Bailey
Sawyer

1951 BIENNIAL INSPECTION

FLIGHT RESEARCH LABORATORY

Most of the research equipment seen during your inspection of the Laboratory today is used for testing models. Development of these model test techniques is very important, of course. But a large part of the knowledge used in airplane design can only come from measurements made on full-scale airplanes in flight.

Measurements on airplanes in flight are the primary source of knowledge as to the loads that will be imposed on an airplane by the pilot in accomplishing his mission, or by the turbulence of the atmosphere. Measurements on airplanes in flight provide virtually the entire basis for current design requirements as to the degree of stability and control that an airplane must have to insure that it can be flown with precision and safety, either by human pilots or by automatic control systems.

Measurements on airplanes in flight are also necessary to provide a final check on the practical significance of conclusions reached in model tests, where exact duplication of all the actual conditions is seldom possible.

The range of subjects being investigated here in Flight is quite broad. As you entered the hangar you probably noticed the B-29 airplane being used to study the way accelerations are distributed along the wing span in turbulent air.

You may also have noticed several jet fighters which are being used to study the damping of lateral oscillations. Here we are going to show sample results from two representative flight investigations, one on the air loads on a wing during buffeting, the other on the effect of friction in power control systems.

As you leave this corner of the hangar you will pass two airplanes being used to study boundary layer control by suction thru porous surfaces. In the opposite corner of the hangar you will see representative samples of the research being conducted on helicopters. At your last stop in this building you will see a short film that shows the actual operation of some of the airplanes and equipment used in conducting flight research in the transonic speed range at our High Speed Flight Research Station at Muroc.

Now I'd like to introduce Mr. Huston, who will describe a recent development in flight research on buffeting, Mr. Huston.

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Speaker - W. B. [illegible]ton   Alternate - Harry L. Goga[illegible] Maneuver Loads Branch

1951 BI
Flight Research
Laboratory

GENERAL FLIGHT RESEARCH

TALK ON BUFFETING

2 Movie Sequences - 2 charts - 5 minutes

Buffeting is a shaking of the airplane due to unsteady lifting forces. It occurs only under certain conditions of flight, but it limits the top speed of high performance airliners or bombers, and it is a very severe restriction on the maneuverability and gunfire accuracy of any transonic fighter airplane. The unsteady conditions responsible for buffeting are illustrated in a movie made with high-speed Schlieren aparatus in one of the wind tunnels, which shows the air flowing over an airfoil.

M O V I E   O N

The flow direction is from the bottom of the screen to the top. The airfoil is at an angle of attack, the upper surface is to your left, the Mach number as shown by the indicator on your left is constant at approximately 0.84. The conspicuous bright line moving back and forth on the upper surface in a somewhat random fashion is a shock wave. The boundary layer, which is the V-shaped region, is very badly separated, and large vortices are being shed into the wake, disturbances which would shake the tail if it were in the extension of this region. Note the extremely disturbed condition of the entire flow field surrounding the airfoil. These disturbances produce large loads on the airfoil.

M O V I E   O F F

It is important to have a technique which will measure the loads imposed on the airplane by these disturbed flows under actual flight conditions. A special pressure distribution manometer has been developed here at Langley which makes such studies possible. There is an opportunity to examine the details of this manometer at lunch. The instrument is small and compact and as shown on the chart it can be placed out in the wing of a fighter-type airplane right at the wing section where a pressure distribution study is to be made. Each pressure measuring cell can then be connected to an orifice in the wing with a short length of tubing, a very desirable feature when pressures are changing rapidly.

Inside the instrument thirty mechanical-optical pressure measuring cells are arranged just as the orifices are spaced along the chord. Each cell reflects a light beam onto a ground glass screen, so that the vertical position of the light spot is proportional to the pressure.

To illustrate some of the preliminary results obtained with this manometer during buffeting, we will show a short movie obtained by photographing the pressure diagram on this ground glass. As you will see it on the screen, the air is flowing over the wing from your left to your right. The leading edge of the wing chord is here, and the pressures over the upper surface from leading edge to trailing edge are shown by these upper dots. Pressures on the lower surface are shown by the lower line of dots. Changes in pressure are shown by up or down movement of the dots. The movie was made during a 5g pull-up from a dive at a Mach number of 0.78, the kind of maneuver which a fighter pilot would frequently make.

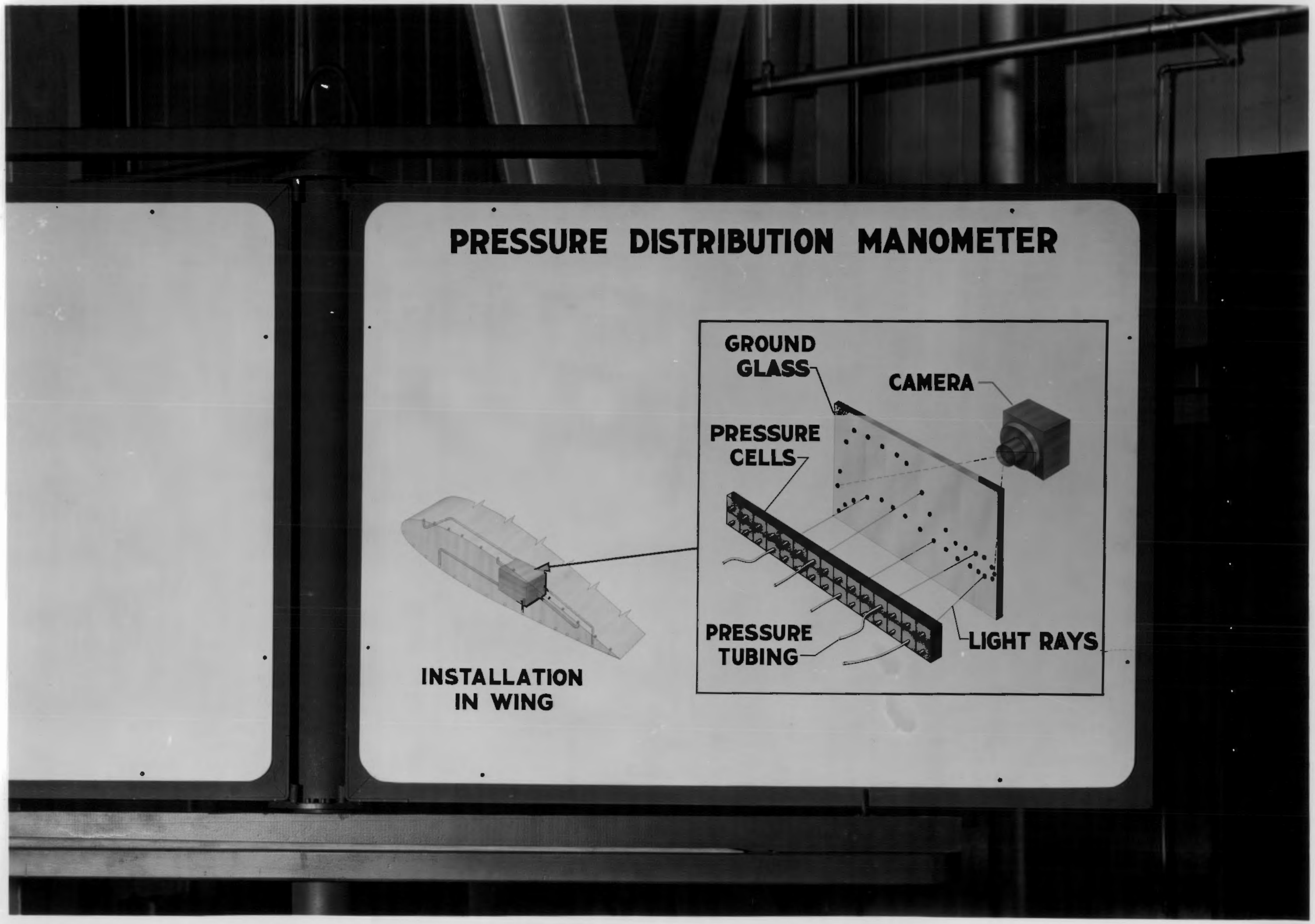
M O V I E   O N

Here we have the pressures during the high-speed dive before the pull-up begins. The pressure fluctuations will be associated with the shock on the upper surface, here evident by the sharp increase in pressure at about 50 percent chord on the upper surface. As the lift increases in the pull-up, the area between the two lines of dots increases, fluctuations around the shock increase in violence, the shock moves forward. These fluctuations represent local changes in pressure of about 200 pounds per square foot. As the airplane recovers to level flight again, the oscillations subside.

MOVIE OFF

The fluctuations in pressure over parts of the airfoil section are violent. The loads actually imposed on the airplane wing can be determined from the data of the movie. This has been done and the results are shown on the next chart as a plot of wing load against time in seconds. The wing load was obtained on the assumption that loads at the representative section are applicable to the entire wing. In this case the biggest change was some 65 percent of the airplane gross weight in about one tenth second, or a load of nearly three tons, with repeated blows of over two tons which adds up to an exceedingly rough ride for the pilot. Loads of this size are confirmed by other measurements on the airplane, which also establish the fact that although the tail is disturbed by the wake, the principal buffeting loads originate on the wing, the only surface large enough to provide loads of this magnitude.

A comprehensive buffeting research program is under way at the various laboratories of the NACA, using these techniques and others, coupled with theoretical studies. Considerable progress is being made, and it appears that with future airplanes, buffeting can be made a less serious limitation than it has been in the past. This concludes the presentation at this stop and your next stop is on the far side of the hangar directly to your rear.



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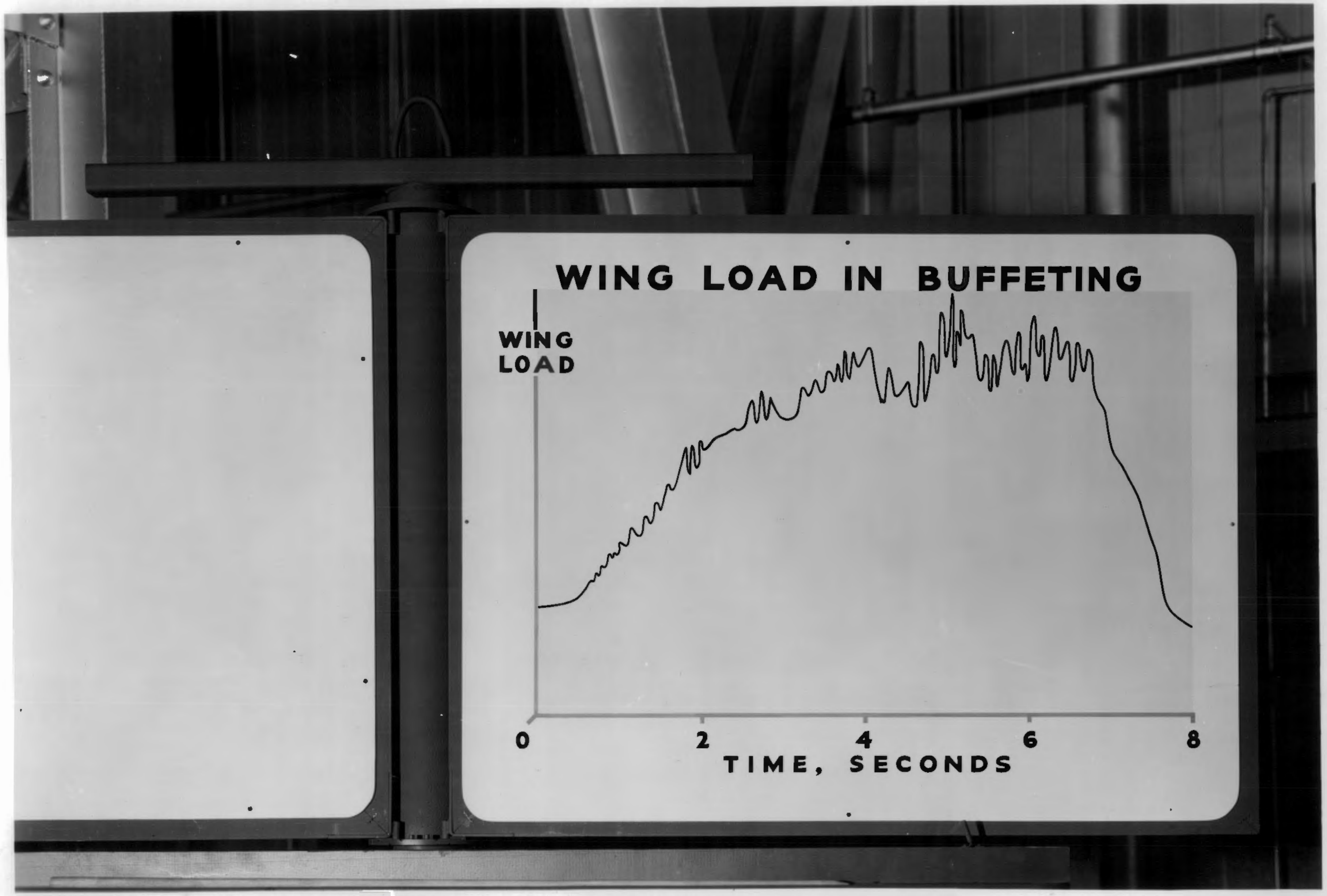

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FRICTION AND CONTROL SYSTEMS

By J. T. Matthews, Jr. and B. P. Brown

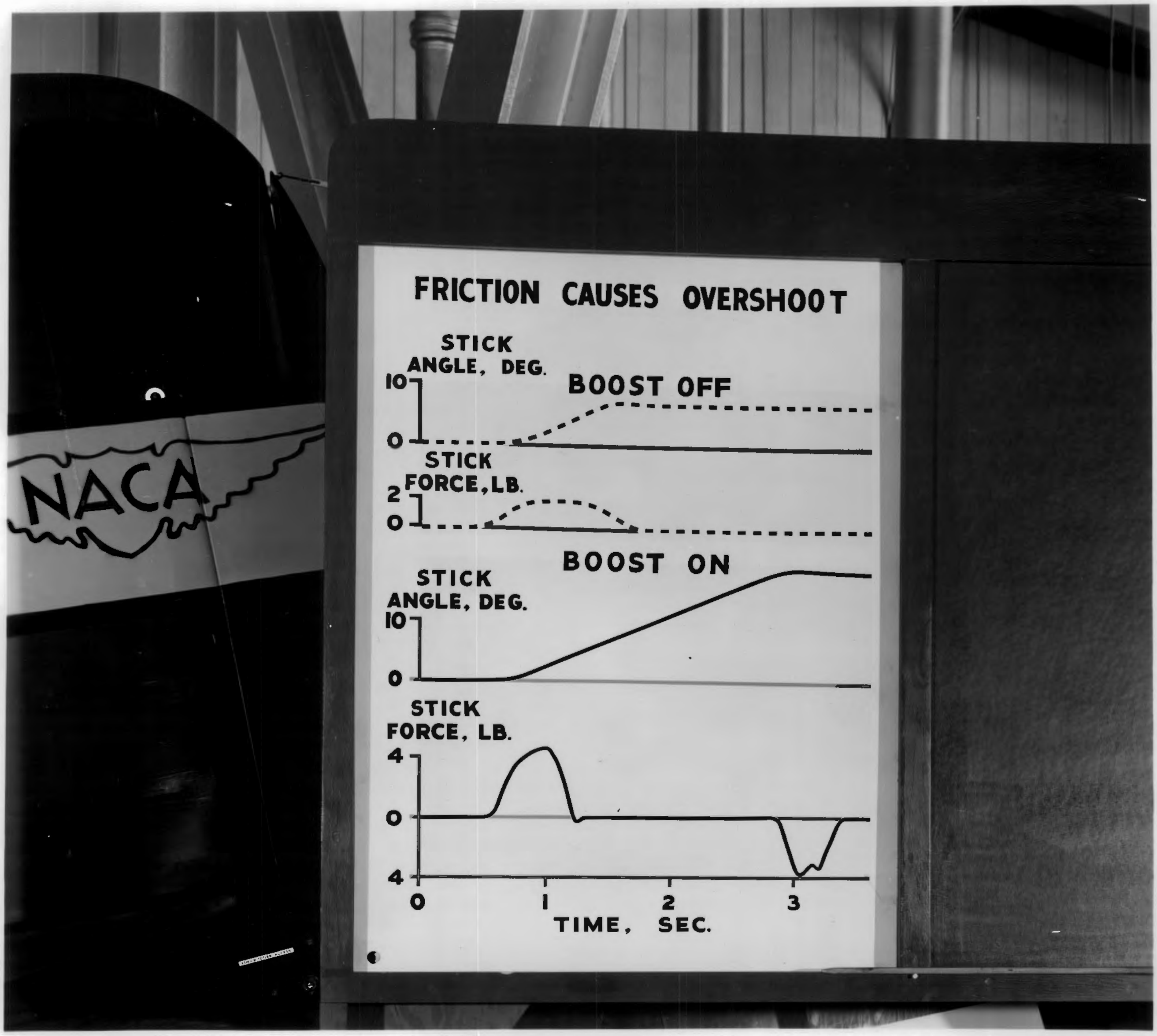
1951 BIENNIAL INSPECTION

The NACA has done a lot of work in the past on flying qualities of airplanes with manual controls. This work has enabled the services to set up handling qualities on a quantitative basis. In newer airplanes, as a result of higher operating speeds and the need in many cases of moving the entire horizontal tail, designers have found it necessary to incorporate power operated controls. So, we have had to extend our studies of flying qualities to include these systems. In many of these systems the pilots have reported a certain longitudinal touchiness, that is the pilot has trouble maintaining a constant speed or acceleration. In order to investigate this problem, we are currently using this Vought Corsair airplane which was borrowed from the Navy. This airplane does not normally have a powered control system, but prior to the NACA procurement, the Navy had a booster system installed for experimental purposes. The system is typical of those that have been giving trouble. The investigations to date, have shown up one difficulty with the system which contributes to the reported longitudinal touchiness. This is friction in the servo-valve. The servo valve, which is connected to the stick, controls the flow of fluid and positions the control surface. We'd like to demonstrate with the actual airplane how this friction affects operation. First, with the booster off, the operator will pull on the stick and you'll notice that when the operator stops pulling, the stick will stop moving. Now we'll do the same thing with the booster on but this time you'll notice that when the operator stops pulling, the stick continues to move until he stops it. Notice also that unless he applies just the right force to stop it, it starts back in the opposite direction. What you have just seen is illustrated in the first chart in the form of time histories of stick force and stick angle. As you saw in the demonstration with the boost off, when a force is applied the stick moves and when the force is released, the stick motion ceases. With boost on however, when the force is released the stick continues to move until an opposite force is applied to stop the motion. In this case, friction is causing the servo valve to stick open allowing fluid to move the controls until an opposite force breaks the friction and closes the valve thus stopping the motion of the control.

The significance of this phenomenon in terms of the pilots' ability to maneuver the airplane is shown on the next chart. This chart shows the variations of stick force and normal acceleration with time during two attempted 4g turns, one with boost off and one with boost on. As with the previous charts the dotted line is for boost off and the solid, boost on. For the case of the boost off, the force and acceleration variations are smooth and the acceleration follows the changes in force closely. For the boost on case the oscillations in force and acceleration illustrates the difficulty encountered by the pilot during this maneuver. This friction is not abnormally high for valves controlling the high pressures involved, however it is obviously too high for satisfactory control. The most obvious solution to the problem would be to eliminate the friction; however, this would be very difficult to do and may not be necessary. We are now working to establish design limits for this type of friction. In addition we are studying various methods of alleviating the problem.


MOKING
PRESSURE DISTRIBUTION MANOMETER
INSTALLATION IN WING
NACA
FRICTION CAUSES OVERSHOOT
BOOST OFF
BOOST ON
TIME, SEC.
FT
392

LAL 70532



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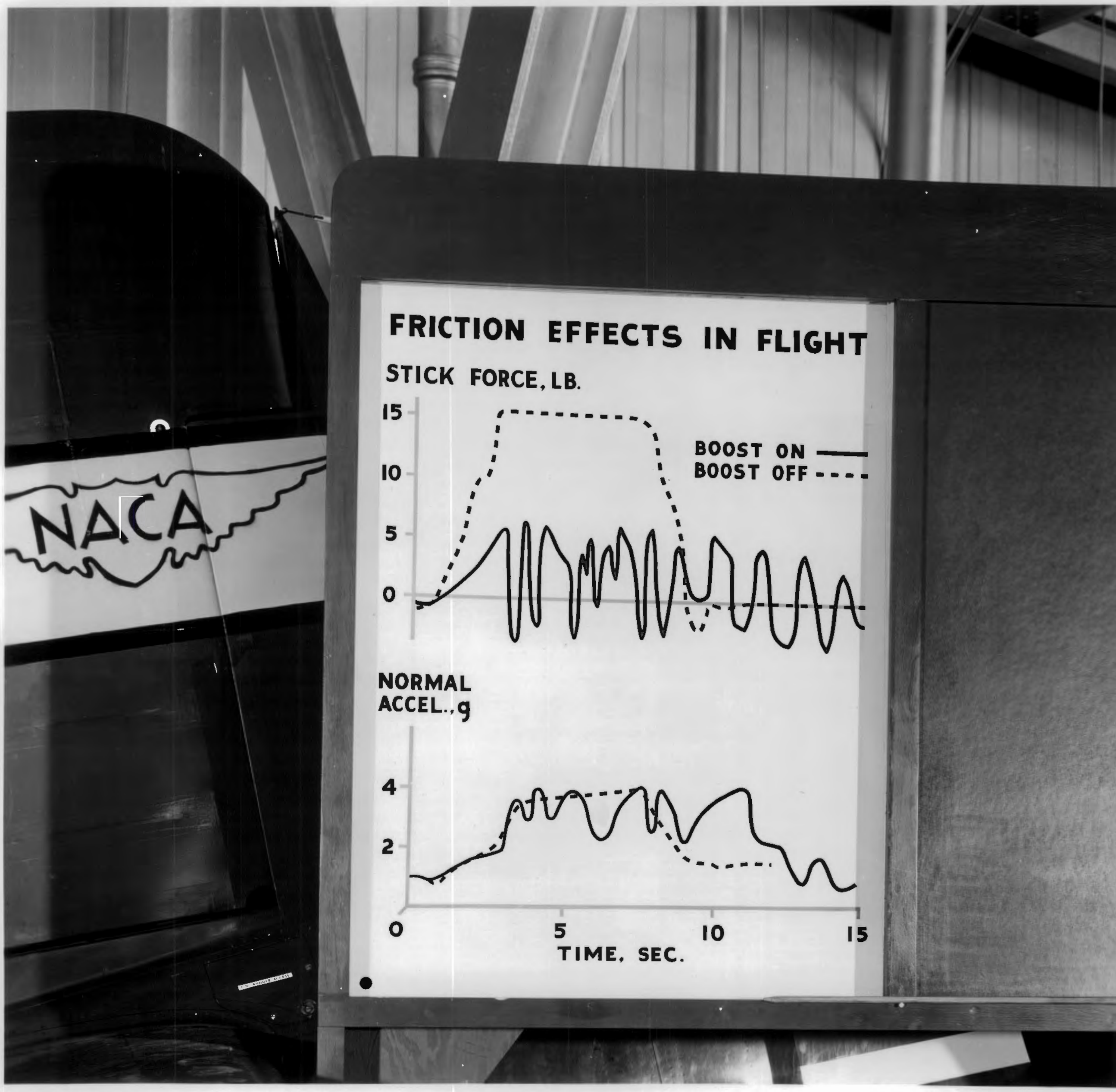
FRICTION CAUSES OVERSHOOT
STICK
ANGLE, DEG.
10
0
BOOST OFF
STICK
FORCE, LB.
2
0
BOOST ON
STICK
ANGLE, DEG.
10
0
STICK
FORCE, LB.
4
0
4
0
1
2
3
TIME, SEC.

LAL 70535



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