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THE DEVELOPMENT OF SATISFACTORY FLYING QUALITIES ON THE DOUGLAS DIVE BOMBER, MODEL SBD-1 THROUGH FLIGHT TESTING SUCCESSIVE MODIFICATIONS IN CONTROL-SURFACE AREA, HINGE-LINE LOCATION, AND AERODYNAMIC-BALANCE NOSE SHAPE

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THE DEVELOPMENT OF SATISFACTORY FLYING QUALITIES ON THE DOUGLAS DIVE BOMBER, MODEL SBD-1 THROUGH FLIGHT TESTING SUCCESSIVE MODIFICATIONS IN CONTROL-SURFACE AREA, HINGE-LINE LOCATION, AND AERODYNAMIC-BALANCE NOSE SHAPE

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SUMMARY

Upon the basis of interest expressed in the methods used to obtain desirable control-force characteristics on the Douglas Model SBD-1 airplane by minor relocation of control-surface hinge line in combination with modifications in aerodynamic balance nose shape, flight-test data contributing to the development of the present SBD-1 flying qualities have been presented. In view of the consideration that such information would be of possible value as a guide for obtaining satisfactory flying qualities on other experimental airplanes, detailed flight-test results indicating the effects of various wing- and control-surface modifications on the stalling characteristics and stability and control of the prototype models are included.

A brief history of the various design phases is given for better understanding of the modifications finally incorporated in the model SBD-1. Flight-test results obtained during these phases are presented and discussed in three sections: stalling characteristics, lateral-directional stability and control, and longitudinal stability and control. All available information is given to describe the detailed nature of each modification in control-surface area, cross section, aerodynamic balance nose shape, hinge-line adjustment, or change in control system. Particularly, the method used to obtain hinge-line adjustment without change in the moveable-to-fixed control-surface gap is shown. A comparison is made between the original and the final airplane configurations, particularly emphasizing the nature of control-surface modifications made.

Certain definitions and symbols, in addition to those given in other NACA publications, were found necessary in order that the detailed control-surface geometry be specifically defined. These are offered for adoption as standard in other technical data to be published on control-surface design. Based upon the extensive flight testing accomplished on the SBD-1 and prototype

models, in combination with other Douglas control-surface-design experience, recommendations are made with respect to (1) providing necessary facilities for adjustment in control-surface hinge line, balance nose shape, and control system; and (2) designing the detailed control-surface shape for most efficient use of aerodynamic nose balance.

INTRODUCTION

This report has been prepared at the request of the National Advisory Committee for Aeronautics and the Bureau of Aeronautics, Navy Department, who expressed interest in the successful methods employed by the El Segundo Plant of the Douglas Aircraft Company in attaining desirable control-force characteristics on the model SBD-1 airplane by minor relocation of control-surface hinge lines in combination with modifications in aerodynamic-balance nose shape. It was considered that such a description would be of service to other manufacturers of military aircraft as a direct aid for obtaining satisfactory flying qualities on experimental airplanes. Since information of this nature must be finally interpreted by the Aerodynamics and Flight Test personnel of any company before specific application to experimental designs is made, particular care has been taken to describe in detail successive control-surface changes made and flight-test results obtained. Because of the possible difficulties in interpreting correctly effects of isolated changes in the balance nose shape and hinge-line location, it was considered advisable to include all available flight-test data contributing to the development of the present SBD-1 flying qualities. It is to be emphasized that most of this information is of a characteristic qualitative nature, having been obtained by several different pilots and observers, and therefore may not be wholly consistent.

NOTATION

Definitions and symbols used in this report follow standard NACA conventions and those given in reference 1. Additional notation was found necessary to specify further detailed control-surface geometry.

It is suggested that these be adopted as standard in other technical data published on control-surface design. Subscripts a, e, r refer to ailerons, elevators, and rudder; subscripts W, H, V to wing, horizontal surface, and vertical surface.

Lengths

l_H, l_V tail lengths measured parallel to fuselage reference line in the plane of symmetry from the 25-percent-chord point of the wing mean aerodynamic chord to the control-surface hinge line at the base of the movable surfaces

l_a perpendicular distance between plane of symmetry and the centroid of the wing area affected by aileron including aileron

b_W, b_a, b_H, b_V* Wing, aileron, and horizontal-surface spans are taken in the horizontal plane perpendicular to the plane of symmetry. The vertical surface span is taken perpendicular to fuselage reference line in the plane of symmetry from the intersection of the fin leading edge with the extension of the top fuselage line.

c_W, c_H, c_V wing and control-surface chord lengths measured parallel to the plane of symmetry and in the chord plane. (Construction tip and root chords are designated by the proper subscripts, T and R, respectively.)

c_{m_a}, c_{m_e}, c_{m_r} total moveable-control-surface chords measured parallel to the plane of symmetry and in the chord plane

c_{b_a}, c_{b_e}, c_{b_r} movable-control-surface chords forward of the hinge line

c_a, c_e, c_r movable-control-surface chords aft of the hinge line

- -

*For the SBD-1, b_V was measured from the base of the rudder to facilitate comparison with and without movable tail cone.

t_W, t_H, t_V mean aerodynamic chord of wing and control surfaces computed in the manner outlined in section II, part II, paragraph 7, revision 4 of the Army Handbook of Instructions for Airplane Designers, volume I

t_a, t_e, t_r mean aerodynamic chord of control surfaces aft of the hinge line

t_{a_t}, t_{e_t}, t_{r_t} mean aerodynamic chord of control surfaces aft of the hinge line affected by the tab including the tab

Areas

S_W, S_H, S_V Gross wing and horizontal-surface areas include cut-outs and portions covered by the fuselage and are measured in a horizontal plane with chordwise dimensions in their true length. Gross vertical-surface area includes only that area above a horizontal line through the intersection of the fin leading edge with the extended top fuselage line.

S_{m_a}, S_{m_e}, S_{m_r} total movable control-surface areas

S_{b_a}, S_{b_e}, S_{b_r} control-surface areas measured forward of the hinge line

S_a, S_e, S_r control-surface areas measured aft of the hinge line

S_{W_a}, S_{H_e}, S_{V_r} amount of total-surface areas affected by movable surface including movable-surface areas

S_{W_t}, S_{H_t}, S_{V_t} amount of total-surface areas affected by tab including tab areas.

S_{a_t}, S_{e_t}, S_{r_t} movable-control-surface areas aft of the hinge line affected by tab including tab areas

S_{t_a}, S_{t_e}, S_{t_r} trim, servo, or balancing-tab areas aft of the hinge line

Ratios

AR_W, AR_H, AR_V wing and control-surface aspect ratios defined as $\frac{(b_W)^2}{S_W}$ $\frac{(b_H)^2}{S_H}$ $\frac{(b_V)^2}{S_V}$

σ_W, σ_H, σ_V wing and control-surface taper ratios defined as $\frac{c_{W_T}}{c_{W_R}}$ $\frac{c_{H_T}}{c_{H_R}}$ $\frac{c_{V_T}}{c_{V_R}}$

B_a, B_e, B_r aerodynamic-balance ratios expressed in terms of control-surface areas aft of the hinge line and defined as $\frac{S_{b_a}}{S_a}$, $\frac{S_{b_e}}{S_e}$, $\frac{S_{b_r}}{S_r}$,

Angles

i_W angle of incidence of the wing using root chord and fuselage reference line

i_t angle of incidence of the horizontal stabilizer using horizontal-surface root chord and fuselage reference line

i_f angle of offset of the vertical stabilizer using the plane of symmetry as a reference (same sign convention as angle of yaw)

δ_a, δ_e, δ_r movable-control-surface angles with respect to fixed-control surfaces

δ_{t_a}, δ_{t_e}, δ_{t_r} trim, servo, or balancing-tab angles with respect to the movable-control surfaces

α_T angle between thrust ℄ and fuselage reference line

HISTORY

For a better understanding of the model XBT-2 configuration at the beginning of the flight tests to be discussed in this report, previous stages in the development of the XBT-2 and comparison with the production model BT-1 are of interest. The 38th airplane of the BT-1 contract was built into the experimental model XBT-2, primarily to furnish a more satisfactory and completely retractable landing gear. Although this change completed on April 25, 1938, resulted in a speed increase, additional performance improvement was desired by the Bureau. Opportunity was taken to change engines at the time of a rework necessitated by a gear-up landing during the initial flight tests. After going through the preliminary demonstration at the plant, the airplane was delivered on August 24, 1938, to the Naval Air Station at Anacostia, D. C., for service-acceptance tests which started on August 27, 1938, and were completed on November 9, 1938. The only Trial Board recommendations concerning changes affecting stability and control were to modify the aileron control system for reduction in forces at high speed and "kick" at the stall. With respect to characteristics affecting stability and control, the XBT-2 at this time differed from the standard production BT-1 airplane in having:

1. Provision for complete instead of partial retraction of the landing gear

2. A change in engine installation from R1535-94 Twin Wasp Junior, rated 750 bhp at 9500 feet to the R1820-32 Cyclone engine, rated at 800 bhp at 16,000 feet

3. A resulting weight increase of 445 pounds and change in center-of-gravity location from 30.2 percent (gear down) and 31.5 percent (gear up) to 26.6 percent M.A.C. with gear up or down

4. A revised wing tip and a $1\frac{1}{2}$-inch extension in aileron chord giving 3.6 square feet additional wing area

5. A pitot-head installation on the top of the fin as well as on the left wing tip

After completion of the service trials in November 1938 the airplane was installed in the NACA full-scale wind tunnel at Langley Field during January and February 1939, for the purpose of investigating possibilities of drag reduction and to determine wing stalling characteristics. During the acceptance trials and the wind-tunnel tests the XBT-2 did not have wing-tip slots.

Upon return of the airplane to the Naval Air Station at Anacostia from Langley Field during the first part of March 1939 additional flight tests were conducted in an overload scout condition comparable to a possible production design with additional equipment and a 30-gallon fuel increase to give the greater range originally obtained on the BT-1 model with the R1535-94 engine. These changes increased the weight 430 pounds and moved the center of gravity aft 2.1 percent to 28.7 percent mean aerodynamic chord, thus adversely affecting the stability and control characteristics of the airplane. In view of the above changes in weight and balance combined with the Bureau's desire to improve the possible production BT-2 stability and control characteristics as compared with the BT-1, specific recommendations for modifications in the control surfaces for application to any future production airplanes were made. One of these suggestions also applicable to the experimental XBT-2 airplane was to incorporate the fixed wing-tip slots already developed from flight tests conducted by the Douglas Aircraft Company on the fiftieth production BT-1 model from March 29, 1939, to April 21, 1939. These tests were concerned with the investigation of stalling characteristics in the carrier-landing condition, and it was desired that the XBT-2 model incorporate modifications which resulted in improvement. Tip slots were incorporated in all existing BT-1 airplanes by Service Change Order to obtain necessary improvement during carrier operation.

Flight tests with which this report is most concerned started at the time the XBT-2 airplane was returned to the plant for incorporation of all recommended Trial Board changes. These changes were made during the period from March 9, 1939, to May 19, 1939. For convenience all flight-test information has been divided into chronological phases, each phase containing a series of tests conducted either at the plant or at Anacostia on wing or control-surface modifications which were possible to make without major rework.

Phase I

Flights 1 to 10, from June 3, 1939, to June 14, 1939, at Plant

As a means of improving wing stalling characteristics, the XBT-2 of phase I incorporated some of the modifications suggested by the full-scale tunnel tests, as well as changes recommended by the Navy Trial Board: Fixed wing slots were incorporated in the wing tips, auxiliary fuel tanks of 30-gallon capacity were added, a gap-sealing strip was added to the outboard end of the flap, the lower-surface aileron-hinge cut-outs were covered, the straight section of the pitot-heat installation on the left wing was replaced by a gooseneck section, the fin pitot head was removed, and the carborundum was removed from the forward 45 inches of the walkways. Trial Board changes affecting the wing were made on the basis of improved stalling characteristics obtained during flight tests of the BT-1 Serial Number 0639 by the Douglas Aircraft Company. An additional change was a 4-inch increase in the height of the overturn structure for increased pilot protection in the event of capsizing. The flights of this phase were made in the scout-overload condition with 210 gallons of fuel. The airplane was loaded so that the center-of-gravity position was located at 27.7 percent mean aerodynamic chord. This forward center-of-gravity movement of 1 percent from the previous overload scout location of 28.7 percent mean aerodynamic chord used during Navy tests prior to this phase was due to the proposed installation of two instead of one .50-caliber fixed machine gun. These flights were mainly concerned with the improvement of the wing-stalling characteristics. Separate effects of fixed wing-tip slots and wing-leading-edge modifications were obtained. It was considered that some of the changes made decreased the aileron-control forces at high speed and tended to eliminate the sudden reversal or "kick" at the stall.

Phase II

Flights 1 to 16, from July 17, 1939, to July 31, 1939 at Plant

Upon completion of the flights in phase I the XBT-2 airplane was returned by Navy pilot to the Naval Air Station at Anacostia on June 21, 1939, where an inspection of the recommended Trial Board changes was conducted. Additional tests were made at the Naval Aircraft Factory with particular emphasis placed on arrested carrier landings. It was concluded that the incorporation of wing-tip slots materially improved the handling qualities of the airplane during carrier approaches and arrested landings. On the basis of additional tests in the overload-scout condition with 210 gallons of fuel (c.g. at 27.7 percent M.A.C.), the Flight Test Section made specific recommendations for the following changes to provide improved stability and control in the carrier-landing condition:

1. Positive lateral stability at from 5 to 10 miles per hour above the stall

2. Additional longitudinal stability with increased elevator motion to produce the stall

On July 14, 1939, the airplane was returned to the plant by Navy pilot, at which time the flights of phase II were made involving the effects of modifications in vertical and horizontal control surfaces, and changes in dihedral angle as a means of obtaining desired characteristics. Temporary additions were made to both the horizontal and the vertical surfaces giving span increases, and the wing dihedral was increased 2°. The flights in this phase were made for the purpose of checking the stability and control characteristics of the airplane in the scout-overload condition, 1000-pound-class-bomber condition, and extreme noseheavy condition with a view to obtaining through necessary control-surface modifications flying characteristics desired by the Navy.

Phase III - Flights 1 to 24,

from September 8, 1939, to September 22, 1939, at Plant

From results obtained in phase II, 2° increase in wing dihedral was maintained and all control surfaces were rebuilt with provisions for hinge-line adjustment and change in balance nose shape. The temporary modifications which increased the area and the span of the horizontal and the vertical surfaces in phase II were permanently incorporated on the basis of the improvements obtained. Provision was made for either a fixed or a movable tail cone and the aileron plan form was changed, giving constant balance chord along the span. To provide positive centering of the ailerons and to eliminate the undesirable reversal of "kick" at the stall, a strut with double-acting spring was included in the left side of the aileron-control system. The degree of bluntness of the aileron nose shape was increased and the elevator and rudder nose shapes were changed from blunt to elliptical. A larger elevator trim tab was provided, and variations in elevator mechanical advantage were tested. Flights of phase III primarily involved determining the most satisfactory control-surface hinge-line positions and balance nose shapes, and deciding whether the tail cone should be fixed to the fuselage or movable with the rudder. The best configuration from this phase was submitted to a pilot representative of the Bureau, who considered that insufficient improvement had been made.

Phase IV - Flights 1 to 21,

from October 6, 1939, to October 11, 1939, at Plant

Since the best control-surface arrangements from phase III were not considered sufficient improvement, an additional set of movable control surfaces was made, all having chord reductions aft of the hinge line. The reduction of $1\frac{1}{2}$ inches in aileron chord resulted in a decrease in wing area of $1\frac{1}{2}$ square feet. Flights of phase IV involved additional elevator hinge-line adjustment, variation of elevator mechanical advantage, changes in elevator, rudder, and aileron balance nose shapes, and further tests with tail cone fixed to the fuselage or movable with the rudder. The effects of increased aileron and elevator control-surface gaps and of increased aileron travel were determined.

Phase V - Flights 1 to 7,

from October 28, 1939, to November 6, 1939, at Anacostia

Upon the basis that the optimum arrangement obtained through tests in phase IV was an improvement, the XBT-2 airplane was flown by a Navy pilot to the Naval Air Station at Anacostia for acceptance. Although longitudinal and lateral stability were considered satisfactory, it was desired that the directional stability and control in the carrier landing condition be improved. For this phase the aileron travel was decreased to 17° up, 10° down, as in phase III. The flights of phase V concerned additional tests conducted by the company pilot at Anacostia on modifications to the fin, the dorsal fin, the rudder, and the rudder tab. During this phase a final satisfactory vertical-surface configuration was approved, except for rudder-trim-tab effectiveness; this was increased on the production model SBD-1, formerly known as the BT-2.

Phase VI_1

Flights 1 to 77, from May 1, 1940, to May 30, 1940 at Plant

The production model SBD-1 incorporated all control-surface arrangements approved in phase V with slight modifications in rudder, elevator, and aileron nose shapes; dorsal fin; rudder trim tab; and elevator cut-out. The elevator hinge line was moved aft 1/16 inch from the location of phase V, the balance nose was changed from a radial to the final modified elliptical shape, the elevator cut-out was replaced with stabilizer area, and the rudder-trim-tab span was increased. A modification on the retracted landing-gear-into-wing fairing resulted in a wing-area increase of 5 square feet. The dorsal fin lines were refaired to give 3.4 square feet rather than 4 square feet, and the tail cone was finally fixed to the fuselage. The fuselage was refaired immediately aft of the cowling in order to eliminate the undesirable "necking-in" reported as increasing the drag in the full-scale-tunnel tests. It was inadvisable to take advantage of an additional possible drag reduction by covering the holes in the dive flaps in view of their desirable effectiveness in eliminating tail buffeting with dive flaps open. Flights of phase VI_1 constituted the preliminary demonstration on SBD-1 (no. 1596) during which final minor adjustments in elevator and aileron hinge lines were made, and the separate effects of wing slots, aileron-to-wing gap, and several wing-leading-edge modifications on the stalling characteristics were determined.

Phase VI_2

Flights 1 to 9, from May 28, 1940 to May 31, 1940 at Plant

Flight tests during this phase were made on the second SBD-1 (no. 1597) and were of supplementary nature to those for the preliminary demonstration. They involved the separate effects of right and left wing-tip slots, pitot head, and aileron-to-wing gap on the stalling characteristics. A comparison of the stability and control characteristics with the XBT-2 of phase V was made. The second SBD-1 (no. 1597) was used in addition to no. 1596 to obtain flight-test results and comparisons on as many modifications as possible in the shortest time. The final wing arrangement included fixed wing-tip slots without leading-edge modifications, and ailerons with minimum upper-surface aileron-to-wing gap.

DISCUSSION - SECTION I

STALLING CHARACTERISTICS
(Reference table IV)

Models BT-1 and XBT-2

Because of piloting difficulties experienced by squadrons operating from aircraft carriers with the low-wing model BT-1 airplane, it was necessary that the stalling characteristics of the airplane in the carrier-landing condition be materially improved. The most objectionable characteristic was reported to be a sudden fall-off of the left wing accompanied by rapid aileron control-force reversal termed aileron "kick" at the stall. Immediate flight tests were conducted at the plant to investigate the validity of these reports and to determine a means of possible improvement. The condition reported was verified by company pilots and several modifications were found which could be incorporated in service and would considerably improve the stalling characteristics: These were the following:

1. An extension of the upper and the lower wing-surface paint-line intersection around the leading edge of the wing to the lower surface, thus avoiding the formation of a paint ridge on the extreme forward portion of the wing

2. A replacement of inspection handhole plates just below the leading-edge center line of the center wing section with new plates having flathead screws for installation

3. Addition of filler at the intersection of the landing-gear fairing and the wing surface

4. Removal of carborundum from the first 45 inches of the walkway

5. Removal of the outside-air-temperature indicator from the pitot-static head on the left wing to a position having no possible effect on the stalling characteristics

6. Installation of a new gooseneck fitting so that the pitot head was below the left wing tip

7. Installation of lower-wing-surface aileron-hinge cut-out covers

In addition to the above modifications a further possible improvement in stalling characteristics was indicated by the observation of tufts over the upper wing surface. Closing the chordwise gaps between flaps and aileron caused a noticeable decrease in the tendency of the aileron to kick at the stall, reducing somewhat the associated tendency for fall-off to the left, and gave some improvement in stall warning.

From the period of March 29, 1939, to April 21, 1939, further tests were made on the stalling characteristics of the BT-1 airplane with all these changes incorporated. These tests were made on BT-1 airplane, Serial Number 0639, for the primary purpose of investigating the effects of fixed wing-tip slots. Although difficulty was experienced in obtaining consistent data from the five pilots participating in these tests, it was finally concluded that fixed wing-tip slots did give improvements in reducing:

1. The tendency for the undersirable fall-off of the left wing at the stall

2. The amount of altitude loss and speed increase necessary to effect recovery from a stall

These improvements were all considered a direct result of increase in aileron effectiveness. To obtain an optimum arrangement, tests were made of the effects of various modifications in wing-tip slot gap and spanwise location. The best arrangement was found to be incorporation of three separate spanwise slot sections similar to those shown in figures 17 and 18 for the SBD-1 model and an upper-surface slot gap of 1/2 inch. Tuft observations substantiated somewhat the improvement gained by the wing-tip slots by indicating the progress of the stall starting from the center section and spreading outboard to the inner wing slot, which acted as a barrier for further outward progress of the stall toward the tip. In this manner the severity of the stall was reduced as slot sections were installed inboard. Structural limitations prevented the addition of more inboard slots. During the flight testing of the various wing-slot configurations several interesting secondary effects were obtained:

1. The BT-1 slots gave no apparent reduction in stalling speed with flaps either up or down.

2. The slots had no effect on the BT-1 airspeed calibration with the pitot head located below the left wing tip, using the original gooseneck fitting.

3. Slots were more effective near the stall with power off than with power on.

4. With a three-slot section on each wing tip and with 1/2-inch gap, the slots caused a 3-miles-per-hour speed reduction from 217 miles per hour at 9500 feet.

During February 1939, tests were made on the XBT-2 model in the NACA full-scale tunnel. One of the purposes of these tests was to determine the manner in which the wing stalled with flaps down. Tuft observation in the tunnel indicated that the left wing tip stalled approximately 1° earlier than the right tip and that both wing tips stalled before maximum lift was reached, thus checking BT-1 flight-test results. It was further noted that the trailing-edge portion of the center section was stalled simultaneously with the left wing tip near the pitot head. It should be emphasized that during these tests none of the improvements obtained during the BT-1 stalling-characteristics investigation had yet been incorporated in the model XBT-2.

After completion of the full-scale-wind-tunnel tests and additional Naval Air Station flights in the scout-overload condition the XBT-2 was returned to the plant for incorporation of Trial Board changes. These changes as outlined in table IV included all the major modifications found to improve the stalling characteristics of the BT-1 airplane. Table IV contains a flight-test summary of all stalling characteristics of the XBT-2 airplane and detailed pilot's comments on various modifications. Before additional changes other than those required by the Trial Board were made, a complete investigation of the XBT-2 basic stalling characteristics was made. (See table IV, Flights I: 1, 2, 3, 4.) In order to improve stalling characteristics in the carrier-approach condition with flaps and gear down, cruising power, by preventing the characteristic sharp fall-off to the left, a sharp leading-edge fairing as shown in figure 2a was added to the left-wing center section. This change gave no significant improvement. The effect of variation in upper slot gap was again investigated and the gap finally increased from 1/2 inch to 3/4 inch. Again the separate effects of the tip slots were determined by complete sealing. From these comparative tests it was concluded that any improvement due to the slot on stalling characteristics or aileron control at the stall was marginal on the XBT-2 airplane. It appeared that the slots provided some improvement in the amount of aileron control just before and right at the stall, but that tests with the best arrangement did not substantially alter the amount of stall warning or contribute to the aileron control after the stall. During this investigation it became increasingly apparent that improvement should be made in the stalling characteristics of the XBT-2 airplane in the carrier-landing condition with flaps and gear down and with approximately 40-percent power (20 in. Hg manifold pressure at 1900 rpm) to avoid the fall-off to the left with insufficient warning. It was noted that the aileron kick at the stall originally present on the XBT-2 airplane was substantially reduced after the incorporation of Trial Board changes as was the case with the BT-1. This reduction was apparently being effected through the reduction of the aileron-flap gap.

After the completion of tests in phase I the XBT-2 airplane was returned to the Naval Air Station at Anacostia for inspection of Trial Board changes. During this period a considerable number of landing tests were conducted by the ship experimental unit and the definite opinion was given that the incorporation of the wing-tip slots on the XBT-2 airplane had materially improved its handling qualities during carrier approaches and arrested landings.

XBT-2 Aileron Control Forces

Initial flight tests on the XBT-2 airplane after the incorporation of Trial Board changes indicated that the aileron control forces were excessive at indicated air speeds above 160 knots. To correct this condition, the aileron balance tab control horn arm length was shortened 3/8 inch to increase the balance tab travel from the former 1-to-1 ratio. Flight tests with this change indicated that the aileron control forces had been reduced at all speeds so that forces at high speed were now considered reasonable. Since the control forces near the stall with the revised balance-tab ratio were quite light, it was considered inadvisable to attempt further aileron-control-force reduction through the use of balance-tab action giving a ratio of tab-to-aileron travel greater than 1.2 to 1. A check on the action of the aileron during stalls indicated that the increased balance-tab action had no adverse effects.

Model SBD-1

During the preliminary demonstration of the SBD-1 model, the subject of wing-tip slots again came up for investigation in flight. Upon the basis of preliminary flight tests conducted on a BT-1 airplane concerning the effect of wood strips with half-rounded cross-sectional shape applied to the center-section wing leading edge, additional tests were made upon the stalling characteristics of the SBD-1 airplane with a view to substituting the "stall control" sticks for the wing-tip slots. A considerable amount of conflicting opinion with respect to whether substitution could be made was obtained from the piloting personnel. For the various positions of the wood strips tried in flight, see figures 2b to 2g. In general it was agreed that the "stall control" sticks reduced the violence of fall-off to the left and increased stall warning; whereas the wing-tip slots increased the aileron effectiveness and recovery after a stall took place. It was considered that the half-round wood strips had not particularly improved the sudden fall-off to the left in the carrier-approach condition. It was finally decided that before any substantial improvement would be gained from this modification the tip stall on the left wing would have to be corrected. This conclusion was based on tuft observation which indicated that by means of proper placement of the half-round strips a root stall could be delayed entirely until after complete tip stall on both wing tips had taken place. Minor modifications of removing the wing-attachment fairings, and smoothing of pitot mast fittings, wing-tip attachments, landing lights, and the forward portion of the wing had insignificant effects on the tip stalling characteristics. The most effective improvement to the stalling characteristics in the carrier-landing condition was obtained by completely sealing the upper-surface aileron-to-wing gap with medical tape allowing for full-down aileron travel. Tuft observation indicated there had been considerable improvement in the tip stall and the pilot reported definite improvement in aileron control force with increased effectiveness at low speed. A further check by a Navy pilot verified that a major improvement had been obtained in the carrier-landing condition with cruising power; although the airplane in this condition still fell to the left in the stall due to the engine-torque effect. The closest practical approach to the complete sealing of the upper aileron-to-wing gap was made by the addition of an extension strip to the wing, closing the gap particularly at the extreme aileron tip. This extension strip can be seen in figures 17 and 18. The absence of variation in gap can be seen with the aileron up. The greater amount of improvement obtained by the aileron-to-wing seal was realized with the addition of this strip. The effect of having only the left wing slot open was compared with that of having both slots closed. An increase in aileron control was obtained. The complete removal of the pitot head from the left wing had no particular effect in reducing the left wing-tip stall. This indicated that miximum improvement had been obtained with the final modifications made to the gooseneck fitting. For the SBD-1 this fitting was refaired from the original rough lines to the relatively streamline shape shown in figure 17.

In view of the substantial improvement obtained in the wing-tip stalling characteristics through the use of the wing-to-aileron extension strips because of the possibility of some improvement through the use of the "stall control" sticks, and in consideration of the structural complexity of the wing-tip slots; the advisability of their incorporation in the production SBD-1 airplane was referred to the Navy for decision. In answer to this request the following conclusive reply was received: "With the wing-tip slots closed the stall is reached with little warning and is characterized by complete loss of aileron control and very sharp roll and pitch from which recovery begins in a steep dive. With slots open considerable warning is given as the stall is approached and aileron control does not entirely disappear unless the stalling control is forced. The recovery is far less severe and much shallower; though improvement of this phase is less marked in landing condition than in the clean condition." Later tests conducted during the NACA investigation of the SBD-1 flying qualities indicated that closing the wing-tip slots had no significant effects on stalling characteristics or aileron-control characteristics with one exception: When the airplane was sideslipped at low speeds near the stall, the aileron-control force reversed at a fairly low angle of yaw, thus indicating qualitative rolling instability with free control in this condition. In some cases the airplane tended to spin out of the sideslip, a condition caused by incipient stalling on the left wing which was prevented when the slots were opened. This function was considered important enough to justify the use of the wing-tip slots, giving marginal positive rolling stability in the carrier-approach condition.

DISCUSSION - SECTION II

LATERAL-DIRECTIONAL STABILITY AND CONTROL
(Reference table V)

After the completion of Service Acceptance Trials on the model XBT-2 in November 1938, the lateral-directional stability and control characteristics were accepted with the provision that Trial Board changes include modification of the aileron-control system for reduction in control forces at high speed and an objectionable kick at the stall. Additional recommendations for improvement came after removal of the airplane from the full-scale tunnel at Langley Field and as a result of tests made in a scout-overload condition with a gross weight of 7407 pounds and balance of 28.7 percent mean aerodynamic chord. In this configuration, the Navy found that the lateral stability was neutral at low speeds in the landing condition with free controls, or that the application of rudder would not raise a wing dropped approximately 15°. It was recommended that the lateral stability in production models of the XBT-2 be improved so that high rudder would pick up a 15° low wing at 75 knots with free aileron controls.

Flight tests were made in phase I after the incorporation of all Trial Board changes to check the ability of the pilot to pick up a wing dropped over 15°. The comments from these tests appear on table IV and do not indicate the difficulty reported by Navy tests. With flaps and gear down, free aileron control, with power idling or at 20 inches of mercury at 1900 rpm (43.5 percent rated power at sea level) no difficulty in raising the low wing with the rudder was reported at any time down to an indicated speed of 60 knots. In view of the fact that, upon return of the airplane to the Naval Air Station for inspection of recommended changes, the Navy again recommended an increase in lateral stability for the landing condition, the above flight-test comments can be interpreted only as a result of differences in testing technique with respect to carrier approaches or a lack of clear understanding of the basic problem. Additional tests in the overload-scout condition by the Flight Test Section at Anacostia furnished a basis for the following recommendation: Provide positive lateral stability at from 5 to 10 miles per hour above the stalling speed in the carrier-landing condition. The flight tests of subsequent phases were concerned with obtaining this desired increase in stability by modifications in vertical surfaces, ailerons, and dihedral angle. Changes made in the fin and rudder areas, location of rudder hinge line, aerodynamic balance nose shape, tail cone, and rudder-trim-tab size are described in detail in figures 4a to 4v. Vertical surface area changes can be more accurately compared qualitatively by reference to the superimposed line diagrams of figure 5, and quantitatively by reference to table I. Changes in aileron cross-sectional shape and hinge-line location are given in figures 6a to 6j. Changes in aileron plan form and in the location of the trim tab are shown in figure 7. Quantitative changes in areas, aerodynamic balance, and design ratios are listed in table II.

In an effort to investigate systemmatically the qualitative lateral-directional characteristics of the XBT-2 airplane, four basic tests were devised for the conditions flaps and gear retracted, power idling; and flaps and gear fully extended for a carrier landing with approximately 40 percent rated power. All tests were made from a steady condition of sideslip with 15° of bank and with the elevator trimmed. Two cases, tests 1 and 3, involved raising the down wing with the use of rudder alone, first with the ailerons held in the position for steady slip, and then with controls free. The other two cases, tests 2 and 4, involved the observation of resulting motion, first after the ailerons were suddenly returned to neutral, and second when the ailerons were control free; the rudder remaining fixed in the position for steady sideslip in both cases. The first step in this investigation was the determination of the characteristics of the XBT-2 in the original condition returned to the factory by performing the four tests described above at indicated airspeeds of 120, 100, and 80 knots with flaps and gear up; 85, 75, and 65 knots with flaps and gear extended. The detailed results of these tests, given in table V, Flight II:1, indicate agreement with Navy tests, since it was impossible to raise a low wing by the use of the rudder at an indicated speed of 85 knots or less with flaps and gear extended, ailerons fixed or free.

The first change made in the airplane to improve this condition was a change in dihedral angle of the outer wing panels by 1°, obtained through the use of shims at the attachments. The results of tests on this modification indicated a slight improvement in lateral stability for ailerons fixed, but a negligible effect with controls free, flaps and gear down. With an additional degree making a total change in dihedral angle of 2°, there was a definite improvement at the lower airspeeds, but recovery was still not possible at 65 knots where full rudder was required to maintain the steady sideslip with 15° angle of bank, flaps and gear extended. In this condition both the aileron and the rudder-control forces were reversed. Aileron overbalance was first noted at 82 knots; whereas no mention was made of this characteristic with the original value of dihedral angle at speeds down to 65 knots. It can be assumed here that the increase of 2° resulted in:

1. An increased tendency for the ailerons to overbalance in a constant sideslip with 15° angle of bank

2. An increase in the amount of rudder angle to hold constant angle of bank at the lower airspeeds

It can be concluded that the increased dihedral resulted in improved low-speed lateral-stability characteristics but disturbed the desired adjustment between aileron and rudder control forces and effectiveness in maintaining a constant sideslip with 15° angle of bank. Upon this basis it appeared desirable to consider modifications to the vertical surfaces and ailerons.

Several combinations of temporary fin and rudder extensions were tried. The first of these is shown in figure 4b. With the large fin and rudder extensions in combination with the 1° increase in dihedral, aileron and rudder reversal took place at 75 knots. At 65 knots it was impossible to maintain more than a 7° bank with the new rudder full over, flaps and gear extended, with 40 percent power. Inability to maintain a 15° bank with full rudder indicated an excessive amount of directional stability; therefore the smaller fin extension with the large rudder was tested in combination with the 2° increase in dihedral. Although it was possible with this arrangement to hold a 15° bank with the rudder at 65 knots, both the aileron and rudder control forces were reversed. The rudder reversal was particularly objectionable. In an attempt to lower the speed at which aileron overbalance took place, the balancing-tab action was removed. This change resulted in an improvement, lowering the speed for overbalance in the landing condition from 82 knots to 75 knots without significant changes in recovery characteristics. A further change in reducing the lower-surface aileron-to-wing gap to 1/4 inch gave a slight improvement. Further changes in rudder-balance area above the upper hinge bracket (fig. 4d) and increase in the width of the fin trailing edge gave no noticeable improvements. The results obtained with the small fin extension and the large rudder formed the basis for the fabrication of a new set of vertical surfaces (fig. 4e). The balance nose shape of the rudder was changed from blunt to elliptical (fig. 3c), and provisions were made for the attachment of the tail cone to the fuselage or the rudder. The ailerons were reconstructed with a constant-balance chord and a minimum lower-surface gap (figs. 6c and 7). The aileron nose shape was made more blunt (fig. 3f). Provisions were also made for the adjustment of hinge-line location on both the ailerons and the rudder.

During the flights of phase III the separate effects of hinge-line location, tail cone movable or fixed, and rudder balancing tab were investigated. With the change in rudder nose shape and with the original hinge-line position (Flight III:1), the rudder control forces were considered heavy in spite of the change in aerodynamic balance from $B_r = 0.148$ to 0.183 resulting from the tail cone being fixed to the fuselage. The combination, however, reduced the undesirable tendency for overbalance. After adjustment of the control forces on rudder and ailerons through movement of the hinge lines, a complete set of tests was made for lateral-stability characteristics. Results indicated that, although reversals in force were not as serious as before, further modifications were necessary. The ailerons reversed at 72 knots in a left slip and 75 knots in a right slip, the rudder at 75 knots and 85 knots, respectively. The next change was to connect the tail cone to the rudder and restrict the travel from $\pm 30^{\circ}$ to $\pm 25^{\circ}$. At the same time the aileron differential was revised to give 10 percent less aileron travel. Since these changes did not provide the desired major improvement, subsequent modifications were made. The hinge line of the rudder was returned to the original position and a balancing-tab motion was incorporated with resulting slight effect on control forces. The tail cone was attached to the fuselage with the interesting results that no apparent loss in rudder effectiveness was obtained, and that the rudder forces were lighter with less tendency for severe reversal. Spin tests were conducted to demonstrate the adequacy of the rudder control without the contribution to rudder area provided by the tail cone, with the result that recovery could be effected either to the left or the right within one-quarter turn, flaps and gear in both extended and retracted positions. The addition of a balancing tab to the ailerons with original travel reduced the control forces to a desirable magnitude in the low-speed range, but did not affect the high-speed region. The balancing tab was removed from the ailerons and the hinge line was moved back to lighten the high-speed forces. Further force reduction was obtained by a change in the control system, reducing the total aileron travel by 25 percent. Aileron reversal, however, still occurred at approximately the same speeds. Increasing the gap between ailerons and wing had no effect on this reversal, but did reduce the control forces; although such a reduction may well have been due to a further 7-percent decrease in total aileron travel.

Upon the basis of relative comparison with the characteristics of the original airplane, it was decided that some definite improvement in the lateral-directional-stability characteristics had been accomplished by the changes resulting in the vertical-surface and aileron configurations shown in figures 4e and 6d, and that the airplane should be flown by a Navy pilot for comments on these improvements. In accordance with this request, a Navy pilot checked the characteristics of the airplane and reported insufficient improvement, giving the recommendation that the possibilities of further improvements be investigated, with particular respect to the aileron and rudder reversal in control forces. In order to investigate the possibilities of improvement in rudder control force by a reduction in chord, a flight was made without the trim tab. Since indications were that a modification of this nature would be very desirable, arrangements were made to construct a new rudder with reduced chord. In the case of the ailerons no modification yet made had effected substantial improvement in the undesirable control reversal or kick obtained in a steady sideslip. Although changes had been made in the hinge-line location, control-surface travel, cross-sectional shape, and plan form; there yet remained one possible solution, which involved the addition of forces within the control system that would give the desired force characteristics. With this in mind, a spring-loaded plunger was added to the control system, providing a force in the direction tending to return or center the ailerons to neutral setting at all times. Flight tests with this device installed indicated a substantial improvement. This result has been verified by later tests wherein it was attempted to eliminate the centering device because of complication in the aileron control system.

For phase IV, a new rudder and a pair of ailerons were constructed having the same aerodynamic-balance nose shapes as formerly, but with chord reduction. In the case of the ailerons, the chord was reduced by a constant $1\frac{1}{2}$ inches so that the trailing edge formed a continuation of that for the landing and dive flaps (figs. 6e and 7). The rudder chord was reduced about 8 inches at the tip (figs. 4h and 5). The adjustable-hinge-bracket feature of both the surfaces was maintained, and the tail cone was so constructed that it could be made part of the rudder or the fuselage.

The spring-centering device formed an integral part of the aileron-control system, and the aileron total travel was kept at 27°. Flight tests with the reduced chord surfaces indicated a very definite improvement in the lateral-directional characteristics. The original blunt aerodynamic-balance nose shape was tested on the rudder and found to be one reason for the difficulties with control-force reversal. The effect of the movable tail cone as part of the rudder was again investigated. Rudder action was considered superior with the cone rigidly attached to the fuselage, since there was less tendency for overbalance and buffeting and very little, if any, loss in effectiveness. Spin tests were again made on the airplane with the tail cone attached to the fuselage, with the results substantially checking those previously obtained. Other minor changes included the smoothing up of the leading edge of the rudder by countersinking balance-weight attaching screws and covering the surface with fabric, and the covering over of a portion of the rudder-hinge cut-outs. The final vertical surface arrangement for this phase is shown in figure 4n, with rudder travel ±30°, hinge line at $5\frac{11}{16}$ feet aft the leading edge at station 40, tail cone fixed to the fuselage, minimum gap between rudder and fin, and without balancing-tab action. In the case of the aileron, the travel is 17° up, 10° down, the hinge line is located $5\frac{1}{4}$ aft the leading edge, and the aileron-to-wing gap is a minimum of 1/4 inch, and no balancing-tab action is used. (See fig. 6f.) A summary of the lateral stability and control characteristics of the XBT-2 airplane at the conclusion of phase IV as interpreted by company flight-testing personnel, is as follows:

1. The lateral stability is considered satisfactory.

2. Recovery by use of rudder alone from a steady sideslip with 15° of bank in the landing condition is possible down to an indicated airspeed of 60 knots. Recovery is positive to a lesser degree with the right wing low, probably because of reduced rudder power when held to the left.

3. Rudder control forces and effectiveness are considered satisfactory throughout the required speed range; although a reversal is possible with full left rudder at indicated speeds below 70 knots with power on.

4. The aileron control forces are considered satisfactory throughout the required flight range. It is possible that the forces may be considered somewhat light below airspeeds of 65 knots.

5. With the reduction in chord and travel, the ailerons produce adequate rolling moments within 5 knots of the stall. Although it is possible to overbalance the ailerons in a steady sideslip with angle of bank 15° at indicated airspeeds below 68 knots, this characteristic is considered not extremely objectionable.

In the configuration described above, the XBT-2 airplane was taken to the Naval Air Station at Anacostia for acceptance. Upon the basis of Navy tests the lateral stability was considered satisfactory; however, directional stability was considered marginal in the carrier-landing condition with flaps and gear extended and with cruising power. It was observed that in this condition the increased dihedral angle caused more roll than is desired for a given amount of yaw, and that the rudder-control force had an undesirable tendency to reverse near full-surface throw. It was desired that positive directional stability and trim be provided in the carrier-landing condition down to 65 knots, with rudder free. The flight tests of phase V were concerned with satisfying this requirement by a successive series of modifications in vertical-surface plan form and rudder trim tab, without jeopardizing the progress already made in obtaining satisfactory lateral stability.

The test used to compare the directional stability in the carrier-landing condition obtained by the various modifications was to find the minimum indicated airspeed for recovery from a directional oscillation started by a 10° displacement of the rudder immediately followed by pedal release, with lateral and longitudinal trim maintained by use of the stick. For the configuration at the beginning of phase V this speed was 85 knots; whereas the desired value was 65 knots. Progressive increase in fin area gave the expected reductions in minimum speed for directional stability in the carrier-landing condition: an increase of 0.8 square foot added by the small fin extension of figure 4p reduced the speed to 72 knots indicated; whereas a further increase of 0.9 square foot added by the large fin extension of figure 4q brought the speed to 68 knots indicated. Although the directional-stability requirements could be met easily by increasing the size of the fin, the additional requirement that the rudder overbalance be eliminated was more difficult since the tendency for reversal increased with the fin extensions. In the case of the combined large fin and trim-tab extension of figure 4r, a prohibitive rudder reversal offset the advantage of fulfilling the directional requirement down to an indicated speed of 65 knots. This isolated effect of trim-tab extension only on the rudder reversal indicated the critical nature of the flow about the base of the rudder and led to the use of the "dorsal" fin, combined with the small fin extension of figure 4s. With the trailing edge of the rudder reworked to accommodate the larger trim tab (fig. 4t), a satisfactory vertical surface was finally obtained; although it was desired that the tab effectiveness be increased for directional trim in the landing condition.

On the production SBD-1 model the span of the rudder trim tab was increased and the aerodynamic balance nose shape was slightly revised (figs. 4v and 3c). The area of the fixed tail cone was increased and the dorsal fin lines were refaired from those used on the temporary modification of figure 4t with a resulting decrease in area from 4.0 square feet to 3.4 square feet. The aileron configuration of the SBD-1 was similar to that of the final XBT-2, except that the nose shape was made more blunt (fig. 3f). During tests on the first two models of the SBD-1, numbers 1596 and 1597, various modifications were added to the ailerons as discussed under the section on stalling characteristics. The final aileron-wing configuration had the extension strips added as shown in figures 6j and 17. Figures 1, 19, and 20 give a comparison of the original SBT-2 and final SBD-1 empennages.

DISCUSSION - SECTION III

LONGITUDINAL STABILITY AND CONTROL
(Reference table VI)

The longitudinal-stability and control characteristics of the BT-1 and the XBT-2 airplanes were considered satisfactory in the normal scout loading with 180 gallons of fuel. In the case of the XBT-2 loaded to represent the scout condition with 210 gallons of fuel, however, the increase in gross weight and rearward movement of the center of gravity, in combination with a general feeling on the part of the Navy that stability requirements should be more rigid than previously for shipboard aircraft, made it necessary that some improvement be obtained. The effect of the increased fuel and other equipment was a 430-pound increase in gross weight and a movement of the center of gravity from 26.6 percent mean aerodynamic chord to 28.7 percent mean aerodynamic chord, a change of 2.1 percent. Navy comments concerning the longitudinal stability characteristics with the scout-overload condition were as follows:

1. With free control and at high speeds, the dynamic longitudinal stability is barely positive, and oscillations are exceedingly slow in damping.

2. In the landing condition with elevator free the airplane is longitudinally unstable at low speeds, and there is no recovery from an applied diving or stalling moment.

3. The controllability is generally similar to that for the BT-1 and XBT-2 with normal scout loading, with the possible exception that the small stick movement necessary to produce a stall seems further reduced.

For any future production BT-2 airplanes, it was definitely recommended by the Bureau that the longitudinal stability for the high-speed and landing conditions be improved, and that the stick movement required to effect a stall be increased. These recommendations were not included in the Trial Board changes affecting the XBT-2; therefore no attempt was made during the flight tests of phase I to obtain the effects of modifications leading to improvement, this phase being primarily concerned with the stalling characteristics of the airplane. Flight I:2 was made, however, to obtain a check on the longitudinal characteristics of the airplane in the overload-scout condition with the center of gravity located at 27.7 percent mean aerodynamic chord, 1 percent farther forward than during the Navy tests. This change was due to a proposed installation of an additional .50-caliber fixed gun. The results of this test indicated that static longitudinal instability existed in the landing condition below 80 knots. Flight tests made by the Navy at Anacostia with the airplane in this same condition indicated that the longitudinal stability was marginally acceptable at indicated airspeeds 5 to 10 miles per hour above the stall, and that the elevator movement to produce a stall with the flaps and gear extended was still too small. From this result, it was apparent that a more detailed investigation into possible methods for improvement was necessary. This investigation was started in conjunction with the lateral-directional stability and control tests of phase II.

A summary of the flight tests made on the longitudinal-stability and control characteristics of the XBT-2 is given in table VI. The detailed nature of changes made in horizontal surface plan form and elevator aerodynamic-balance nose shape is shown in figures 3d, 8a to 8l, and 9. Quantitative data on areas and design ratios are presented in table III. It should be pointed out that the longitudinal-stability tests outlined in table VI were made at several different center-of-gravity locations substantially corresponding to the following loading conditions: 1000-pound and 500-pound class bombers, normal scout with 180 gallons of fuel, overload scout with 210 gallons of fuel, and extreme noseheavy and tailheavy loadings.

In order to determine specifically the longitudinal-stability and control characteristics, quantitative measurements were taken of stick force against indicated airspeed for three basic conditions: level flight with flaps and gear retracted, level flight with flaps and gear extended, and gliding flight with flaps and gear extended. For the first case, the airplane was trimmed at an indicated airspeed of 180 knots at approximately 6000 feet altitude. With constant trim-tab setting stick forces and elevator positions were recorded by an observer at several speeds between trim and the stall while the pilot maintained level flight by reduction in power and/or revolutions per minute. A similar procedure was followed for the second case with trim speed at 110 knots. For the power-off glide with flaps and gear down the indicated trim speed was 120 knots at approximately 12,000 feet. Throughout these tests, some variations in trim airspeed were obtained, thus somewhat affecting accurate comparisons between modifications.

By use of this procedure, the effect of the elevator balancing tab was first obtained. The changes in elevator control force and angle to trim for various airspeeds are shown in figure 10. A comparison of the curves indicates that the balancing tab had little effect on the control forces or elevator angle in level flight, but did affect those in the glide with flaps and gear down. For this same case, the stability was considerably reduced as indicated by a comparison of the curves of elevator angle to trim versus airspeed. Another significant point is that the elimination of the balancing tab changed the characteristic shape of the control force versus airspeed curve for flaps and gear down, power off, so that the forces did not decrease near the stall. The next tests were made to determine the effect of a 2-percent forward movement of the center of gravity with the balancing tab still disconnected.

The data obtained and compared in figure 11 indicate that no substantial improvement could be realized by such a change, particularly in level flight with flaps and gear down. The characteristics with the extreme noseheavy loading were obtained with the center of gravity at 21.2 percent. The control forces with this center-of-gravity position were considered heavy in comparison with those at 27.7 percent. It is interesting to note the consistent variation of control force and elevator angle with airspeed for the various center-of-gravity locations, particularly with the flaps and gear up in level flight. Upon the basis that no significant improvements had yet been obtained, it was decided to increase temporarily the horizontal surface span by two feet (fig. 8b), giving an increase in aspect ratio from 3.72 to 4.30. This modification gave a sufficient improvement (fig. 12) to justify the construction of a new set of horizontal surfaces with increased span, also incorporating a change in elevator balance nose shape from blunt to elliptical (figs. 3d and 8c). Provisions were also made for the adjustment of hinge-line location so that the most desirable location could be determined experimentally. Upon the basis that previous tests (Flight II:16) indicated a minimum of 25° up elevator required for landing in the noseheavy condition, the travel of the new elevator was adjusted to $25\frac{1}{2}°$ up, 25° down.

Flight tests in phase III were concerned with tests on this new horizontal surface, as well as with the effects of modifications to the ailerons and vertical surfaces previously described. Because of the heavy elevator-control forces obtained with the first hinge-line location, the hinge line was moved progressively back from 4 inches to $4\frac{1}{2}$ inches from the elevator leading edge. The comparison between the blunt and elliptical aerodynamic-balance nose shapes is given in figure 13. The only significant changes in the shape of the curves are for the cases flaps and gear extended, level flight or glide.

Considering the increased value of aerodynamic balance with the elliptical nose, these changes indicate that the reduction of control forces near the stall with flaps and gear down could be caused by the blunt elevator balance nose shape (fig. 3d). The effect of increasing the mechanical advantage of the stick-to-elevator travel by 19 percent, limiting the elevator throw from ±25° to -22°, $+20\frac{1}{2}°$, is given in figure 14. It can be seen that the magnitude of the control forces was considerably reduced at all speeds for all conditions. In the opinion of the flight-testing personnel, this reduction gave control forces which were desirable and should be obtained in the final arrangement, if possible. It was desired to obtain the characteristics of this improved configuration during pull-outs from dives before making any final conclusion. Preliminary dives indicated that more up-tab travel should be provided for trim and that elevator-control forces at high speed were greater than desired. To provide such a reduction, a special balancing-tab action was installed on the elevator so that no balancing effect was obtained at full elevator throw. Since, seemingly, the longitudinal stability was not materially affected by this change, dives were made with dive flaps open and closed. The pull-out forces were favorable and the airplane was submitted to a Navy pilot representative for check. Although the characteristics in a pull-out were acceptable, the longitudinal stability was considered unsatisfactory because of insufficient stick motion required to effect a stall and insufficient control force during the stall approach in the carrier-landing condition. Considering the effect of the balancing tab on longitudinal stability at the beginning of these tests for the case of a glide with flaps and gear extended, it is reasonable to assume that some adverse effect still existed with the arrangement just described; even though the tab did not move after the elevator had reached a travel of 20°.

To obtain the desired elevator-control-force magnitude and to provide sufficient surface movement near the stall in the landing condition, it was evident that the elevator chord would have to be reduced. This meant that the elevator travel would have to be increased to provide trim with forward center-of-gravity location. Flight tests of phase IV were made with a new horizontal surface having the elevator chord reduced approximately 7 inches at the inboard end (figs. 8e and 9). The shape of the elevator aerodynamic balance nose was not changed. Provisions were again made for adjustable elevator hinge line and the elevator travel was increased to -30°, + 25°. Longitudinal-stability characteristics were obtained for this new arrangement with the overload-scout loading and center-of-gravity position of 28.1 percent mean aerodynamic chord. The effect of the elevator-chord reduction is shown in figures 15 and 16. The magnitude of the control forces compares favorably with that of the former surface with increased mechanical advantage (fig. 14). For the gliding condition with flaps and gear down, the control forces do not exhibit the original tendency to decrease below an indicated airspeed of 80 knots, and the elevator angle to trim over a speed range of from 113 knots to 70 knots was increased 50 percent compared to the original configuration of Flight II:1. Because of the differences in trim speed for the case of gliding flight, flaps and gear down, it is difficult to obtain any significant comparison from figure 15, with the possible exception that the elevator angle for trim seems to increase more rapidly near the stall for the reduced-chord case. There is no apparent explanation for the wide variation in control forces near the stall for the case of level flight with flaps and gear extended, with and without reduced chord.

Preliminary dives indicated the need for additional aerodynamic balance to reduce control forces at high speed. The elevator nose shape was accordingly changed from elliptical to radial as shown in figures 3d and 8f to provide more aerodynamic balancing for small elevator movement. Since this change did not provide sufficient improvement, the hinge line was moved back 3/8 inch, or 3/4 inch from the starting position. This change gave satisfactory characteristics in pull-out, and the elevator effectiveness for landing with forward center of gravity was checked. Since more than enough elevator control was available with the maximum throw, -30°, the travel was again reduced to -25° and the effect of a 1-inch gap between elevator and stabilizer was obtained. This change gave a "flat spot" in the elevator control which was not considered satisfactory for control in dives where small positive displacements are needed. With the elevator moved forward again, the horizontal surface was considered satisfactory, and the longitudinal stability considerably improved. A summary of the longitudinal-stability and control characteristics of the XBT-2 at the conclusion of phase IV, as interpreted by company testing personnel, is as follows:

1. The characteristics have been improved to an acceptable degree by the changes incorporated.

2. The elevator control is very effective throughout the required speed range, and the limited up travel is more than adequate to effect a three-point landing with the maximum forward center-of-gravity location of 22.1 percent mean aerodynamic chord.

3. The elevator-control forces are considered satisfactory at all speeds above 90 knots indicated, and elevator control during dives is considered excellent in view of the positive control for small movements.

4. Characteristics previously reported undesirable have been improved; although there is still a gradual decrease in elevator-control force at indicated air-speeds below 90 knots in level flight with flaps and gear down. For the case with power idling, however, the variation of control force with airspeed has been considerably improved, and the amount of stick travel required in a stall approach has been substantially increased.

5. The existence of a positive degree of static longitudinal stability is established at airspeeds above the stall with flaps and gear retracted or extended, since a constantly increasing up-elevator angle is required for trim as the stall is approached.

After delivery of the XBT-2 to the Naval Air Station at Anacostia, additional tests were made on the airplane by Navy personnel prior to the directional-stability tests of phase V at the 210-gallon scout loading with a gross weight of 7330 pounds and a center-of-gravity location of 29.6 percent mean aerodynamic chord. The Navy comments from this test were that, although positive longitudinal stability had been provided in the overload-scout condition, the control-column movement to effect a stall approach in the landing condition was still small and was accompanied by light elevator-control forces. It should be pointed out that these tests were made at a center-of-gravity location 1.5 percent mean aerodynamic chord farther aft than that used during the tests of phase IV. Realizing the critical effect of the balance on the desired longitudinal-stability characteristics, the engine of the production model SBD-1 was moved 5 inches forward to keep the center-of-gravity location at 27.5 percent mean aerodynamic chord in the 210-gallon scout condition, when referred to the XBT-2 mean aerodynamic chord of 97.5 inches. Actually, the increase in wing area effected by a better fairing over the retracted landing-gear wheel (fig. 1) for the SBD-1 changed the mean-aerodynamic-chord length to 100 inches, giving an equivalent center-of-gravity location of 28.6 percent mean aerodynamic chord for this same loading.

The horizontal surface configuration finally used in production on the SBD-1 model incorporated all the modifications from previous flight tests found to improve the longitudinal-stability characteristics. Minor differences were that the aerodynamic-balance nose shape of the elevator was changed from radial to a modified ellipse used successfully on other Douglas designs, the cut-out at the base of the elevator was replaced with fixed stabilizer area, and the trim tab was slightly revised at the outboard and inboard ends (see figs. 3d, 8i, and 9). The maximum elevator travel was increased to -30°, + 20°. During the preliminary demonstration of the model SBD-1, the hinge-line position of the elevator was again adjusted (see table VI, phase VI). Further adjustment was required on the basis that the pull-out forces from a dive had increased over those for the XBT-2. With the hinge line moved back 5 inches from the elevator leading edge, although the force characteristics in a pull-out were satisfactory, there was an undesirable tendency for the control force to reverse at low speeds in the landing condition near the stall.

An intermediate location of $4\frac{13}{16}$ inches, 1/16 inch aft of the final location on the XBT-2 (Flight IV:18), was finally used upon the basis that it would be more satisfactory to favor improvement of the stalling characteristics in the carrier-approach condition than to reduce the dive pull-out forces. With this location the stick force necessary to pull out of a dive with an acceleration of 7.5g was approximately 40 pounds with the dive flaps open and with the 1000-pound bomber loading. The only remaining change which was made on the SBD-1 was to increase the nose-up trim-tab travel 6° in order to provide additional trimming power for power off, flaps and gear down. For a comparison of the original and final empennages, see figures 1, 19, and 20.

The longitudinal-stability and control characteristics for the various basic configurations throughout the various test phases are compared in figure 16. It can be seen that the magnitude of the control forces has not varied from the original, particularly in level flight, flaps and gear up. There is ample evidence that the control forces with flaps and gear down, power off, increase up to the stall with initial trim speeds as low as 90 knots indicated. Unfortunately, no data are available on the variation of control force with airspeed for the final SBD-1 configuration in level flight with flaps and gear down. It is probable, however, that the forces decrease below 90 knots in the manner illustrated by Flight IV:3, figure 16.

In view of the extensive experimental flight testing accomplished to improve the longitudinal-stability and control characteristics of the production SBD-1 model, it is of considerable interest to note the results of recent overload tests made at Anacostia on the model SBD-3 airplane, which does not differ aerodynamically from the previous models:

The stability and control characteristics of the subject model were investigated at gross weights up to 10,330 pounds and center-of-gravity locations aft to 33.1 percent mean aerodynamic chord. At a gross weight of 9200 pounds with the center of gravity at 33.1 percent mean aerodynamic chord the longitudinal stability was found to be very close to neutral, varying from slight instability in high-power climb to definite positive stability, power off. In level flight the stability was close to the borderline but very slightly positive. At a gross weight of 10,423 pounds with the center of gravity located at 33.2 percent mean aerodynamic chord the longitudinal stability was slightly improved over the condition above. Positive stability appeared at cruising speed in level flight, and only at high powers did stability become neutral or slightly negative. The control forces are very light and reach zero under some conditions. For this reason, control at high speeds is not entirely satisfactory. It is considered that the airplane is satisfactory for service use in the conditions tested and described herein, provided high-speed dives and maneuvers are undertaken only after instruction and indoctrination in the airplane and in the effects of reduced stability on control characteristics.

DESIGN RECOMMENDATIONS

In reviewing the results of flight tests made on the XBT-2 and SBD-1 airplanes during the several design stages discussed in this report, it becomes evident that a considerable number of required control-surface adjustments may take place before desirable flying qualities finally can be obtained. If such a possibility is kept in mind during the initial design stages, and provisions for such adjustments are made in the airplane, a substantial time saving can be realized in obtaining flight-test approval of the prototype design. The following suggestions are made:

1. The hinge brackets for the rudder, ailerons, and elevator should be so designed that the hinge lines can be adjusted through a reasonable range of aerodynamic-balance values without variation in the gap between fixed and movable surfaces. The method used during the XBT-2 tests is illustrated in figure 23.

2. Some satisfactory method should be available for providing variation in the wing-dihedral setting, either by shims or replaceable fittings.

3. The horizontal- and vertical-surface plan forms should be chosen with a taper ratio permitting possible area increase.

4. The forward part of the movable control surfaces should be so designed that a rework of the aerodynamic-balance nose shape is possible without requiring a new surface.

5. As far as possible, the main-control-surface hinges should be advantageously located with respect to the trim tabs, thus permitting the installation of balance-tab action if absolutely required.

6. The control systems should be so designed that bell cranks can be replaced to give full stick, wheel, or pedal travel with reduced control-surface throw. Consideration should also be given to the possible necessity for including in the elevator- or aileron-control system an internal-hinge-moment contribution similar to the spring centering device used on the SBD-1.

Incorporation of the above suggestions will, of course, have no beneficial effect in the case of a design with fundamental deficiencies which should have been apparent, either from wind-tunnel testing or previous design experience. With respect to recommended practice in the detailed design of control surfaces, some observations which may be of value can be made from the flight-test data contained in this report. The superimposed three-views shown in figure 1 were prepared in order to illustrate in an effective manner the changes made from the original XBT-2 model, in arriving at the final control-surface arrangements of the SBD-1. This comparison in combination with the detailed flight-test results on the XBT-2 and general-design experience gained on other Douglas airplanes, permits the following comments:

<u>1. Control-surface airfoil section.</u>- The control-surface airfoil sections used on the SBD-1 airplane are shown in figures 3a and 3b for the vertical and horizontal surfaces. These airfoils are basic N-69 sections modified by a 12-percent chord extension to give a straight-sided afterbody over the movable-control-surface portion. In the case of the horizontal surface the thickness is a constant 10 percent, and for the vertical surface the

thickness is varied from 10.9 percent to 7.5 percent. In general, it is considered advisable to keep the thickness at a constant value not less than 10 percent. The airfoil section most frequently used on other Douglas designs is the NACA 0012 modified with the 12-percent chord extension in the same manner, giving a thickness of 10.7 percent. If the chordwise location of the maximum thickness is desired further aft, the 0012-64 section can be used with the same modification to give the straight-sided afterbody. With this section, a greater control-surface movement can be obtained without unporting of the balance nose.

2. Control-surface plan form.- More favorable results have been obtained with control surfaces having chordwise dimensions proportional along the span, particularly where the overhang or nose type of aerodynamic balance is used on the movable surface. In this manner, where constant thickness is also used, the amount of balance-nose unporting is likewise proportional. A low taper ratio of the order 0.5 is usually advisable, since it allows a better distribution of area. For the SBD-1 the taper ratios for the horizontal and vertical surfaces are 0.58 and 0.30, respectively. From the standpoint of possible overbalance due to excessive unporting, it has been found advisable to reduce the aerodynamic balance at the control-surface tips as shown in figures 17, 19, and 20 for the SBD-1. This reduction also protects the leading edge of the movable surface from possible overbalance due to ice formation over the unprotected portion.

3. Movable-control-surface chord.- It is of interest to note from the comparisons given in figure 1 that all movable-control-surface areas were reduced in going from the original to the final configuration. This definitely indicates that there exists an optimum ratio of movable to fixed control-surface area for obtaining the proper balance between control effectiveness and force. These values for the SBD-1 are 0.428, 0.230, and 0.300 for the rudder, ailerons, and elevator, using the ratio of movable-control-surface area aft of the hinge line to the total-surface area effected.

4. Aerodynamic nose balance.- Best results have been obtained with this type of aerodynamic balance when proportionality is used. Hinge cut-outs should be kept to a minimum, and the movable surface should be cut perpendicular to the hinge line, thus allowing aerodynamic balance to be effected element by element spanwise along the control surface. Cut-outs at the base of the movable surfaces for operating mechanism should be avoided if possible.

Comparison of the aerodynamic-balance nose shapes shown in figure 1 for the elevator and rudder show the change from blunt to modified elliptical shape. The blunt nose usually gives difficulty because of its adverse hinge-moment characteristics at large surface throws, resulting in a tendency for overbalance. The shapes given in figures 3a and 3b have proven quite satisfactory for a number of Douglas designs, giving a satisfactory compromise between loss in control-free stability and reduction in control-surface hinge moments.

5. Balance tab.- The use of the balance tab with uniform ratio to the main-control-surface travel in combination with the overhang type of aerodynamic balance, usually should be discouraged. Although the expected reduction in hinge moment can be obtained, the accompanying change in free-floating angle of the movable control surface effects a considerable reduction in stability. In cases where no overhang-type aerodynamic balance is used, the balance tab offers an effective method of hinge-moment reduction. As indicated in the flight tests on longitudinal stability with the SBD-1 model (table VI, phase VI), difficulty was experienced in obtaining the desired elevator control forces over the required speed range. The use of a balance tab would probably have reduced the pull-out forces, but would have further aggravated the low-speed overbalance.

6. Control-surface gap.- In general, it can be said that the gap between the fixed and the movable control surfaces should be kept to the minimum possible clearance for manufacture. From the XBT-2 tests, where the gap between the elevator and the stabilizer was increased, a flat spot in the variation of control force with angle occurred. In the case of the ailerons, there was some indication that the control forces became lighter. From a performance point of view, the additional drag caused by a large control-surface gap is not desirable. The ideal arrangement from all points of view except manufacture is the pressure-seal type of aerodynamic balance.

7. Tail cone.- On the XBT-2 it was found inadvisable to have the tail cone move with the rudder. No essential differences were obtained with the tail cone fixed to the fuselage or movable with the rudder concerning ability for spin recovery, and considerable difficulty was found in effectively balancing this portion when connected to the rudder. With the tail cone attached to the fuselage, there was less tendency for rudder-force reversal with essentially the same control effectiveness.

8. Dorsal fin.- The dorsal fin has been effectively applied to multiengine aircraft to improve the directional characteristics after engine failure. Its primary effect is to increase the angle of yaw at which stalling of the vertical surface occurs, without substantially affecting the directional stability. In the case of the XBT-2, the dorsal fin was a major factor contributing to the elimination of the undesirable rudder-force reversal during directional oscillations or sideslips at low airspeeds (table V, phase V). The use of the dorsal fin is recommended to improve damping in yaw, to reduce the rudder angle required for directional trim at high powers on a single-engine design, and to eliminate possible interference effects at the intersection of the vertical surface and the fuselage which may contribute to a premature vertical surface stall or rudder-force reversal.

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1. Root, L. E.: Empennage Design with Single and Multiple Vertical Surfaces. Jour. Aero. Sci., vol. 6, no. 9, July 1939, pp. 353-60.

TABLE I : Vertical Surface Areas and Design Ratios for Modifications During Lateral-Directional Stability Tests on Models XBT-2 and SBD-1

VERTICAL SURFACE AREAS AND DESIGN RATIOS

Configuration			Areas (sq.ft.)						Ratios					
Figure Number	Flight Number	HL * Location	S_v ** $S_v = S_{vr}$	S_r	S_{br}	S_{mr}	S_{tr}	$S_{T.C.}$	$\frac{S_r}{S_{vr}}$ +	Tail B_r Cone Fixed	Tail B_r Cone Movable	$\frac{S_{tr}}{S_r}$	$\frac{S_v}{S_w}$ ◊	AR $b_{v_1} = 60.75''$ $b_{v_2} = 69.75''$
4a	I:(1-10) II:(1-5)(7)	5 15/16	22.6	13.04•	2.11•	15.15•	0.80	2.5	(0.467)	(0.200)	0.162	0.061	0.070	1.13 (b_{v_1})
4b	II:(6)	5 15/16	27.9	15.04	2.32	17.36	0.80	2.5	(0.450)	(0.185)	0.154	0.053	0.087	1.21 (b_{v_2})
4c	II:(8-10)	5 15/16	25.2	15.04	2.32	17.36	0.80	2.5	(0.498)	(0.185)	0.154	0.053	0.078	1.34
4d	II:(11-13)	5 15/16	25.2	15.04	2.22	17.26	0.80	2.5	(0.498)	(0.177)	0.148	0.053	0.078	1.34
	III:(1)	5 15/16	25.3	12.66	2.32	14.98	0.84	-	0.500	0.183	-	0.066	0.079	1.34
	III:(2)	6 1/16	25.3	12.60	2.38	14.98	0.84	-	0.499	0.189	-	0.068	0.079	1.34
4e	III:(3)	6 1/8	25.3	12.57	2.41	14.98	0.84	-	0.497	0.192	-	0.067	0.079	1.34
	III:(7-9)	5 15/16	25.3	12.66	2.32	14.98	0.84	-	0.500	0.183	-	0.066	0.079	1.34
	III:(10-21)(24)	5 11/16	25.3	12.78	2.20	14.98	0.84	-	0.505	0.172	-	0.066	0.079	1.34
4f	III:(4)	6 1/4	25.3	15.31	2.47	17.78	0.84	2.8	(0.495)	(0.197)	0.161	0.055	0.079	1.34
	III:(5-6)	5 15/16	25.3	15.46	2.32	17.78	0.84	2.8	(0.500)	(0.183)	0.150	0.054	0.079	1.34
4g	III:(22-23)	5 11/16	24.5	11.94	2.20	14.14	-	-	0.488	0.184	-	-	0.076	1.38
4h,j	IV:(1-3)(6-8)	5 11/16	21.8	9.24	2.20	11.44	0.60	-	0.424	0.238	-	0.065	0.068	1.55
4k,n	IV:(9)(12-21)	5 11/16	21.8	9.24	2.20	11.44	0.60	-	0.424	0.238	-	0.065	0.068	1.55
4i	IV:(4-5)	5 11/16	21.6	9.04	2.20	11.24	0.40	-	0.419	0.244	-	0.044	0.067	1.57
4ℓ,m	IV:(10-11)	5 11/16	21.8	11.64	2.20	13.84	0.60	2.4	(0.424)	(0.238)	0.189	0.052	0.068	1.55
4o	V:(1)	5 11/16	21.8	9.24	2.04	11.28	0.60	-	0.424	0.221	-	0.065	0.068	1.55
4p	V:(2)	5 11/16	22.6	9.24	2.04	11.28	0.60	-	0.409	0.221	-	0.065	0.071	1.50
4q	V:(3)	5 11/16	23.5	9.24	2.04	11.28	0.60	-	0.393	0.221	-	0.065	0.073	1.44
4r	V:(4)	5 11/16	23.9	9.61	2.04	11.65	0.97	-	0.403	0.210	-	0.093	0.075	1.41
4s	V:(5)	5 11/16	23.0	9.61	2.04	11.65	0.97	-	0.418	0.210	-	0.093	0.072	1.47
4t	V:(6)	5 11/16	23.3	9.88	2.04	11.92	0.97	-	0.426	0.207	-	0.096	0.073	1.45
4u	V:(7)	5 11/16	24.2	9.88	2.04	11.92	0.97	-	0.408	0.207	-	0.096	0.076	1.40
4v	VI_1:(1-77) VI_2:(1-9)	5 11/16	23.1	9.88	2.04	11.92	1.2	-	0.428	0.207	-	0.122	0.071	1.46

* Hinge line location given from leading edge of rudder at Station 40 (26 3/4" from rudder base line).

** Effective vertical surface area is taken as that above rudder base line regardless of movable tail cone, and does not include dorsal fin area. (Dorsal fin area - #2 (Phase V) = 4.0, SBD-1 = 3.4 sq.ft.)

\+ Values in parenthesis do not include movable tail cone as rudder area.

◊ S_W = 321.5 sq.ft. for Phases I-III, 320 sq.ft. for Phases IV-V, 325 sq.ft. for Phase VI. Ratio of tail length to wing span, ℓ_v/b_w = 0.494

• Two places not justified except to show areas corresponding to HL variation.

TABLE II: Aileron Areas and Design Ratios for Modifications During Lateral-Directional Stability Tests on Models XBT-2 and SBD-1

AILERON AREAS AND DESIGN RATIOS

Configuration			Areas (sq.ft.)					Ratios				
Figure Number	Flight Number	HL Location*	S_{wa}	S_a	S_{ba}	S_{ta}	S_{ma}	B_a	$\frac{S_a}{S_{wa}}$	$\frac{S_a}{S_w}$ ◊	$\frac{S_{ta}}{S_a}$	$\frac{2b_a}{b_w}$ +
6a,6b	I:(1-10) II:(1-13)	4 5/8	80.6	20.72•	4.12•	0.94	24.84•	0.199	0.257	0.064	0.045	0.34
6c	III:(1)	4 7/8	80.6	20.16	5.12	0.94	25.28	0.254	0.250	0.063	0.047	0.34
6c	III:(2)	5	80.6	20.01	5.27	0.94	25.28	0.263	0.248	0.062	0.047	0.34
6c	III:(3)	5 1/8	80.6	19.86	5.42	0.94	25.28	0.273	0.246	0.062	0.047	0.34
6c	III:(4-8) III:(11-14)	5 1/4	80.6	19.72	5.56	0.94	25.28	0.282	0.245	0.061	0.048	0.34
6c	III:(9)	5 3/8	80.6	19.57	5.71	0.94	25.28	0.292	0.243	0.061	0.048	0.34
6c	III:(10)	5 1/2	80.6	19.42	5.86	0.94	25.28	0.302	0.241	0.060	0.048	0.34
6d	III:(15-24)	5 1/4	80.6	19.72	5.56	0.94	25.28	0.282	0.245	0.061	0.048	0.34
6e-6j	IV, V	5 1/4	79.0	18.02	5.62	0.47	23.64	0.312	0.228	0.056	0.026	0.34
6e-6j	VI_1, VI_2	5 1/8	79.0	18.17	5.47	0.47	23.64	0.302	0.230	0.056	0.026	0.34

* Hinge location is given from aileron leading edge at inboard end in chordwise direction

◊ S_w = 321.5 sq.ft. for Phases I-III; 320 sq.ft. for Phases IV-V, 325 sq.ft. for Phase VI.

\+ $2b_a$ = 170 inches, b_w = 498 inches, l_a = 201 inches.

• Two places not justified except to show areas corresponding to HL variation.

TABLE III: Horizontal Surface Areas and Design Ratios for Modifications During Longitudinal Stability and Dive Tests on Models XBT-2 and SBD-1

HORIZONTAL SURFACE AREAS AND DESIGN RATIOS

Configuration			Areas (sq.ft.)							Ratios					
Figure Number	Flight Number	H Location *	S_H **	S_{He}	S_e	S_{be}	S_{me}	S_{te} Trim	S_{te} Bal.	$\frac{S_e}{S_{He}}$	B_e	S_{te}/S_e Trim	S_{te}/S_e Bal.	$\frac{S_H}{S_W}$ ◊	AR_H (b_{H_1} = 189", b_{H_2} = 213")
8a	I:(1-10)														
	II:(1)	3 19/32	66.6	55.9	20.29•	4.21•	24.5	2.3	.8	.363	.207	.113	.039	.207	3.72(b_{H_1})
8b	II:(2-8)	3 19/32	66.6	55.9	20.29	4.21	24.5	2.3	-	.363	.207	.113	-	.207	3.72
	II:(9-16)	3 19/32	73.3	62.6	22.28	4.82	27.1	2.3	-	.340	.216	.103	-	.228	4.30(b_{H_2})
8c	III:(1)	4"	75.7	65.0	23.11	4.79	27.9	3.3	-	.356	.207	.143	-	.236	4.16
	III:(2)	4 1/4	75.7	65.0	22.78	5.12	27.9	3.3	-	.351	.225	.145	-	.236	4.16
	III:(3-14)(22-23)	4 1/2	75.7	65.0	22.44	5.46	27.9	3.3	-	.346	.243	.147	-	.236	4.16
8d	III:(15-21)	4 1/2	75.7	65.0	22.44	5.46	27.9	2.5	.8	.346	.243	.111	.036	.236	4.16
8e	IV:(1-8)	4"	70.8	61.5	19.61	4.79	24.4	2.2	-	.319	.244	.112	-	.221	4.45
8f	IV:(9-12)	4 3/8	70.8	61.5	19.11	5.29	24.4	2.2	-	.311	.277	.115	-	.221	4.45
8g	IV:(13-16)(18-21)	4 3/4	70.8	61.5	18.61	5.79	24.4	2.2	-	.303	.311	.118	-	.221	4.45
	V:(1-7)														
8h	IV:(17)	4 3/4	72.1	62.8	18.61	5.79	24.4	2.2	-	.296	.311	.118	-	.226	4.37
8i	VI_1:(1-52)	4 3/4	70.8	61.8	18.60	5.60	24.2	2.2	-	.301	.301	.118	-	.218	4.45
8j	VI_1:(53-55)	5"	70.8	61.8	18.27	5.93	24.2	2.2	-	.296	.325	.121	-	.218	4.45
8k	VI_1:(56-57)	4 7/8	70.8	61.8	18.44	5.76	24.2	2.2	-	.298	.312	.119	-	.218	4.45
8ℓ	VI_1:(58-77)														
	VI_2:(1-9)	4 13/16	70.8	61.8	18.52	5.68	24.2	2.2	-	.300	.306	.119	-	.218	4.45

* Hinge Location given aft elevator leading edge. Aerodynamic balance chord is constant along span.
** Total horizontal surface area includes cutouts and that covered by fuselage.
◊ S_W 321.5 sq.ft. for Phases I-III, 320.0 sq.ft. for Phases IV-V, 325.0 sq.ft. for Phase VI. Ratio of tail length to wing M.A.C., l_H/t_W 2.39.
• Two places not justified except to show areas corresponding to H variation.

TABLE IV: FLIGHT TEST SUMMARY ON STALLING CHARACTERISTICS.

FLIGHT LOG					CONFIGURATION: VERTICAL SURFACE									CONFIGURATION: AILERON								
DATE	FL'T. NO.	PILOT & OBSERVER	GROSS WEIGHT	C.G.	S_v	S_r	S_{b_r}	S_{t_r}	B_r	H/L (STA.40)	NOSE SHAPE	δ_r	FIGURE	S_a	S_{b_a}	B_a	H/L (STA.192)	δ_a	FIGURE	CHANGE	TEST	STALL WARNING
6-2-39	I:1	3	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	ORIGINAL XBT-2 AIRPLANE WITH FOLLOWING CHANGES: FIXED WING TIP SLOTS. FIG. 3e. SEALING STRIP ADDED TO OUTBOARD END OF FLAP TO CLOSE FLAP-AILERON GAP. GOOSE NECK TYPE PITOT HEAD INSTALLED ON WING. FIG. 17. LOWER SURFACE AILERON HINGE CUTOUTS SHIELDED. FORWARD SECTION OF CARBORUNDUM WALKWAYS REMOVED. 4" HIGHER ENCLOSURE. FIG. 22. AILERON BALANCE TAB RATIO 1:1.	CHECK AND FAMILIARIZATION FLIGHT	
6-5-39	I:2	3 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7		STALLS	
6-5-39	I:3	3 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7		F. & G. UP. IDLE POWER. $V_{i_{STALL}}$ = 55 KN.	GOOD STALL WARNING.
																					F. & G. UP. POWER ON (20" Hg. AT 1900 R.P.M. AT 5000 FT.) $V_{i_{STALL}}$ = 46 KN.	WARNING OF IMPENDING STALL STARTED AT ABOUT 49 KNOTS.
																					F. UP & G. DN. IDLE POWER $V_{i_{STALL}}$ = 56 KN.	ADEQUATE WARNING ABOUT 3 KNOTS ABOVE STALL.
																					F. UP & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 50 KN.	WARNING OF IMPENDING STALL ADEQUATE BELOW 54 KNOTS.
																					F. & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 49 KN.	VERY GOOD WARNING FOR ABOUT 5 KNOTS BEFORE FINAL STALL.
																					F. & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 46 KN.	NO AILERON WARNING.
6-6-39	I:4	8 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7		F. & G. UP. IDLE POWER. $V_{i_{STALL}}$ = 57 KN.	FAIR STALL WARNING.
																					F. & G. UP. POWER ON. (20" Hg. AT 1900 RPM AT 9000 FT.) $V_{i_{STALL}}$ = 52-53 KN.	LITTLE STALL WARNING EXCEPT JUST BEFORE STALL.
																					F. UP & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 57 KN.	GOOD WARNING OF THE IMPENDING STALL.
																					F. UP & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 52-53 KN.	STALL WARNING CONSIDERED ADEQUATE BUT NOT PRONOUNCED.
																					F. & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 53-55 KN.	GOOD STALL WARNING, BUT WHEN NOT HEEDED FELL HARD TO LEFT.
																					F. & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 46-47 KN.	NO WARNING.
6-6-39	I:5	3 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	SHARP LEADING EDGE FAIRING OF ABOUT 18" SPAN ADDED AT ROOT OF LEFT WING. FIGURE 2a. TIP SLOT GAP INCREASED TO 5/16" FIGURE 3e.	F. & G. UP. IDLE POWER. $V_{i_{STALL}}$ = 55 KN.	GOOD WARNING OF IMPENDING STALL.
																					F. & G. UP. POWER ON. (20" Hg. AT 1900 RPM AT 6000 FT.) $V_{i_{STALL}}$ = 49 KN.	ADEQUATE STALL WARNING BEGAN ABOUT 4 KN. BEFORE FINAL STALL.
																					F. UP & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 55 KN.	ADEQUATE STALL WARNING BEGAN ABOUT 4 KN. BEFORE FINAL STALL.
																					F. UP & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 50 KN.	VERY LITTLE WARNING OF IMPENDING STALL.
																					F. & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 50 KN.	GOOD WARNING OF IMPENDING STALL.
																					F. & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 44 KN.	ONLY A SUGGESTION OF WARNING BETWEEN 1-2 KN. BEFORE STALL.
6-7-39	I:6	3 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	TIP SLOT GAP INCREASED TO 3/4".	F. & G. UP. IDLE POWER. $V_{i_{STALL}}$ = 55 KN.	ADEQUATE WARNING BELOW 59 KN.
																					F. & G. UP. POWER ON (20" Hg. AT 1900 RPM AT 5000 FT.) $V_{i_{STALL}}$ = 50 KN.	GOOD STALL WARNING BELOW 53 KN.
																					F. UP & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 56 KN.	FAIR STALL WARNING.
																					F. UP & G. DN. POWER ON. (20" Hg. AT 1900 RPM. AT 6000 FT.) $V_{i_{STALL}}$ = 48 KN.	FAIR WARNING OF IMPENDING STALL.
																					F. & G. DN. IDLE POWER. $V_{i_{STALL}}$ = 49 KN.	VERY GOOD WARNING OF IMPENDING STALL.
																					F. & G. DN. POWER ON. (SAME AS ABOVE) $V_{i_{STALL}}$ = 45 KN.	NO SIGNIFICANT WARNING.
6-7-39	I:7	3 & 1	7566 * (210 GAL.)	27.7	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	AILERON BALANCE TAB ACTION INCREASED ABOUT 20%. LENGTH OF ARM SHORTENED 3/8". TAB RATIO: 1:1.2	AILERON CONTROL FORCE CHECK.	
6-8-39	I:8	3	6690	24.3	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	SHARP LEADING EDGE FAIRING REMOVED. C.G. MOVED FORWARD		
6-8-39	I:9	8 & 1	6860	26.0	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	SLOTS TAPED OVER (CLOSED). C.G. MOVED AFT.	F. & G. UP. IDLE POWER. $V_{i_{STALL}}$ = 57 KN.	GOOD WARNING OF IMPENDING STALL.
																					F. UP & G. DN. IDLE POWER $V_{i_{STALL}}$ = 55 KN.	GOOD WARNING OF IMPENDING STALL BELOW 59 KNOTS.
																					F. & G. DN. IDLE POWER $V_{i_{STALL}}$ = 52 KN.	FAIR WARNING.
																					F. & G. DN. POWER ON (22" AT 1900 RPM AT 9000 FT.) $V_{i_{STALL}}$ = 45 KN.	NO WARNING.
6-14-39	I:10	3 & 1	6860	26.0	22.6	13.04	2.11	.80	.162	5 15/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	SLOTS OPENED. AIRPLANE READY FOR DELIVERY.	CHECK ON LATERAL STABILITY. FLAPS AND GEAR DOWN.	
																				CHANGE	TEST	STALL
5-26-40	II; 1-56	-	-	-	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	SBD-1 AIRPLANE #1596	-	
5-26-40	II; 57	4	8254 1000# (150 GAL.)	28.4	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	6 1/8	-17,10	6g,7	LEADING EDGE MODIFICATION ADDED. FIGURE 2b. ("STALL CONTROL" STICKS.).	STALL	
5-28-40	II; 62	4 & 10	8355 1000# (130 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	L.E. MODIFICATION REMOVED.	CHECK	

* ALL CONDITIONS NOT NOTED ARE EITHER SCOUT OR BOMBER, WITHOUT BOMB LOADINGS.

FOLD-OUT # 1

TEST RESULTS

FALL OFF AT STALL	RECOVERY	LOSS OF ALTITUDE	AILERON	MISC.
	NAVY COMMENTS PRIOR TO PHASE I: AS OVERLOAD SCOUT WITH GROSS WEIGHT 7,407 LBS. AND C.G. AT 28.7% M.A.C. LATERAL STABILITY NEUTRAL AT LOW SPEEDS IN THE LANDING CONDITION WITH AILERON FREE. HIGH RUDDER WILL NOT PICK UP A WING DROPPED 15°. STALL CHARACTERISTICS: SMALL STICK MOVEMENT REQUIRED FOR STALL. LEFT AILERON BUFFETING GIVES AMPLE STALL WARNING. TUFT OBSERVATIONS INDICATED THE FOLLOWING: AT 4 TO 5 KNOTS ABOVE THE INDICATED STALLING SPEED OF THE AIRPLANE, THE EXTREME WING TIPS BEGIN TO STALL; AT 1 TO 2 KNOTS ABOVE THE INDICATED STALLING SPEED, WHEN LEFT AILERON COMMENCES TO BUFFET, THE WING SECTION COVERING 4 FEET INSIDE THE PITOT TUBE BOOM IS PARTIALLY STALLED; AT THIS LATTER SPEED LIFT ON RIGHT WING HAS NOT BROKEN DOWN EXCEPT AT THE EXTREME TIP. AT SPEEDS WELL ABOVE THE STALL, THE TUFTS INDICATED CONSIDERABLE SPILLAGE OF AIR THROUGH THE AILERON TO WING SLOT. RECOMMENDATIONS: (1) IMPROVE LATERAL STABILITY IN THE LANDING CONDITION SUCH THAT HIGH RUDDER WILL PICK UP 15° LOW WING AT 75 KNOTS WITH FREE AILERON CONTROLS. (2) MODIFY AILERON CONTROL SYSTEM TO REDUCE FORCES AT HIGH SPEED AND "KICK" AT STALL. NOTE: PRIOR TO ABOVE NAVY TESTS THE XBT-2 MODEL HAD BEEN ACCEPTED WITH THE PROVISION THAT RECOMMENDATION (2) BE INCORPORATED IN THE EXPERIMENTAL MODEL FOR ADDITIONAL TESTS. IT WAS INTENDED THAT RECOMMENDATION (1) AFFECT ALL FUTURE BT-2 PRODUCTION AIRPLANES BUT NOT THE XBT-2 AT THIS TIME.			
FELL OFF SLIGHTLY RIGHT. SLIGHT YAW TO RIGHT. DURING REPEAT STALLS AIRPLANE FELL OFF ESSENTIALLY LEVEL.	RECOVERY EFFECTED RAPIDLY AND WITH VERY LITTLE SPEED INCREASE.	ABOUT 150 FT.	GOOD AILERON CONTROL.	
GENTLE LEFT ROLL AND YAW.	VERY SLIGHT SPEED INCREASE REQUIRED FOR RECOVERY.	ABOUT 300 FT.	VERY LITTLE AILERON KICK. FAIR AILERON CONTROL.	PRONOUNCED BUFFETING AT STALL. LATERAL AND DIRECTIONAL CONTROL COULD BE MAINTAINED DURING THE INITIAL STALL USING FULL AILERON THROWS. BUT THIS CAUSED MORE VIOLENT FALL OFF AFTER COMPLETE STALL.
FELL GENTLY EITHER LEFT OR RIGHT.	BETWEEN 10 AND 12 KNOTS SPEED INCREASE REQUIRED TO EFFECT A COMPLETE RECOVERY.	150 TO 200 FT.	VERY LITTLE AILERON KICK. FAIR AILERON CONTROL.	
FELL MODERATELY LEFT AND DROPPED THE NOSE.	REQUIRED ABOUT 5 KNOTS SPEED INCREASE FOR COMPLETE RECOVERY.	100 TO 150 FT.	LITTLE AILERON KICK. FAIR AILERON CONTROL.	
FELL LEVEL OR SLIGHTLY LEFT AND DROPPED THE NOSE.	VERY LITTLE SPEED INCREASE REQUIRED FOR COMPLETE RECOVERY.	ABOUT 150 FT.	NO AILERON KICK. VERY GOOD AILERON CONTROL.	
FELL VERY HARD LEFT WITH LEFT YAW AND TENDED TO SPIN. FALL OFF OUT OF STALL NOT VIOLENT.		500-1000 FT.	MODERATE AILERON KICK. NO AILERON CONTROL AFTER STALL.	
FAVORED FALL OFF TO RIGHT, BUT DROPPED NOSE AFTER STALL. TENDED TO YAW TO THE RIGHT.	REQUIRED 6-8 KNOTS SPEED INCREASE TO OBTAIN ADEQUATE AILERON CONTROL FOR RECOVERY.	ABOUT 150 FT.		
FELL LEVEL OR SLIGHTLY RIGHT. VERY LITTLE TENDENCY TO YAW AFTER STALL. DROPPED THE NOSE AFTER THE STALL.	RECOVERY EFFECTED EASILY AFTER SPEED INCREASE OF 5-7 KNOTS TO REGAIN AILERON CONTROL.	LESS THAN 100 FT.		
FELL SLIGHTLY EITHER LEFT OR RIGHT. VERY SLIGHT YAW EITHER LEFT OR RIGHT. DROPPED THE NOSE AFTER THE STALL.	SPEED INCREASE OF 13-15 KNOTS REQUIRED TO CORRECT STALL (AS EVIDENCED BY SHAKE AND KICK IN AILERON CONTROL).	ABOUT 150 FT.	AILERON CONTROL WAS INADEQUATE UNTIL CONSIDERABLE SPEED HAD BEEN REGAINED.	
FELL HARD LEVEL WITH LITTLE ROLL EITHER LEFT OR RIGHT. NO TENDENCY TO YAW AFTER STALL.		LESS THAN 100 FT.	GOOD CONTROL DURING & AFTER STALL BUT AILERONS KICK & SHAKE UNTIL AIR SPEED PICKS UP TO 65 KNOTS.	
FELL OFF LEVEL OR SLIGHTLY LEFT. VERY SLIGHT TENDENCY TO YAW LEFT.	RECOVERY EFFECTED EASILY AT 58-60 KNOTS.	LESS THAN 150 FT.	GOOD AILERON CONTROL.	
FELL HARD LEFT WITHOUT WARNING, ACCOMPANIED WITH LEFT YAW.	ADEQUATE CONTROL REGAINED AT 50 KNOTS FOR RECOVERY.	ABOUT 250 FT.	AILERON CONTROL SLOPPY JUST BEFORE STALL.	AIRPLANE BEHAVIOUR AFTER STALL WAS AS IF PILOT MADE DELIBERATE ATTEMPT TO ENTER LEFT SPIN.
FELL HARD RIGHT AFTER FULL STALL. TENDED TO YAW RIGHT. ALSO DROPPED THE NOSE AFTER STALL. FELL LEVEL OR SLIGHTLY LEFT OUT OF THE "INITIAL STALL", WHEN ALLOWED TO.	VERY LITTLE SPEED INCREASE REQUIRED FOR RECOVERY.	LESS THAN 100 FT. AFTER FULL STALL	GOOD AILERON CONTROL IN STALL. NO AILERON KICK.	
FAIRLY SHARP FALL OFF TO LEFT WITH LEFT YAW.		ABOUT 200 FT.	AILERON CONTROL CONSIDERED GOOD IN STALL.	CHARACTERISTIC STALL SHAKE CONTINUED AFTER STALL FOR SPEED INCREASE BETWEEN 8-10 KNOTS.
MODERATE FALL OFF TO LEFT AND DROPPED NOSE. FELL LEVEL OUT OF INITIAL STALL.		ABOUT 200 FT.	AILERON CONTROL CONSIDERED GOOD.	STALL SHAKE "HANGS ON" AFTER SPEED INCREASE BETWEEN 8-10 KN.
FELL MODERATELY TO LEFT AND DROPPED THE NOSE. YAWED TO RIGHT.	RECOVERED EASILY WITH ABOUT 5 KNOTS SPEED INCREASE.	LESS THAN 300 FT.	AILERON CONTROL FAIR AT STALL AND WAS RECOVERED RAPIDLY. LITTLE AILERON KICK AT STALL.	
FELL OFF LEVEL OR GENTLY TO LEFT.	VERY LITTLE SPEED INCREASE REQUIRED FOR COMPLETED RECOVERY.	LESS THAN 100 FT.	GOOD CONTROL DURING AND AFTER STALL NO AILERON KICK.	CONSIDERED AN EXCELLENT STALL.
FELL VERY HARD LEFT WITH LEFT YAW, AND DROPPED THE NOSE.	RECOVERY EFFECTED ONLY AFTER CONSIDERABLE LOSS OF ALTITUDE.		NO AILERON CONTROL AT THE STALL.	AIRPLANE BEHAVED AS THOUGH PILOT ATTEMPTED DELIBERATE SPIN. VERY UNSATISFACTORY STALL CHARACTERISTICS.
DEFINITE FALL OFF TO RIGHT WITH RIGHT YAW, WHEN FULLY STALLED. FELL LEVEL WITH NO YAW WHEN INITIAL STALL WARNING WAS HEEDED.	ABOUT 6 KNOTS SPEED INCREASE REQUIRED FOR RECOVERY.	150 TO 200 FT.	GOOD AILERON CONTROL DURING AND AFTER STALL.	
FELL GENTLY LEFT WITH LITTLE LEFT YAW AND DROPPED THE NOSE.		LESS THAN 100 FT.	GOOD AILERON CONTROL.	
FELL MODERATELY LEFT, ACCOMPANIED BY LEFT YAW, WHEN FULLY STALLED. FELL LEVEL OR SLIGHTLY LEFT FROM INITIAL STALL. NOSE DROPPED AFTER STALL.	REQUIRED 4 TO 6 KNOTS SPEED INCREASE TO EFFECT RECOVERY.	DEPENDED ON STALL SEVERITY. NOT GREATER THAN 350 FT.	FAIR AILERON CONTROL AT THE STALL.	STALL SHAKE CONTINUED UNTIL SPEED INCREASED BETWEEN 5 AND 7 KNOTS.
FELL OFF EITHER LEVEL, SLIGTLY RIGHT OR SLIGHTLY LEFT WITH VERY LITTLE YAW. SEEMED TO FAVOR FALL OFF TO LEFT.	ABOUT 5 KNOTS SPEED INCREASE REQUIRED FOR RECOVERY FROM STALL.	LESS THAN 150 FT.	GOOD AILERON CONTROL DURING AND AFTER STALL. (NOTICEABLE IMPROVEMENT OVER PREVIOUS CONDITIONS.)	
FELL OFF LEVEL OR VERY SLIGHTLY RIGHT. LITTLE, IF ANY, YAW AFTER STALL.	RECOVERED VERY READILY WITH VERY LITTLE SPEED INCREASE.	LESS THAN 75 FT.	VERY GOOD AILERON CONTROL DURING AND AFTER STALL.	CONSIDERED AN EXCELLENT STALL.
FELL VERY HARD LEFT WITH NO SIGNIFICANT WARNING, YAWED HARD LEFT AND DROPPED NOSE.	RECOVERY EFFECTED WITHOUT DIFFICULTY BUT WITH CONSIDERABLE SPEED INCREASE.	ABOUT 300 FT.	NO AILERON CONTROL AT, OR IMMEDIATELY AFTER, STALL.	THIS STALL CONDITION WAS NOT NOTICEABLY CHANGED BY INCREASED SLOT GAP.
			CONTROL FORCES CONSIDERABLY REDUCED AT ALL SPEEDS. FORCES AT HIGH SPEEDS WERE REASONABLE. FORCES WERE LIGHT BETWEEN 60-80 KNOTS BUT CONSIDERED VERY SATISFACTORY DOWN TO STALL. NO ADVERSE EFFECT IN ANY STALL CONDITION.	
GENTLE FALL OFF TO LEFT WITH LITTLE LEFT YAW.	LESS THAN 5 KNOTS SPEED INCREASE REQUIRED TO GAIN FULL AILERON CONTROL.	LESS THAN 100 FT.	-	
GENTLE FALL OFF TO LEFT WITH LITTLE LEFT YAW. AIRPLANE FELL LEVEL WHEN STALL WARNING WAS HEEDED.	ABOUT 8-10 KN. SPEED INCREASE REQUIRED TO REGAIN FULL AILERON CONTROL AND ELIMINATE AILERON BUFFETING.	ABOUT 100 FT.	GOOD AILERON CONTROL DURING WARNING PERIOD, DOWN TO STALL.	CONSIDERED A VERY GOOD STALL.
FELL OFF LEVEL OR SLIGHTLY LEFT. SLIGHT YAW TO LEFT.	ABOUT 5 KN. SPEED INCREASE REQUIRED FOR RECOVERY.	LESS THAN 200 FT.	FAIR AILERON CONTROL DOWN TO STALL.	
FELL OFF SHARPLY TO LEFT WITHOUT WARNING. YAWED TO LEFT AND DROPPED THE NOSE.		ABOUT 350 FT.	NO AILERON CONTROL AT STALL. AILERON CONTROL WAS REGAINED QUICKLY (IN POINT OF TIME)	ANGLE BETWEEN TOP OF FUSELAGE AT GUNNER'S COCKPIT AND THE HORIZON WAS ABOUT 20° NOSE UP.

COMMENTS
(ALL COMMENTS ARE BY COMPANY PILOTS UNLESS OTHERWISE NOTED)

EFFECT OF 2 - .50 CALIBER FIXED GUNS INSTEAD OF 1 - .50 CALIBER FIXED GUN CHANGED C.G. LOCATION TO 27.7 %.

LATERAL STABILITY: DURING FLIGHTS, CHECKS WERE MADE ON THE ABILITY OF THE PILOT TO PICK UP A WING DROPPED ABOUT 30°. WITH FLAPS AND GEAR UP RUDDER ALONE WOULD PICK UP A WING FROM A NORMAL TURN OR STEADY SLIP. RUDDER MOVEMENT AND FORCE WERE MODERATE. THERE WAS LITTLE CHANGE IN HEADING. WITH NO DIFFICULTY RUDDER ALONE WOULD ROLL THE AIRPLANE RIGHT OR LEFT, TO ANGLES OF BANK OF 20°. IN THESE MANEUVERS THE AILERONS DISPLACED FROM NEUTRAL IN SUCH A DIRECTION AS TO ASSIST THE ROLL. (MORE PRONOUNCED WITH TIP SLOTS OPEN THAN WITH UNSLOTTED WING.) SIMILAR CHECKS WERE MADE WITH AILERON CONTROL FREE, FLAPS AND GEAR DOWN, AT V_i'S AS LOW AS 60 KNOTS, ANGLES OF BANK OF 30°, WITH POWER IDLE AND WITH 20" Hg. AT 1900 R.P.M. AT 5000 FT. NO DIFFICULTY WAS EXPERIENCED BY THE PILOT IN PICKING UP THE LOW WING.

IN GENERAL THE NOTED CHANGES IMPROVED ALL STALL CONDITIONS VERY SLIGHTLY. THE TENDENCY TO FALL OFF AFTER STALL APPEARED TO BE A LITTLE MORE SHARP, BUT THERE WAS SOME IMPROVEMENT IN AILERON CONTROL (SLIGHT) BEFORE AND DURING INITIAL STAGES OF STALL, AND SOME INCREASE IN AILERON BUFFETING. A LITTLE LESS SPEED INCREASE AFTER THE STALL WAS REQUIRED TO GAIN AILERON CONTROL. THE LAST STALL CONDITION (F.& G. DOWN POWER ON) SEEMED TO HAVE BEEN IMPROVED SLIGHTLY DUE TO A SUGGESTION OF A WARNING OF THE IMPENDING STALL AND TO THE SOMEWHAT MORE RAPID RECOVERY OF AILERON CONTROL AFTER THE STALL. THE IMPROVEMENT WAS NOT CONSIDERED SIGNIFICANT.

ANY IMPROVEMENT IN STALLING CHARACTERISTICS OR IN AILERON CONTROL AT THE STALL DUE TO INSTALLATION OF WING TIP SLOTS WAS THOUGHT TO BE MARGINAL. IT APPEARED THAT SLOTS PROVIDED SOME IMPROVEMENT IN AMOUNT OF AILERON CONTROL AVAILABLE JUST BEFORE AND AT THE STALL, BUT THAT THE BEST SLOT ARRANGEMENT TESTED DID NOT GREATLY ALTER THE AMOUNT OF STALL WARNING OR CONTRIBUTE TO THE AMOUNT OF AILERON CONTROL AFTER THE STALL. THE TENDENCY TO DROP THE NOSE AFTER A STALL WAS SOMEWHAT LESS WITH THE SLOTS COVERED.

AILERON KICK AT STALL: THERE WAS NO APPRECIABLE KICK IN THE AILERON CONTROL DURING ANY OF THE STALLS. THE REDUCTION OF THE KICK HAD APPARENTLY BEEN EFFECTED THROUGH THE REDUCTION OF THE GAP BETWEEN THE INBOARD ENDS OF THE AILERONS AND THE OUTBOARD ENDS OF THE LANDING FLAPS.

DURING INSPECTION OF XBT-2 TRIAL BOARD CHANGES, THE FOLLOWING NAVY COMMENT WAS OBTAINED AFTER CONDUCTING CARRIER APPROACH AND ARRESTED LANDINGS AT NAVAL AIR FACTORY BY SHIP EXPERIMENTAL UNIT PERSONNEL, JUNE 29, 1939: THE INCORPORATION OF WING TIP SLOTS ON THIS AIRPLANE HAS MATERIALLY IMPROVED ITS HANDLING QUALITIES DURING CARRIER APPROACHES AND ARRESTED LANDINGS.

TENDENCY TO ROLL	CONTROL	MISC.	COMMENTS
NAVY PILOT COMMENT - THE DROPPING OF THE LEFT WING AT THE STALL IS UNSATISFACTORY & THE WORST CONDITION NOTED. THE WHIP AT THE STALL IS ALWAYS TO THE LEFT IN ONE STALL CONDITION WITH MUCH REDUCED POWER, F.&G. DN. - A SIMULATED CARRIER LANDING APPROACH - THE AIRPLANE ALMOST ROLLED OVER ON ITS BACK INTO A SEMI-INVERTED POSITION. IT IS A VERY SATISFACTORY AIRPLANE EXCEPT FOR THIS ONE CONDITION.			TEST PILOT - THE FALL OFF TO THE LEFT IS MORE VIOLENT AND PRONOUNCED THAN EITHER BT-1 OR XBT-2 AIRPLANES. THE AIRPLANE IS EXCEPTIONALLY GOOD AT LANDING.

FOLD-OUT #2

W-81

TABLE IV (CONT'D): FLIGHT TEST SUMMARY ON STALLI

FLIGHT LOG					CONFIGURATION															
					VERTICAL SURFACE									AILERON						
DATE	FL'T. NO.	PILOT & OBSERVER	GROSS WEIGHT	C.G.	S_v	S_r	S_{b_r}	S_{t_r}	B_r	℄ (IN.)	NOSE SHAPE	δ_r	FIGURE	S_a	S_{b_a}	B_a	℄ (IN.)	δ_a	FIGURE	CHANGE
5-28-40	II1:63	4&1	8055 # (110 GAL.)	28.1	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	WOOL TUFTS 1 FT. SPACING ON BOTH WINGS
5-28-40	II1:64	4&1	8355 1000# (130 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	WING JUNCTION FAIRINGS REMOVED, TUFTS REMAI
5-28-40	II1:65	4&1	8265 # (115 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	"STALL CONTROL" STICKS INSTALLED (8" LONG BY 1/2" DIA HALF ROUND WOOD STICKS). LOCATED JUST OUTBOA WING JUNCTION FAIRING ON ROW OF RIVETS AT L.E. CHORD LINE. FIGURE 2c.
5-28-40	II1:66	4&1	8217 1000# (107 GAL.)	28.4	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	STICKS REMOVED. WING SLOTS COVERED WIT DURAL PLATES AND CELLULOSE TAPE.
5-29-40	II1:67	4	8355 # (140 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	WING JUNCTION FAIRING INSTALLED. PITOT MAST ING, WING TIP ATTACHMENT, LANDING LIGHTS, L.E. GA ATTACHING FAIRING WAXED SMOOTH.
5-29-40	II1:68	4&1	8265 # (115 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	25" BY 1/2" STICKS LOCATED ON L.E. RIVET LINE INBOARD FROM POINT 6" INBOARD OF WING ATTA ANGLE. FIGURE 2d.
5-29-40	II1:69	4&1	8355 1000# (130 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	REMOVED STICKS AND INSTALLED 12" BY 1/2" STICKS MEDIATELY OUTBOARD OF WING ATTACHING ANGLE. FI
5-29-40	II1:70	4&1	8265 # (115 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6h,7	UPPER AILERON- WING GAP SEALED WITH MEDICA
5-29-40	II1:71	2&9	8175 # (100 GAL.)	28.3	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6h,7	
5-30-40	II1:74	4	8095 500# (170 GAL.)	28.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6j,7	MEDICAL TAPE, SMOOTHING WAX, SLOT COVERS, ST AND TUFTS REMOVED. AILERON - WING UPPER SU GAP STRIP ADDED.
5-30-40	II1:75	4&10	7825 500# (125 GAL.)	28.1	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6j,7	WOOL TUFTS ON BOTH WINGS.
5-30-40	II1:76	4&10	7765 500# (115 GAL.)	28.0	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6j,7	WING SLOTS COVERED WITH PLATES AND TA
5-30-40	II1:77	4&10	7675 500# (100 GAL.)	27.9	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6j,7	14" BY 1/2" STICKS LOCATED IMMEDIATELY OUTBO OF WING ATTACHING ANGLE. FIGURE 2f.
5-28-40	II2:1	4	6992 # (100 GAL.)	26.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	SBD-1 AIRPLANE NO. 1597.
5-28-40	II2:2	4&1	7067 # (85 GAL.)	26.7	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	PITOT TUBE AND GOOSE NECK REMOVED.
5-29-40	II2:3	2	7172 # (100 GAL.)	27.3	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	PITOT TUBE AND GOOSE NECK INSTALLED.
5-29-40	II2:4	2&12	7652 # (180 GAL.)	28.0	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	BOTH SLOTS COVERED. WOOL TUFTS ON TOP SU OF WING.
5-30-40	II2:5	2&12	7562 # (165 GAL.)	27.9	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6g,7	RIGHT WING SLOTS COVERED. LEFT WING SLO OPEN.
5-30-40	II2:6	4&10	7472 500# (160 GAL.)	27.8	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6i,7	RUBBER SEALING STRIP IN LOWER WING AILERO
5-31-40	II2:7	4&1	7382 # (150 GAL.)	27.5	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6i,7	LEFT WING SLOTS COVERED. AILERON - WING SURFACE GAP STRIP ADDED.
5-31-40	II2:8	4&1	7282 # (110 GAL.)	27.3	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6i,7	PITOT REMOVED.
5-31-40	II2:9	4&1	7172 # (100 GAL.)	27.3	23.1	9.88	2.04	1.2	.207	5 11/16	ELLIPTICAL	±30	4v,5	18.17	5.47	.302	5 1/8	-17,10	6i,7	LEFT AILERON- WING GAP REDUCED BY BENDI OF ATTACHED GAP-SEAL PLATE AND BY ADDI OF TAPE TO L.E. OF AILERON TO FILL HOLLOW

TABLE V: FLIGHT TEST SUMMARY ON LATERAL, D

7-17-39	II:1	3&1	7281 # (210 GAL.)	27.7	22.6	13.04	2.11	0.8	.162	5 11/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	XBT-2 AIRPLANE AS IN PHASE I FLIGHT I
7-19-39	II:5	3&1	7281 # (210 GAL.)	27.7	22.6	13.04	2.11	0.8	.162	5 11/16	BLUNT	±30	4a,5	20.72	4.12	.199	4 5/8	-27,13	6a,7	INCREASED DIHEDRAL 1°.

FOLD-OUT #1

\# ALL CONDITIONS NOT NOTED ARE EITHER
SCOUT OR BOMBER WITHOUT BOMB LOADINGS

NG CHARACTERISTICS.

	TEST	TEST RESULTS: STALL	TENDENCY TO ROLL	CONTROL	MISC.	COMMENTS
	STALL	CENTER SECTION STALL ORIGINATED AT THE TRAILING EDGE ON EITHER SIDE OF THE ATTACHING ANGLE FAIRING. IT SPREAD FORWARD AND OUTWARD FAIRLY RAPIDLY. THE TIP STALL, WHICH STARTED LATER, APPEARED 6" INBOARD OF OUTER END OF WING SLOT AT LEADING EDGE. MOVED IN THREE FT. DURING PROGRESSION OF ROOT STALL.	WHEN TIP AND CENTER SECTION STALLED PORTIONS MET, AS INDICATED BY TUFTS, THE AIRPLANE ROLLED TO THE LEFT. THIS APPEARED TO BE DUE TO THE FACT THAT THE COMPLETELY STALLED AREA OF THE LEFT WING PROGRESSED TO A MORE FORWARD POSITION ACROSS THE WING THAN IT DID ON THE RIGHT WING ALTHOUGH BOTH WINGS WERE STALLED OVER THE COMPLETE SPAN.	WITH EITHER THE TIP STALL OR ROOT STALL ALONE IN EFFECT, IT WAS POSSIBLE TO FLY AND CONTROL THE AIRPLANE. WITH BOTH STALLS THERE WAS A LOSS IN CONTROL DURING CONSIDERABLE LOSS IN ALTITUDE.	THE RIGHT WING WAS STALLED BY THE USE OF RUDDER IN A TURN. THIS STALL ORIGINATED AT THE OUTER REAR SECTION OF THE WING, MOVED INBOARD WITHOUT MOVING FORWARD UNTIL THE ENTIRE TRAILING EDGE OF THE WING WAS STALLED. THEN THE INNER END OF THE STALL MOVED FORWARD AT THE SAME RATE AS THE OUTER END, STALLING THE ENTIRE WING SMOOTHLY WITH THE PROGRESS EVEN FROM THE TRAILING EDGE TO THE LEADING EDGE.	IN THE POWER OFF AND THE CARRIER APPROACH CONDITIONS THE STALL OF THE LEFT WING OCCURRED AND SPREAD BEFORE A SMALL STALLED AREA AT THE TRAILING EDGE OF THE WING ATTACHING ANGLE ATTAINED ANY IMPORTANCE. THE FLOW AT THE EXTREME INBOARD END OF THE WING CENTER SECTION WAS UNDISTURBED IN ALL CONDITIONS.
ED.	STALL					RESULTS IDENTICAL WITH PREVIOUS FLIGHT.
D OF F	STALL	INDICATED THAT SOME CONTROL OF THIS STALL COULD BE DERIVED BUT IMPROVEMENT OF STALL CHARACTERICS APPEARED IMPOSSIBLE UNTIL AFTER CORRECTION OF RATHER VIOLENT TIP STALL.				
Y	STALL	DELAY IN ORIGIN OF STALL.	LESS VIOLENT ROLL FROM STALLED ATTITUDE. UNDER SOME CONDITIONS POSSIBLE TO ROLL AIRPLANE RIGHT AFTER INITIAL TENDENCY TO ROLL LEFT HAD BEEN CORRECTED WITH THE AILERON.			
FAIR- WING	STALL					NO IMPROVEMENT.
ING	STALL					SOME IMPROVEMENT.
N- RE 2_e.	STALL					
TAPE.	STALL			CONSIDERABLE IMPROVEMENT IN CONTROL FORCE & EFFECTIVENESS AT LOW SPEEDS		DECIDED IMPROVEMENT.
	CHECK FLIGHT					NAVY PILOT: F & G. DN., CRUISING POWER, CONDITION MAJOR IMPROVEMENT. ALTHOUGH STILL FELL TO LEFT AT STALL.
CKS FACE	DIVE					
	STALL			TEST PILOT- THERE HAS BEEN CONSIDERABLE IMPROVEMENT IN AILERON CONTROL FORCES-THEY ARE SMOOTHER. THE AILERONS ARE MORE EFFECTIVE AT LOW SPEED FOR A GIVEN AILERON ANGLE AND STICK FORCE.	NAVY PILOT- THE AIRPLANE IS NOW A LOT BETTER. THE STALL CHARACTERISTICS ARE EASILY 100% BETTER THAN THEY WERE THE LAST TIME I FLEW. YOU CAN NOW HOLD THE AIRPLANE RIGHT AT THE STALL IN THE "CLEAN" CONDITION (F & G. UP). THERE IS PLENTY OF WARNING. IT IS A FINE AIRPLANE. IN THE F & G. DN CONDITION MUCH IMPROVEMENT WAS SHOWN.	TEST PILOT - THE POWER ON STALL IS VERY GOOD. IT ALWAYS OCCURS AT THE ROOT. THE STALL IN THE APPROACH CONDITION (F & G. DN., APPROACH POWER) IS FAIR. THE AIRPLANE USUALLY WHIPS TO THE LEFT (FOUR OUT OF FIVE TIMES). IN POWER OFF STALLS THE AIRPLANE INVARIABLY FALLS OFF TO THE LEFT. THERE IS STILL A DEFINITE LEFT ROLL OUT OF A STALLED TURN.
E.	STALL			TEST PILOT- THERE'S MORE AILERON CONTROL AVAILABLE BOTH BEFORE AND AFTER THE STALL WITH THE WING TIP SLOTS CLOSED OFF.	TEST PILOT- CLOSING UP THE WING SLOTS CAUSED A MINOR IMPROVEMENT IN THE STALL CHARACTERISTICS UNDER ALL CONDITIONS.	
RD	STALL	THE ROOT STALL WAS DELAYED BY THE STICKS UNTIL AFTER THE TIP STALL ON BOTH WINGS.			THE ADDITION OF THE STICKS CAUSED AN IMPROVED STALL. THE RIGHT WING TIP COULD BE MADE TO STALL FIRST.	
	STALL	STALLED IN SAME WAY AS # 1596 EXCEPT FOR WHAT EFFECT MAY BE DUE TO LOAD.				
	STALL	NO EFFECT ON STALL CHARACTERISTICS.				
	STABILITY-TO CHECK XBT-2 PHASE V	CRUISING POWER, F & G. DN. - GOOD WARNING. IN THIS CONDITION STALL CONSIDERED MORE SEVERE THAN ON XBT-2 BECAUSE OF MORE PRONOUNCED LEFT ROLL.	SEVERE ROLL TO LEFT AT STALL IN CARRIER LANDING CONDITION WITH CRUISING POWER. WAS NOT IMPROVED OVER XBT-2. WING-TO-AILERON EXTENSION STRIPS MAY IMPROVE THIS CONDITION. SINCE THIS MODIFICATION WAS NOT INSTALLED ON NO. 1597 ON THIS FLIGHT NO COMPARISONS COULD BE MADE.		CRUISING POWER, F & G. DN.- DIRECTIONAL STABILITY: OK DOWN TO 65 KN. NEUTRAL TO 63 KN. LATERAL STABILITY: OK TO 60 KN. IN RIGHT SLIP. OK TO 75 KN. IN LEFT SLIP (RAN OUT OF RUDDER.) POWER OFF, F & G. DN. - DIRECTIONAL STABILITY: OK DOWN TO 70 KN. LATERAL STABILITY: OK TO 70 KN. IN RIGHT SLIP. OK TO 84 KN. IN LEFT.	ELEVATOR CONTROL FORCES TOWARD STALL STILL LIGHT AND CONTROL COLUMN TRAVEL SMALL. STABILITY AT LEAST AS GOOD AS XBT-2 AND DIRECTIONALLY MUCH BETTER.
FACE	STALL	POWER OFF, F & G. DN: LEFT WING STALL STARTED BACK OF PITOT TUBE, HEADED ~~DOWNWARD AND INWARD TO AILERON~~. NO ROOT STALL. AS STALL PROGRESSED, ROOT EVENTUALLY STALLED BUT DID NOT PROGRESS TO ROOT. ROOT STALLED INDEPENDANTLY AND PROGRESSED DOWNWARD AND OUTWARD. POWER ON, F & G. DOWN: SAME EXCEPT ROOT HELD ON LONGER.	POWER OFF, F & G. DN. MEAN WHIP TO LEFT.	POWER ON, F & G. DN. LOSS OF CONTROL BEFORE ROOT STALLED.		ON THE BASIS OF THESE FLIGHT TEST RESULTS, THE CONTRACTOR ON JUNE 5, 1940 RAISED A QUESTION CONCERNING THE EFFECTIVENESS OF WING TIP SLOTS ON THE SBD-1. THE NAVY'S ANSWER WAS AS FOLLOWS: "WITHOUT WING TIP SLOTS THE STALL IS REACHED WITH LITTLE WARNING AND IS CHARACTERIZED BY A COMPLETE LOSS OF AILERON CONTROL AND VERY SHARP ROLL AND PITCH, FROM WHICH RECOVERY BEGINS IN A STEEP DIVE. WITH SLOTS OPEN CONSIDERABLE WARNING IS GIVEN AS THE STALL IS APPROACHED, AND AILERON CONTROL DOES NOT ENTIRELY DISAPPEAR UNLESS THE STALLING CONTROL IS FORCED. THE RECOVERY IS FAR LESS SEVERE AND MUCH SHALLOWER, THOUGH IMPROVEMENT OF THIS PHASE IS LESS MARKED IN LANDING CONDITION THAN IN THE CLEAN CONDITION."
S	STALL	COMPANY PILOT COMMENTS: YOU CAN FIGHT THE STALL. MORE AILERON - CONTROL HOLDS LONG ENOUGH TO STALL RIGHT - RIGHT STALLS BEHIND OUTBOARD SLOT AND SPREADS IN AND DOWN TO ROOT OF AILERON - STALLING ENTIRE AILERON. AS STALL REACHES EDGE OF AILERON, ROOT STALLS DOWN AND OUT.	STILL FELL TO LEFT.	CONTROL HELD ON LONGER THAN XI_t:3		
GAR	STALL					FINAL ARRANGEMENT - WING FIXED WING TIP SLOTS HAVE BEEN INCORPORATED IN THE PRODUCTION MODEL. NO LEADING EDGE MODIFICATIONS WERE USED. SEE FIGURE 3e FOR SLOT SECTION.
UPPER	STALL	STALL MUCH IMPROVED.	TENDED TO DROP LEFT WING AS STALL WAS APPROACHED AND TO FALL OFF LEFT AT THE STALL.	ALL STALLS COULD BE QUITE WELL CONTROLLED. SOMETIMES FELL OFF TO RIGHT		
	STALL	NO IMPROVEMENT.				FINAL ARRANGEMENT - AILERON THE CONFIGURATION OF PHASE III WAS FINAL EXCEPT FOR THE ADDITION OF UPPER SURFACE WING-TO-AILERON EXTENSION STRIPS. FOR COMPARISON BETWEEN FINAL AND ORIGINAL AILERONS SEE FIGURES 3f, 6e, 6j AND 7.
S TION	STALL					

IRECTIONAL STABILITY AND CONTROL.

TEST *		SPEED AND RUDDER TO MAINTAIN BANK IN STEADY SLIP	RECOVERY	SPEED INCREASE DUE TO ADDITIONAL RUDDER DEFLECTION - PITCH	RUDDER FORCE (OVERBALANCE)	AILERON FORCE (OVERBALANCE)	MISC.
STABILITY	1 *		(A) ~~RECOVERED IN 3 SEC. OR LESS AT ALL SPEEDS.~~ (B) SEVERAL SECS. AT HIGHER SPEEDS. AT 65 KN. SHIP DIVED AT CONST. ϕ AND APPEARED UNABLE TO RECOVER. MIGHT HAVE EVENTUALLY RECOVERED FROM LEFT SLIP.	(B) NOSE DROPPED.	(A) GOOD CONTROL [illegible]		(B) ϕ - ANGLE OF BANK.
	2		(A) RECOVERED AT ALL SPEEDS AS READILY AS AILERONS WERE NEUTRALIZED. RECOVERED WITH SOME SKID. (B) RECOVERED ABOVE 85 KN. (AT 85, 6 SEC.) QUESTIONABLE BELOW 85 KN.	(B) NOSE DROPPED HARD, GAINED SPEED, SKIDDED AND DID NOT RECOVER FROM BANK.			(A) SLIP COULD NOT BE MAINTAINED AFTER NEUTRALIZING AILERONS.
	3		(A) RECOVERY AT ALL SPEEDS. (B) NO RECOVERY AT 85 KN. OR BELOW.	(A) NOSE DROPPED, GAINED SPEED. (B) NOSE DROPPED, GAINED SPEED, LEFT BANK REMAINED CONSTANT, RIGHT BANK INCREASED SLOWLY.			
	4		(A) OK. TIME INCREASED WITH SPEED DECREASE. (B) NO RECOVERY.	(A) LEFT SLIP, NOSE ROSE. RIGHT SLIP, NOSE DROPPED. (B) DIVED AND TURNED.			
STABILITY	1		(A) 2 SEC. AT 120 KN. 3 SEC. AT 80 KN. (B) 12 SEC. (LEFT SLIP) AT 85 KN. AND 6 SEC. (RIGHT SLIP)	(A) NOSE DROPPED, GAINED SPEED (7 KN. AT 120, 20 KN. AT 80.) MORE DROP FROM LEFT SLIP. (B) SAME AS (A) (20 KN. AT 85, 30 KN. AT 65.)			(A) LITTLE CHANGE IN HEADING (YAW). (B) NO CHANGE IN HEADING. INITIAL REACTION AFTER ADD. RUDDER WAS TO YAW AGAINST BANK.
	2		(A) AT 120 KN. RECOVERED WITH SOME SKID AS RAPIDLY AS AILERONS NEUTRALIZED. AT 80 KN INDICATION OF NEUTRAL REACTION TO RETURN OF AILERONS TO NEUTRAL. (B) 2-3 SEC. AT 85 KN. OK AT ALL SPEEDS. TIME DECREASED AS SPEED OF RETURNING AILERONS TO NEUTRAL INCREASED.	(A) AT 120 KN., NO PITCH. (B) LITTLE GAIN IN SPEED.			(A) AT 120 KN. INITIAL REACTION WAS TO YAW IN DIRECTION OF BANK. (B) TENDENCY TO YAW IN DIRECTION OF BANK.
	3		(A) 2 SEC. AT 120 KN. BECAME SLUGGISH AT LOW SPEEDS. ROLLED BEYOND LEVEL. (B) RECOVERED IN TIME FROM LEFT SLIP BUT PROHIBITIVE. FROM RIGHT SLIP AIRPLANE SPIRALED TO RIGHT (DIVERGENT.)	(A) 10 KN. AT 120, 25 KN. AT 80. MORE DROP FROM LEFT SLIP. (B) DIVED VERY FAST. AIRPLANE WAS PERMITTED TO GAIN 35 - 40 KN.			(A) INITIAL YAW AGAINST BANK. MORE TENDENCY TO YAW FROM RIGHT SLIP.
	4		(A) 3 SEC. AT 120 KN; 4 SEC. (RIGHT SLIP) AND 6 SEC. (LEFT SLIP) AT 100 KN; 6 SEC. (RIGHT) AND 16 SEC. (LEFT) AT 80 KN. (B) RECOVERED FROM LEFT SLIP. SPIRALED FROM RIGHT SLIP. (DIVERGENT.)	(A) AT 120 KN. VERY LITTLE INCREASE. 15 KN. (RIGHT) AND 20 KN. (LEFT) AT 80 KN. (B) GAINED SPEED FROM LEFT SLIP. RECOVERED AFTER GAIN OF 35 KN.			(A) DUTCH ROLL TO 15° ϕ AT 100 KN. BY USING RUDDER, STICK FREE. (B) TENDENCY TO TURN IN DIRECTION OF BANK MORE PRONOUNCED FROM RIGHT SLIP.

* NOTE: DEFINITION OF TESTS 1, 2, 3 AND 4.
FROM STEADY SLIP WITH 15° ANGLE OF BANK:
(1) MAINTAINED COURSE WITH RUDDER AND HELD STICK IN THE DISPLACED POSITION REQUIRED TO MAINTAIN THE SLIP. ATTEMPTED TO PICK UP WING WITH USE OF RUDDER ALONE.
(2) RETURNED STICK TO NEUTRAL AND HELD. KEPT RUDDER FIXED IN POSITION REQUIRED FOR STEADY SLIP. NOTED MOTION.
(3) RELEASED STICK AND ATTEMPTED TO PICK UP WING WITH RUDDER ALONE. NOTED MOTION.
(4) RELEASED STICK AND MAINTAINED RUDDER IN POSITION REQUIRED TO HOLD STEADY SLIP. NOTED MOTION.
PERFORMED ABOVE TESTS WITH (A) FLAPS AND GEAR UP AT V_i = 120, 100, 80 KNOTS.
PERFORMED ABOVE TESTS WITH (B) FLAPS AND GEAR DOWN AT V_i = 85, 75, 65 KNOTS.

FOLD-OUT #2

W-81

TABLE V (CONT'D): FLIGHT TEST SUMMARY ON LATERA

FLIGHT LOG					CONFIGURATION															
					VERTICAL SURFACE									AILERON						
DATE	FL'T NO.	PILOT & OBSERVER	GROSS WEIGHT	C.G.	S_v	S_r	Sb_r	St_r	B_r	l/l (STA. 40)	NOSE SHAPE	δ_r	FIGURE	S_a	Sb_a	B_a	l/l (STA. 180)	δ_a	FIGURE	CHANGE
7-21-39	II:6	2 & 1	7300 / * 210	27.7	27.9	15.04	2.32	0.80	.154	$5\frac{15}{16}$	BLUNT	±30	4b,5	20.72	4.12	.199	$4\frac{5}{8}$	-27,13	6a,7	LARGE FIN EXTENSION. LARGE R… EXTENSION.
7-24-39	II:7	2 & 1	7300 / * 210	27.7	22.6	13.04	2.11	0.80	.162	$5\frac{15}{16}$	BLUNT	±30	4a,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6a,7	ORIGINAL FIN AND RUDDER. INCR… DIHEDRAL 1° (TOTAL INCREASE = 2°).
7-24-39	II:8	2 & 1	7300 / * 210	27.7	25.2	15.04	2.32	0.80	.154	$5\frac{15}{16}$	BLUNT	±30	4c,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6a,7	SMALL FIN EXTENSION. LARGE R… TENSION.
7-26-39	II:10	2 & 1	7300 / * 210	27.9	25.2	15.04	2.32	0.80	.154	$5\frac{15}{16}$	BLUNT	±30	4c,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6a,7	AILERON BALANCE TAB DISCONN… LOCKED IN NEUTRAL.
7-27-39	II:11	2 & 1	7300 / * 210	27.7	25.2	15.04	2.22	0.80	.148	$5\frac{15}{16}$	BLUNT	±30	4d,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6a,7	BALANCE AREA ABOVE UPPER H… BRACKET REDUCED. (RUDDER)
7-27-39	II:12	2 & 1	7300 / * 210	27.7	25.2	15.04	2.22	0.80	.148	$5\frac{15}{16}$	BLUNT	±30	4d,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6b,7	TRAILING EDGE FIN WIDTH INCREA… METAL COVERING OF RUDDER EXTENS… REMOVED BELOW UPPER HINGE AT L… EDGE. REDUCED AILERON-WING LOWER … SLOT GAP TO $\frac{1}{4}$".
7-28-39	II:13	2 & 1	7300 / * 210	27.7	25.2	15.04	22.2	0.80	.148	$5\frac{15}{16}$	BLUNT	±30	4d,5	20.72	4.12	.199	$4\frac{5}{8}$	$-27\frac{1}{2}$,13	6b,7	TRAILING EDGE FIN WIDTH INCR…
9-8-39	III:1	2	6267 / * 105	24.4	25.3	12.86	2.32	0.84	.183	$5\frac{15}{16}$	ELLIPTICAL	±30	4e,5	20.16	5.12	.254	$4\frac{7}{8}$	-27,13	6c,7	REBUILT FIN, RUDDER, AND AIL… TAIL CONE ATTACHED TO FUSE… AILERON NOSE SHAPE MORE B… NO BALANCE TAB.
9-9-39	III:2	2 & 1	7039 / * 210	28.5	25.3	12.60	2.38	0.84	.189	$6\frac{1}{16}$	ELLIPTICAL	30,25	4e,5	20.01	5.27	.263	5	-27,13	6c,7	RUDDER H/L MOVED $\frac{1}{8}$" AFT. AILERON H/L MOVED $\frac{1}{8}$" AFT.
9-10-39	III:3	2 & 1	7039 / * 210	28.5	25.3	12.57	2.41	0.84	.192	$6\frac{1}{8}$	ELLIPTICAL	35,30	4e,5	19.86	5.42	.273	$5\frac{1}{8}$	$-26\frac{1}{2}$,$12\frac{1}{2}$	6c,7	RUDDER H/L MOVED $\frac{1}{16}$" AFT. AILERON H/L MOVED $\frac{1}{8}$" AFT.
9-12-39	III:4	2 & 11	7039 / * 210	28.5	25.3	15.31	2.47	0.84	.161	$6\frac{1}{4}$	ELLIPTICAL	±25	4f,5	19.72	5.56	.282	$5\frac{1}{4}$	$-21\frac{1}{2}$,$14\frac{1}{2}$	6c,7	RUDDER H/L MOVED $\frac{1}{8}$" AFT. TAIL CON… TO RUDDER. RUDDER TRAVEL RESTR… AILERON H/L MOVED $\frac{1}{8}$" AFT. AILERON D… IAL CHANGED TO $21\frac{1}{2}$° UP AND $14\frac{1}{2}$° DO…
9-13-39	III:5	2 & 1	7039 / * 210	28.5	25.3	15.46	2.32	0.84	.150	$5\frac{15}{16}$	ELLIPTICAL	±30	4f,5	19.72	5.56	.282	$5\frac{1}{4}$	-27,13	6c,7	RUDDER H/L MOVED $\frac{5}{16}$" FORWARD … RUDDER BALANCE TAB SET IN FIR… THROW ±30. ORIGINAL AILERON DIFFERENTIAL IN…

† NOTE: DEFINITION OF TESTS 1,2,3, AND 4.
FROM STEADY SLIP WITH 15° ANGLE OF BANK:
(1) MAINTAINED COURSE WITH RUDDER AND HELD STICK IN THE … POSITION REQUIRED TO MAINTAIN THE SLIP. ATTEMPTED TO P… WING WITH USE OF RUDDER ALONE.
(2) RETURNED STICK TO NEUTRAL AND HELD. KEPT RUDDER FIXE… POSITION REQUIRED FOR STEADY SLIP. NOTED MOTION.
(3) RELEASED STICK AND ATTEMPTED TO PICK UP WING WITH R… ALONE. NOTED MOTION.
(4) RELEASED STICK AND MAINTAINED RUDDER IN POSITION REQ… HOLD STEADY SLIP. NOTED MOTION.
PERFORMED ABOVE TESTS WITH (A) FLAPS AND GEAR UP AT V_i = 120,…
PERFORMED ABOVE TESTS WITH (B) FLAPS AND GEAR DOWN AT V_i = 85,…

* ALL CONDITIONS NOT NOTED ARE EITHER SCOUT OR BOMBER, WITHOUT BOMB LOADING

FOLD-OUT #1

...L, DIRECTIONAL STABILITY AND CONTROL.

	† TEST		TEST RESULTS: SPEED AND RUDDER TO MAINTAIN BANK IN STEADY SLIP	RECOVERY	SPEED INCREASE DUE TO ADDITIONAL RUDDER DEFLECTION - PITCH	RUDDER FORCE (OVERBALANCE)	AILERON FORCE (OVERBALANCE)	MISC.
...DDER	STABILITY	1	(B) AT 85 KN. 85% δ_r. AT 75 KN. INSUFFICIENT RUDDER (HELD 10-12°). AT 65 KN. HELD 5-7°.	(A) ESSENTIALLY SAME AS PREVIOUS FLIGHT. (B) NORMAL RECOVERY WITH GRADUAL RUDDER. SUDDEN RUDDER REVERSED DIRECTION OF BANK WITH PITCH AND SPEED INCREASE.	(A) INCREASING TENDENCY TO DROP NOSE WITH DECREASE IN SPEED.	(A) FORCES APPEARED HIGHER. (B) FROM RIGHT SLIP, REVERSAL IN DIRECTION OF FORCE AFTER WINGS PASSED LEVEL (WITH ALMOST 100% δ_r). FROM LEFT SLIP, NONE	(A) AILERONS TENDED TO RETURN TO NEUTRAL AT 120KN. TENDENCY REDUCED TO ZERO AT 80 KN. (B) AT 75 KN. SLIGHT REVERSAL AT 65 KN. DEFINITE REVERSAL.	(A) INITIAL TENDENCY TO YAW AGAINST BANK (B) MODERATE TAIL BUFFETING AT 85 KN.
...ISPLACED ...CK UP		2		(A) O.K. WITH SOME SKID. SHIP ENTERED NORMAL TURN AS WINGS PASSED THROUGH LEVEL. MORE SLUGGISH AT LOW SPEEDS. RECOVERY FROM LEFT SLIP MORE RAPID. (B) POSSIBLE AT ALL SPEEDS. SLUGGISH AT LOWER SPEEDS.		(A) LESS FORCE AND MORE δ_r NEEDED TO MAINTAIN SLIP AT LOW SPEED. (B) VERY HIGH, ESP. IN RIGHT SLIP.	(B) LESS FORCE TO MAINTAIN SLIP AT 85 KN. AILERONS BECAME HEAVY NEGATIVELY AT LOWER SPEEDS.	(A) RESPONSE TO CONTROL MOVEMENT WAS GOOD.
...IN ...UDDER ...UIRED TO ...00,80 KN. ...,65 KN.		3		(A) RECOVERED READILY WITH LITTLE ADDITIONAL RUDDER. VERY SLOW RECOVERY AT 80 KN. FASTER WITH FASTER APPLIED RUDDER. (B) MIGHT HAVE EVENTUALLY RECOVERED.	(A) NOSE UP RIGHT SLIP AND DOWN FOR LEFT SLIP (SLIGHT). MORE WITH FASTER APPLIED RUDDER. (B) DIVED. INCREASE OF 40 KN. INSUFFICIENT FOR RECOVERY.	(A) LESS FORCE AND MORE δ_r NEEDED TO MAINTAIN SLIP AT LOW SPEEDS.	(A) AT 120KN. AILERONS RETURNED 75% TO NEUTRAL.	(A) LITTLE OPPOSITE YAW. (B) MOTION IN ROLL DID NOT APPEAR TO BE DIVERGENT.
		4		(A) WINGS ROLLED PAST LEVEL AND SHIP ENTERED SPIRAL WITH INCREASING SPEED. MORE TIME NEEDED AT LOWER SPEEDS. 4 SEC (RIGHT SLIP) AND 8 SEC. (LEFT) AT 80KN. (B) NOTE: SAME AS (B) IN 3 ABOVE - 3 WAS CONDUCTED WITH FULL APPLIED RUDDER.	(A) NOSE DOWN. SPEED INCREASED. AT 100 KN. MORE FROM RIGHT SLIP. MORE AT LOWER SPEEDS 12-15 KN. AT 80KN. FROM LEFT SLIP.		(A) ZERO OR SLIGHTLY NEGATIVE AT 80KN.	
...EASED	STABILITY	1	(B) AT 85 KN. 65% δ_r RUDDER AND AILERON FORCES LIGHT. RUDDER FORCES LIGHTER IN RIGHT SLIP. AT 75 KN. 80% δ_r AILERON FORCES REVERSED. RUDDER FORCES LIGHT ESP. IN RIGHT SLIP. AT 65 KN. 100% δ_r AILERON AND RUDDER FORCES REVERSED. RUDDER FORCE ABOUT ZERO. AILERON FORCE HEAVY NEGATIVELY, ESP. IN LEFT SLIP. RIGHT SLIP δ_a IS TWICE LEFT SLIP δ_a.	(B) MODERATE SUCCESS AT 85KN. (3 SEC.) SUDDEN RUDDER CAUSED OVERBALANCE. MORE DIVE AND ROLLED BEYOND NEUTRAL. BETTER TO STEADILY APPLY RUDDER.	(B) AT 85 KN. DIVED AND GAINED SPEED (12-15 KN). DIVED MORE AT 75 KN. LESS AT 65 KN. (NO EXCESS RUDDER).	(B) APPROACHES ZERO OR OVERBALANCE AT 95% δ_r.		
		2		(B) DEFINITE AND RAPID AT 85 KN. ROLLED THROUGH NEUTRAL AND ENTERED NORMAL TURN.	(B) AT 85KN. PRACTICALLY NO CHANGE. AT 65 KN. TENDENCY FOR NOSE UP WITH LEFT SLIP AND NOSE DOWN WITH RIGHT.			
		3		(A) SEEMED SATISFACTORY DOWN TO 80KN. (B) ENTERED VIOLENT DIVE WITH NEGATIVE ACCELERATION. UNDESIRABLE AND DISAGREEABLE RECOVERY AT 85 KN. - NO RECOVERY AT 65 KN. RIGHT SPIRAL FROM RIGHT SLIP.	(B) 25-30 KN. AT 85. MORE DIVE FROM RIGHT SLIP.			(A) LITTLE CHANGE IN HEADING. (B) INITIALLY YAWED AGAINST BANK.
		4		(A) SLOW RECOVERY FROM LEFT SLIP AT 80 KN. FROM RIGHT SLIP A TENDENCY TO RECOVER WAS NOTED. (B) EVENTUALLY RECOVERED FROM LEFT SLIP AT 85 KN. APPEARED TO SPIRAL FROM RIGHT SLIP AT 85 KN. NO RECOVERY BELOW 85 KN.	(A) LITTLE TENDENCY TO PITCH. (B) DIVED AND RAPIDLY GAINED SPEED.	(A) LIGHT BUT POSITIVE.	(A) NEUTRAL OR SLIGHTLY NEGATIVE.	(A) LITTLE CHANGE IN HEADING.
...DDER EX-	STABILITY	1	(A) AT 100 KN. RUDDER FORCE ZERO AND AILERON FORCE LIGHT. LEFT SLIP REQUIRED POSITIVE RUDDER AND AILERON FORCES. AT 80 KN. FORCES DEFINITELY REVERSED (B) AT 85 KN. SAME AS FLIGHT NO. 7 EXCEPT LESS δ_r NEEDED. AT 75 KN. SAME AS FLIGHT 7.	(A) MODERATELY WELL. AT 100 KN. (2-3 SEC.) LESS POSITIVE AT 80 KN. (B) GOOD AT 85 KN. OK AT 75 KN. DIFFICULT AT 65 KN. ABOVE MORE SEVERE WITH RIGHT SLIP.	(A) GENTLE DIVE AND 10-12 KN. AT 100 KN. MORE PITCH AT 80 KN. (B) SLIGHT PITCH AT 85 KN. MORE SERIOUS DIVE AT 75 KN. LESS TENDENCY TO DIVE AT 65 KN. BUT PRONOUNCED PITCH. RIGHT SLIP MORE SEVERE.	(A) REVERSAL AT EXTREME THROWS. (B) REVERSED AT 85 KN. REVERSED AT 75 KN. REVERSED DANGEROUSLY AT 65 KN. RIGHT SLIP MORE SEVERE.	(B) NEUTRAL OR REVERSED AT 85 KN. REVERSED AT 75 KN. RIGHT SLIP MORE SEVERE.	(A) INITIAL YAW IN DIRECTION OF APPLIED RUDDER. OPPOSITE YAW AT 80 KN.
		2		(A) SAME AS FLIGHT NO. 7 FOR ALL SPEEDS. (B) SAME AS FLIGHT NO. 7 FOR ALL SPEEDS.				
		3		(A) READILY AT 100 OR 80 KN. SPEED INCREASE NECESSARY. FASTER FROM LEFT SLIP BUT NATURE OF RECOVERY BETTER FROM RIGHT SLIP. (B) SITUATION DANGEROUS DUE TO RUDDER REVERSAL.	(A) MODERATE PITCH. MORE FROM LEFT SLIP. (B) DIVED HARD AT ALL SPEEDS.	(B) DANGEROUS REVERSAL.		(A) OPPOSITE YAW DUE TO ADDITIONAL RUDDER.
		4		(A) POSITIVE BUT SLUGGISH DOWN TO 80 KN. FROM RIGHT SLIP AT 80 KN. WITH STICK FREE & RUDDER FIXED RECOVERY COULD BE EFFECTED. (B) SIMILAR TO FLIGHT NO. 7.	(A) DIVED AND GAINED ABOUT 15 KN.	(A) REVERSAL AT LOW SPEEDS. (B) REVERSED AT OR NEAR FULL THROW.	(A) REVERSAL (B) REVERSED BETWEEN 82-85 KN.	
...ECTED.	STABILITY			(B) MORE TIME TO EFFECT RECOVERY.	(B) MORE PRONOUNCED DIVE AND SPEED GAIN.	(B) REVERSAL AT LOW SPEED AND FULL THROWS UNCHANGED. MORE SEVERE USING LEFT RUDDER	(A) STEADY SLIP WITH ϕ = 15° OVERBALANCE AT 68 KN. IN LEFT SLIP AND 70 KN. IN RIGHT SLIP (B) STEADY SLIP WITH ϕ = 15° OVERBALANCE AT 75 KN. IN LEFT SLIP AND 65 KN. IN RIGHT SLIP	
...NGE	STABILITY		(B) 15° ϕ - LEFT SLIP AT 65 KN. RIGHT SLIP AT 55 KN.	(A) WINGS RECOVERED FROM SLIP READILY.	(A) MODERATE PITCH. (B) LESS THAN (A).	(A) REVERSAL AT 75 KN. RIGHT SLIP 90% δ_r AND AND AT 70 KN. LEFT SLIP 100% δ_r - REVERSAL SLIGHTLY REDUCED FROM PREVIOUS FLIGHT. (B) REVERSAL GREATER IN RECOVERY FROM RIGHT SLIP THAN LEFT SLIP	CHANGE OF ϕ BY 20 LB. CONTROL FORCE FOR 5 SEC. RIGHT ϕ 52°, 52°, 55° LEFT ϕ 50°, 50°, 50°	(A) MODERATE YAW AGAINST BANK.
...SED ½". ...ON ...ADING ...URFACE	STABILITY					(A) NO OVERBALANCE DOWN TO SPEEDS AS LOW AS POSSIBLE. (STALL) - 15° ϕ AND STEADY SLIP. THIS WAS FOR GEAR AND FLAPS UP. (B) NO OVERBALANCE IN LEFT SLIP. OVERBALANCE BELOW 75 KN WITH 85% δ_r IN RIGHT SLIP.	AS IN FLIGHT NO. 11 RIGHT ϕ 48°, 48°, 50°, 45° LEFT ϕ 58°, 55°, 55°, 55°	
...ASED.	STABILITY					(B) NO OVERBALANCE DOWN TO 60 KN. IN LEFT SLIP. IN RIGHT SLIP OVERBALANCE BELOW 75 KN. AND 85% δ_r.		WIDTH INCREASED TO PREVENT OVERBALANCE.
...RONS. ...AGE. ...UNT. FIG. 3F	STABILITY					(B) CONTROL FORCES HEAVY THROUGH FULL RANGE. OVERBALANCE TO LEFT ONLY AT 60 KN.	(B) CONTROL FORCES HEAVY THROUGH FULL RANGE. FOR FLAPS AND GEAR DOWN, OVERBALANCED AT 65 KN. IN 15° BANK TO LEFT AND 10° BANK TO RIGHT.	
	STABILITY					SLIGHT REDUCTION IN FORCE.	NO APPARENT CHANGE IN FORCE.	
	STABILITY	1	(B) AT 75 KN. FULL LEFT RUDDER TO HOLD 15° BANK.	(A) AT 120 KN. RECOVERED READILY FROM EITHER DIRECTION. AT 100 KN. FAIR RECOVERY. AT 80 KN. SLOW RECOVERY. (B) NO RECOVERY IN LEFT SLIP.	(A) SLIGHT TENDENCY TO DROP NOSE. NO SPEED GAINED AT 120 KN. (B) 3 KN. AT 85 KN.	(A) AT 100 KN. SLIGHT TENDENCY TO REVERSE AT 80 KN. LEFT RUDDER JUST OVER-BALANCED, BUT EASILY CORRECTED. RIGHT RUDDER BUFFETED BUT DID NOT OVERBALANCE. (B) AT 85 KN. RIGHT RUDDER BUFFETED. LEFT RUDDER REVERSED. AT 75 KN. RIGHT RUDDER REVERSED.		(A) AT 120 KN. LITTLE CHANGE IN HEADING.
		2		(A) DIFFICULT TO HOLD RIGHT WING DOWN. RECOVERY EXCELLENT AT LOWER SPEEDS BUT SLOWER. (B) RECOVERY SAME AS IN EARLIER TESTS.		(A) RUDDER HEAVY. (B) AT 75 KN. OVERBALANCED, LEFT OR RIGHT. IN 15° SLIP RUDDER OVERBALANCED. AT LESS THAN 90% THROW, RUDDED BUFFETED	(A) AILERON HEAVY AT 75 KN. AILERONS REMAINED DISPLACED DID NOT RETURN TO ℄. (B) OVERBALANCED, AT 72 KN. LEFT, AT 7? KN. RIGHT.	
		3		(A) RECOVERED READILY BUT SLOWLY AT LOW SPEEDS.	(A) FROM RIGHT SLIP DROPPED NOSE. (B) DIVED HARD.	(A) AT 75 KN. RUDDER REMAINED DISPLACED AT 65% THROW, LEFT OR RIGHT. STILL SOME RUDDER POWER LEFT. (B) BUFFETED AND REVERSED. BUT NOT AS BAD AS EARLIER TESTS.		
		4		(A) RECOVERED AS IN TEST 3, BUT MORE SLOWLY. ENTERED REVERSE SPIRAL WITH SKID. AT SLOW SPEEDS RECOVERED MORE QUICKLY FROM RIGHT THAN LEFT SLIP. (B) TOOK TOO LONG FOR WING TO RECOVER.	(A) FROM RIGHT SLIP DROPPED NOSE. 6 KN GAIN IN SPEED. (B) DIVED MODERATELY. LESS PITCH FROM RIGHT.			
...F CONNECTED ...NCTED TO ±25 ...FFERENT- ...WN.	STABILITY		AT 68 KN., 100% δ_r IN RIGHT. AT 78 KN., 100% δ_r IN LEFT.			REDUCED FROM PREVIOUS FLIGHT. STILL SLIGHTLY HEAVY BUT CONSIDERED O.K. NO REVERSAL TO RIGHT BUT BAD REVERSAL TO LEFT BELOW 80 KN.	TOO HEAVY FROM 150 - 200 KN. WITH FLAP AND GEAR UP, REVERSED AT 68 KN.	
...(ORIGINAL). ...ST POSITION ...STALLED.	STABILITY		(B) AT 78 KN. FULL LEFT. AT 60 KN. FULL RIGHT. FOR POWER OFF AT 85 KN FULL LEFT OR RIGHT.			OVERBALANCE, LEFT AT 86% δ_r AND RIGHT AT 100% δ_r.	REVERSED AT 76 KN. LEFT AND AT 74 KN. RIGHT. STILL HEAVY.	

FOLD-OUT #2

TABLE V (CONT'D): FLIGHT TEST SUMMARY ON LATER

FLIGHT LOG					CONFIGURATION															
					VERTICAL SURFACE									AILERON						
DATE	FL'T. NO.	PILOT & OBSERVER	GROSS WEIGHT	C.G.	S_r	S_r	S_{br}	St_r	B_r	# STR. 46	NOSE SHAPE	δr	FIGURE	S_a	S_{ba}	B_a	# STR. 102	δa	FIGURE	CHANGE
9-13-39	III:6	2 & 1	7039 * (210 GAL.)	28.5	25.3	15.46	2.32	.84	.150	5 11/16	ELLIPTICAL	±30	4f,5	19.72	5.56	.282	5 1/4	-27,13	6c,7	RUDDER BALANCING TAB ACTION REM
9-13-39	III:7	2 & 1	7039 * (210 GAL.)	28.5	25.3	12.66	2.32	.84	.183	5 11/16	ELLIPTICAL	±30	4e,5	19.72	5.56	.282	5 1/4	-27,13	6c,7	TAIL CONE ATTACHED TO FUSELAGE. BALANCE CONNECTED.
9-14-39	III:8	2 & 11	70 39 * (210 GAL.)	28.5	25.3	12.66	2.32	.84	.188	5 15/16	ELLIPTICAL	±30	4e,5	19.72	5.56	.282	5 1/4	-27,13	6c,7	AILERON BALANCE TAB CONNECTED.
9-14-39	III:9	2	7089 * (210 GAL.)	28.5	25.3	12.66	2.32	.84	.188	5 15/16	ELLIPTICAL	±30	4e,5	19.57	5.71	.292	5 3/8	-27,13	6c,7	AILERON # MOVED 1/8" AFT. AILERON TAB CHANGED TO TRIM TAB.
9-15-39	III:10	2	7089 * (210 GAL.)	28.5	25.3	12.78	2.20	.84	.172	5 11/16	ELLIPTICAL	±30	4e,5	19.42	5.86	.302	5 1/2	-27,13	6c,7	RUDDER # MOVED 1/4" FORWARD. (1" FOR MAIN SPAR.) RUDDER BALANCE TAB A TO SECOND HOLE. AILERON # MOVED 1/8" AFT.
9-16-39	III:11	2	7039 * (210 GAL.)	28.5	25.3	12.78	2.20	.84	.172	5 11/16	ELLIPTICAL	±30	4e,5	19.72	5.56	.282	5 1/4	-19 1/2,11	6c,7	AILERON # MOVED 1/4" FORWARD. NE CRANK INSTALLED.
9-19-39	III:16	4	6976 * (180 GAL.)	27.3	25.3	12.78	2.20	.84	.172	5 11/16	ELLIPTICAL	±30	4e,6	19.72	5.56	.282	5 1/4	-17,10	6d,7	AILERON AND # MOVED AFT 1/2". AILE CHANGED PRIOR TO FLIGHT 14.
9-21-39	III:22 23	4	7598 1000# (115 GAL.)	27.3	24.5	11.94	2.20	0	.184	5 11/16	ELLIPTICAL	±30	4g,5	19.72	5.56	.282	5 1/4	-17,10	6d,7	RUDDER TAB COMPLETELY REMOVED
9-22-39	III:24	4 & 11	7598 1000# (115 GAL.)	27.3	25.3	12.78	2.20	.84	.172	5 11/16	ELLIPTICAL	±30	4e,5	19.72	5.56	.282	5 1/4	-17,10	6d,7	RUDDER TRIM TAB INSTALLED. SPRIN DEVICE ATTACHED TO AILERON CONTR
10-6-39	IV:1	4	6260 * (210 GAL.)	24.4	21.8	9.24	2.20	.60	.238	5 11/16	ELLIPTICAL	±30	4h,5	18.02	5.62	.312	5 1/4	-17,10	6e,7	RUDDER CHORD REDUCTION (8" AT TIP, AILERON CHORD REDUCTION (1 1/2").
10-7-39	IV:4,5	4; 4 & 1	7030 * (210 GAL.)	28.1	21.6	9.04	2.20	.40	.244	5 11/16	BLUNT	±30	4i,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	ORIGINAL WOODEN NOSE (BLUNT) REPLACEL NOSE. NOSE RIVETS FAIRED OVER. INSTALLEL STANT CHORD TAB. TAB DEFLECTION INCREI AILERON AND # MOVED 1/2" FORWARD TO
10-7-39	IV:6	4 & 1	7020 * (210 GAL.)	28.1	21.8	9.24	2.20	.60	.238	5 11/16	BLUNT	±30	4j,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	INSTALLED RUDDER TAB OF FL'T. IV:(
10-7-39	IV:7	2	—	—	21.8	9.24	2.20	.60	.238	5 11/16	BLUNT	±30	4j,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	CHANGED C.G.
10-7-39	IV:8	4	6216 * (100 GAL.)	23.4	21.8	9.24	2.20	.60	.238	5 11/16	BLUNT	±30	4j,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	
10-8-39	IV:9	4 & 1	7019 * (210 GAL.)	28.1	21.8	9.24	2.20	.60	.238	5 11/16	BLUNT	±30	4k,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	TAIL CONE REWORKED TO CONFORM TO RU ATTACHED TO FUSELAGE. TOP OF CONE FL
10-8-39	IV:10	4 & 6	6899 * (210 GAL.)	28	21.8	11.64	2.20	.60	.189	5 11/16	BLUNT	±30	4l,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	TAIL CONE ATTACHED TO RUDDER.
10-8-39	IV:11	4 & 5	6809 * (210 GAL.)	27.7	21.8	11.64	2.20	60	.189	5 11/16	ELLIPTICAL	±30	4m,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	BLUNT RUDDER NOSE REPLACED WITH NOSE OF FL'T. IV:(1).
10-8-39	IV:12	4 & 13	6749 * (210 GAL.)	27.8	21.8	9.24	2.20	.60	.238	5 11/16	ELLIPTICAL	±30	4n,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	TAIL CONE ATTACHED TO FUSELAGE.
10-9-39	IV:13	4	7019 * (210 GAL.)	28.1	21.8	9.24	2.20	.60	.238	5 11/16	ELLIPTICAL	±30	4n,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	TOP OF TAIL CONE FLUSHED WITH CARDBO HINGE CUTOUTS COVERED. PUTTY ADDED T L.E. TO SMOOTH OVER SCREWS FOR BAL. WT. ATT LEFT AILERON "DROOPED" ONE FULL T
10-28-39 TO 11-6-39	V:1	2	7330 * (210 GAL.)	29.6	21.8	9.24	2.04	.60	.221	5 11/16	ELLIPTICAL	±30	4o,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	XBT-2 AS DELIVERED TO ANACOSTIA
	V:2	2	7330 * (210 GAL.)	29.6	22.6	9.24	2.04	.60	.221	5 11/16	ELLIPTICAL	±30	4p,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	SMALL FIN EXTENSION.
	V:3	2	7330 * (210 GAL.)	29.6	23.5	9.24	2.04	.60	.221	5 11/16	ELLIPTICAL	±30	4q,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	LARGE FIN EXTENSION REPLACED SM
	V:4	2	7330 * (210 GAL.)	29.6	23.9	9.61	2.04	.97	.210	5 11/16	ELLIPTICAL	±30	4r,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	TAB EXTENDED.
	V:5	2	7330 * (210 GAL.)	29.6	23.0	9.61	2.04	.97	.210	5 11/16	ELLIPTICAL	±30	4s,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	SMALL FIN EXTENSION REPLACED LA DORSAL FIN ADDED. (4.0 SQ. FT.).
	V:6	2	7330 * (210 GAL.)	29.6	23.3	9.88	2.04	.97	.207	5 11/16	ELLIPTICAL	±30	4t,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	RUDDER REWORKED FOR EXTENDED
	V:7	2	7330 * (210 GAL.)	29.6	24.2	9.88	2.04	.97	.207	5 11/16	ELLIPTICAL	±30	4u,5	18.02	5.62	.312	5 1/4	-17,10	6f,7	LARGE FIN EXTENSION REPLACED SM. DORSAL FIN REMOVED.

* ALL CONDITIONS NOT NOTED ARE EITHER SCOUT OR BOMBER, WITHOUT BOMB, LOADINGS.

FOLD-OUT #1

AL, DIRECTIONAL STABILITY AND CONTROL

	TEST	SPEED AND RUDDER TO MAINTAIN BANK IN STEADY SLIP.	TEST RESULTS: RECOVERY	SPEED INCREASE DUE TO ADDITIONAL RUDDER DEFLECTION - PITCH	RUDDER FORCE (OVERBALANCE)	AILERON FORCE (OVERBALANCE)	MISC.
OVED.	STABILITY	(A) AT 78 KN. FULL LEFT. AT 64 KN. FULL RIGHT. FOR POWER OFF AT 82 KN. LEFT AND 78 KN. RIGHT. (B) AT 71 KN. FULL LEFT. AT 58 KN. FULL RIGHT. FOR POWER OFF AT 82 KN. LEFT AND RIGHT.	*NOTE: DEFINITION OF TESTS 1, 2, 3 AND 4. FROM STEADY SLIP WITH 15° ANGLE OF BANK: (1) MAINTAINED COURSE WITH RUDDER AND HELD STICK IN THE DISPLACED POSITION REQUIRED TO MAINTAIN THE SLIP. ATTEMPTED TO PICK UP WING WITH USE OF RUDDER ALONE. (2) RETURNED STICK TO NEUTRAL AND HELD. KEPT RUDDER FIXED IN POSITION REQUIRED FOR STEADY SLIP. NOTED MOTION. (3) RELEASED STICK AND ATTEMPTED TO PICK UP WING WITH RUDDER ALONE. NOTED MOTION. (4) RELEASED STICK AND MAINTAINED RUDDER IN POSITION REQUIRED TO HOLD STEADY SLIP. NOTED MOTION. PERFORMED ABOVE TESTS WITH (A) FLAPS AND GEAR UP AT V_i = 120, 100, 80 KNOTS. PERFORMED ABOVE TESTS WITH (B) FLAPS AND GEAR DOWN AT V_i = 85, 75, 65 KNOTS.		POWER ON: DEFINITE REVERSAL WITH LEFT AND AND SLIGHT WITH RIGHT. POWER OFF: SLIGHT WITH LEFT AND NONE WITH RIGHT. RUDDER FORCES SLIGHTLY HIGHER THAN FLIGHT NO.5.	SATISFACTORY FORCES IN NORMAL RANGE OF OPERATION.	
RUDDER	STABILITY				RUDDER FORCES LESS THAN FLIGHT NO.6. RUDDER POWER ABOUT SAME. REVERSAL LESS SEVERE.		
	STABILITY	(A) AT 86 KN. FULL LEFT. AT 74 KN. FULL RIGHT. (B) AT 90 KN. FULL LEFT. AT 85 KN. FULL RIGHT.			FORCES OK. BUT SLIGHTLY HEAVY. POWER ON, UNDER 90 KN. BAD REVERSAL WITH LEFT RUDDER.	FORCES OK. IN NORMAL RANGE. (60 - 150 KN.) HEAVY FROM 150 - 200 KN. REVERSAL OCCURED AT HIGHER RATE. FORCES TO LEFT, LIGHTER THAN TO RIGHT, DUE TO TAB ACTION.	
BALANCE	SPIN & STABILITY				REVERSAL SAME AS FLIGHT NO. 8.	FORCES HEAVY. (B) OVERBALANCED AT 85 KN. LEFT, 75 KN. RIGHT.	
WARD OF DJUSTED	STABILITY				SAME AS FLIGHT NO. 9.	FORCES HEAVY IN HIGH SPEED. OVERBALANCED AT ABOUT 2 KN. SLOWER THAN FLIGHT NO. 9.	
/ BELL	STABILITY				NO CHANGE.	REVERSAL OCCURRED AT 72 KN. RIGHT AND LEFT.	
ON THROW	STABILITY					FORCES LIGHTER THAN FLIGHT NO. 11. REVERSED AT 72 KN. LEFT AND 68 KN. RIGHT.	
	STABILITY						
G CENTERING L SYSTEM.	STABILITY						NAVY PILOT COMMENT AFTER CHECK FLIGHT (CONFIGURATION OF FLIGHTS (III : 20, 21): LATERAL STABILITY CHARACTERISTICS INSUFFICIENTLY IMPROVED. SUGGEST POSSIBILITY OF FURTHER IMPROVEMENT BE INVESTIGATED.

	TEST	RUDDER FORCE. (OVERBALANCE)	AILERON FORCE (OVERBALANCE)	MISC.	COMMENTS
	CHECK				
ELLIPTICAL NEW CON- SED. EDUCE GAP.	STABILITY				
).	STABILITY				
	STABILITY				
DDER CHORD. USHED.	STABILITY	RUDDER ACTION & EFFECTIVENESS UNCHANGED OVER LAST FLIGHT. RUDDER OVERBALANCED AT ANY SPEED (FULL THROWS) - WORSE WITH FULL LEFT RUDDER - UNDESIRABLE OVERBALANCE AT LOW SPEEDS WITH FULL LEFT RUDDER.	DEFINITE REDUCTION IN AILERON EFFECTIVENESS AT SPEEDS BELOW 70 KN. BUT DID NOT PREVENT RECOVERY FROM SLIP.		
	STABILITY	RUDDER ACTION WORSE. MORE SEVERE OVERBALANCE, ESPECIALLY AT LOW SPEEDS. HIGHER CONTROL FORCES. SOMEWHAT IMPROVED RUDDER POWER.			
ELLIPTICAL	STABILITY	DEFINITE IMPROVEMENT IN OVERBALANCE CONDITION AT ALL SPEEDS, ESPECIALLY AT LOW SPEEDS. LOW SPEED OVERBALANCE DEPENDED ON TRIM TAB SETTING.		PILOT CONSIDERED RUDDER ABOUT SAME AS IN FLIGHT NO. 1.	
	STABILITY	BEST RUDDER CONDITION. LESS RUDDER POWER. BETTER ACTION, LESS OVERBALANCE & BUFFETING TENDENCY.		BEST VERTICAL SURFACE COMBINATION OBTAINED TO DATE.	
RD. RUDDER RUDDER ACHMENT. IRN.	STABILITY	NO NOTICEABLE CHANGE.	NO CHANGE IN FEEL.	MARGINAL BUT POSITIVE RECOVERY FROM SLIPS.	FINAL ARRANGEMENT - AILERONS THE CONFIGURATION OF PHASE IV WAS FINAL EXCEPT FOR THE ADDITION OF UPPER SURFACE WING-TO-AILERON EXTENSION STRIPS. FOR COMPARISON BETWEEN FINAL AND ORIGINAL AILERONS SEE FIGURES 3f, 6a, 6j AND 7.

	TEST	MINIMUM SPEED FOR DIRECTIONAL STABILITY (RUDDER DISPLACED 10° AND RELEASED, MAINTAINING LAT. AND LONG. TRIM WITH STICK).	RUDDER FORCES, REVERSAL AND OVERBALANCE.	RUDDER TRIM	LATERAL STABILITY
	STABILITY. (CRUISING POWER. F.&G. DN. COWL FLAPS OPEN).	85 KN. (RUDDER FREE) 68 KN. (RUDDER FIXED)			
		72 KN. (RUDDER FREE)			
ALL.		68 KN. (RUDDER FREE)	REVERSAL WITH POWER ON AND OFF (AT ANY SPEED BELOW 110 KN. AND 100% RUDDER THROW. RUDDER REMAINED AT 100% THROW). FORCES WERE LIGHTER ESPECIALLY WITH POWER OFF.		
		65 KN. (RUDDER FREE)	REVERSAL CONSIDERED PROHIBITIVE.	COULD NOT TRIM RUDDER BELOW 68 KNOTS.	DECREASED.
RGE.		63 KN. (RUDDER FREE)	NO REVERSAL. FORCES LIGHT. RUDDER POWER DECREASED.	SATISFACTORY BUT CONFUSED BY REVERSAL.	
TAB.		65 KN. (RUDDER FREE)	NO REVERSAL. FORCES INCREASED OK WITH ADDITION TO RUDDER.	TAB EFFECTIVENESS SHOULD BE INCREASED.	DECREASED FROM 62 TO 65 KNOTS.
LL.		F.& G. DN, POWER OFF, HOODS OPEN 82 KN. F.& G. UP, POWER ON, HOODS CLOSED 70 KN. POWER OFF 90 KN.	REVERSAL STILL PRESENT. NOT SATISFACTORY	MORE POSITIVE BUT NOT AT LOWER SPEEDS.	SAME AS PREVIOUS TEST.

NAVY COMMENTS PRIOR TO FLIGHT (V:1) 210 GAL. SCOUT LOADING G.W. = 7330 C.G. 28.6 % MAC.

SATISFACTORY LATERAL STABILITY HAS BEEN PROVIDED. DIRECTIONAL STABILITY, ALTHOUGH SATISFACTORY AT HIGH SPEEDS, IS MARGINAL IN THE CARRIER LANDING CONDITION WITH FLAPS AND GEAR DOWN, CRUISING POWER. IN THIS CONDITION THE INCREASED DIHEDRAL CAUSES MORE ROLL THAN DESIRABLE FOR A GIVEN AMOUNT OF YAW. THE RUDDER HAS A TENDENCY TOWARD AN UNDESIRABLE FORCE REVERSAL NEAR FULL THROW. POSITIVE DIRECTIONAL STABILITY AND TRIM ARE DESIRED IN THE CARRIER LANDING CONDITION DOWN TO 65 KNOTS WITH RUDDER FREE. (RECOMMENDED RETURN TO CONTRACTORS' PILOT FOR ADDITIONAL TESTS OF PHASE V).

FINAL ARRANGEMENT - VERTICAL SURFACES.

THE CONFIGURATION OF (V:6) WAS ACCEPTED AS SATISFYING ALL STABILITY AND CONTROL REQUIREMENTS EXCEPT RUDDER TRIM IN LANDING CONDITION. MINOR REVISIONS FROM THIS CONFIGURATION HAVE BEEN MADE IN THE PRODUCTION SBD-1 MODEL: THE RUDDER TRIM TAB SPAN HAS BEEN INCREASED AND THE DORSAL FIN LINES HAVE BEEN REFAIRED TO GIVE 3.4 SQ.FT. RATHER THAN 4.0 SQ.FT. AS ON (V:6) AND THE RUDDER BALANCE NOSE SHAPE HAS BEEN MODIFIED. WITH THE ABOVE ARRANGEMENT THE TAIL CONE IS FIXED TO THE FUSELAGE. FOR A COMPARISON BETWEEN FINAL AND ORIGINAL VERTICAL SURFACES, SEE FIGURES 3c, 4a, 4v AND 5.

FOLD-OUT #2

TABLE VI: FLIGHT TEST SUMMARY ON LONGITUDINAL STABILITY AND CONTROL

FLIGHT LOG					HORIZONTAL SURFACE CONFIGURATION											TEST RESULTS			
DATE	FL'T NO.	PILOT & OBSERVER	GROSS WEIGHT	C.G.	S_H	S_e	S_{b_e}	S_{t_e} TRIM	S_{t_e} BAL.	B_e	H/L (STA 46)	NOSE SHAPE	δ_e	FIGURE	CHANGE	TEST	ELEVATOR FORCES	MISC.	COMMENTS*
6-5-39	I:2	3 & 1	7566 * (210 GAL.)	27.7	66.6	20.29	4.21	2.3	.8	.207	3 19/32	BLUNT	-32,25	8a,9	ORIGINAL XBT-2 (BAL. TAB RATIO = 1:1)	STABILITY	NAVY COMMENTS PRIOR TO PHASE D: AS OVERLOAD SCOUT WITH GROSS WEIGHT 7,407 POUNDS AND C.G. AT 28.7% M.A.C., DYNAMIC LONGITUDINAL STABILITY: BARELY POSSIBLE AT HIGH SPEEDS WITH FREE CONTROLS. OSCILLATIONS ARE EXCEEDINGLY SLOW IN DAMPING. STATIC LONGITUDINAL STABILITY: UNSTABLE AT LOW SPEEDS IN THE LANDING CONDITION WITH ELEVATOR FREE. NO RECOVERY FROM AN APPLIED DIVING OR STALLING MOMENT. CONTROLLABILITY: GENERALLY SIMILAR TO THE BT-1 AND XBT-2. THE SMALL STICK MOVEMENT TO PRODUCE A STALL IN THE XBT-2 APPEARS FURTHER REDUCED WITH THE INCREASED WING LOADING (NORMAL SCOUT LOADING, WEIGHT AT 6,977 POUNDS, C.G. AT 26.6% M.A.C.) RECOMMENDATIONS: IMPROVE LONGITUDINAL STABILITY FOR THE HIGH SPEED AND LANDING CONDITIONS. MAKE NECESSARY CHANGES TO INCREASE ELEVATOR MOVEMENT FOR STALL IN THE LANDING CONDITION.		DYNAMIC STABILITY WAS POSITIVE FROM 100 TO 180 KNOTS. STATIC INSTABILITY IN LANDING CONDITION WAS PRESENT BELOW 80 KNOTS. EFFECT OF 2 -.50 CALIBER FIXED GUNS INSTEAD OF 1 - .50 CALIBER FIXED GUN CHANGED CG LOCATION TO 27.7 % M.A.C.
7-17-39	II:1	3 & 1	7281 * (210 GAL.)	27.7	66.6	20.29	4.21	2.3	.8	.207	3 19/32	BLUNT	-32,25	8a,9		STABILITY	STICK FORCE & δ_e VS. V_i. FIGURE 10, 16.	NOTE: THE XBT-2 MODEL WAS PROVISIONALLY ACCEPTED BY THE NAVY. THE ABOVE RECOMMENDATIONS WERE TO AFFECT ALL FUTURE BT-2 PRODUCTION AIRPLANES BUT NOT THE XBT-2 AT THIS TIME	NAVY COMMENTS PRIOR TO PHASE II: LONGITUDINAL STABILITY MARGINALLY ACCEPTABLE AT SPEEDS 5-10 M.P.H. ABOVE STALL IN LANDING CONDITION. ELEVATOR MOVEMENT TO PRODUCE STALL TOO SMALL - APPROXIMATELY 1/3 TRAVEL FROM NEUTRAL TO FULL UP ELEVATOR.
7-17-39	II:2	3 & 1	7281 * (210 GAL.)	27.7	66.6	20.29	4.21	2.3	-	.207	3 19/32	BLUNT	-32,25	8a,9	DISCONNECTED BAL. TAB AND FIXED TO ELEVATOR.	STABILITY	STICK FORCE & δ_e VS. V_i FIGURES 10-12.		BALANCE TAB: BAL. TAB REDUCED F_s AND DECREASED STABILITY. MOST APPARENT IN FLAPS AND GEAR DOWN. POWER IDLING CASE. C.G. MOVEMENT: CONSISTENT VARIATION OF F_s AND δ_e WITH C.G. CHANGE. F_s MOST SATISFACTORY IN 27.7% POSITION. SPAN INCREASE: F_s INCREASED WITH ADDITIONAL ELEVATOR AREA. δ_e FOR TRIM ONLY SLIGHTLY AFFECTED.
7-18-39	II:3	3 & 1	7061 * (210 GAL.)	25.7	66.6	20.29	4.21	2.3	-	.207	3 19/32	BLUNT	-32,25	8a,9	C.G. MOVED FORWARD	STABILITY	STICK FORCE & δ_e VS. V_i FIGURE 11.		
7-18-39	II:4	3 & 1	6451 * (100 GAL.)	21.2	66.6	20.29	4.21	2.3	-	.207	3 19/32	BLUNT	-32,25	8a,9	C.G. MOVED FORWARD.	STABILITY	STICK FORCE & δ_e VS. V_i FIGURE 11.		
7-26-39	II:9	2 & 1	7300 * (210 GAL.)	28.4	73.3	22.28	4.82	2.3	-	.216	3 19/32	BLUNT	-32,25	8b,9	2 FT. SPAN INCREASE. C.G. MOVED AFT	STABILITY	STICK FORCE & δ_e VS. V_i FIGURES 12, 13.		
7-31-39	II:14	2 & 1	7103 * (210 GAL.)	26.0	73.3	22.28	4.82	2.3	-	.216	3 19/32	BLUNT	±25	8b,9	UP ELEVATOR LIMITED TO 25°. C.G. MOVED FORWARD.	LANDING		FULL UP-ELEVATOR NOT REQUIRED	
7-31-39	II:15	2	6900 * (210 GAL.)	23.0	73.3	22.28	4.82	2.3	-	.216	3 19/32	BLUNT	±25	8b,9	C.G. MOVED FORWARD.	LANDING		FULL UP- ELEVATOR REQUIRED	
7-31-39	II:16	2	6620 * (180 GAL.)	21.2	73.3	22.28	4.82	2.3	-	.216	3 19/32	BLUNT	±25	8b,9	C.G. MOVED FORWARD	LANDING		FULL UP- ELEVATOR REQUIRED	
9-8-39	III:1	2	6267 * (105 GAL.)	24.4	75.7	23.11	4.79	3.3	-	.207	4	ELLIPTICAL	-25 1/2,25	8c,9	REBUILT SURFACES INCLUDING LARGER TRIM TAB.	STABILITY	F_s - HEAVY WHEN TRIMMED AT 110 KN. F_s REMAINED POSITIVE TO STALL.		ELLIPTICAL NOSE SHAPE: VARIATION OF F_s SHOWED BLUNT NOSE WAS ONE CAUSE OF UNDESIRABLE FORCE DECREASE NEAR STALL. F_s UNCHANGED WITH NEW NOSE AT OTHER SPEEDS. MECHANICAL ADVANTAGE INCREASE: 19% INCREASE EFFECTIVELY REDUCED F_s AT ALL SPEEDS.
9-9-39	III:2	2 & 1	7039 * (210 GAL.)	28.5	75.7	22.78	5.12	3.3	-	.225	4 1/4	ELLIPTICAL	-25 1/2,25	8c,9	C.G. AND H/L MOVED AFT	STABILITY	SLIGHT REDUCTION IN F_s.		
9-10-39	III:3	2 & 1	7039 * (210 GAL.)	28.5	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	±25	8c,9	H/L MOVED AFT	STABILITY	STICK FORCE & δ_e VS. V_i FIGURES 13-15.		
9-12-39	III:4	2 & 11	7039 * (210 GAL.)	28.5	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8c,9	δ_e LIMITED TO -22° & 20 1/2° SAME STICK TRAVEL.	STABILITY	STICK FORCE & δ_e VS. V_i FIGURE 14. F_s CONSIDERED OK.		
9-16-39	III:12	4	7748 1000# (100 GAL.)	29.1	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8c,9	C.G. MOVED AFT.	DIVE			
9-16-39	III:13	4	7748 1000# (100 GAL.)	29.1	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8c,9		DIVE			
9-17-39	III:14	4	7708 1000# (100 GAL.)	28.1	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8c,9	UP TAB DEFLECTION INCREASED BY 3°. C.G. MOVED FORWARD.	DIVE			
9-19-39	III:15	4	6976 * (180 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9	SPECIAL BAL. TAB (0 BAL. AT ±20° δ_e) INSTALLED.	STABILITY			
9-19-39	III:16	4	6976 * (180 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9		DIVE			
9-19-39	III:17	2	6976 * (180 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9		STABILITY			
9-20-39	III:18	4	7598 1000# (115 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9	DIVE FLAPS OPEN.	DIVE	PULLOUT F_s = 30 LBS. 6.95g PULLOUT (V-G.D.) TRIMMED IN DIVE.	V_i MAX = 265 KN. (V-G. DIAGRAM).	ELEVATOR CHORD REDUCTION: CONTROL FORCE MAGNITUDE CONSIDERABLY REDUCED FOR LEVEL FLIGHT, HIGH SPEED CONDITION TO COMPARE FAVORABLY WITH ORIGINAL (II:1). WITH FLAPS AND GEAR DOWN, POWER IDLING, CONTROL FORCES DID NOT HAVE CHARACTERISTIC DECREASE BELOW 80 KNOTS AS IN THE ORIGINAL CASE BUT CONTINUED TO INCREASE TO THE STALL. IN THIS CONDITION THE ELEVATOR ANGLE REQUIRED TO TRIM OVER A SPEED RANGE FROM 113 TO 70 KNOTS WAS INCREASED APPROXIMATELY 50% OVER THE ORIGINAL (II:1). REDUCTION IN AREA AFT HINGE LINE ALLOWED GREATER VARIATION IN AERODYNAMIC BALANCE AND CONTRIBUTED TO DECREASED F_s AS WELL AS POSSIBLE INCREASE IN STICK MOTION DURING STALL APPROACH.
9-20-39	III:19	4	7598 1000# (115 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9	DIVE FLAPS CLOSED.	DIVE	PULLOUT F_s = 40 LBS. 6.95g PULLOUT (V-G.D.). DIVE F_s = 10 LBS.	V_i MAX = 330 KN. (V-G. DIAGRAM).	
9-20-39	III:20,21	7	7598 1000# (115 GAL.)	27.3	75.7	22.44	5.46	2.5	.8	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8d,9	NAVY TESTS.	STAB & DIVE	NAVY PILOT COMMENT: INSUFFICIENT IMPROVEMENT. PROVIDE MORE ELEVATOR MOVEMENT AT STALL. F & G. DN.		
9-21-39	III:22,23	4	7598 1000# (115 GAL.)	27.3	75.7	22.44	5.46	3.3	-	.243	4 1/2	ELLIPTICAL	-22,20 1/2	8c,9	INSTALLED TAB OF (III:1.)	CHECK			
10-6-39	IV:1,2	4 & 2	6260 * (100 GAL.)	24.4	70.8	19.61	4.79	2.2	-	.244	4	ELLIPTICAL	-30,25	8e,9	REBUILT ELEVATOR WITH REDUCED CHORD.	CHECK			
10-6-39	IV:3	4	7080 * (210 GAL.)	28.1	70.8	19.61	4.79	2.2	-	.244	4	ELLIPTICAL	-30,25	8e,9	C.G. MOVED AFT.	STABILITY	STICK FORCE & δ_e VS. V_i FIGURE 15, 16.		
10-8-39	IV:9	4 & 1	7019 * (210 GAL.)	28.1	70.8	19.11	5.29	2.2	-	.277	4 3/8	RADIAL	-30,25	8f,9	BALSA NOSE FAIRING REWORKED FROM ELLIPTICAL TO RADIAL SHAPE ✧ H/L MOVED AFT.	STABILITY	NO REDUCTION IN F_s IN RECOVERING FROM DIVES.	NO SUBSTANTIAL CHANGE IN LONGITUDINAL STABILITY OR CONTROL AS MEASURED IN (IV:3)	✧ RADIUS = 1/2 SPAR DEPTH.
10-9-39	IV:13	4	7019 * (210 GAL.)	28.1	70.8	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-30,25	8g,9	H/L MOVED AFT. DIVE FLAPS CLOSED IN DIVE.	STAB. & DIVE	- PULLOUT F_s = 35 LBS. 5g PULLOUT. CONTROL FORCE VARIATION SATISFACTORY.	V_i MAX = 300 KNOTS.	
10-9-39	IV:15	4	6041 * (50 GAL.)	22.1	70.8	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-30,25	8g,9	C.G. MOVED FORWARD.	LANDING		THREE POINT LANDINGS WITH APPROX. 2" STICK MOTION UNUSED. CONSIDERED OK	
10-10-39	IV:17	4	7598 1000# (100 GAL.)	27.6	72.1	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-25,16	8h,9	C.G. MOVED AFT. ELEVATOR AND H/L MOVED 1 IN. AFT. δ_e LIMITED TO -25° AND 16°	STABILITY		FLAT SPOT IN ELEVATOR CONTROL. PROBABLY ENOUGH ELEVATOR CONTROL FOR FORWARD C.G. LANDINGS, BUT TESTS NOT CONCLUSIVE.	GAP CAUSED "FLAT SPOT" SO DIVING CONTROL FOR SMALL δ_e NOT AS GOOD.
10-10-39	IV:18	4	7598 1000# (100 GAL.)	27.6	70.8	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-25,16	8g,9	ELEVATOR & H/L MOVED 1" FORWARD	STABILITY			SURFACE CONSIDERED SATISFACTORY FOR DEMONSTRATION.
10-10-39	IV:19	2 & 11	7598 1000# (100 GAL.)	27.6	70.8	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-25,16	8g,9		CHECK			
10-11-39	IV:20,21	4	6041 * (50 GAL.)	22.1	70.8	18.61	5.79	2.2	-	.311	4 3/4	RADIAL	-25,16	8g,9		CHECK LANDING			
✣ 5-23-40	V:49	4	7987 500# (150 GAL.)	28.3	70.8	18.60	5.60	2.2	-	.301	4 3/4	ELLIPTICAL	-30,20	8i,9	PRODUCTION MODEL SBD-1 #1596. DIVE FLAPS CLOSED.	DIVE	F_s GREATER THAN ON XBT-2. 6.5g PULLOUT (V-G DIAGRAM) TRIMMED AT 320 KN.	V_i MAX = 340 KNOTS (V-G DIAGRAM).	PILOT RECOMMENDED REDUCTION IN F_s FOR 7.5g PULLOUT BY INCREASE IN B_e.
5-25-40	V:53	4	8110 500# (170 GAL.)	28.6	70.8	18.27	5.93	2.2	-	.325	5	ELLIPTICAL	-30,20	8j,9	H/L MOVED AFT. DIVE FLAPS OPEN.	DIVE	PULLOUT F_s = 40 LBS. 6.6g PULLOUT (V-G DIAGRAM)	V_i MAX = 290 KNOTS (V-G DIAGRAM).	F_s IN PULLOUT ACCEPTABLE WITH THIS H/L. DEFINITE TENDENCY TO OVERBALANCE AT LOW SPEEDS.
5-26-40	V:56	4	8434 1000# (180 GAL.)	28.6	70.8	18.44	5.76	2.2	-	.312	4 7/8	ELLIPTICAL	-30,20	8k,9	H/L MOVED FORWARD. DIVE FLAPS OPEN.	DIVE	TRIMMED IN DIVE. PULLOUT F_s = 40 LBS. 6.4g PULLOUT (V-G DIAGRAM)	V_i MAX = 295 KNOTS (V-G DIAGRAM)	TENDENCY TO OVERBALANCE AT LOWER SPEEDS AND IN ATTITUDE FOR CARRIER LANDING STILL PRESENT BUT IMPROVED.
5-26-40	V:58	4	8352 1000# (130 GAL.)	28.5	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	H/L MOVED FORWARD.	STABILITY	STICK FORCE VS. V_i. FIGURE 16. POWER OFF: SMALL STEADY INCREASE IN F_s WITH DECREASE IN AIRSPEED. POWER ON: DEFINITE REDUCTION IN F_s WITH AIRSPEED.		BEST COMPROMISE POSITION FOR F_s IN PULLOUT AND AT LOW SPEEDS.
5-28-40	V:62	4 & 10	8355 1000# (130 GAL.)	28.5	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	NAVY CHECK FLIGHT	CHECK	NAVY PILOT — "THE STICKFORCE VARIATION IS NOT BAD. THERE IS A NORMAL STICK TRAVEL AND FORCE DURING THE STALL APPROACH, BUT A SLIGHT REVERSAL SLIGHTLY PRIOR TO THE STALL - MORE FORCE IN THE ELEVATOR CONTROL AT THE STALL MIGHT REDUCE THE TENDENCY FOR A VIOLENT STALL BECAUSE OF AN INCREASE IN THE FORCE REQUIRED TO COMPLETE THE STALL - I WOULD MUCH RATHER IMPROVE THE STALL CONDITION IN AN UNACCELERATED STALL APPROACH CONDITION AND PERMIT A HIGH ELEVATOR CONTROL FORCE IN DIVE RECOVERY." (ON THIS BASIS H/L LEFT AT 4 13/16)		
5-29-40	V:72	4	8355 1000# (130 GAL.)	28.5	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	DIVE FLAPS 0°. DIVE FLAPS FULL OPEN	DIVE	TRIMMED IN DIVE. PULLOUT F_s = 60 LBS. 7.2g PULLOUT. (V-G DIAGRAM) F_s IN 6.8g PULLOUT NOT RECORDED.	V_i MAX = 320 KNOTS (V-G DIAGRAM). V_i MAX = 235 KNOTS (V-G DIAGRAM)	FINAL ARRANGEMENT - HORIZONTAL SURFACES: AT THE START OF PHASE V CONFIGURATION OF (IV:15) WAS ACCEPTED AS SATISFYING LONGITUDINAL STABILITY AND CONTROL REQUIREMENTS. MINOR REVISIONS HAVE BEEN MADE IN THE PRODUCTION SBD-1 MODEL: THE ELEVATOR BALANCE NOSE SHAPE MODIFIED, HINGE LINE MOVED AFT 1/16" AND THE ELEVATOR CUTOUT REPLACED WITH STABILIZER AREA. FOR A COMPARISON BETWEEN FINAL AND ORIGINAL HORIZONTAL SURFACES SEE FIGURES 3d, 8a, 8e AND 9. "NOSE UP" TRIM TAB TRAVEL INCREASED FROM 6° TO 12° FOR LANDING CONDITION ON PRODUCTION MODEL.
5-30-40	V:74	4	8095 500# (170 GAL.)	28.5	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	DIVE FLAPS 0°. DIVE FLAPS FULL OPEN	DIVE	PULLOUT F_s = 60 LBS. 7.6g PULLOUT (V-G DIAGRAM). TRIMMED IN DIVE. PULLOUT F_s = 40 LBS. 7.7g PULLOUT (V-G DIA).	V_i MAX = 310 KNOTS (V-G DIAGRAM). V_i MAX = 235 KNOTS (V-G DIAGRAM).	
5-28-40	VI:1	4	6992 * (100 GAL.)	25.5	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	SECOND SBD-1 AIRPLANE #1597. DIVE FLAPS FULL OPEN	DIVE	PULLOUT F_s = 60-70 LBS (EST) 7g PULLOUT. C.G. POSITION FORWARD 3%.	V_i MAX = 290 KNOTS	
5-29-40	VI:3	2	7172 * (100 GAL.)	27.3	70.8	18.52	5.68	2.2	-	.306	4 13/16	ELLIPTICAL	-30,20	8l,9	CHECK FLIGHT TO COMPARE WITH XBT-2 OF PHASE V	STABILITY	F_s TO STALL SBD-1 SLIGHTLY LIGHTER THAN XBT-2 (V:6). SBD-1 STICK TRAVEL NOT SUBSTANTIALLY INCREASED OVER XBT-2 (V:6) BUT IMPROVED OVER ORIGINAL (I:1).	THE STABILITY OF THE SBD-1 FAVORABLE WITH RESPECT TO XBT-2 (V:6). WITH CRUISING POWER, F & G. DN. THE LONGITUDINAL STABILITY WAS GOOD DOWN TO 65 KN. WITH POWER OFF F & G. DN. THERE WAS NOT ENOUGH TAB TO TRIM BELOW 105 KNOTS.	

* ALL CONDITIONS NOT NOTED ARE EITHER SCOUT OR BOMBER, WITHOUT BOMB LOADINGS.

✣ CONFIGURATION OF IV:21 USED THROUGHOUT PHASE V. - 210 GAL. SCOUT. G.W. = 7330, C.G. AT 29.6 % M.A.C.

NAVY COMMENTS AT START OF PHASE V: POSITIVE LONGITUDINAL STABILITY HAS BEEN PROVIDED IN THE OVERLOAD SCOUT CONDITION BUT SHOULD BE INCREASED ON THE PRODUCTION MODELS IF POSSIBLE. CONTROL COLUMN TRAVEL TO EFFECT A STALL IN THE LANDING CONDITION IS STILL SMALL WITH LIGHT ELEVATOR CONTROL FORCES. (ON PRODUCTION SBD-1 AIRPLANE ENGINE WAS MOVED 5 INCHES FORWARD TO KEEP REAR C.G. OF 210 GALLON SCOUT CONDITION NEAR 27.5% M.A.C. WHEN REFERRED TO XBT-2 M.A.C. OF 97.5 INCHES.)

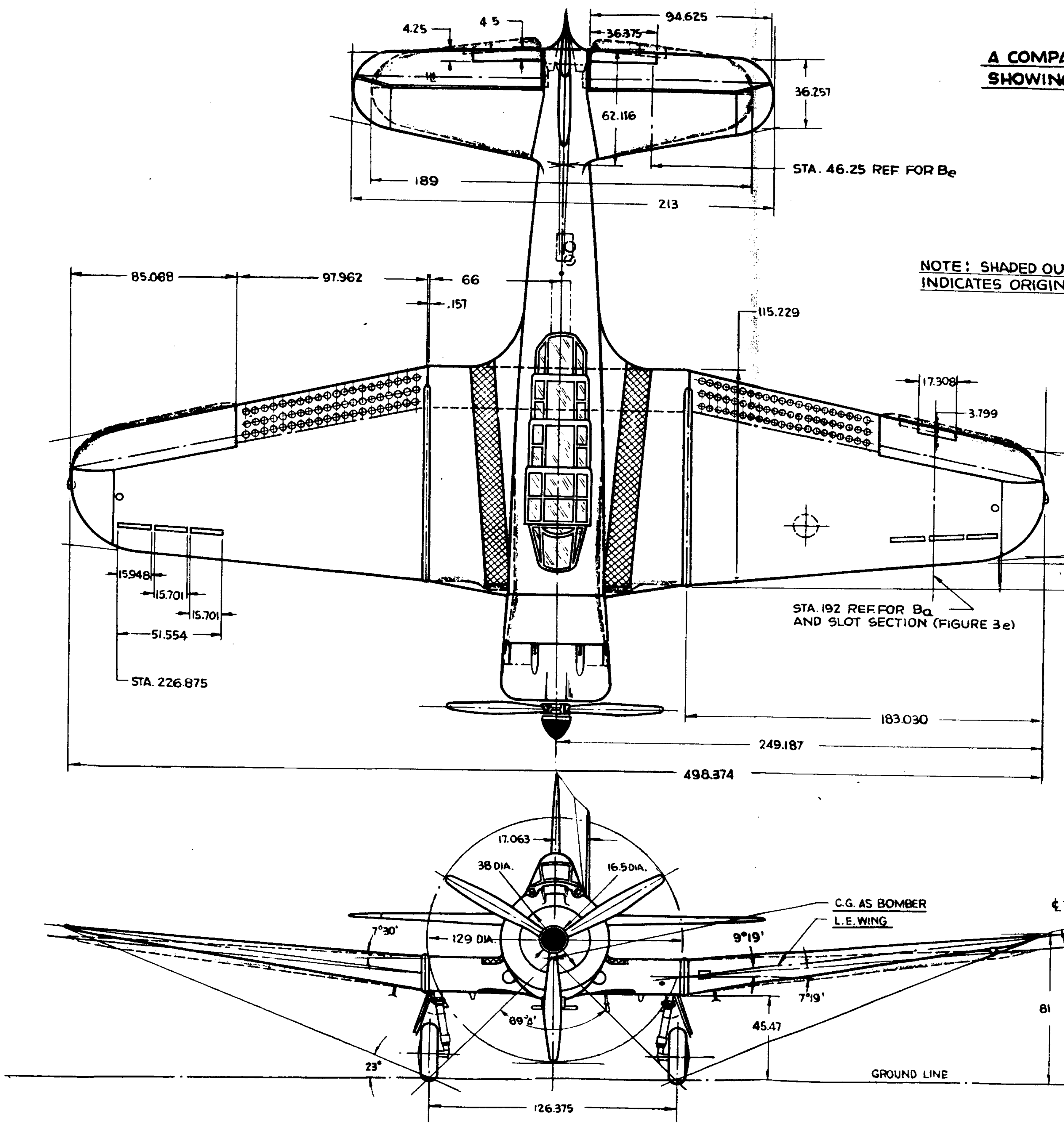
ACTUALLY THE INCREASED WING AREA OF THE SBD-1 CHANGED M.A.C. LENGTH AND LOCATION SUCH THAT C.G. IN 210 GALLON SCOUT CONDITION WAS AT 28.6 % WHEN REFERRED TO NEW M.A.C. OF 100 INCHES.

FIGURE I : MODEL SBD-1 THREE VIEW

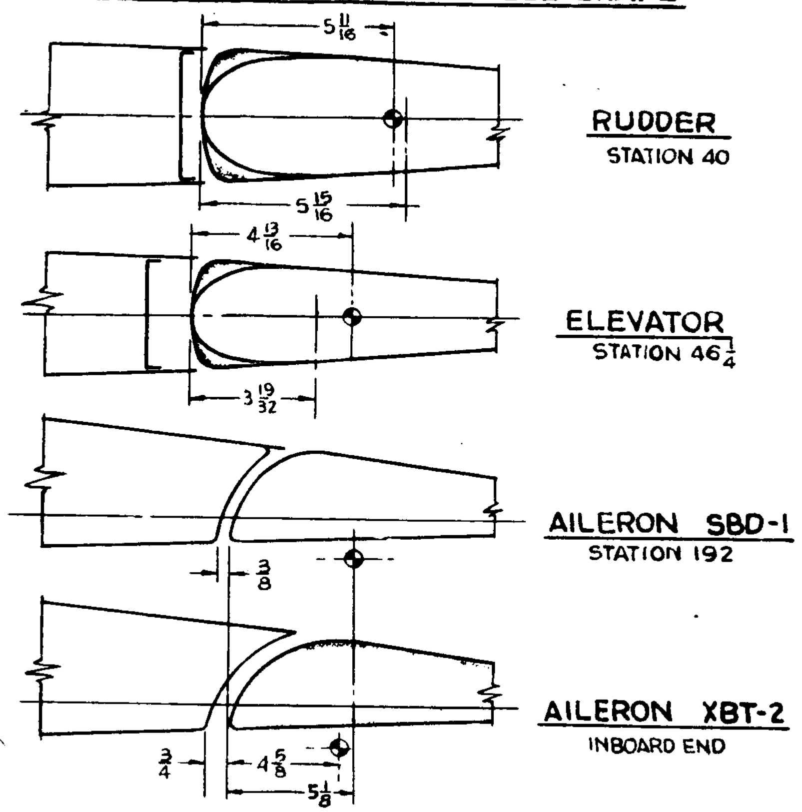
A COMPARISON BETWEEN ORIGINAL AND FINAL CONFIGURATIONS
SHOWING CONTROL SURFACE AND AERODYNAMIC BALANCE CHANGES
SCALE: 1"=60" **DIMENSIONS IN INCHES**
REFERENCE: FIGURES 21.22

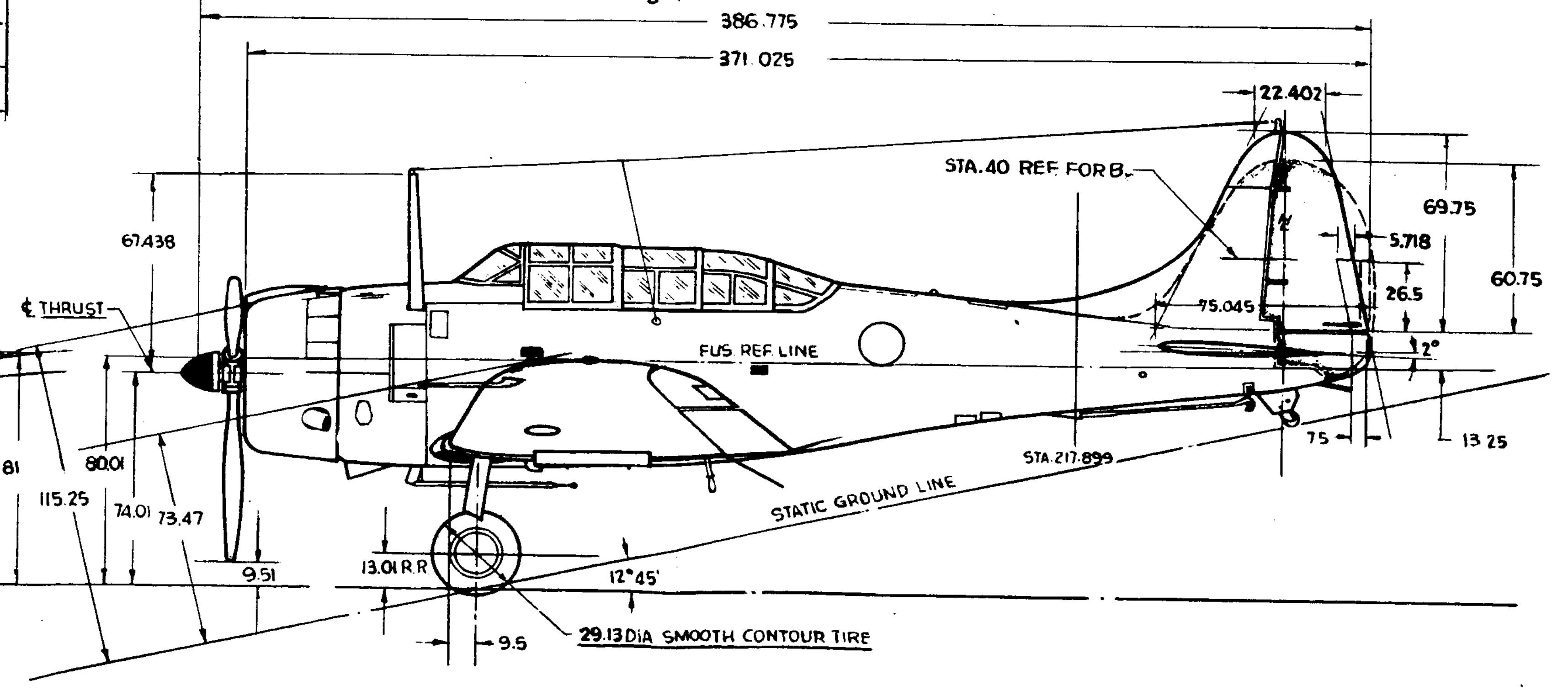
COMPARISON OF AREAS AND DESIGN RATIOS (AREAS IN SQ.FT.)	ORIGINAL XBT-2	FINAL SBD-1
Γ	7°19'	9°19'
S_W	321.5	325.0
S_H	66.6	70.8
S_{He}	55.9	61.8
S_e	20.29	18.52
S_{te}	2.3 + 0.8	2.2
B_e	0.207	0.306
AR_H	3.72	4.45
S_e/S_{He}	0.363	0.300
S_H/S_W	0.207	0.218
l_H/t_W	2.39	2.39
S_{Wa}	80.6	79.0
S_a	20.7	18.2
S_{ta}	0.94	0.47
B_a	0.199	0.302
S_a/S_{Wa}	0.257	0.230
S_a/S_W	0.064	0.056
$2b_a/b_W$	0.34	0.34
$2l_a/b_W$	0.81	0.81
S_V	22.6	23.1
S_r	13.0	9.9
S_{tr}	0.8	1.2
B_r	0.162	0.207
AR_V	1.13	1.46
S_r/S_{Vr}	0.467	0.428
S_V/S_W	0.070	0.071
l_V/b_W	0.494	0.494

NOTE: SHADED OUTLINE INDICATES ORIGINAL XBT-2 MODEL



TYPICAL CONTROL SURFACE SECTIONS SHOWING CHANGES IN BALANCE NOSE SHAPE





W-81

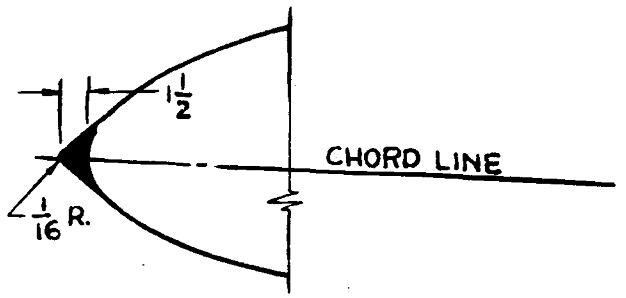


FIGURE 2a: SHARP WING LEADING EDGE ADDED FOR 18 INCHES ALONG SPAN, LEFT WING ONLY. SEE FIG. 2g FLIGHT [I:(5-6)]

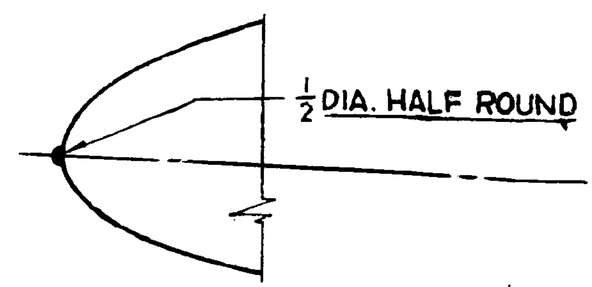


FIGURE 2b: "STALL CONTROL" STICKS ADDED FOR 18 INCHES ALONG SPAN, BOTH WINGS. SEE FIG. 2g FLIGHT [VI:57]

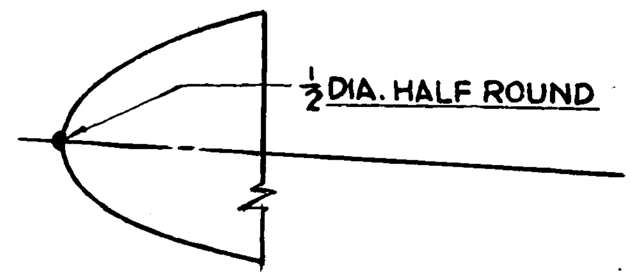


FIGURE 2c: "STALL CONTROL" STICKS ADDED FOR 8 INCHES ALONG SPAN, BOTH WINGS. SEE FIG. 2g FLIGHT [VI:65]

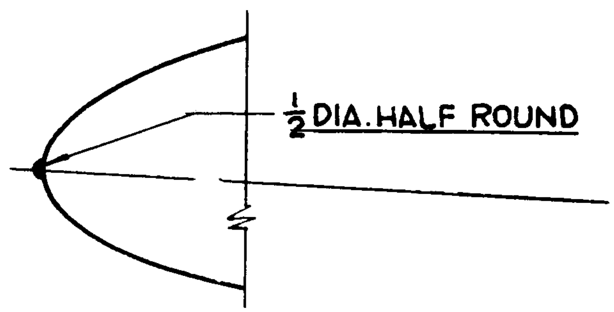


FIGURE 2d: STALL CONTROL" STICKS ADDED FOR 25 INCHES ALONG SPAN, BOTH WINGS SEE FIG. 2g FLIGHT [VI:68]

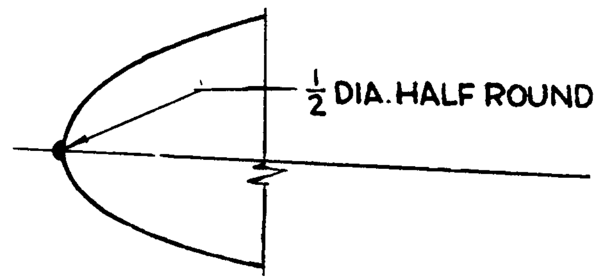


FIGURE 2e: "STALL CONTROL" STICKS ADDED FOR 12 INCHES ALONG SPAN, BOTH WINGS. SEE FIG. 2g FLIGHT [VI:(69-71)]

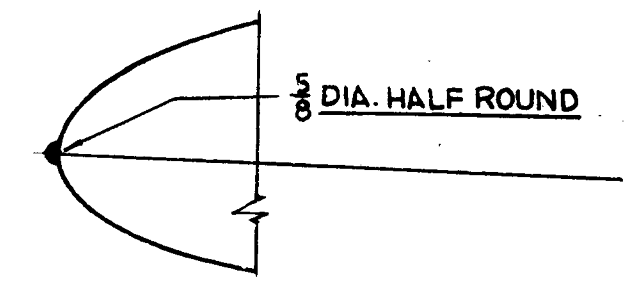
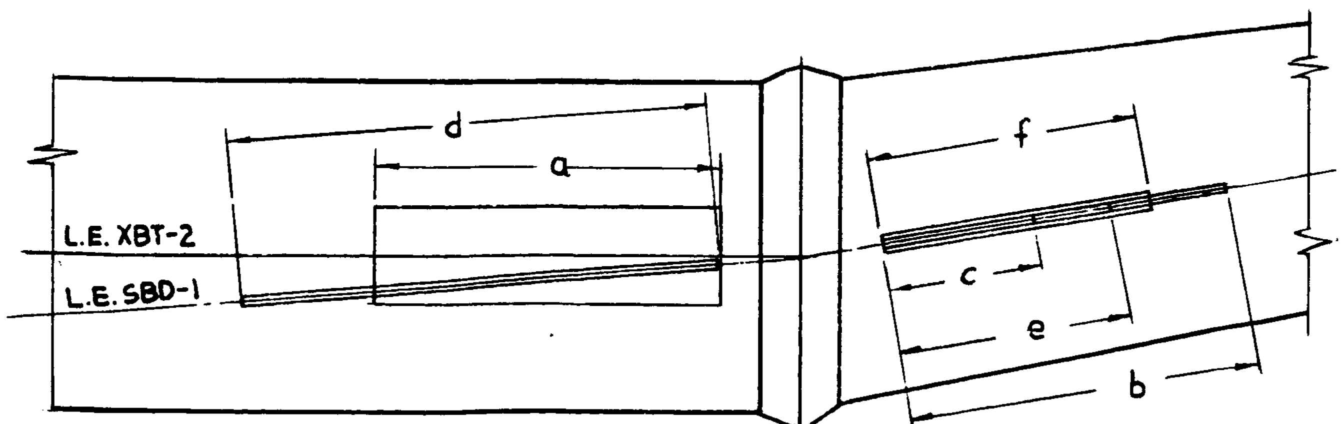


FIGURE 2f: "STALL CONTROL' STICKS ADDED FOR 14 INCHES ALONG SPAN, BOTH WINGS. SEE FIG. 2g FLIGHT [VI:77]



NOTE: ON SBD-1 WING LEADING EDGE DROPS TO FAIR INTO WHEEL WELL.

FIGURE 2g: SPANWISE LOCATION OF VARIOUS LEADING EDGE MODIFICATIONS. LETTERS CORRESPOND TO FIGURES.

FIGURES 2a TO 2g WING LEADING EDGE MODIFICATIONS MADE DURING XBT-2 AND SBD-1 FLIGHT TESTS ON STALLING CHARACTERISTICS

SCALE: $\frac{1}{10}$ SIZE

DIMENSIONS IN INCHES

W-81

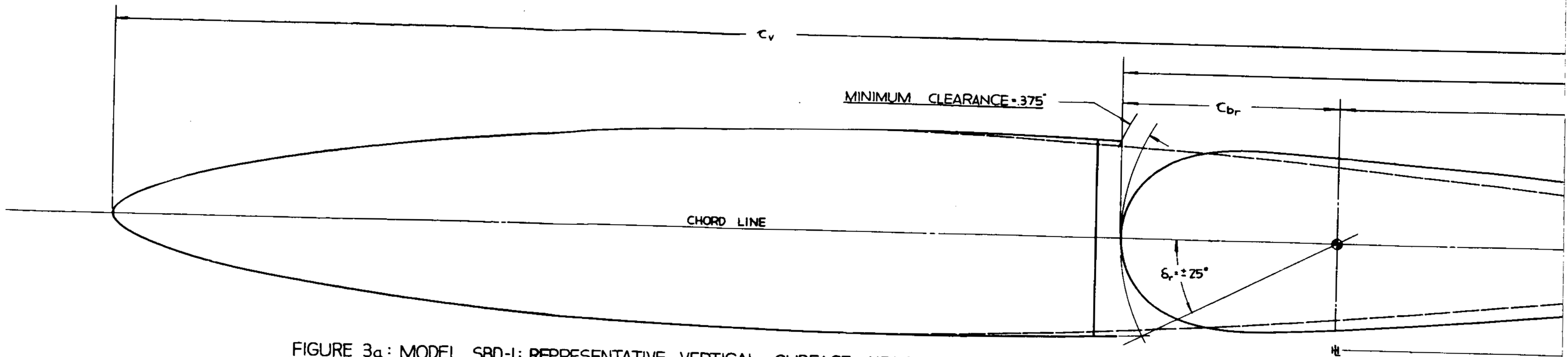


FIGURE 3a : MODEL SBD-1: REPRESENTATIVE VERTICAL SURFACE AIRFOIL SECTION WITH FINAL RUDDER BALANCE NOSE SHAPE

AIRFOIL : MODIFIED N-69 WITH 12% CHORD EXTENSION TO 10% THICKNESS AND STRAIGHT SIDED AFTERBODY, THICKNESS CONSTANT ALONG SPAN
RUDDER TRAVEL : THEORETICAL LIMIT FOR UNPORTING : ±25° DESIGN STOPS AT : ± 30°
SECTION TAKEN AT REFERENCE STATION 40 : CHORD = 54.85 INCHES

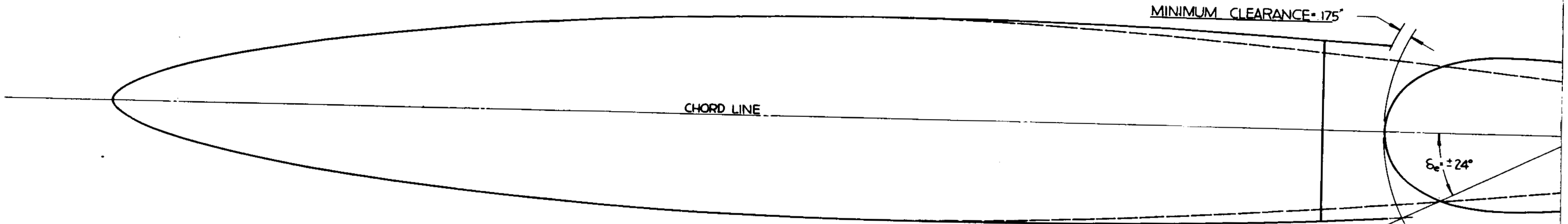


FIGURE 3b : MODEL SBD-1: REPRESENTATIVE HORIZONTAL SURFACE AIRFOIL SECTION WITH FINAL ELEVATOR BALANCE NOSE SHAPE

AIRFOIL : MODIFIED N-69 WITH 12% CHORD EXTENSION AND STRAIGHT SIDED AFTERBODY, THICKNESS VARIABLE FROM 10.9% TO 7.5% ALONG SPAN
ELEVATOR TRAVEL : THEORETICAL LIMIT FOR UNPORTING : ±24° DESIGN STOPS AT 30° UP, 20° DOWN
SECTION TAKEN AT REFERENCE STATION $46\frac{1}{4}$: CHORD = 50.83 INCHES

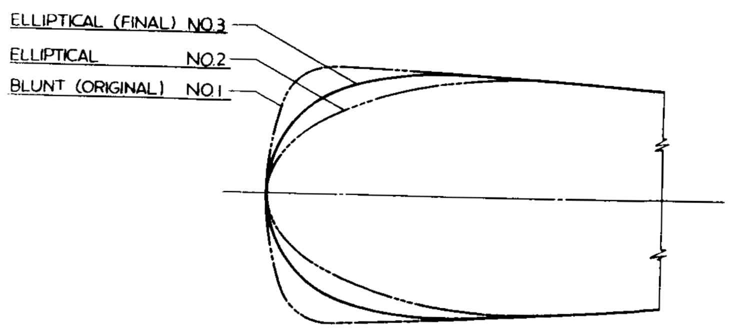


FIGURE 3c : AERODYNAMIC BALANCE NOSE SHAPES FLIGHT TESTED ON RUDDER
SECTION TAKEN AT REFERENCE STATION 40

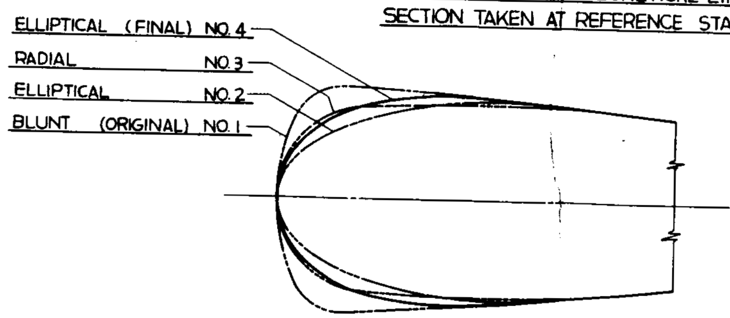


FIGURE 3d : AERODYNAMIC BALANCE NOSE SHAPES FLIGHT TESTED ON ELEVATOR
SECTION TAKEN AT REFERENCE STATION $46\frac{1}{4}$

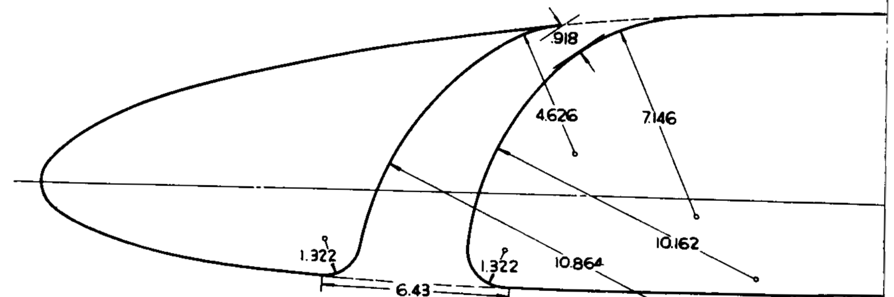
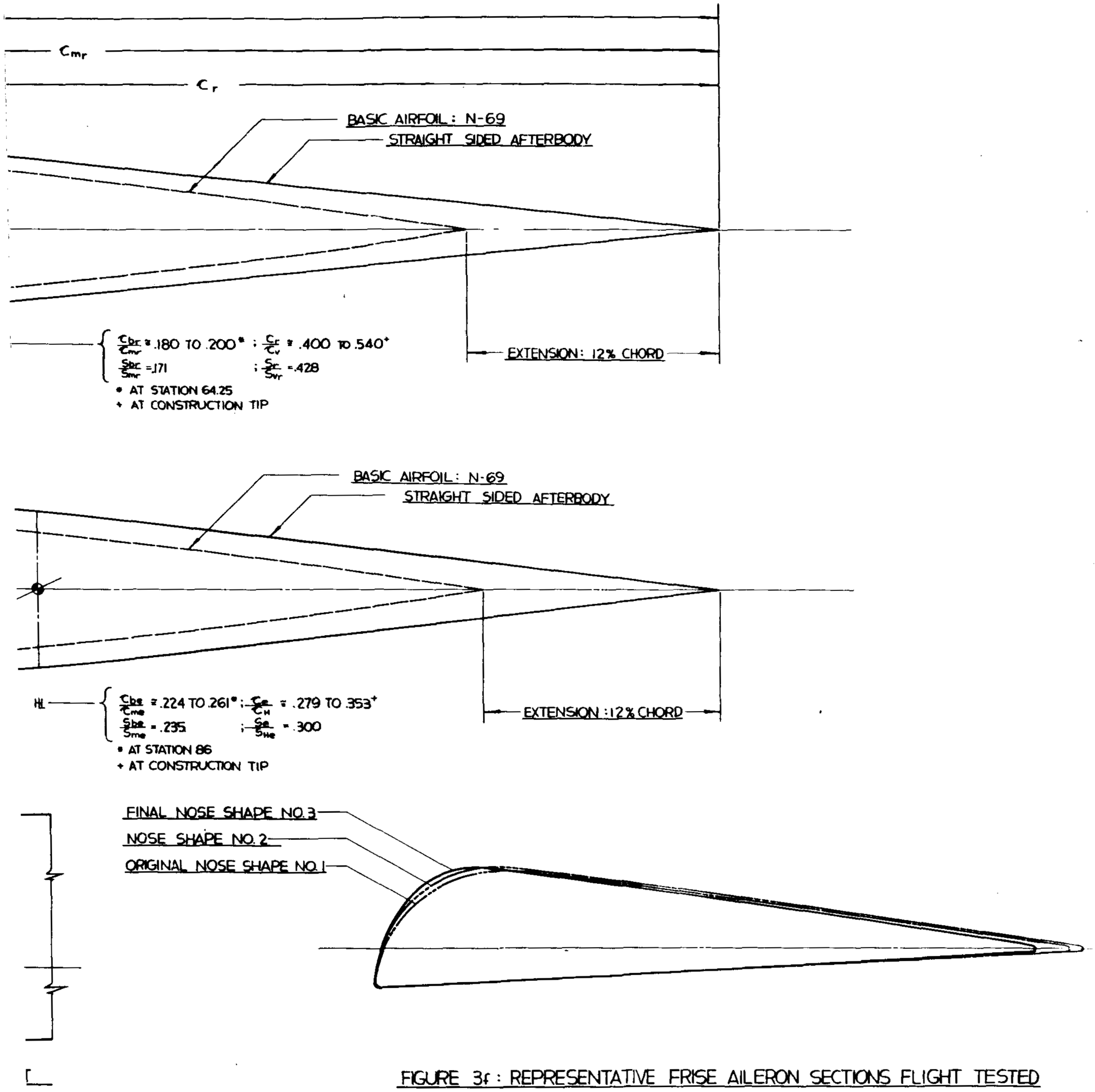


FIGURE 3e : REPRESENTATIVE SECTION THROUGH FIXED WING TIP SLO
REFERENCE : FIGURES 17 & 18
DIMENSIONS IN PERCENT CHORD. SECTION TAKEN AT REFERENCE STA. 192 , CHORD = 75.6

FIGURES 3a TO 3f : REPRESENTATIVE CONTROL SURFACE SECTIONS FLIGHT TESTED ON MODELS XBT-2
WING AND CONTROL SURFACE SECTIONS SHOWN ALL BASED ON SAME CHORD

FOLD-OUT #1



5 INCHES

FIGURE 3f: REPRESENTATIVE FRISE AILERON SECTIONS FLIGHT TESTED

WING AIRFOIL: NACA 2415 AT STATION 66 TAPERING TO NACA 2409 AT CONSTRUCTION TIP

FINAL AILERON TRAVEL: 17°UP 10°DOWN. SECTIONS TAKEN AT WING REFERENCE STATION 192

AND SBD-1, INCLUDING FINAL ARRANGEMENT

FOLD-OUT #2

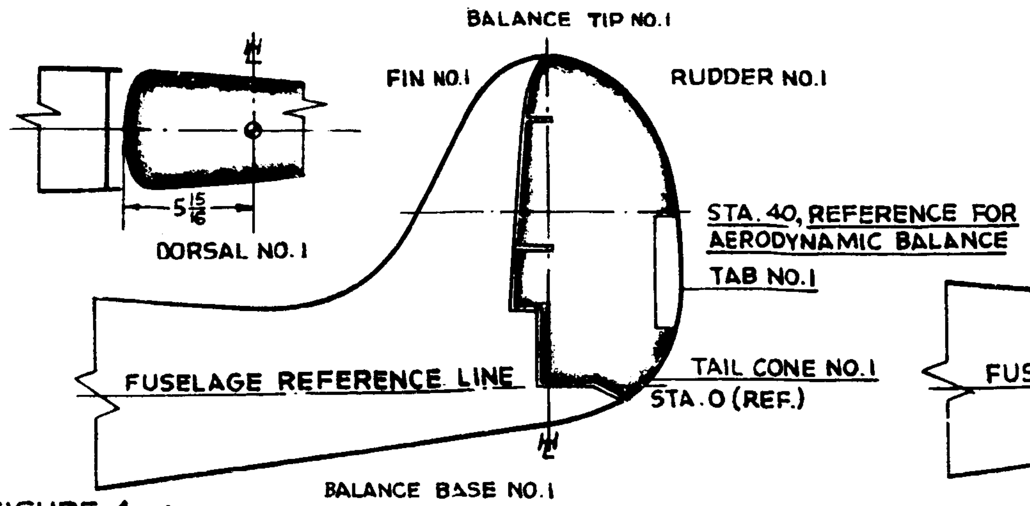


FIGURE 4a:
ORIGINAL SURFACE WITH BLUNT RUDDER BALANCE NOSE:
REFERENCE: FIGURE 19
USED ON FLIGHTS: [I: (1-10)] [II: (1-5,7]
AERODYNAMIC BALANCE: $B_r = 0.162$ (0.200 WITHOUT TAIL CONE)

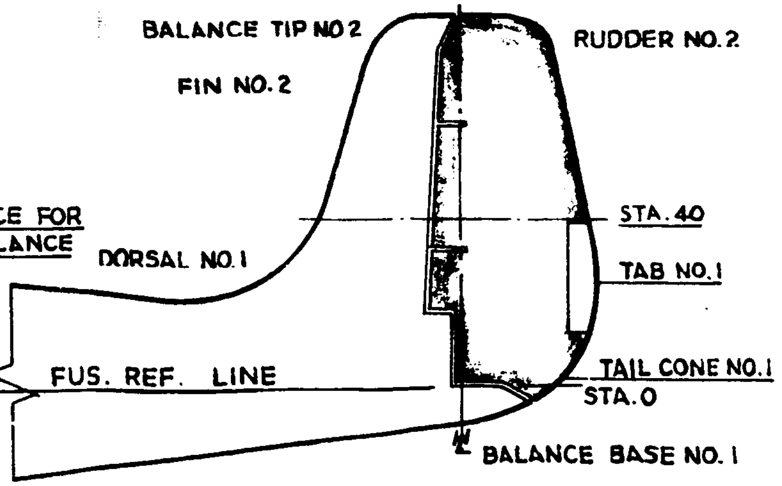


FIGURE 4b:
LARGE FIN AND RUDDER EXTENSIONS:
USED ON FLIGHT: [II: (6)]
AERODYNAMIC BALANCE: $B_r = 0.154$ (0.185 WITHOUT TAIL CONE)

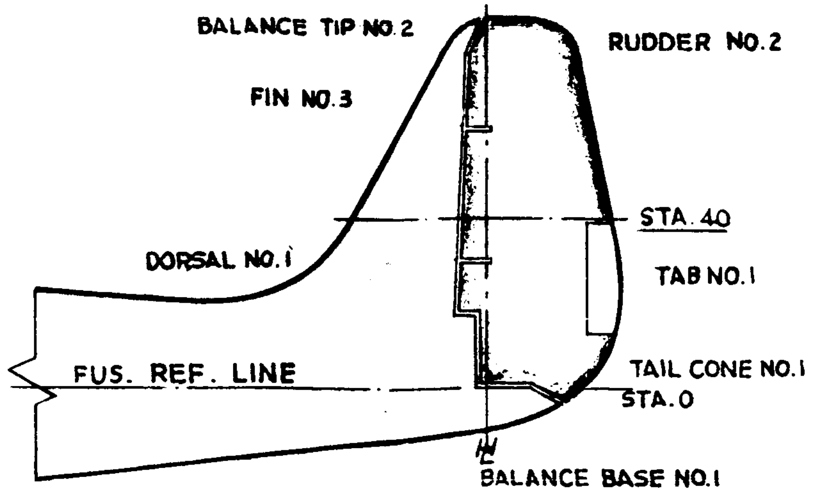


FIGURE 4c:
SMALL FIN EXTENSION WITH LARGE RUDDER:
USED ON FLIGHTS: [II: (8-10)]
AERODYNAMIC BALANCE UNCHANGED

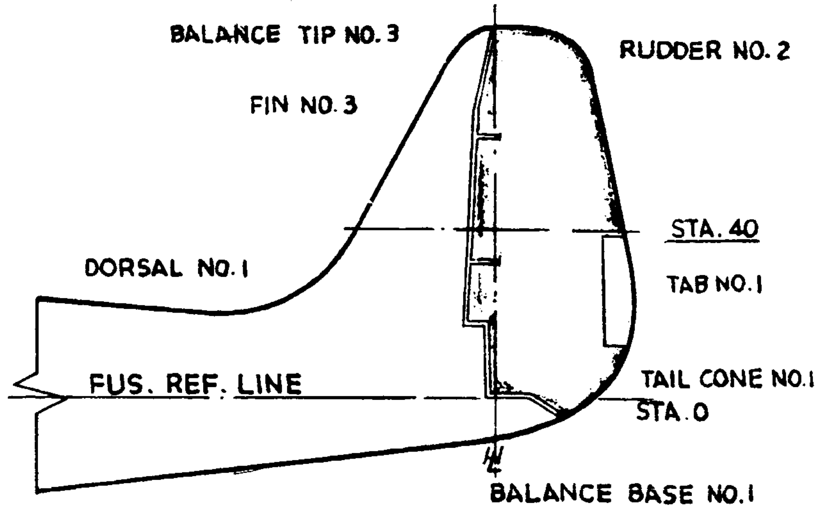


FIGURE 4d:
SMALL FIN EXTENSION, LARGE RUDDER, MODIFIED BALANCE TIP:
USED ON FLIGHTS: [II: (11-13)]
AERODYNAMIC BALANCE: $B_r = 0.148$ (0.177 WITHOUT TAIL CONE)

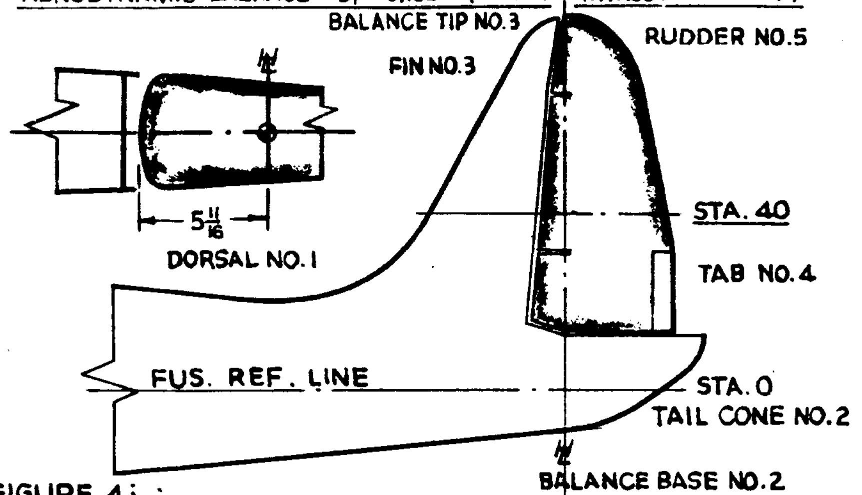


FIGURE 4i:
RUDDER WITH REDUCED CHORD, CONSTANT CHORD TAB, BLUNT RUDDER BALANCE NOSE:
USED ON FLIGHTS. [IV: (4,5)]
AERODYNAMIC BALANCE: $B_r = 0.244$

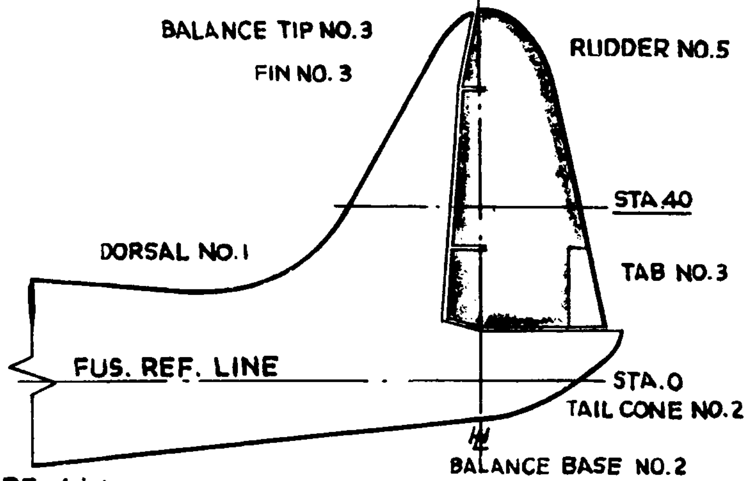


FIGURE 4j:
VARIABLE CHORD TAB
USED ON FLIGHTS [IV: (6-8)]
AERODYNAMIC BALANCE: $B_r = 0.238$

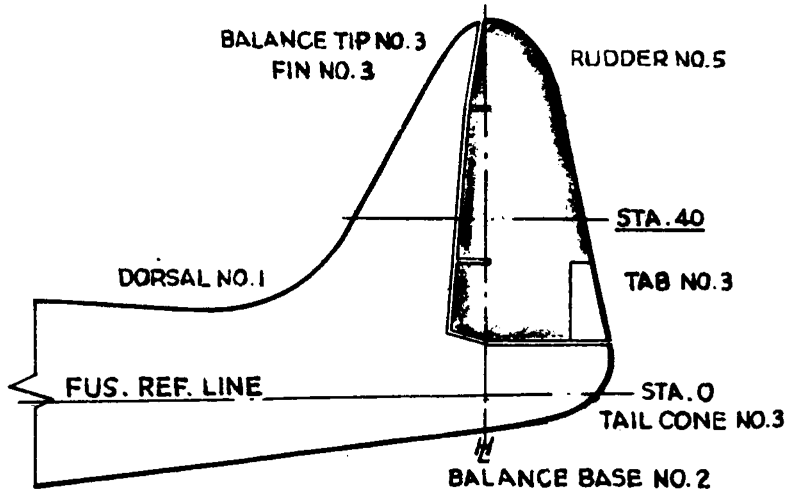


FIGURE 4k:
TAIL CONE REWORKED:
USED ON FLIGHT: [IV: (9)]
AERODYNAMIC BALANCE: $B_r = 0.238$

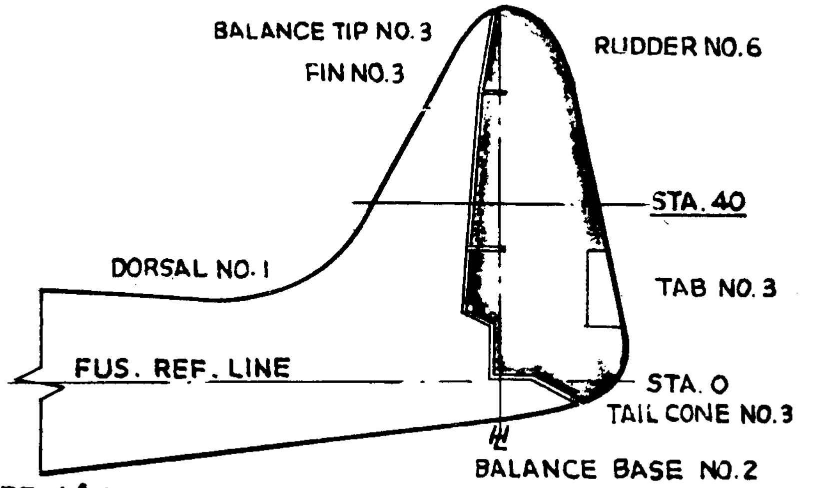


FIGURE 4ℓ:
TAIL CONE MOVABLE
USED ON FLIGHT: [IV: (10)]
AERODYNAMIC BALANCE: $B_r = 0.189$ (0.238 WITHOUT TAIL CONE)

FIGURES 4a TO 4v: VERTICAL SURFACE CONFIGURATIONS FLIGHT TESTED ON MODELS XBT-2 & SBD-1

SCALE: SURFACES 1/40 SIZE; NOSE SHAPES 1/8 SIZE

REFERENCES
1. LINE DIAGRAM, FIGURE 5
2. AREAS AND DESIGN RATIOS, TABLE I
3. AIRFOIL AND BALANCE NOSE SECTIONS, FIGURES 3a, 3c.

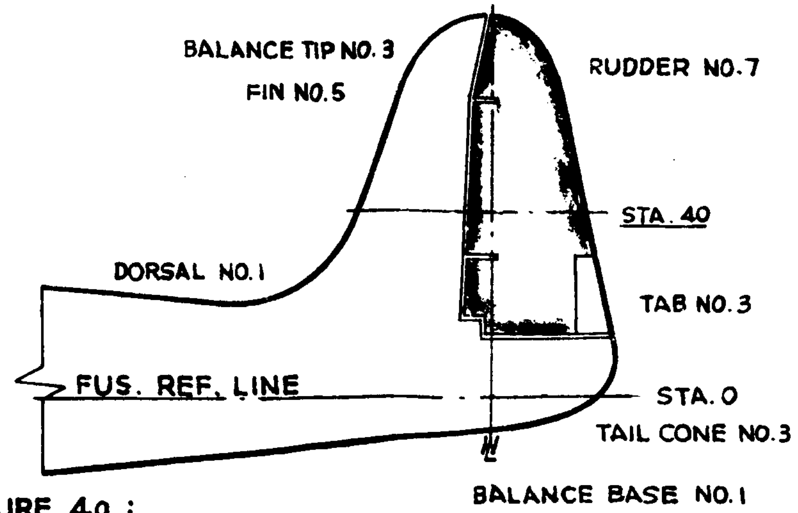


FIGURE 4q:
LARGE FIN EXTENSION:
USED ON FLIGHT: [V: (3)]
AERODYNAMIC BALANCE UNCHANGED

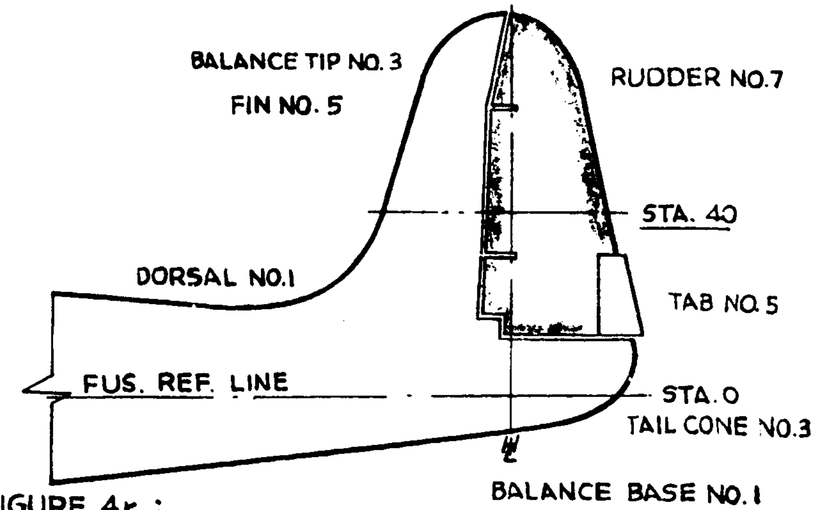


FIGURE 4r:
TRIM TAB EXTENSION:
USED ON FLIGHT: [V: (4)]
AERODYNAMIC BALANCE: $B_r = 0.210$

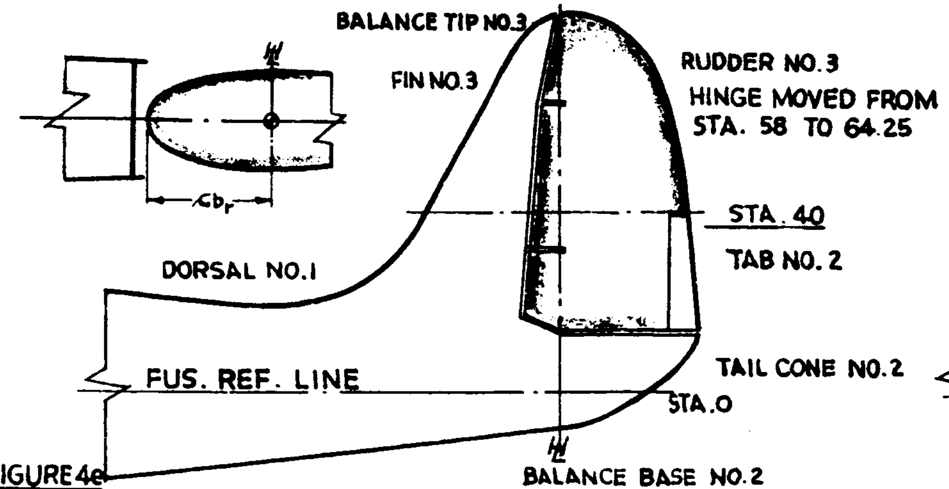


FIGURE 4e
REBUILT RUDDER WITH ELLIPTICAL NOSE BALANCE, SMALL FIN EXTENSION, BALANCE NOSE CHANGED, TAIL CONE FIXED:
USED ON FLIGHT: [III: (1)] $c_{b_r} = 5\frac{15}{16}$, $B_r = 0.183$; ON FLIGHT [III: (2)] $c_{b_r} = 6\frac{1}{16}$, $B_r = 0.189$
ON FLIGHT: [III: (3)] $c_{b_r} = 6\frac{1}{8}$, $B_r = 0.192$; ON FLIGHT: [III: (7-9)] $c_{b_r} = 5\frac{15}{16}$, $B_r = 0.183$
ON FLIGHT: [III: (10-21, 24)] $c_{b_r} = 5\frac{11}{16}$, $B_r = 0.172$

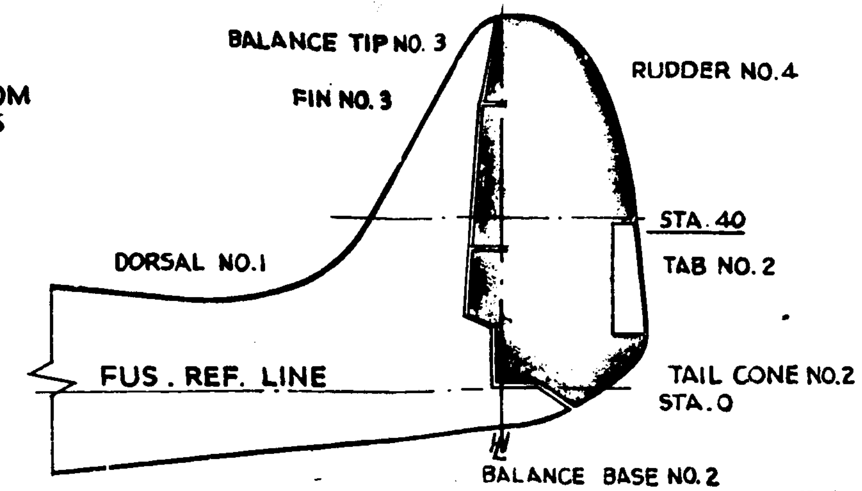


FIGURE 4f:
TAIL CONE ATTACHED TO RUDDER:
USED ON FLIGHT: [III: (4)] $c_{b_r} = 6\frac{1}{4}$, $B_r = 0.161$, B_r (WITHOUT TAIL CONE) = 0.197
ON FLIGHT: [III: (5-6)] $c_{b_r} = 5\frac{15}{16}$, $B_r = 0.150$, B_r (WITHOUT TAIL CONE) = 0.183

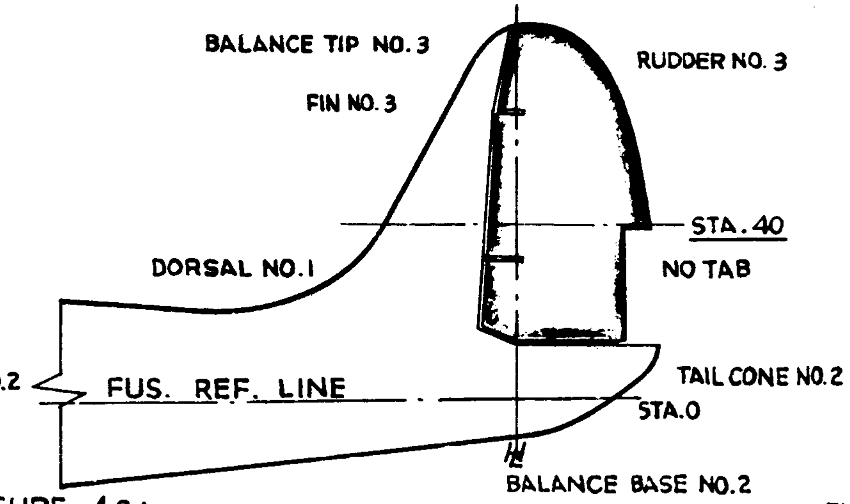


FIGURE 4g:
TAB REMOVED, TAIL CONE FIXED:
USED ON FLIGHTS: [III: (22-23)]
AERODYNAMIC BALANCE: $B_r = 0.184$

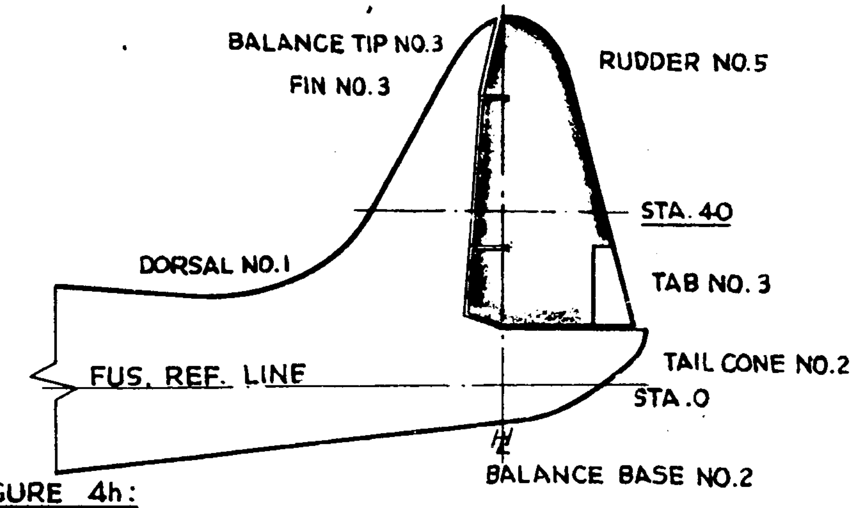


FIGURE 4h:
RUDDER WITH REDUCED CHORD, TAIL CONE FIXED:
USED ON FLIGHTS: [IV: (1-3)]
AERODYNAMIC BALANCE: $B_r = 0.238$

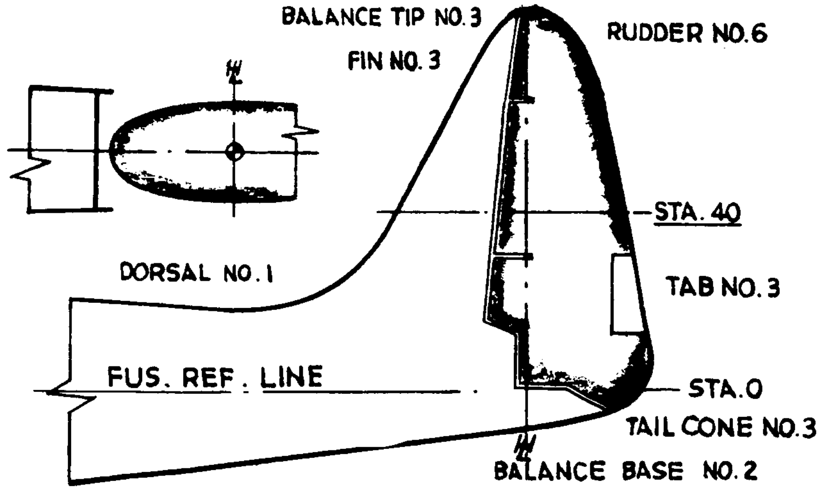


FIGURE 4m:
ELLIPTICAL BALANCE NOSE:
USED ON FLIGHT: [IV: (11)]
AERODYNAMIC BALANCE: $B_r = 0.189$ (0.238 WITHOUT TAIL CONE)

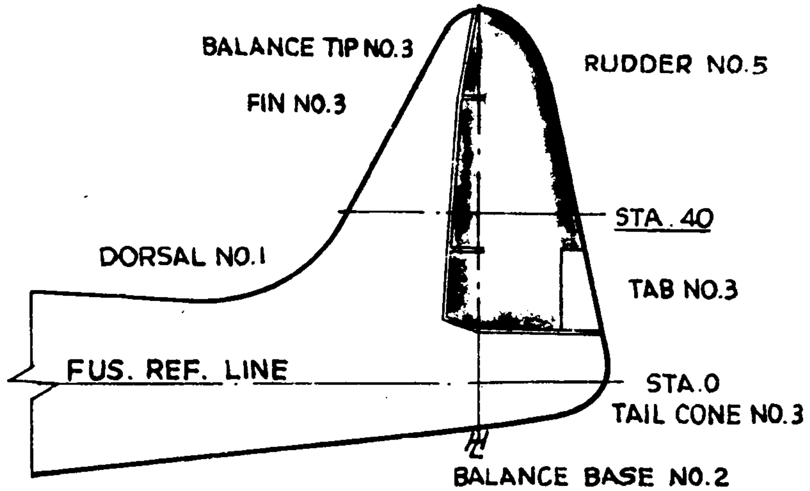


FIGURE 4n:
TAIL CONE FIXED:
USED ON FLIGHTS: [IV: (12-21)]
AERODYNAMIC BALANCE: $B_r = 0.238$

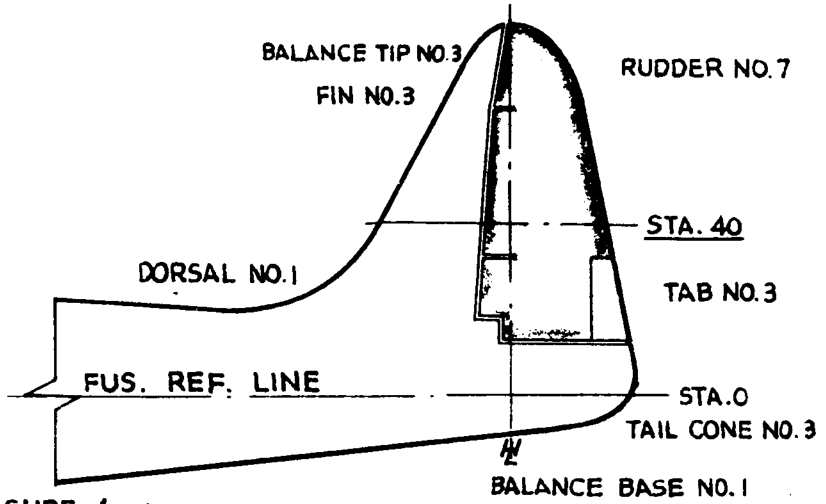


FIGURE 4o:
RUDDER BALANCE BASE TO ORIGINAL:
USED ON FLIGHT: [V: (1)]
AERODYNAMIC BALANCE: $B_r = 0.221$

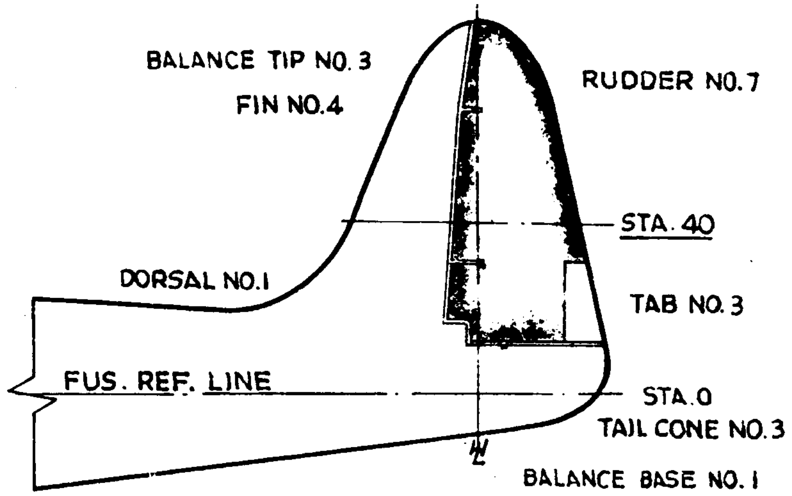


FIGURE 4p:
SMALL FIN EXTENSION:
USED ON FLIGHT: [V: (2)]
AERODYNAMIC BALANCE UNCHANGED

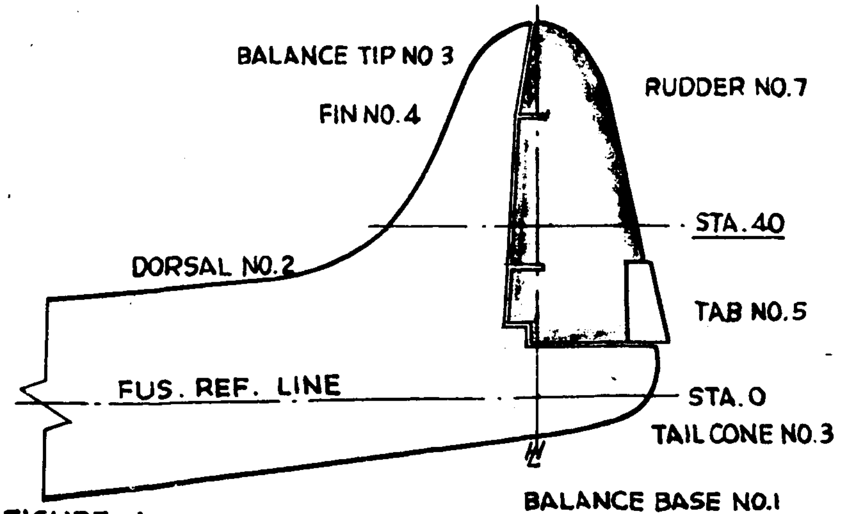


FIGURE 4s:
SMALL FIN EXTENSION WITH DORSAL, TAB EXTENSION:
USED ON FLIGHT: [V: (5)]
AERODYNAMIC BALANCE UNCHANGED

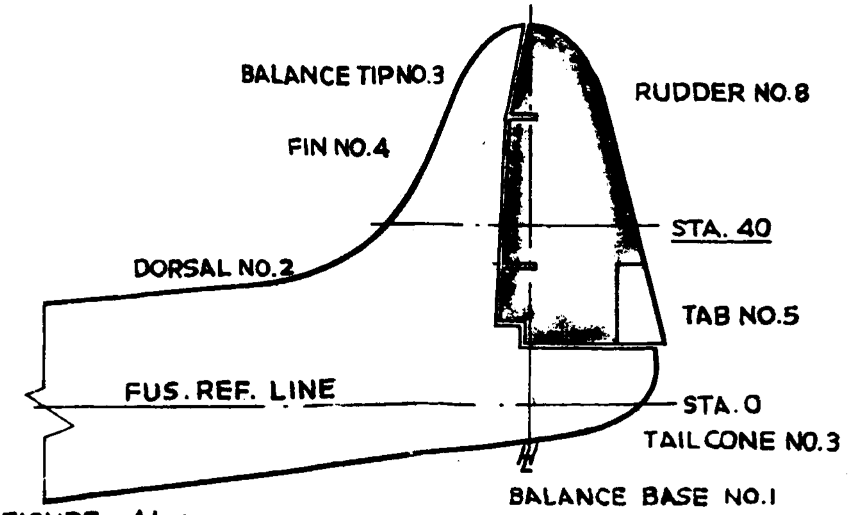


FIGURE 4t:
REWORKED RUDDER FOR EXTENDED TAB:
USED ON FLIGHT: [V: (6)]
AERODYNAMIC BALANCE: $B_r = 0.207$

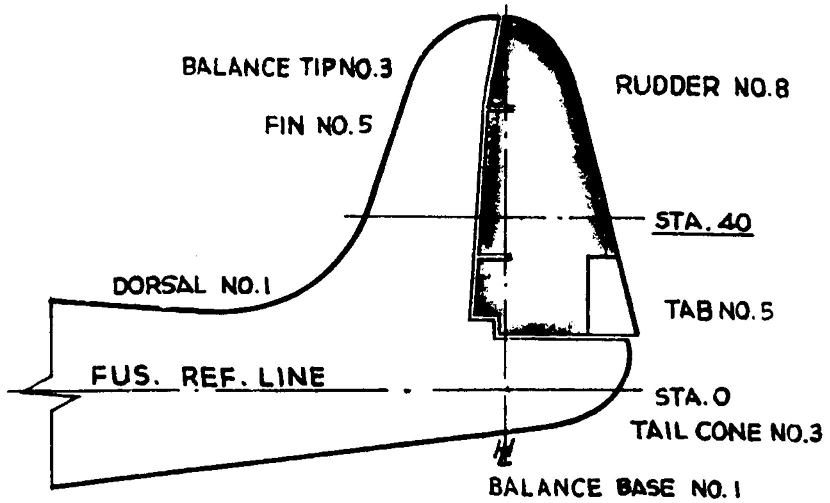


FIGURE 4u:
LARGE FIN EXTENSION:
USED ON FLIGHT: [V: (7)]
AERODYNAMIC BALANCE UNCHANGED

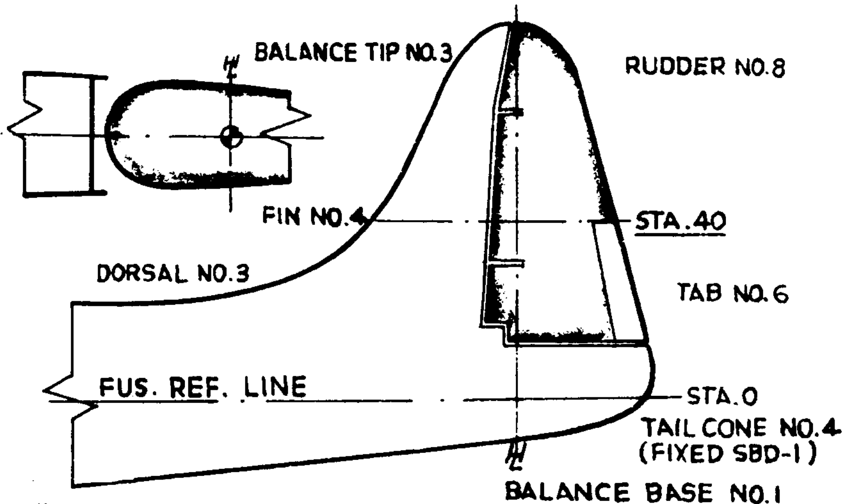


FIGURE 4v:
FINAL SBD-1 CONFIGURATION: SMALL FIN EXTENSION WITH DORSAL, LARGER TRIM TAB, TAIL CONE REWORKED, BALANCE NOSE MODIFIED:
REF. FIGURE 20 ; USED ON FLIGHTS: [VI_1: (1-77)] [VI_2: (1-9)]
AERODYNAMIC BALANCE: $B_r = 0.207$

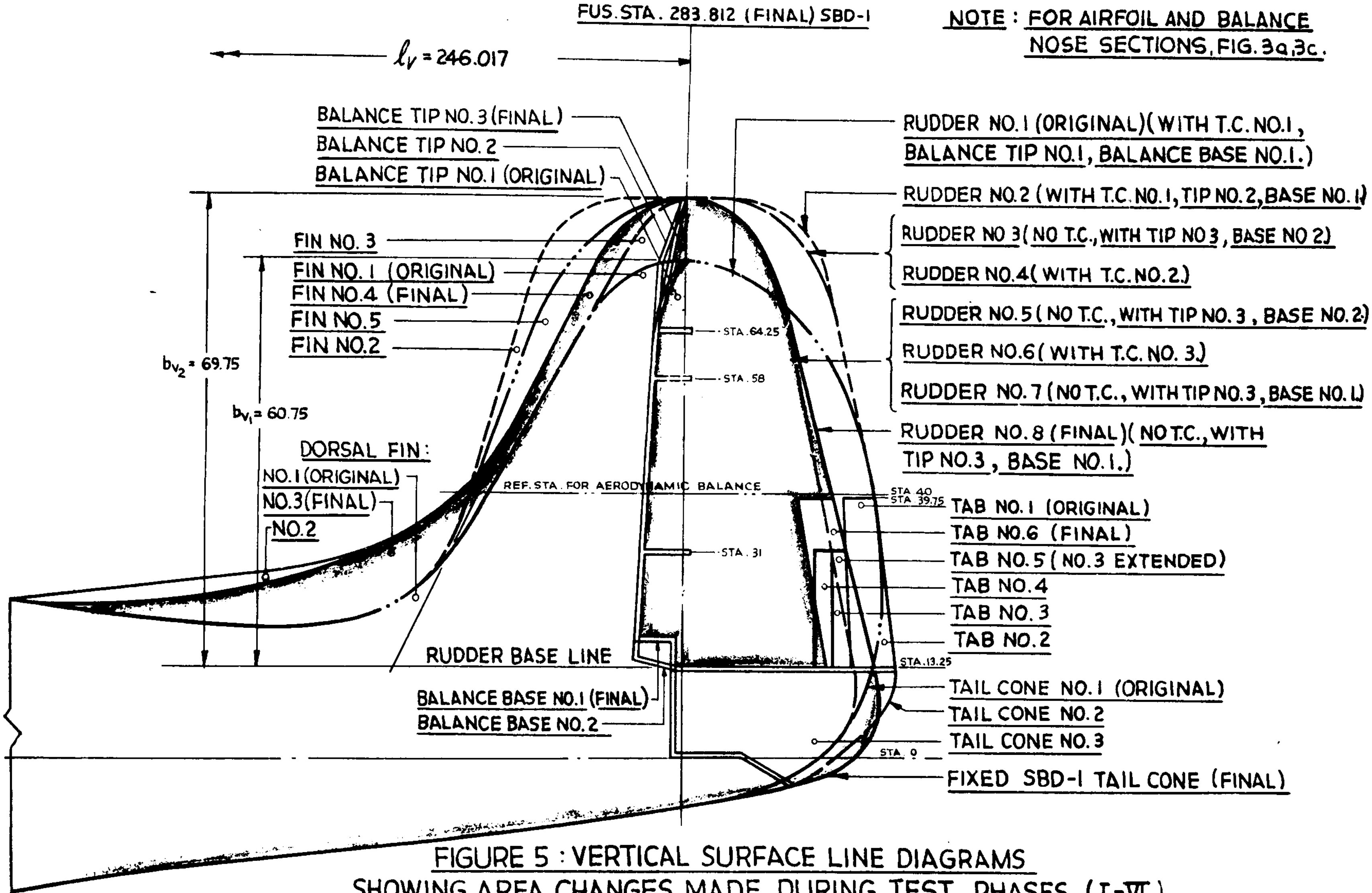


FIGURE 5 : VERTICAL SURFACE LINE DIAGRAMS
SHOWING AREA CHANGES MADE DURING TEST PHASES (I-VI)
MODEL XBT-2 & SBD-1 ; SCALE 1/20 SIZE

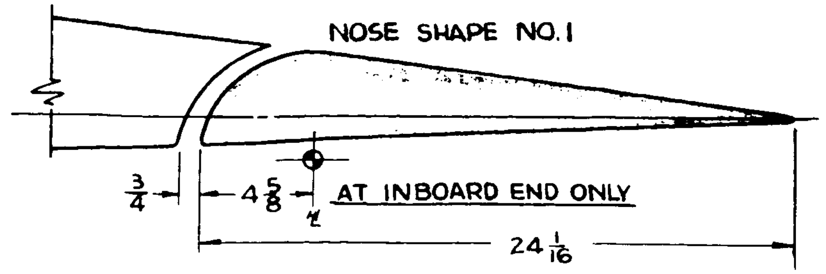


FIGURE 6a: ORIGINAL XBT-2 AILERON
REFERENCE: FIGURE 21
USED ON FLIGHTS: [I:(1-10)] [II:(1-11)]
AERODYNAMIC BALANCE: B_a = 0.199

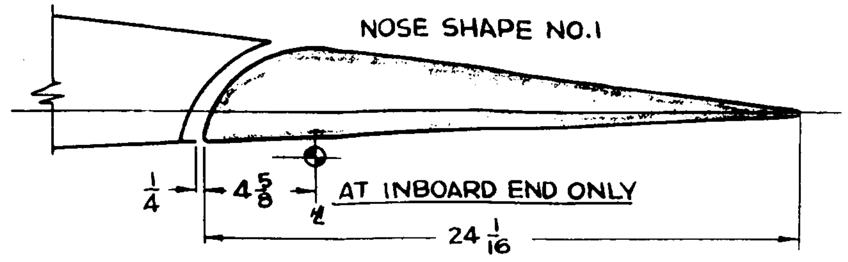


FIGURE 6b: LOWER SURFACE GAP REDUCED TO 1/4"
USED ON FLIGHTS: [II:(12-16)]
AERODYNAMIC BALANCE: B_a = 0.199

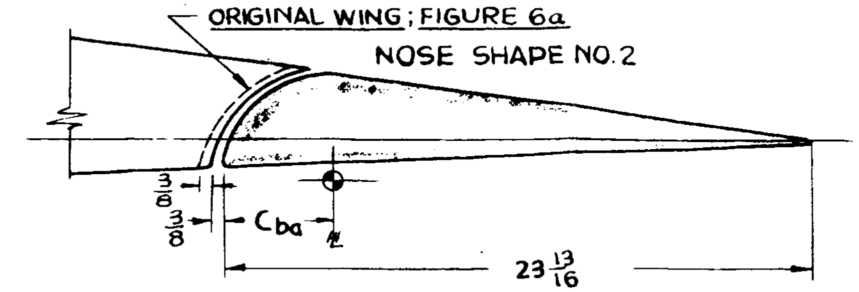


FIGURE 6c: REBUILT WITH MINIMUM LOWER SURFACE GAP, WITH CONSTANT BALANCE CHORD
FLIGHT: [III:1], C_{ba} = $4\frac{7}{8}$, B_a = .254
FLIGHT: [III:2], C_{ba} = 5, B_a = .263
FLIGHT: [III:3], C_{ba} = $5\frac{1}{8}$, B_a = .273
FLIGHTS: [III:(4-8)(11-14)], C_{ba} = $5\frac{1}{4}$, B_a = .282
FLIGHT: [III:9], C_{ba} = $5\frac{3}{8}$, B_a = .292
FLIGHT: [III:10], C_{ba} = $5\frac{1}{2}$, B_a = .302

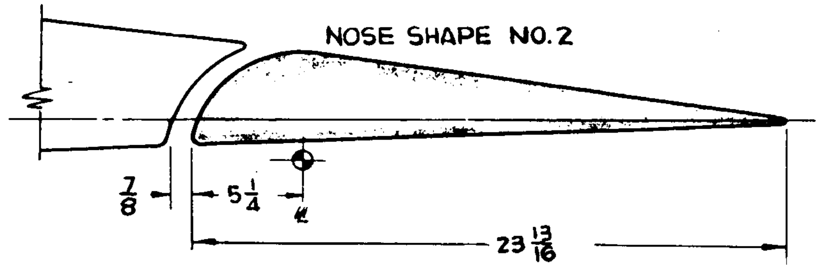


FIGURE 6d: LOWER SURFACE GAP INCREASED TO 7/8"
USED ON FLIGHTS: [III:(15-24)]
AERODYNAMIC BALANCE: B_a 0.282

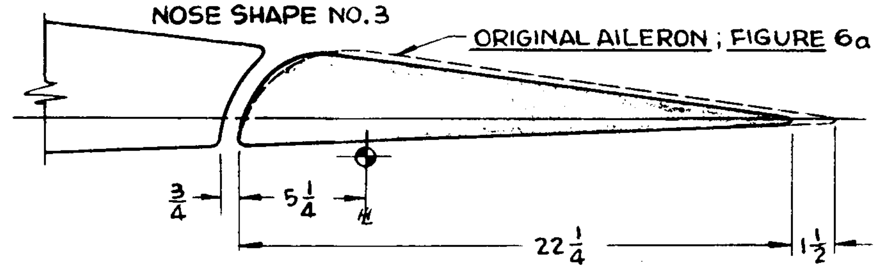


FIGURE 6e: NEW AILERON WITH CHORD REDUCED 1 1/2"
USED ON FLIGHTS: [IV:1]
AERODYNAMIC BALANCE: B_a = 0.312

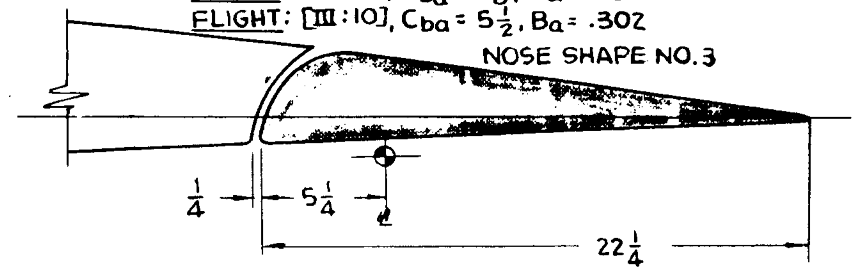


FIGURE 6f: LOWER SURFACE GAP REDUCED TO 1/4"
USED ON FLIGHTS: [IV:(2-21)] [V:(1-7)]
AERODYNAMIC BALANCE: B_a = 0.312

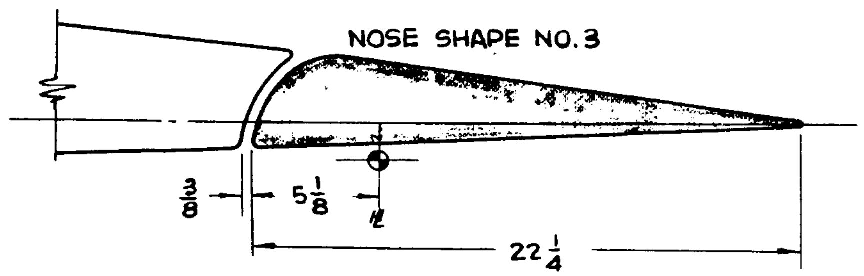


FIGURE 6g: BASIC SBD-1 AIRFOIL
USED ON FLIGHTS: [VI_1:(1-69)(72-73)] [VI_2:(1-5)]
AERODYNAMIC BALANCE: B_a = 0.302

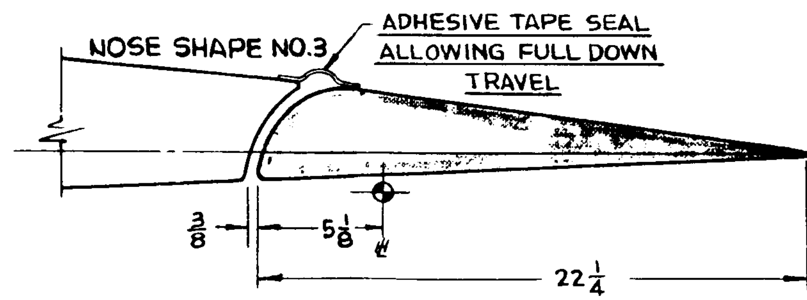


FIGURE 6h: UPPER SURFACE GAP SEALED
USED ON FLIGHTS: [VI_1:(70-71)]
AERODYNAMIC BALANCE: B_a = 0.302

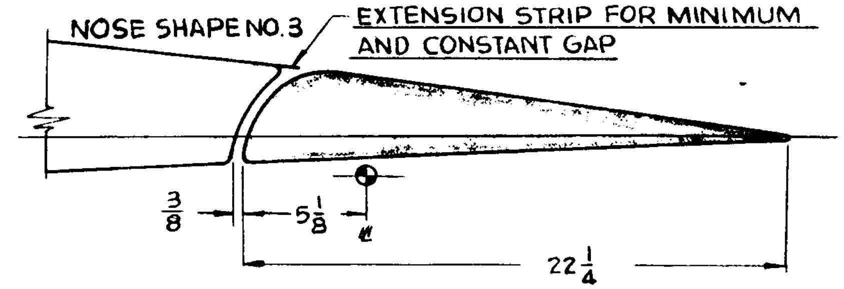


FIGURE 6j: FINAL SBD-1 AILERON WITH UPPER SURFACE EXTENSION STRIP
REFERENCE: FIGURES 17, 18
USED ON FLIGHTS: [VI_1:(74-77)]
AERODYNAMIC BALANCE: B_a = 0.302

FIGURE 6i: BASIC SBD-1 AILERON WITH UPPER SURFACE EXTENSION STRIP AND LOWER SURFACE SEAL
USED ON FLIGHTS: [VI_2:(6)] WITH LOWER GAP ONLY SEALED,
[VI_2:(7-9)] WITH BOTH UPPER AND LOWER GAP CLOSED
AERODYNAMIC BALANCE: B_a = 0.302

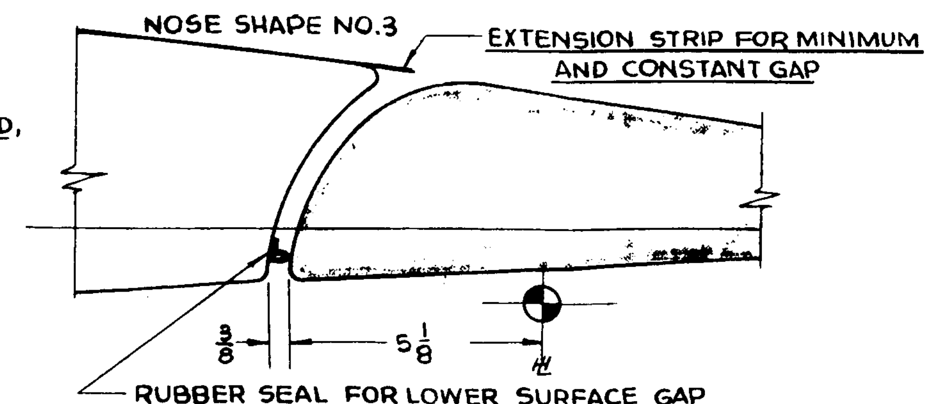


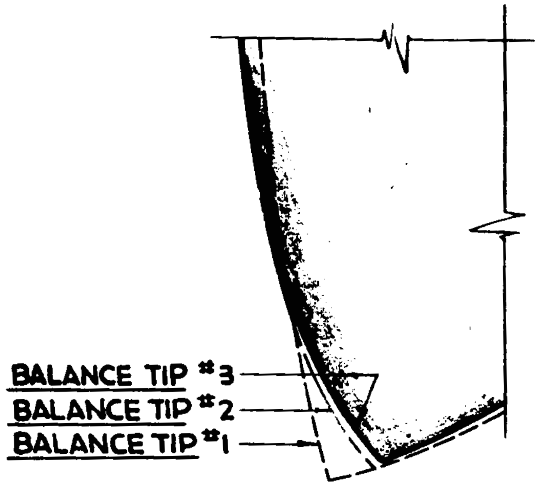
FIGURE 6a TO 6j: FRISE AILERON CONFIGURATIONS FLIGHT TESTED ON MODELS XBT-2 & SBD-1

SCALE 1/8 DIMENSIONS TAKEN CHORDWISE

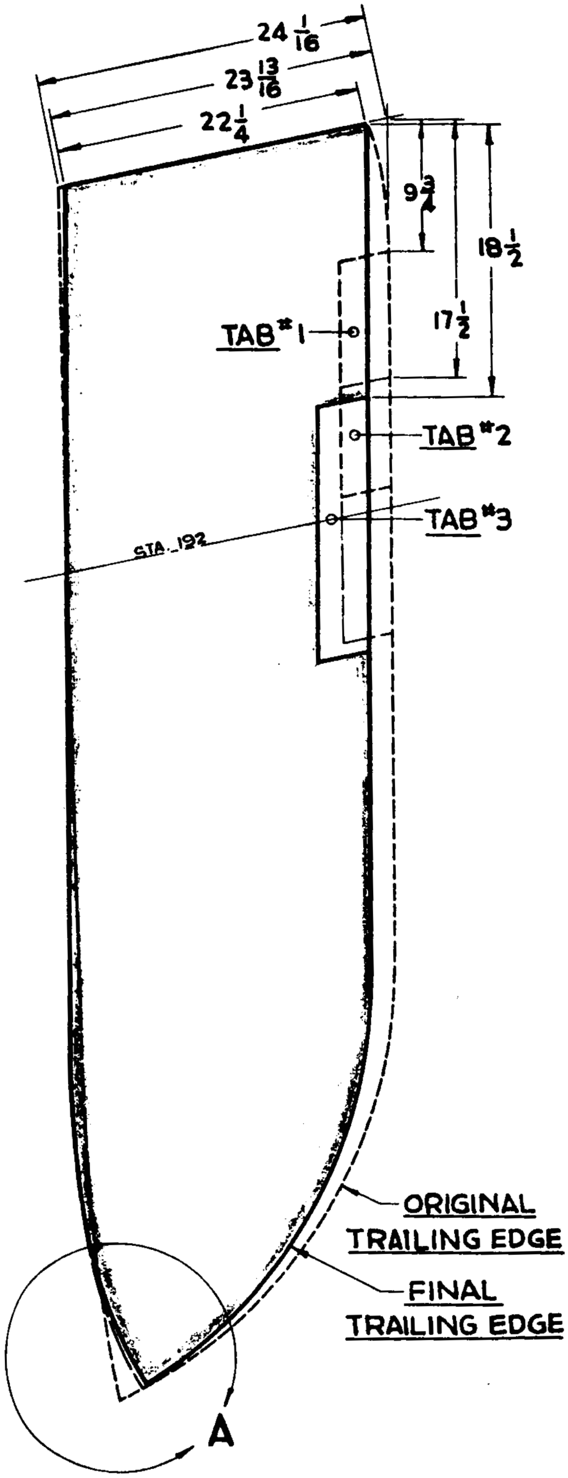
REFERENCES:

1. LINE DIAGRAM, FIGURE 7
2. AREAS AND DESIGN RATIOS, TABLE II
3. LARGE SCALE SECTIONS, FIGURE 3f

W-81



VIEW A



CONFIGURATIONS TESTED:

ORIGINAL: (FIGURE 6a) WITH TAB #1, BALANCE TIP #1, CHORD 24 1/16", BALANCE CHORD VARIABLE

REBUILT: (FIGURE 6c) WITH TAB #2 BALANCE TIP #2, CHORD 23 13/16", BALANCE CHORD CONSTANT

FINAL: (FIGURE 6e) WITH TAB #3, BALANCE TIP #3, CHORD 22 1/4" BALANCE CHORD CONSTANT

NOTE: FOR NOSE SHAPES SEE FIGURE 3f.

FIGURE 7: AILERON LINE DIAGRAM SHOWING AREA CHANGES MADE DURING FLIGHT TESTS

MODEL: XBT-2 & SBD-1

SCALE: 1/12 SIZE

DIMENSIONS TAKEN CHORDWISE

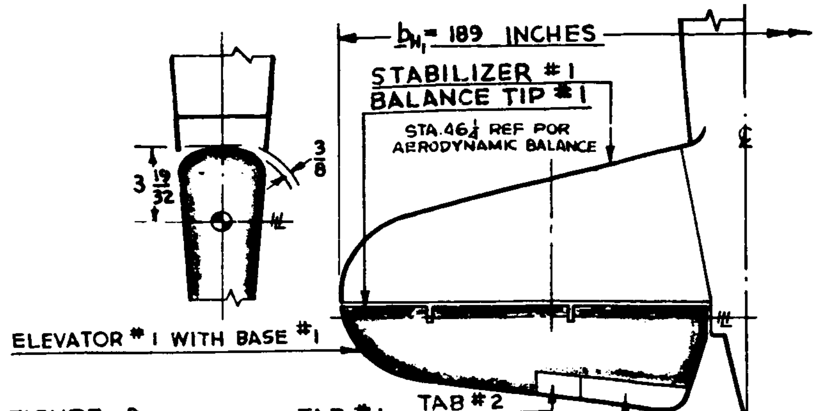


FIGURE 8a:
ORIGINAL SURFACE WITH BLUNT ELEVATOR BALANCE NOSE SHAPE
REFERENCE : FIGURE 19
USED ON FLIGHTS : [I : (1-10)][II : (1)]
AERODYNAMIC BALANCE : Be = 0.207 WITH BALANCE TAB RATIO 1:1.
BALANCE TAB FIXED TO ELEVATOR FOR FLIGHTS [II : (2-8)]

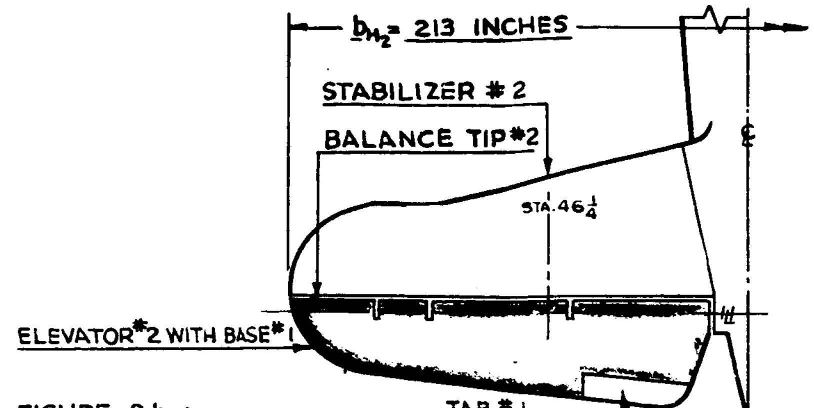


FIGURE 8b:
ELEVATOR AND STABILIZER EXTENSION, 2 FT. SPAN INCREASE
USED ON FLIGHTS : [II : (9-16)]
AERODYNAMIC BALANCE : Be = 0.216

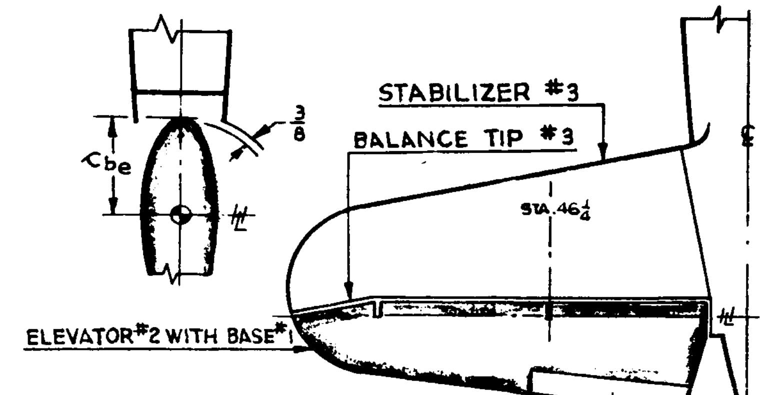
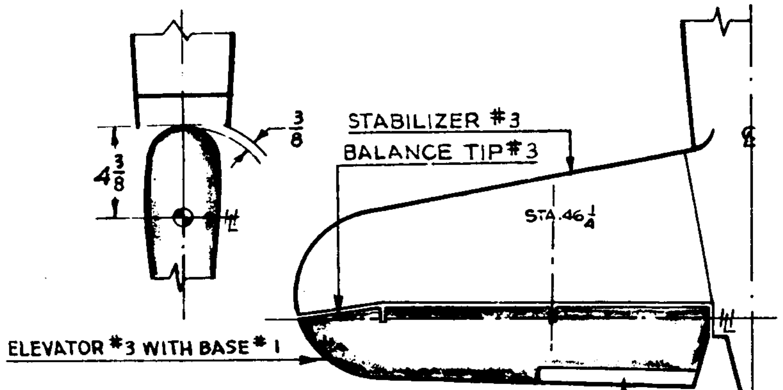


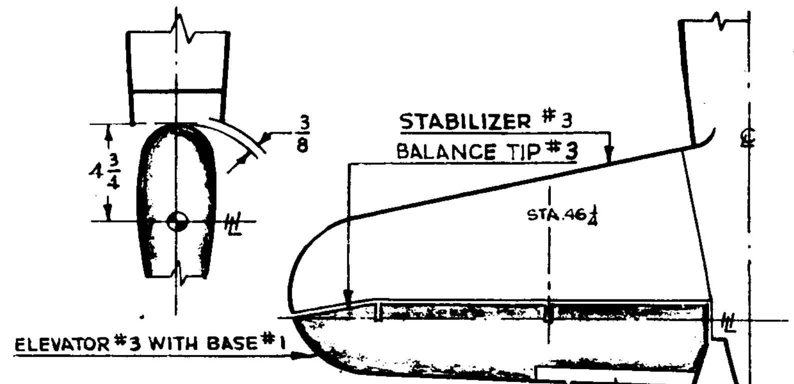
FIGURE 8c:
REBUILT WITH EXTENSION,
BALANCE TIP TAPERED, ELLIPTICAL ELEVATOR NOSE SHAPE
USED ON FLIGHTS [III : (1-14), (22-23)
FLIGHT [III : (1)], Be = 0.207, c_{be} = 4
FLIGHT [III : (2)], Be = 0.225, c_{be} = 4 ¼
FLIGHTS [III : (3-14), (22-23), Be = 0.243, c_{be} = 4½

FIGURE 8d:
BALANCE TAB WI
USED ON FLIGHTS
AERODYNAMIC BAL
RATIO: 0° AT δe =



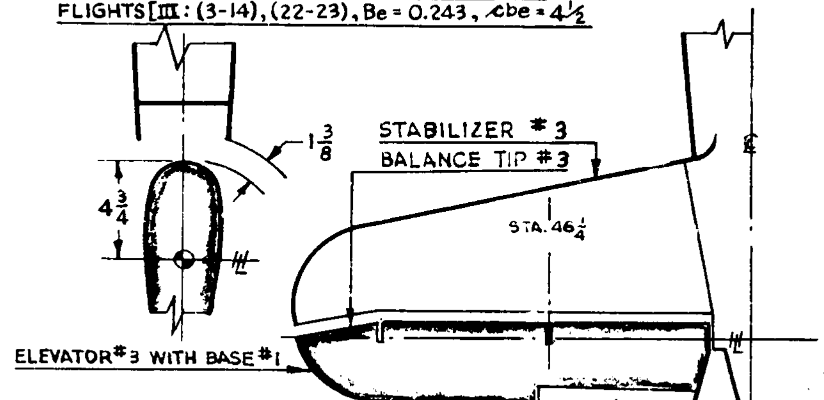
TAB #4

FIGURE 8f:
RADIAL ELEVATOR BALANCE NOSE SHAPE :
USED ON FLIGHTS : [IV : (9-12)]
AERODYNAMIC BALANCE : Be = 0.277



TAB #4

FIGURE 8g:
RADIAL ELEVATOR BALANCE NOSE SHAPE :
HINGE LINE MOVED AFT 3/8 TO 4 3/4
USED ON FLIGHTS : [IV : (13-16, 18)], [V : (1-7)]
AERODYNAMIC BALANCE : Be = 0.311



TAB #4

FIGURE 8h:
RADIAL ELEVATOR BALANCE NOSE SHAPE :
ELEVATOR-STABILIZER GAP INCREASED ONE INCH : ℄ AT 4 3/4
USED ON FLIGHT: [IV : (17)]
AERODYNAMIC BALANCE : Be = 0.311

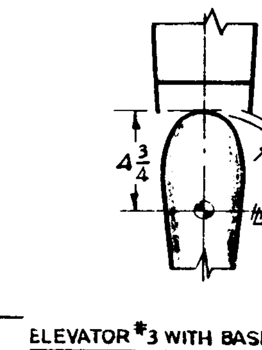


FIGURE 8i:
BASIC SBD-1 S
ELEVATOR BAL
USED ON FLIGH
AERODYNAMIC

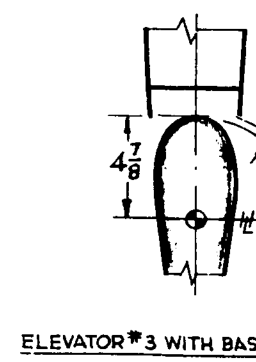
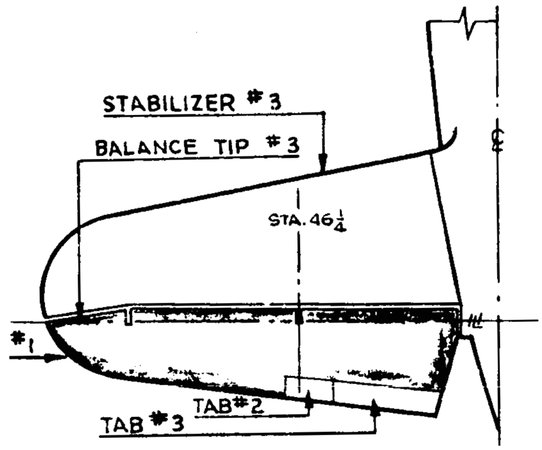


FIGURE 8k:
ELLIPTICAL ELEVA
HINGE LINE MOVE
USED ON FLIGHTS
AERODYNAMIC BAL

FIGURE 8a TO 8ℓ : HORIZONTAL SURFACE CONFIGURATIONS
FLIGHT TESTED ON MODELS XBT-2 & SBD-1
SCALE : SURFACES 1/40 SIZE ; NOSE SHAPES 1/8 SIZE
REFERENCES :
1. LINE DIAGRAM, FIGURE 9
2. AREAS & DESIGN RATIOS, TABLE III
3. AIRFOIL AND BALANCE NOSE SECTIONS, FIGURES 3b, 3d.

FOLD-OUT #1



TH VARIABLE RATIO
: [III : (15-21)]
.ANCE : Be = 0.243 WITH BALANCE TAB
± 20°

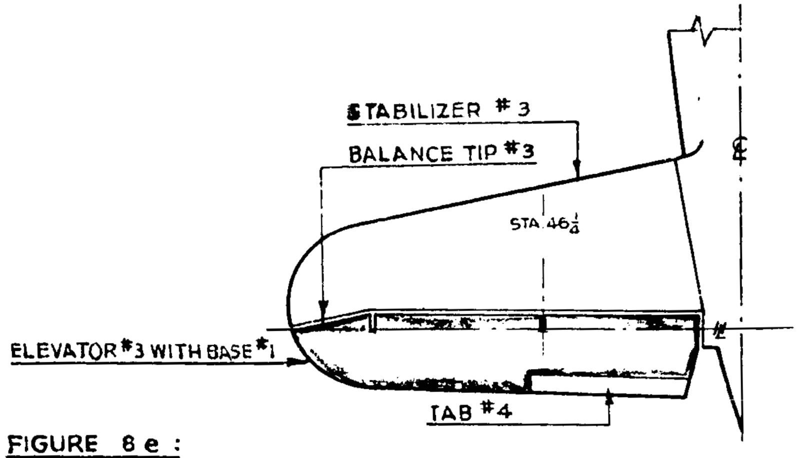
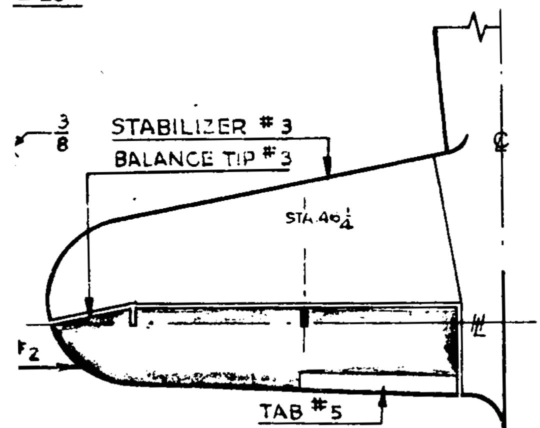


FIGURE 8 e :
REDUCED ELEVATOR CHORD, REVISED TAB :
USED ON FLIGHTS : [IV : (1-8)]
AERODYNAMIC BALANCE : Be = 0.244



URFACE, NO CUT OUT, ELLIPTICAL
ANCE NOSE SHAPE :
TS : [VI₁ : (1-52)]
BALANCE : Be = 0.301

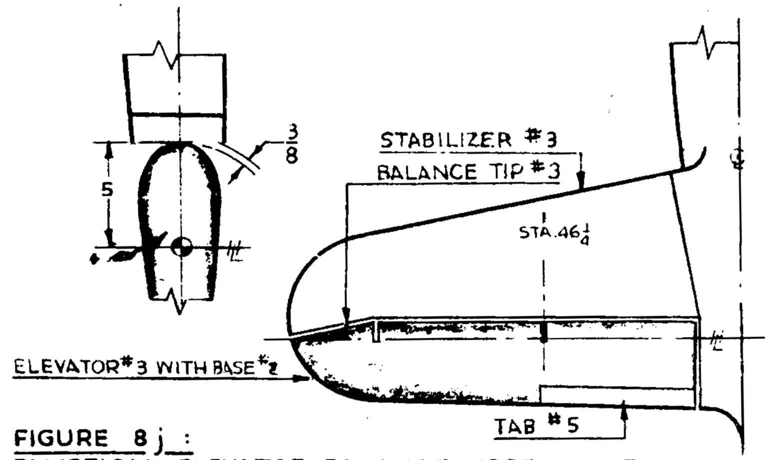
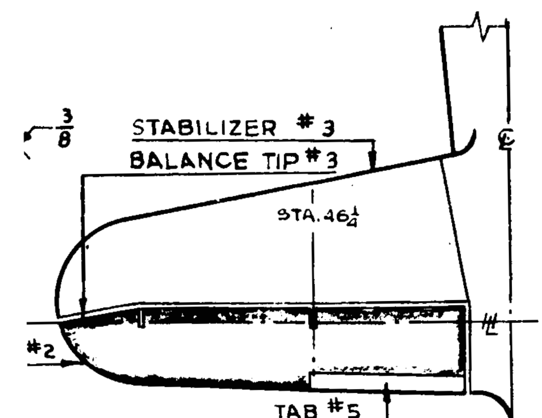


FIGURE 8 j :
ELLIPTICAL ELEVATOR BALANCE NOSE SHAPE :
HINGE LINE MOVED AFT ¼ TO 5 :
USED ON FLIGHTS : [VI₁ : (53-55)]
AERODYNAMIC BALANCE : Be = 0.325



TOR BALANCE NOSE SHAPE :
) FORWARD ⅛ TO 4 ⅞ :
[VI₁ : (56-57)]
.NCE : Be = 0.312

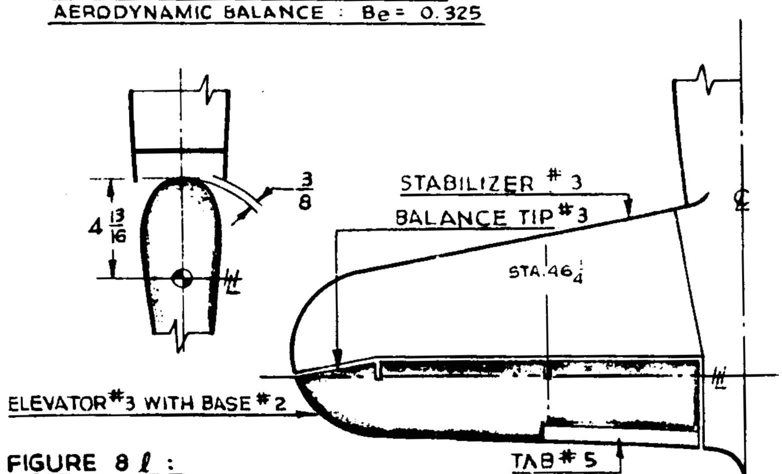


FIGURE 8 l :
FINAL SBD-1 CONFIGURATION ; ELLIPTICAL ELEVATOR
BALANCE NOSE SHAPE : ℄ MOVED FORWARD 1/16 TO 4 13/16
REFERENCE : FIGURE 20
USED ON FLIGHTS : [VI₁ : (58-77)] [VI₂ : (1-9)]
AERODYNAMIC BALANCE : Be = 0.306

FOLD-OUT #2

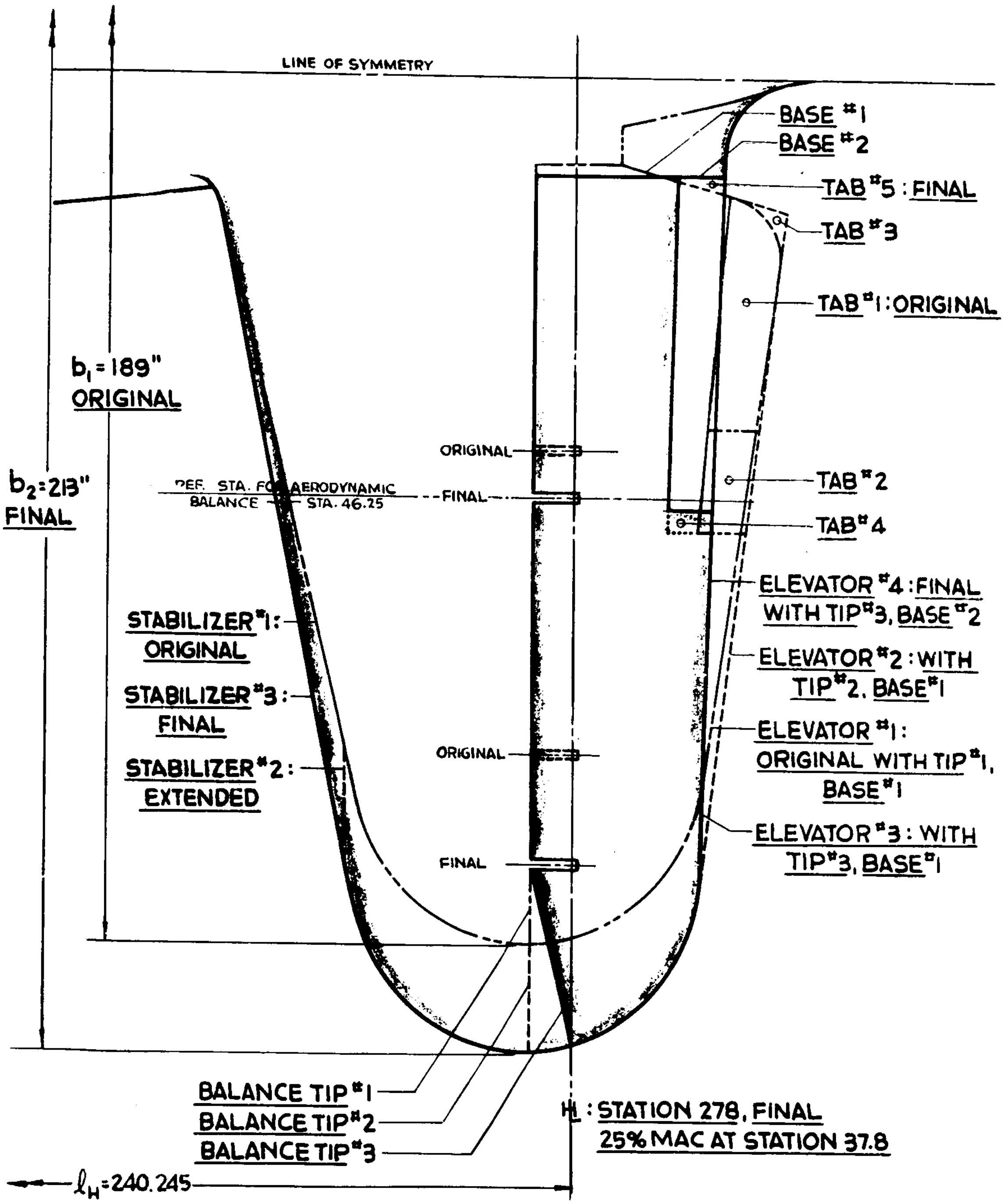


FIGURE 9: HORIZONTAL SURFACE LINE DIAGRAM SHOWING AREA CHANGES MADE DURING FLIGHT TESTS

MODEL: XBT-2 & SBD-1

SCALE: $\frac{1}{16}$ SIZE

FOR AIRFOIL AND BALANCE NOSE SECTIONS, FIGURES 3b, 3d.

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FIGURE 10: EFFECT OF BALANCE TAB WITH 1:1 RATIO ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

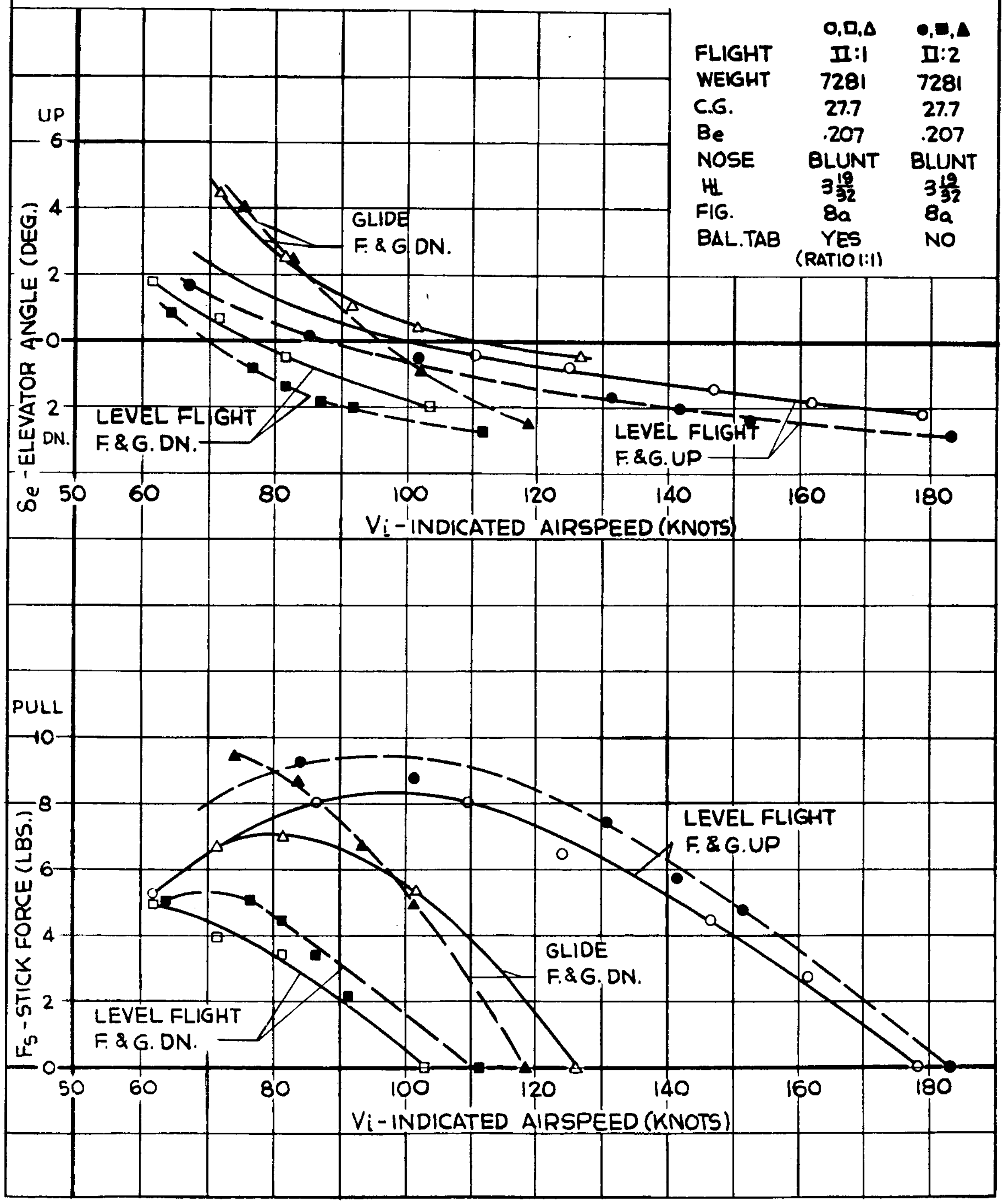

FIGURE 11: EFFECT OF CENTER OF GRAVITY MOVEMENT ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

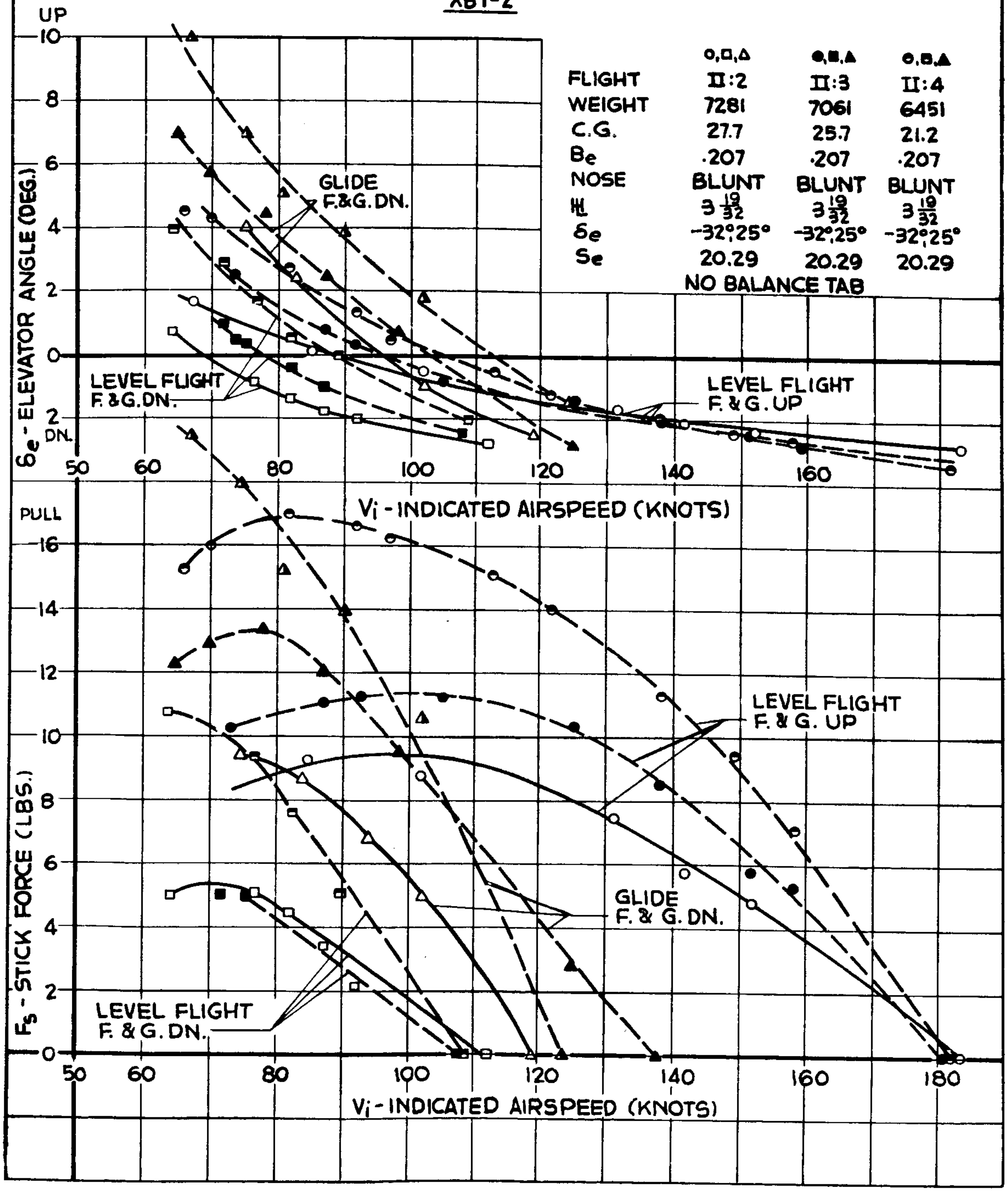

FIGURE 12: EFFECT OF A TWO-FOOT INCREASE IN HORIZONTAL SURFACE SPAN ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

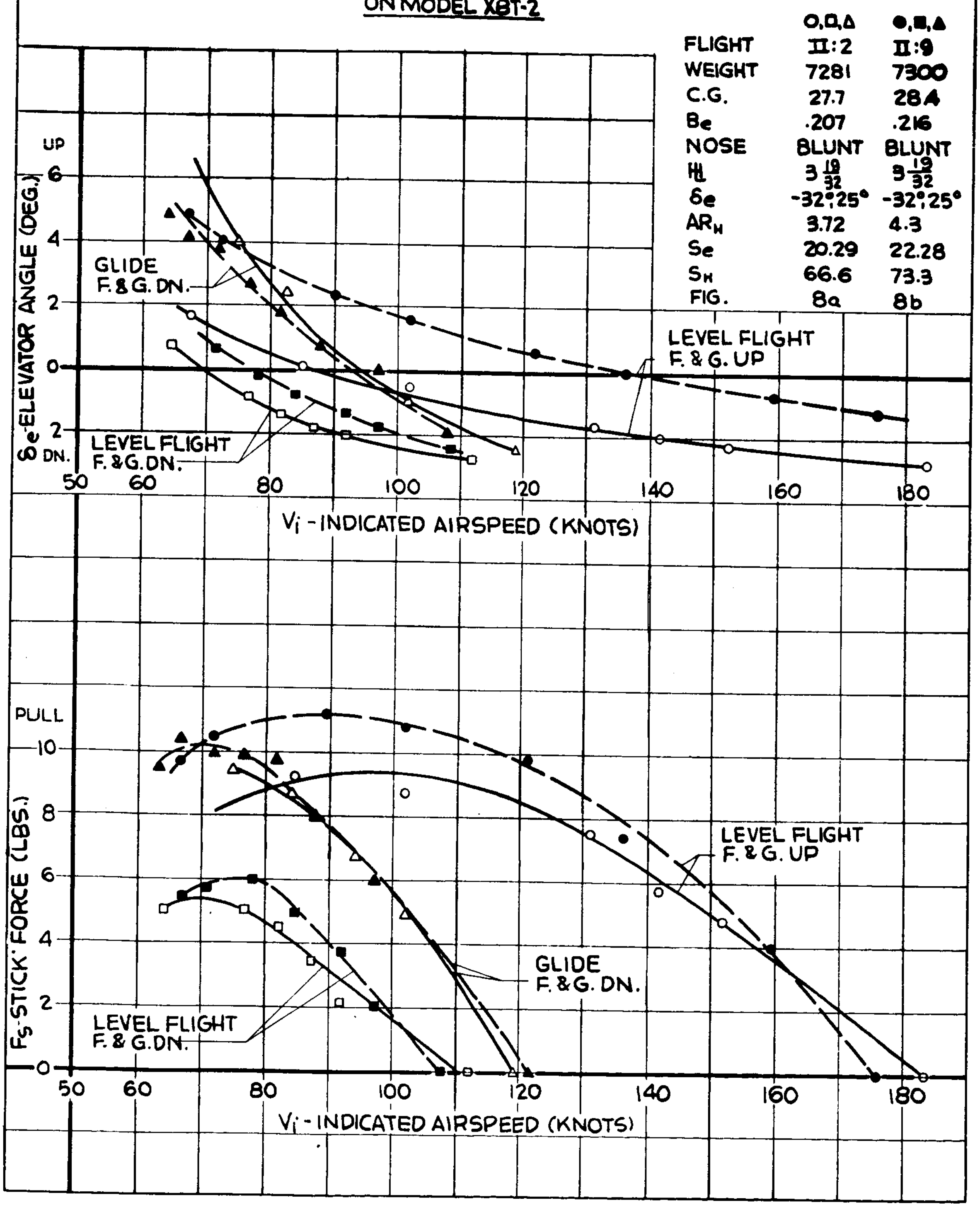

FIGURE 13: EFFECT OF A CHANGE IN ELEVATOR BALANCE NOSE SHAPE FROM BLUNT TO ELLIPTICAL ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

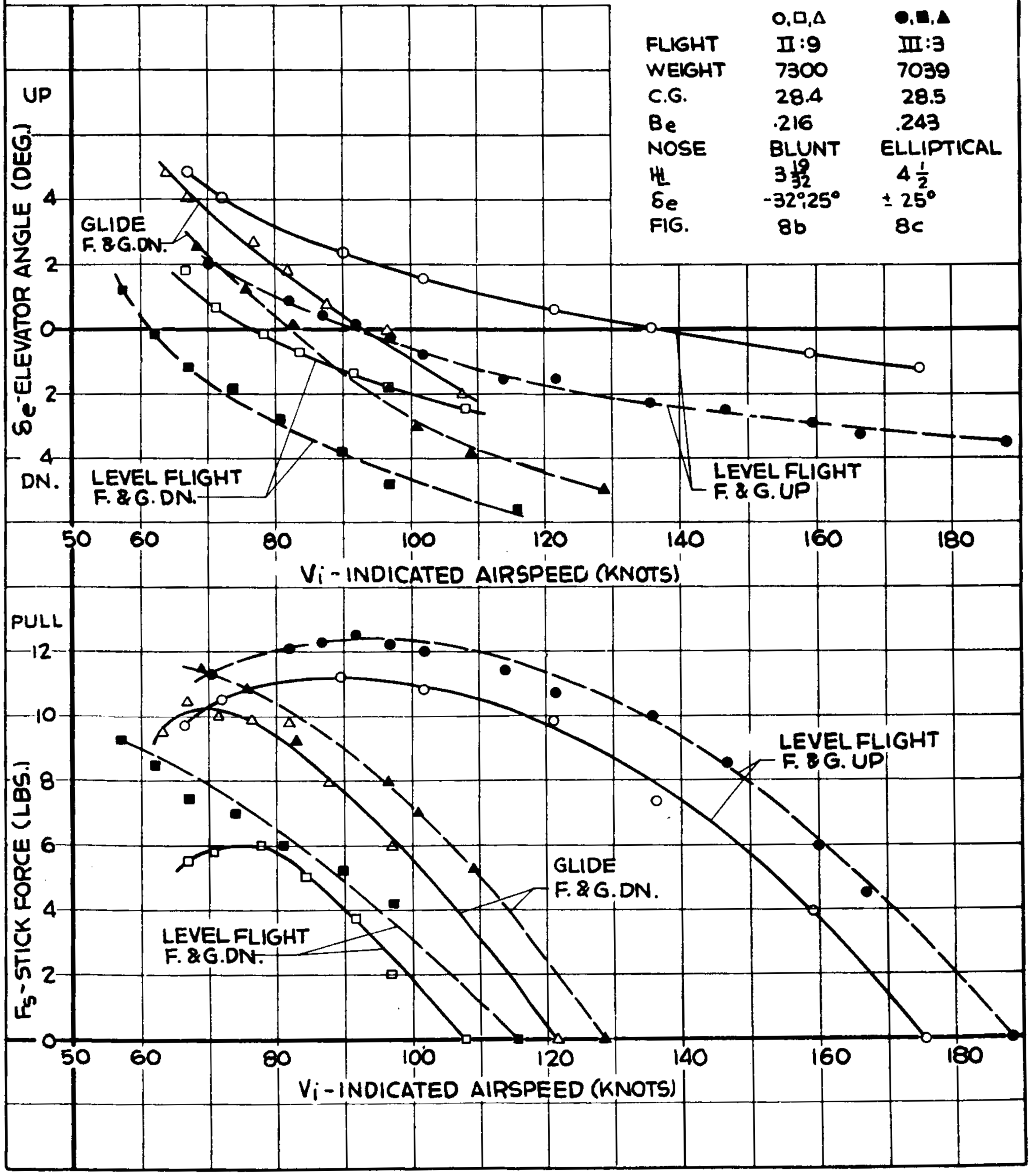

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FIGURE 14: EFFECT OF A 19% INCREASE IN THE ELEVATOR CONTROL MECHANICAL ADVANTAGE ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

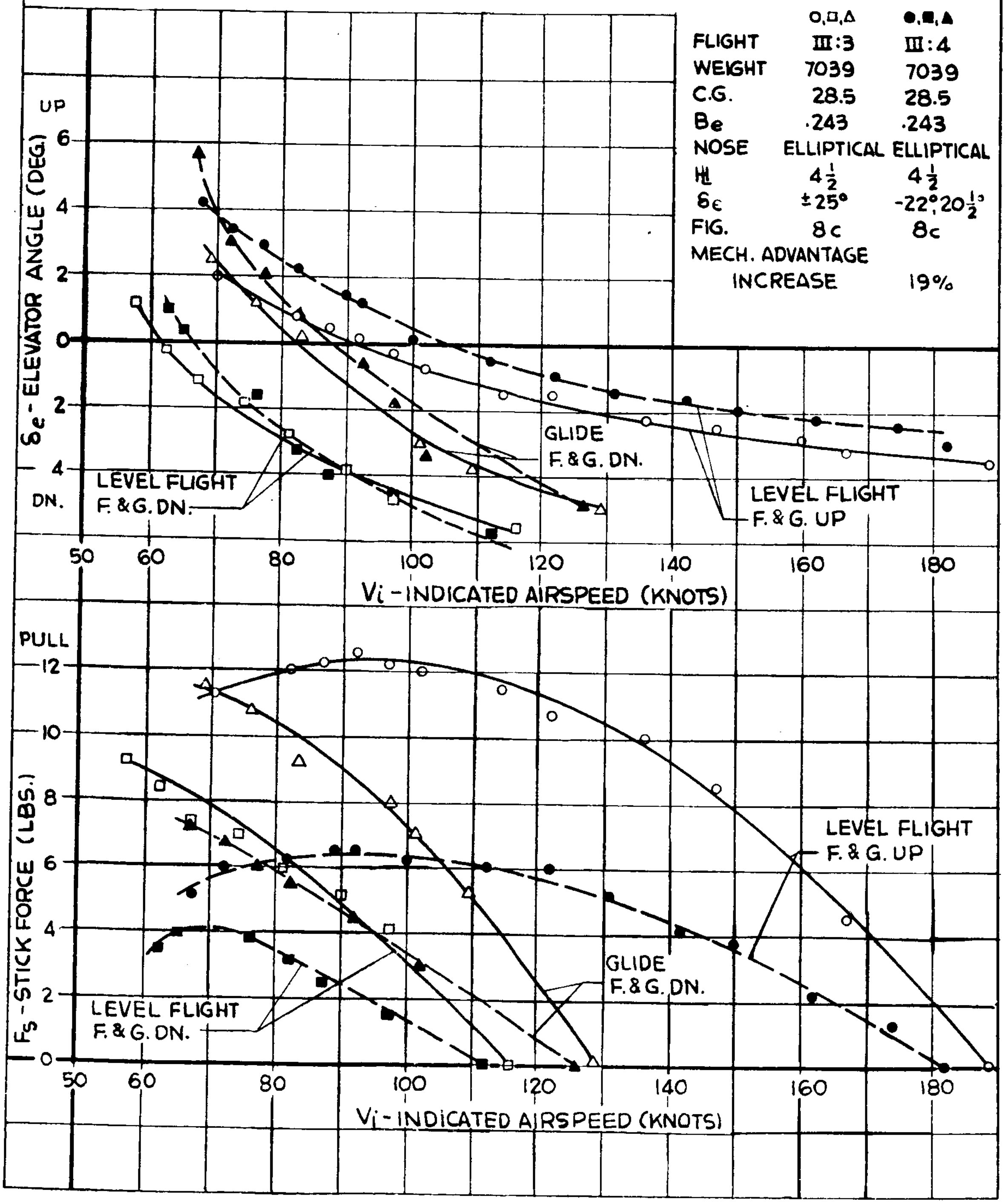


FIGURE 15 : EFFECT OF REDUCED ELEVATOR CHORD ON ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR SEVERAL FLIGHT CONDITIONS ON MODEL XBT-2

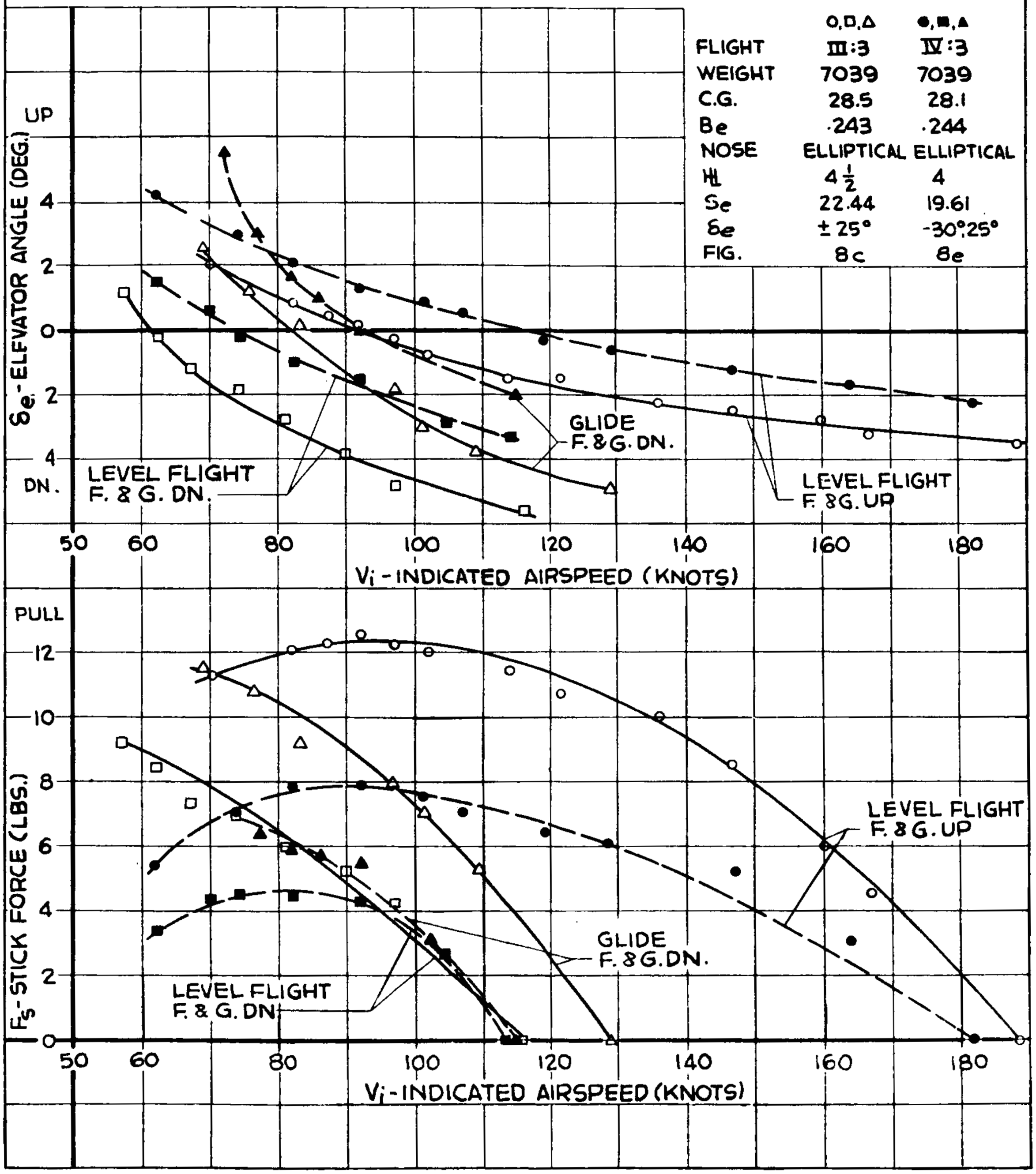
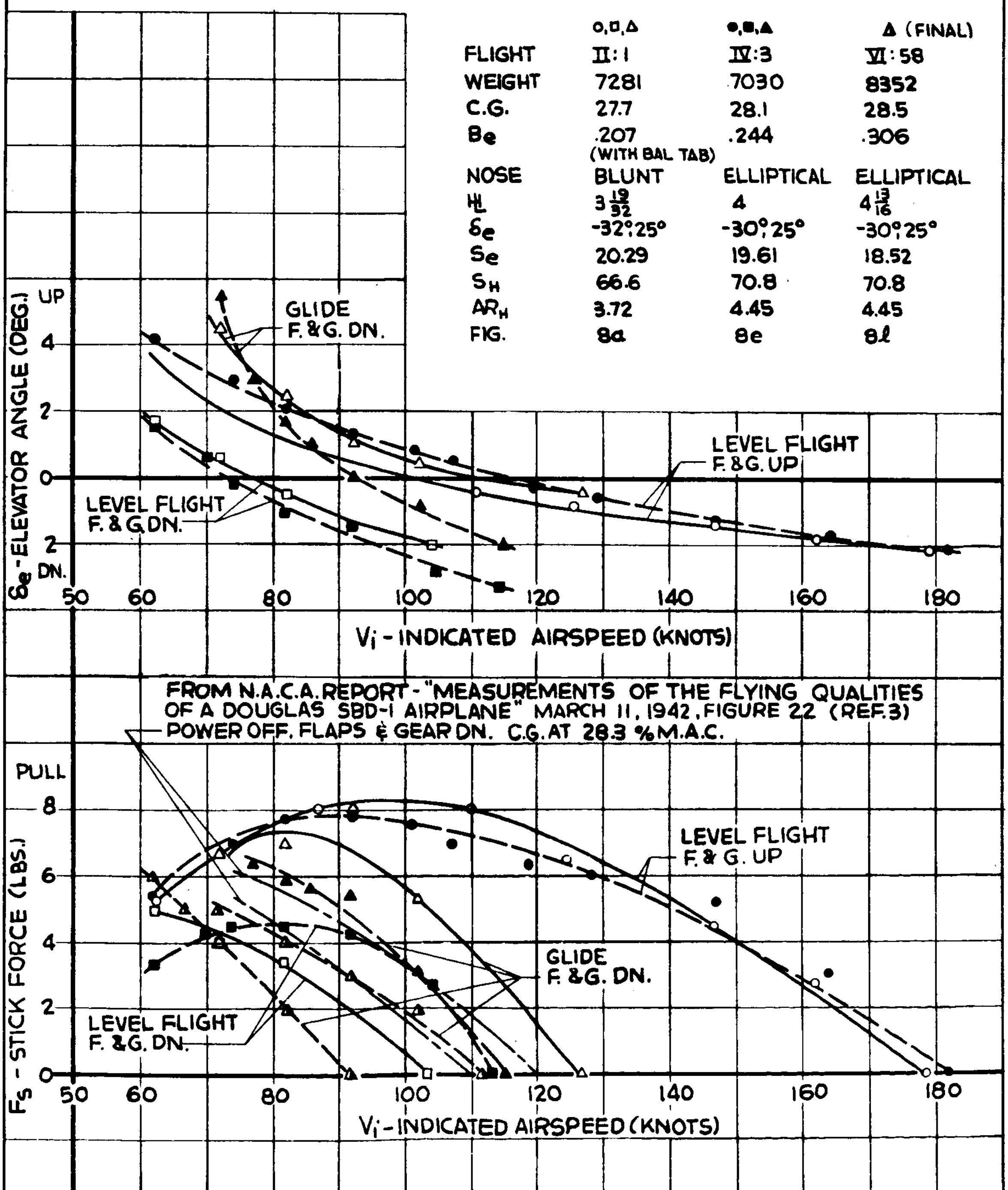


FIGURE 16: COMPARISON OF ELEVATOR ANGLE AND CONTROL FORCE TO TRIM FOR ORIGINAL, REDUCED CHORD, AND FINAL HORIZONTAL SURFACE CONFIGURATION ON MODELS XBT-2 AND SBD-1



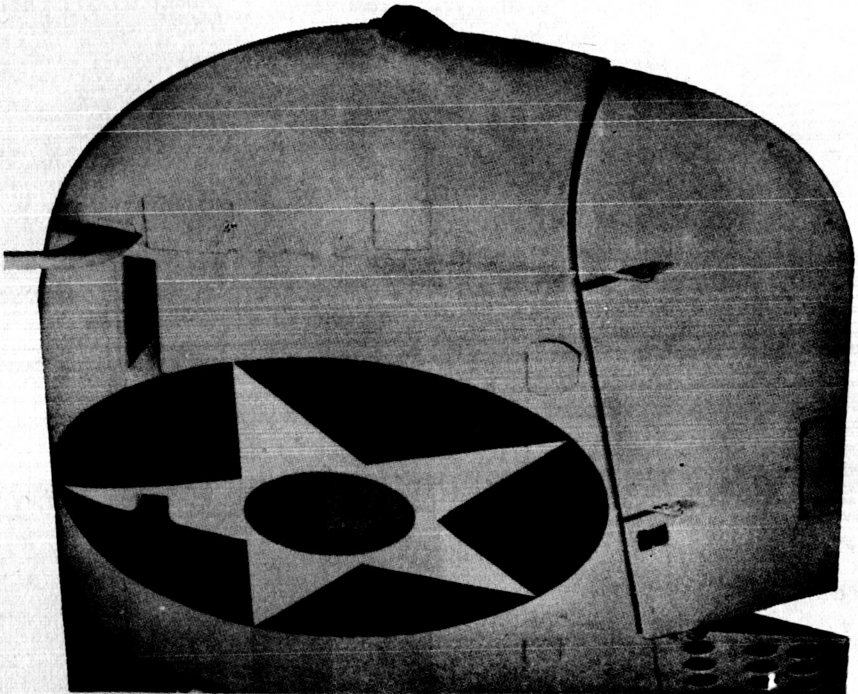
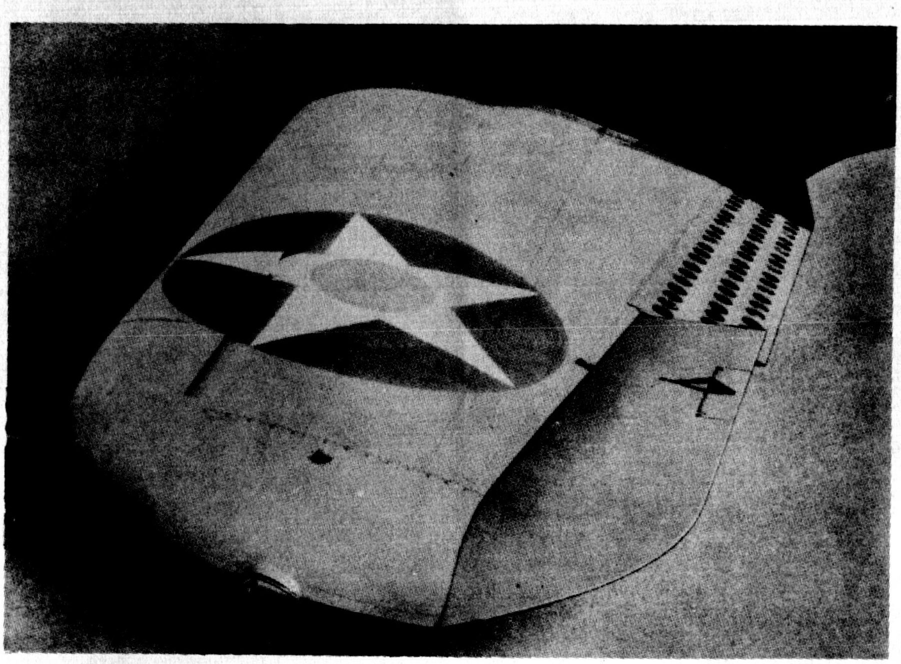


FIGURE 17. DOUGLAS MODEL SBD-1,-2,-3 LEFT WING LOWER SURFACE SHOWING FIXED WING SLOTS, "GOOSE NECK" TYPE PITOT HEAD FAIRING, AND FINAL AILERON CONFIGURATION. NOTE EXTENSION STRIP SHOWING AT EXTREME TIP.



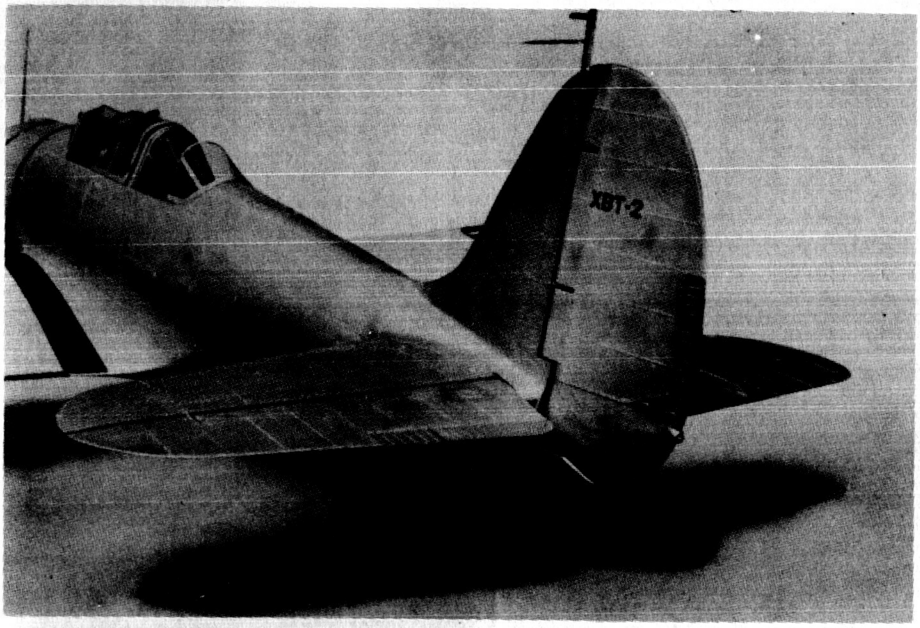
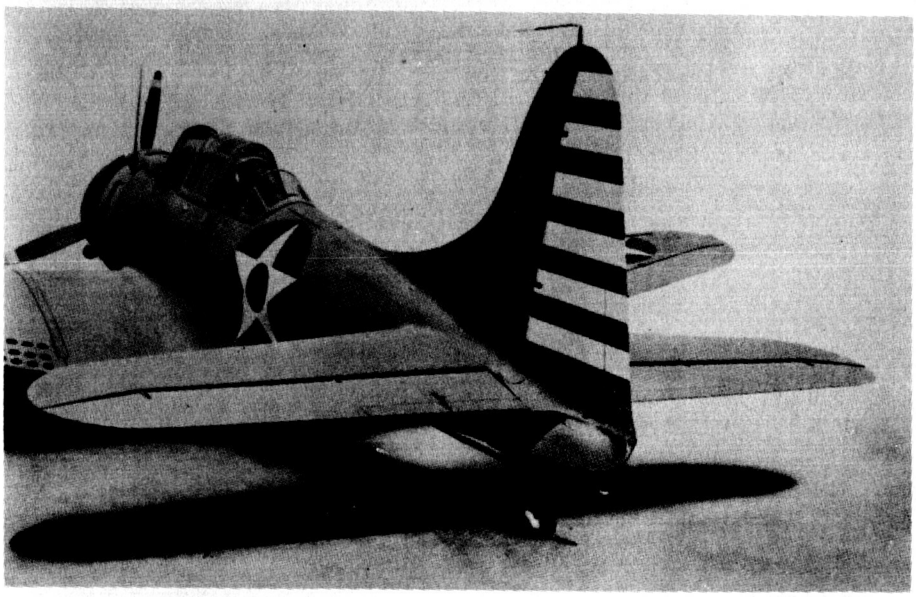


FIGURE 19: DOUGLAS MODEL XBT-2 EMPENNAGE (ORIGINAL)
NOTE MOVABLE TAIL CONE, BLUNT AERODYNAMIC BALANCE
NOSE SHAPES, ELEVATOR BALANCE TAB, AND PITOT HEAD ON FIN.



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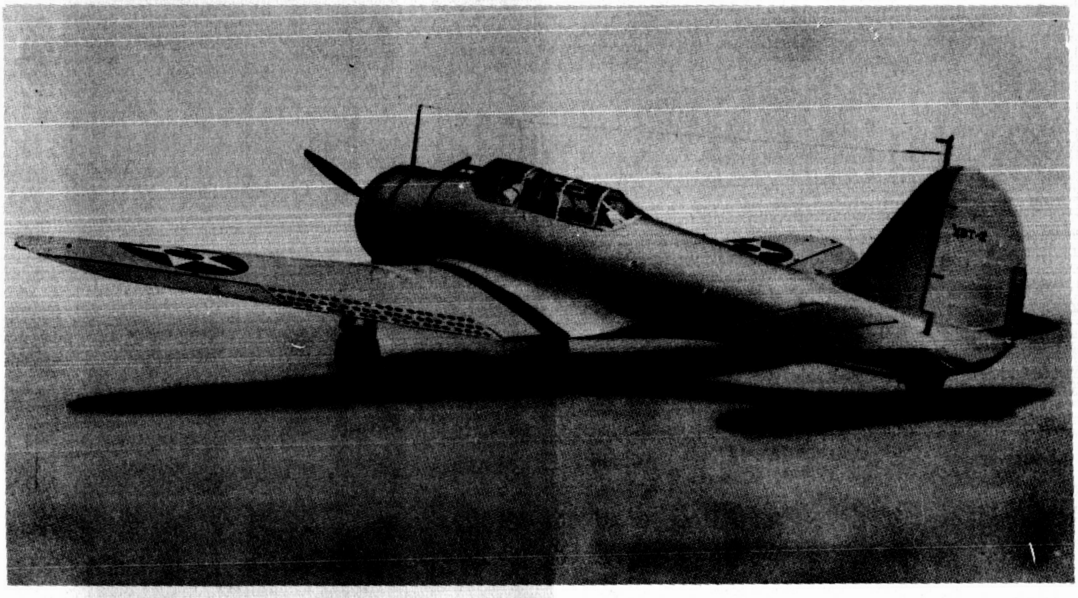
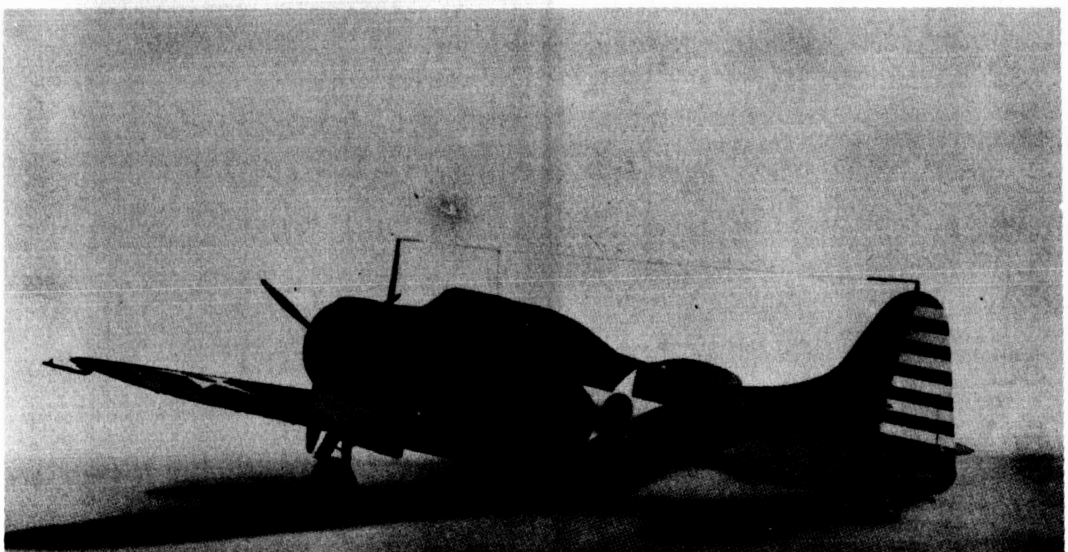
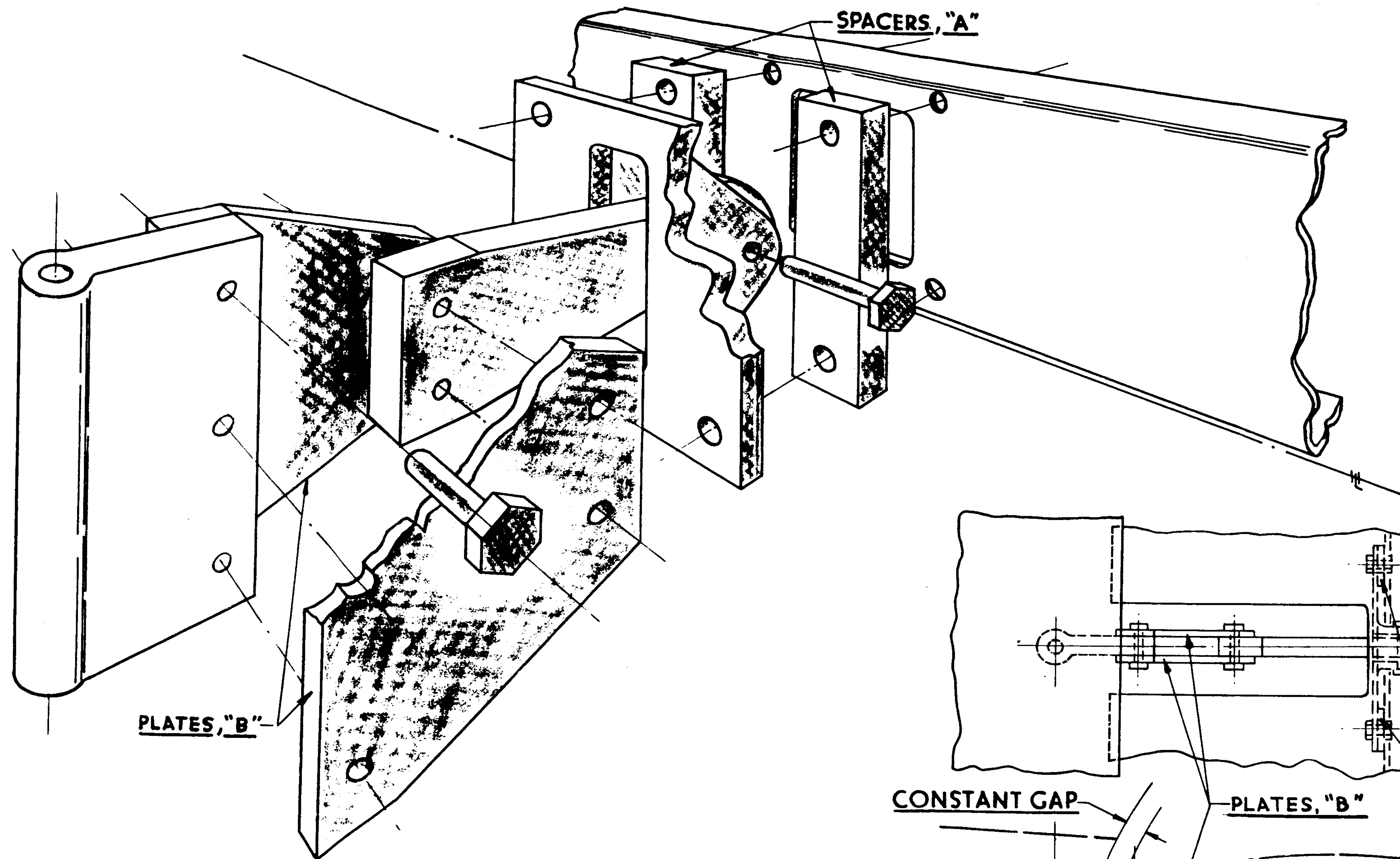


FIGURE 21: LEFT REAR VIEW, DOUGLAS MODEL XBT-2 (ORIGINAL)





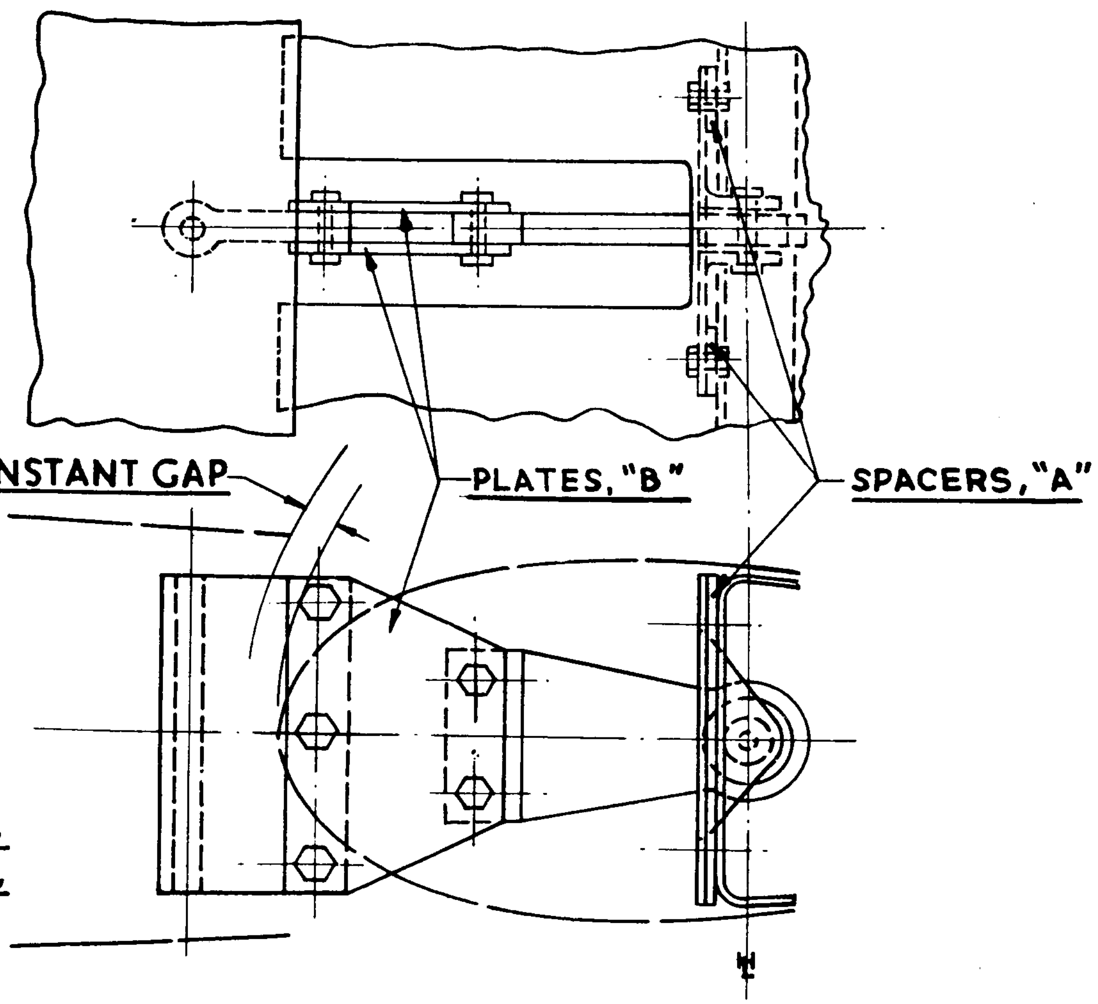


FIGURE 23

METHOD USED ON XBT-2 TO GIVE ADJUSTABLE HINGE LINE LOCATIONS MAINTAINING CONSTANT MOVABLE-TO-FIXED CONTROL SURFACE GAP.

1. TO OBTAIN THE DESIRED HINGE LINE LOCATION, REPLACE SPACERS, "A", WITH SIMILAR PARTS HAVING THE NECESSARY THICKNESS.
2. TO MAINTAIN CONSTANT MOVABLE-TO-FIXED CONTROL SURFACE GAP, REPLACE PLATES, "B", WITH SIMILAR PARTS MATCHED WITH SPACERS, "A", FOR CONSTANT GAP.