TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 253

WIND TUNNEL STANDARDIZATION DISK DRAG

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Summary

This report deals with the resistances of a series of three similar disks placed normal to the wind as determined in the atmospheric wind tunnel of the National Advisory Committee for Aeronautics. This is the first of the standardization tests to be made in American wind tunnels using these particular disks. The curves of drag coefficient plotted against Reynolds Number for this tunnel show discrepancies between overlapping values which are to be attributed to the presence of the tunnel walls.

Introduction

The disk standardization program, a part of the general standardization program, is for the purpose of further obtaining and correlating data from the several wind tunnels now in operation in the United States. At a meeting of the Aerodynamics Committee, Dr. Zahm suggested that these tunnels measure the drag of a given normal disk to determine whether each could obtain the same value with the simplest model, if small enough to obviate wall interference. The Committee then resolved to use three similar disks to show the scale effect. The tests herein described were carried out in the five-foot closed throat atmospheric density wind tunnel of the Langley Memorial Aeronautical Laboratory (Reference 5). The Reynolds Number varied from 33,000 to 670,000, using the diameter of the disk as the characteristic length.

Methods and Apparatus

The disks were four, eight, and twelve inches in diameter, and the ratio of all other dimensions was also 1 : 2 : 3. Even the supporting wires had conforming diameters different from each other. The disk thickness was 1/64 the diameter. The circumference had a 45-degree bevel to a sharp edge, the bevel being placed downstream. The supporting spindle was designed so that its interference with the disk would be as small as possible.

The testing was done in approximately the same longitudinal position in the throat, and with the disks concentric with the tunnel wall. The velocities ranged from 5 to 35 meters per second, taken in five-m.p.s. steps. The "service Pitot" used in determining these velocities was of the N.A.C.A. type with hemispherical nose, and was located in the entrance cone of the tunnel forward of the small honeycomb. This Pitot by prior calibration gave the average throat velocity for the condition of unobstructed flow. The effect of the 12-inch disk upon this Pitot was investigated and found to be negligible.

The determination of the drag coefficients of the disks was made by direct force measurements using a wire suspension and the regular drag balance of the tunnel. Figs. 1 and 2 show the 12-inch disk set up for determining total drag and wire drag, respectively. At the left of Fig. 2 is shown the auxiliary spindle used to support the disk when the tare measurements were made. The disk was close to the drag spindle, but not touching it as shown by an electric circuit and lamp. In this manner the true interference conditions of the disk upon the supports were maintained, the interference of the auxiliary spindle and wires, of course, being entirely negligible.

Results

Fig. 3 shows the results obtained for each of the disks in terms of the absolute drag coefficient plotted against Reynolds Number C_D vs. E). The drag coefficient is that customarily obtained from

$$C_D = \frac{D}{qS}$$

where D = measured drag
S = area of disk
q = dynamic pressure as measured by the "service" Pitot tube,

all units being consistent.

Discussion

The error of measurement and calculation was less than one per cent, repeated measurements agreeing inside that error, with the exception of three points out of a total of fifty.

At a Reynolds Number of 100,000, the 12-inch disk appears to produce an unstable or critical condition of flow. In the vicinity of 180,000 the C_D curve of the 4-inch disk shows a point of inflection. The curve for the 8-inch disk is without any marked inflection.

The discrepancies between the three curves may be accounted for largely by a consideration of the variation in blocking of the air flow by the disks. No attempt is made here to apply a correction for this effect, for the purpose of this investigation is the determination of these discrepancies. The results are submitted as being characteristic of this tunnel only, for the conditions herein specified, and not as being characteristic of a circular disk moving in an unlimited air space.

Table I.

12-inch disk (average of two tests).

Reynolds Number	C_D
98,000	1.500
146,000	1.280
195,000	1.270
292,000	1.274
390,000	1.281
488,000	1.286
585,000	1.287
682,000	1.298

Table II.

8-inch disk (average of two tests).

Reynolds Number	C_D
65,000	1.158
130,000	1.167
195,000	1.182
260,000	1.186
325,000	1.186
398,000	1.189
455,000	1.187

Table III.

4-inch disk (average of three tests).

Reynolds Number	C_D
33,000	1.096
65,000	1.125
98,000	1.141
130,000	1.159
163,000	1.162
195,000	1.159
228,000	1.177

References

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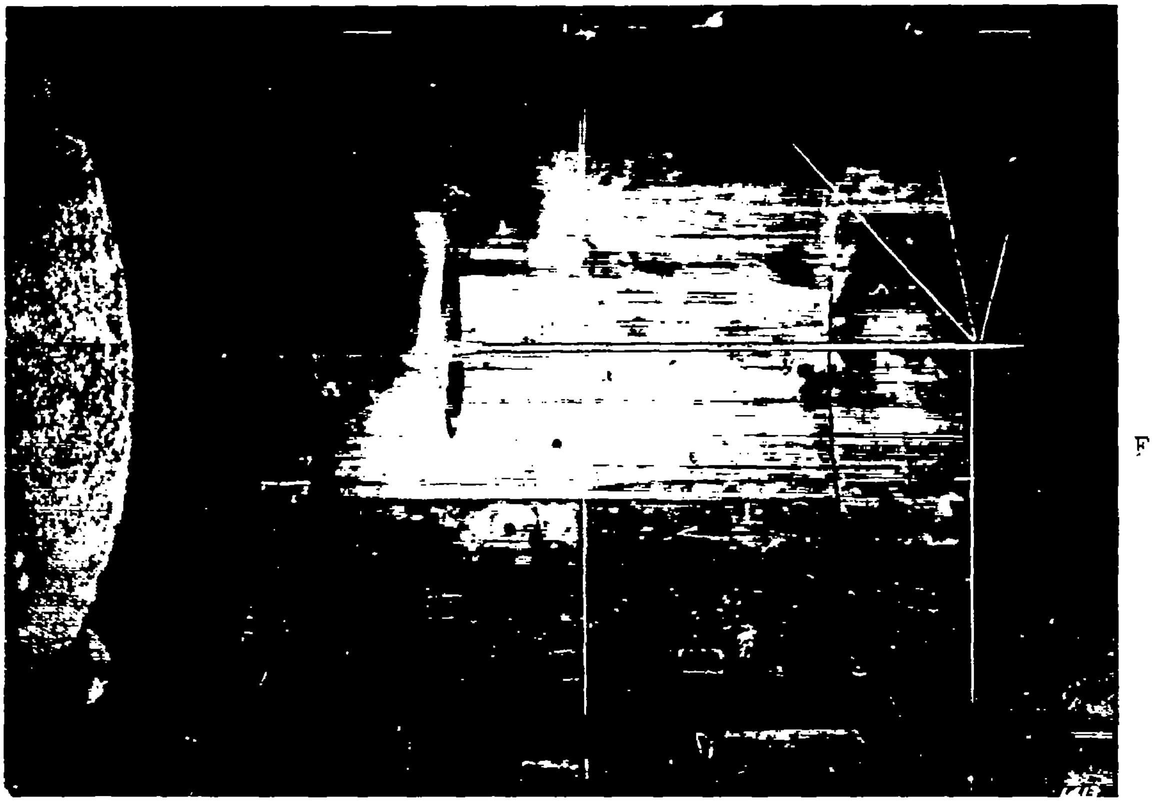

Fig.1

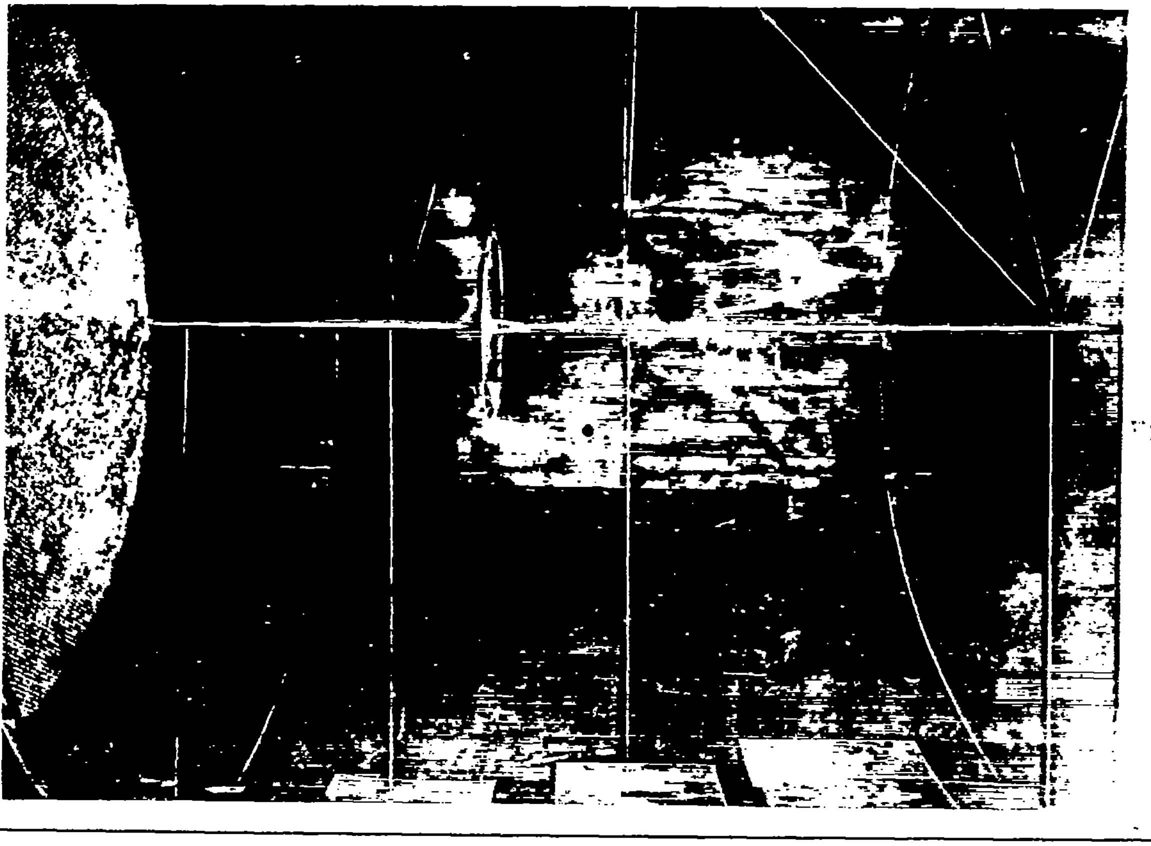

Fig.2

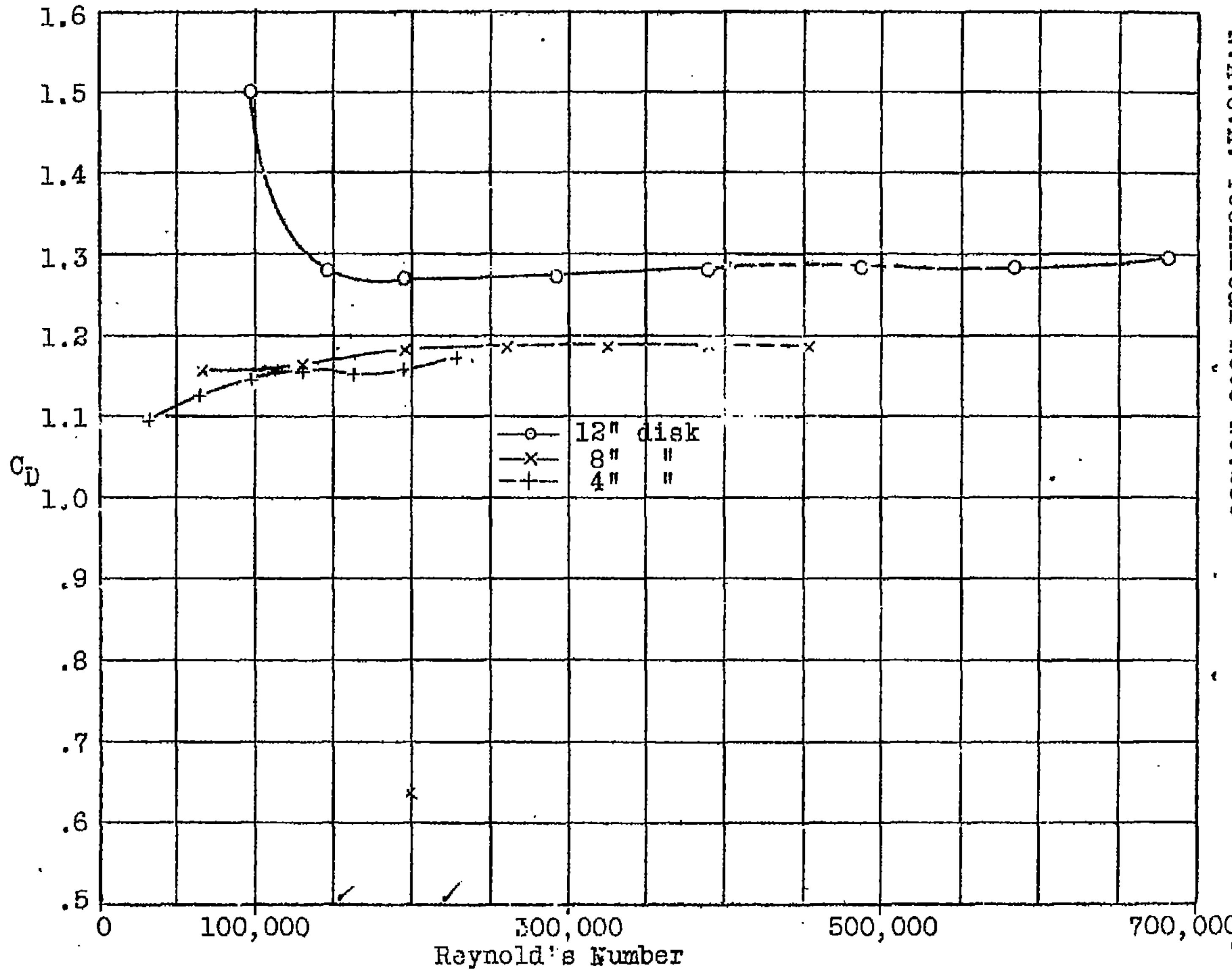

Fig.3 Absolute drag coefficient against Reynolds Number for disks.