NAVY DEPARTMENT
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TESTS TO DETERMINE THE FLOODING RATE OF THE TAIL CONE OF THE 325-POUND MARK 17 DEPTH BOMB

by

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DAVID TAYLOR MODEL BASIN

PERSONNEL

The tests were conducted and the report was written by M. Kirstein.

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ABSTRACT

The time required to flood the tail cone of a 325-pound, Mark 17, Modification 1 aerial depth bomb was estimated from the pressures measured inside the bomb tail and was also measured directly. The tests were performed at the David Taylor Model Basin by towing the bomb in a horizontal position 28 1/2 inches below the water surface at speeds up to 9 knots. The water entered the tail cone of the bomb through an orifice in the apex of the cone. The tests were run with two forms of bomb noses, one flat and one hemispherical.

The experimental results indicated that, within the speed range covered by the tests, the tail cone fills more slowly when the nose of the bomb is hemispherical than when it is flat. The time difference is small, and is in agreement with the rates estimated from measurements of the pressure inside of and behind the tail cone.

INTRODUCTION

The 325-pound, Mark 17, Modification 1 aerial depth bomb consists of two main assemblies, a cylindrical body with a square base and hemispherical head, and a tail made up of a sheet-metal cone with four fins and a cylindrical shroud ring.

As this bomb was found to ricochet when first placed in service, a spoiler head was added over the hemispherical head to make the nose nearly square and to make the bomb bite into the water upon impact. The assembly of these three parts is shown in Figure 1.

When this bomb is dropped the tail is full of air. Before the bomb can reach its maximum sinking rate under any given conditions, the air must be vented from the tail and all the space inside the latter must be filled with water.

To aggravate this situation, when the bomb is dropped at high speed from aircraft and it enters the water, a cavity is formed which is larger than and envelopes the bomb and which persists for some time as the bomb is slowing down in the water. The tail cannot begin to flood, of course, until this cavity has closed and solid water comes in contact with the tail.

It can be seen therefore that the time interval required for water to flood the tail of the bomb enters as a parameter in the determination of the bomb's underwater trajectory.

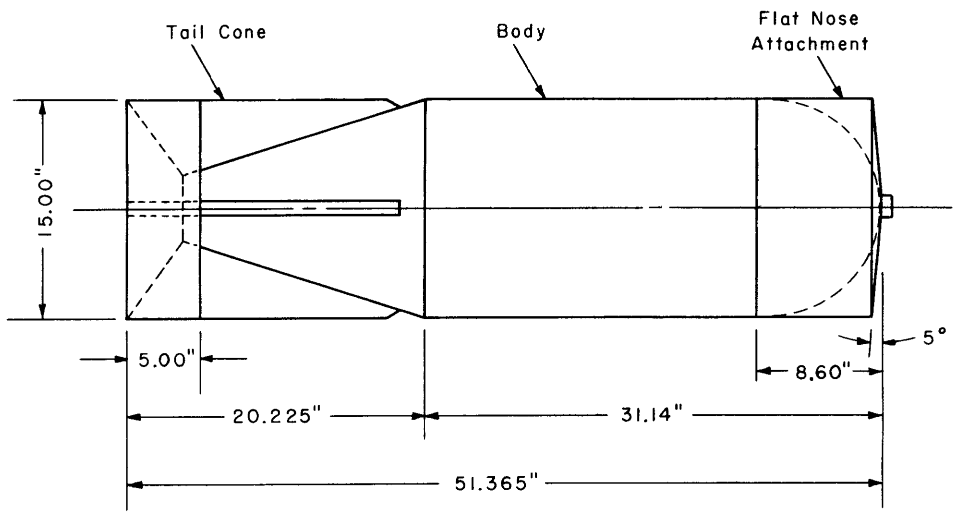

Figure 1 - Assembly of 325-Pound, Mark 17 Aerial Depth Bomb

Without considering the attitude and the attendant conditions of the bomb as it strikes the water, the David Taylor Model Basin, at the oral request of a representative of Section Re3 of the Bureau of Ordnance, measured the pressures in the tail cone of a full-scale 325-pound, Mark 17 depth bomb and determined the time required to fill the cone when the bomb was fitted with a flat and with a hemispherical nose.

TEST PROCEDURE

It appeared to be quite out of the question to attempt to simulate the motion of the bomb in the water, corresponding to an aircraft drop. It was decided, therefore, to place the bomb under water and to tow it at a speed corresponding to its speed in the water trajectory. By making the tail watertight, and by flooding it through a valve at the end of the cone, the actual service conditions could be reproduced to a certain degree.

The bomb was held horizontally under the towing carriage with the top submerged 28 1/2 inches, and tests were performed at speeds of 3 knots to 9 knots. In the determination of the comparative time to fill the tail when the bomb was fitted with a flat and a hemispherical nose, two independent tests were made In the first of these tests, the pressures inside of and outside of the bomb tail were measured. From these data, the time to fill the tail was calculated. In the second test, the time to fill the bomb tail was measured directly and recorded on a chronograph.

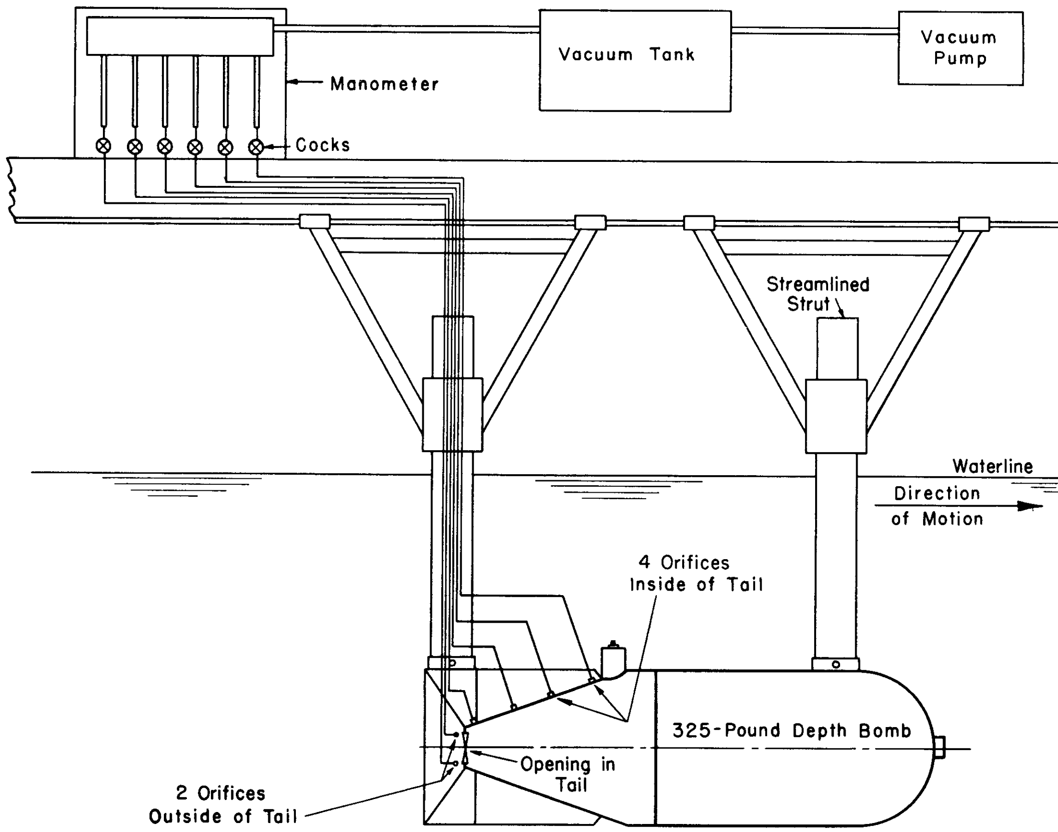

Figure 2 - Arrangement for Pressure Measurements in the Tail Cone

In the first test, four point-pressure orifices were installed inside and two outside the tail cone at the stern opening as shown in Figure 2. These pressure fittings were connected by tubing to a manometer mounted on the towing carriage. Since the tubing was not protected, copper tubing was used for the underwater section to obtain reliable pressure readings.

For the second test, in which the time required to fill the bomb tail was measured directly, a second tail was made up watertight and fitted to the bomb. The tail was equipped with a spring-operated door controlled from the carriage, as shown in Figure 3. The door-operating mechanism was fitted with a quick-acting switch, connected to a time pen on a chronograph indicated in Figure 4. The highest portion of the bomb tail was equipped with a float chamber, in which a float closed one of the chronograph circuits when the tail was filled. The interval of time between the opening of the door and the closing of the float circuit was the time required to fill the bomb tail.

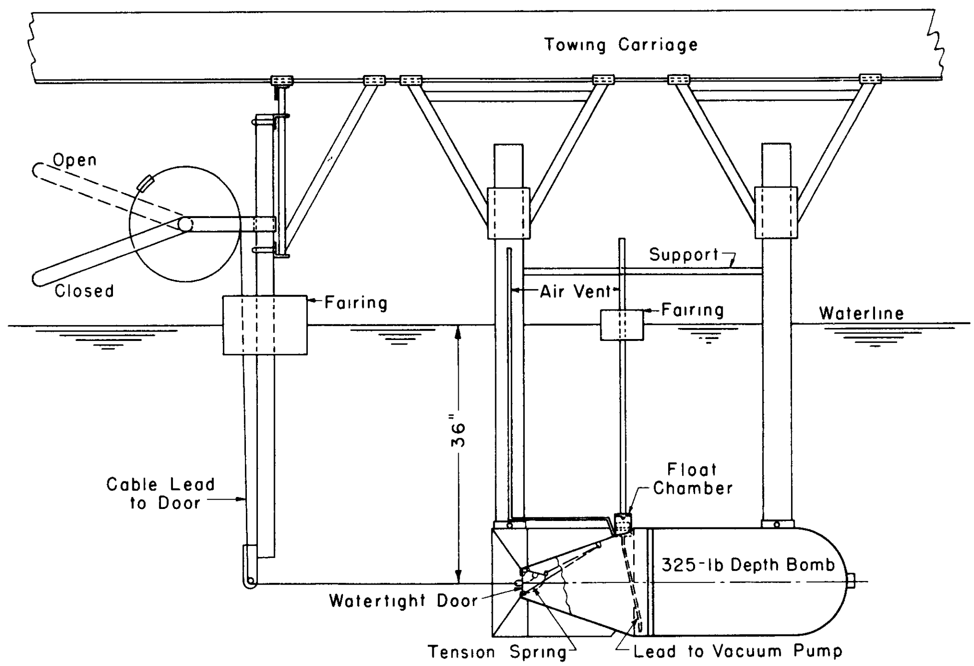

Figure 3 - Mechanical Arrangement for Measuring Time to Fill Tail Cone

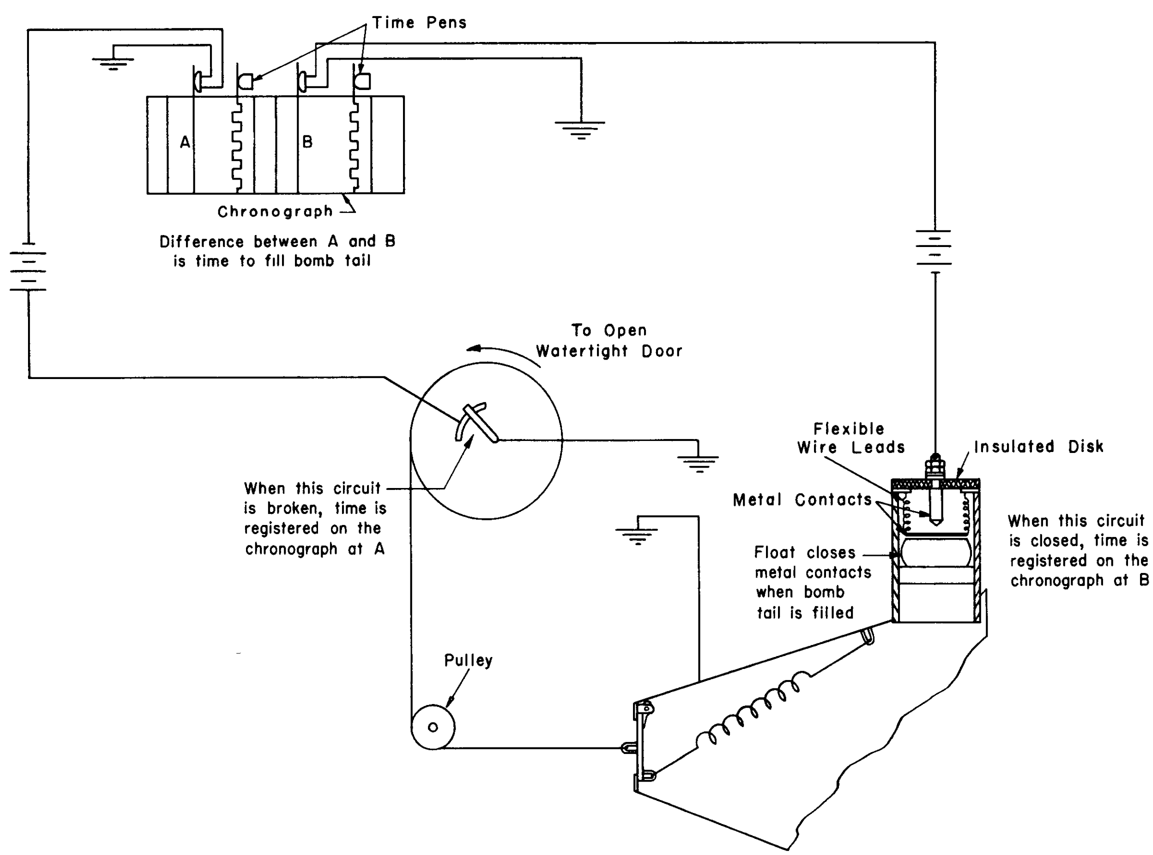

Figure 4 - Wiring Diagram of Arrangement Used for Measuring Time to Fill Tail Cone

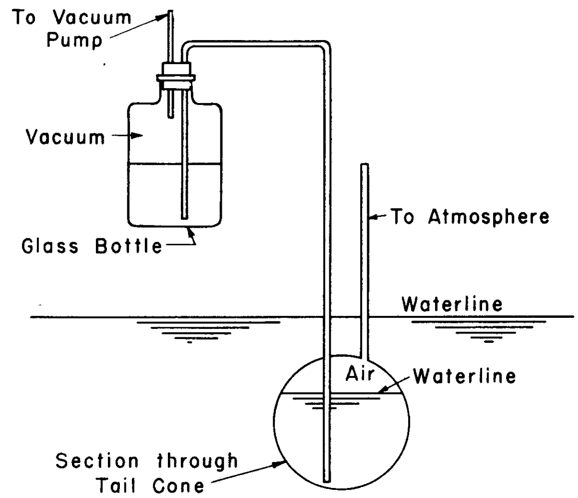

Figure 5 - Diagram of Apparatus Used for Pumping Water Out of the Tail Cone between Test Runs

The time required to fill the tail cone depends almost entirely on the size of the air vents. For these tests the air vents had a total area of 0.265 square inch, which was considered sufficient for the purpose. Figure 5 shows the method used in pumping water out of the tail cone between test runs.

Views of the bomb with the watertight tail, the original tail cone, and the false flat nose are reproduced in Figures 6, 7, and 8.

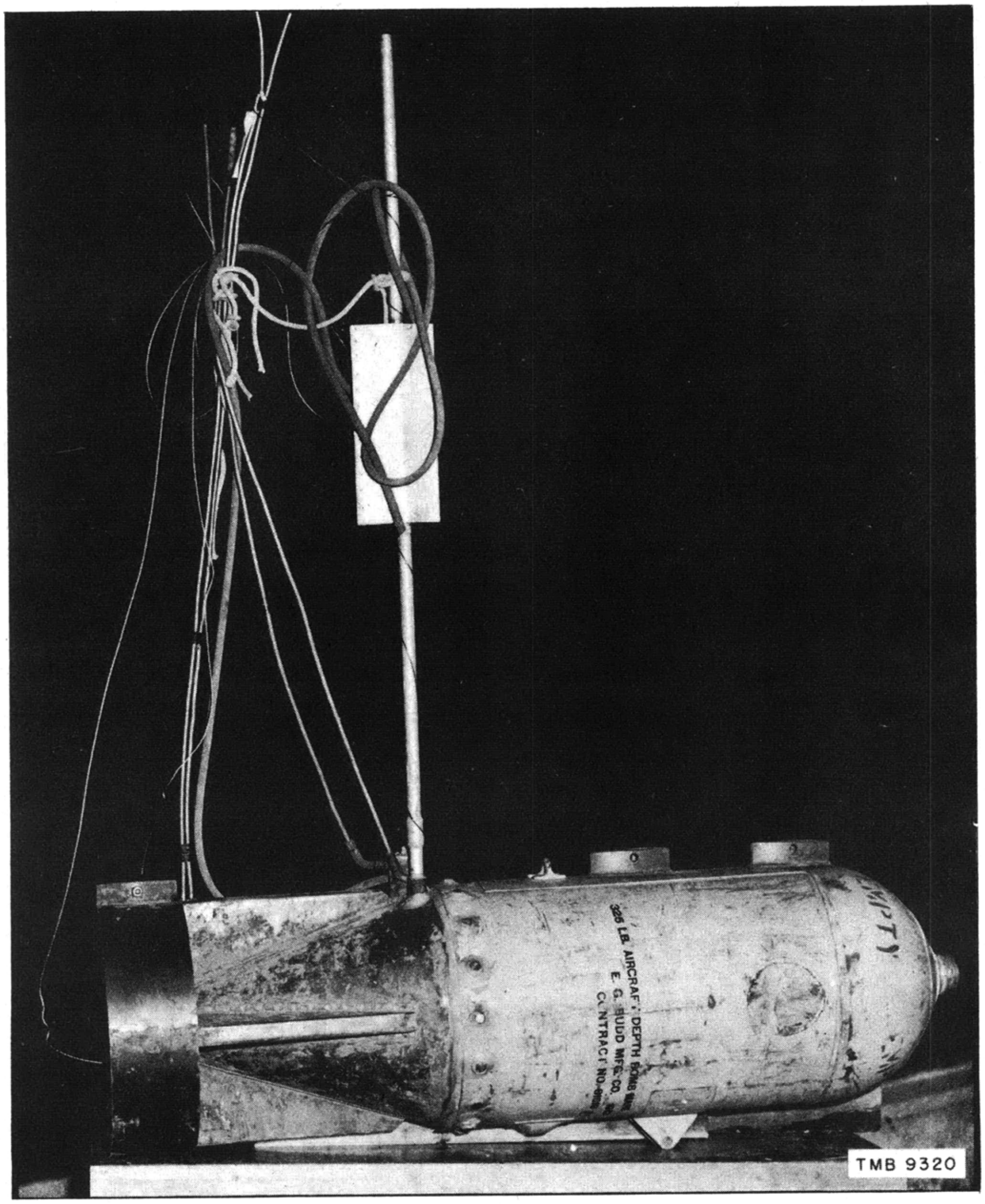

Figure 6 - Side View of Model Showing Hemispherical Nose and New Watertight Tail with Air Vents and Float Chamber

The general arrangement of the watertight tail construction and float is given in TMB Drawings A-6060 and A-6061.

The three long projections on top of the bomb and the tail are for the attachment of the towing struts.

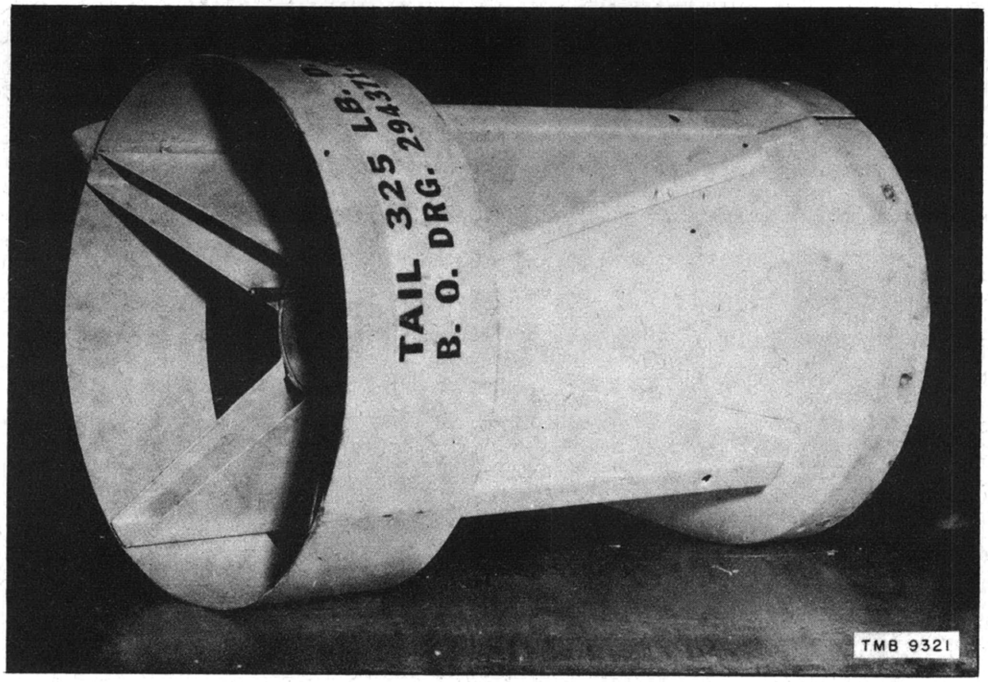

Figure 7 - Original Tail Cone in Which Pressure Taps were Fitted as Shown in Figure 2

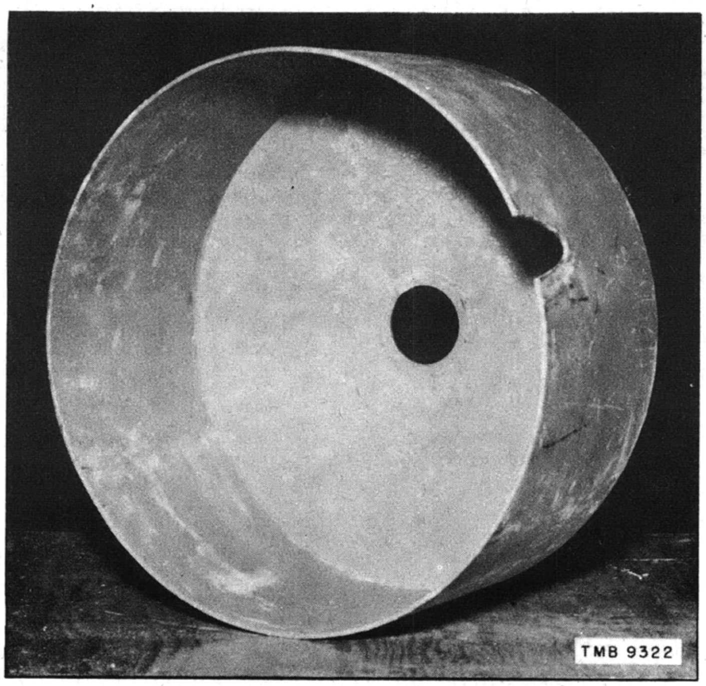

Figure 8 - Flat Nose Attachment Built to Fit over the Hemispherical Nose

The attachment actually has a 5-degree slope on the face; the outer corner is square with only a small radius.

TEST RESULTS

As explained in the Introduction, the attitude of the bomb in these tests was not similar to that which occurs in the field. The physical conditions of these tests correspond generally to water under a constant pressure head flowing through an orifice. The resultant pressure inside the bomb tail is equal to the depth to the centerline of the bomb, 36 inches, minus the dynamic pressure drop in inches of water. This resultant pressure, assuming an orifice coefficient of 0.60, was used to calculate the curves of estimated time to fill the bomb tail. These are given in Figure 9.

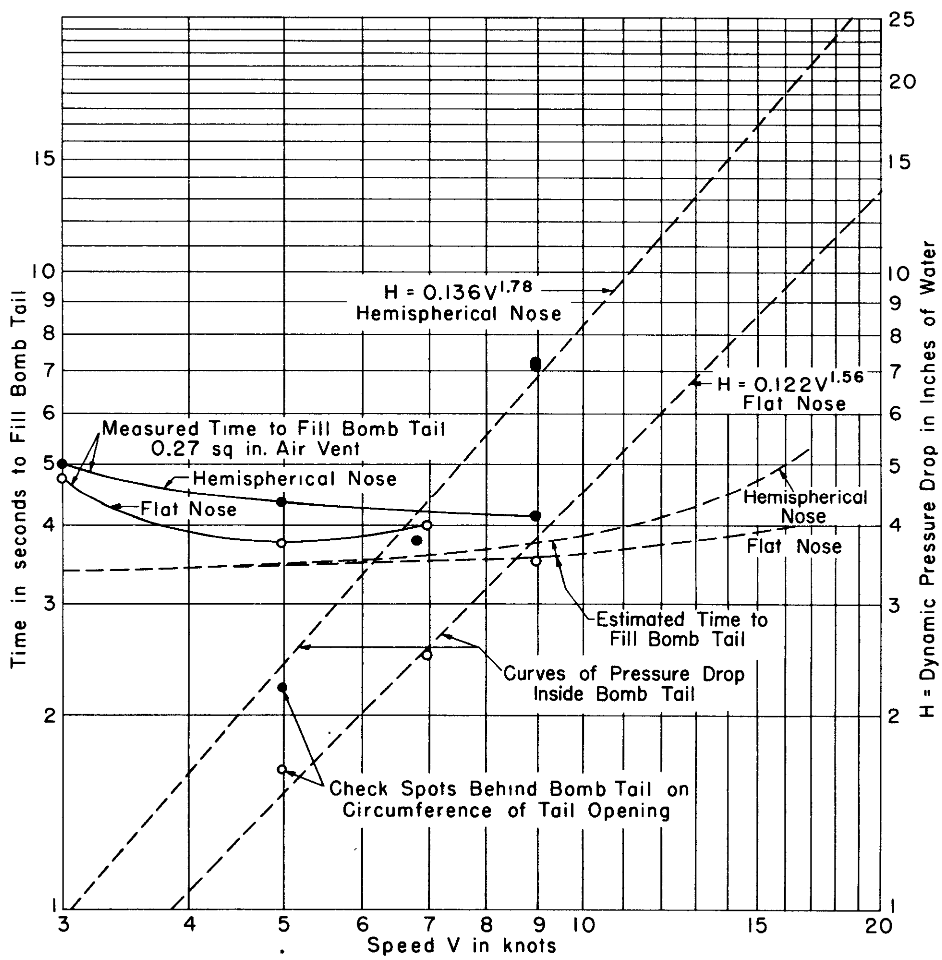

Figure 9 - Curves of Reduction in Pressure Inside Bomb Tail and Time to Fill Bomb Tail with Water

A sample calculation follows: If we neglect the effect of the varying pressure head on the bomb tail due to filling, the velocity through the orifice is $V = c\sqrt{2gh}$ and $Q = \frac{A}{144}c\sqrt{2gh}$. Since $t \cdot Q$ = Volume,

$$t = \frac{\text{Volume}}{Q} = \frac{\text{Volume} \times 144}{A\,c\,\sqrt{2g}\,\sqrt{h}} = \frac{0.96 \times 144}{4.91 \times 0.60 \times 8.02\sqrt{h}} = \frac{5.84}{\sqrt{h}}$$

where Q is the flooding rate in cubic feet per second,

Volume of the tail cone is 0.96 cubic foot,

A is the area of orifice, 4.91 square inches,

t is the time in seconds,

Static pressure at opening of bomb tail is 36 inches of water,

H is the dynamic pressure drop in inches of water, and

h is the resultant pressure inside bomb tail in feet of water, or $\frac{36 - H}{12}$.

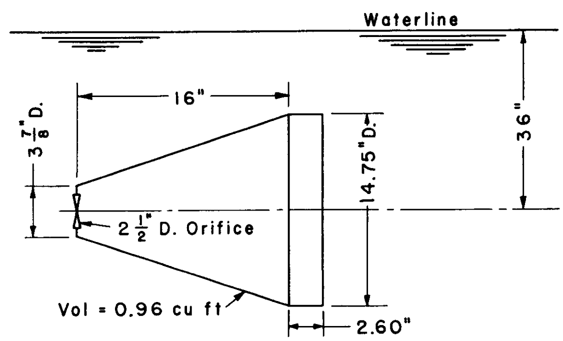

Figure 10 - Tail Outline for Volume Calculation

From Figure 9 for the bomb with the hemispherical nose and a speed of 9 knots

H = 6.8 inches dynamic pressure drop

and

$$h = \frac{36 - 6.8}{12} = 2.43 \text{ feet resultant pressure at the opening in the bomb tail}$$

$$t = \frac{5.84}{\sqrt{h}} = \frac{5.84}{1.56} = 3.75 \text{ seconds}$$

which agrees with the curve of the estimated time to fill the bomb tail, shown in Figure 9.

The results of the tests, as plotted in Figure 9, give curves of pressure drop in inches of water inside of the bomb tail, as well as the estimated time and measured time to fill the bomb tail for each of the nose shapes.

CONCLUSIONS

1. The dynamic pressure drop in the tail cone of the Mark 17 aircraft depth bomb expressed in inches of water is $0.136\,V^{1.78}$ for the hemispherical nose and $0.122\,V^{1.56}$ for the flat nose, where V is the speed in knots.

2. The tail cone requires about 4 seconds to fill when the bomb is towed horizontally with its axis 3 feet below the water surfaces at speeds between 3 knots and 9 knots.

3. The tail cone requires slightly longer to fill when the bomb has the hemispherical nose than when the bomb has the flat nose attachment.