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Two prototype XA2A and XA3A air vanes and fuse-arming mechanisms for weapon "A" were tested in a wind tunnel to determine the rotational speed of the vanes, time to reach constant speed, and the drag of the vanes. The tests were conducted at wind velocities of approximately 60, 96, 113, 138, and 160 knots. The time to reach constant speed decreased with an increase in wind velocity between 2.4 and 1.2 sec for the windmilling condition. Drag did not increase in regular manner with the wind velocity. The average time to arm the XA2A and XA3A arming mechanisms is also discussed.
NAVY DEPARTMENT
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.

WIND-TUNNEL TESTS OF THE XA2A AND XA3A FUSE-
ARMING MECHANISMS FOR WEAPON "A"

by

J. Beebe

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August 1947

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DAVID W. TAYLOR MODEL BASIN
NAVY DEPARTMENT

4 Sep '47
INTRODUCTION

At the oral request of the Naval Ordnance Laboratory, two prototype XA2A and XA3A airvanes and fuse-arming mechanisms for Weapon "A" were tested in the David Taylor Model Basin 8' by 10-foot Wind Tunnel 1. Tests were made to determine the rotational speed of the vanes, the time to reach constant speed, and the drag of the vanes. This was a continuation, at higher wind speeds, of an investigation made in the 6' - 4" wind-tunnel at the Naval Gun Factory. Subsequent tests were made (Reference 1), to determine the arming times of the prototypes of the XA2A and the XA3A fuse-arming mechanisms, and the minimum rotational velocity of the airvane necessary to arm the XA3A mechanism. Naval Ordnance Laboratory personnel assisted with the tests. The results of these tests are presented herein.

MODEL AND APPARATUS

The two prototype airvanes, one XA2A and one XA3A
fuse-arming mechanism, and all test equipment and instruments, except those necessary for the measurement of the drag force, were supplied by the Naval Ordnance Laboratory.

Airvanes - Basically the airvanes designated Propeller 1 and Propeller 2 were similar; both had 10 blades, a 49 degree blade angle, and were 6 inches in diameter. However, Propeller 1 had each two consecutive blades formed from a single piece of sheet steel having a thickness of 0.0625 inch and a chord of 1 inch, while the individual blades of Propeller 2 were formed from 0.040-inch thick sheet steel, were mutually reinforcing, and had a 1.125-inch chord, as shown in Figure 1.

The airvane was mounted on a shaft at the small end of a truncated cone which represented the fuse-arming housing. The cone was mounted on the balance support for the drag tests, Figure 2, while a streamlined strut, as shown in Figures 3 and 4, was used for the rotational speed tests. For these tests a disk 9.75 inches in diameter or a rounded-nose shape 12.75 inches in diameter was installed at the large end of the cone to simulate the aerodynamic effect of the bomb on the airvane. A torque load could be imposed upon the airvane by loading a small electric generator which was mounted behind the disk or the rounded nose, as shown in Figure 5.

The airvane rotational speeds were measured by a Strobotac, and the time to reach a constant speed by a stop watch and the Strobotac.

Fuse-Arming-Mechanisms - The major difference in the XA2A
and the XA3A mechanisms is that the XA2A arms the fuse when the
air-vane has made a fixed number of revolutions, and the XA3A
arms the fuse when the airvane has attained a certain rotational
speed. The XA2A fuse-arming mechanism is shown in Figure 6.

The fuse-arming mechanism was mounted on a streamlined
strut together with a 12.75-inch diameter rounded fairing to
simulate the nose of the actual missile, see Figures 7 and 8. A
wire was provided to release the airvane when the wind speed
was at the desired value. To prevent damage to the wind tunnel,
a metal guard, which may be seen in Figure 7, retained the air-
vane and arming assembly upon arming.

TEST PROCEDURE

The tests on the airvanes were conducted in the David
Taylor Model Basin 8-by 10-foot closed-throat atmospheric Wind
Tunnel 1 at wind speeds of approximately 60, 96, 113, 138, and
160 knots.

The first series of tests were made to determine the
constant rotational speed of the airvanes for each wind speed.
Then with the wind speed held constant, and the Strobotac set
for the previously measured constant rotational speed, the
propeller was released and the time for the airvane to reach
full rotational speed was obtained. This procedure was re-
peated for a free windmillin; condition (zero torque) and for
a load run (10 inch-ounces of torque) with several combinations
of propeller, wind speed, and simulated bomb nose. The rounded
nose shape and the disk were each mounted behind Propeller 2,
while only the disk was used with Propeller 1.

The drag tests were made with only Propeller 2 and the truncated cone housing. An image support was installed as shown in Figure 2 for obtaining the tare and interference drag.

The arming time tests on the fuse arming mechanisms were made at a constant dynamic pressure of 87.13 pounds per square foot which corresponds to a wind speed of about 160 knots. Two observers measured the time to arm and three trials were made with both the XA2A and XA3A (centrifugal mechanism) which was allowed to windmill while the wind speed was increased and the rotational velocity at the instant of arming was measured by means of the Strobotac.

RESULTS AND DISCUSSION

The results of the tests are given in Table 1 and in Figures 9 and 10. The drag forces were corrected for the tare and interference of the support strut. No tunnel-wall or blocking corrections were applied to these data.

The measured rotational speeds of Propeller 2 were greater than for Propeller 1. This difference in speed is probably due to the smaller thickness ratio of the blades of Propeller 2. The time to reach constant speed decreased with an increase in wind speed and varied between 2.4 and 1.2 seconds for the free windmillin-; condition (Table 1). This time, however, is merely qualitative since the difference in time over the wind-speed range was of the order of one-half
second, for a particular condition, and the individual observer's reaction time was too slow to obtain a low percentage error.

The measured drag did not increase in a regular manner with the wind speed, Figure 10.

The average time to arm the XA2A arming mechanism (gear type) was 1.3 seconds at a wind speed of 160 knots (plus or minus one percent), while the average time for the XA3A (centrifugal type) was 1.7 seconds.

When the wind speed was gradually increased the XA3A fuse-arcing mechanism armed at 5600 revolutions per minute at a wind speed of 142 knots. This mechanism was designed to arm at 6000 revolutions per minute.

REFERENCES
1. Naval Ordnance Laboratory Conf Ltr FN-27/S76-2 (2642) to TMB dated 19 May 47.

Aeromechanics Division
David Taylor Model Basin
Washington, D.C.
August 1947
TABLE I
Table Showing RPM and Time to Reach Constant Speed
for Various Wind Velocities

<table>
<thead>
<tr>
<th>Propeller</th>
<th>Wind Speed in knots</th>
<th>Free Run (No Torque)</th>
<th>Load Run (10 In-oz Torque)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RPM</td>
<td>Time to Reach Constant Speed in seconds</td>
<td>RPM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Time to Reach Constant Speed in seconds</td>
</tr>
<tr>
<td><strong>DISK NOSE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>95.2</td>
<td>4,025</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>112.5</td>
<td>4,975</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>138.2</td>
<td>6,050</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>160.0</td>
<td>7,000</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>96.4</td>
<td>4,150</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>112.6</td>
<td>4,925</td>
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</tr>
<tr>
<td></td>
<td>138.7</td>
<td>6,175</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>160.3</td>
<td>7,225</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>ROUNDED NOSE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>60.8</td>
<td>2,400</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>95.3</td>
<td>4,200</td>
<td>1.7</td>
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<td></td>
<td>112.5</td>
<td>5,000</td>
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<td></td>
<td>138.5</td>
<td>6,250</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>160.1</td>
<td>7,325</td>
<td>1.4</td>
</tr>
</tbody>
</table>
Figure 1 - Sketch Showing Types of Blade Construction for the two XA.S.A Airvanes

J.A.D. 6-10-47
Figure 2 - Propeller 2 and Truncated Cone Housing Mounted for Drag Tests.

The image strut for determining tear corrections is shown in place.

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Figure 3 - Front View of Airvane Assembly with Propeller and Disk

Rotational speeds were measured with this installation.
Figure 4 - Front View of Airvane Assembly With Propeller 2 and Rounded-Rose Shape
Figure 5 - Side View of Airvane Assembly Showing Generator Modified for use as Torque Indicator
Figure 6 - The Prototype F-2C Fuse-Arming Mechanism

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Figure 7 - The XAJA Fuse-Arming Mechanism Mounted in the Wind Tunnel
The simulated missile nose and the metal retaining guard may be seen.
Figure 8 - Rear View of the ZAJA Fuse-Arming Mechanism Showing the Method of Mounting on the Strut for the Arming Tests