ENGINEERING RESEARCH INSTITUTE
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PROGRESS REPORT NO. 4

RESEARCH DESIGN PROBLEMS RELATING TO FACILITIES FOR SIMULATING THE AERODYNAMIC EFFECTS OF ATMOSPHERIC GUSTS ON AIRCRAFT COMPONENTS

July 26, 1953—October 26, 1953

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Summary

A vortex generator device for simulating atmospheric gusts has been placed in operation and the major mechanical and instrumentation difficulties have been corrected. A sample of the type of test data to be obtained is included in this report. Channel modifications necessary for continued development of the instrumentation have been completed. Design studies on larger scale gust simulation models are underway.

I VORTEX GENERATOR

The vortex generator makes use of the induced field in the vicinity of a moving vortex sheet to provide a non-stationary distribution of velocity over a wing. A series of vortices which approximate a vortex sheet is generated by rapidly changing the angle of attack of 7 parallel airfoils that span the tunnel. A mechanical description of the system has been given in progress report number 2.

This gust generator was completed and checked out during the present period. Photographs of the unit are shown in figures 1 and 2. Extreme oscillations developed during the operation of the generator and by means of high speed photography, the trouble was traced to the shape of the cam. Reshaping the cam corrected the difficulty.

The angle of the airfoils in the vortex generator is measured by the deflection of a cantelever beam upon which two strain gauges are mounted. The gauges form two legs of an A.C. bridge which uses a Brush "Universal Analyzer" Model 320 as the oscillator, amplifier, and detector unit. The output from the analyzer is fed directly to the oscilloscope. It is necessary to use a low pass filter in the circuit in order to eliminate the various high frequency components that are carried through the Brush instrument. The filter used is a General Radio Low Pass Wave Filter type 830 G. With the insertion of this filter the response of the strain gauge is satisfactory.

In figure 3 is shown an oscillogram of the angle of attack history. A trace of the dynamic response of the strain gauge, a sine wave of 100 c.p.s., and a static calibration of the system for airfoil angles of 0, 5, 10, and 15 degrees are shown. The lowest curve corresponds to an angle of attack of 0°. In figure 4 is shown a series of dynamic runs in order to check repeatibility. From this data it appears that the system is repeatible.

Instrumentation for the series of tests consists of both hot wire and balance measurements. The hot wire technique and equipment is the same as that used for the moving bump system and is reported in progress report number 3.

For this series of tests the airfoil is mounted vertically. In figure 5 is shown a photograph of the balance system with the airfoil attached to it. The operation of the balance system is described below. Reference should be made to the sketch in figure 6. The airfoil is mounted as a cantelever beam that is attached at one end by means of a flexural hinge. Bending is restricted to motion in the roll direction. Deflection due to drag or moment are not permitted. Block (E) is attached to the base of the airfoil and serves as an attachment for the flexural hinge for (A) and for the extension arm (B) which actuates the core of the Schaevitz Linear Deflection Transformer (C). To the base of the balance system (D) is attached the other end of the flexural hinge (A). The Schaevitz transformer (C) is also mounted in the base (D). Rotation of the airfoil due to lift loads causes a change in the position of the core within the transformer (C). The motion of the core is detected by using an oscillator, amplifier, detector unit whose trade name is "Dynamyke". The output from this unit is fed directly to the oscilloscope.

In order to measure the nonstationary effect due to the gust it is necessary to keep the inertia of the airfoil as small as possible. To do this, the airfoil was carved from foam polystyrene plastic, covered with model airplane tissue paper and painted with airplane dope. This has produced a very light and rigid airfoil.

II CHANNEL MODIFICATION

As reported in progress report number 3, a fluctuation existed in the tunnel stream and was observed in the measurements. The hot wire technique is particularly sensitive to these flow fluctuations. Since the hot wire is an important part of the instrumentation for the vortex type of gust generation it is necessary that the flow be improved. To this end, the settling chamber was enlarged and new screens installed.

III NEW TEST MODEL

With the present gust generation model it is possible to test to Reynolds numbers of 130,000 with an airfoil chord of six inches. This is too low a Reynolds number to accurately access the operation of either the gust generating devices or the instrumentation. Therefore, it is necessary to build a larger model. Tests on the present model have served as a guide to the design of the new model. The new test model will have a test section 5 feet high, 7 feet wide, and 25 feet long, and will be capable of wind speeds up to 250 feet per second. Design work and a detailed cost estimate of this model are currently being studied.

IV WORK PLANNED FOR NEXT PERIOD

In the next period it is expected that the following will be accomplished:

1. Tests will be continued on the vortex type of gust generator.
2. An evaluation of the various methods of gust generation will be made.
3. Design of the new test model will be continued.

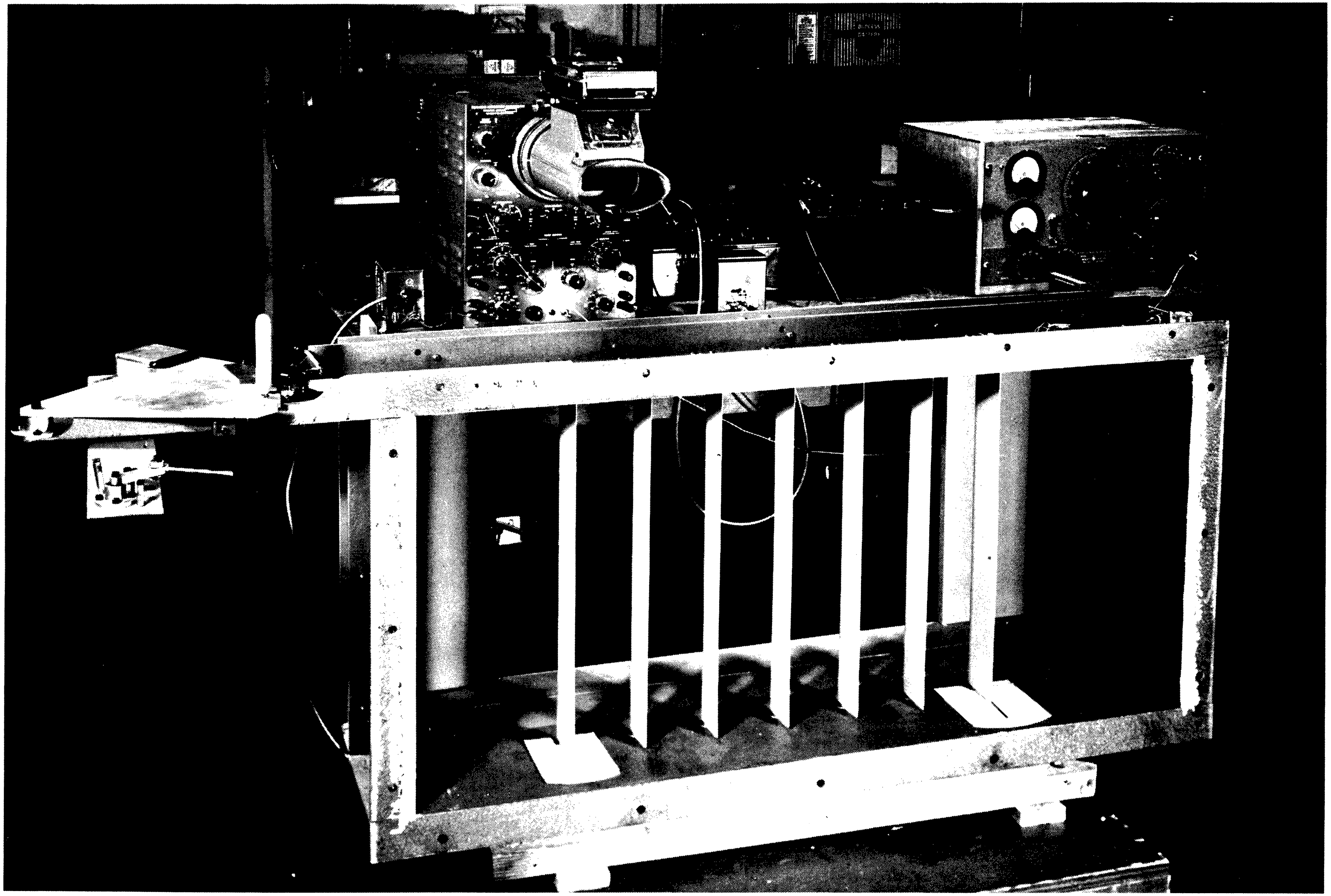


FIGURE 1

PHOTOGRAPH SHOWING BENCH CALIBRATION OF VORTEX GENERATOR
AND THE ASSOCIATED ELECTRICAL EQUIPMENT

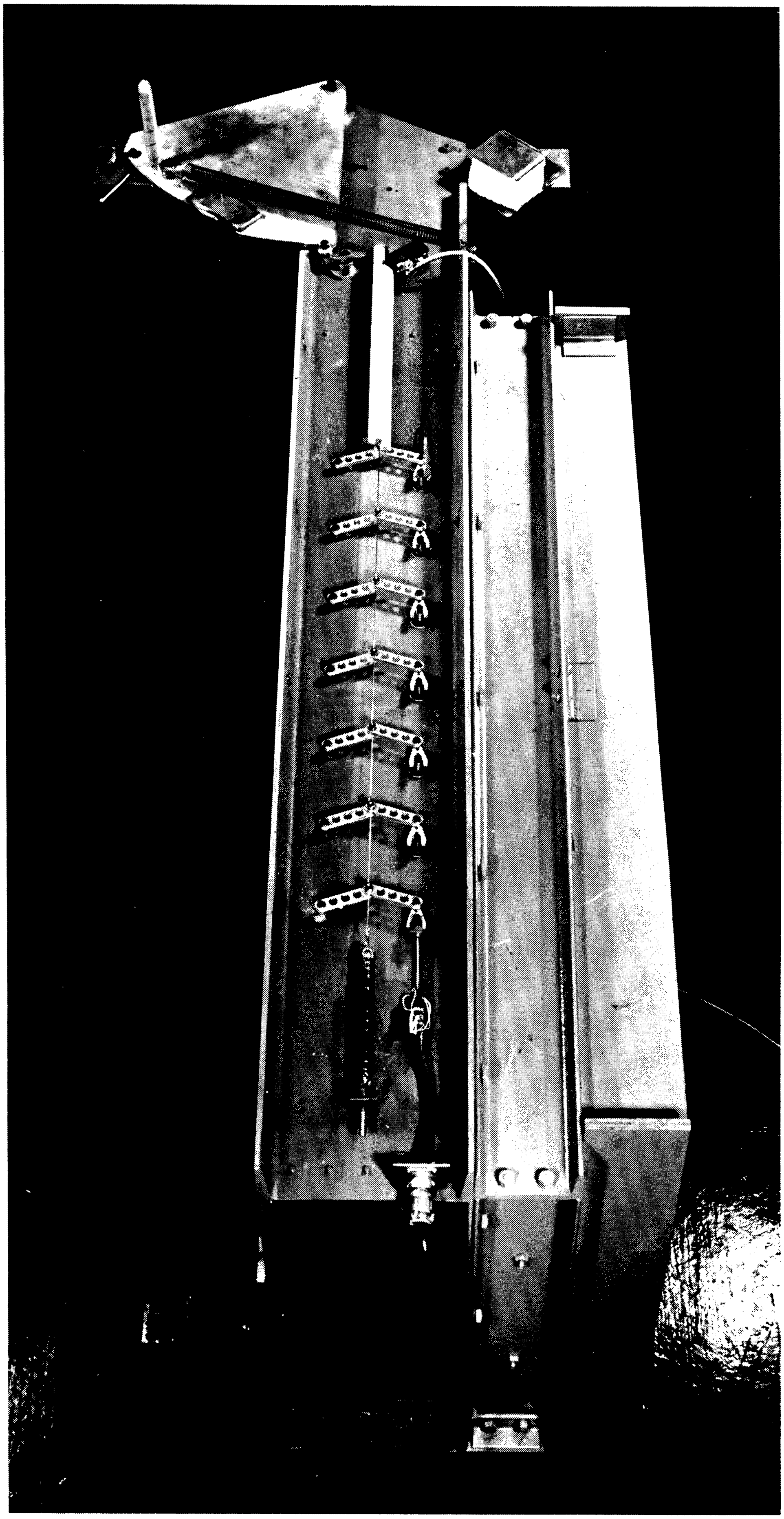


FIGURE 2

VIEW OF LINKAGE MECHANISM OF THE VORTEX GENERATOR

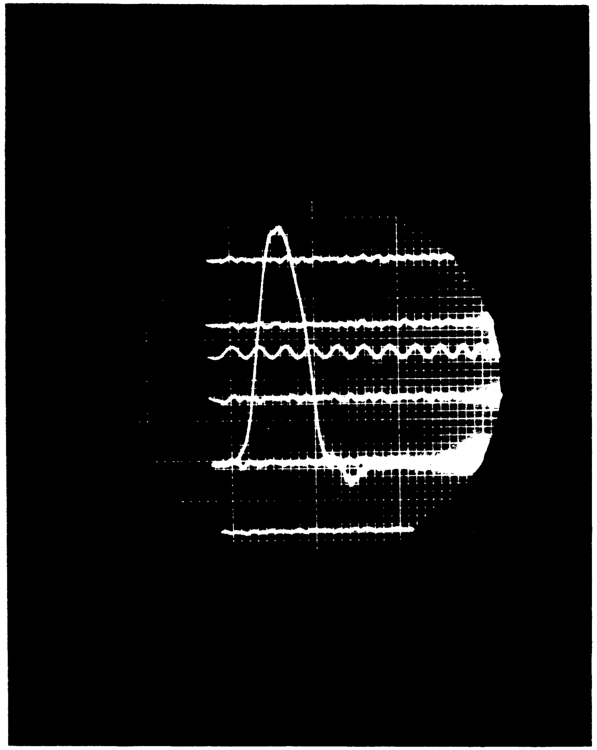


FIGURE 3

OSCILLOGRAM OF AIRFOIL ANGLE OF ATTACK HISTORY. TRACES SHOWN ARE: 100 C.P.S. SINE WAVE FOR TIMING PURPOSES, DYNAMIC RESPONSE OF AIRFOIL, STATIC CALIBRATION RESPONSE OF AIRFOIL FOR ANGLES OF 0, 5, 10, AND 15 DEGREES. LOWEST STATIC RESPONSE CURVE IS FOR 0 DEGREES

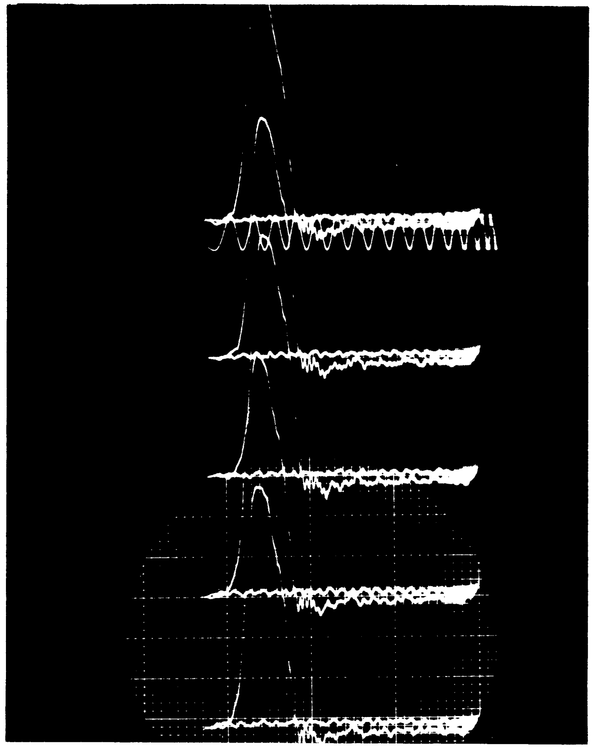


FIGURE 4

REPEATABILITY CHECK OF THE AIRFOIL HISTORY FOR 5 RUNS UNDER IDENTICAL CONDITIONS

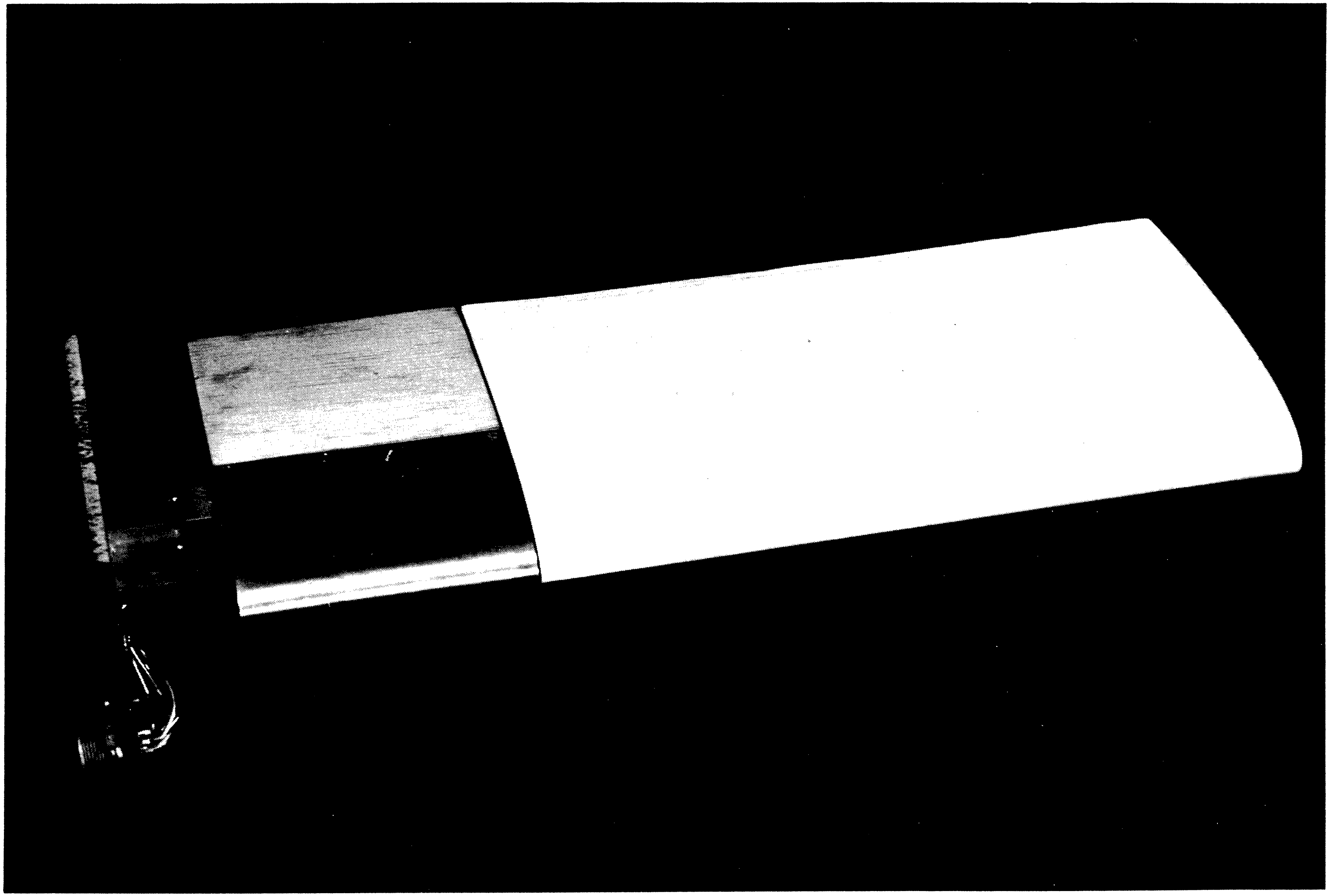
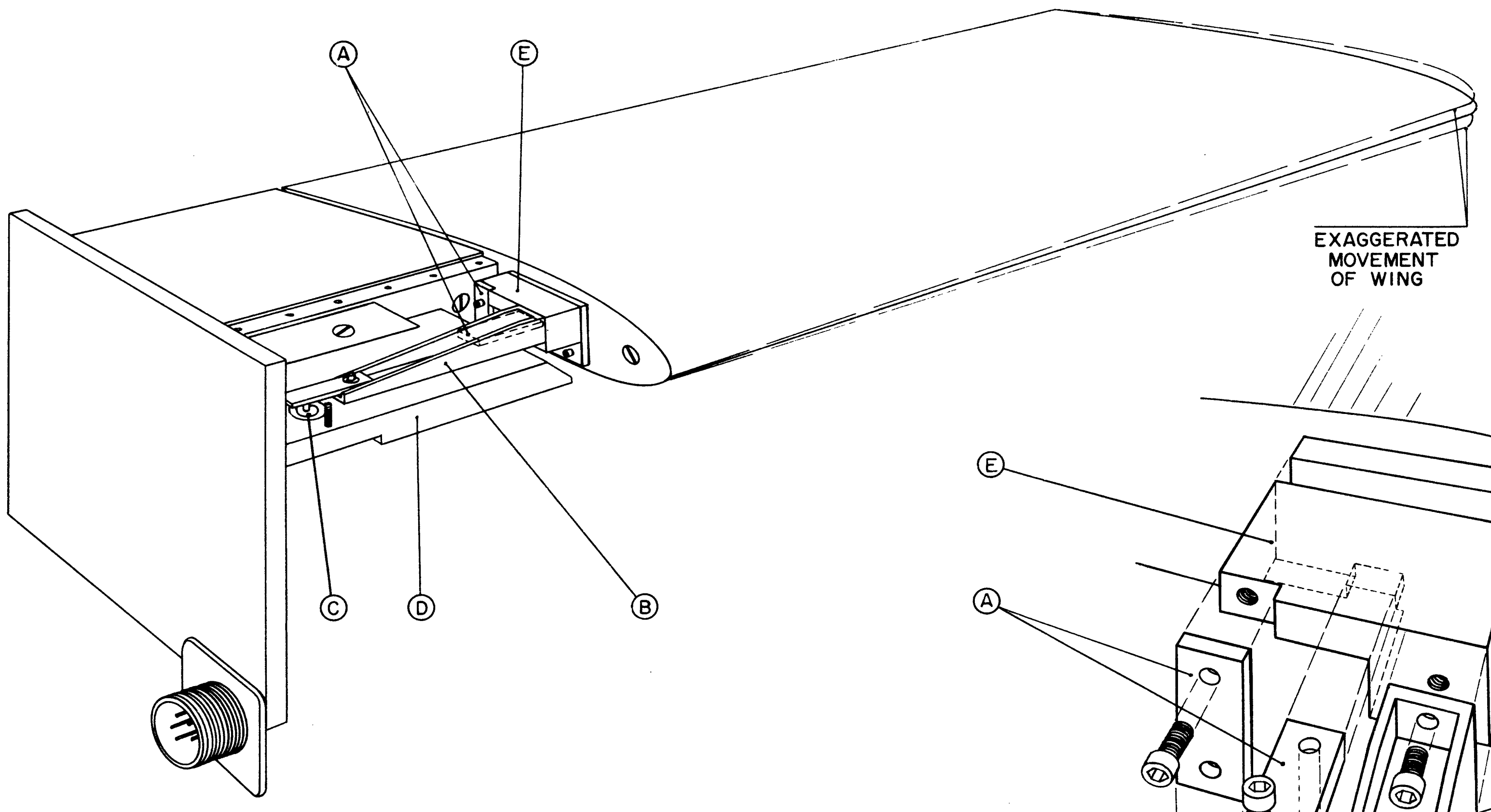


FIGURE 5

PHOTOGRAPH OF BALANCE SYSTEM AND AIRFOIL



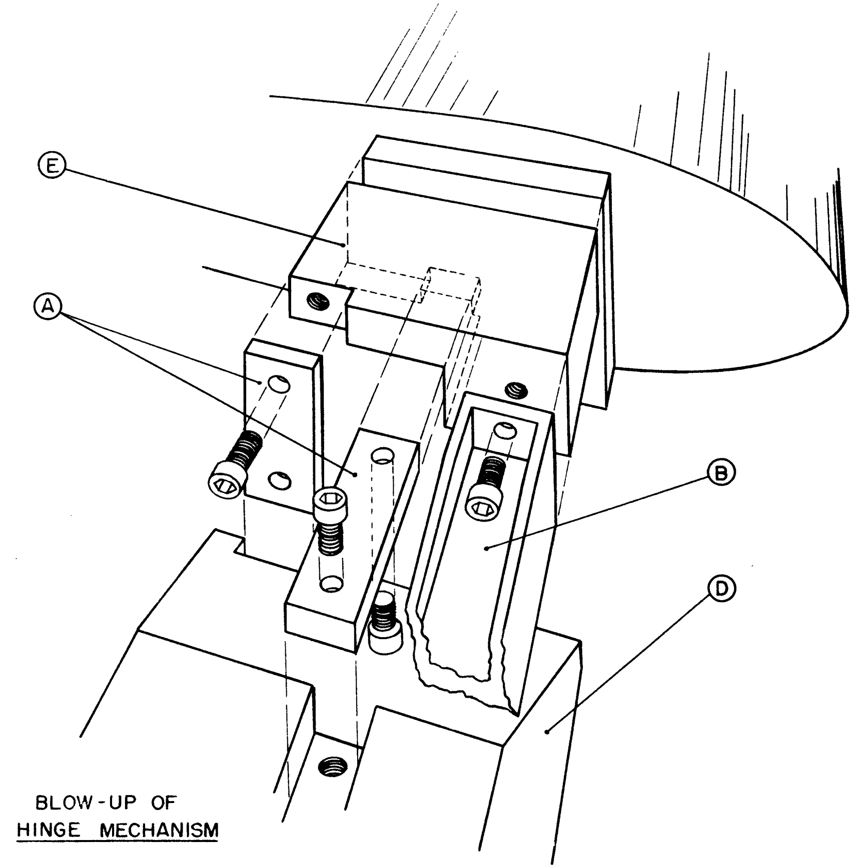


FIGURE 6

OPERATIONAL SKETCH OF BALANCE SYSTEM

See page 3 for parts called out