FS/CVL 48 (P-R-287)

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AIRFLOW TESTS OVER FLIGHT DECK OF 1/48-SCALE MODEL OF CVL48 WITH VARIOUS LEADING EDGES

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by

J. Norman Fresh

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PERSONNEL

This test was conducted by J. Norman Fresh of the Aeromechanics Division with the assistance of W.F. Barnett and J.E. Blalock. The report is the work of Mr. Fresh.

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AIRFLOW TESTS OVER FLIGHT DECK OF 1/48-SCALE MODEL OF CVL48 WITH VARIOUS LEADING EDGES

ABSTRACT

Investigations of the airflow over the forward end of the flight deck of a model of the small Aircraft Carrier CVL48 were made in the 8- by 8-foot closed-throat atmospheric wind tunnel at the Washington Navy Yard. Leading edges of six different shapes were tested to determine which shape produced the best airflow for airplane take-off. The airflow was investigated by velocity surveys with pitot-static tubes, and by flow surveys with a wool tuft on a wand. The results indicated that rounded leading edges should be used in preference to square-faced leading edges.

INTRODUCTION

It is important that there should be no large or sudden changes in apparent wind velocity and direction over the leading edge of the flight deck of an aircraft carrier. If the flight path of an airplane during take-off should pass through a turbulent region, the airplane might experience a sudden change in lift which could result in loss of control and consequent damage to or loss of the aircraft.

The Bureau of Ships requested that airflow tests be made on an existing 1/96-scale model of the Aircraft Carrier CV22 to obtain design information for a flight-deck leading edge for the small Aircraft Carrier CVL48 (1).* After the problem had been studied, it was decided that this model was too small for these tests. A 1/48-scale model of CVL48 was therefore designed and constructed at the David Taylor Model Basin (2).

The requests for tests specified that a square-faced leading edge and a quarter-round leading edge should be investigated (1). Since very little additional test time would be required, the types of leading edges were increased to six to give a more complete picture of the situation. Velocity surveys were made with pitot-static tubes and flow surveys were made with a wool tuft on a wand. This report presents the results of these investigations.

TEST SETUP AND PROCEDURE

The tests were made in the 8- by 8-foot closed-throat atmospheric wind tunnel at the Washington Navy Yard.

The ship model on which the leading edges were tested is shown in Figures 1, 2, and 3. The model simulated that portion of the vessel above

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* Numbers in parentheses indicate references on page 4 of this report.

the waterline from the bow aft, including the island structure and a portion of the deck beyond.

The design leading edge and the five other types investigated are shown on Figure 4. The alternates were designated as a square-faced edge; a quarter-round edge with 4-foot radius; a half-round edge with 2-foot radius; a parabolic edge; and a quarter-round edge with 8-foot radius.

The model was installed in the wind tunnel on a board, 12 feet long, which represented the water surface and extended completely across the test section; see Figure 1. The model was located about 3 feet aft of the leading edge of the board and at approximately the center of the airstream.

Velocity surveys were made at heights corresponding to full-scale values of 2.5, 5, 10, 15, and 20 feet above the flight deck; and at stations 5 feet forward of the leading edge, at the leading edge, and 5, 15, 30, 50, 75, 100, 130, and 175 feet aft of the leading edge. Holes were drilled in the flight deck and extended through the model for the insertion of pitot-static tubes as shown in Figures 2 and 3. Three pitot-static tubes were used simultaneously, one on the centerline and one on each side of the flight deck 20 feet outboard of the centerline. Holes not in use were covered with cellulose tape.

The airflow over the flight deck was carefully observed by the use of a wool tuft on a wand. Since this wand could be moved to any point, it was possible to cover a larger area forward and along the flight deck than was explored in the velocity surveys.

All of the investigations were made with a test wind speed of approximately 50 miles per hour.

TEST RESULTS

The results of the velocity surveys, for the various leading edges, are presented in the form of contours of constant velocity ratios, V/V_0, Figures 5 to 10 inclusive, where

$$\frac{V}{V_0} = \frac{\text{Velocity at a particular station}}{\text{Free stream velocity}}$$

It may be noted that the velocities for all of the leading edges are slightly higher on the port side. This is due to a velocity gradient across the test section which appears as a velocity gradient across the flight deck.

The airflow characteristics as noted from the wool-tuft observations for the various leading edges were as follows:

DESIGN LEADING EDGE

The flow was very turbulent over the flight deck from the leading edge to approximately 30 feet aft and 5 feet above the deck. Unsteady flow extended to about 175 feet aft.

SQUARE-FACED EDGE

Flow was similar to that produced by the design leading edge except that the turbulent region extended farther aft and higher above the deck.

QUARTER-ROUND EDGE WITH 4-FOOT RADIUS

The flow was very good over the entire deck and at any height. There was no turbulence or unsteadiness evident.

HALF-ROUND EDGE WITH 2-FOOT RADIUS

Unsteady flow was observed on the deck for a very short distance aft of the leading edge; otherwise the flow was good above and along the deck.

PARABOLIC EDGE

The flow was slightly unsteady on the deck for a short distance behind the gun directors; otherwise it was very uniform over the rest of the flight deck.

QUARTER-ROUND EDGE WITH 8-FOOT RADIUS

The flow was similar to that with the parabolic leading edge except that the unsteadiness behind the gun directors was a little more pronounced.

DISCUSSION OF RESULTS

As previously stated, it is essential that the variation in velocity ratio over the flight deck of an aircraft carrier should be limited to a small value.

A summary of the test results is given in Table 1, with the various leading edges listed in order of preference.

In determining the order of preference, it should be remembered that the wool-tuft surveys give only an indication of the turbulence and direction of the airflow. Another consideration is the proximity of turbulent or unsteady flow to the flight deck. There may be some unsteadiness present, but if the flight path of an airplane never encounters this region, it may be considered unimportant.

As was to be expected, the rounded leading edge types guided the streamlines smoothly over the edge while the sharp edge of the square-faced

TABLE 1

Variations in Velocity as Determined by Pitot-Static Tubes and Wool Tuft

The pitot-static observations are considered accurate to about one per cent.

Leading-Edge Shape	Velocity Survey V/V_0 Variation	Wool-Tuft Survey
Parabolic	1.00 to 1.08	Slightly unsteady behind gun directors, otherwise very good.
Half-round 2-foot radius	1.00 to 1.12	Unsteady short distance aft leading edge, otherwise very good.
Quarter-round 8-foot radius	1.00 to 1.12	Unsteady behind gun directors, otherwise very good.
Quarter-round 4-foot radius	0.88 to 1.20	Very good over entire deck and for any height.
Design	0.44 to 1.20	Very turbulent from leading edge to 30 feet aft, unsteady to 175 feet aft.
Square-faced	0.36 to 1.12	Similar to design edge but more turbulent.

types caused the flow to break away, resulting in turbulent airflow with large velocity variations.

CONCLUSIONS

The parabolic leading edge is considered the best of those tested. The other rounded leading edges are satisfactory to varying degrees.

The use of square-faced leading edges should always be avoided.

REFERENCES

(1) BuShips Letter S1-2(332) of 22 May 1944 to TMB.

(2) Aeromechanics Memorandum of 13 June 1944 to Engineering and Design, TMB.

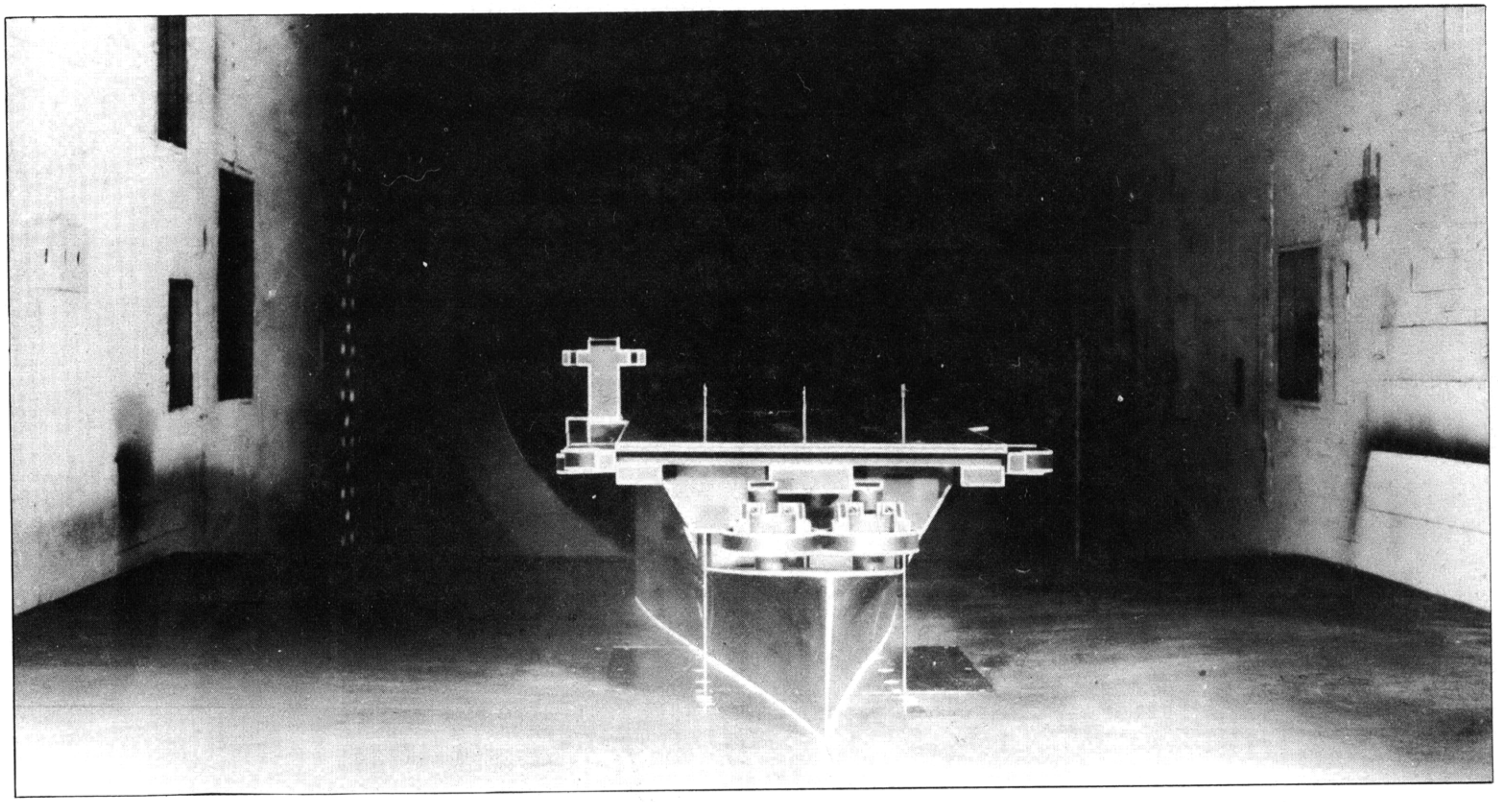

Figure 1 - Front View of Model Mounted in Tunnel Showing the Pitot-Static Tubes Installed in the Flight Deck and Extending through the Platform

TMB 12556 14 July 1944

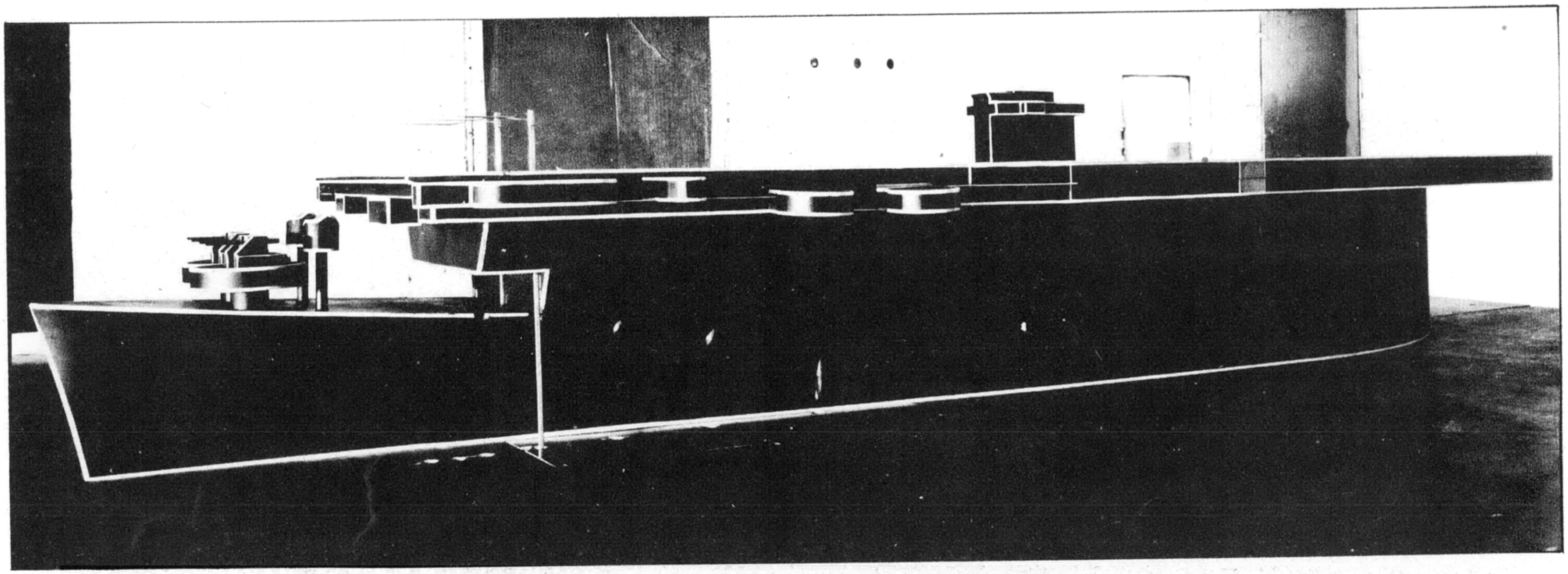

Figure 2 - Side View of Model in Tunnel Showing Design Leading Edge of Flight Deck in Place
TMB 12552 14 July 1944

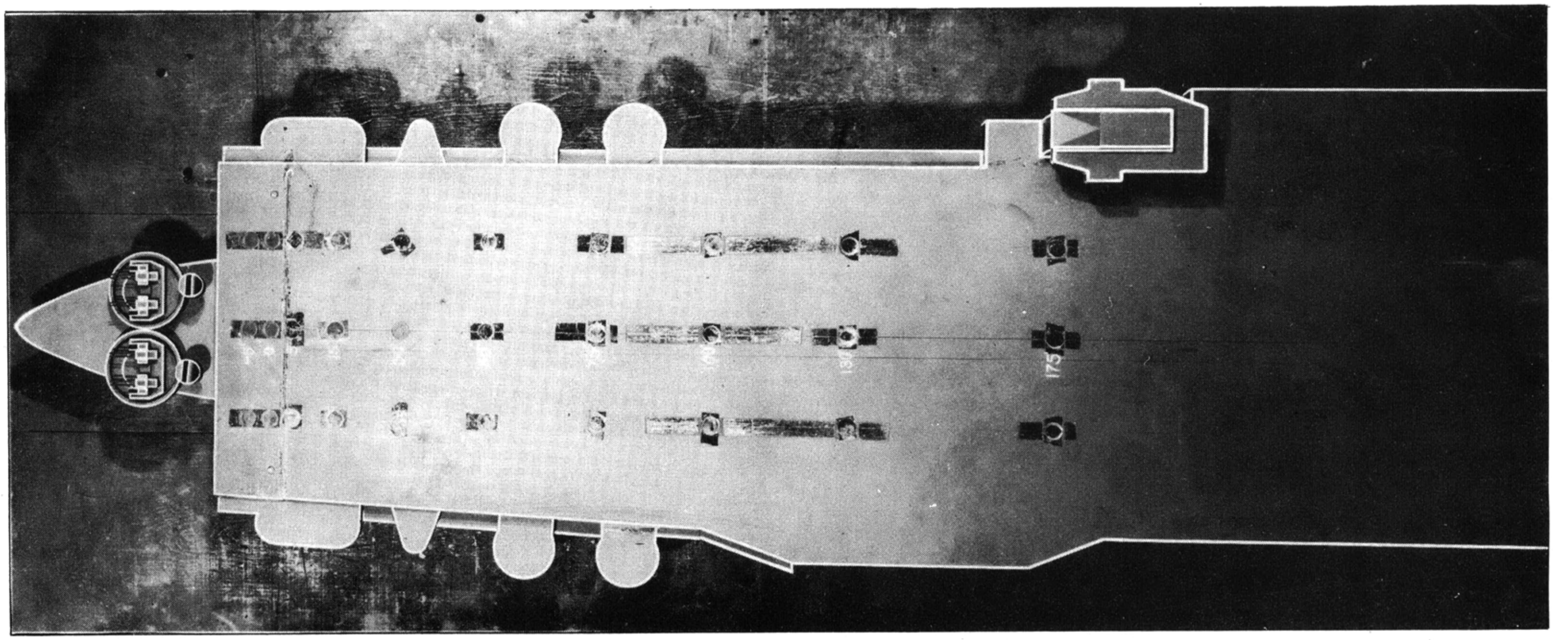

Figure 3 - Plan View of Model Showing Holes (Covered with Cellulose Tape) in Flight Deck for Inserting Pitot-Static Tubes

TMB 12600 14 July 1944

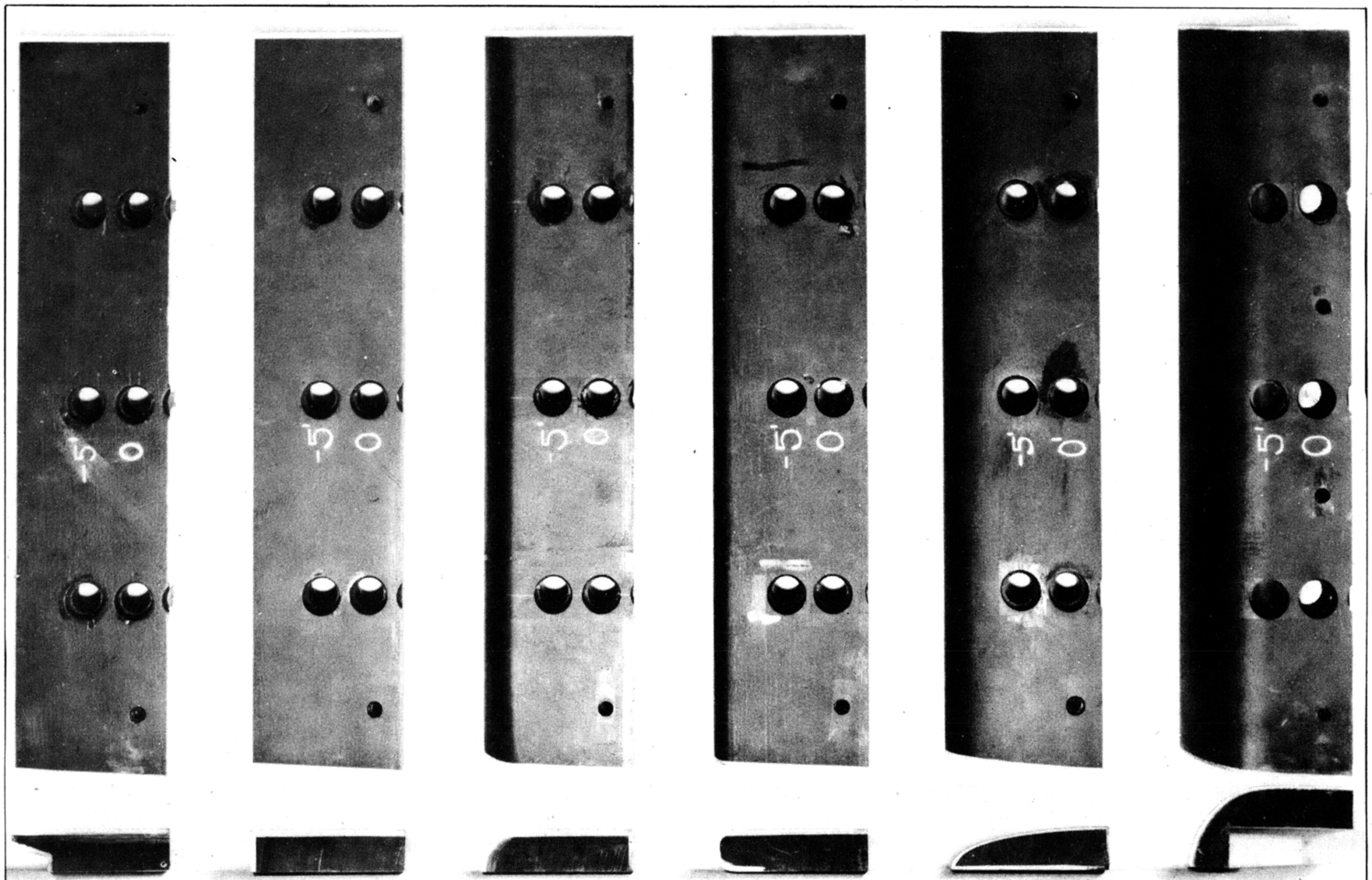

Figure 4 - Various Types of Flight Deck Leading Edges Tested on Model TMB 12550 and 12551 14 July 1944

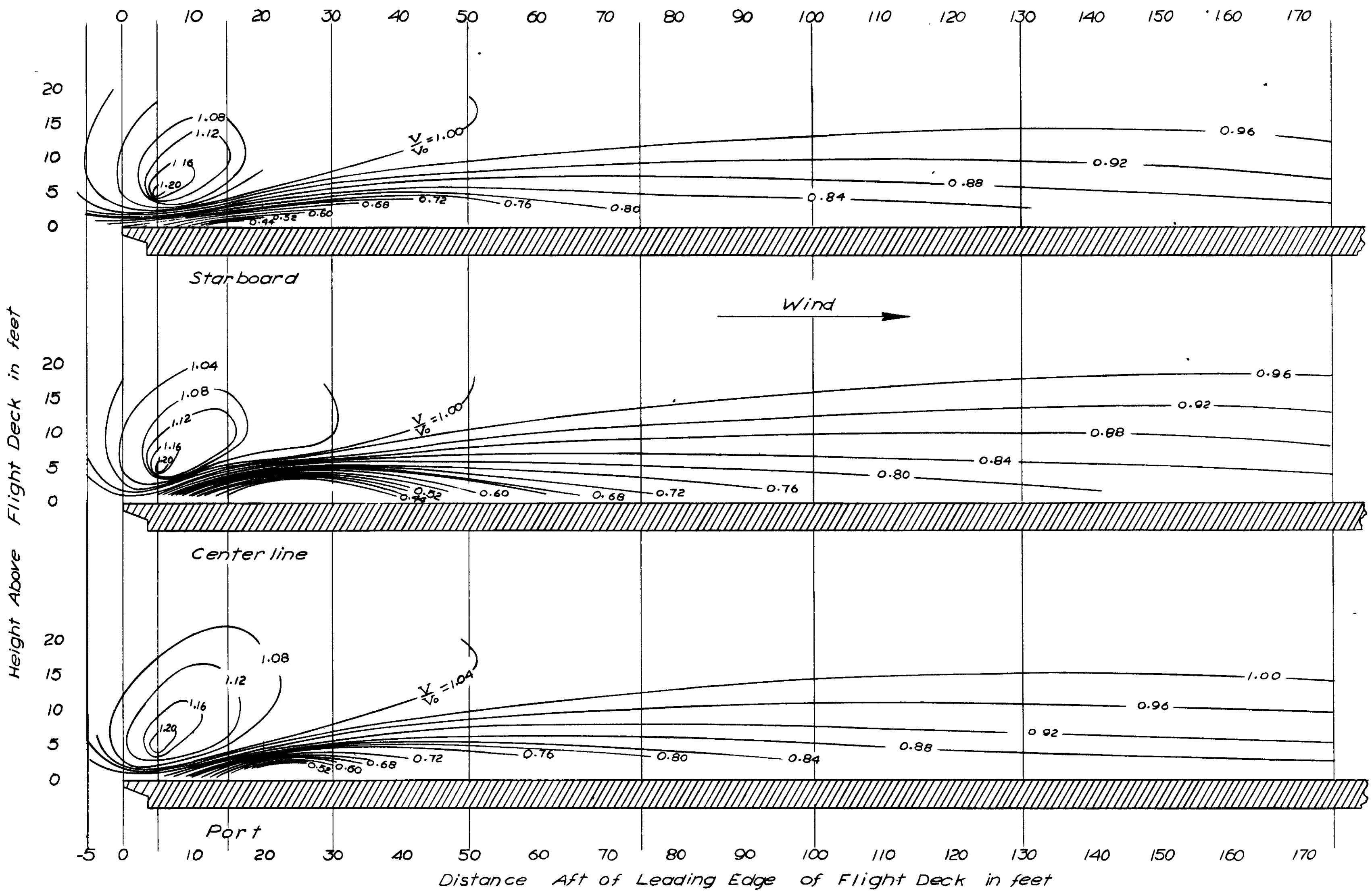

Figure 5 - Contours of Constant Velocity Ratios V/V_0 for Design Leading Edge

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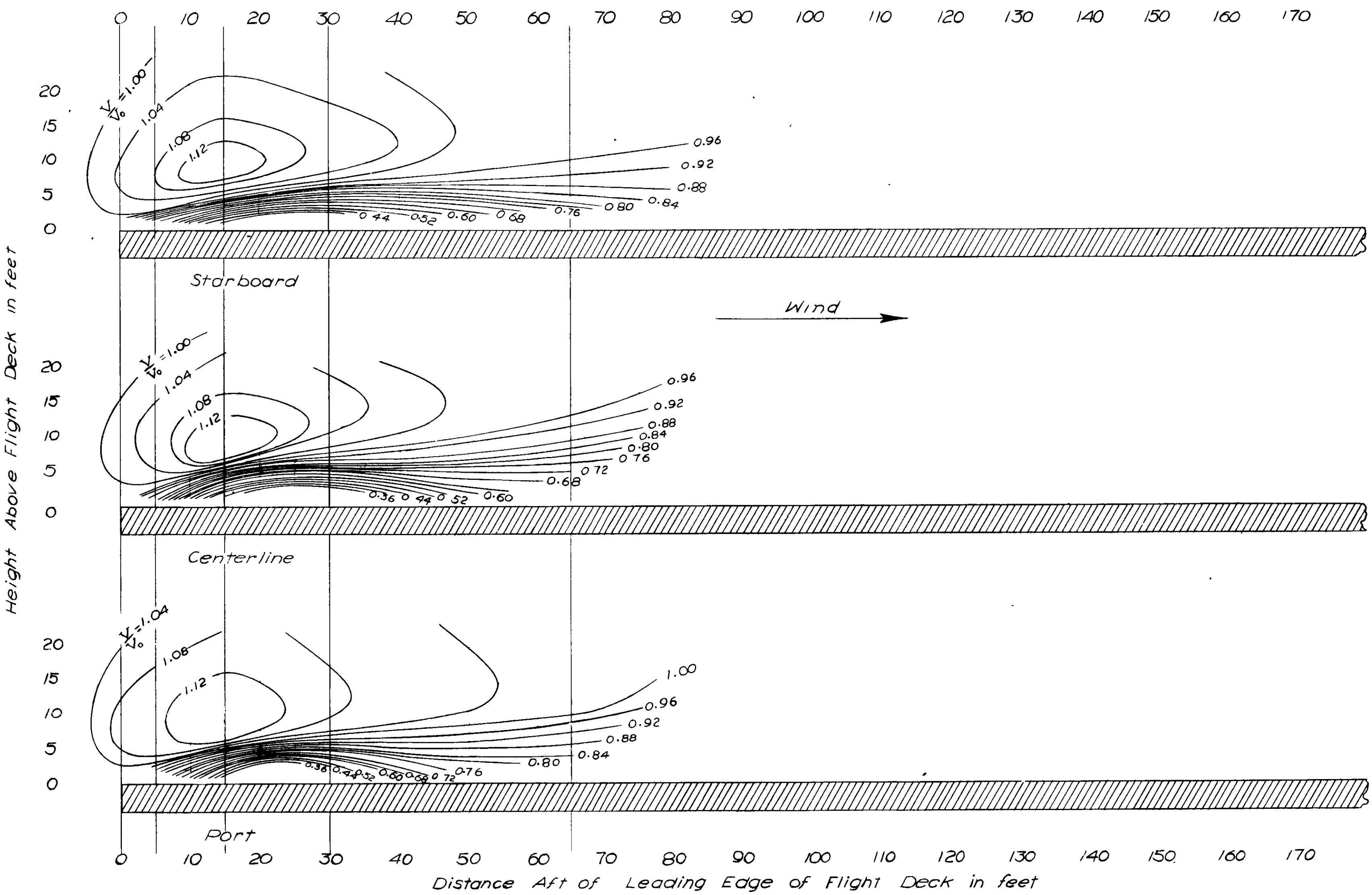

Figure 6 - Contours of Constant Velocity Ratios V/V_0 for Square-Faced Leading Edge

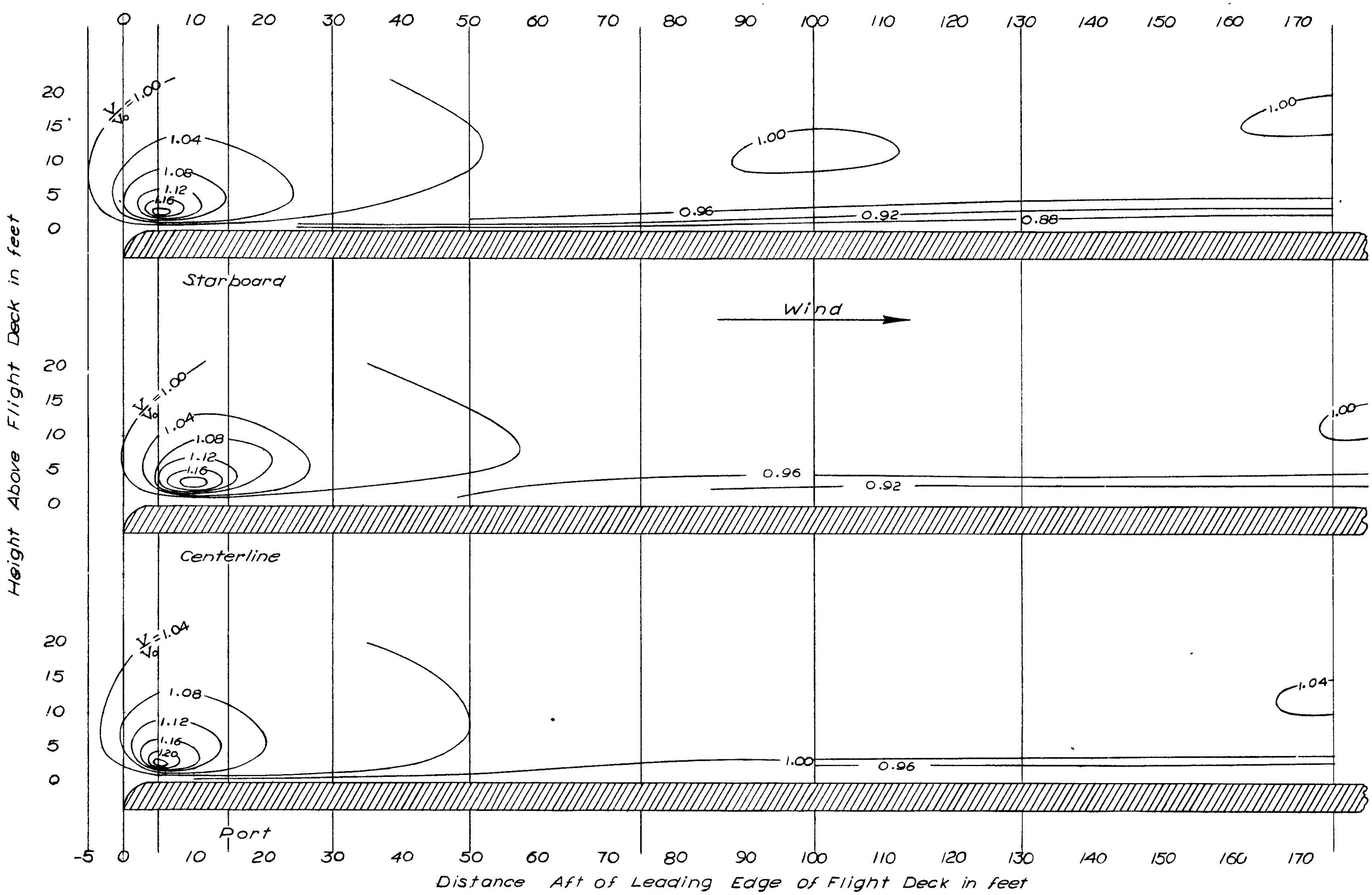

Figure 7 - Contours of Constant Velocity Ratios V/Vo for 1/4-Round Leading Edge with 4-Foot Radius

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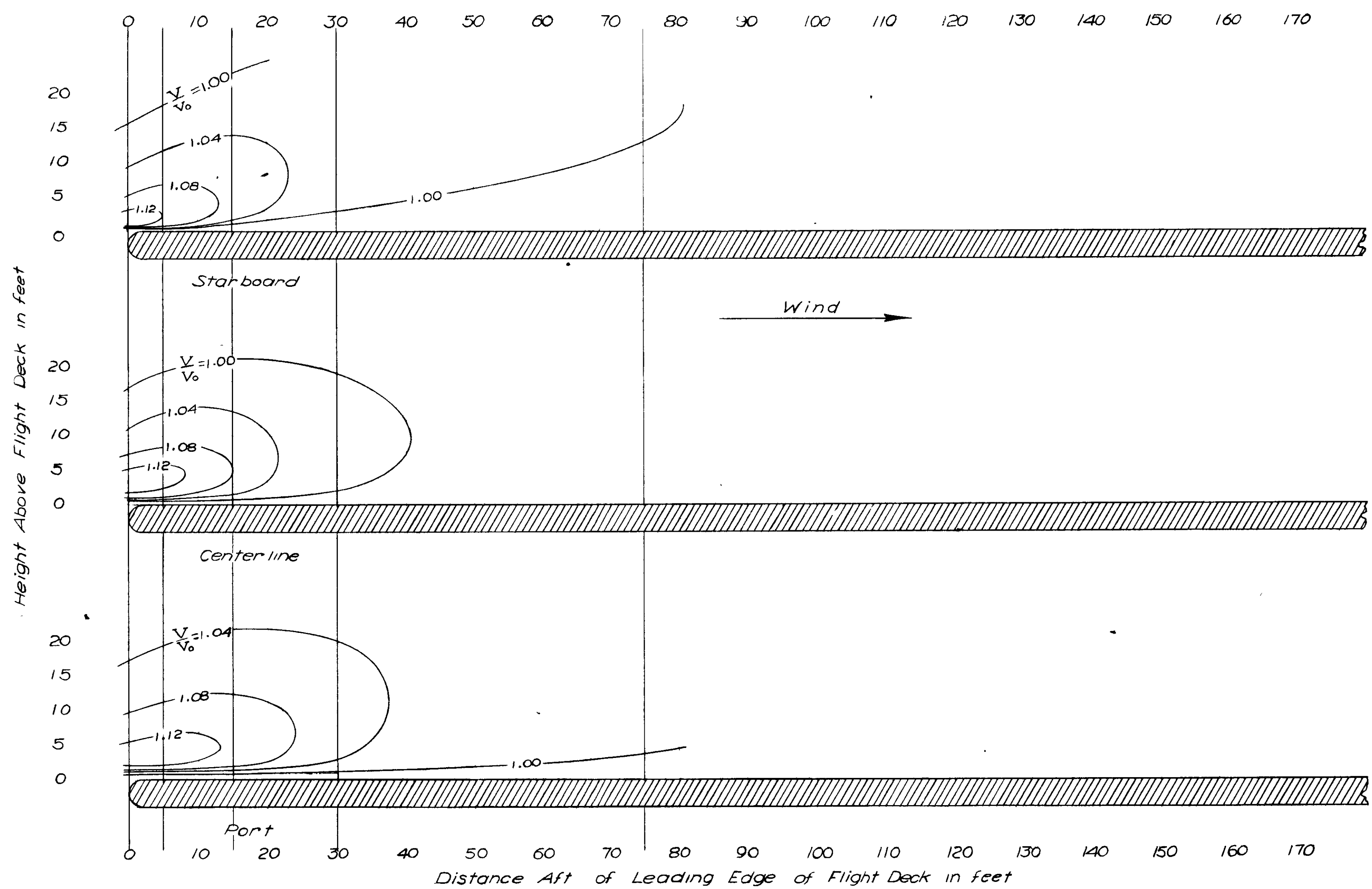

Figure 8 - Contours of Constant Velocity Ratios V/V_o for 1/2-Round Leading Edge with 2-Foot Radius

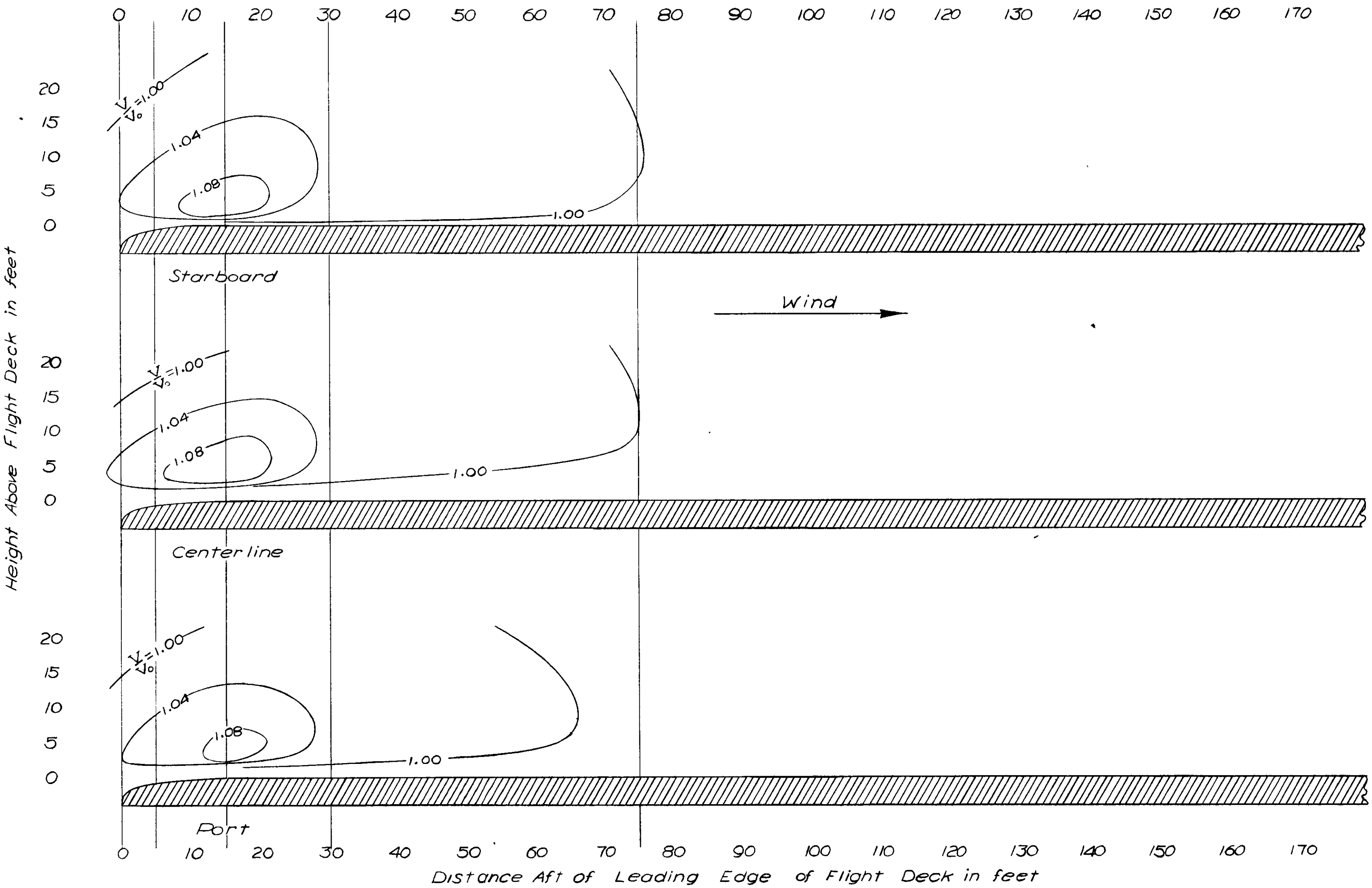

Figure 9 - Contours of Constant Velocity Ratios V/V_o for Parabolic Leading Edge

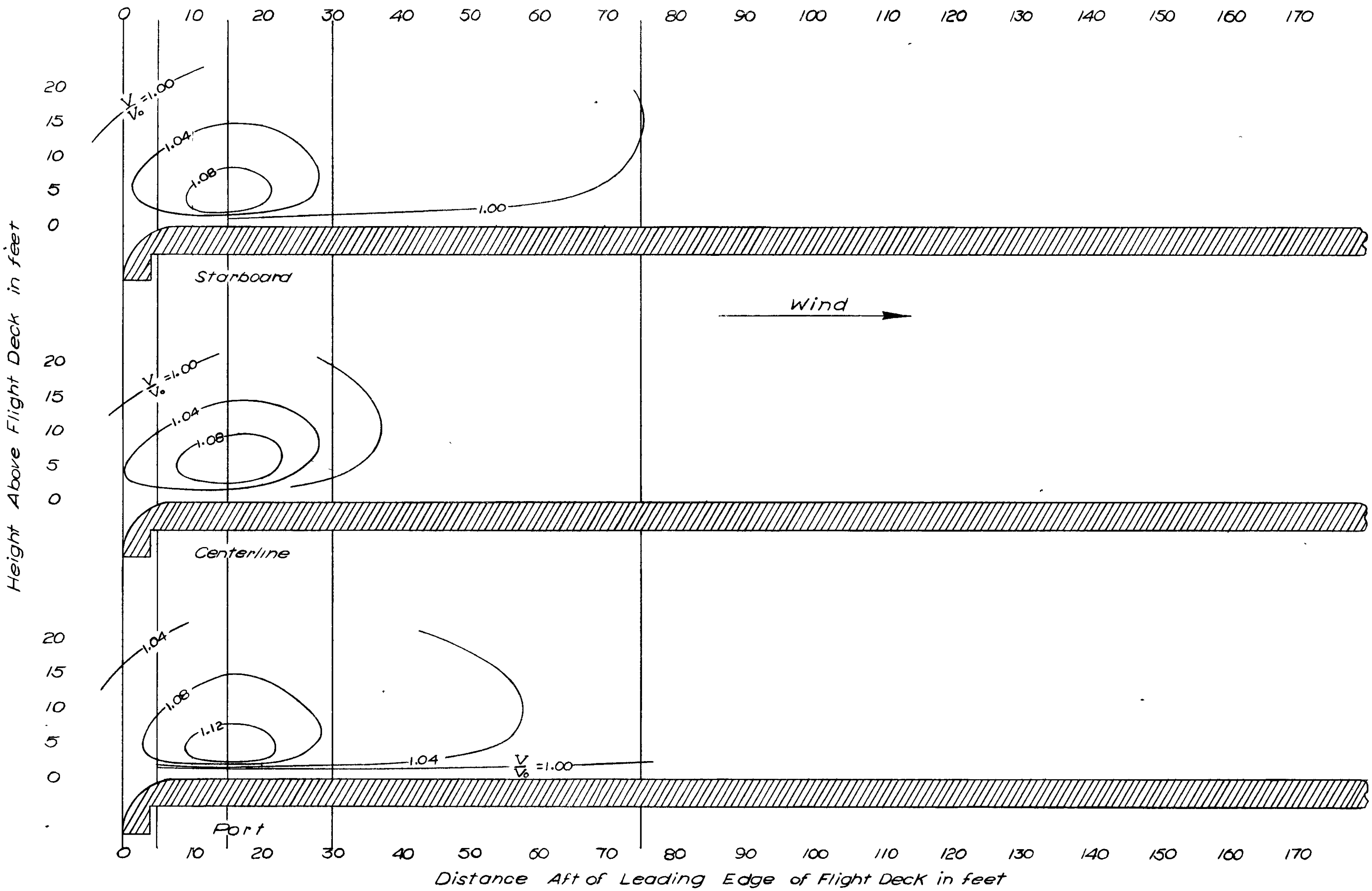

Figure 10 - Contours of Constant Velocity Ratios V/Vo for 1/4-Round Leading Edge with 8-Foot Radius