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## A FLIGHT INVESTIGATION OF FUSELAGE STATIC-PRESSURE-VENT AIRSPEED INSTALLATIONS

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ADVANCE RESTRICTED REPORT

# A FLIGHT INVESTIGATION OF FUSELAGE STATIC-PRESSURE-VENT AIRSPEED INSTALLATIONS

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## SUMMARY

Flight tests have been conducted at the NACA Ice Research Project, Minneapolis, Minn., to determine the departure of the static pressure measured at fuselage static-pressure vents from the static pressure of the ambient air. Several locations for the fuselage static-pressure vents were investigated on an XB-24F and a Lockheed 12A airplane. The static-pressure-vent installations were also tested in natural icing conditions to determine the effect of icing on the static-pressure measurement.

The tests indicated that the average pressure at the fuselage static-pressure vents departed less from the static pressure of the ambient air than did the average static pressure at the conventional airspeed heads. Flights in natural icing conditions indicated that the pressures measured by the fuselage static-pressure vents were much less likely to be erratic as a result of ice formations than those measured by the commonly used airspeed head.

It was concluded that a more accurate representation of the indicated airspeed in straight flight with symmetric power could be obtained by using a fuselage static-pressure vent in conjunction with a total-pressure head in place of the conventional type of airspeed head mounted near the front of the fuselage.

## INTRODUCTION

The airspeed heads on most multiengine airplanes are mounted on struts which extend normal to the fuselage near the front of the airplane. The dynamic pressure at this position of the airspeed head frequently is not the dynamic pressure of the ambient stream, owing to the pressure field surrounding the airplane. A careful selection of the location of the airspeed head will minimize the necessary correction to the indicated airspeed for a given airspeed or flap condition. At the other conditions, however, this correction may become larger. Flights in icing conditions have shown that ice formations on the support strut of the airspeed head increase the blocking effect and therefore change the indicated-airspeed error.

If the airspeed head is mounted on a boom extending from the front of the fuselage a distance not less than the maximum diameter of the fuselage, or extending ahead of the wing-tip leading edge by approximately one chord length, the correction to the indicated airspeed is usually small for most flight conditions. The use of booms which protrude from the front of the fuselage or from the wing tips, however, has not been favorably accepted because of service problems which arise from such installations.

Unreported investigations by the Royal Aircraft Establishment, Farnborough, England, have indicated that the use of a static-pressure vent installed on the side of the fuselage in combination with a total-pressure head will provide a more nearly correct indicated airspeed than the commonly used airspeed-head installations. The NACA has continued this research by applying the fuselage static-pressure vent to several airplanes and conducting flight tests to determine the magnitude of the indicated-airspeed correction and the vulnerability of the systems to icing conditions.

The flight tests were conducted by personnel of the AAL at the NACA Ice Research Project, Minneapolis, Minn.

## EQUIPMENT AND INSTALLATION

The fuselage static-pressure-vent installations were made on the XB-24F and the NACA Lockheed 12A airplanes. Three pairs of vents were installed on each airplane at three fore-and-aft stations along the sides of the fuselage between the wing and the empennage. The vents in each pair were located exactly opposite each other, as shown in figure 1.

Preliminary tests to locate the final position of the static-pressure vents on the XB-24F airplane were made with surface orifices formed by drilling holes in the fuselage skin. The type of fuselage static-pressure vents employed in the final installation on the XB-24F airplane consisted of a 17/32-inch-diameter orifice in a 1/8-inch-thick plate attached to the outer surface of the fuselage. This type of vent complies with the recommendations of the Royal Aircraft Establishment and is shown in figure 2.

Static-pressure "mice" were used as preliminary vents in the tests with the Lockheed 12A airplane. The final fuselage static-pressure vents on the Lockheed 12A airplane consisted of 1/8-inch-diameter holes in the side of the fuselage as shown in figure 3. Care was taken to prevent any surface variations in the fuselage skin near the orifice when the inner fitting was riveted in place.

The total-pressure heads used in conjunction with the static-pressure vents for this investigation are shown in figures 4 and 5. The locations of the total-pressure heads are shown in figure 1. The total-pressure head used on the XB-24F airplane was a type G-1 head, manufactured by the Aero Instrument Company, Columbus, Ohio, and was provided with an electric heating element. The total-pressure head on the Lockheed 12A airplane was built integrally with the forward lower radio-antenna mast and was also electrically heated.

The service airspeed installations were retained to provide a comparison with the fuselage static-pressure vent and total-pressure-head airspeed installation. The XB-24F airplane was equipped with two electrically heated "shark-fin" type airspeed heads mounted on struts extending normal to the sides of the fuselage near the front of the airplane. The Lockheed 12A airplane was equipped with a "bayonet" type airspeed head which was electrically heated and was mounted on a mast below the forward part of the fuselage. The locations of these airspeed installations are shown in figure 1.

During a part of the investigation, an airspeed head was mounted on a boom extending 4 feet ahead of the nose of the XB-24F airplane in the same location as the total-pressure head shown in figures 1 and 4.

A trailing static-pressure head was used to obtain the ambient static pressure. Standard airspeed indicators, calibrated prior to the flight tests, were used to observe the pressure data in the XB-24F airplane. An NACA photographic pressure recorder was used to obtain the pressure data in the Lockheed 12A airplane.

## TESTS

Preliminary tests were conducted to determine a satisfactory location for the fuselage static-pressure vents on each airplane. These tests consisted in determining the departure of the static pressure measured at each static-pressure vent on the XB-24F airplane, or at each pair of mice on the Lockheed 12A airplane from the ambient static pressure as measured by the trailing static-pressure head.

Subsequent to the determination of a satisfactory location for the fuselage static-pressure vents, tests were conducted to compare the indicated airspeed as measured by the final static-pressure-vent and total-pressure-head installations with that measured by the service airspeed installations. Tests were also conducted on the XB-24F airplane to afford an additional comparison with the indicated airspeed as measured with a nose-boom-type installation.

The flight tests were conducted at constant pressure altitude from landing speed to about 200 miles per hour. Data were obtained with the flaps up, flaps at take-off position, and flaps down. In addition, flight tests were made in a wide variety of natural icing conditions to observe the effects of icing on the different installations.

## RESULTS AND DISCUSSION

The results show the variation, with dynamic pressure $q_o$ of the departure of the static pressure measured at the vents $p$ from the ambient static pressure $p_o$ expressed in percent of the dynamic pressure.

A comparison of the average static-pressure departures on the XB-24F airplane indicates that the pressures at vents 3 and 6 and at vents 2 and 5 were nearest to the ambient static pressure. Vents 3 and 6 were chosen for the final installation, since they would be affected less by the opening of the waist hatches than would vents 2 and 5. Figure 7 indicates that the No. 3 pair of mice were the most satisfactory on the Lockheed 12A airplane. Figure 8 shows a comparison of the departures from ambient static pressure of the pressures measured at the final static-pressure vents, at the nose-boom airspeed head, and at the service airspeed installations for the XB-24F airplane. Figure 9 gives a similar comparison between pressures measured at the service airspeed head and at the fuselage static-pressure vents on the Lockheed 12A airplane. The difference between the data taken at the location of vent pair No. 3 plotted in figures 7 and 9 is due to the change from static-pressure mice (fig. 7) to surface orifices (fig. 9). The relations between the observed and correct indicated airspeeds for the installations on the airplanes are given in figures 10 and 11.

The deflection of the wing flaps changed the static pressure at all locations at which data were obtained. The flap deflection decreased the error in the observed indicated airspeed for the XB-24F airplane service head and increased the error for the fuselage static-pressure-vent system. As shown in figure 8, however, the resulting error in the fuselage static-pressure-vent system remained less than that for the service head. Figures 7, 9, and 11 show that the effect of flap deflection on the Lockheed 12A airplane was to decrease the pressure departure.

It is believed that the fuselage static-pressure-vent installation should consist of two connected orifices, one on each side of the fuselage at the same station. Although no data were taken with the airplanes yawed, it seems apparent that unless vents are located on opposite sides of the fuselage and connected together, a large error would result. For this reason, the final installation of the static-pressure-vent systems was provided with two connected vents. The effect of yawed flight on the pressure measured at fuselage static-pressure vents should be investigated.

Several failures of the service airspeed installations on the test airplanes were experienced in icing conditions. On the same flights the fuselage static-pressure vents were unaffected by ice formations. The failures of the service installations were due principally to ice accretions on the support struts such as shown in figure 12. The ice formations caused a gradual change in the static pressure at the airspeed head, which resulted in an apparent loss of airspeed.

## CONCLUSIONS

1. In straight flight with symmetric power, the average departure from ambient static pressure on the airplanes tested is less at a properly selected vent on the side of the fuselage than at the service airspeed head.

2. The static-pressure measurements which are obtained from the fuselage static-pressure vents are less affected by ice formations than those measured by the service installations on the airplanes tested.

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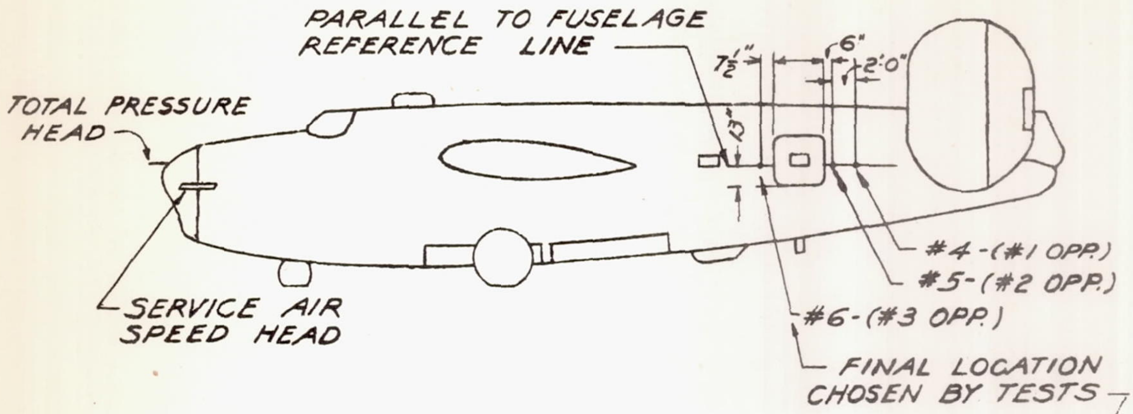
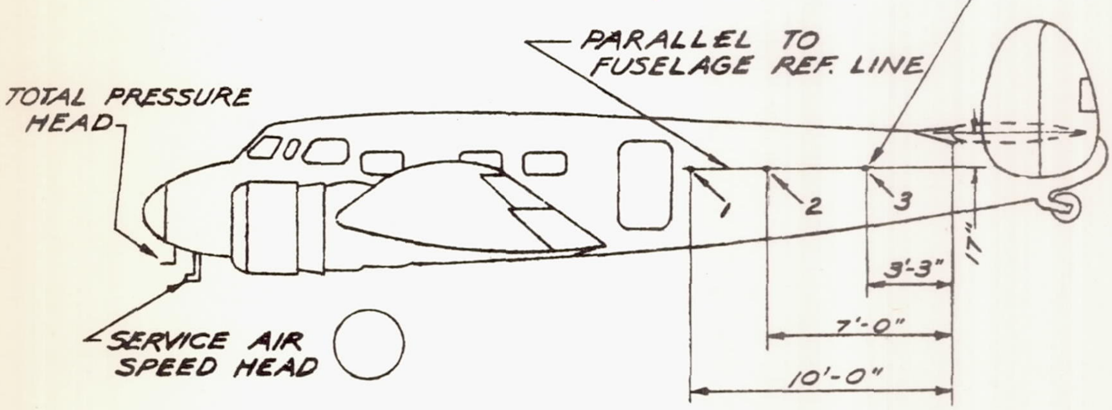



XB-24 F






LOCKHEED 12A

FIGURE 1- THE LOCATION OF THE FUSELAGE STATIC PRESSURE VENTS ON THE XB-24F AND LOCKHEED 12A AIRPLANES.

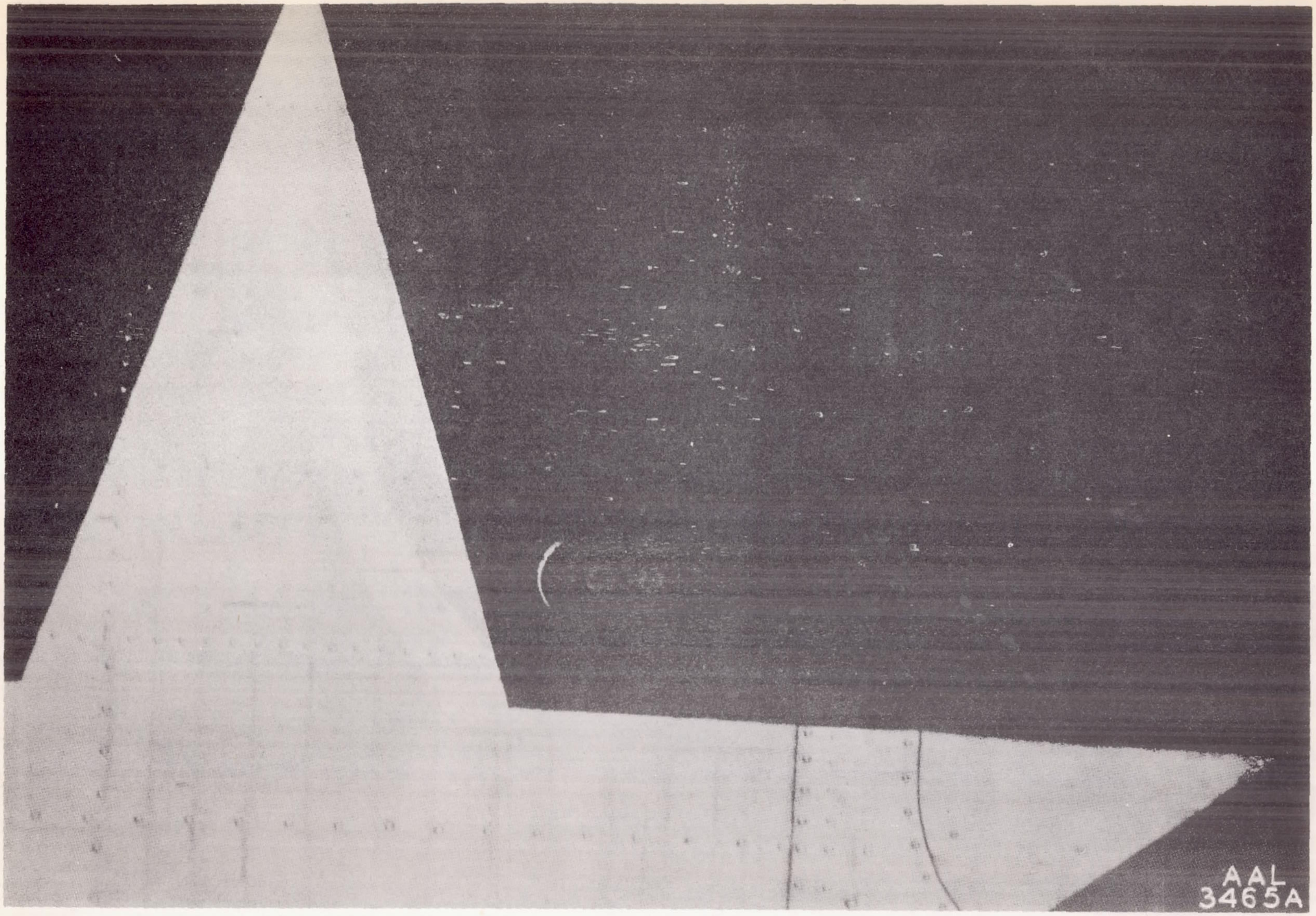



Figure 2.- The final fuselage static-pressure vent on the XB-24F airplane.

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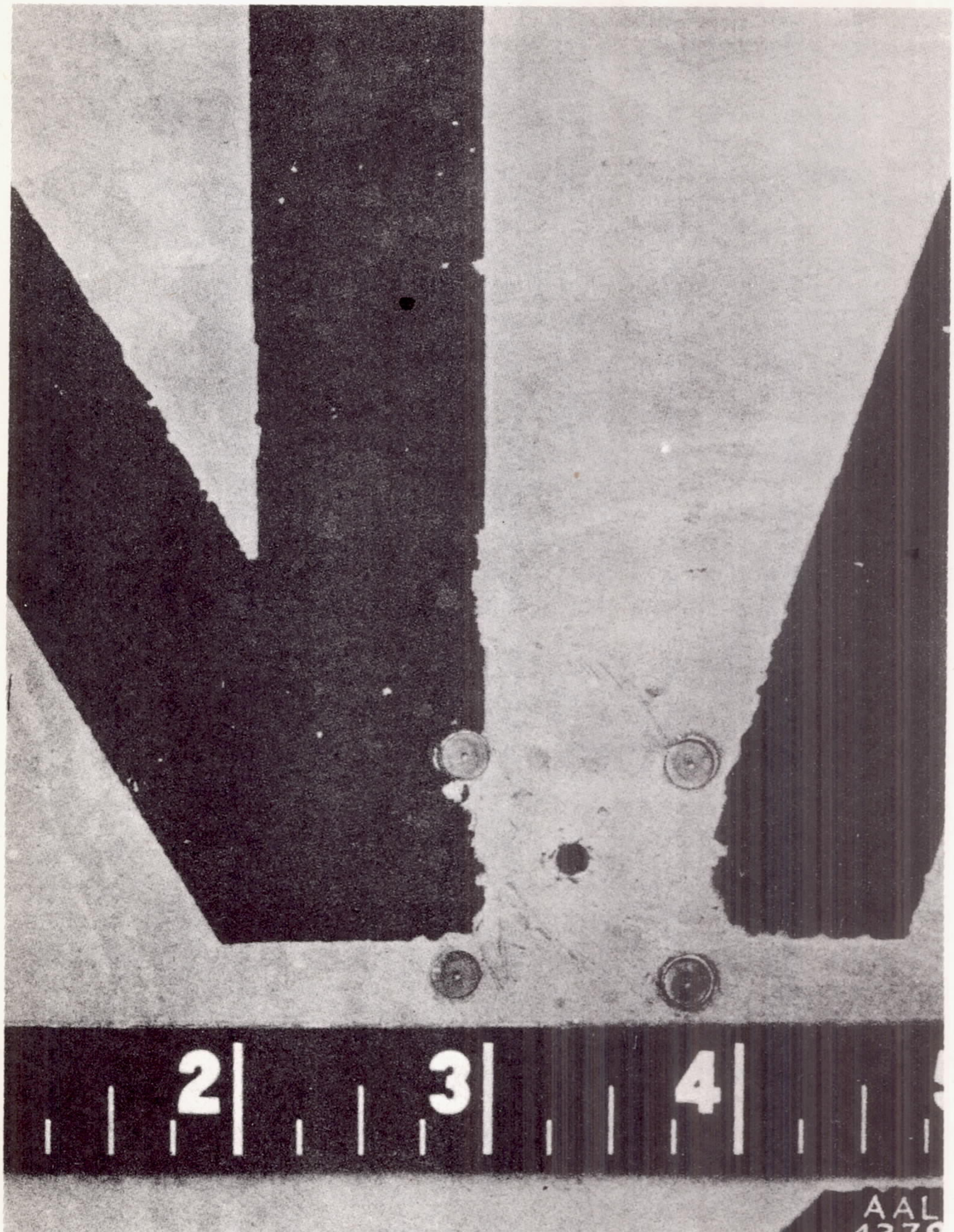


Figure 3.- The final fuselage static-pressure vent on the Lockheed 12A airplane.

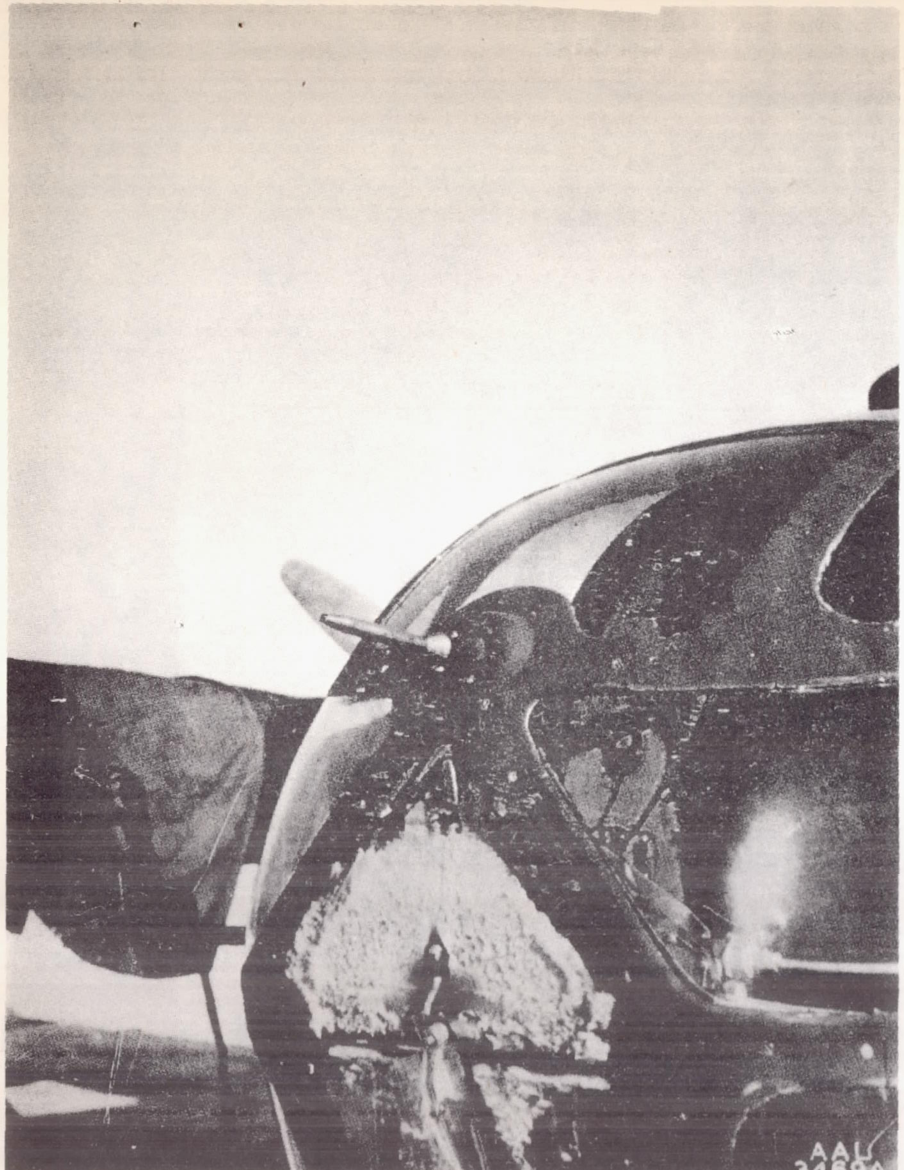


Figure 4.- The total-pressure-head installation on the XB-24F airplane.

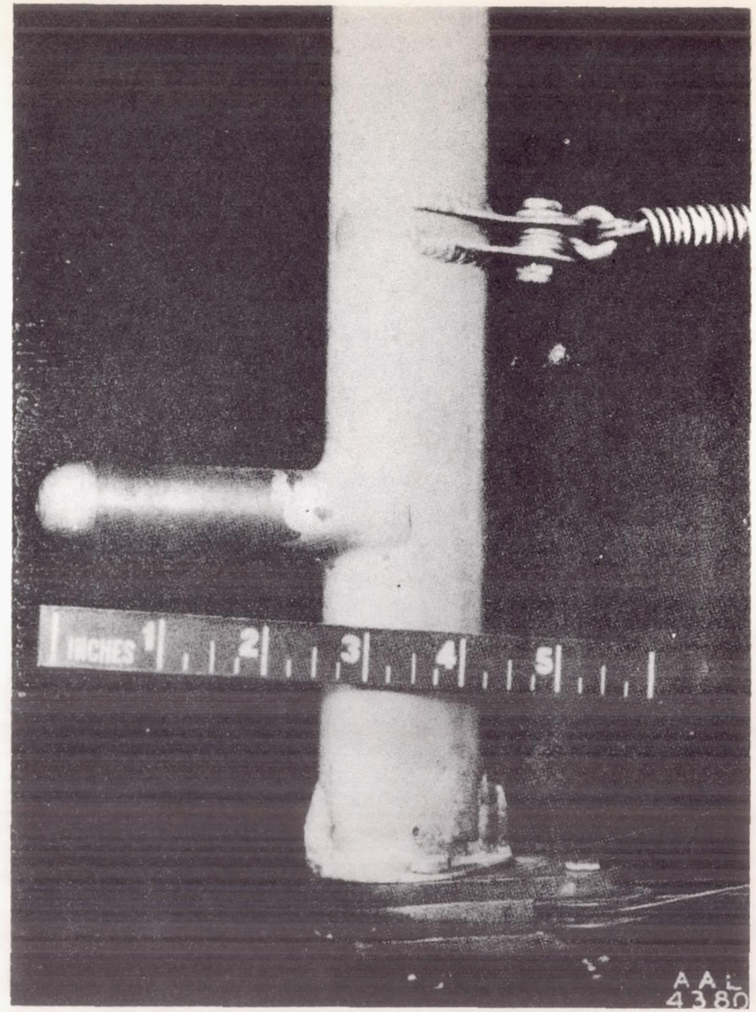


Figure 5.- The total-pressure head on the Lockheed 12A airplane.

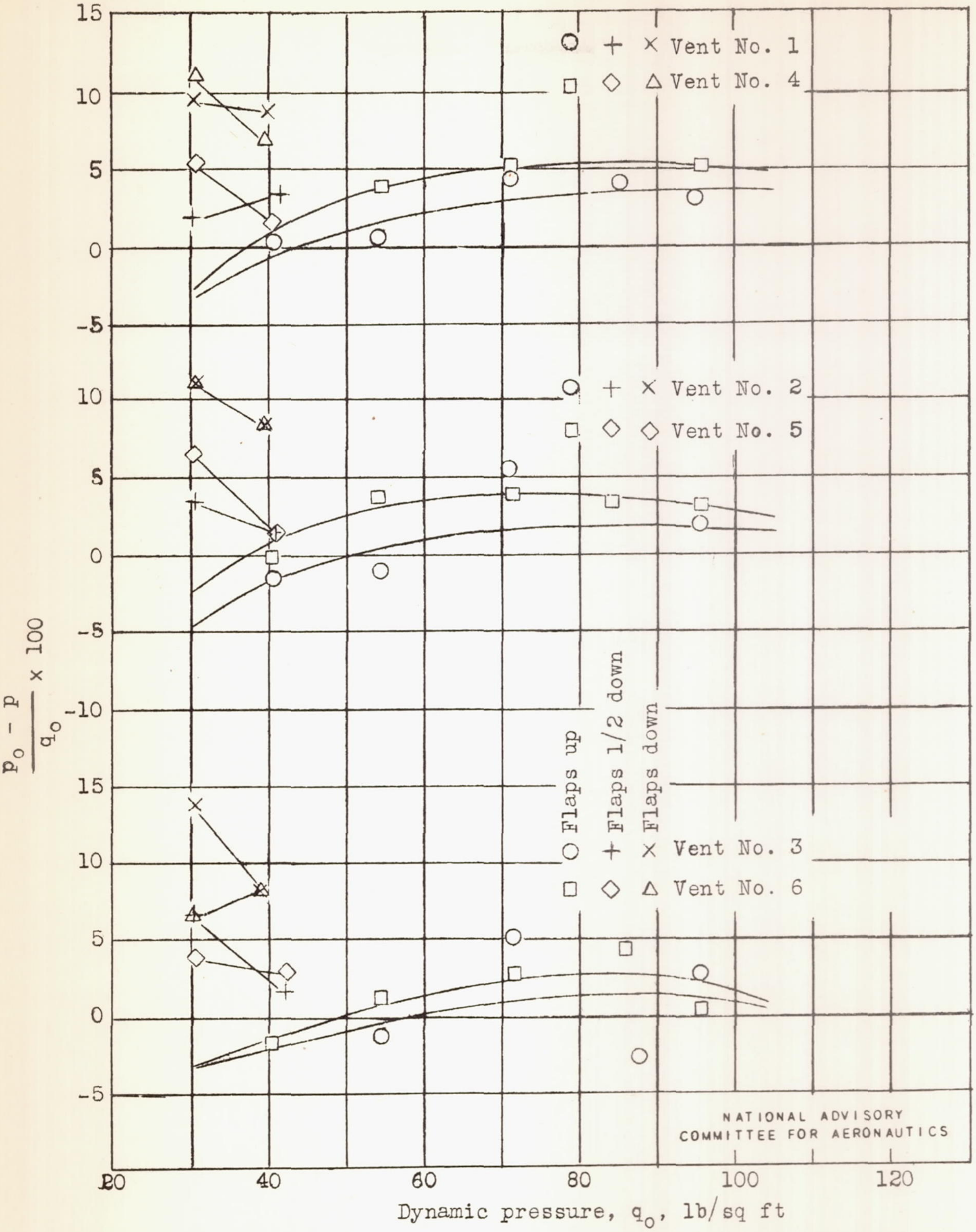


Figure 6.- Departure of the static pressure, measured at the fuselage static pressure vent, from the ambient static pressure for various flap deflections on the XB-24F airplane with the surface orifices.

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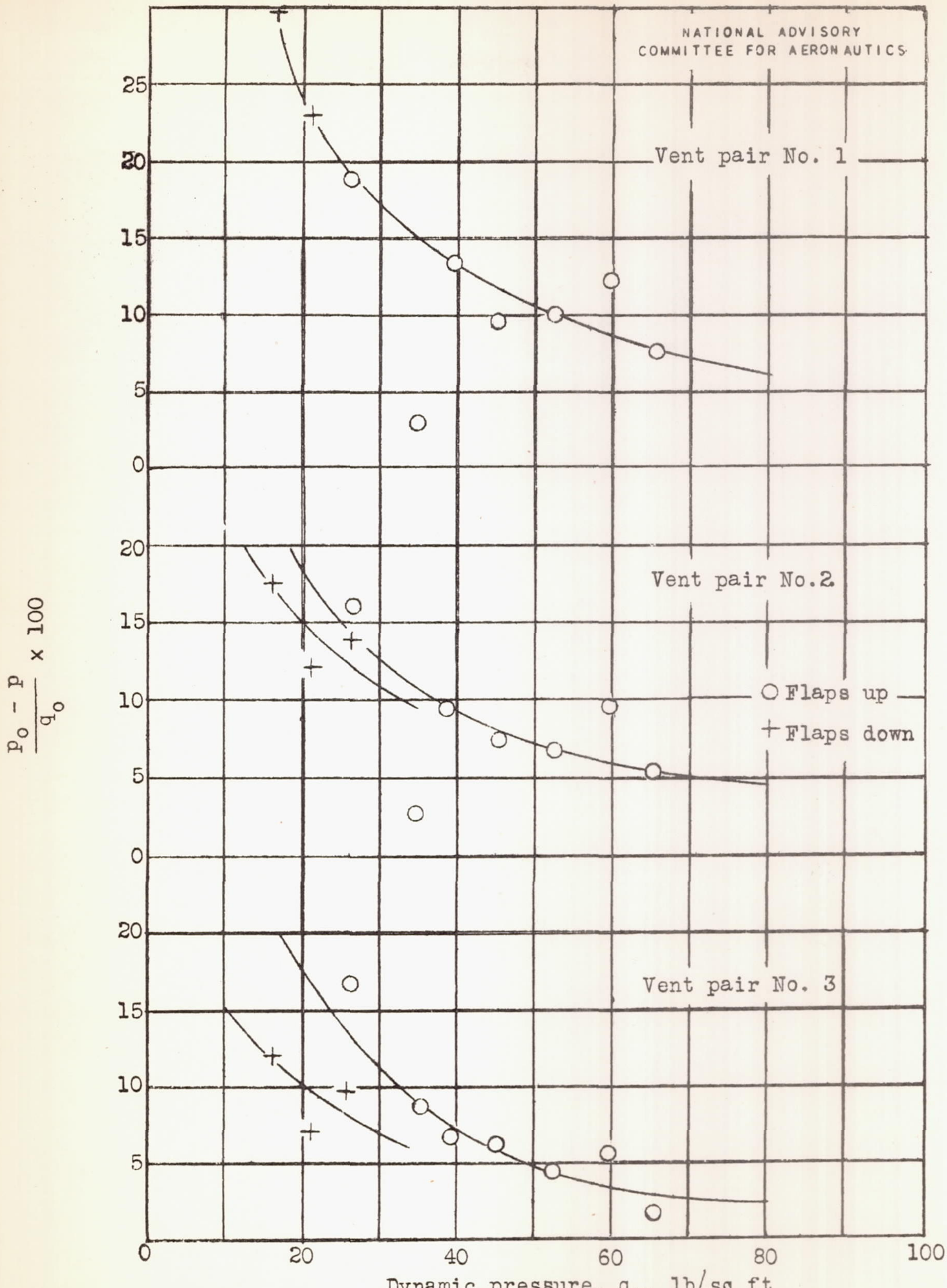


Figure 7.- Departure of the static pressure, measured with the fuselage static pressure "mice" from the ambient static pressure for various flap deflections on the Lockheed 12A airplane.

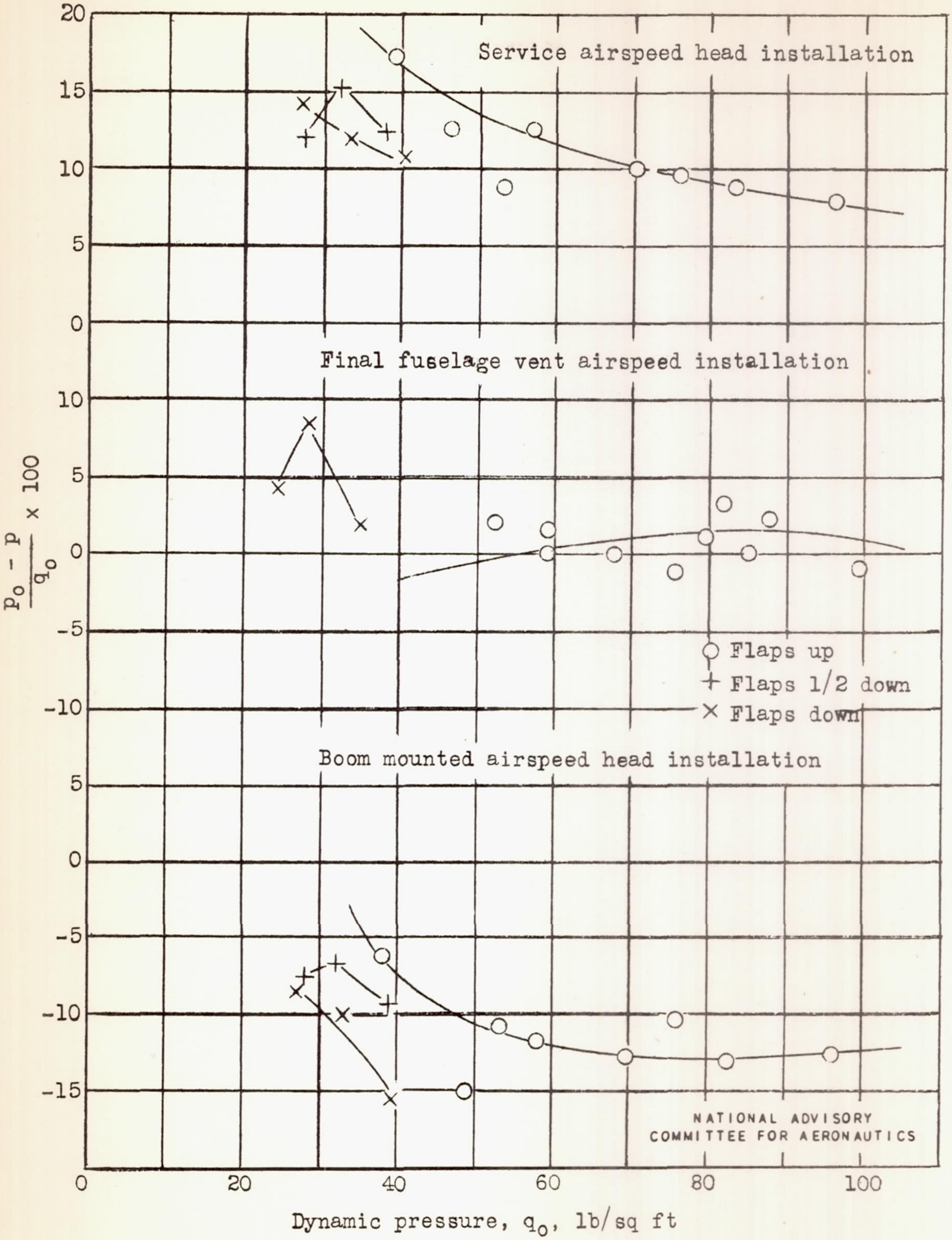


Figure 8.- Departure of the static pressure measured at the service airspeed head, fuselage static pressure vent and the boom mounted airspeed head, from the ambient static pressure for various flap deflections on the XB-24F Airplane.

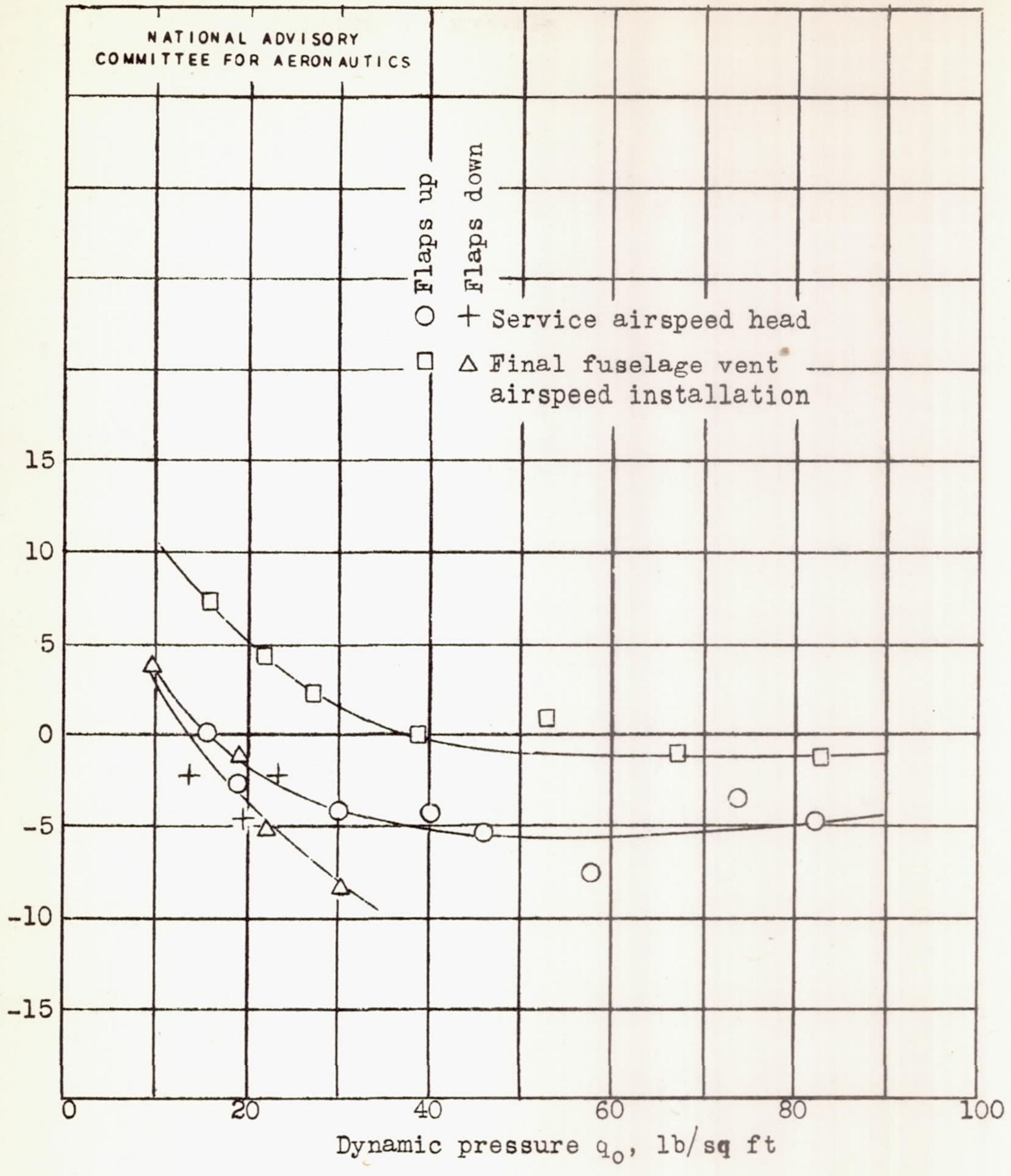


Figure 9.- Departure of the static pressure, measured at the service airspeed head and fuselage static pressure vent, from ambient static pressure for various flap deflections on the Lockheed 12A airplane.

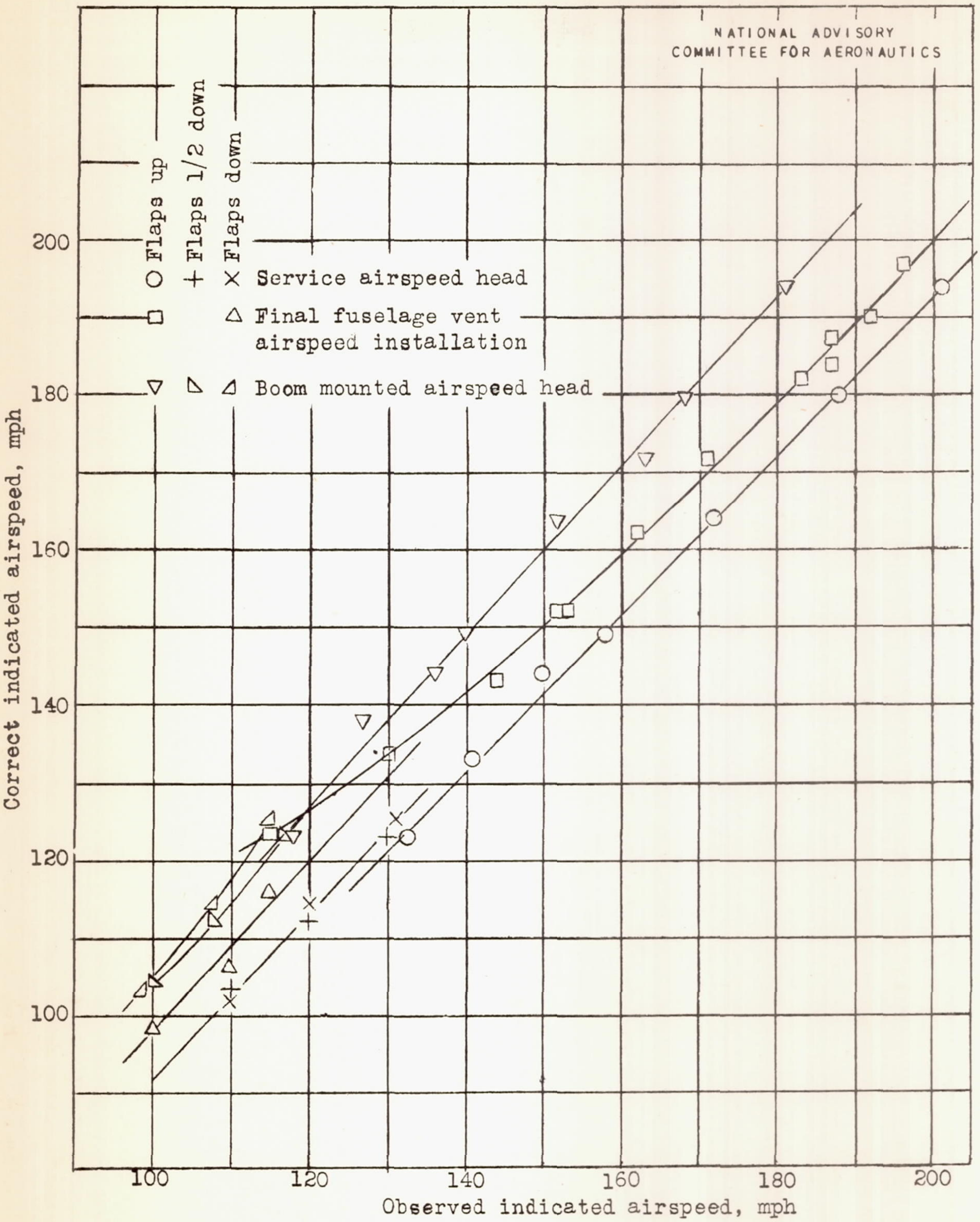


Figure 10.- Comparison of the observed and correct indicated airspeeds for the airspeed installations tested on the XB-24 F airplane.

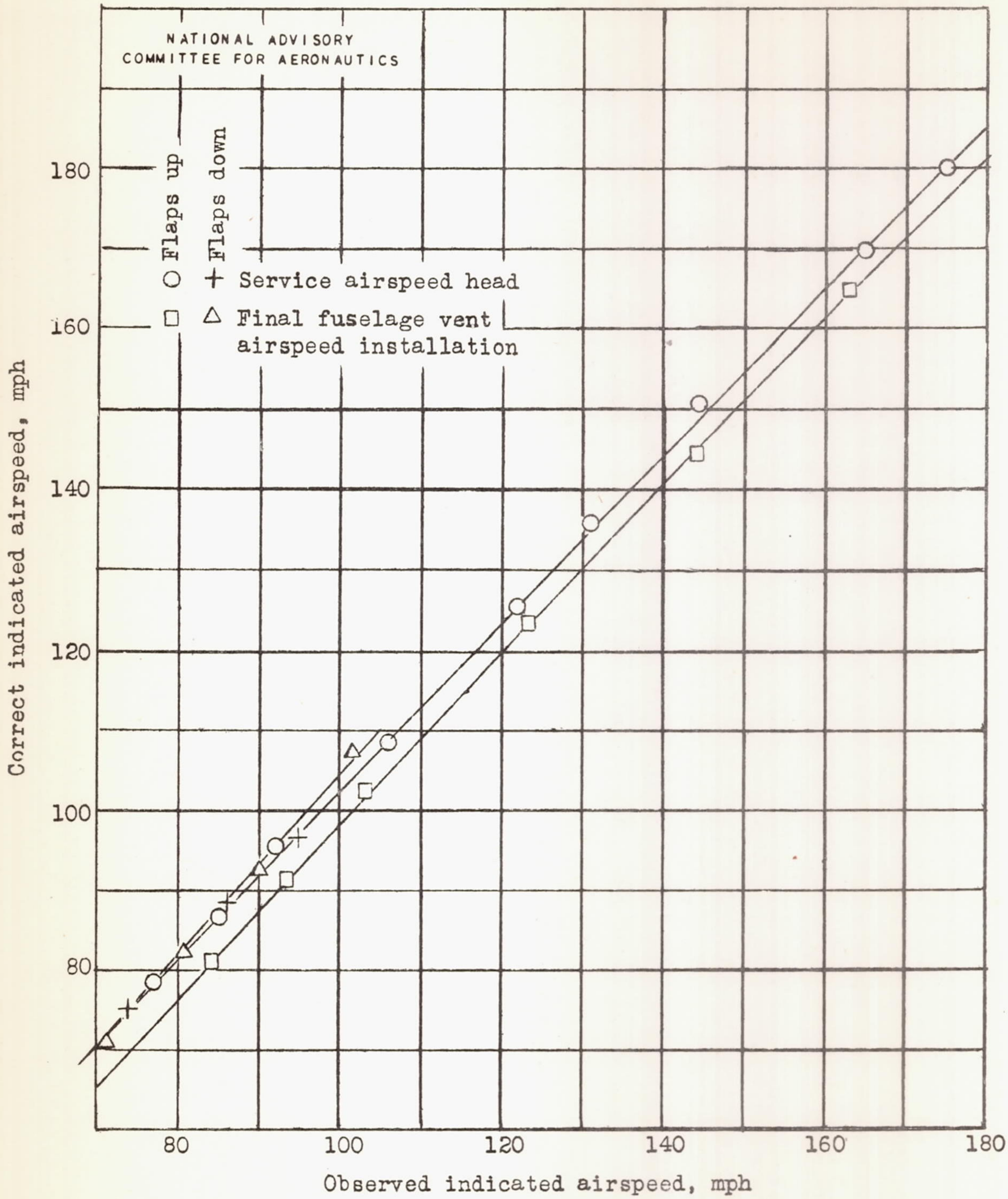


Figure 11.- Comparison of the observed and correct indicated airspeeds for the airspeed installations tested on the Lockheed 12A airplane.

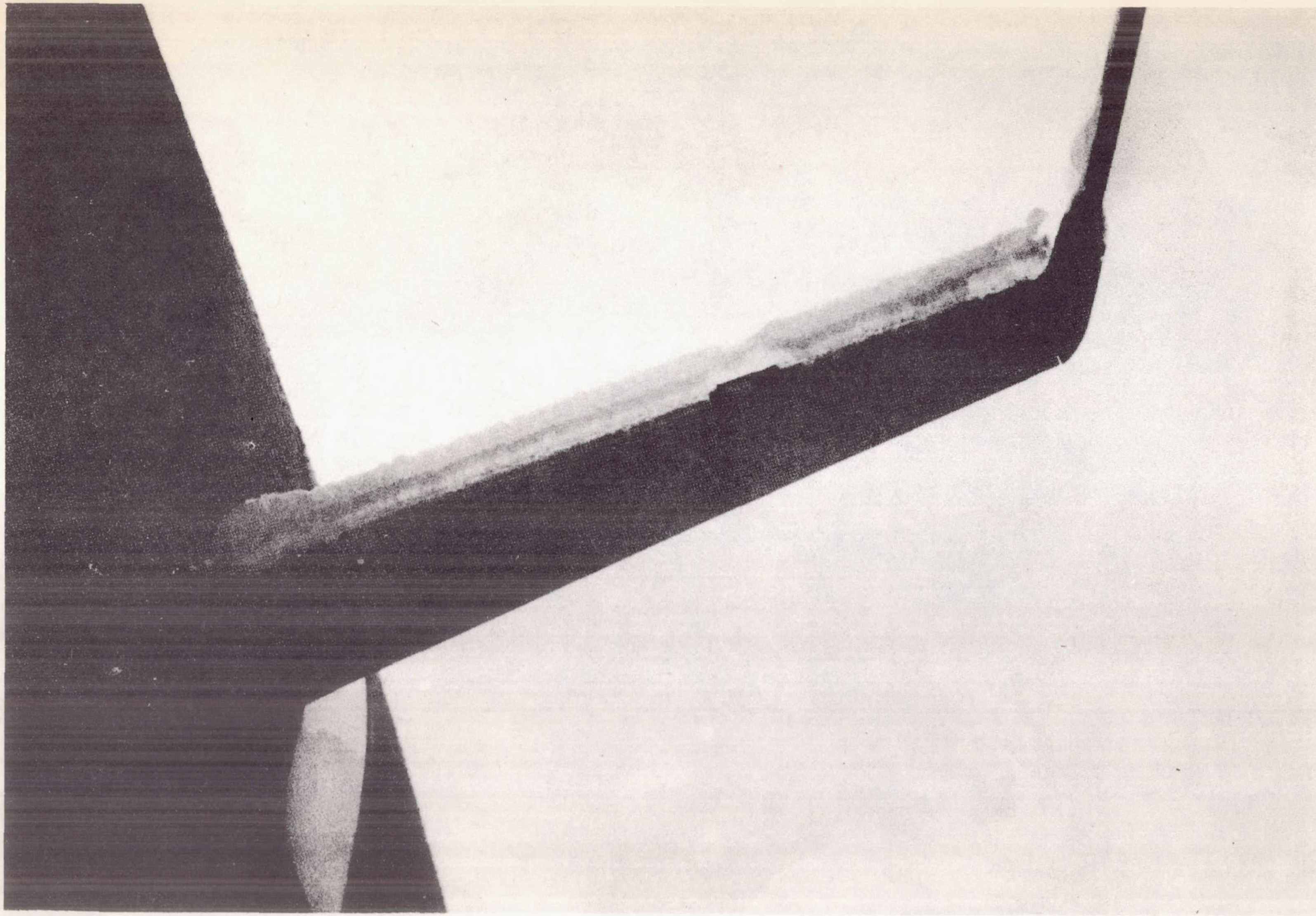

Figure 12.- Ice formation on the left airspeed-head support strut on the XB-24F airplane.