TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 274

THE EFFECT OF THE SPERRY MESSENGER FUSELAGE ON THE AIR FLOW AT THE PROPELLER PLANE

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Summary

In order to study the effect of the fuselage, landing gear, and engine on the air flow through the propeller, a survey was made in the plane of the Sperry Messenger propeller with the propeller removed. The tests were made in the 20-foot air stream of the propeller research tunnel of the National Advisory Committee for Aeronautics at Langley Field, Virginia. The variation of the velocity with distance from the center in the propeller plane was found to be appreciable and well worth consideration in the design of propellers. It was also found that the velocity through the propeller plane was affected by the presence of the engine, and that the velocity in front of the landing gear was lower than that at other points in the propeller plane having the same radius.

Introduction

Propellers as used on aircraft are usually mounted directly in front of or behind a body of some kind. The presence of the body influences the air flow through the propeller and consequently affects the horsepower absorbed by the propeller and the propulsive efficiency. In order to design a propeller having the highest obtainable efficiency for a given set of conditions a knowledge of the air flow through the propeller as affected by the body is necessary. This effect has not been definitely known, and has been a source of error in the design of propellers.

Considering the air flow past an ordinary tractor fuselage without the propeller in place, the velocity of the air at the nose of the fuselage varies considerably with the radial distance from the center of the nose. If the velocity at each radius is known, each section of the propeller can be designed for the velocity at its particular radius.

In the present tests, which were made in the propeller research tunnel of the National Advisory Committee for Aeronautics at Langley Field, Virginia, the air flow was explored in the propeller plane of a Sperry Messenger airplane without the propeller in place. This airplane was used because it had already been mounted in the tunnel for propeller experiments, and it is intended to make similar surveys with all airplanes mounted in the tunnel for other tests.

Methods and Apparatus

The propeller research tunnel is an open jet wind tunnel with an air stream 20 ft. in diameter, in which velocities up to 110 M.P.H. are obtainable. A detailed description of the tunnel will be published in the near future.

The airplane was mounted in the tunnel as shown in Figure 1. The wings and tail surfaces had been removed and the cockpit covered for previous tests. A cylindrical wooden block representing the propeller boss was held between the standard hub flanges, and a bar having seven Pitot static tubes was mounted on it radially. In the photograph this bar is shown projecting vertically upward. The dynamic pressure indicated by these Pitot static tubes is influenced by the interference due to the bar. In order to calibrate them, a standard Prandtl tube was mounted opposite to and at the same radius as Pitot tube No. 5 of the bank. Thus, when the bank ran downward the Prandtl tube was up and vice versa; and readings at the No. 5 point, both up and down, were made with both the Prandtl tube and No. 5 of the bank. It was found that the correct dynamic pressure as indicated by the Prandtl tube averaged 6.9 per cent higher than that indicated by tube No. 5 of the bank, and all of the readings obtained from the tubes in the bar were therefore multiplied by the factor 1.069. This factor was checked in a calibration test in another wind tunnel for Pitot tubes No. 5 and 6 of the bank.

The dynamic pressure was measured by means of a standard N.A.C.A. micro-manometer at ground level, simultaneously with the equivalent free air speed (i.e., the velocity of the air outside the influence of the body).

Runs were made with the Pitot bank vertically upward, horizontally to the left, and vertically downward. The 3-cylinder radial engine was then removed and the cylinder and carburetor holes in the nose cowling covered smoothly by means of sheet metal, carrying out the shape of the nose, and the above runs repeated.

In the first runs the readings were taken at various air speeds, but when it was found that the ratio of the velocity at any point to the equivalent free air velocity was constant for all the speeds in the tests, the remaining runs were all made at about 75 M.P.H.

Results

The method of plotting the results is illustrated in Fig. 3, which shows the nose of the fuselage with a diagram of the air velocity in the plane of the propeller. The position of the standard propeller for the Sperry Messenger airplane is indicated by dotted lines. As can be seen from the diagram the velocity is much lower at the center than at the radius of the propeller tips, and that even at the tip radius, it is a little lower than the free air velocity. Also the velocity near the tips is lower for the down position than for the up position, this evidently being due to the drag of the landing gear. Figure 4 shows the relative velocities in the vertical and horizontal planes more accurately. It will be noticed that inside the 20-inch radius the lowest velocity is at the top due to the proximity of the upper cylinder of the engine, but at greater radii the landing gear and supports cause the lowest velocity to occur at the lower portion of the propeller disc. At the tip radius the velocity varies about 3 per cent from top to bottom. Figure 5 has the same curves as Figure 4 but for the faired nose without engine.

The average velocity around the disc at each radius has been computed both for the engine in place and for the engine removed, and the results plotted in Figure 6. The engine evidently reduces the velocity of the air about 5 per cent near the hub and 1 per cent near the tip.

Conclusions

The variation of the velocity with distance from the center in the propeller plane, due to the proximity of the body, is appreciable and well worth consideration in the design of propellers.

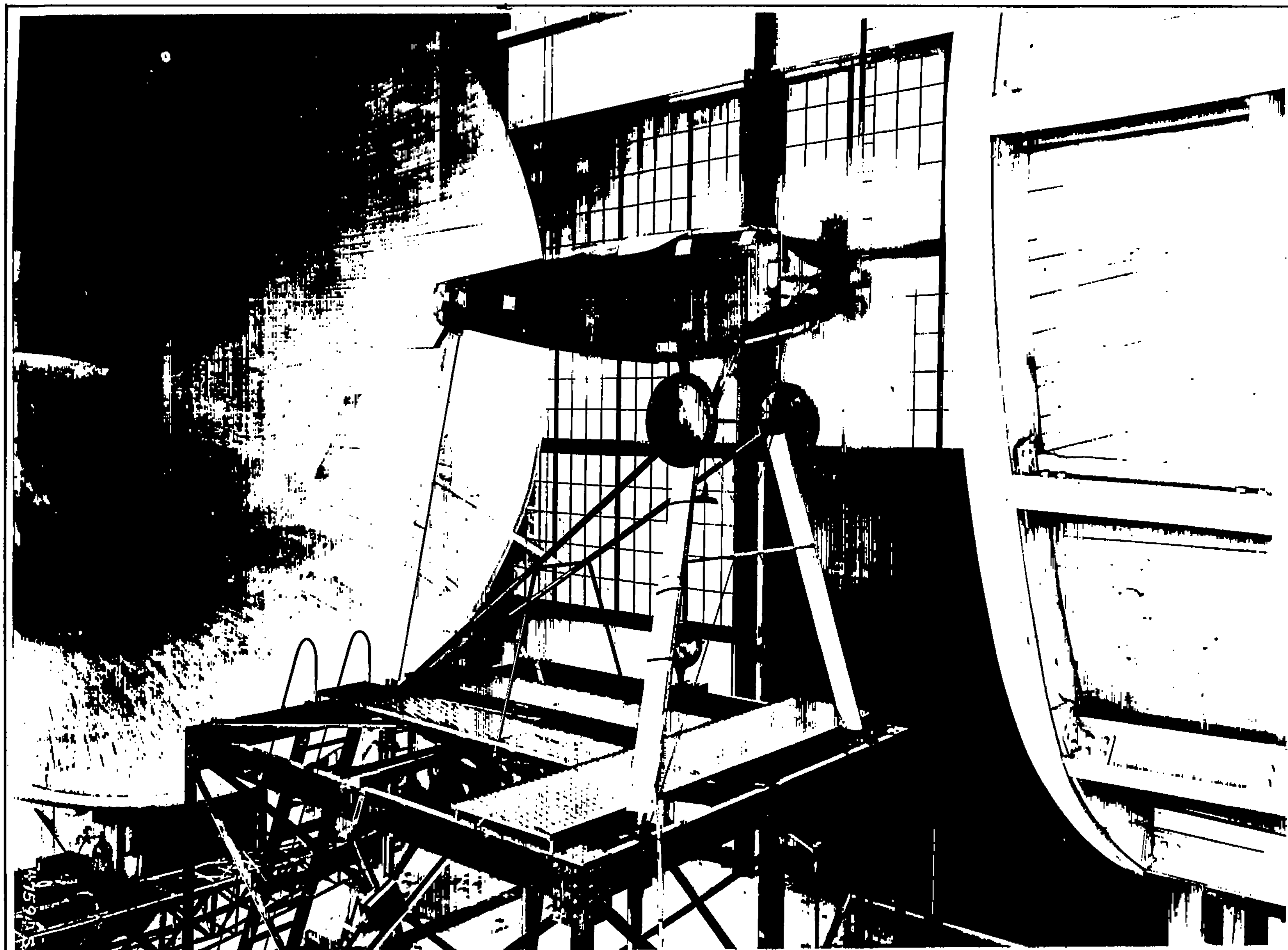

Fig.1 Sperry Messenger fuselage mounted in the propeller research tunnel

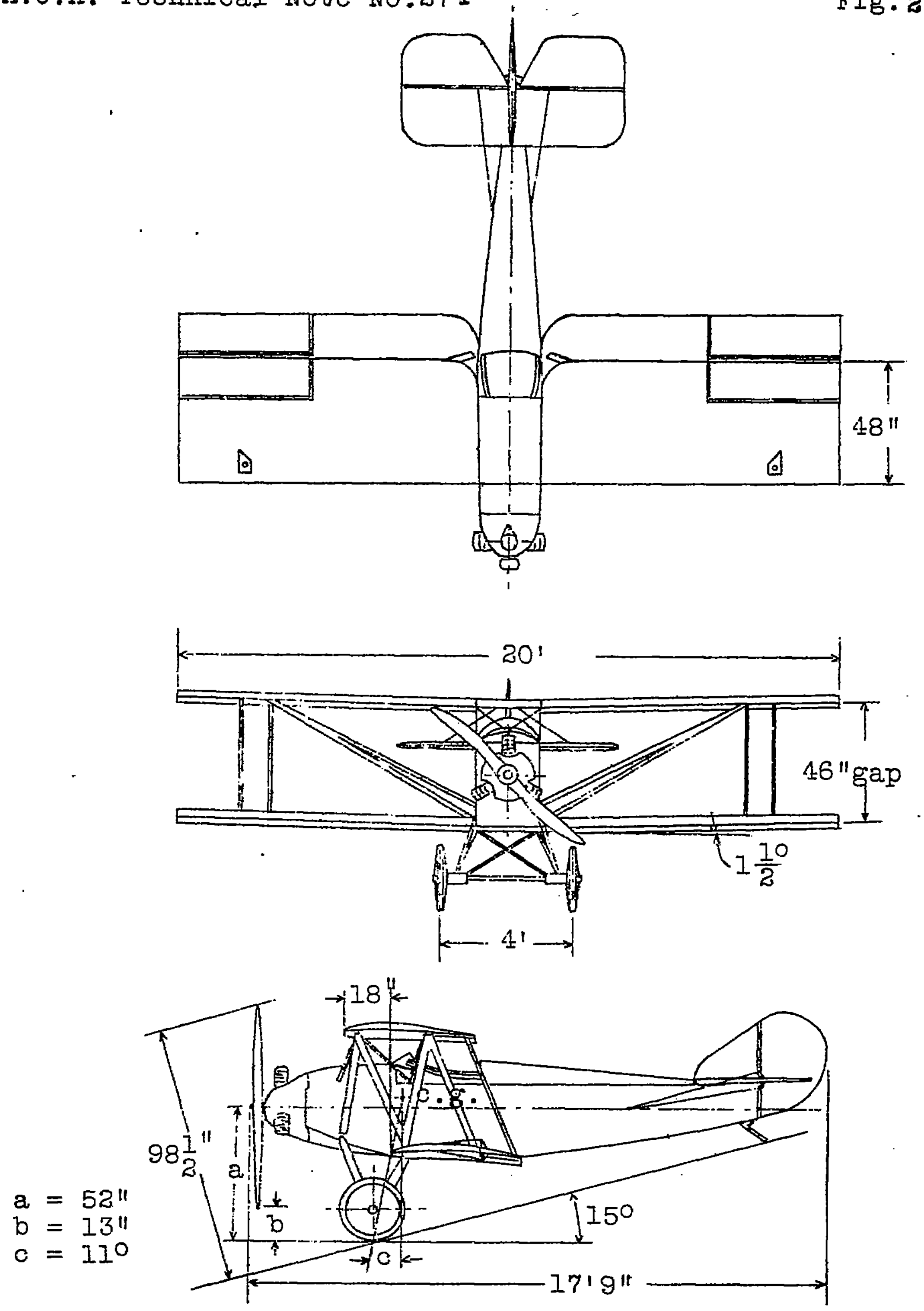

Fig.4 General arrangement drawing of Sperry Messenger airplane.

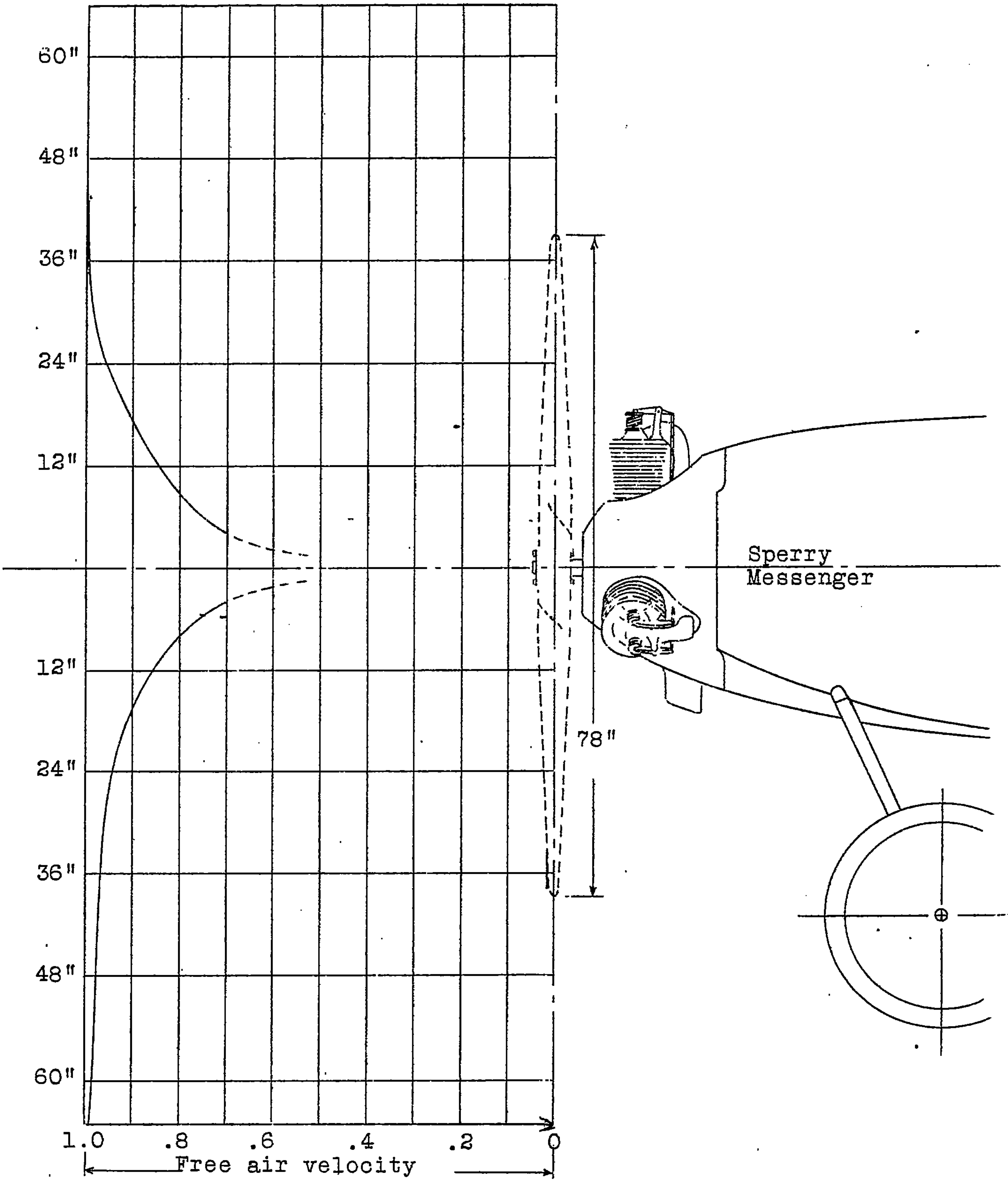

Fig.3 Ratio of velocity on vertical axis of propeller plane to free air velocity.

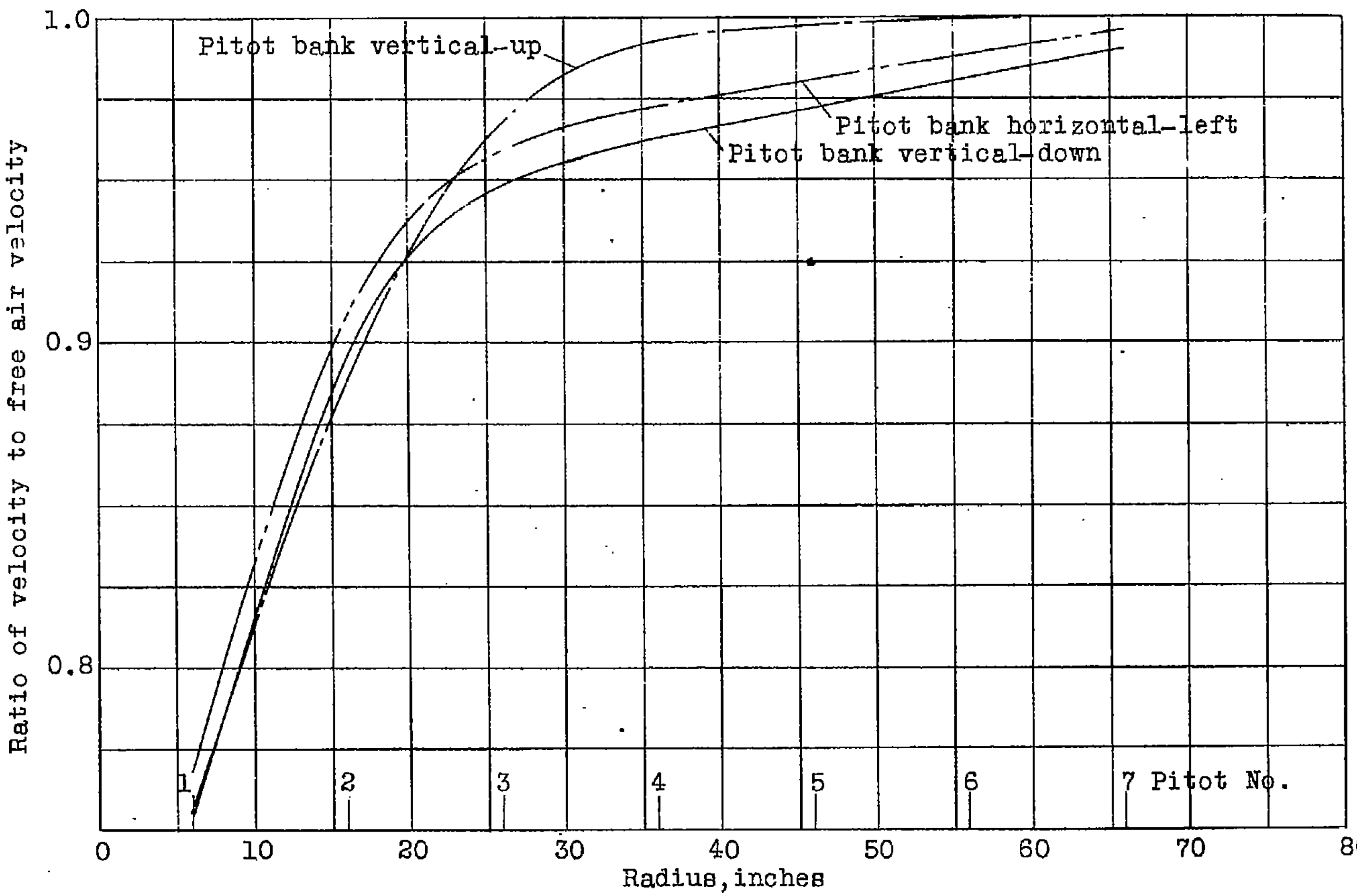

Fig.4 Variation of velocity with radius, engine in.

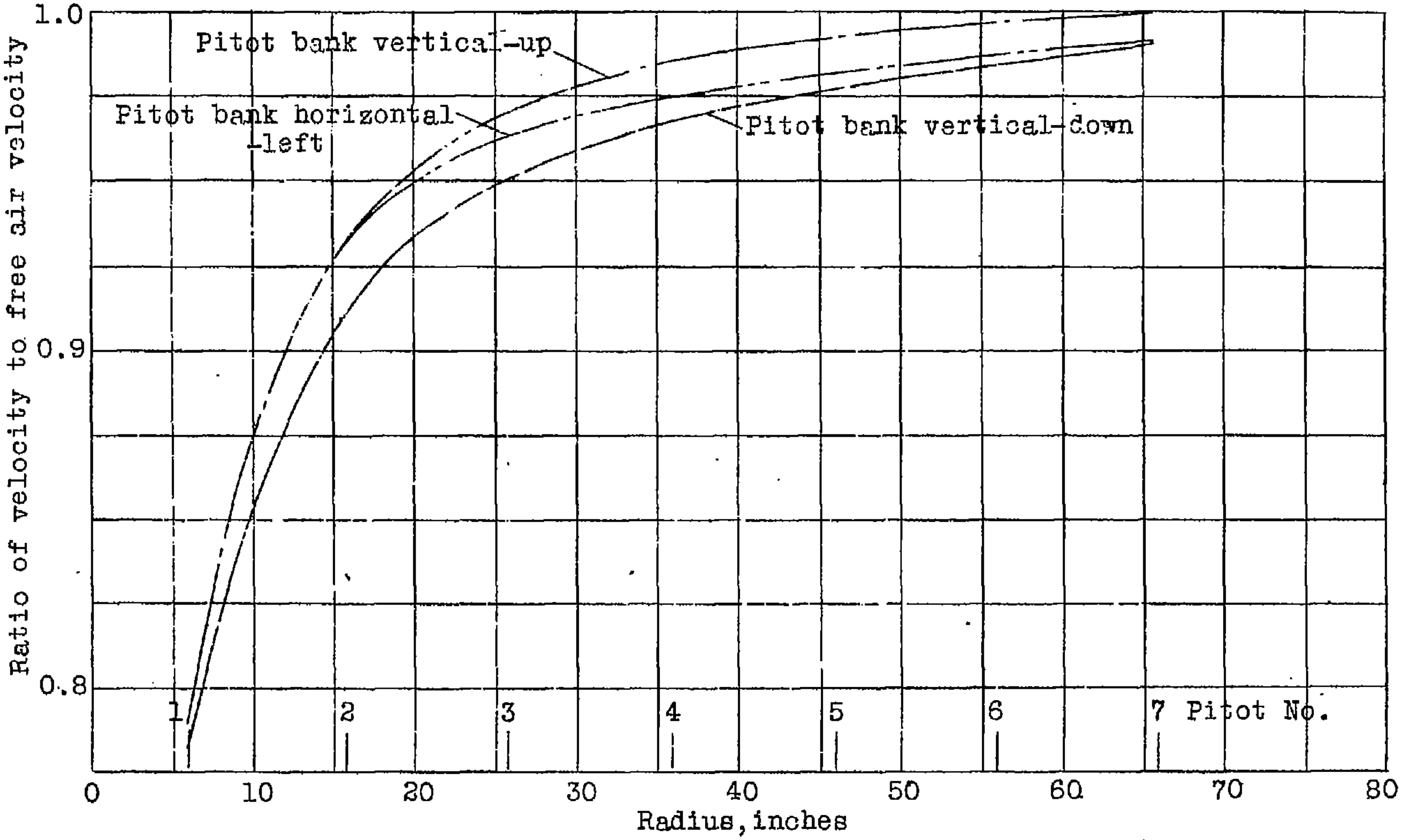

Fig.5 Variation of velocity with radius, engine out.

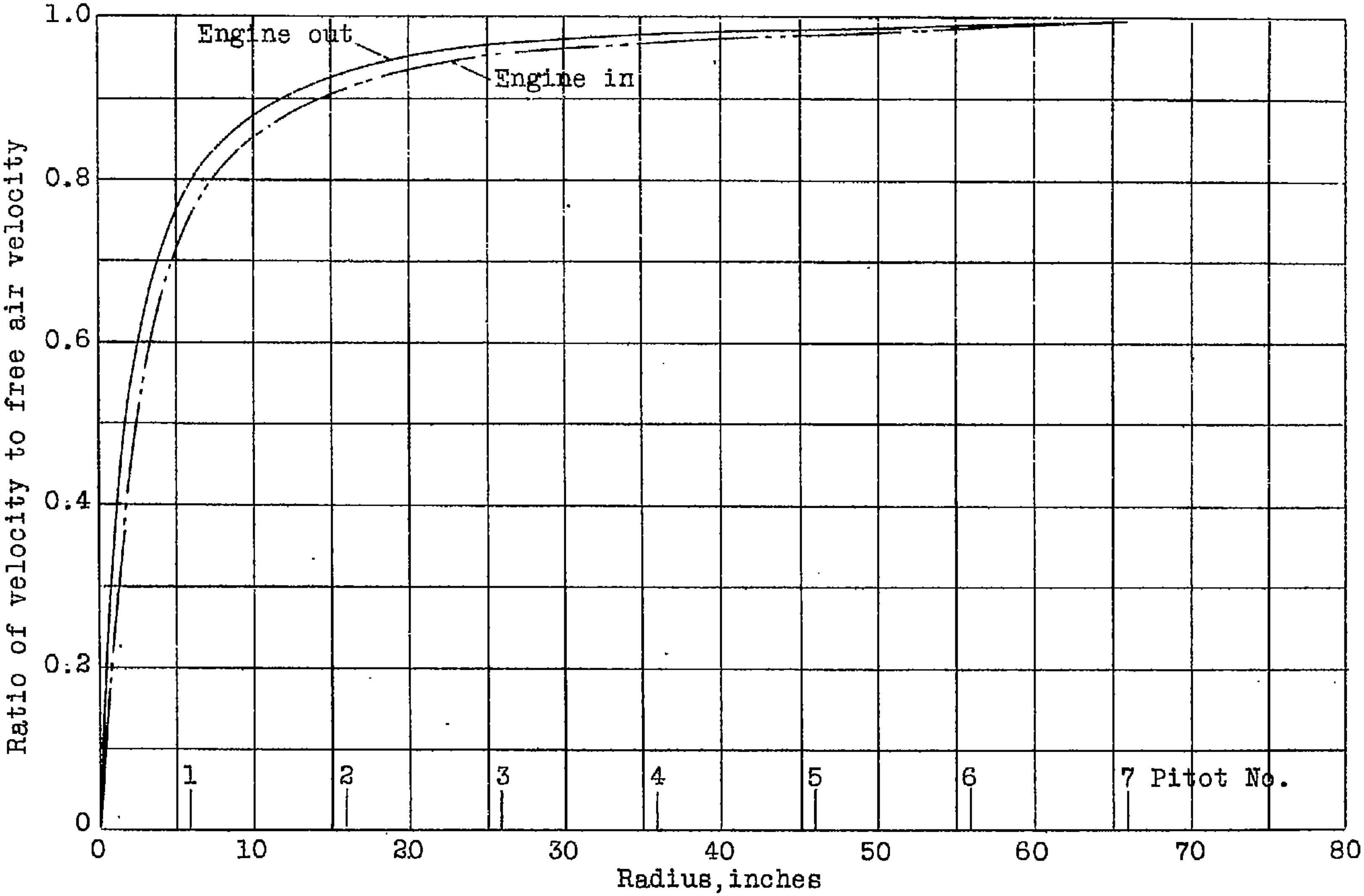

Fig.6 Average velocity variation with radius.