NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3441

AN NACA VANE-TYPE ANGLE-OF-ATTACK INDICATOR FOR USE AT SUBSONIC AND SUPERSONIC SPEEDS

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SUMMARY

A vane-type angle-of-attack indicator suitable for measurements at both subsonic and supersonic speeds has been developed by the National Advisory Committee for Aeronautics. A brief history is given of the development, and a wind-tunnel calibration of the indicator is presented together with a discussion of the corrections to be applied to the indicated readings.

INTRODUCTION

The purpose of this paper is to present a description of an angle-of-attack indicator developed in 1948 by the NACA for recording angles of attack at subsonic and supersonic speeds. The instrument was designed by the cooperative efforts of the Langley Pilotless Aircraft Research Division and the Langley Instrument Research Division. Use of the indicator has been limited mainly to experiments on rocket-propelled models. However, no basic limitations are inherent in the design which would prohibit its use for other testing techniques.

DESCRIPTION

A sketch of the NACA vane-type angle-of-attack indicator is shown as figure 1. This indicator consists of a conical body with a flat-plate triangular vane mounted at the rearward part. The vane is pivoted about a point ahead of the aerodynamic center and is statically balanced about this pivot axis so that the air forces and moments will cause the vane to float at zero angle relative to the wind. Rotation of the vane about the pivot axis is converted by means of push rods to translation of an iron core (also counter-balanced) which moves inside

[1]Supersedes recently declassified NACA RM L9F28a, 1949.

an inductance coil. The angular position of the vane relative to the sting is then obtained as a function of inductance. The stops shown in the sketch limit the range of the instrument. With no stops the maximum angle-of-attack range of this instrument is about $\pm 15^{\circ}$. Figure 2 is a photograph of the angle-of-attack indicator mounted on the nose of a rocket-propelled research model.

DISCUSSION

Some of the early flight tests of this angle-of-attack indicator mounted in the high-speed flow over the wing of a fighter-type airplane and on rocket-propelled models gave evidence of a flutter or buzzing phenomenon occurring in some cases near a Mach number of 1.0 and in one case near a Mach number of 2.0. An investigation of this buzzing phenomenon conducted in the Langley 8-foot high-speed tunnel indicated that buzzing was due to a mechanical failure of the ball or pivot-type bearings. Since these tests, all indicators have been equipped with plain sleeve-type bearings and no further trouble has been encountered with flutter.

After the investigation of the buzzing phenomenon, one of tbe indicators was tested at zero angle of yaw through an angle-of-attack range of -4° to 12° at Mach numbers of 0.85, 0.95, and 1.20. The results are given in figure 3 as a plot of the angle of attack of the sting against the angle measured by the indicator. The agreement between the two angles of attack is best at a Mach number of 1.2. In any case, however, with due consideration given to the accuracy of the measurements, the data indicate that the instrument has a calibration factor of 1.0.

Measurements obtained with this angle-of-attack indicator, first on special rocket-propelled test vehicles and then on actual research models, indicate that, with a symmetrical and carefully balanced instrument, reliable data can be obtained. Great care must be taken in the construction, surface finishing, alinement, and positioning of the indicator if it is to read absolute angles of attack correctly. In any case, the indicated variations of angle of attack have been shown to be very good.

Figure 4 presents a reproduction of a section of a telemetered record of some angle-of-attack data obtained on the rocket-propelled research model shown in figure 2. The trace of angle of attack follows the normal acceleration with no apparent time lag.

CORRECTIONS

Small corrections for rate of pitch about the center of gravity must be made to the indicated angles of attack to convert them to angles of attack at the center of gravity of the model as shown in the following formula:

$$\alpha_{cg} = \alpha_i + \frac{x}{V} \dot{\theta}$$

where

α_{cg} angle of attack at center of gravity of model, deg

α_i angle of attack measured by indicator, deg

x distance between aerodynamic center of vane and center of gravity of model (positive when vane is ahead of center of gravity), ft

V model velocity, ft/sec

$\dot{\theta}$ pitching velocity of model about its center of gravity, deg/sec

In the usual installation, with the vane mounted ahead of the wing-fuselage combination, it may be necessary to make corrections for the effect of upwash at subsonic speeds. For any given configuration this upwash is a function of the distance of the vane ahead of the wing-fuselage combination and the flight Mach number such that the correction to the indicated angle of attack decreases with increasing distance and with increasing Mach number. As the Mach number increases to 1.0, the upwash should decrease to zero, as no disturbances can exist ahead of the wing-fuselage combination at or above sonic velocity. Theoretical methods for calculating upwash are available in references 1 and 2. Calculations based on these theories indicate that, for a typical rocket-propelled research configuration at high subsonic speeds, the upwash effect is small if the vane is mounted at least 3 or 4 mean wing chords ahead of the wing and about 1 body diameter ahead of the body. It is recommended that, for subsonic installations of the angle-of-attack indicator, the vane be mounted as far ahead of the wing-fuselage combination as is feasible to minimize the upwash effect.

CONCLUDING REMARKS

A vane-type angle-of-attack indicator suitable for measurements at both subsonic and supersonic speeds has been developed by the NACA. Measurements made with the indicator mounted on rocket-propelled models indicate that, if the following precautions are observed, the vane will give reliable results:

1. The vane should be mounted as far forward of the wing as is feasible to minimize errors due to upwash at subsonic speeds.

2. Care should be used in the manufacture and installation of the vane so that absolute angles of attack will be correct.

3. Corrections should be applied for rate of pitch to the indicated readings.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 23, 1949.

REFERENCES

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2. Letko, William, and Danforth, Edward C. B., III: Theoretical Investigation at Subsonic Speeds of the Flow Ahead of a Slender Inclined Parabolic-Arc Body of Revolution and Correlation With Experimental Data Obtained at Low Speeds. NACA TN 3205, 1954.

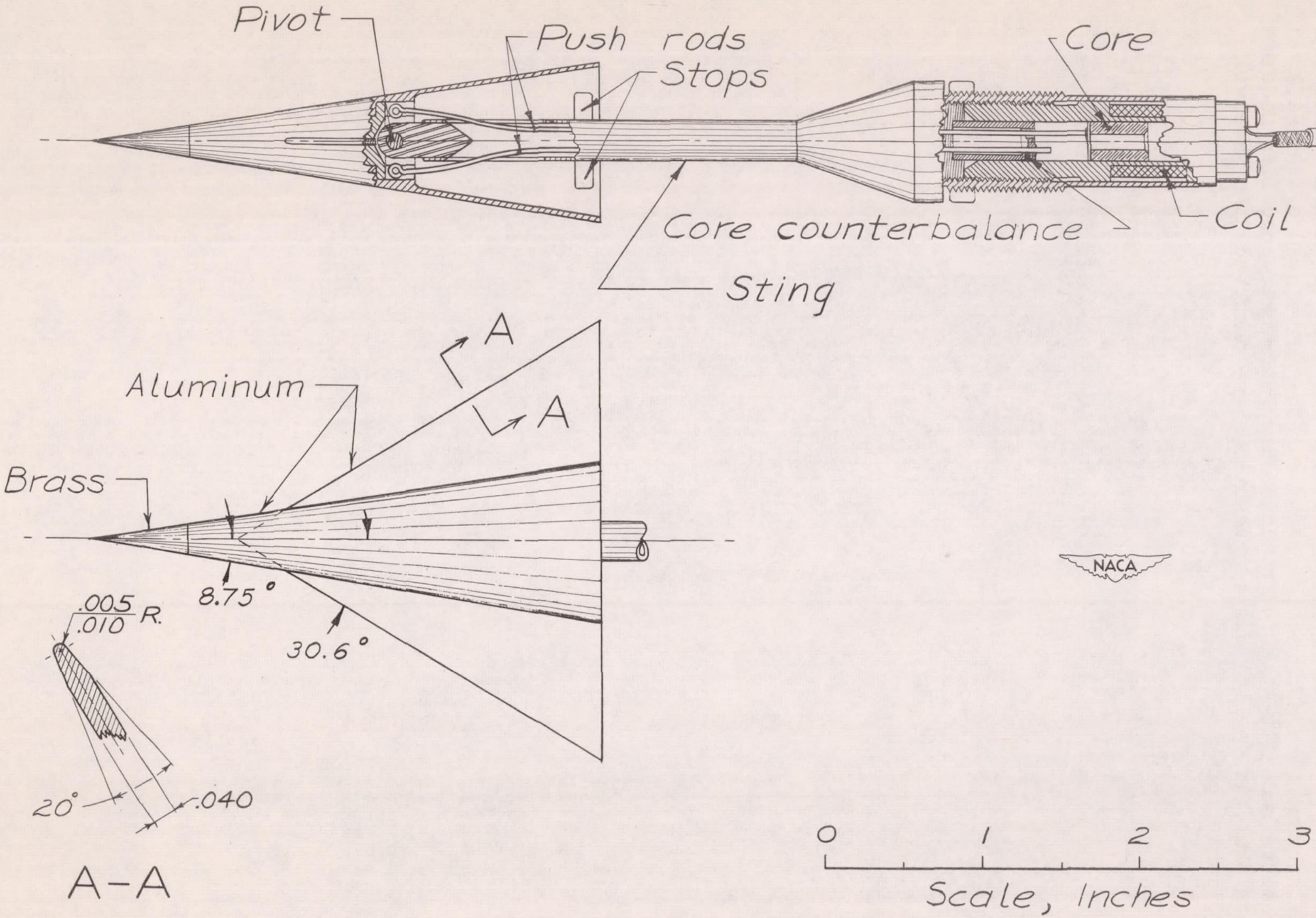

Figure 1.- NACA vane-type angle-of-attack indicator.

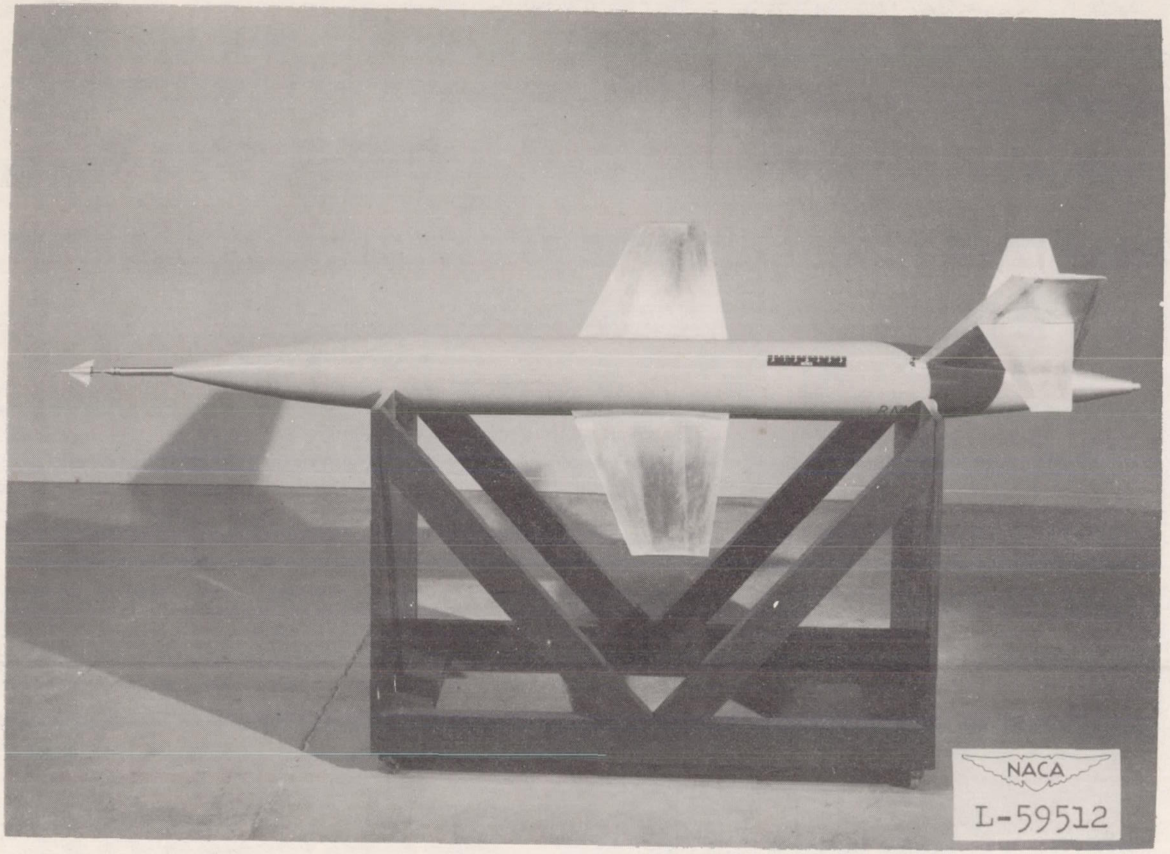

Figure 2.- Typical installation of an angle-of-attack indicator on a rocket-propelled model.

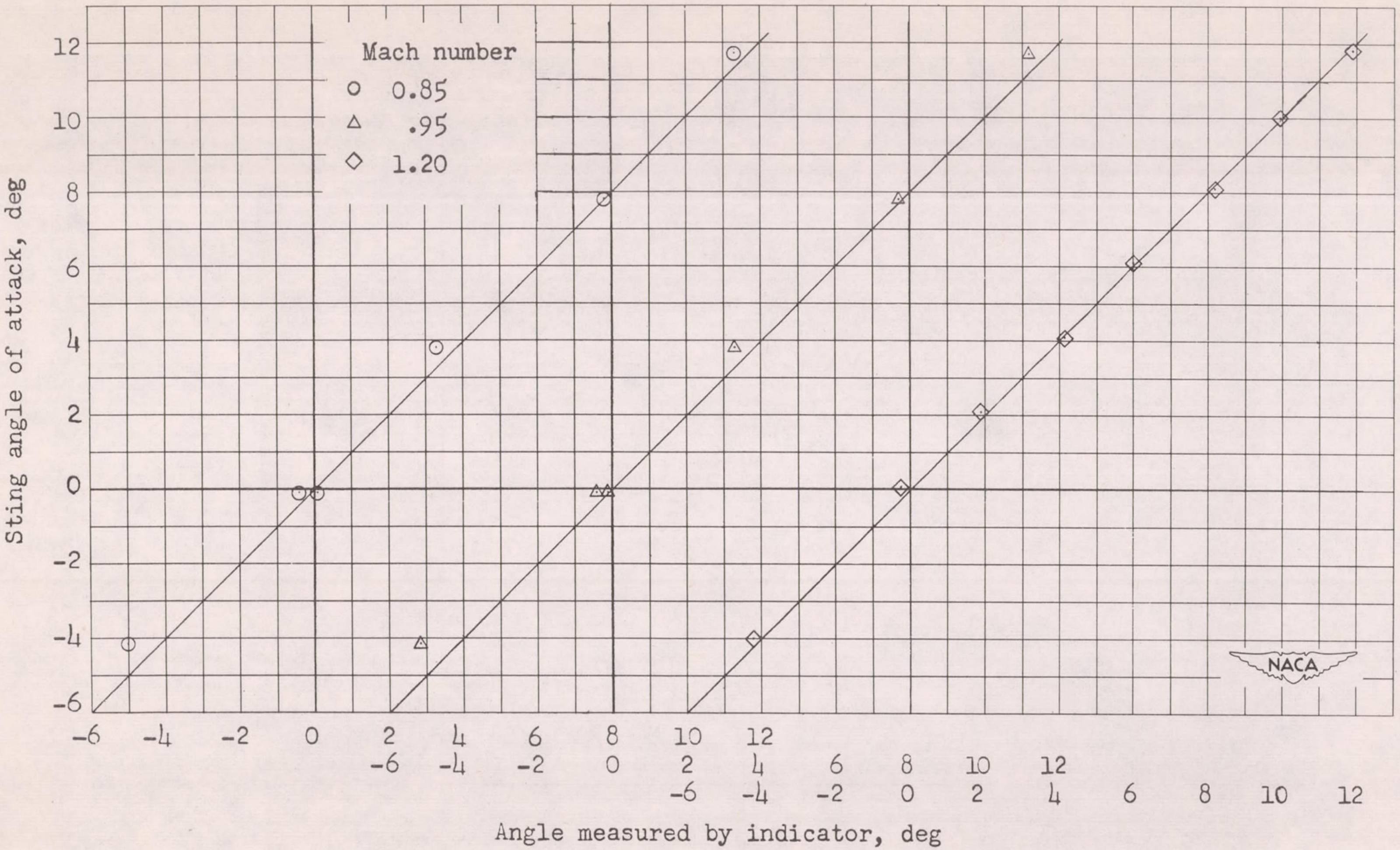

Figure 3.- Calibration of NACA vane-type angle-of-attack indicator in Langley 8-foot high-speed tunnel.

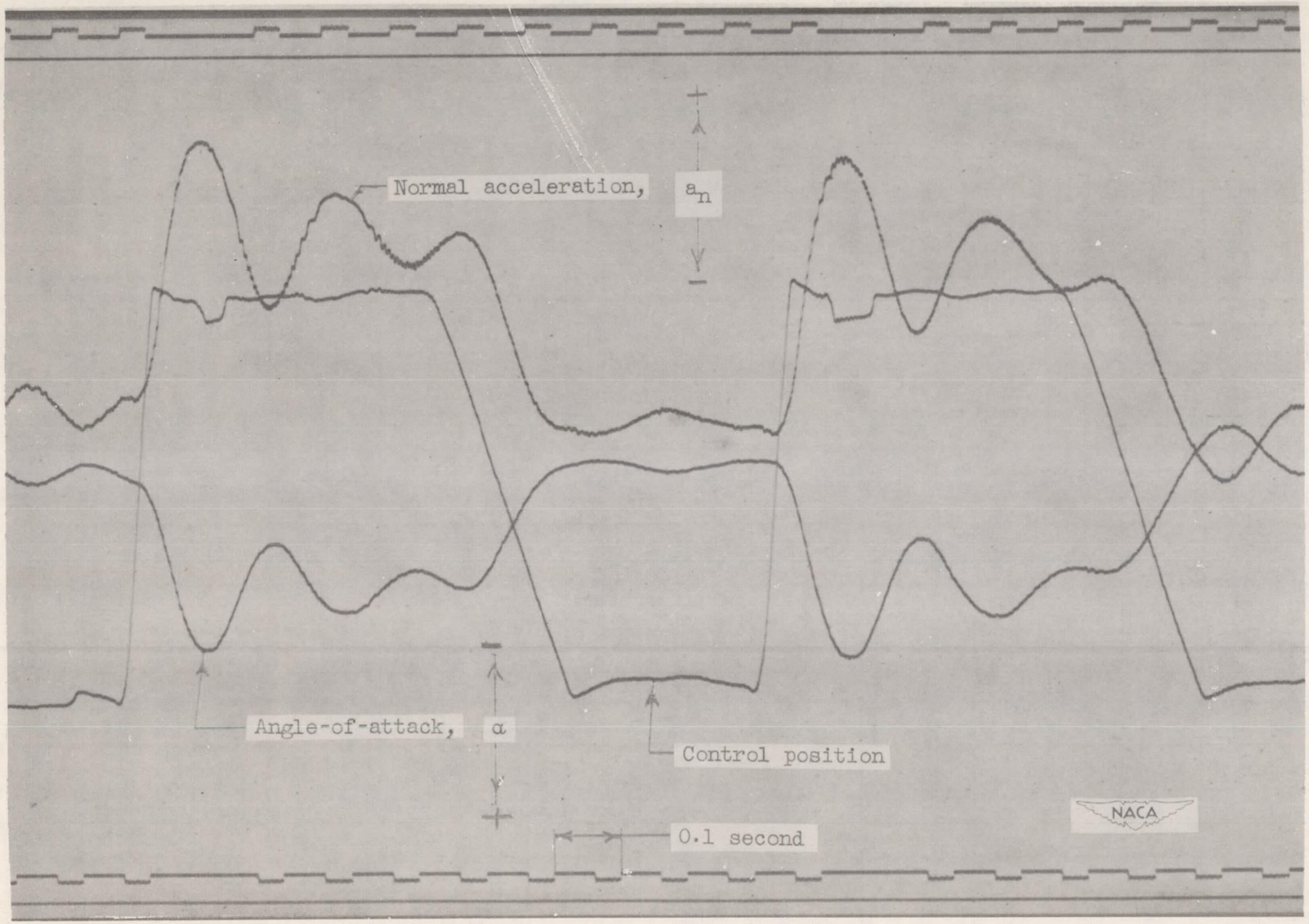

Figure 4.- Typical telemetered trace of angle of attack obtained with NACA vane-type angle-of-attack indicator.

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