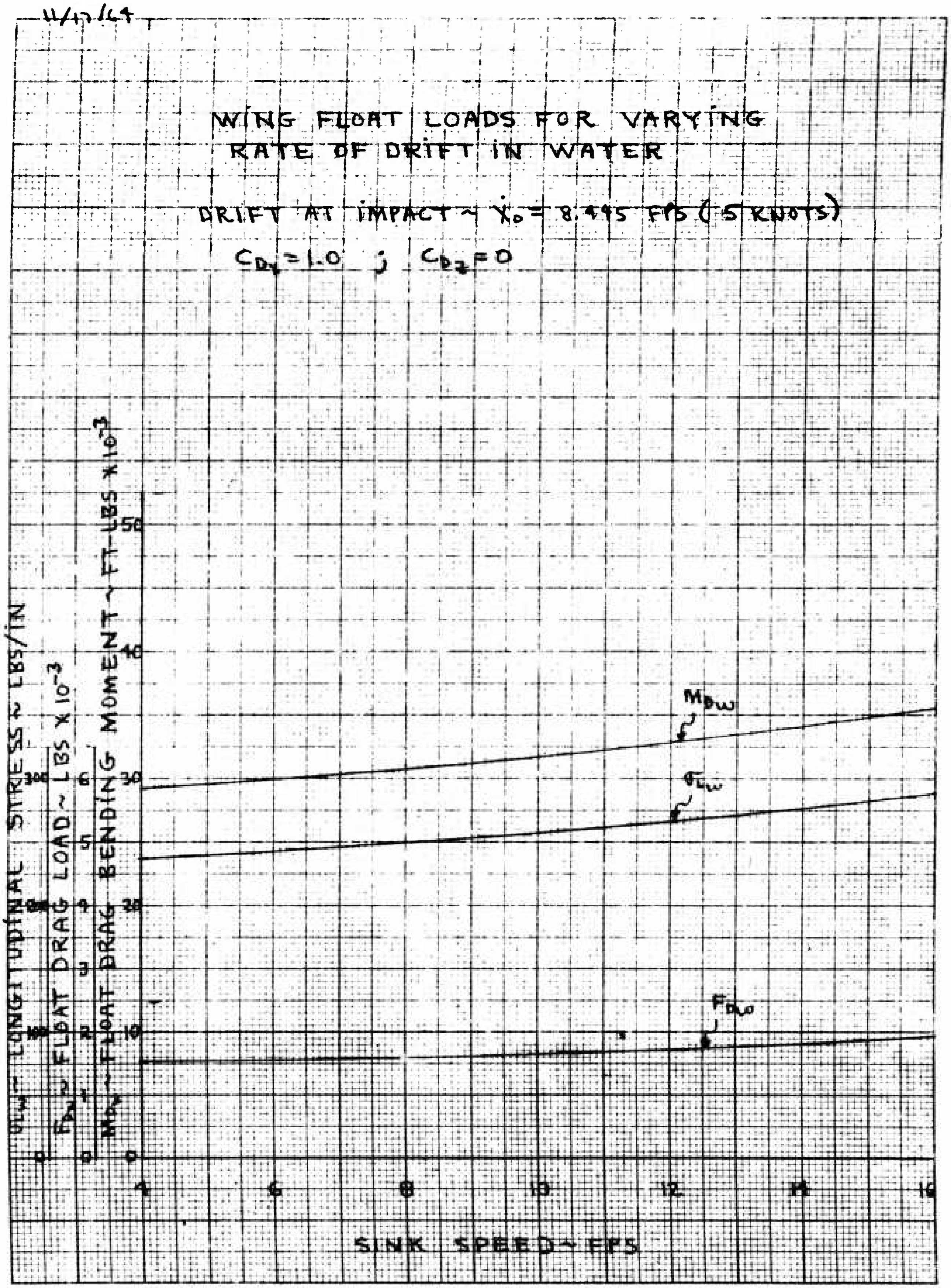


Figure 27 - Wing Float Loads for Varying Rate of Drift in Water

E.a.E.
11/12/64

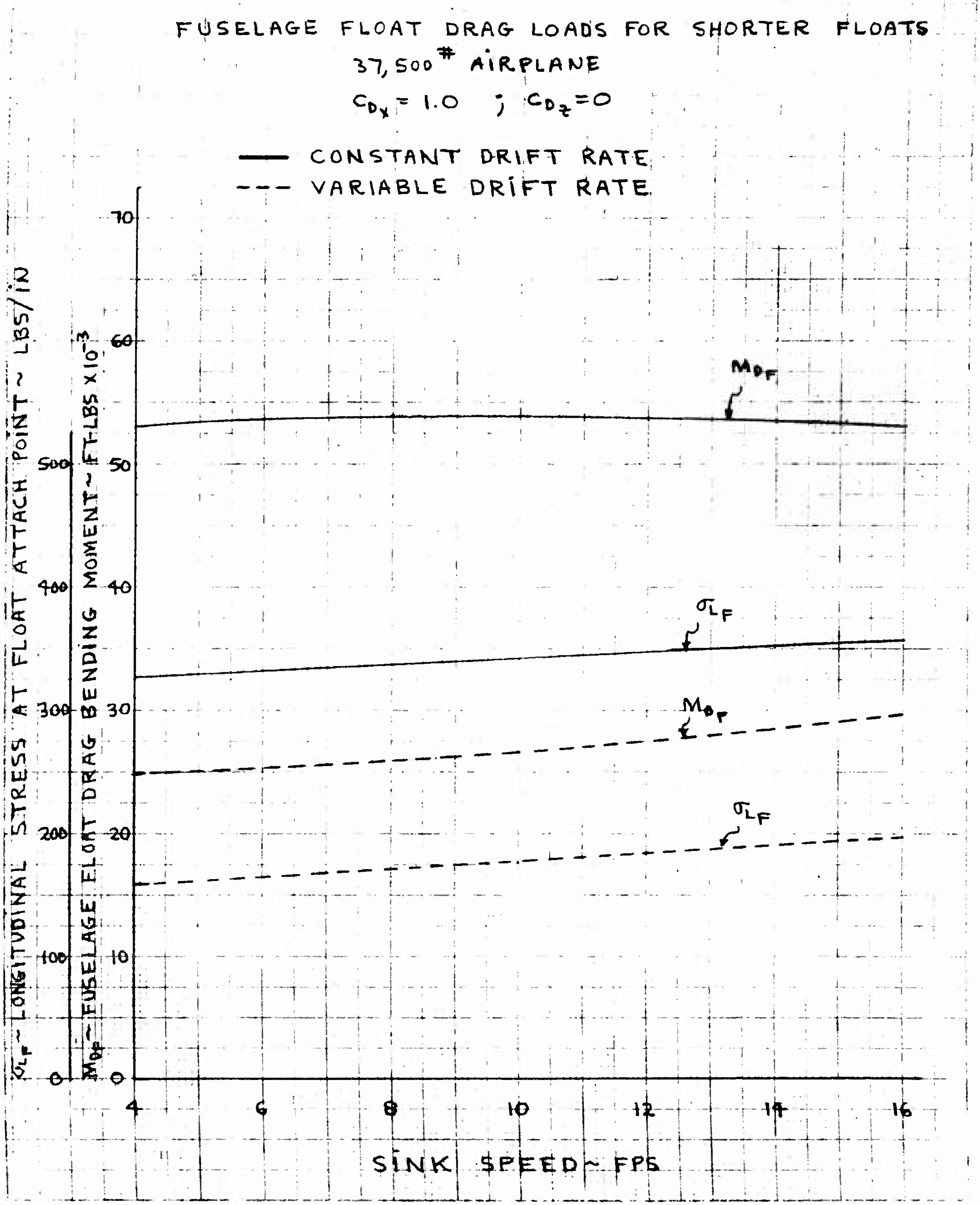


Figure 28 - Fuselage Float Drag Loads for Shorter Floats

E. a. J.
11/13/64

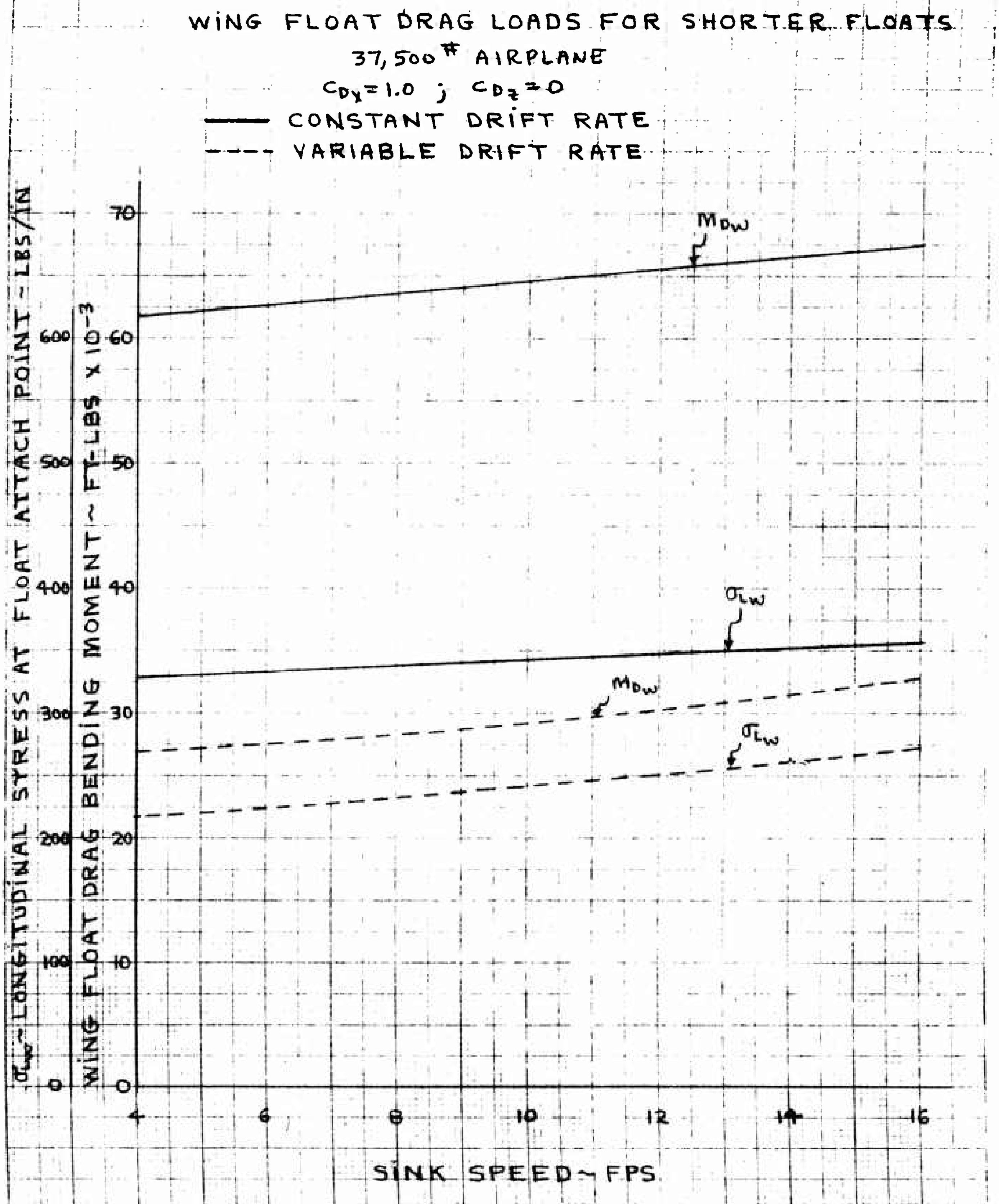


Figure 29 - Wing Float Drag Loads for Shorter Floats

E.a.L.
11/20/64

17

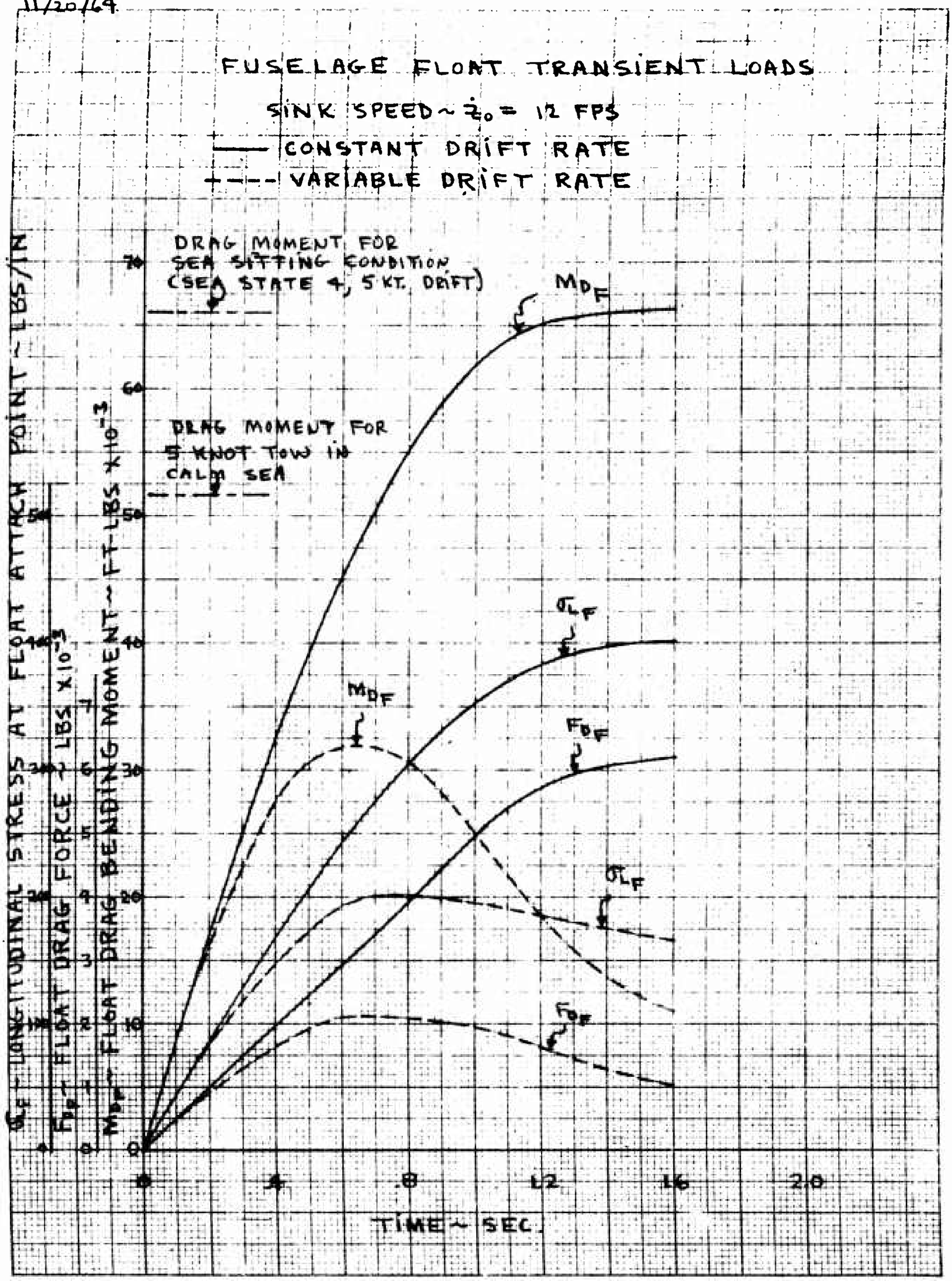


Figure 30 - Fuselage Float Transient Loads

E. a. -ɭ.
11/20/64

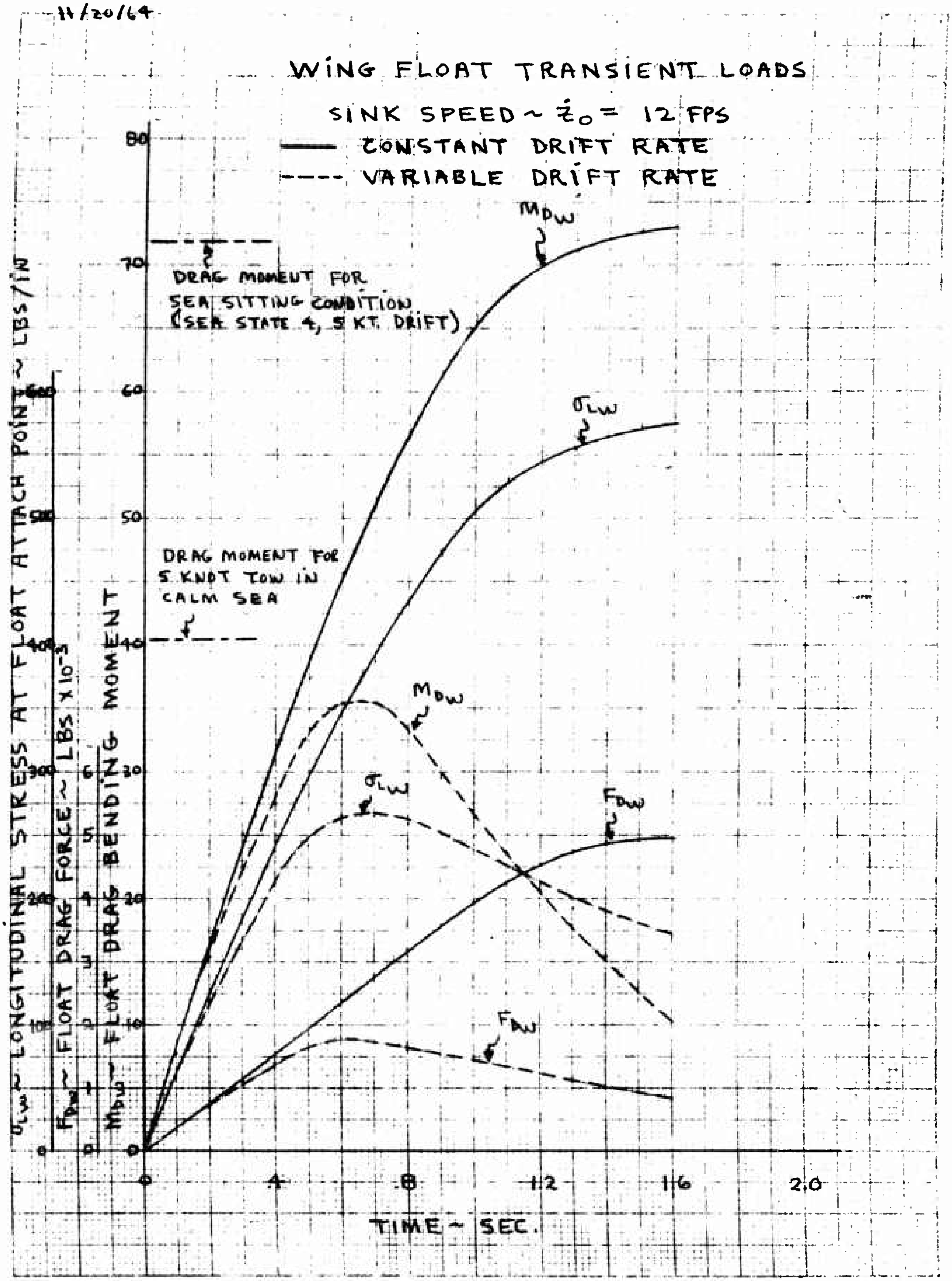


Figure 31 - Wing Float Transient Loads

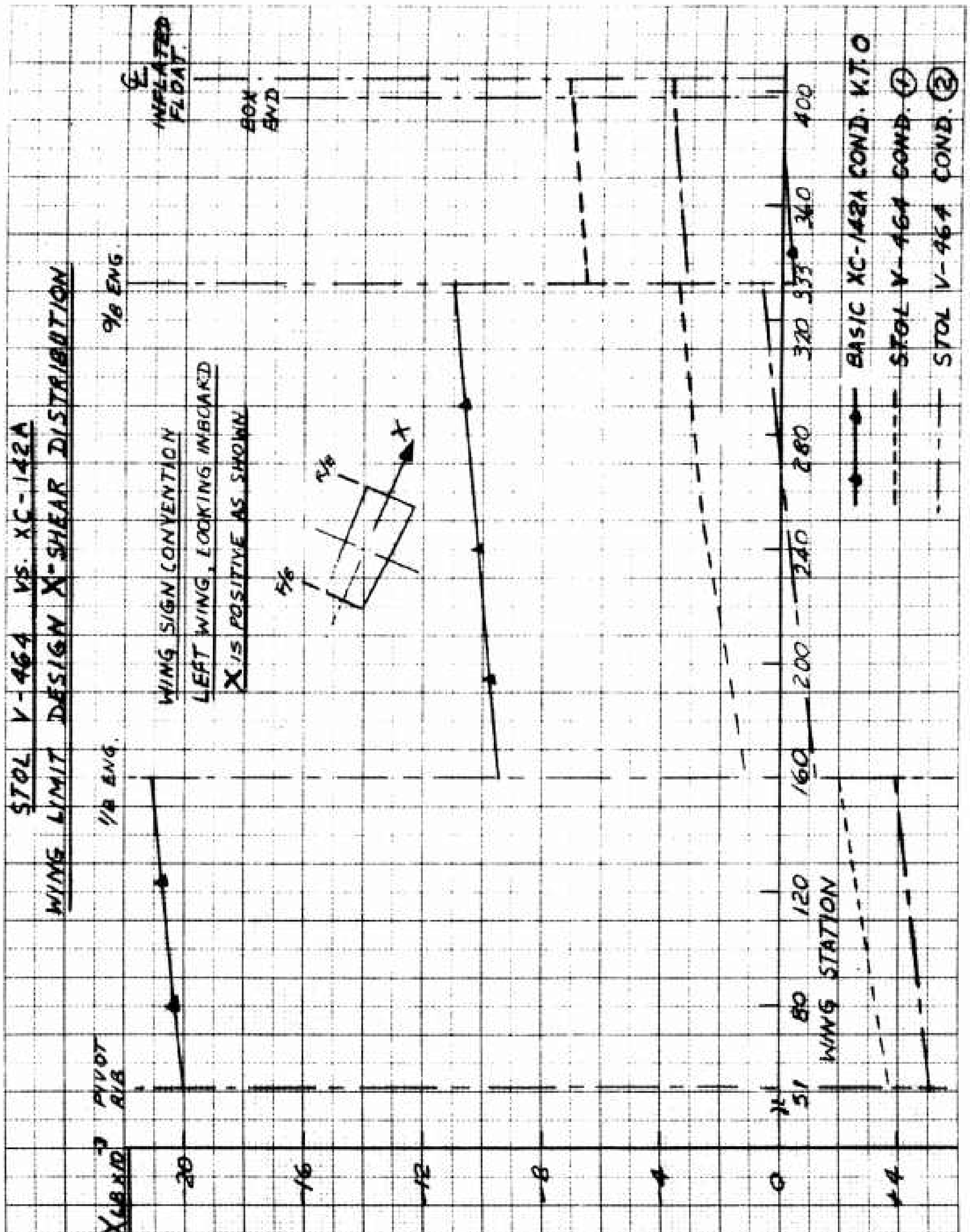


Figure 32 - STOL V-464 vs XC-142A Wing Limit Design; X- Shear Distribution

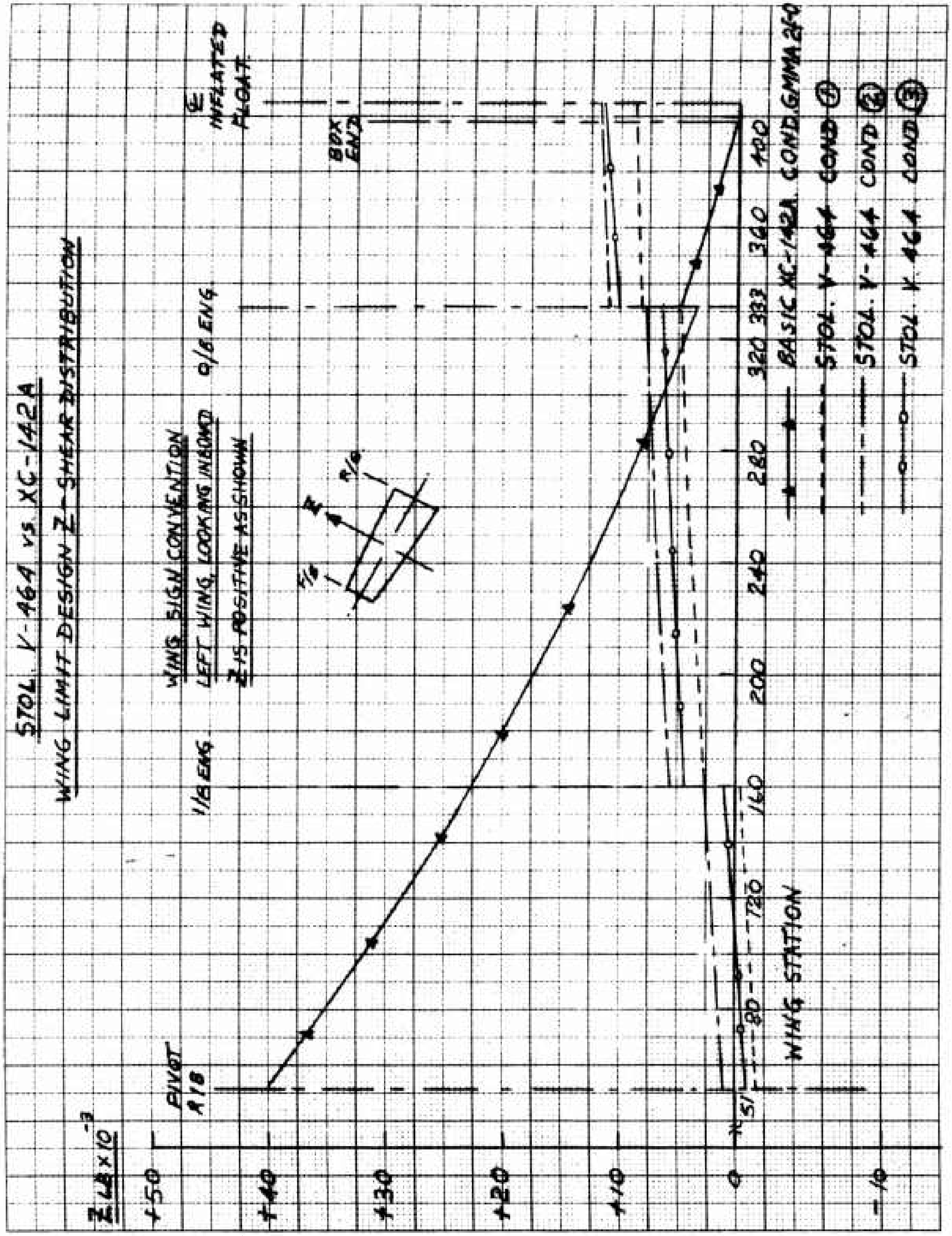


Figure 33 - STOL V-464 vs XC-142A Wing Limit Design; Z - Shear Distribution

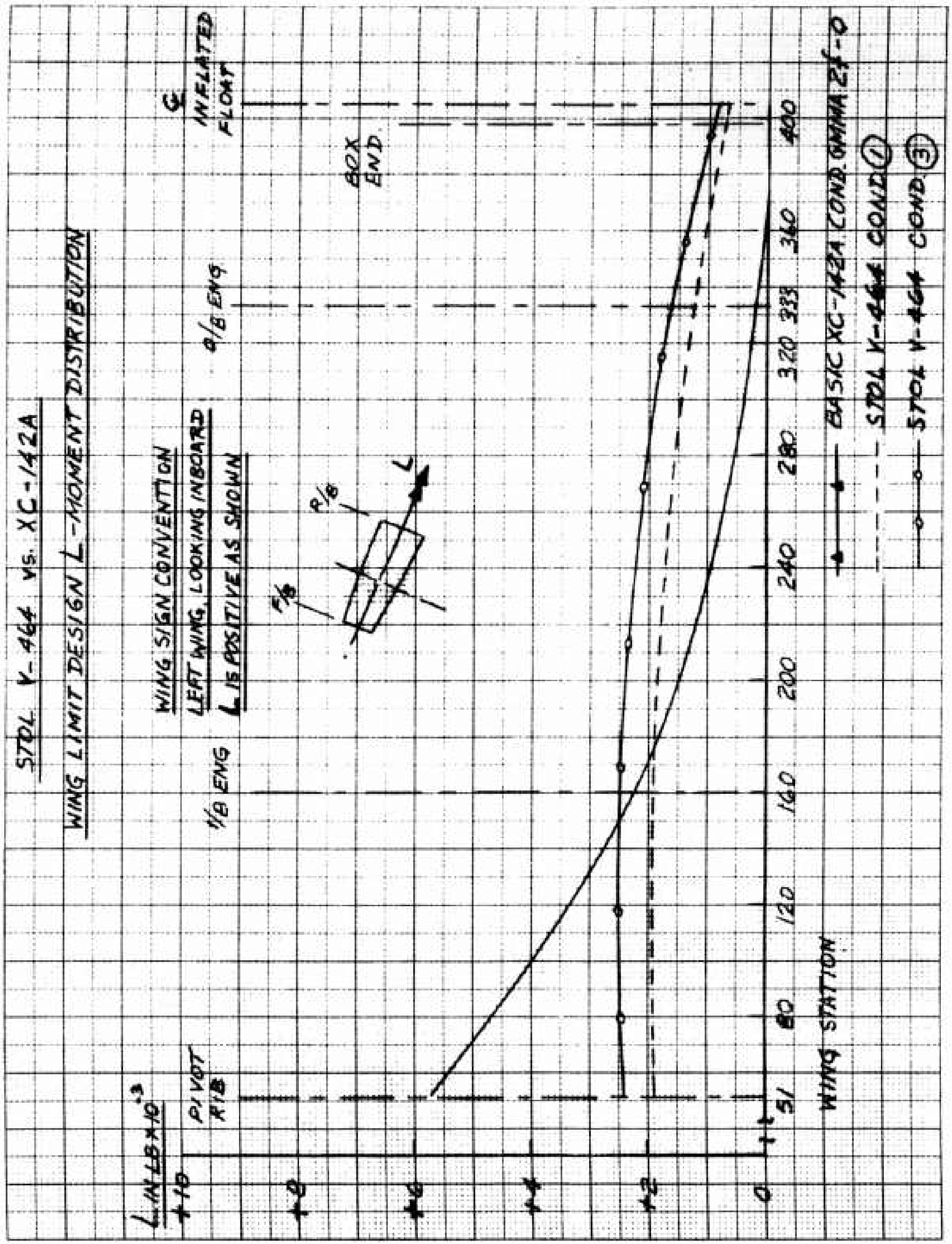


Figure 34 - STOL V-464 vs XC-142A Wing Limit Design;
L - Moment Distribution

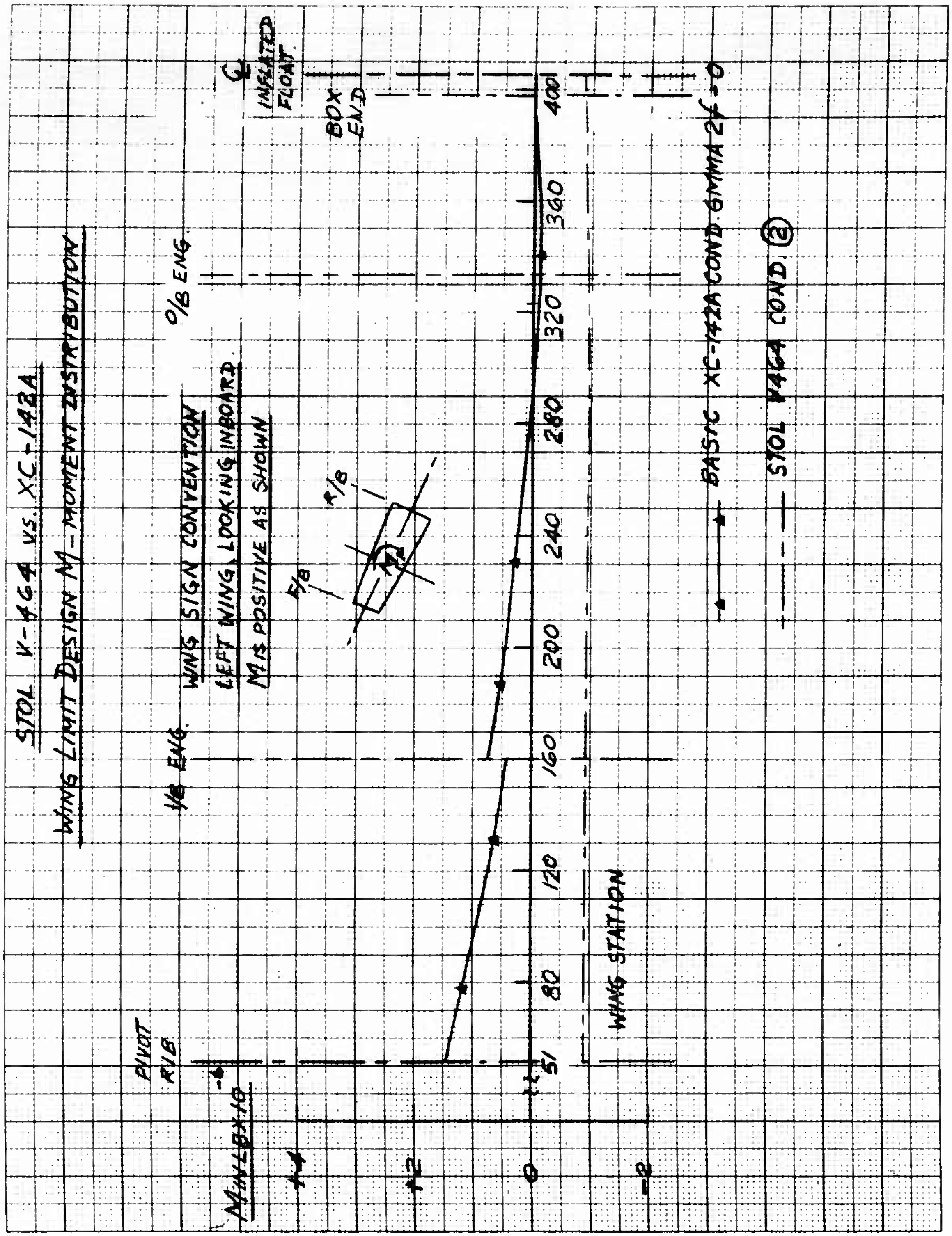


Figure 35 - STOL V-464 vs XC-142A Wing Limit Design;
M - Moment Distribution

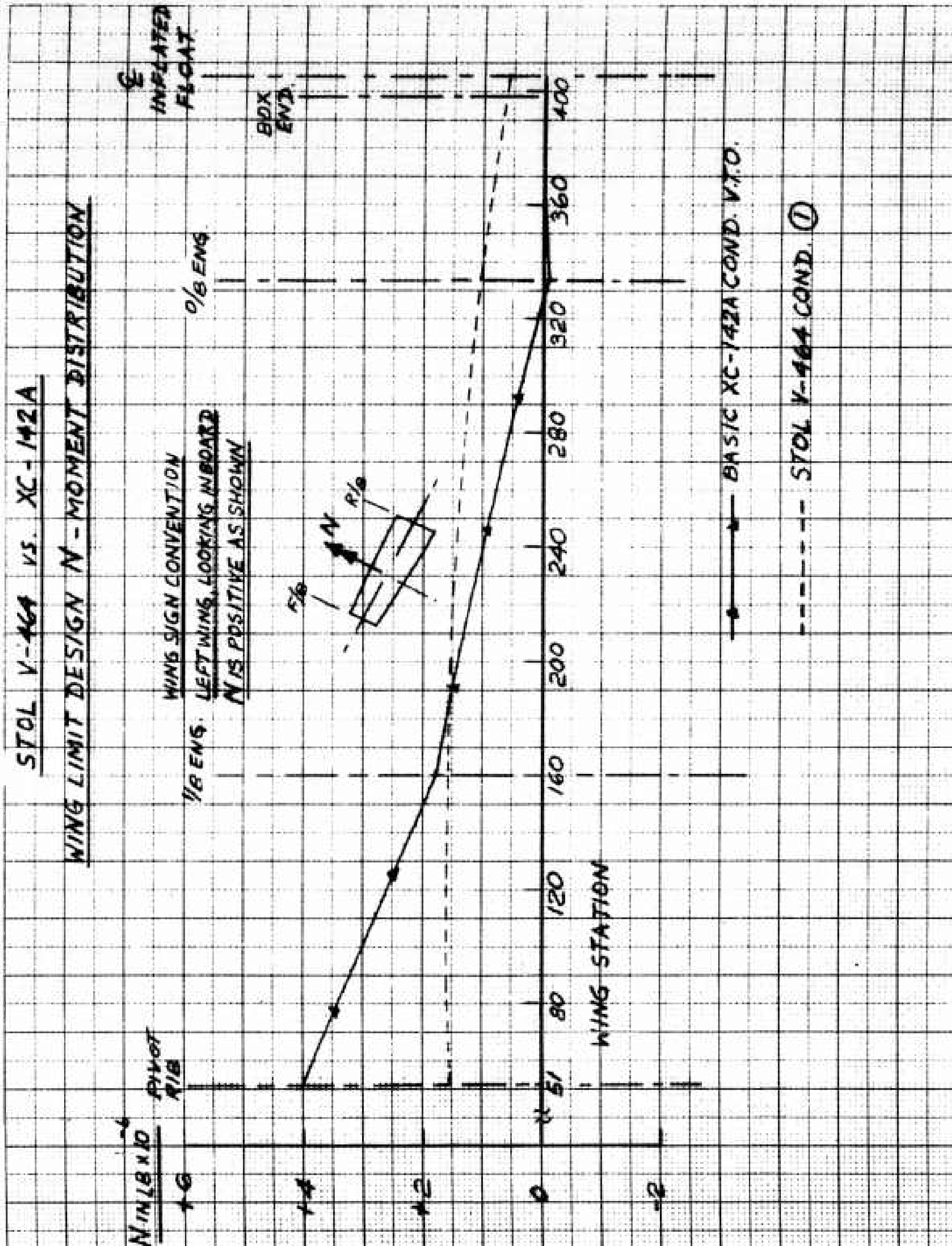


Figure 35 - STOL V-464 vs XC-142A Wing Limit Design;
N - Moment Distribution

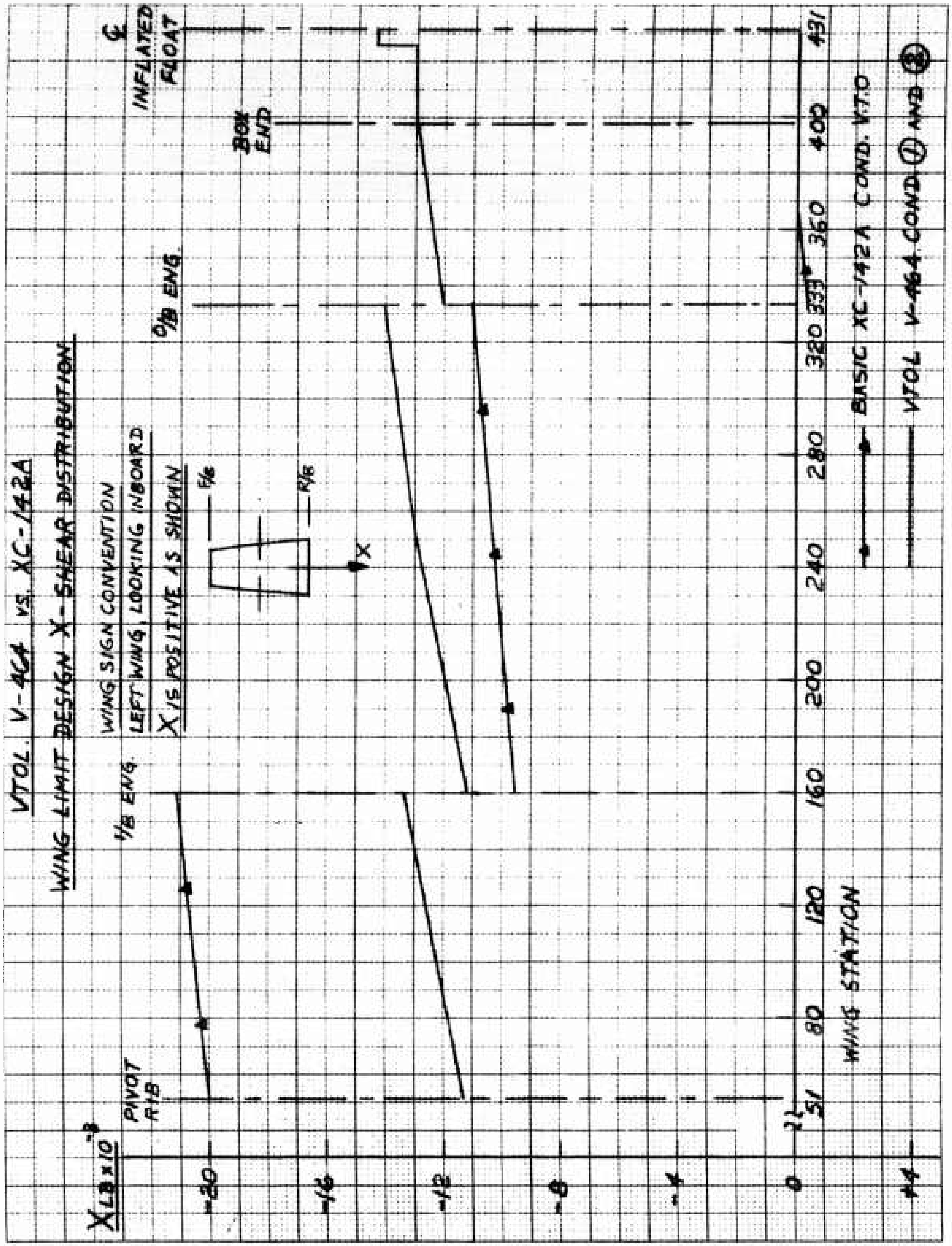


Figure 37 - VTOL V-464 vs XC-142A Wing Limit Design; X- Shear Distribution

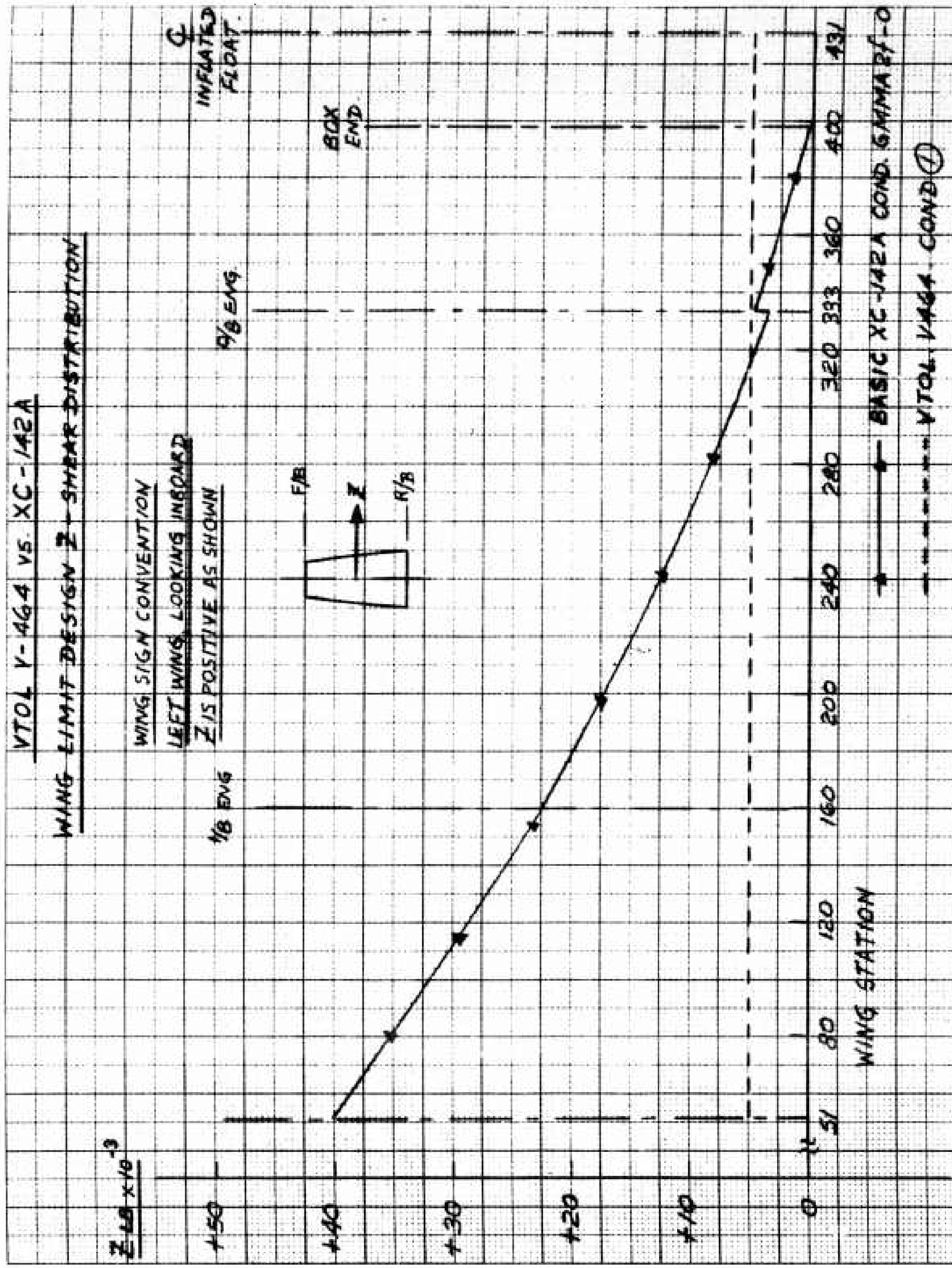


Figure 38 - VTOL V-464 vs XC-142A Wing Limit Design; Z - Shear Distribution

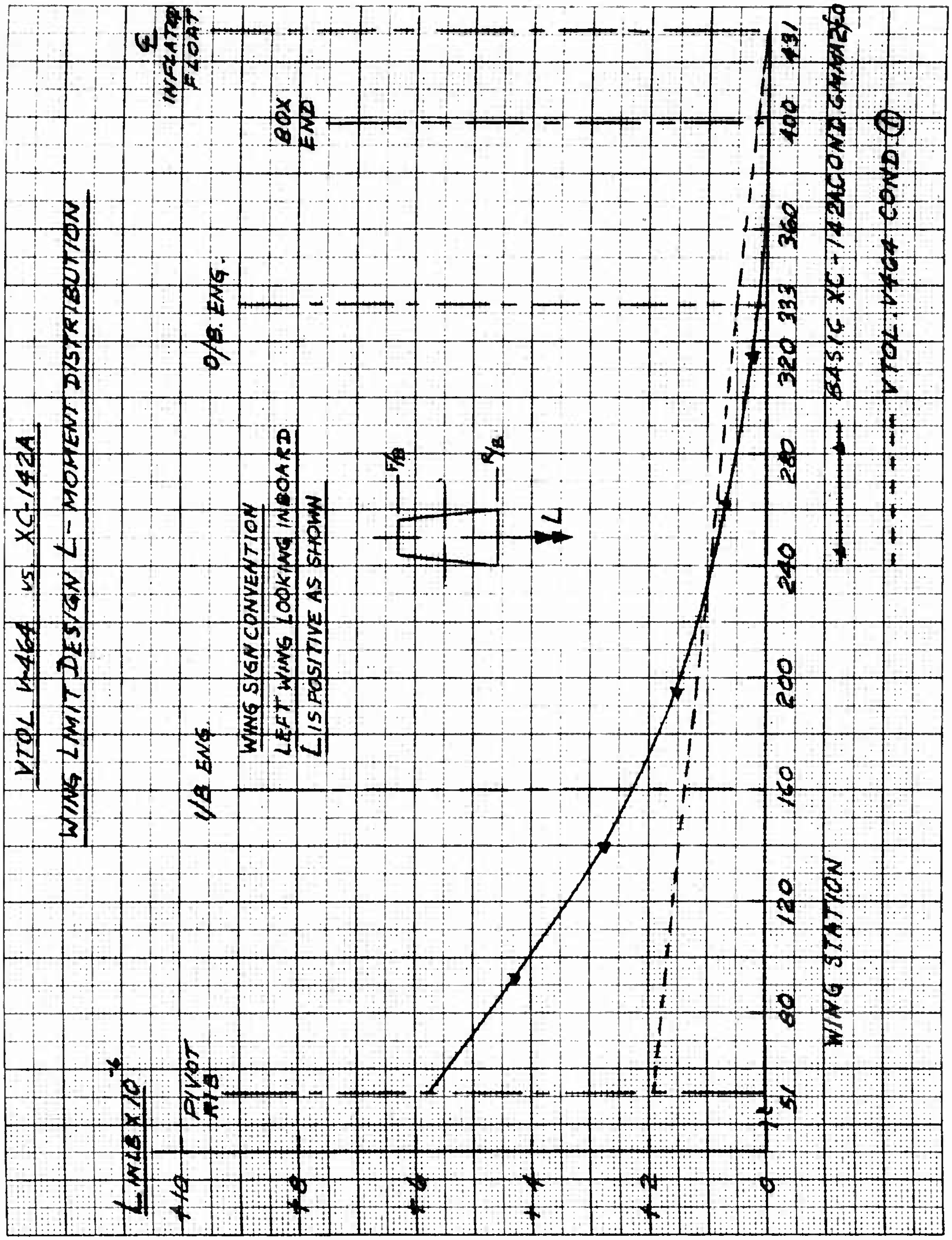


Figure 39 - VTOL V-464 vs XC-142A Wing Limit Design;
L- Moment Distribution

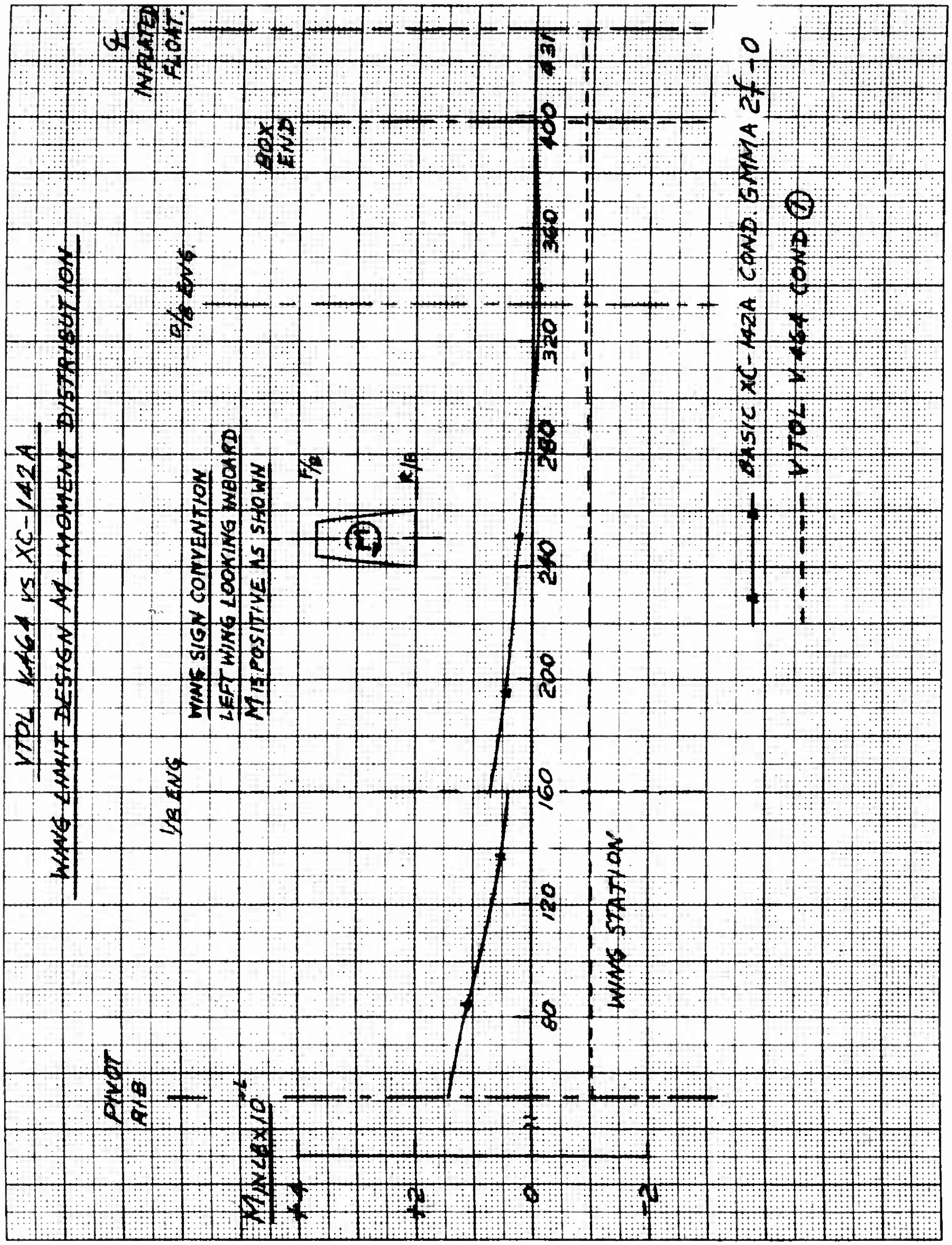


Figure 40 - VTOL V-464 vs XC-142A Wing Limit Design; M - Moment Distribution

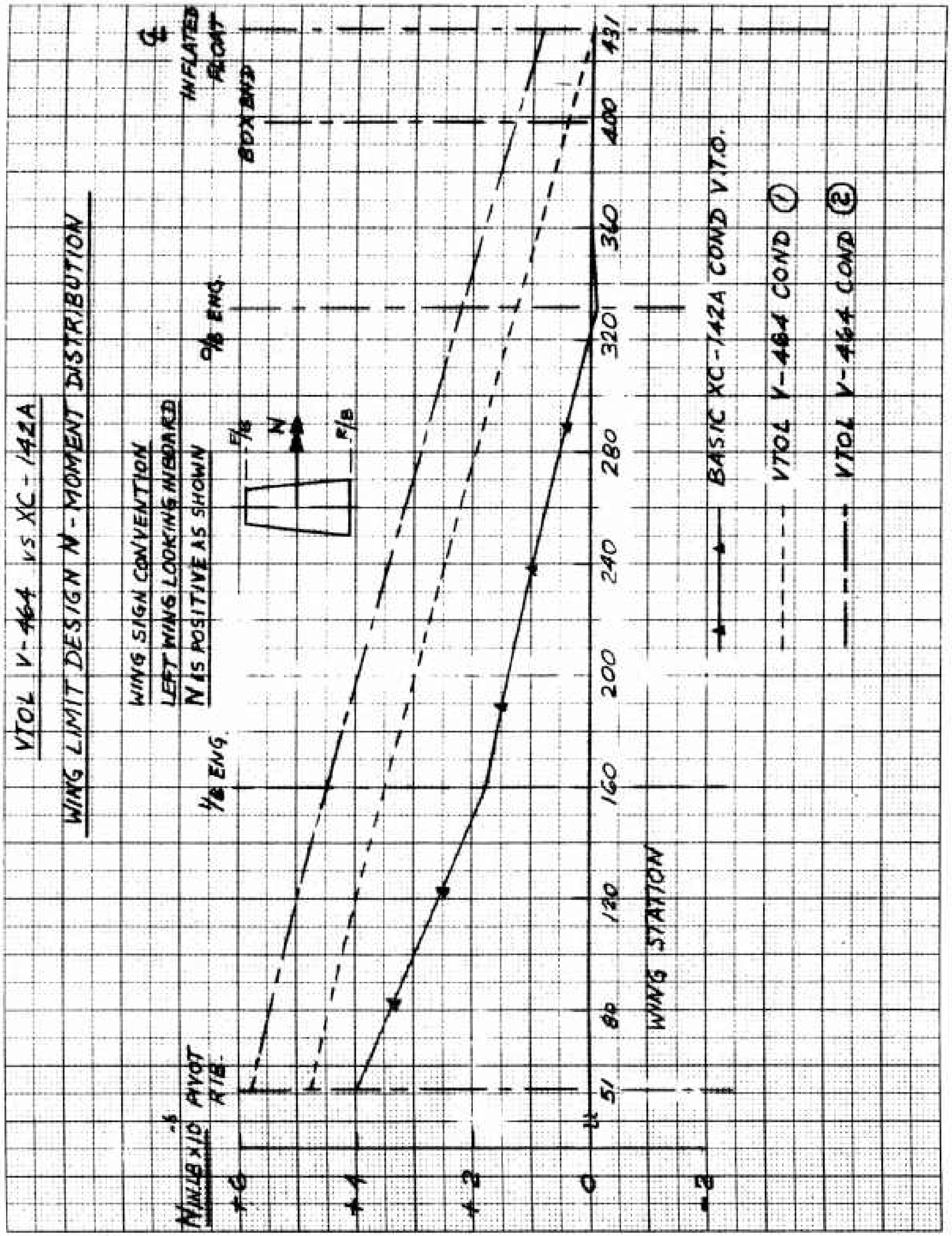


Figure 41 - VTOL V-464 vs XC-142A Wing Limit Design; N - Moment Distribution

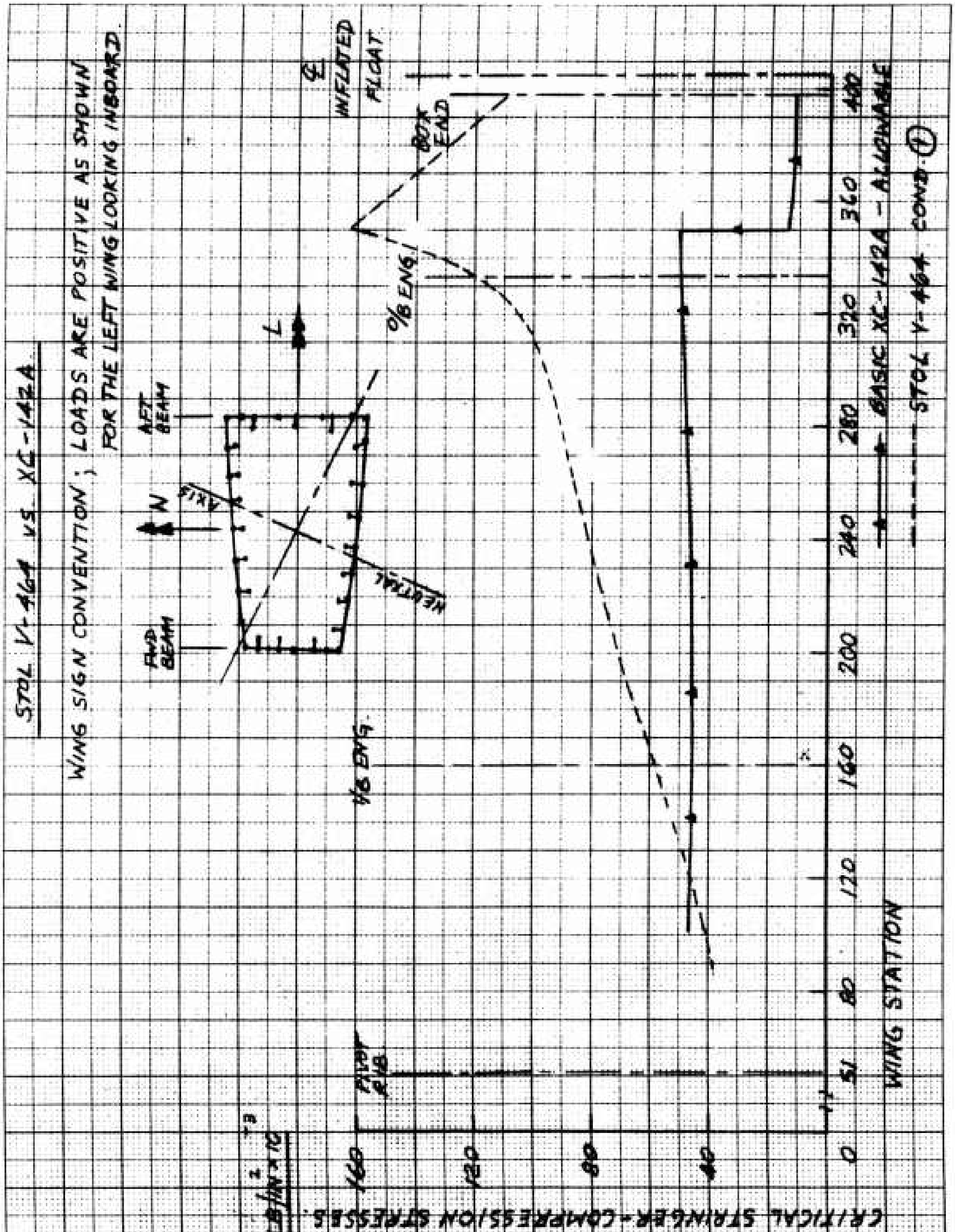


Figure 42 -- STOL V-464 vs XC-142A Wing Strength;
Extreme fiber flange stresses cond. 1

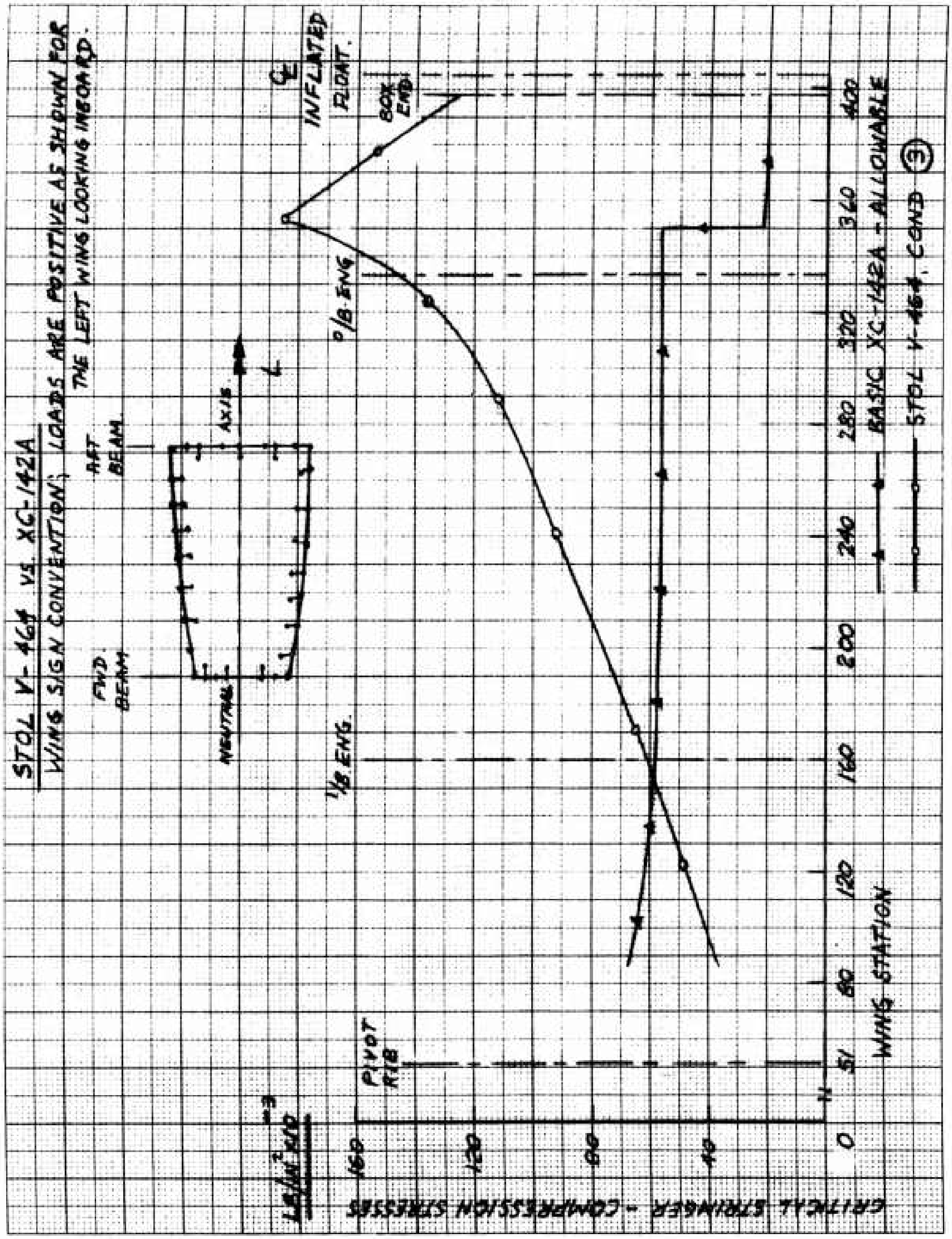


Figure 43 - STOL V-464 vs XC-142A Wing Strength;
Extreme fiber flange stresses cond. 3.

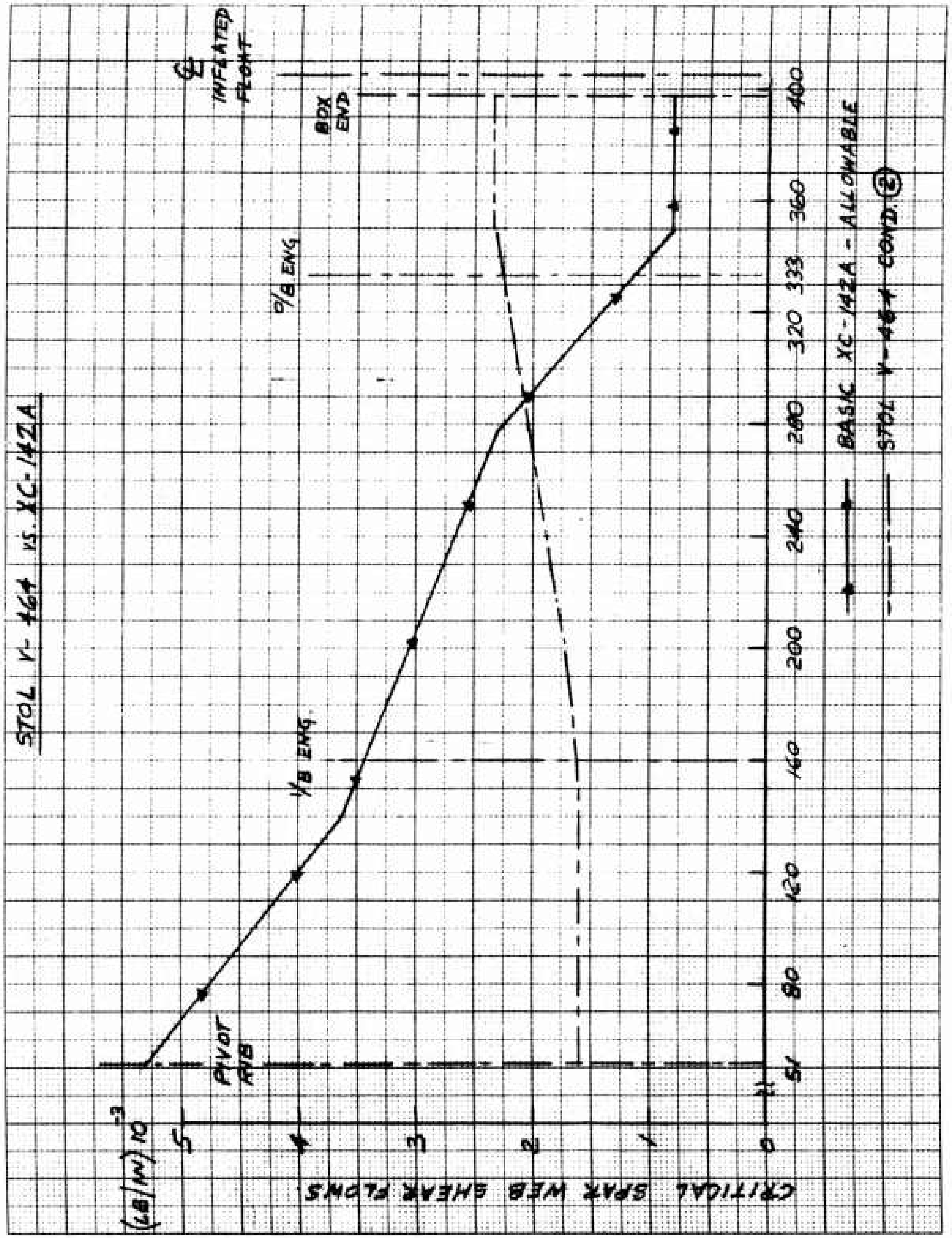


Figure 44 - STOL V-464 vs XC-142A Wing Strength; Rear beam web shear stresses cond. 2

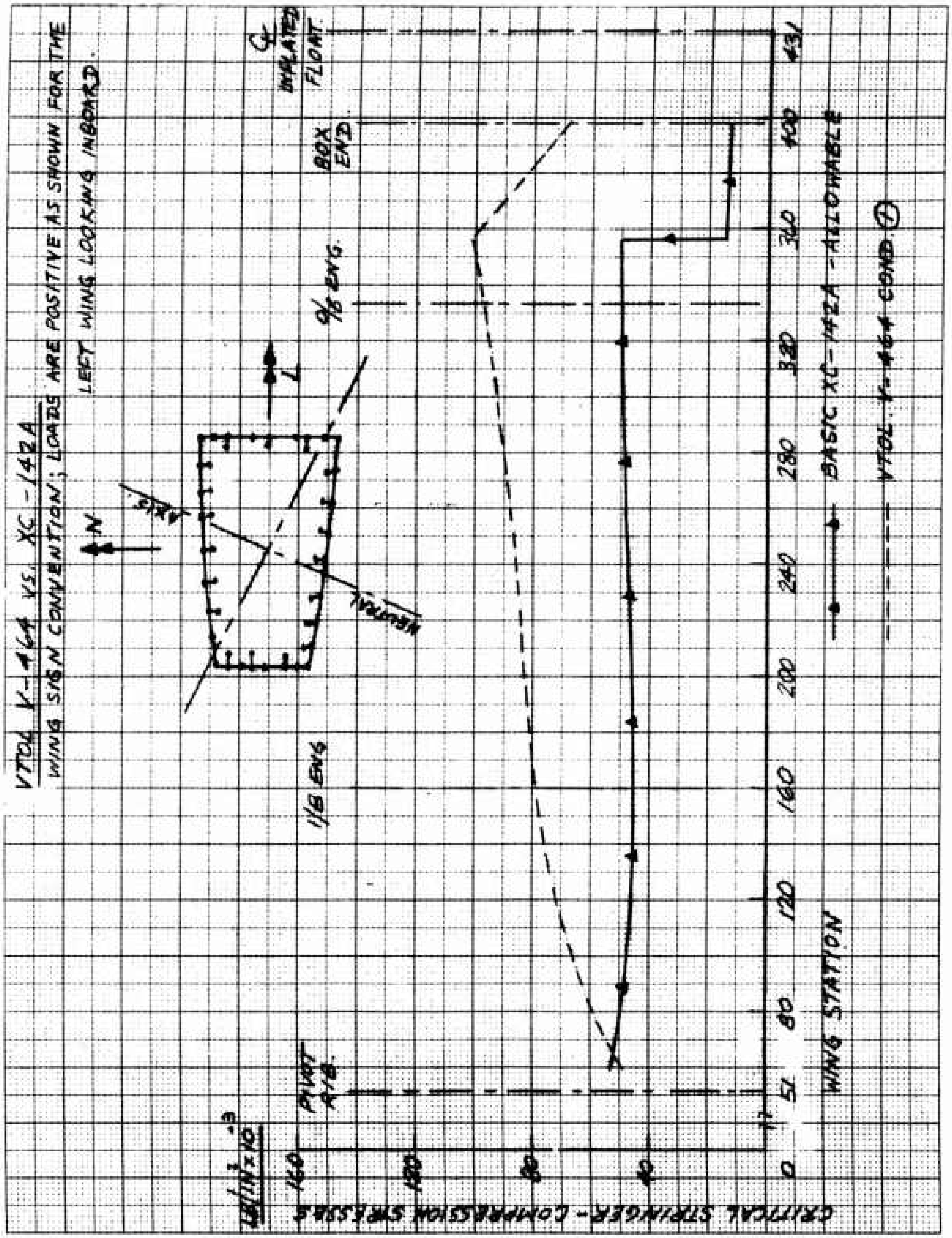


Figure 45 - VTOL V-464 vs XC-142A Wing Strength; Extreme Fiber flange stresses cond. 1

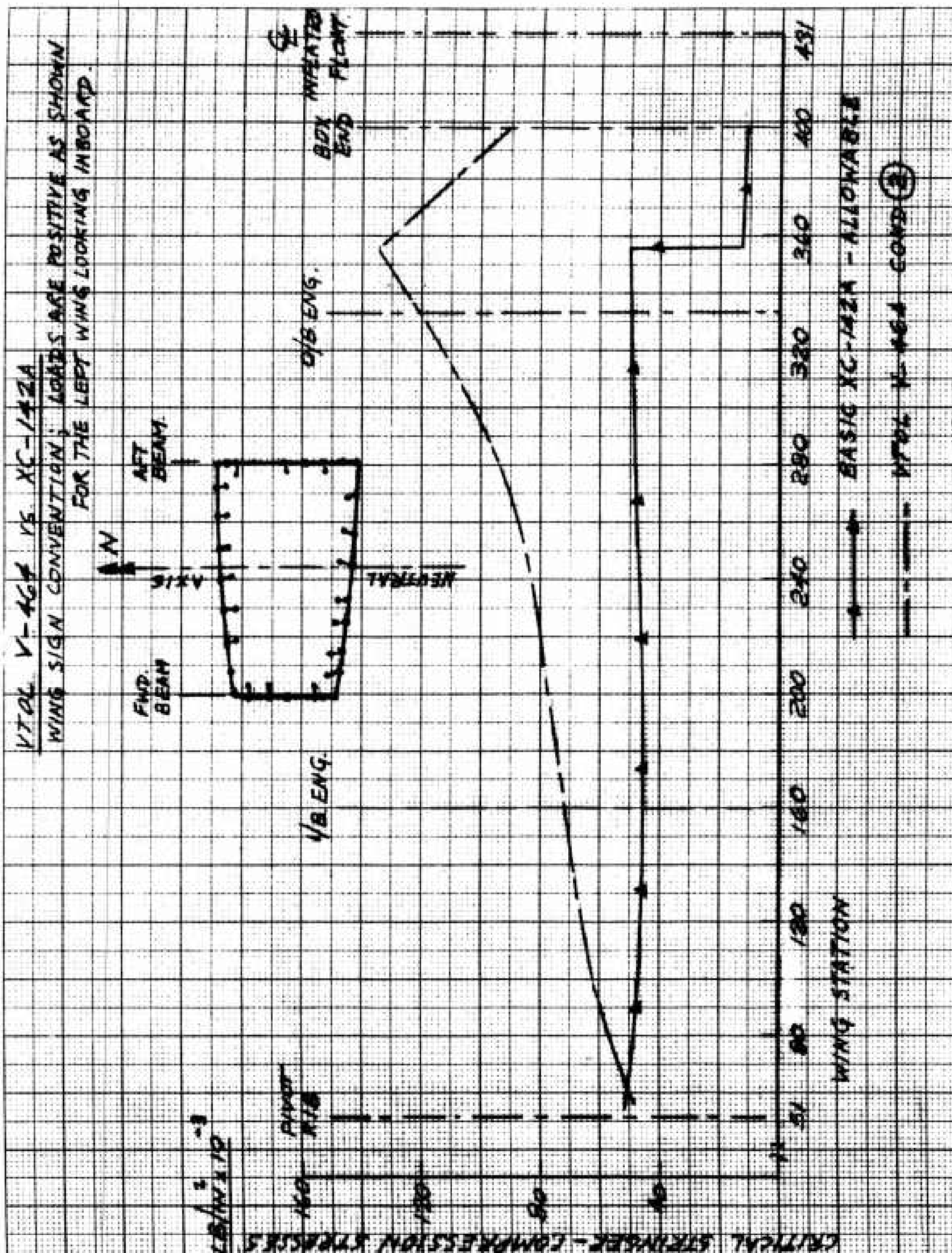


Figure 46 - VTOL V-464 vs XC-142A Wing Strength; Extreme fiber flange stresses cond. 2

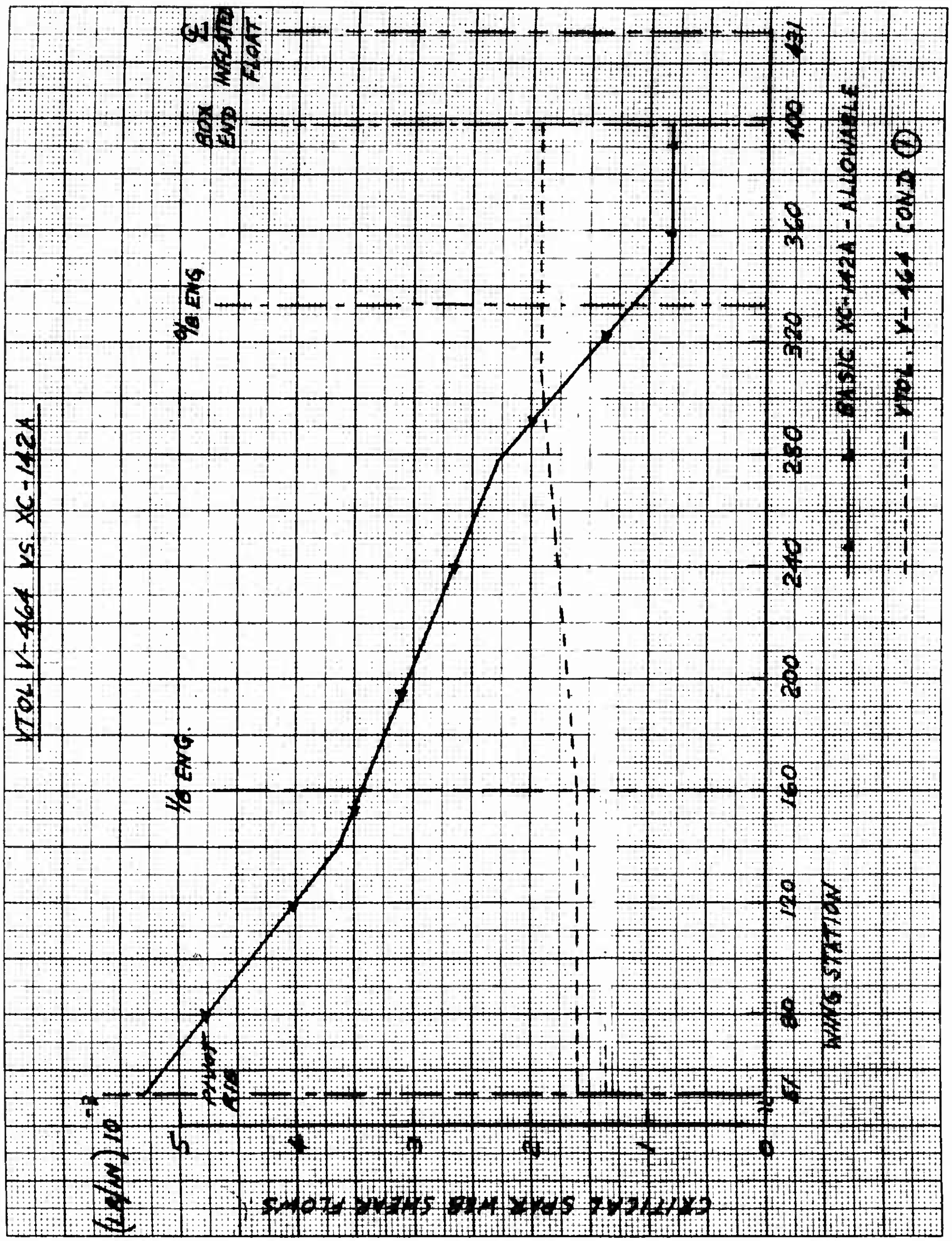


Figure 47 - VTOL V-464 vs XC-142A Wing Strength; Rear beam web shear stresses cond. 1

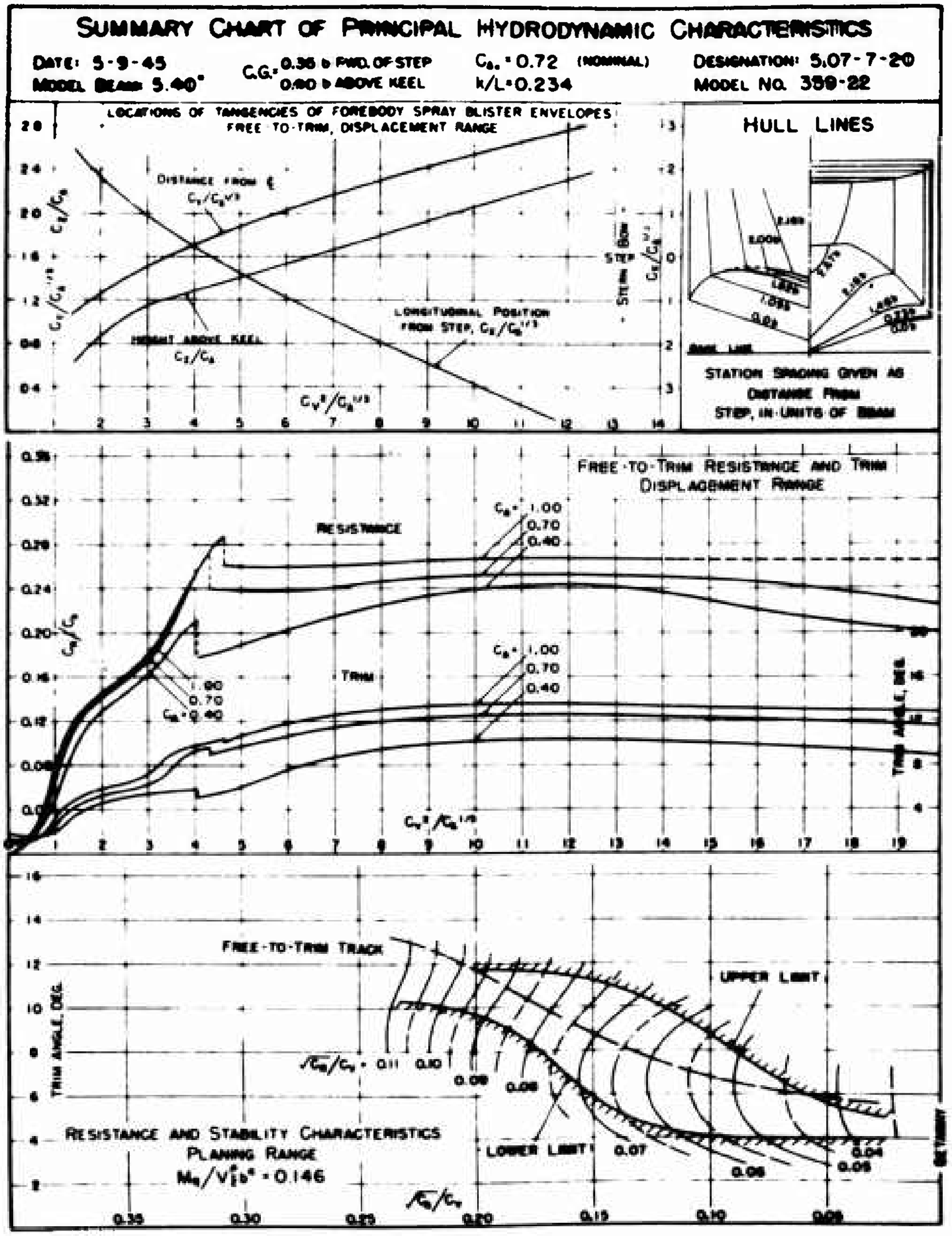


Figure 48 - Summary Chart of Hydrodynamic Characteristics

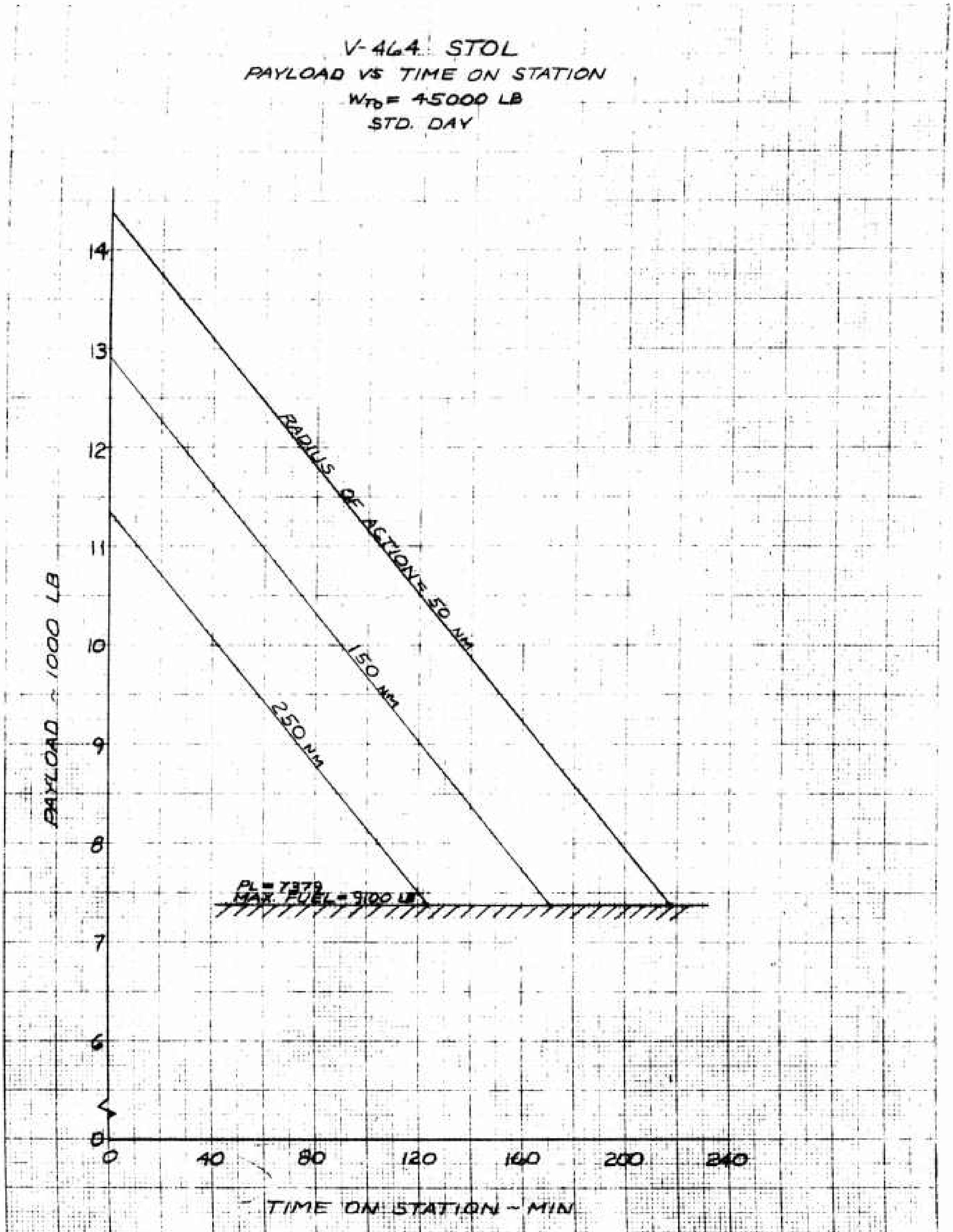


Figure 49 - STOL V-464 Payload vs Time on Station

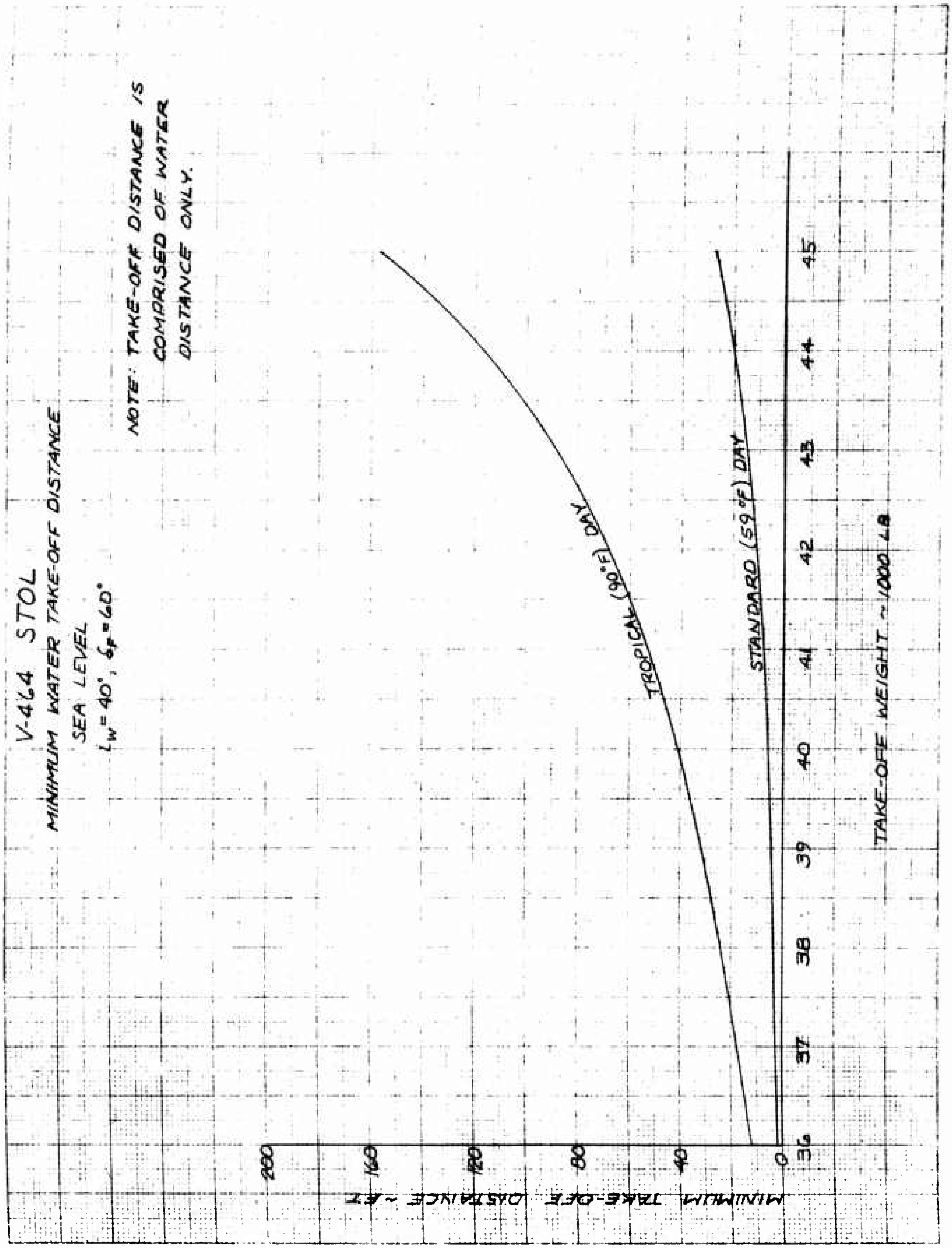


Figure 50 - STOL V-464 Minimum Water Takeoff Distance

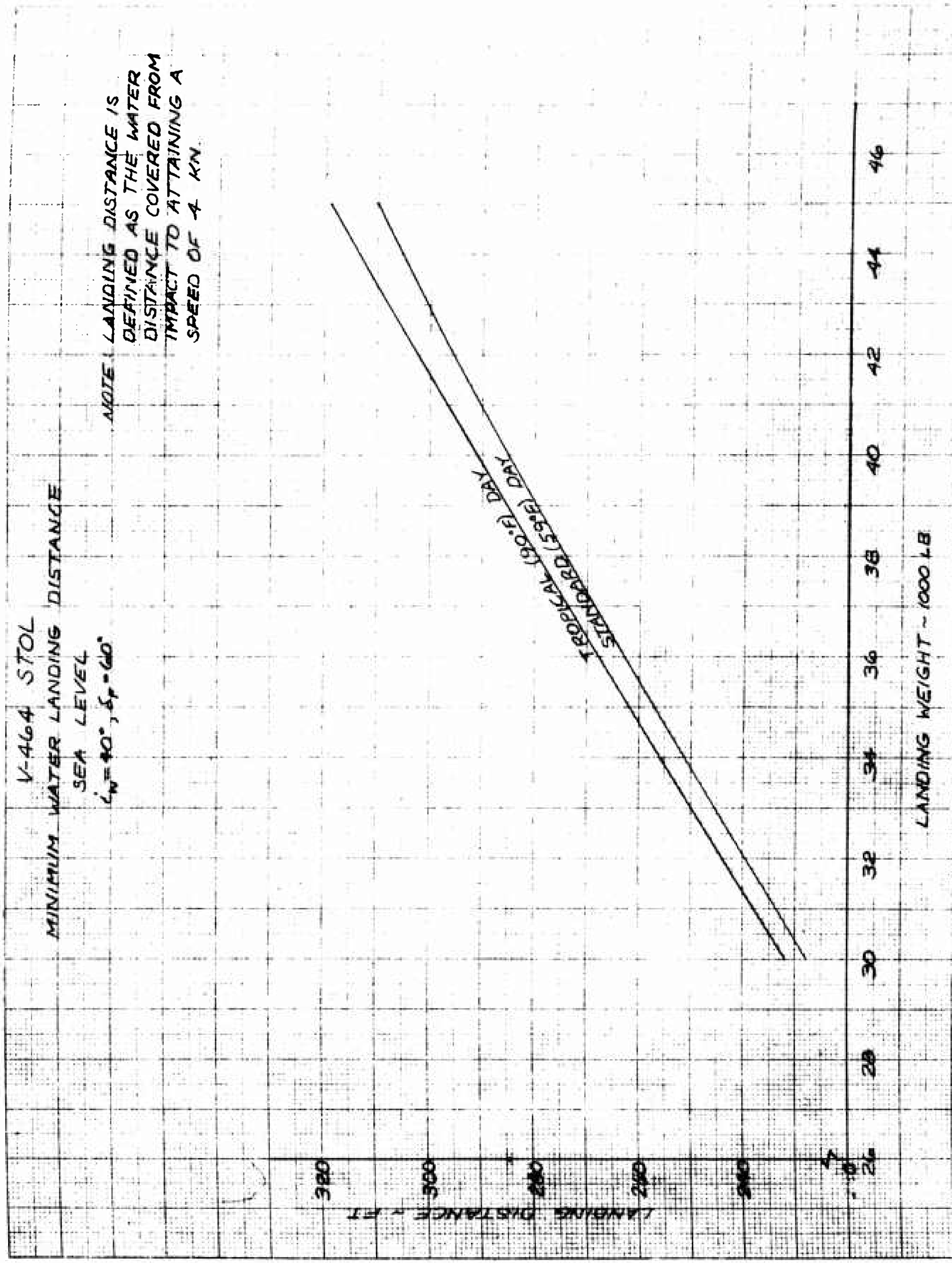


Figure 51 - STOL V-464 Minimum Water Landing Distance

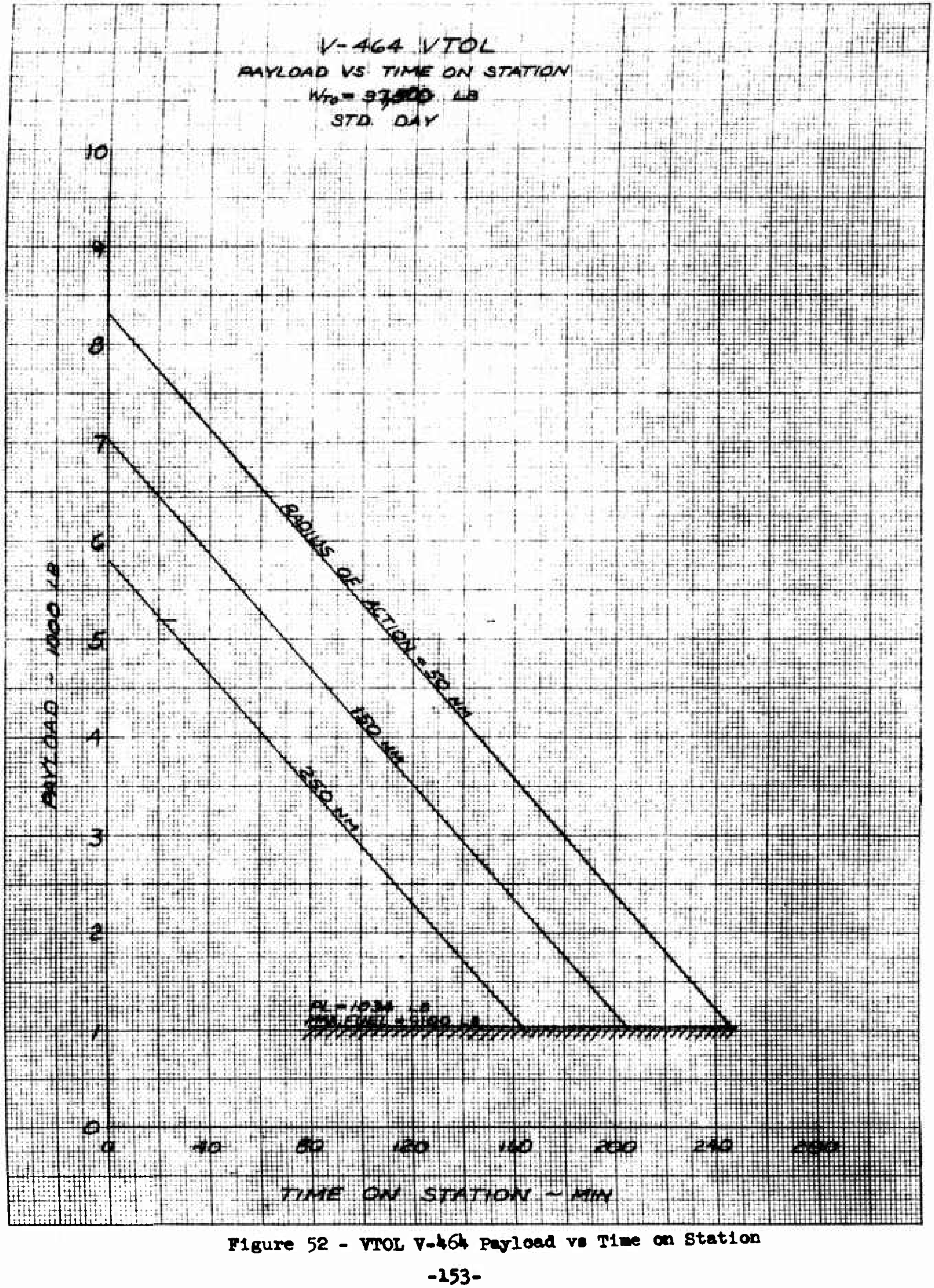


Figure 52 - VTOL V-464 Payload vs Time on Station

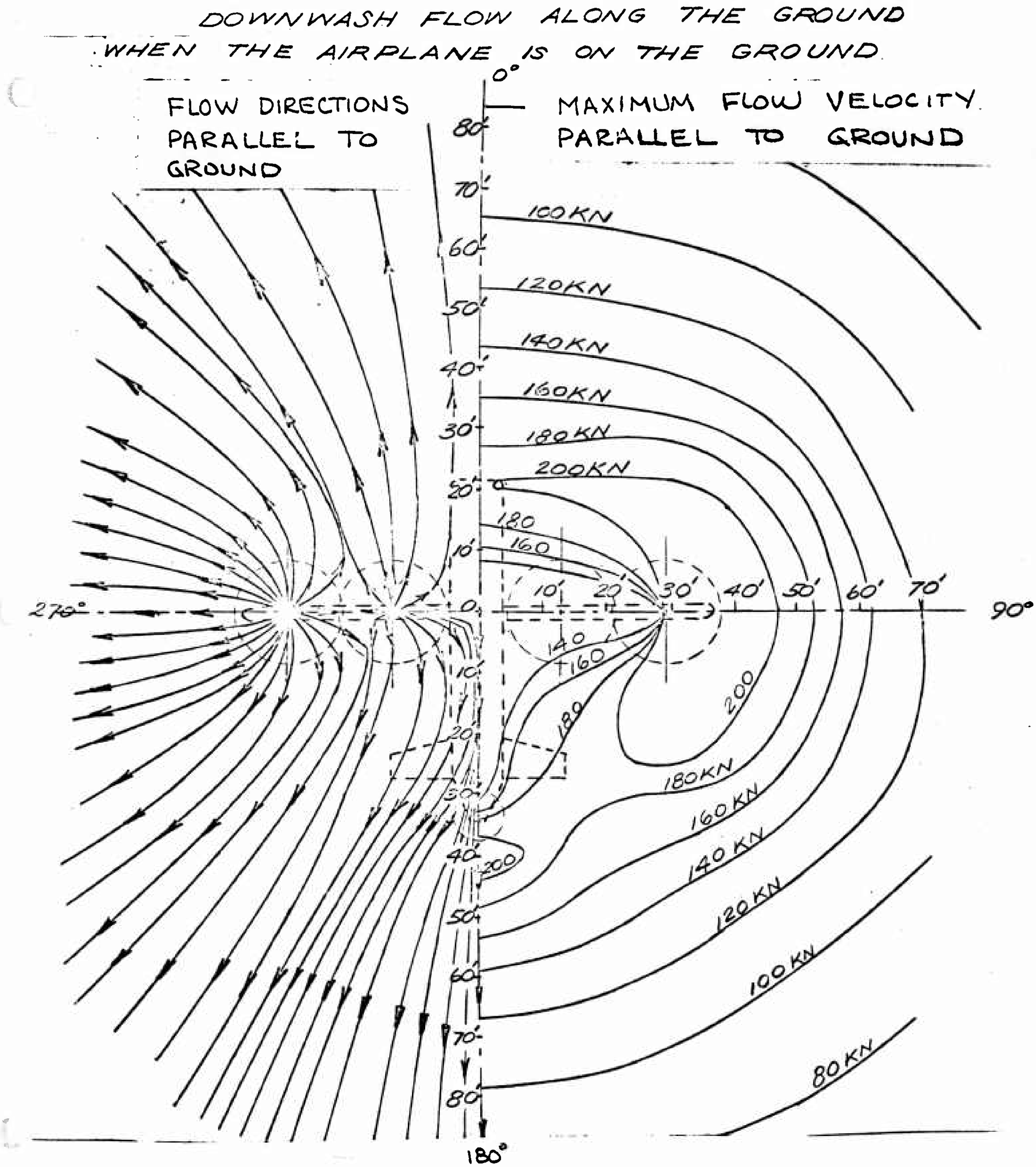


Figure 53 - Downwash Flow Along the Ground

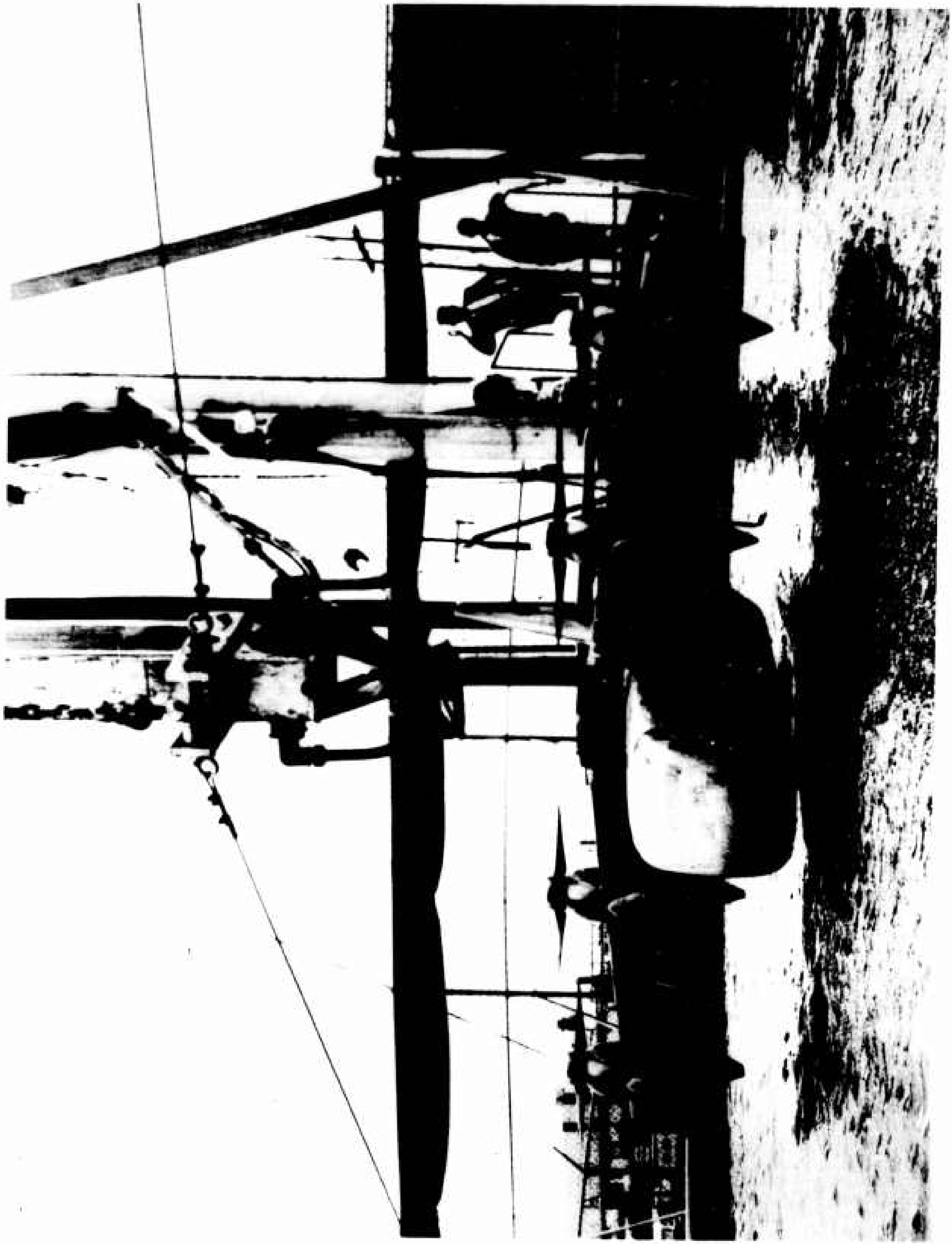


Figure 54. XC-142A Model Hover Over Water Site

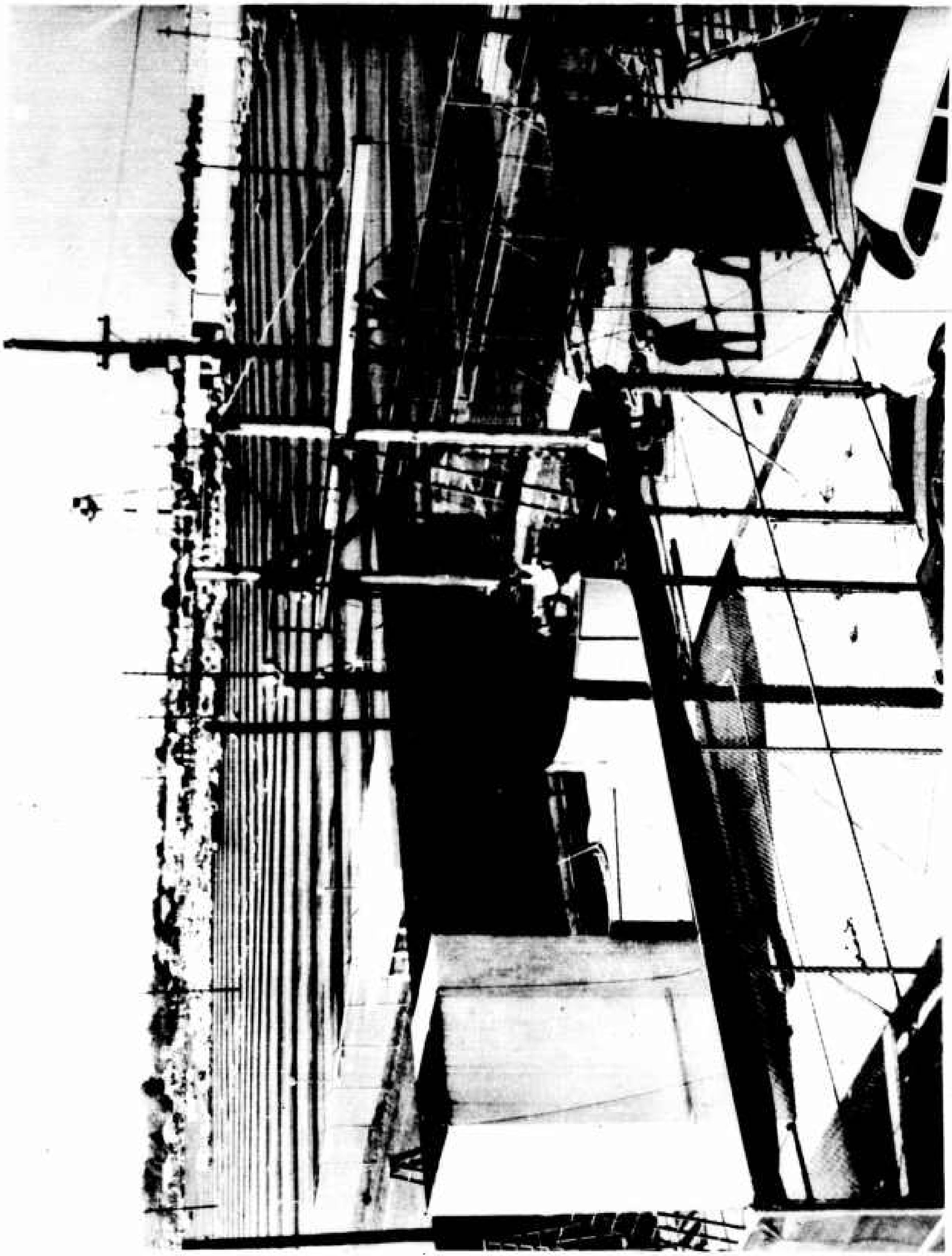
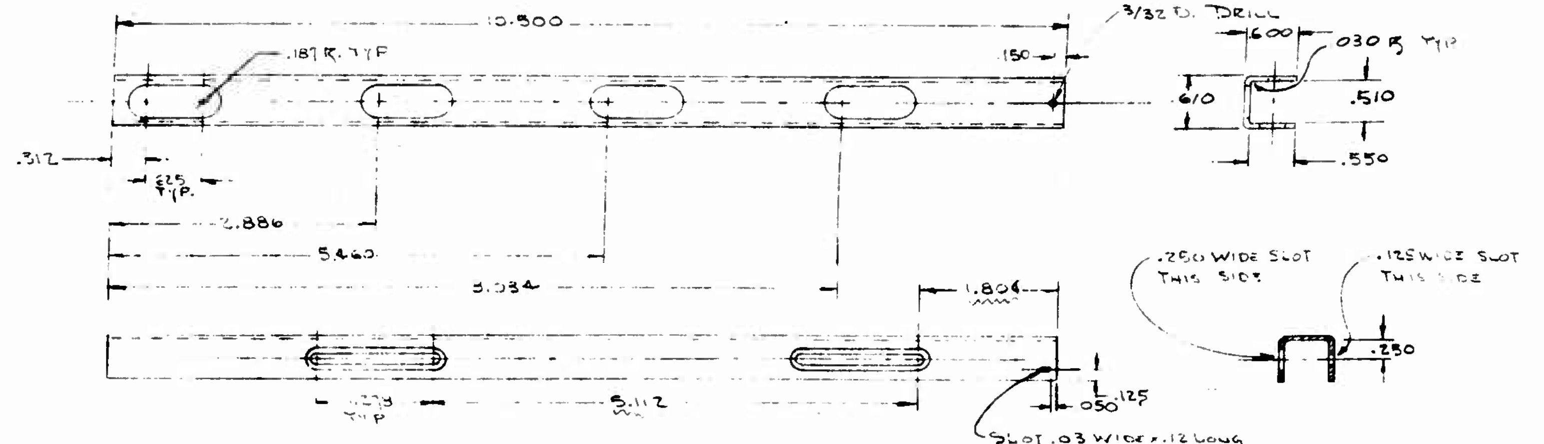
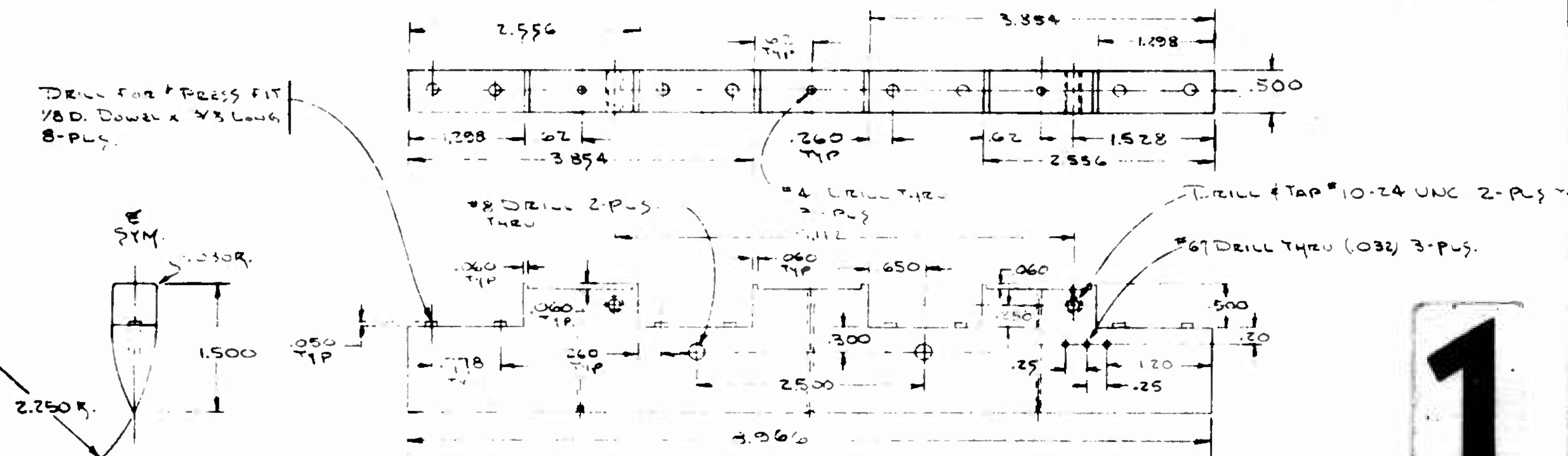


Figure 55. XC-142A Model Hover Over Water Site -156-

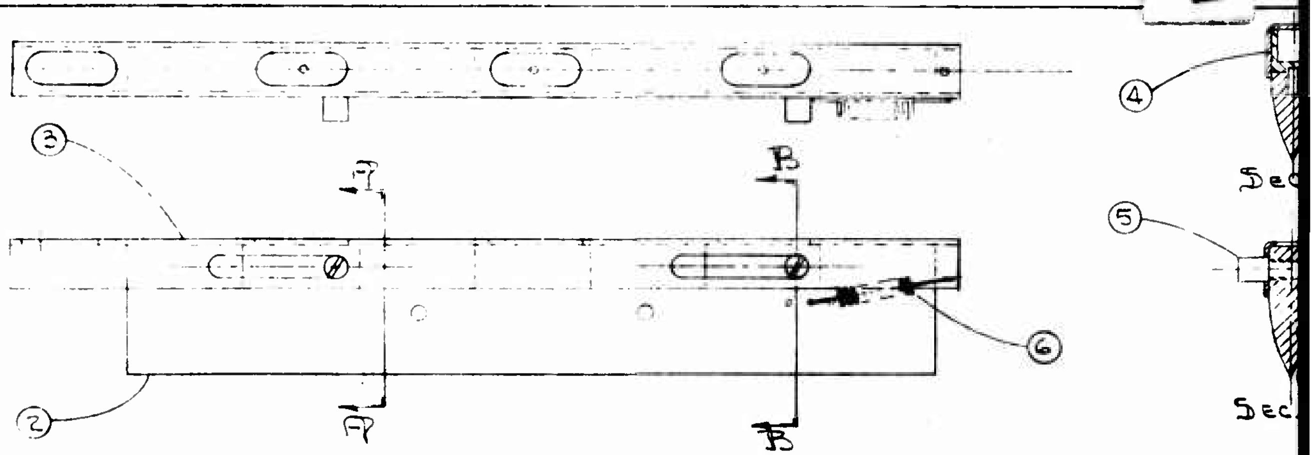


-3 COVER



-2 BODY

1



-1 METER ASSEM

USED ON	QTY REQD FINAL ASSY	NEXT ASSEMBLY	FROM	THRU	USED ON	QTY REQD FINAL ASSY	NEXT ASSEMBLY	FROM	THRU		MATERIAL	MATERIAL SPECIF
										M9		
										M8		
										M7		
										M6		
										M5		
										M4	REN 3260	
										M3	STL. MUSIC WIRE	QQ-W-470
										M2	17-4PH CRES	AMS 5643
										M1	7075T651 ALUM	QQ-A-250/12

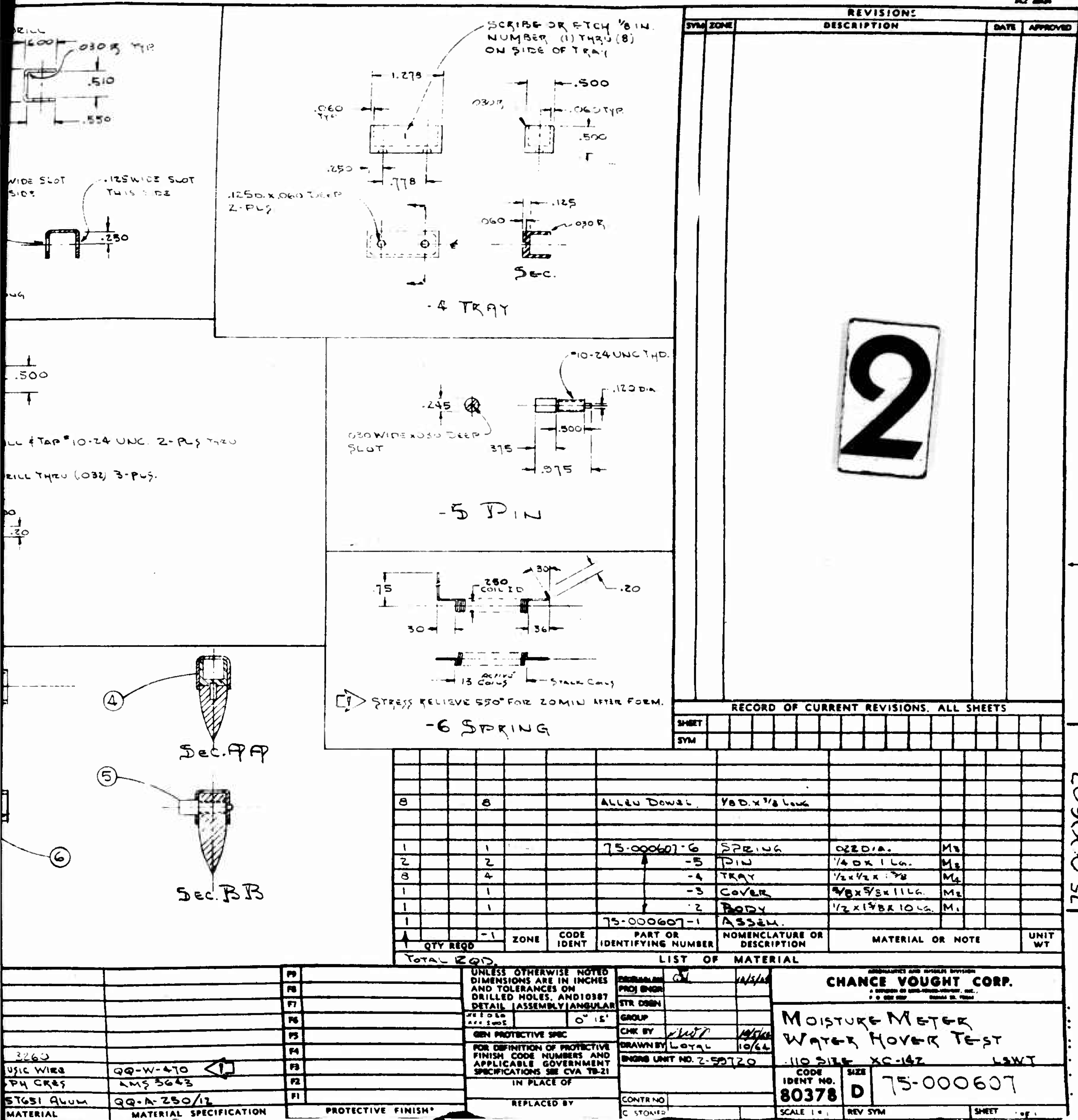
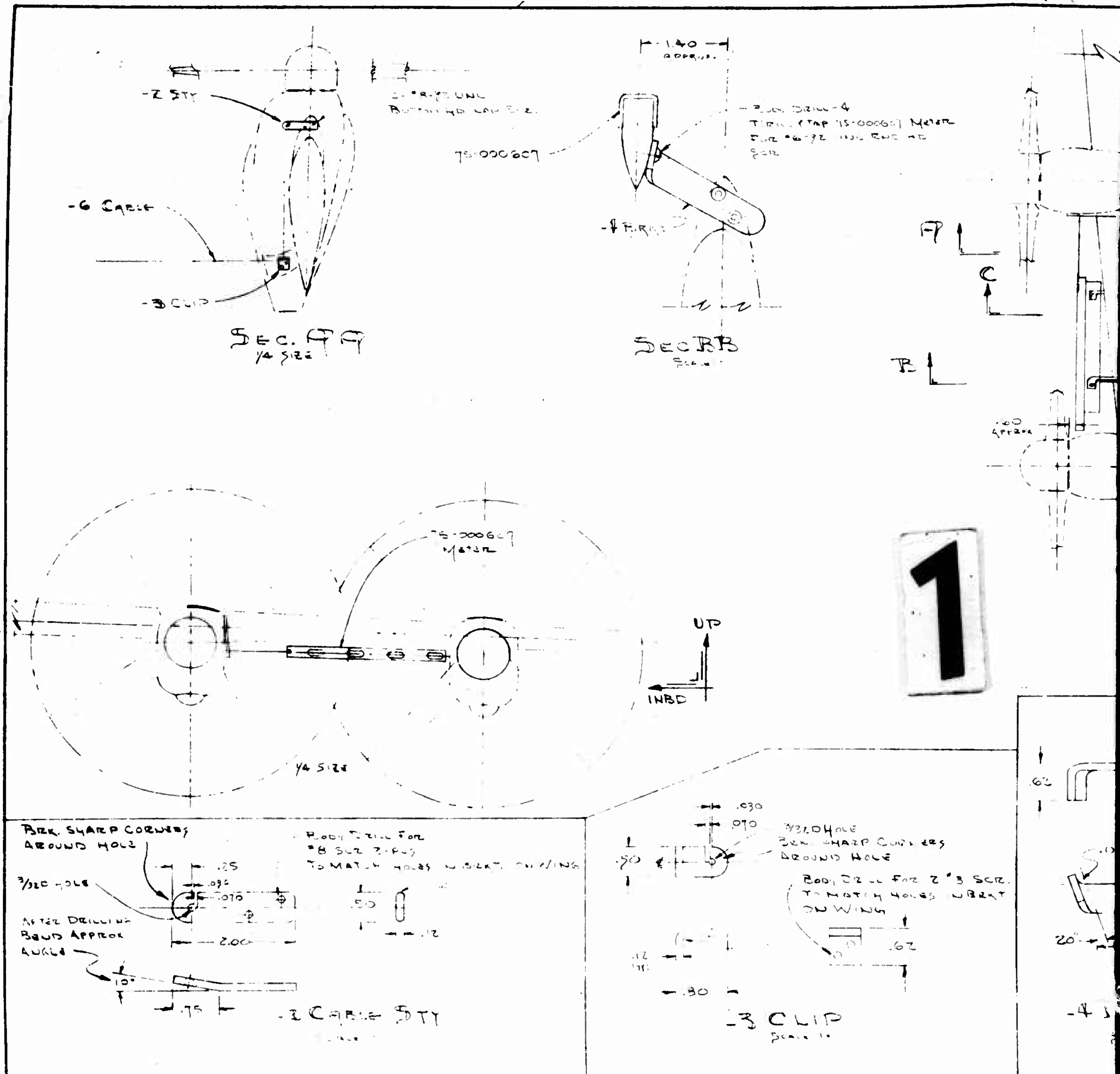
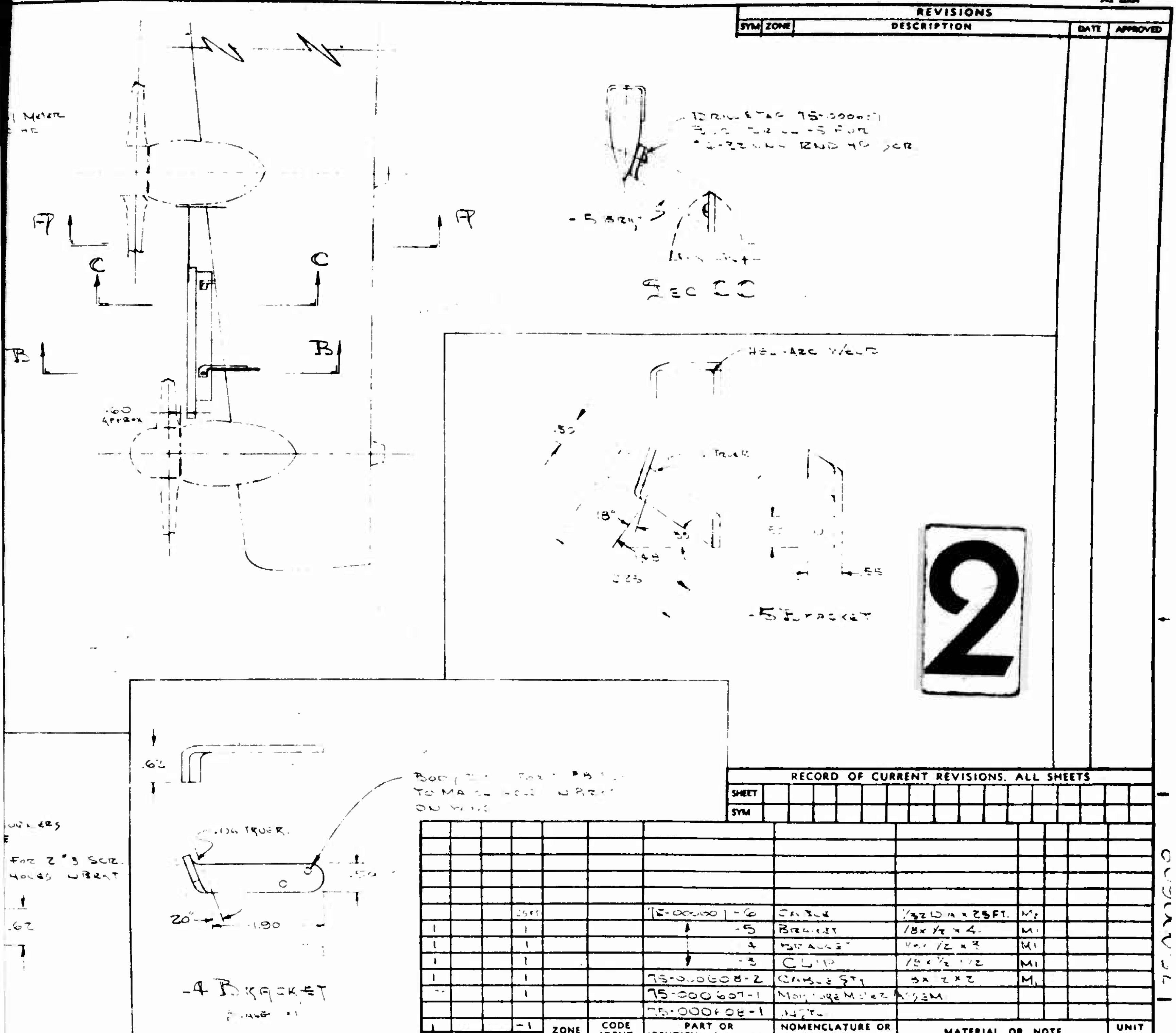


Figure 56 - Moisture Meter; Hover Test



USED ON	QTY REQD FINAL ASSY	NEXT ASSEMBLY	FROM	THRU	USED ON	QTY REQD FINAL ASSY	NEXT ASSEMBLY	FROM	THRU		MATERIAL	MATERIAL SPECIF
										M9		
										M8		
										M7		
										M6		
										M5		
										M4		
										M3		
										M2	CRES FLEX WIRE ROPE	MIL-C-5424
										M1	17-7PH CRES	[illegible]



	25 FT			75-000600-6	CABLE	1/32 DIA x 25 FT.	M2		
1	1			-5	BRACKET	1/8 x 1/2 x 4	M1		
1	1			-4	BRACKET	1/2 x 3	M1		
1	1			-3	CLIP	1/8 x 1/2 x 1/2	M1		
1	1			75-000608-2	CABLE STY	2 x 2	M1		
--	1			75-000607-1	MOISTURE METER ASSEM				
				75-000608-1	INSTL				
QTY REQD	-1	ZONE	CODE IDENT	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE			UNIT WT

RECORD OF CURRENT REVISIONS, ALL SHEETS

LIST OF MATERIAL

MATERIAL	MATERIAL SPECIFICATION		PROTECTIVE FINISH
		F9	
		F8	
		F7	
		F6	
		F5	
		F4	
		F3	
FLEX WIRE ROPE	MIL-C-5424	F2	
CRES		F1	

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES AND TOLERANCES ON DRILLED HOLES, AND10387

DETAIL | ASSEMBLY | ANGULAR

GEN PROTECTIVE SPEC

FOR DEFINITION OF PROTECTIVE FINISH CODE NUMBERS AND APPLICABLE GOVERNMENT SPECIFICATIONS SEE CVA TB-21

IN PLACE OF

REPLACED BY

PROJ ENGR

STR DSGN

GROUP

CHK BY

DRAWN BY

ENGRG UNIT NO Z-5

CONT ON

AERONAUTICS AND MISSILES DIVISION

CHANCE VOUGHT CORP.

INSTL. MOISTURE METER WATER HOVER TEST

CODE IDENT NO 80378 | SIZE D

SCALE | REV SYM | SHEET

Figure 57 - Installation; Moisture Meter; Hover Test

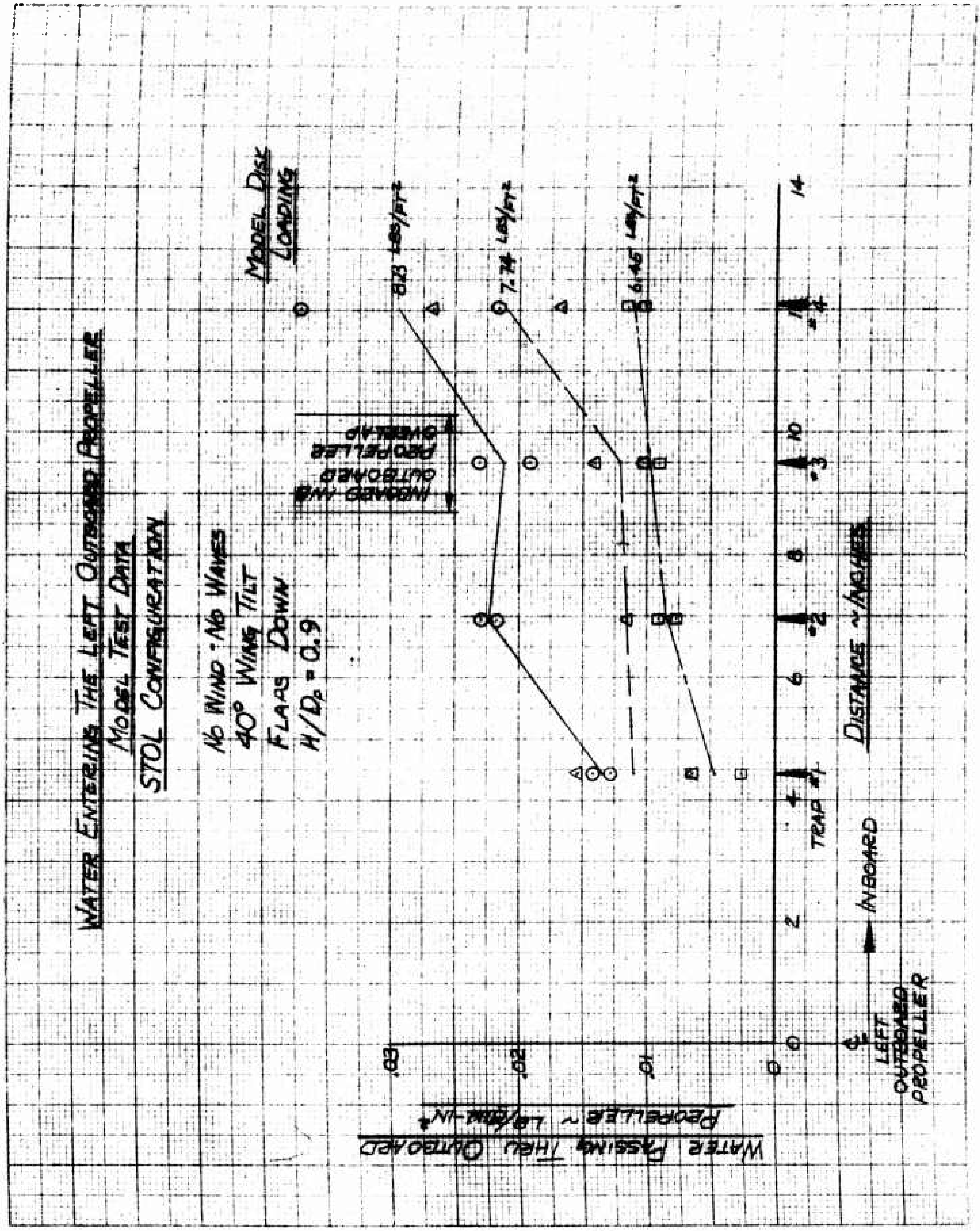


Figure 58 - STOL V-464; Water Passing Thru Outboard Propeller; Hover Test

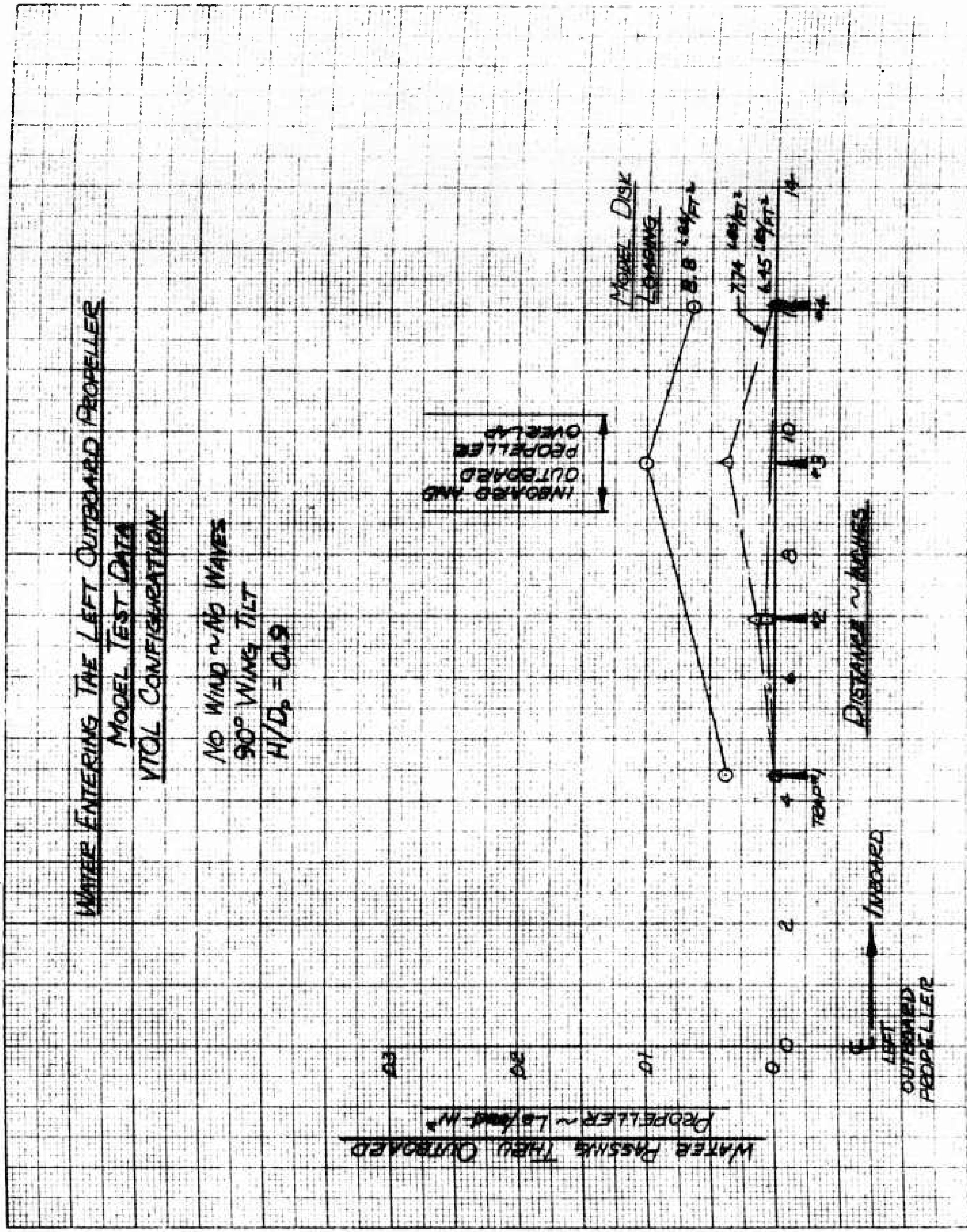


Figure 59 - VTOL V-464; Water Passing Thru Outboard Propeller; Hover Test

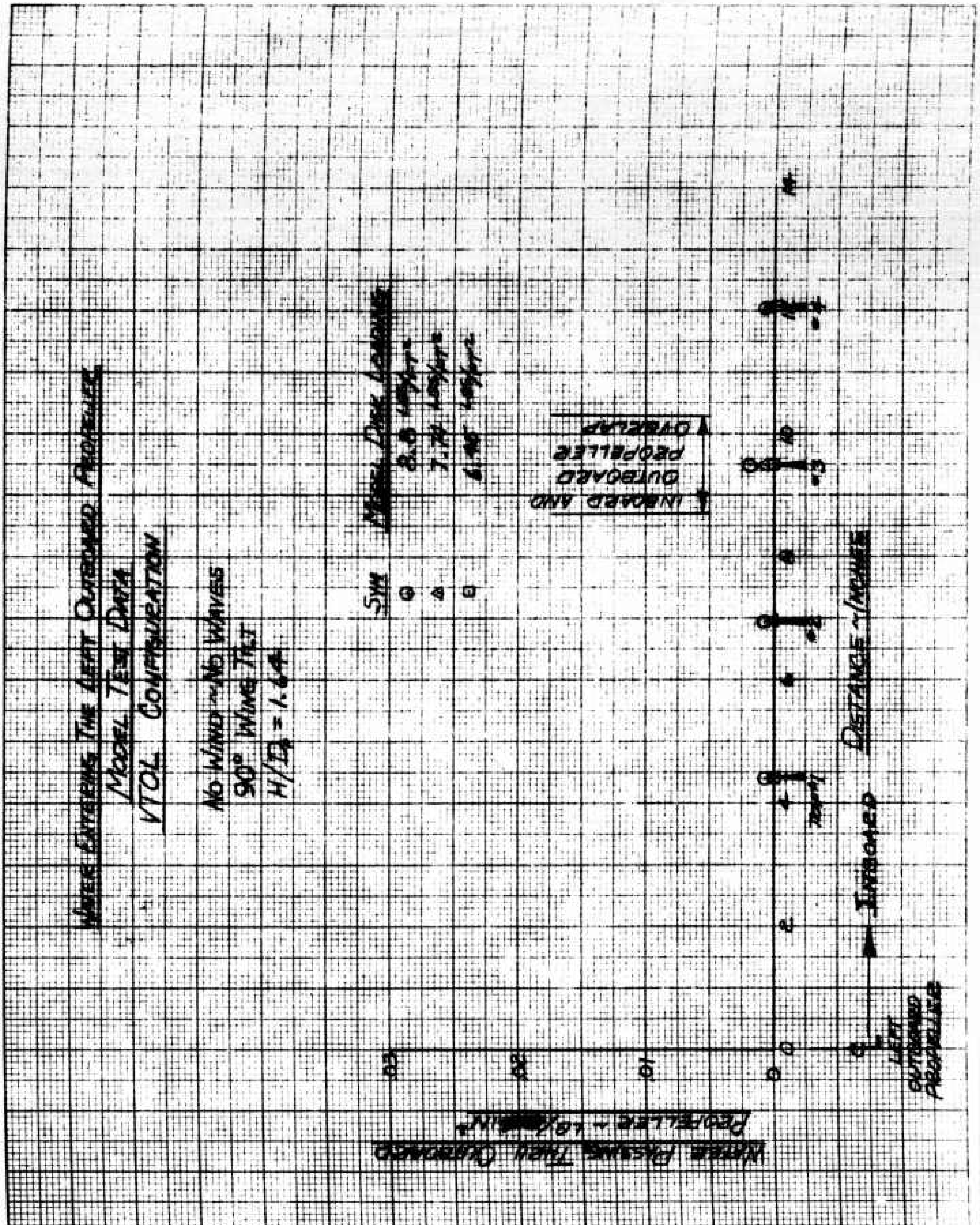


Figure 60 - VTOL V-464; Water Passing Thru Outboard Propeller; Hover Test

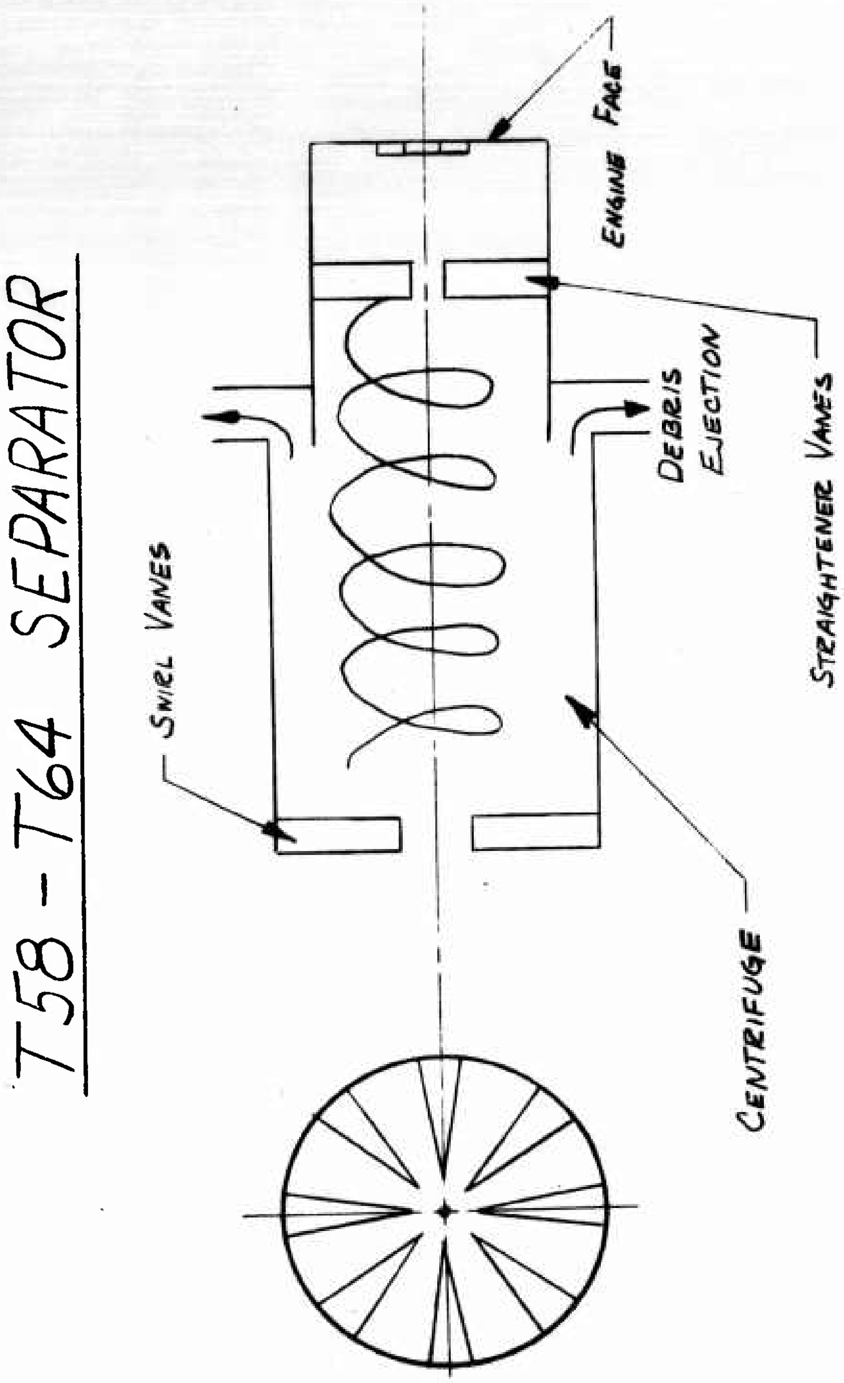


Figure 61 - T58-T64 Separator

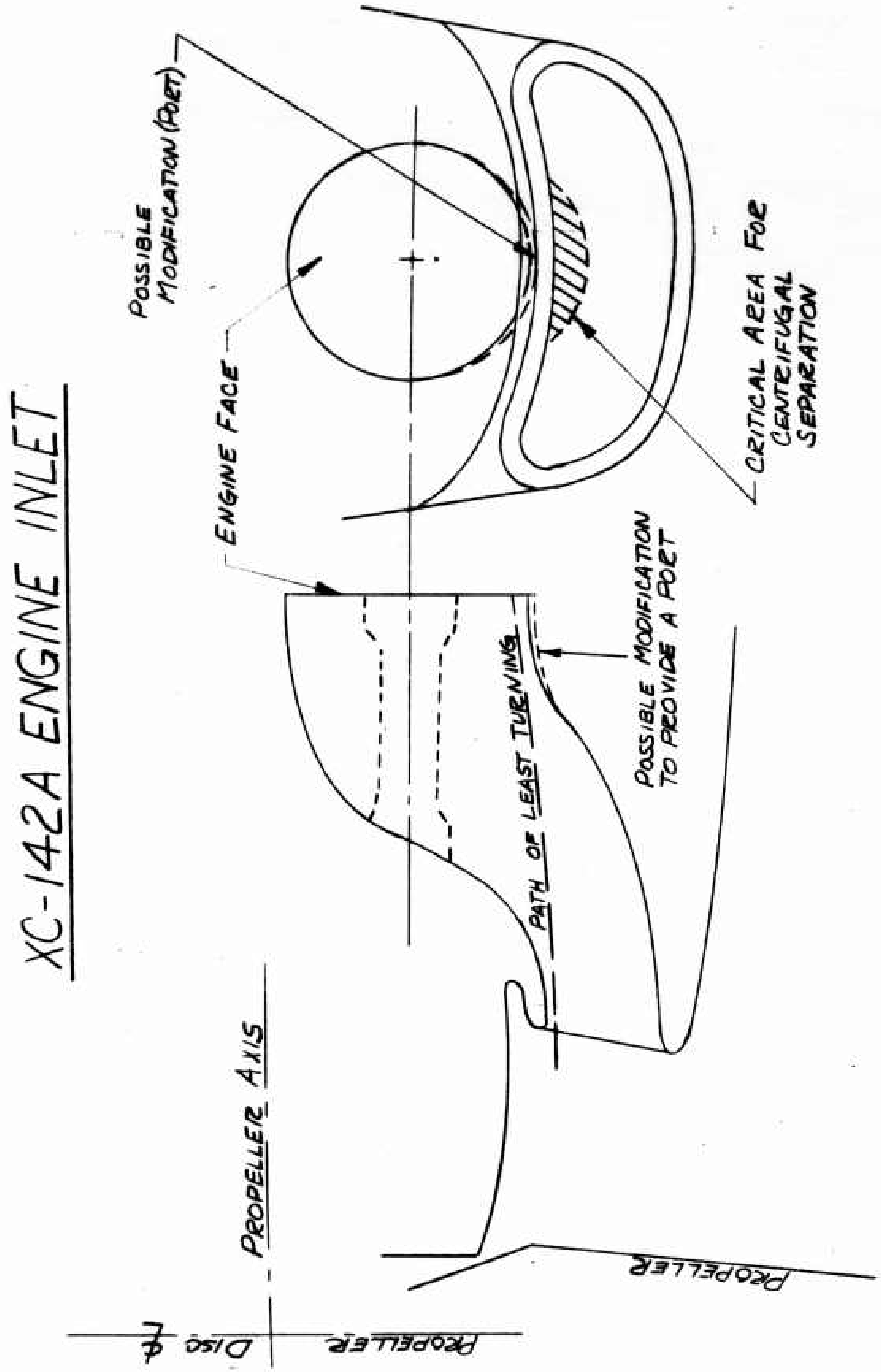


Figure 62 - XC-142A Engine Inlet

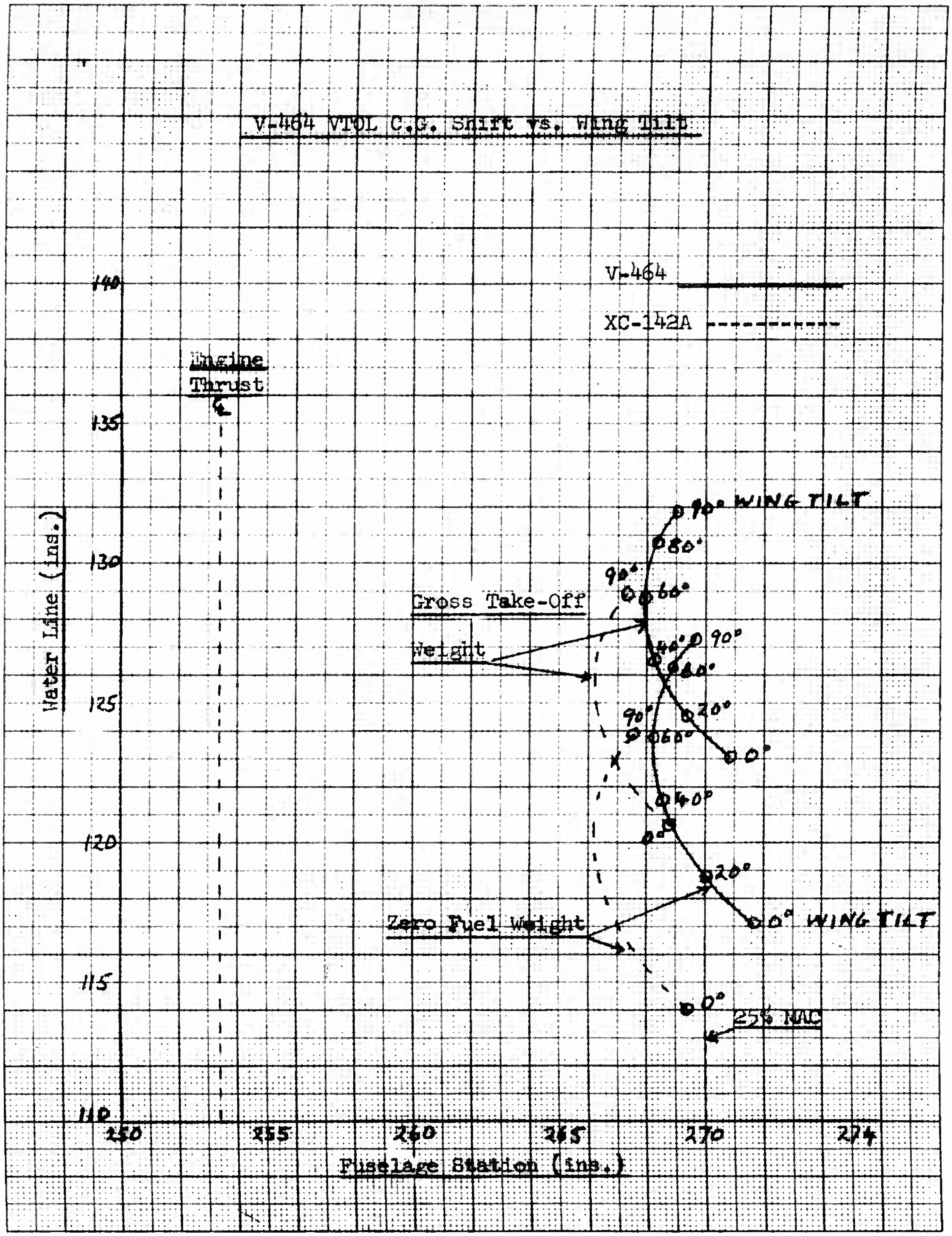


Figure 63 - VTOL V-464 Center of Gravity Shift vs Wing Tilt

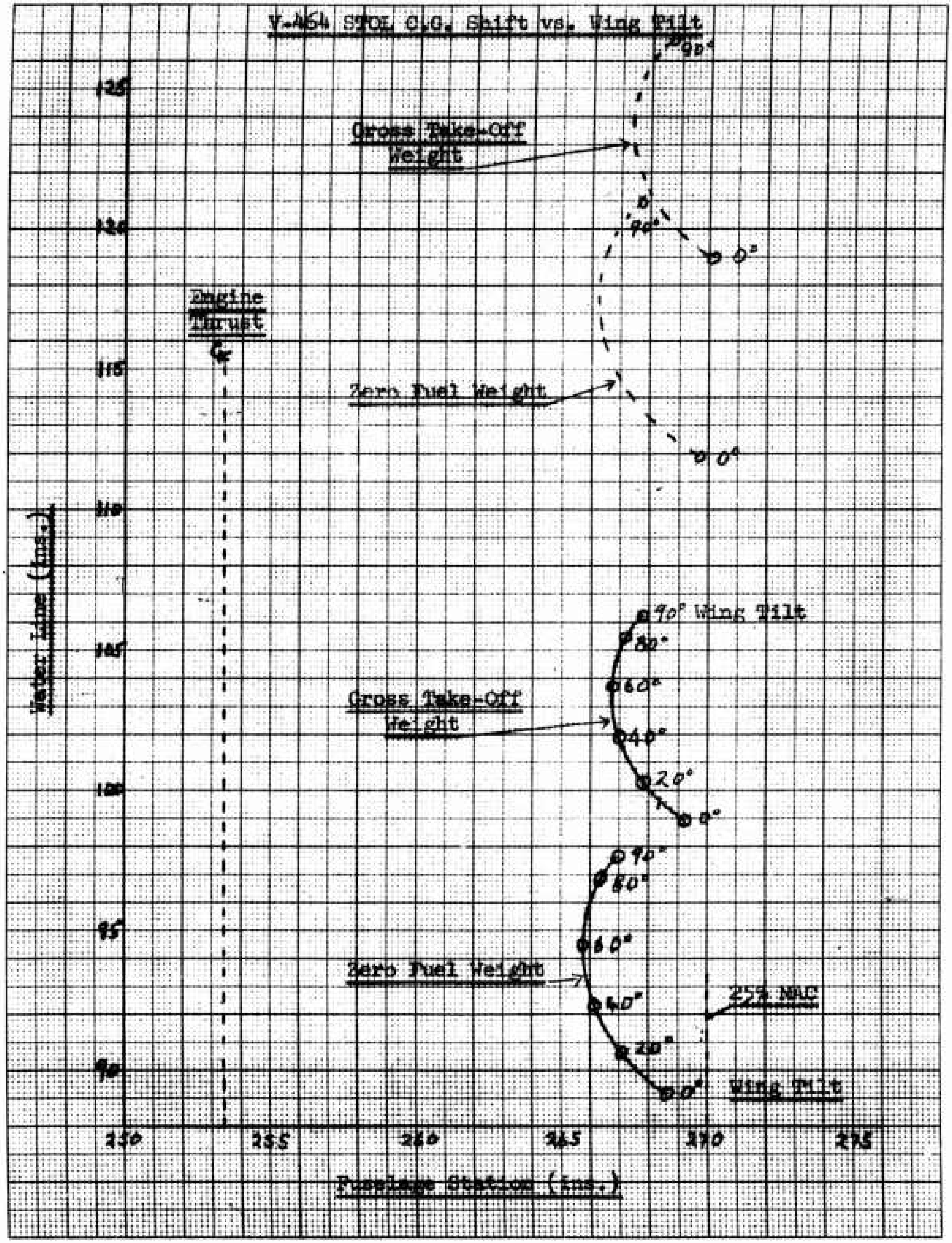


Figure 64 - STOL V-464 Center of Gravity vs Wing Tilt

3. APPENDICES

APPENDIX A

COMPUTER PROGRAM

for

ANALYSIS OF V-464 INFLATABLE VERTICAL FLOAT LOADS

COMPUTER PROGRAM

for

ANALYSIS OF V-464 INFLATABLE VERTICAL FLOAT LOADS

The following program is developed for use on a Control Data 160-A Computer.

The program computes motion and loads for the two degree-of-freedom system shown in the X-Z plane of figures 4A and 4B. The two coordinates of motion are the immersion, Z, of the fuselage floats and the lateral drift, X, of the airplane.

The program performs a numerical integration, for small time increments, of the following expressions for acceleration at the airplane C.G. The procedure is divided into two phases: (1) motion prior to immersion of the shorter wing floats, and (2) motion after the wing floats start to submerge.

Phase (1)

$$\ddot{Z} = \frac{W - L - 2\, K_{BF}\, Z - 2\, D_{ZF}\, \dot{Z}^2}{M} \qquad (49)$$

$$\ddot{X} = \frac{-2\, D_{XF}\, Z\, \dot{X}^2}{M} \qquad (50)$$

where

$$D_{ZF} = 1/2\ \rho_w\, C_{DZ}\, A_{FZ} \qquad (51)$$

$$D_{XF} = 1/2\ \rho_w\, C_{DX}\, A_{FX} \qquad (52)$$

The parameters involved in these equations have been previously discussed and defined elsewhere in the report.

Initial conditions at t = 0 are Z = 0 and $\dot{Z}_0$ = a range of sink speeds. The displacements at the end of the first time increment were assumed to be:

$Z = \dot{Z}_0\,(\Delta t)$

$X = \dot{X}_0\,(\Delta t)$

After the first time instant all velocities and displacements come from a subroutine integration of equations (49) and (50).

The computed displacement, Z, is tested at the end of each interval to determine if the immersion depth, ΔH, has been reached. This value indicates the end of phase (1). When $Z = \Delta H$, the acceleration equations become:

$$\ddot{Z} = \frac{W-L + 2\,(\Delta H)\,K_{BW} - 2\,(K_{BF} + K_{BW})\,Z - 2\,(D_{ZF} + D_{ZW})\,\dot{Z}^2}{M} \qquad (53)$$

$$\ddot{X} = \frac{2\,(\Delta H)\,D_{XW} - 2\,(D_{XF} + D_{XW})\,Z\dot{X}^2}{M} \qquad (54)$$

where $D_{ZW} = 1/2\ \rho_\omega\ C_{DZ}\ A_{WZ}$ (55)

$D_{XW} = 1/2\ \rho_\omega\ C_{DX}\ A_{FX}$ (56)

The phase (2) integration procedure is continued to the point where $\dot{Z} = 0$. This is the point of maximum float immersion.

At specified intervals, the program computes and punches out the resulting buoyant forces, drag forces, drag moments, and longitudinal stresses on the fuselage and wing floats.

From the time plots of the tabulated results, the peak loads are determined.

In summary, the program handles variations in the following parameters:

(1) Airplane weight

(2) Airplane sink speed

(3) Rate of drift in water

(4) Float Dimensions

(5) Float Drag Coefficients

(6) Wave Impact Conditions

APPENDIX B

WATER SEPARATION STUDY OF THE V-464 INLET

WATER SEPARATION STUDY OF THE V-464 INLET

The V-464 has a potential engine problem because of sea water ingestion in the STOL and VTOL configurations. Water will enter the engine entrained in the air or impinge on the inlet duct and run back into the engine.

The configuration of the V-464 inlet incorporates abrupt turns to conform to a geometry which places the engine face behind the propeller gearbox. A study has been made to evaluate the centrifugal separation characteristics of the abrupt inlet turns on the water drop-air mixture entering the inlet and to propose modifications to the duct to decrease or eliminate water ingestion by the engine.

Water drops passing through that cross sectional area of the inlet just below the upper lip and on the inlet centerline need to turn very little to clear the lower duct wall and enter the engine (figure 62). In addition, the water drop entering at this location is subjected to the greatest turning effect by duct airflow. Analysis to determine the path of water drops within the duct has been done for the critical entry location with water drop diameters from 10 through 300 microns and with the duct flowing military rated airflow.

A two-dimensional analysis was obtained by using a vertical cross-section through the centerline of the duct. Velocities of the stream lines were corrected from the apparent two-dimensional diffusion to the actual constant area condition by transforming the V-464 duct to a constant area rectangular duct with the existing cross-section and correcting the apparent two-dimensional stream line velocities. Actual duct stream line velocities are plotted versus duct station in figure 65.

Stream lines were obtained from a Schwarz-Christoffel transformation of reference (18) and adjusted to fit the duct cross-section as well as was considered feasible. This resulted in velocity directions and magnitudes for all locations in the duct as was necessary to obtain water drop trajectories.

Water drop trajectories were calculated using the method of reference (19). For an initial point each drop was assumed to be traveling at the velocity of the air at the inlet face and from there its path was calculated until it was determined whether it would collide with the duct, or enter the engine. The effect of gravity upon the water drop path was minor. As seen in figure 66, the 10 micron radius water drop follows the path of the stream lines quite closely and most drops of this size entering any section of the inlet can be expected to enter the engine. A 10 micron drop size is typical of small cloud droplets. The 150 micron radius drop entering the top of the inlet duct also enters the engine. Drops of this size entering the inlet outside of the critical area would be expected to collide with the lower wall before reaching the engine face. This drop size is typical of very small raindrops. The 300 micron radius drop also enters the engine but its location indicates that droplets slightly larger than this would strike the lower duct wall no matter what the inlet entry location. Figure 67 is a curve of the approximate percent of water droplets ingested by the engine referenced to water droplets entering the inlet. Less than 10 percent of the water at a 150 micron diameter will enter the engine.

Suitable modification of the inlet duct to dump water impinging on the lower surface could include a diverting channel of small height leading to a port just prior to the engine face. Another more desirable configuration modification would increase the diameter of the lower inlet duct beyond that of the engine face to form a semi-annular port through which water might flow (figure 62). The size of the required port will determine any need to increase the duct inlet cross sectional area. Positive pumping means will be required at the port for either design to prevent reverse flow of nacelle air into the duct. A small ejector would suffice.

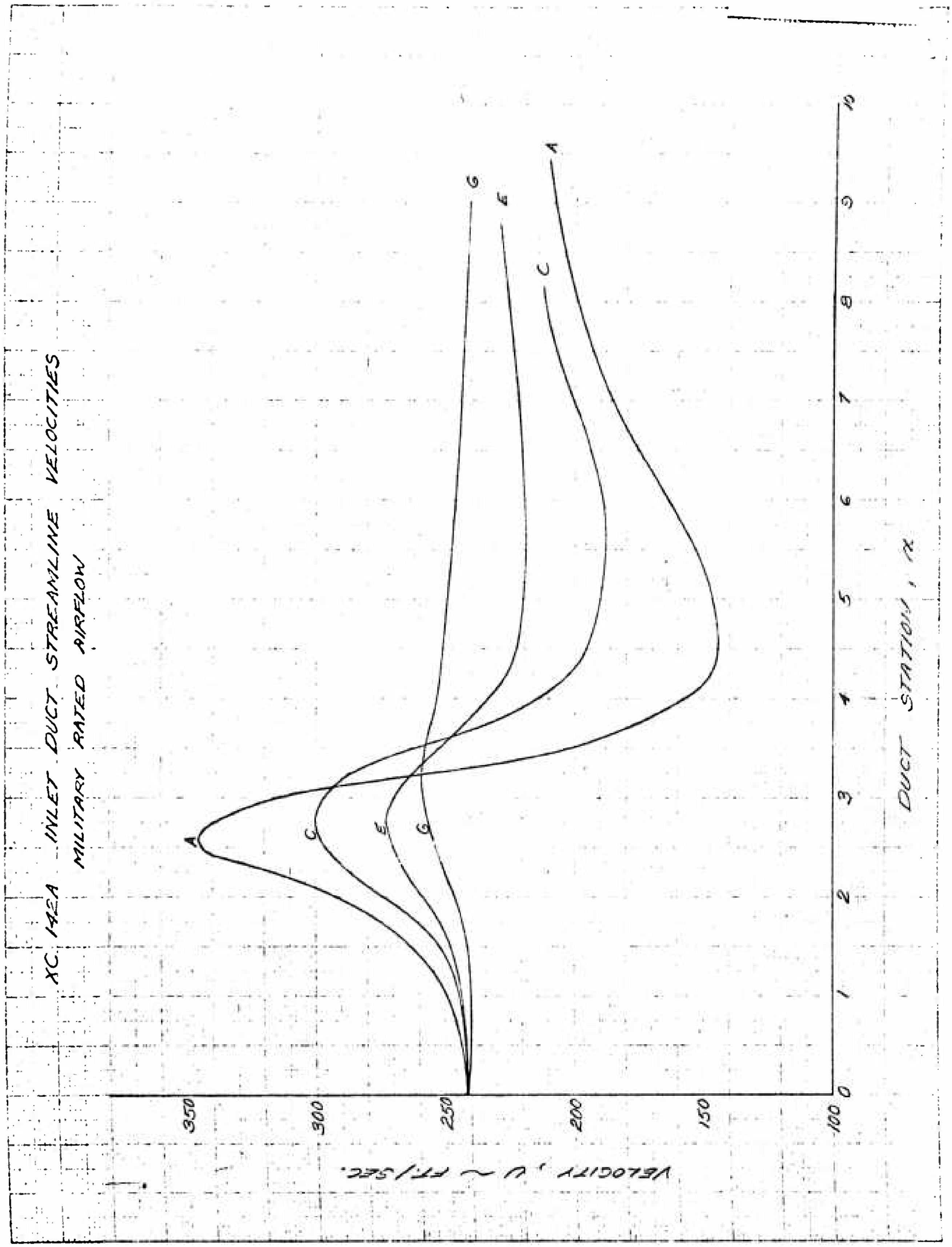


Figure 55 - XC-142A Inlet Duct Streamline Velocities

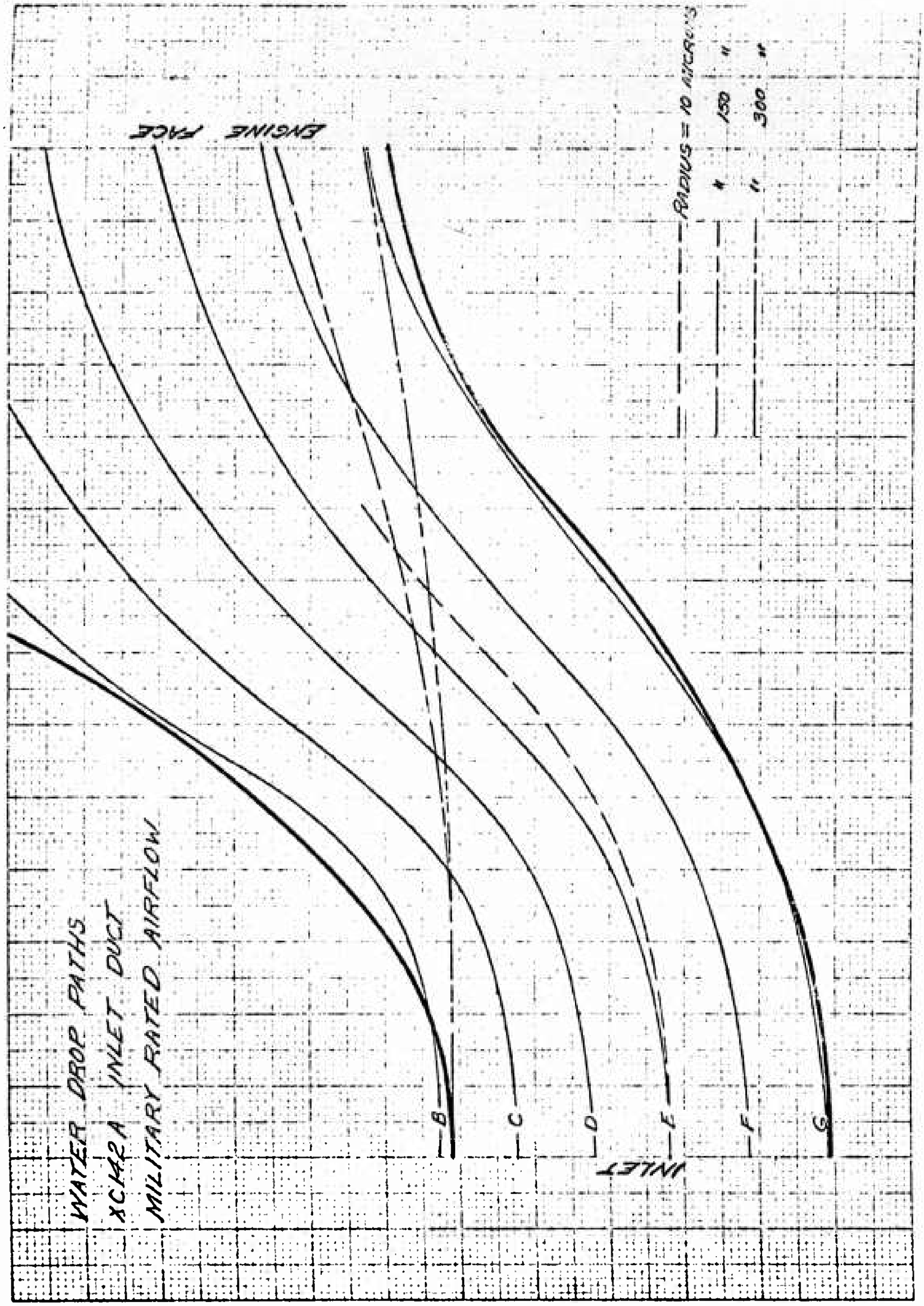


Figure 66 - Water Drop Paths, XC-142A Inlet Duct

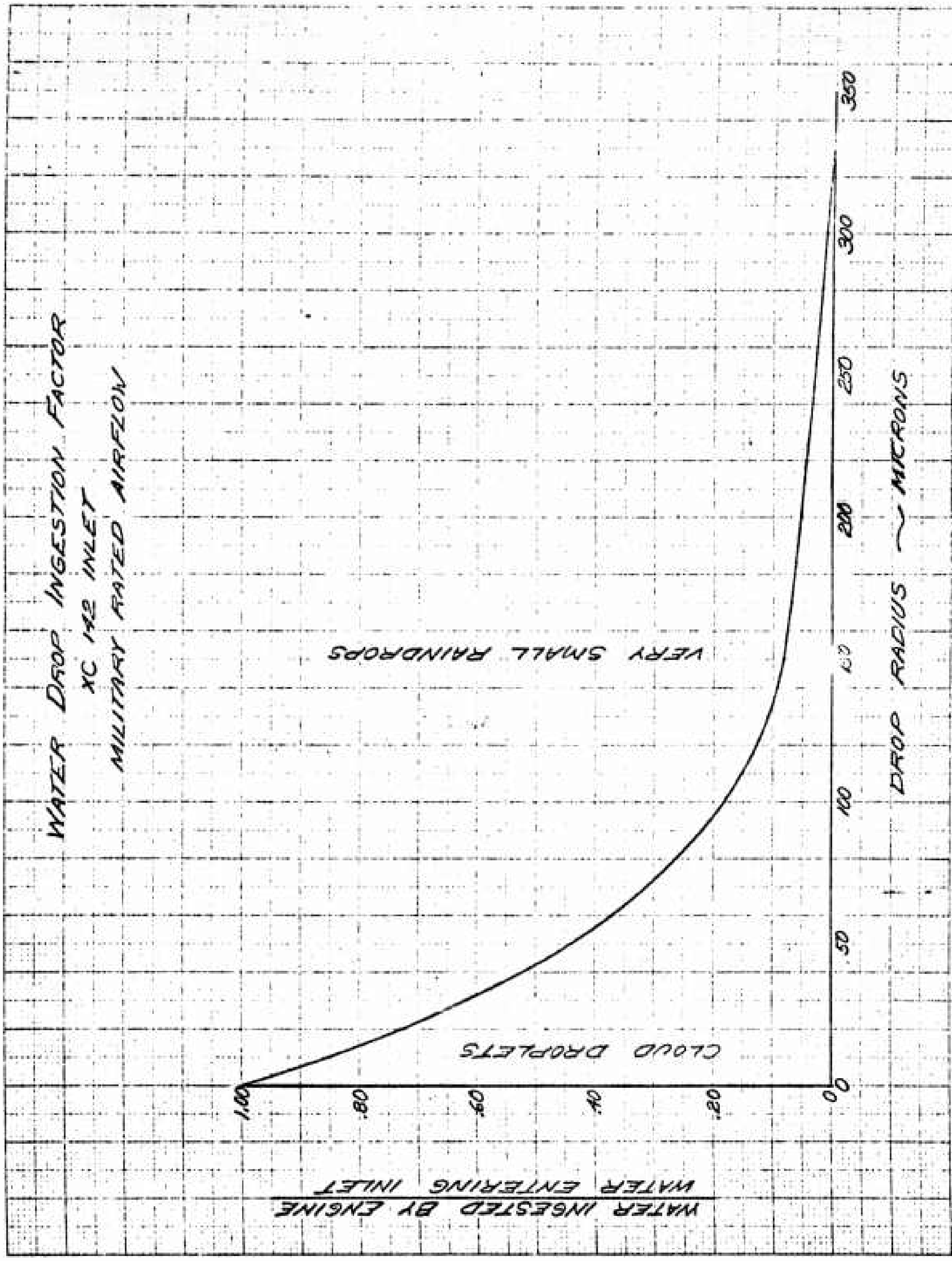


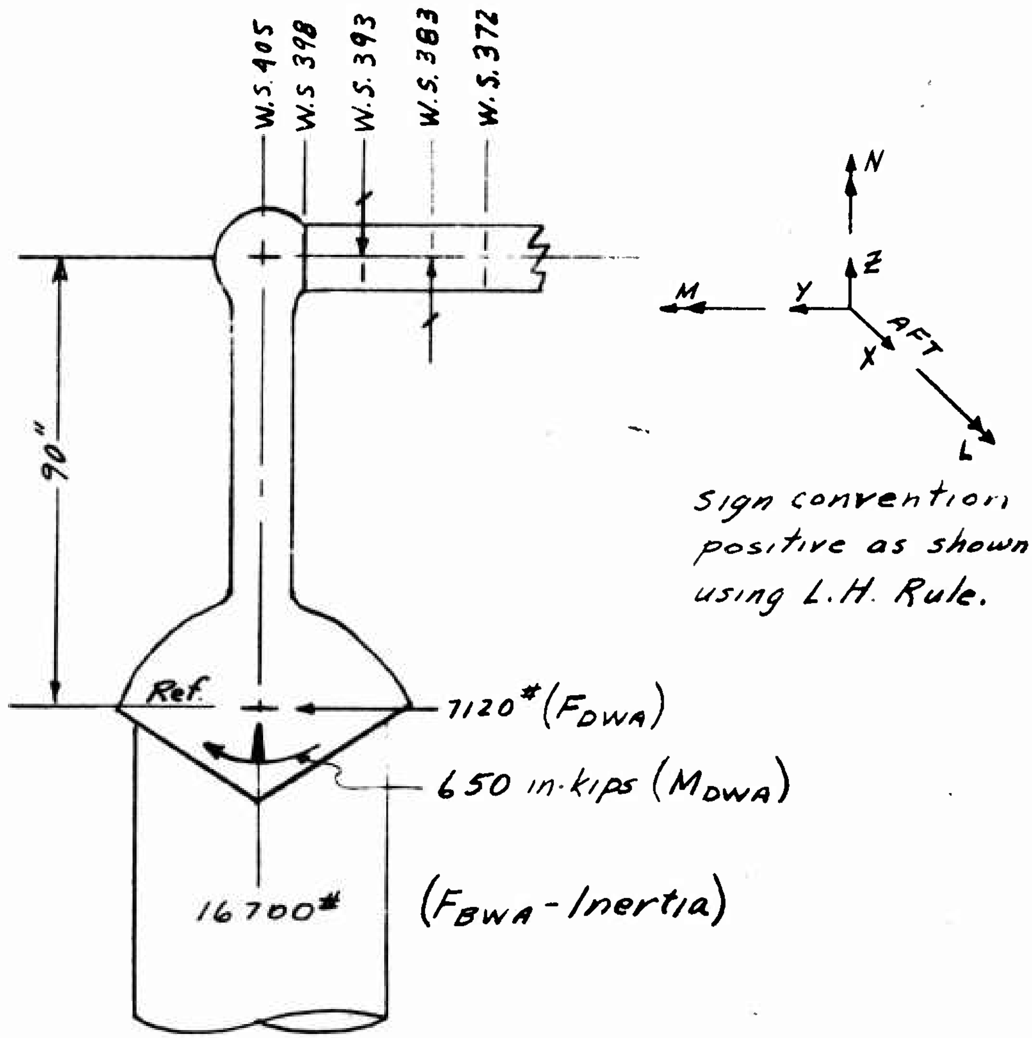
Figure 67 - Water Drop Ingestion Factor

APPENDIX C

V-464 PIVOT-PYLON STRUCTURAL ANALYSIS

STOL Axle and Pylon

Float loads are applied at wing station 405. The main axle bearing is 12 inches inb'd. at W.S. 393. The secondary axle bearing is 22 inches inboard at W.S. 383 The pivot lock support is at W.S. 372.



L.H. Pylon - looking forward
STOL Cond. 1 shown

STOL Axle at W.S. 393

Design Conditions at W.S. 393

Loads \ Cond.	STOL Cond. 1	STOL Cond. 2
X	0	7.12 kips
Y	7.12 kips	0
Z	16.7 kips	16.7 kips
L	1490.0 in-kips	200.0 in-kips
M	0	-1290.0 in-kips
N	0	80.0 in-kips

Material: 17-4 PH (H900)

O.D. = 8.0 in.

$t = 0.16$ in.

$A_e = 50.3$ in.^{2}

$A = 3.94$ in.^{2}

$I/c = 7.57$ in.^{3}

STOL Cond. 1 (Critical Bending Condition)

$D/t = 8/.16 = 50$

$$f_b = \frac{P}{A} + \frac{Mc}{I} = \frac{7}{4} + \frac{1490}{7.57} = 199 \text{ ksi}$$

$F_B = 200$ ksi

$$\text{M.S. (Margin of Safety)} = \frac{200}{199} - 1 = 0$$

STOL Cond. 2 (Critical Shear Condition)

18.2 kips = X ⟶ Z

200 in-kips = L ⟶ N

$$R_{393} = \frac{220 + 18.2(22)}{10} = 62 \text{ kips}$$

$$S_{393} = 62 - 18 = 44 \text{ kips}$$

$$f_s = \frac{2S}{A} + \frac{T}{2A_e t} = \frac{2(44)}{3.94} + \frac{1290}{2(50.3)(.16)} = 102 \text{ ksi}$$

$$\text{M.S.} = \frac{120}{102} - 1 = .17$$

STOL Pylon

For weight estimation an equivalent section is used at the reference point of the auxiliary float.

Material 17-4PH (H900)

O.D. = 8.0 in.

t = 0.10 in.

I/c = 4.85 in.^{3}

A = 2.48 in^2

D/t = 80

F_B = 170 ksi

$$f_b = \frac{F_{BWA}}{A} + \frac{M_{DWA}}{I/c} = \frac{16.7}{2.48} + \frac{650}{4.85} = 141 \text{ ksi}$$

$$M.S. = \frac{170}{141} - 1 = .20$$

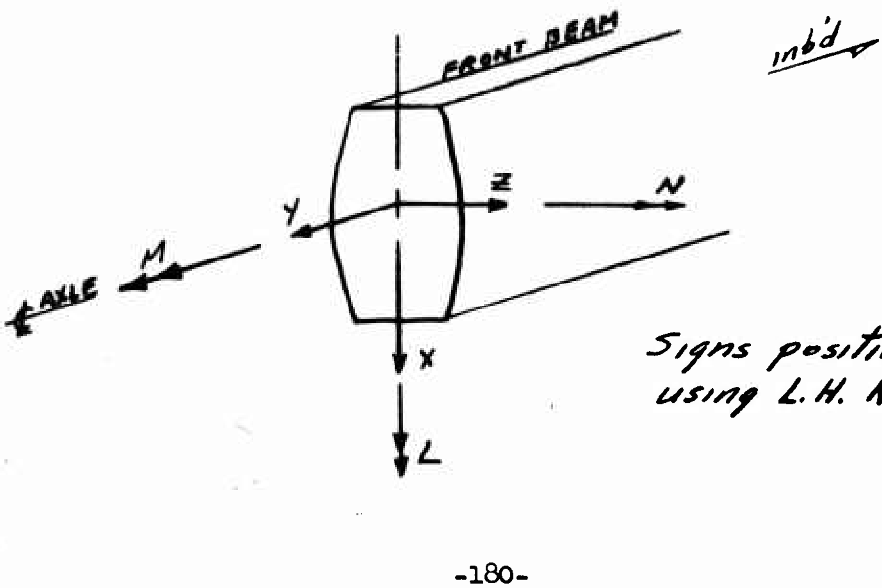
VTOL Axle

Float loads are applied at W.S. 431 and transferred to the end of the wing box at W.S. 398 in the wing plane convention of loading.
The float pod to axle support structure is assumed to be a weldment of load-carrying-capacity equivalent to the axle section at W.S. 393.

Design Conditions at W.S. 398

Load \ Cond.	VTOL Cond. 1	VTOL Cond. 2
X	-20 kips	-20 kips
Y	0	7.5 kips
Z	7.5 kips	0
L	250 in-kips	0
M	-1350 in. kips	0
N	600 in. kips	1950 in. kips

Wing Plane Convention ~ $i_w = 90°$



Signs positive as shown using L.H. Rule.

VTOL Axle at W.S. 393

Material 17-4PH (H900)

O.D. = 8.0 in.

t = 0.25 in.

A_e = 50.3 $in.^2$

A = 6.04 $in.^2$

I/c = 11.40 $in.^3$

VTOL Cond. 2 (Critical Bending Condition)

$D/t = 40$

F_B = 215 Ksi

Y_{393} = 7.5 kips

M_{393} = 2050 in-kips

$$f_b = \frac{P}{A} + \frac{Mc}{I} = \frac{7.5}{6.04} + \frac{2050}{11.40} = 181 \text{ Ksi}$$

$$M.S = \frac{215}{181} - 1 = .19$$

VTOL Cond. 1 (Critical Shear Condition)

S_{393} = 75 Kips

T_{393} = 1350 in. kips

F_{su} = 120 Ksi

$$f_s = \frac{2S}{A} + \frac{T}{2A_e t} = \frac{2(75)}{6.04} + \frac{1350}{2(50.3)(.25)} = 79 \text{ ksi}$$

$$M.S. = \frac{120}{79} - 1 = .52$$

5

APPENDIX D

GROWTH POTENTIALS

GROWTH POTENTIALS

In order to evaluate the implications of fitting a much larger airplane with inflatable vertical floats, LTV Model V-459 airplane (Figure 68) has been analyzed with the assumptions that its weight and drag would be increased by the same percentage as the VTOL version of the Model V-464 airplane. The Model V-459 airplane is an advanced tilt-wing, deflected slipstream logistics transport airplane designed to transport troops, supplies, and equipment in tactical assault situations - the same design goals of the Model XC-142A airplane. Its gross weight at a thrust to weight ratio of 1.15 on a sea level standard day is 82,600 pounds and its design mission is to transport an 8 ton payload on a 500 nautical mile radius of action. The design mission calls for a high-low-high-low altitude mission profile where the high altitude cruise Mach number and radius distance are 0.7 and 300 nautical miles, respectively, and the low altitude cruise speed and distance are 300 knots and 200 nautical miles, respectively. It is powered by four GE-1/S1 engines (8,920 SHP) driving four 17.5 foot diameter Hamilton Standard variable camber propellers through an interconnected transmission system similar to that used on the XC-142A. In addition, two turbojet engines (rated at 3,300 pounds of thrust each) are located in the aft fuselage section to provide longitudinal control during hover and transition. The cargo compartment's unobstructed dimensions are nine feet high, ten feet wide and thirty eight feet long. Environmental features include air-conditioning and pressurization for the cockpit and cargo compartment, ice protection for critical portions of the aircraft, and a windshield rain removal and windshield washer system.

The Model V-464 VTOL airplane's airframe weight is increased by 9.4% of the design VTOL weight (a guaranteed T/W = 1.15 on a sea level standard day) and its minimum drag coefficient is increased by 6% due to the installation of inflatable vertical floats. The airframe weight and drag of the Model V-459 have been increased by the same percentages and the resulting payload versus radius of action curve is shown in Figure 69 . On the basis of these assumptions, the Model V-459 airplane fitted with inflatable vertical floats could have a radius of action of 1,000 nautical miles and carry a 4,300 pound load of ASW equipment and/or extra fuel for maneuvering while on station.

A plot of the airplane weight versus its payload for a radius of action of 1000 nautical miles is presented in Figure 70 . This curve has been developed from the two points of Figure 69, and it represents a first approximation of the performance potential of a V/STOL seaplane fitted with inflatable floats.

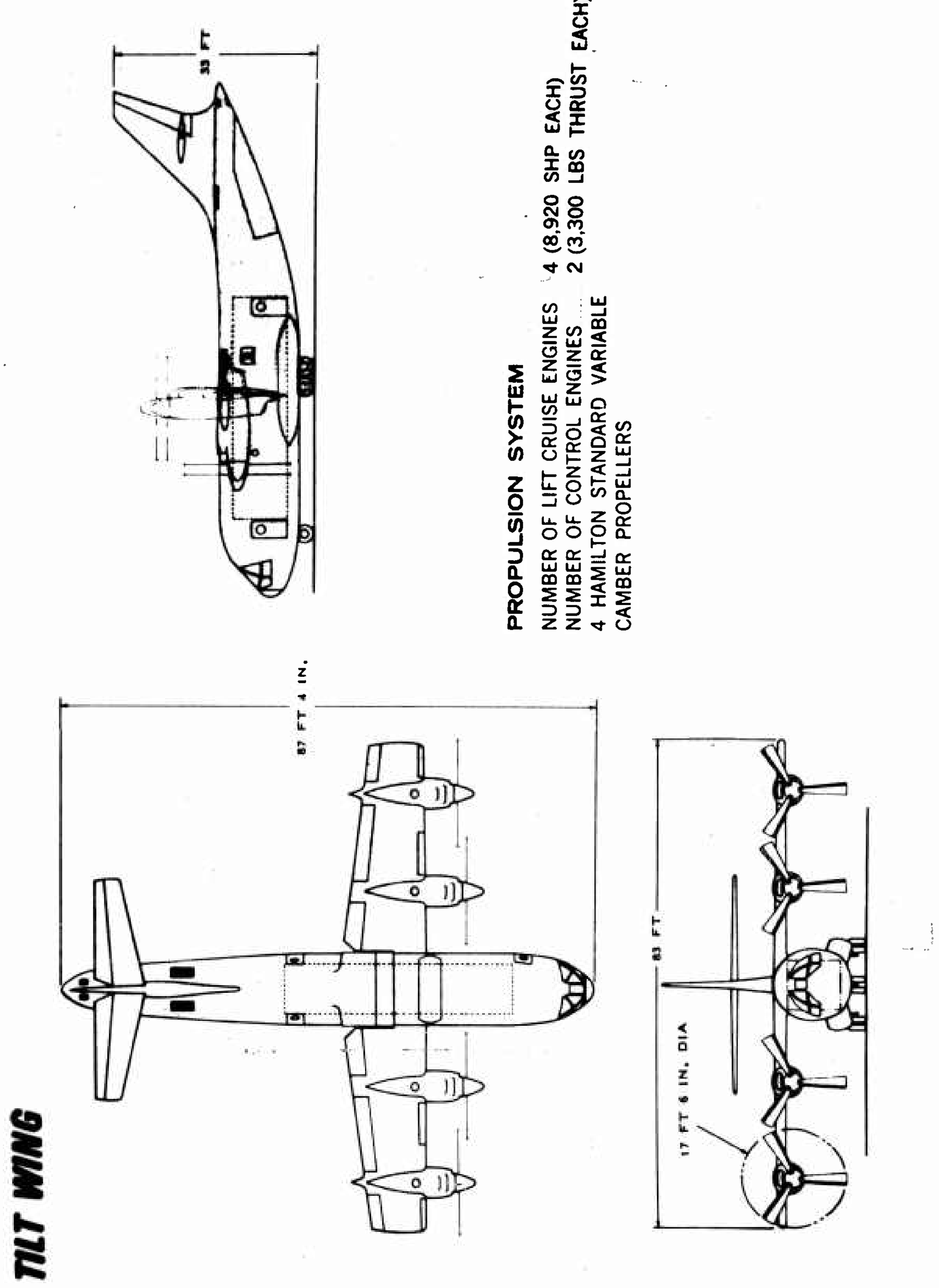


Figure 68. LTV V-459 Tiltwing V/STOL Transport Airplane

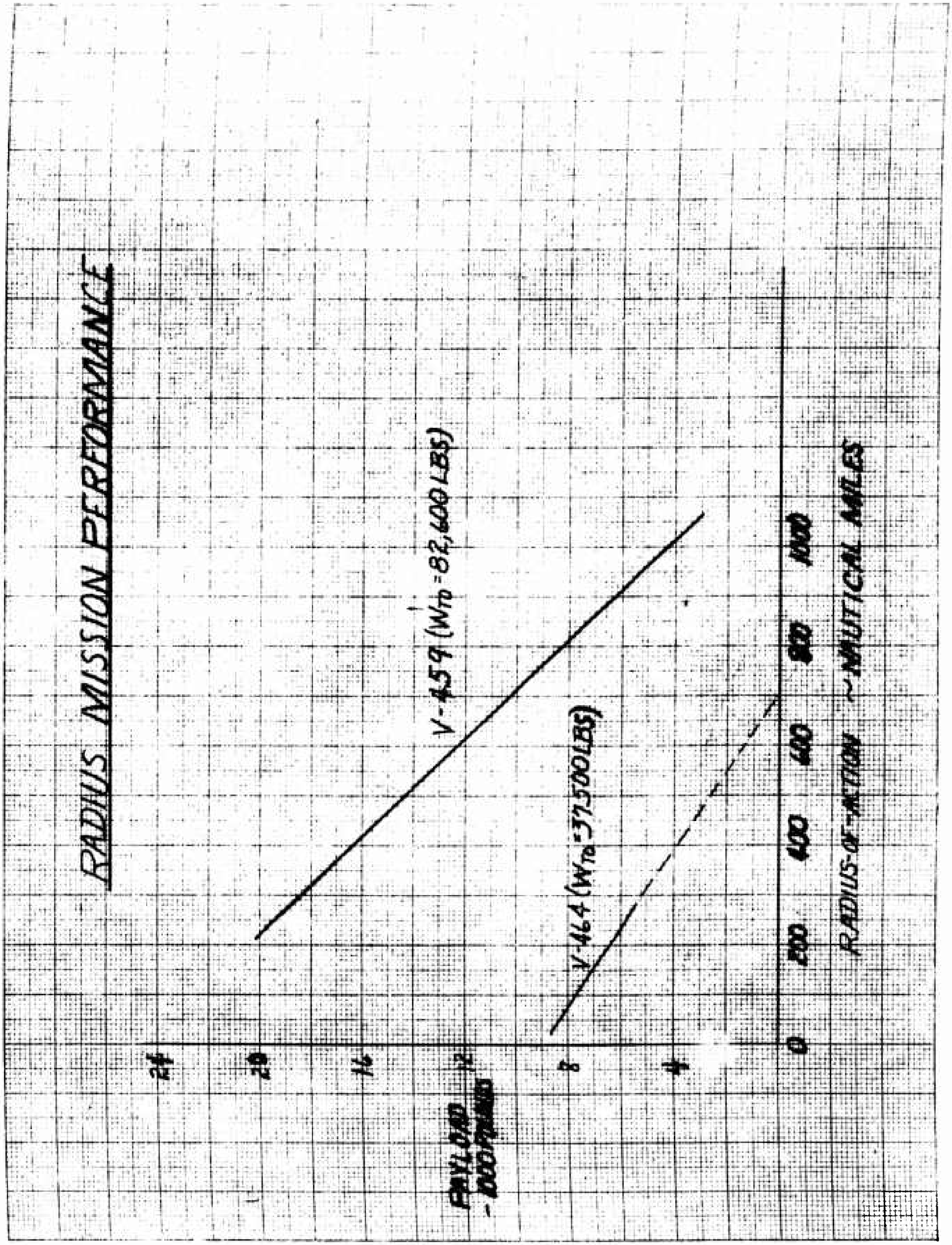


Figure 69. Radius Mission Performance

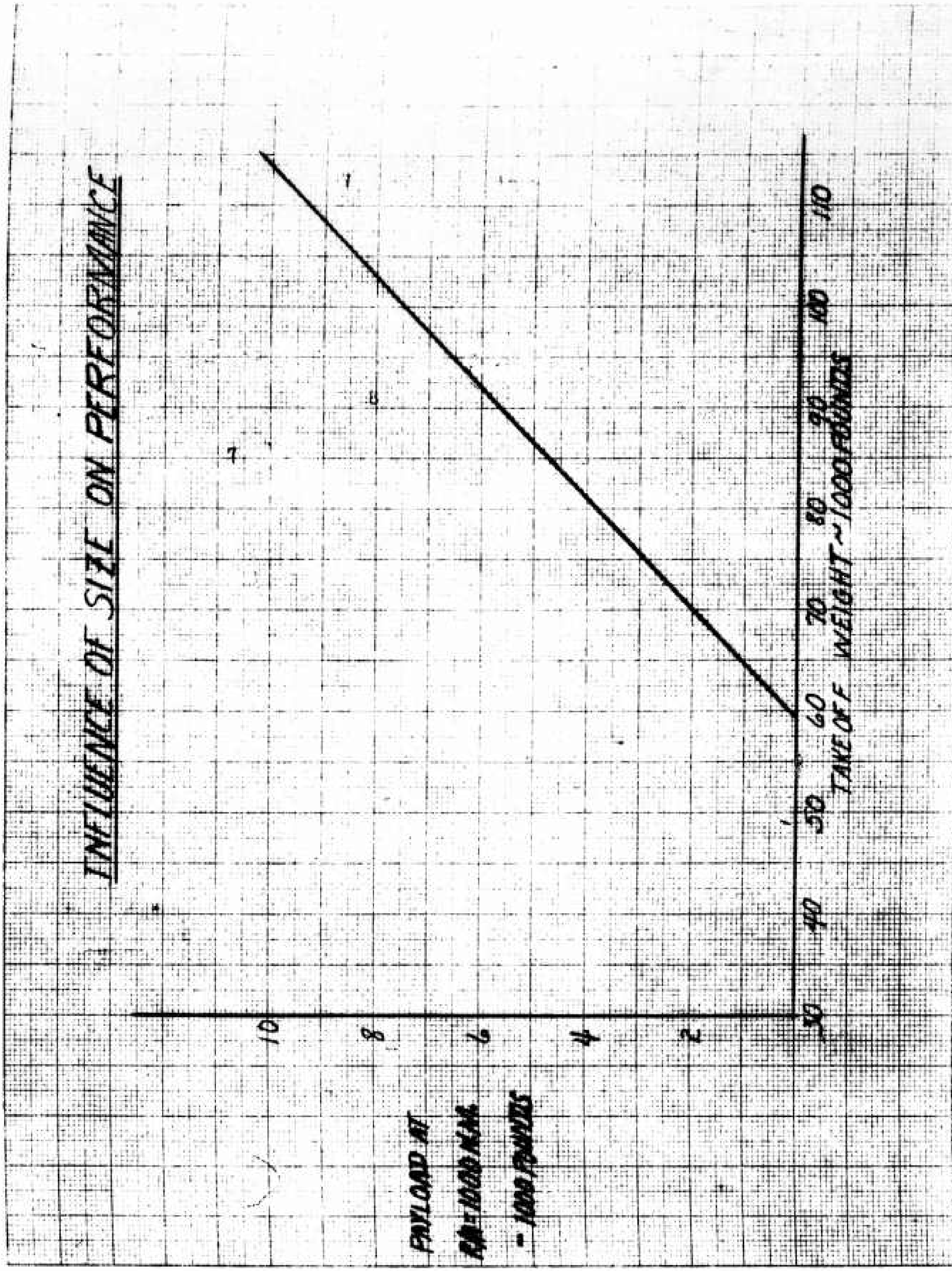


Figure 70. Influende of Size on Performance

4. SUMMARY

A study has been performed to determine the feasibility of developing a seaplane version of the Model XC-142A V/STOL transport airplane. For this study inflatable vertical floats, which provide platform stability to the airplane while it is sitting on the water, have been fitted to a STOL seaplane and a VTOL seaplane version of the Model XC-142A airplane. The study has confirmed the feasibility of developing seaplane versions of the Model XC-142A airplane.

The addition of the inflatable vertical floats to these airplanes requires that the main wing structure be "beefed up" to withstand loads imposed by these floats. The STOL seaplane version of the Model XC-142A airplane is also fitted with a seaplane type hull in order that it can land and take off like a conventional seaplane. It jacks itself upon its inflatable vertical floats while it is sitting on the water. The VTOL airplane extends its inflatable vertical floats while hovering and lands and takes off vertically, only.

The STOL seaplane version of the Model XC-142A airplane suffers from a potentially severe sea water recirculation problem, while the VTOL seaplane version of the Model XC-142A airplane is apparently free from any high technical risk problems.

This study has used several simplifying assumptions, including the structural integrity of the inflatable vertical floats; and it is necessary that future engineering effort scrutinize each of these assumptions.

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