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TESTS OF A LARGE SPHERICAL TURRET AND A MODIFIED TURRET ON A TYPICAL BOMBER FUSELAGE

By Axel T. Mattson

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

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TESTS OF A LARGE SPHERICAL TURRET AND A MODIFIED TURRET ON A TYPICAL BOMBER FUSELAGE

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The drags of two alternate turrets for a military airplane were investigated through a Mach number range of 0.22 to 0.70 at angles of attack of 3°, 5°, and 7°, in the 8-foot high-speed tunnel. Force and pressure measurements were made with the turrets mounted on a bomber model.

The results show that a large spherical turret added about 10 percent to the fuselage drag. A smaller, better-shaped turret added only about 1 percent to the fuselage drag.

INTRODUCTION

Tests of two turrets for a bomber-type airplane were made in the 8-foot high-speed tunnel. The main purpose of the test was to obtain data to aid in performance estimation of proposed military airplanes.

One turret corresponds to a 90-inch-diameter spherical turret installed on a fuselage of 100-inch diameter. The other turret corresponds to a 60-inch spherical turret with a 20-inch tail fairing installed on a fuselage of 100-inch diameter.

The turrets were installed on the fuselage of a typical bomber model, which was available at the time the tests were requested.

APPARATUS AND METHOD

The NACA 8-foot high-speed tunnel is a single-return, closed-throat tunnel in which the speed can be controlled from 90 to more than 500 miles per hour.

The large spherical turret will be referred to as "turret A" and the modified turret will be referred to as "turret B."

Turret A is spherical in shape and includes four .50-caliber machine guns. In the full-scale airplane the turret is 90 inches in diameter and protrudes 15 inches from the top of the fuselage. Turret B has a spherical nose with an afterbody fairing. This full-scale turret has a diameter of 60 inches with the after-body fairing extending 20 inches. Turret B protrudes 12 inches from the top of the fuselage.

Models of the turrets were constructed by the NACA. Figures 1 and 2 show the model dimensions.

The models were scaled down with relation to the model fuselage to obtain results that would be comparable with the turrets installed on a 100-inch-diameter fuselage. Figures 3 and 4 illustrate the turrets mounted on the fuselage.

The turrets were tested on a typical bomber model of a wing-fuselage combination supplied by the U.S. Army Air Forces. The wing spanned the test section and was mounted on the balance ring in the usual manner. The model fuselage is 114.96 inches long and has a maximum cross-sectional area of 0.832 square foot.

Turret A was tested at two locations on the fuselage. One location is rearward of the wing and on top of the fuselage at 59.0 percent of the fuselage length. The alternate location is forward of the wing and on top of the fuselage at 24.9 percent of the fuselage length. Turret B was tested at only the 59.0-percent fuselage location. Figure 5 shows the location of the turrets on the model.

Force-test and pressure measurements were taken at Mach numbers ranging from 0.22 to 0.70. The angle of attack of the wing was set at 3°, 5°, and 7°. The angle of wing setting is 5° with relation to the fuselage center line.

The corresponding average Reynolds number range based on mean aerodynamic chord of the wing (17.66 in.) ranged from approximately 2,000,000 to 5,000,000.

Figure 6 is a plot of the average test Reynolds number against the test Mach number.

RESULTS AND DISCUSSION

Incremental Drag Coefficients, ΔC_{D_F}

The turret-drag results are presented as incremental drag coefficients ΔC_{D_F} plotted against Mach number. The incremental drag coefficients are defined as follows:

$$\Delta C_{D_F} = \frac{\text{drag of the complete model wing, fuselage, turret} - \text{drag of the wing and fuselage}}{\text{dynamic pressure} \times \text{fuselage max. cross-sectional area}}$$

in which the model fuselage maximum cross-sectional area is 0.832 square foot. Thus the drag coefficients include interference drag as well as direct drag.

Figure 7 shows the incremental drag of both turrets plotted against Mach number. At a Mach number of 0.5 and an angle of attack of 5° turret A has a drag increment of 0.028 in the forward location and 0.011 in the rearward location. Turret B, in the rearward location, shows a low drag increment of 0.0005, increasing to 0.0010 in the upper speed range. The drag increment for turret B is for practical purposes negligible. This low drag increment of turret B agrees with the results on streamline blisters reported in reference 1.

On the basis of a fuselage drag increment of 0.11, which may be taken as typical for bomber-type fuselages, turret A in the rearward location would increase the fuselage drag by about 10 percent; turret B would add only about 1 percent. In the forward location, turret A added about 28 percent.

It must be remembered that small differences in airplane drag of large bombers and escort planes seriously affect their range and armament capacity and thus the differences in turret drags, although small, are important.

In the design of turrets for a bomber-type airplane, it appears highly desirable to use streamline turrets and to limit the size of the turrets as much as possible.

The present tests serve to emphasize the large gains attainable through the use of streamline turrets of as small a size as possible.

Pressure measurements were taken at five orifice locations on both turrets. (See figs. 1 and 2 for orifice locations and turret length.) The results were reduced to pressure coefficients. Pressure coefficient P is defined as follows:

$$P = \frac{\text{local static pressure} - \text{stream static pressure}}{q}$$

in which

$$q = \frac{1}{2} \rho V^2$$

where

q dynamic pressure

ρ air density

V airspeed

Table I shows the pressure coefficients for each angle of attack and Mach number. These values are for both turrets located at 59.0 percent of the fuselage length.

The pressures occurring on the side orifice for both turrets at 59.0 percent fuselage location are plotted in figures 8 and 9, which also include a curve of theoretical critical pressure coefficient P_{cr}, for a value of P where the local static pressure corresponds to the velocity of sound.

Critical Speed

Figure 10 shows the maximum pressure coefficient P_{max} recorded on the top of the turret. The indicated critical speed of turret A occurs at a Mach number of 0.65 at an angle of attack of 5°. The corresponding indicated critical Mach number of turret B is 0.69.

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For turret A in the forward fuselage location, the negative pressure peak was increased and the critical Mach number decreased to 0.625 at an angle of attack of 5°. (See fig. 11.)

CONCLUSIONS

1. Turret A increased the fuselage drag coefficient by about 10 percent at a Mach number of 0.5 when located at the 59.0 percent fuselage station. At the same location on the fuselage, turret B increased the fuselage drag coefficient approximately 1 percent throughout a Mach number range of 0.22 to 0.675.

2. When located at 24.9 percent of the fuselage length, turret A increased the fuselage drag coefficient by approximately 25 percent at a Mach number of 0.5.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va.

REFERENCE

1. Stack, John, and Moberg, Richard J.: Drag of Several Gunner's Enclosures at High Speeds. NACA A.C.R. July 1941.

TABLE I

VALUES OF PRESSURE COEFFICIENT P TAKEN ON TURRETS LOCATED 59.0 PERCENT OF FUSELAGE LENGTH

[x/l is the ratio of orifice location on turret to turret length]

x/l \ M	0.22	0.26	0.35	0.41	0.475	0.525	0.575	0.600	0.625	0.650	0.675	0.700
Turret A; $\alpha = 3^\circ$												
0.01523	0.433	0.412	0.416	0.421	0.423	0.410	0.423	0.395	0.388	0.385	0.341	0.383
.4310	-.794	-.796	-.805	-.819	-.871	-.873	-.896	-.904	-.940	-.968	-1.024	-1.051
.8350	-.025	-.030	-.052	-.060	-.074	-.089	-.101	-.104	-.118	-.127	-.140	-.163
.9850	-.008	-.0052	-.026	-.030	-.037	-.042	-.065	-.062	-.074	-.076	-.087	-.106
Turret A; $\alpha = 5^\circ$												
0.01523	0.347	0.350	0.274	0.330	0.324	0.312	0.273	0.287	0.281	0.285	0.288	------
.4310	-.778	-.809	-.804	-.830	-.857	-.873	-.912	-.936	-.963	-.980	-1.051	------
.8350	-.034	-.055	-.077	-.092	-.109	-.129	-.143	-.161	-.179	-.175	-.176	------
.9850	-.008	-.017	-.031	-.044	-.053	-.082	-.098	-.119	-.125	-.130	-.133	------
Turret A; $\alpha = 7^\circ$												
0.01523	0.297	0.304	0.235	0.290	0.270	0.260	0.253	0.220	0.226	------	------	------
.4310	-.806	-.795	-.811	-.835	-.865	-.899	-.932	-.946	-.990	------	------	------
.8350	-.085	-.098	-.088	-.128	-.152	-.183	-.201	-.203	-.219	------	------	------
.9850	-.034	-.036	-.050	-.065	-.088	-.117	-.118	-.127	-.137	------	------	------
Turret B; $\alpha = 3^\circ$												
0.01531	0.399	0.397	0.400	0.416	0.420	0.403	0.396	0.394	0.386	0.380	0.380	------
.2840	-.720	-.703	-.730	-.747	-.769	-.776	-.785	-.805	-.821	-.822	-.863	------
.6100	-.209	-.198	-.202	-.231	-.198	-.192	-.178	-.176	-.175	-.166	-.166	------
.9620	.183	.188	.192	.193	.202	.109	.180	.201	.195	.199	.193	------
Turret B; $\alpha = 5^\circ$												
0.01531	0.327	0.340	0.333	0.320	0.332	0.311	0.294	0.290	0.289	0.285	0.299	------
.2840	-.709	-.714	-.745	-.754	-.788	-.799	-.806	-.831	-.845	-.879	-.892	------
.6100	-.199	-.206	-.188	-.200	-.197	-.190	-.175	-.168	-.162	-.164	-.160	------
.9620	.173	.164	.171	.156	.168	.158	.156	.156	.149	.151	.150	------
Turret B; $\alpha = 7^\circ$												
0.01531	0.285	0.296	0.291	0.287	0.269	0.261	0.273	0.273	0.260	------	------	------
.2840	-.721	-.714	-.740	-.753	-.805	-.820	-.876	-.848	-.877	------	------	------
.6100	-.190	-.237	-.189	-.184	-.187	-.179	-.176	-.163	-.173	------	------	------
.9620	.138	.139	.143	.136	.138	.124	.126	.137	.139	------	------	------

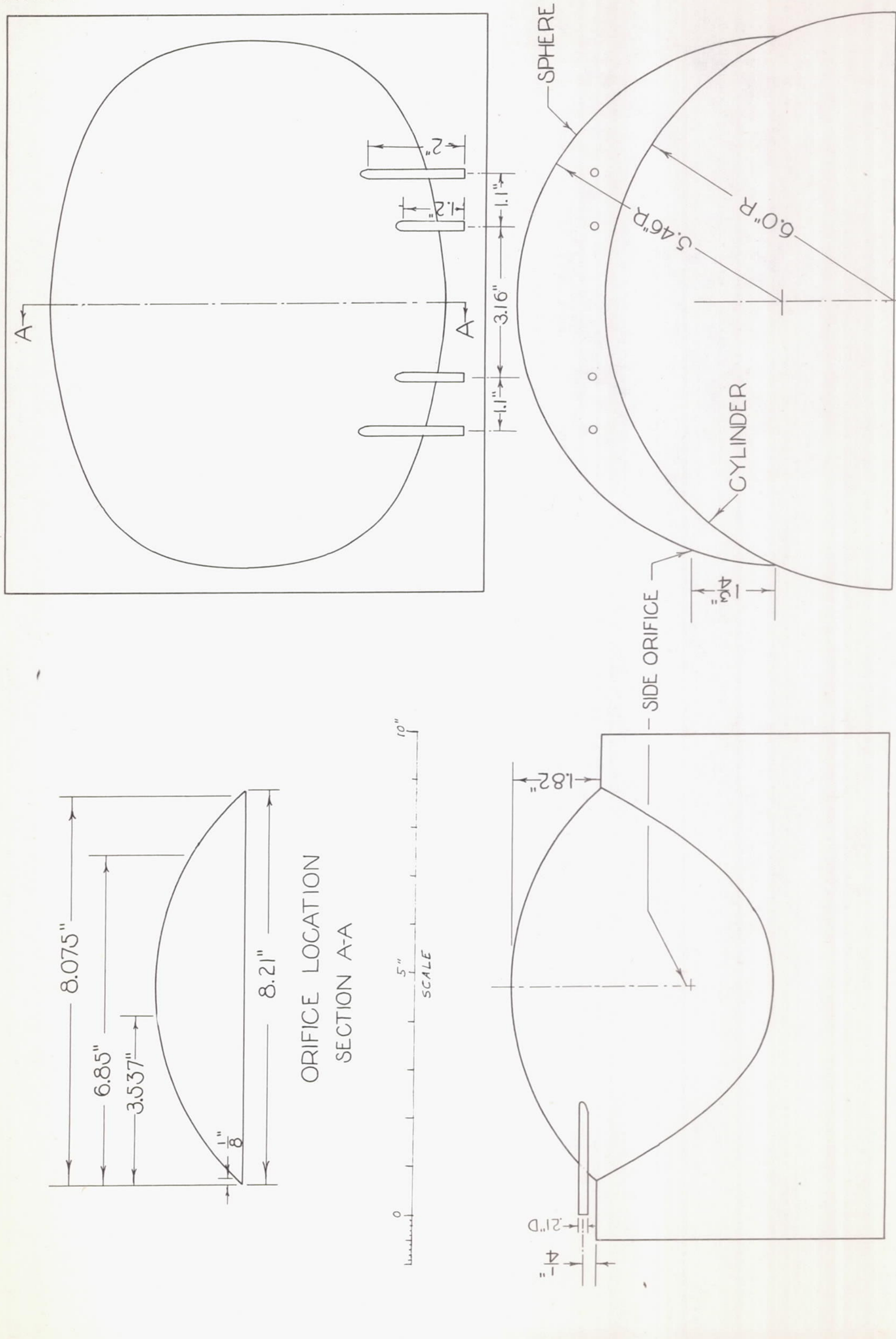


FIGURE 1.-TURRET A.

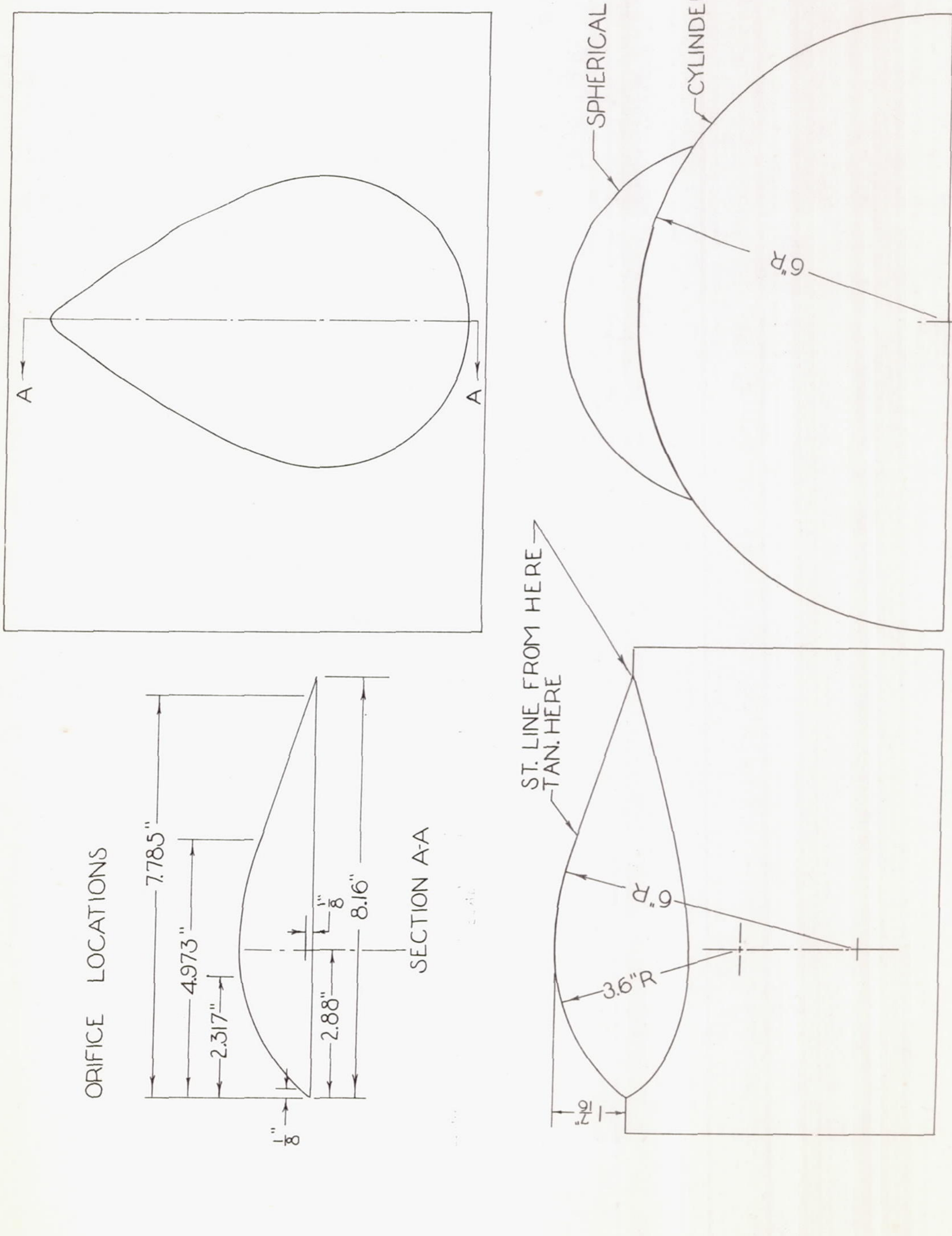
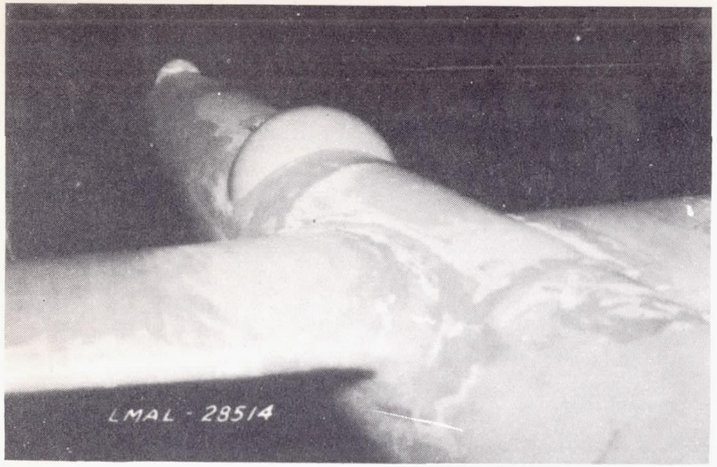
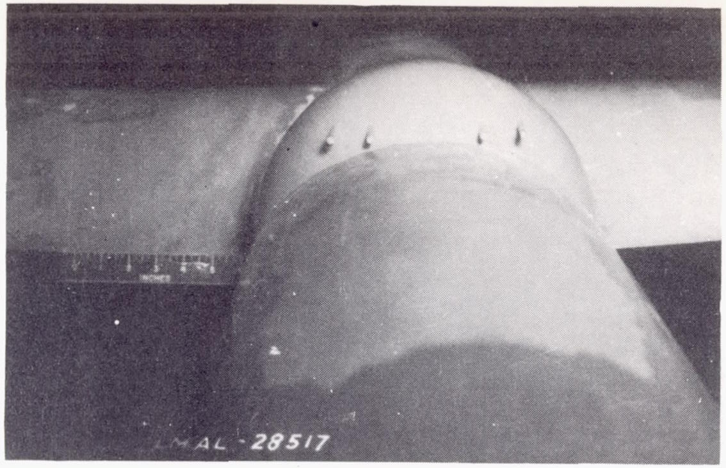


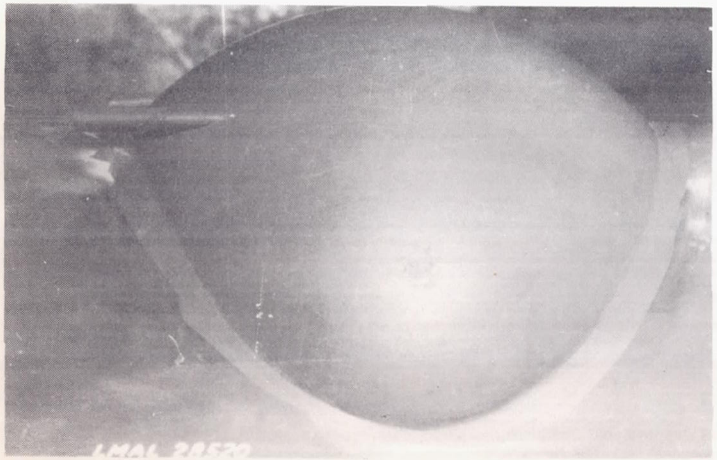
FIGURE 2.- TURRET B.



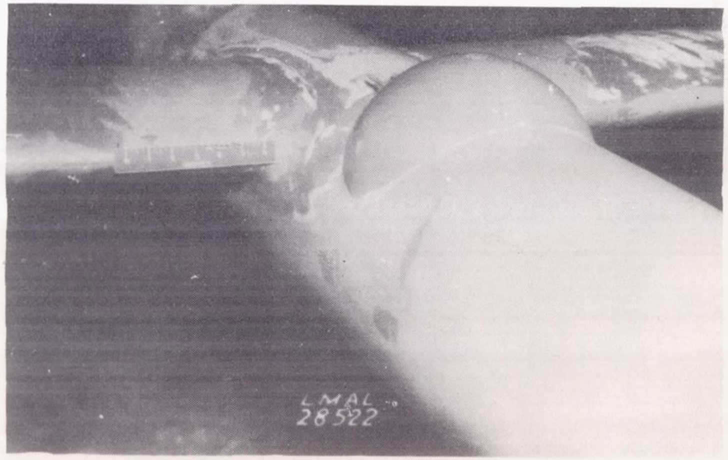
(a) Looking to the rear of fuselage.



(b) Rear view on model fuselage.

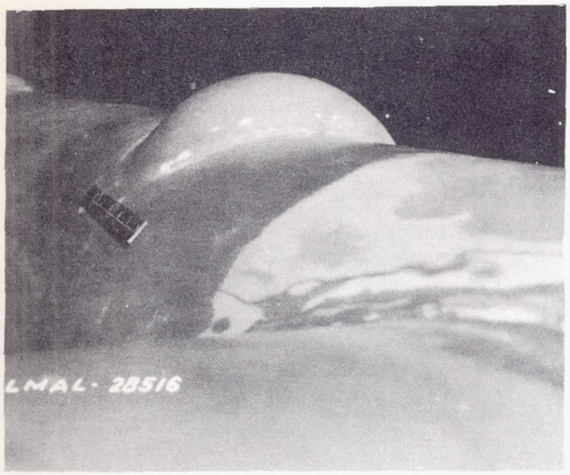


(c) Side view of turret on model fuselage.

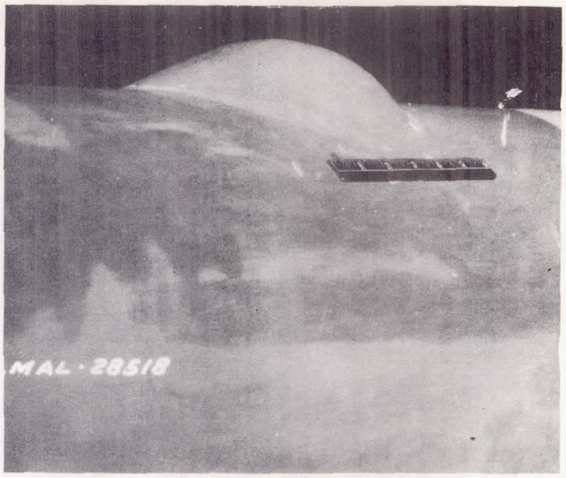


(d) Turret in forward location on model fuselage.

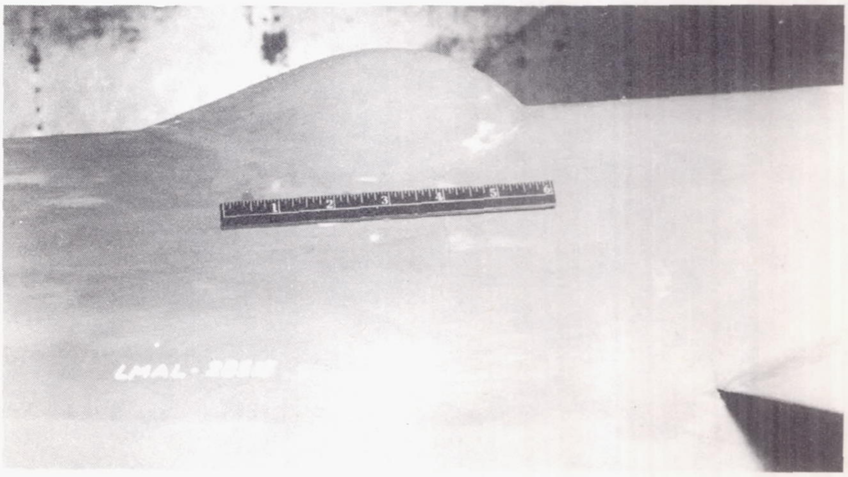
Figure 3.- Views of turret A.



(a) Looking to the rear of fuselage.



(b) Rear view of turret on model fuselage showing afterbody fairing.



(c) Side view of turret on model fuselage.

Figure 4.- Views of turret B.

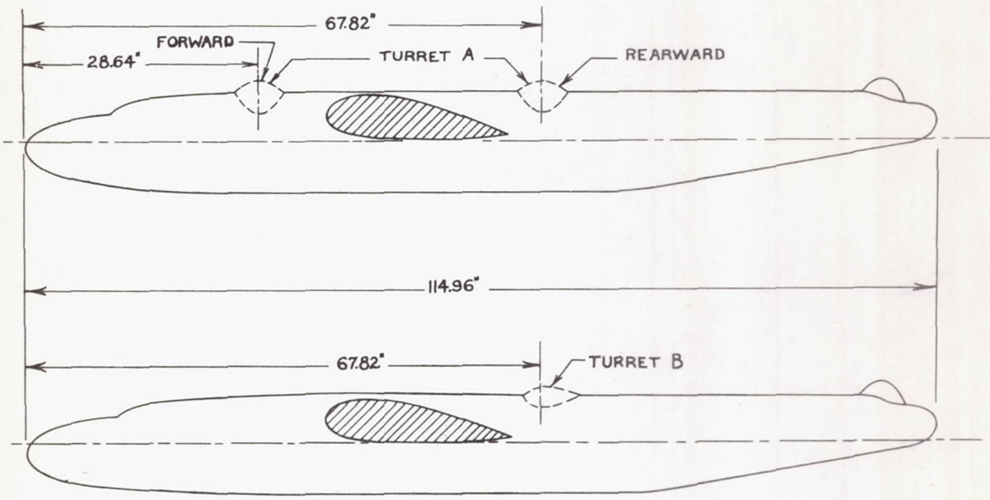


FIGURE 5.- LOCATION OF TURRETS AS TESTED ON MODEL. DIMENSIONS ARE MODEL SIZE

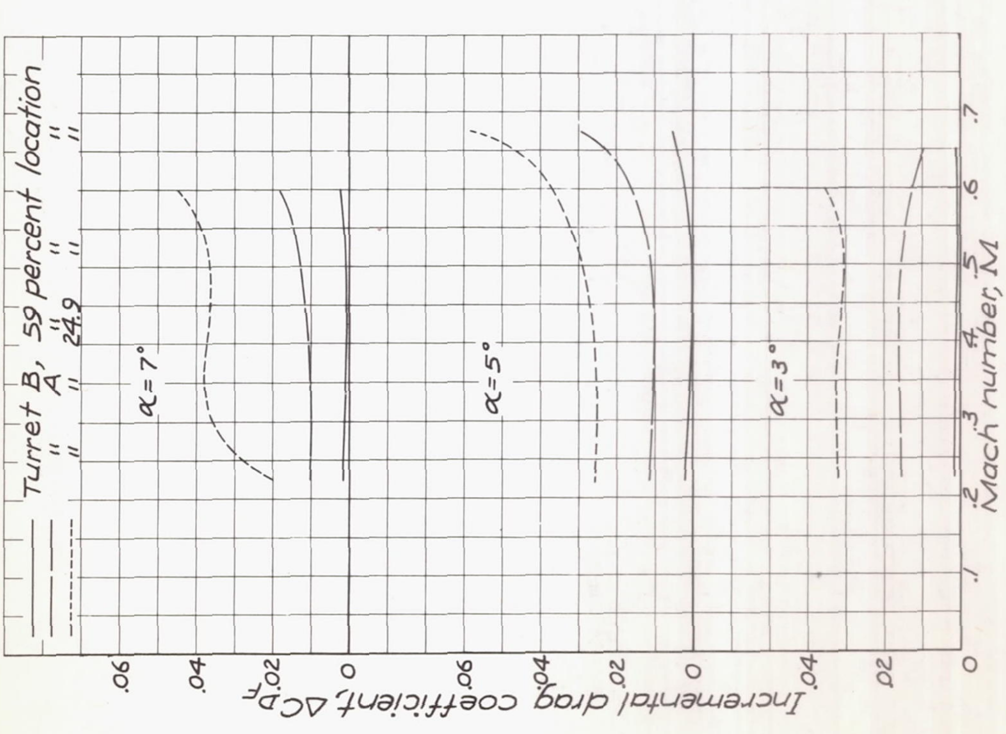


Figure 7.- Variation of incremental drag coefficient with Mach number for turrets A and B.

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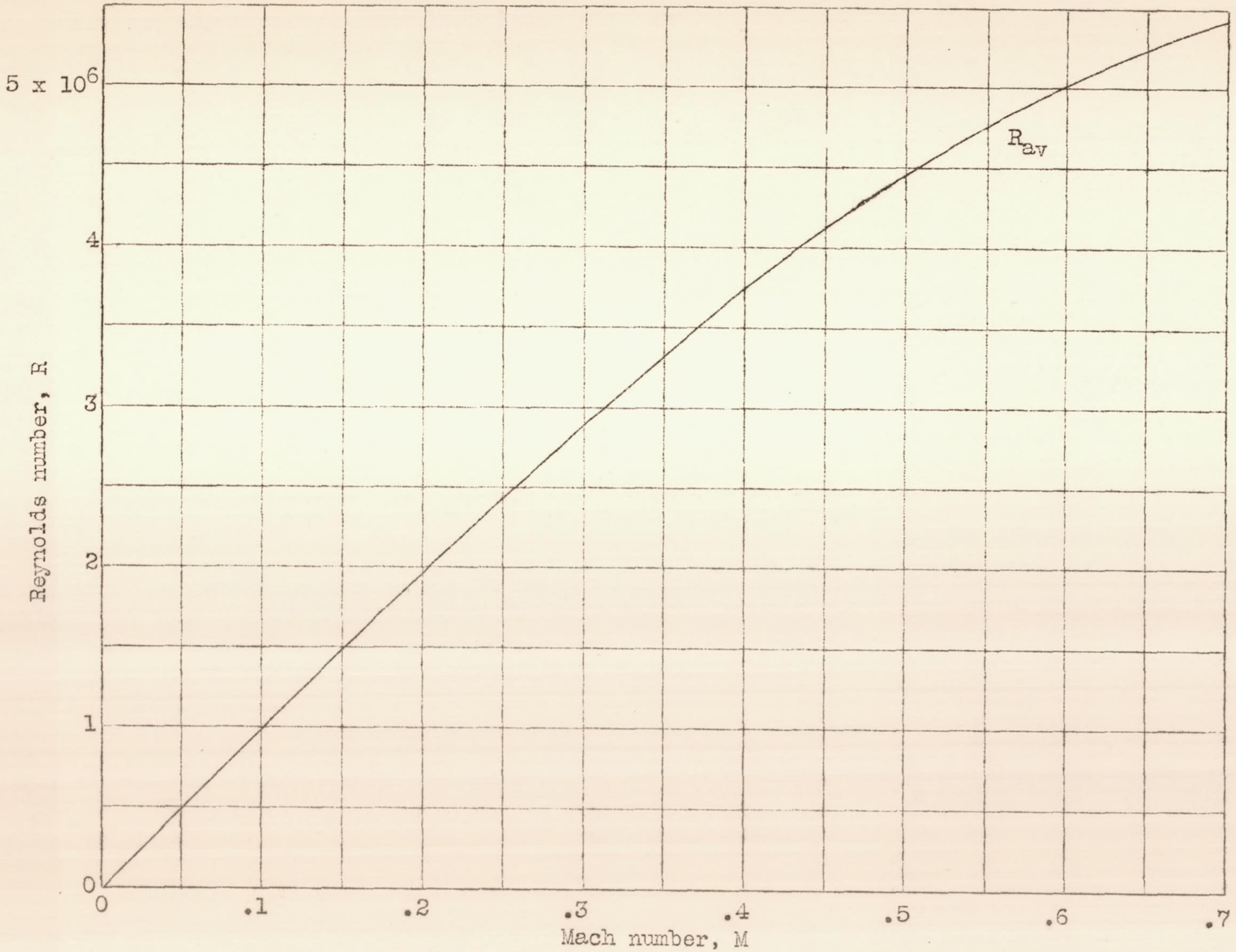

Figure 6.- Variation of test Reynolds number with Mach number.

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Fig. 6

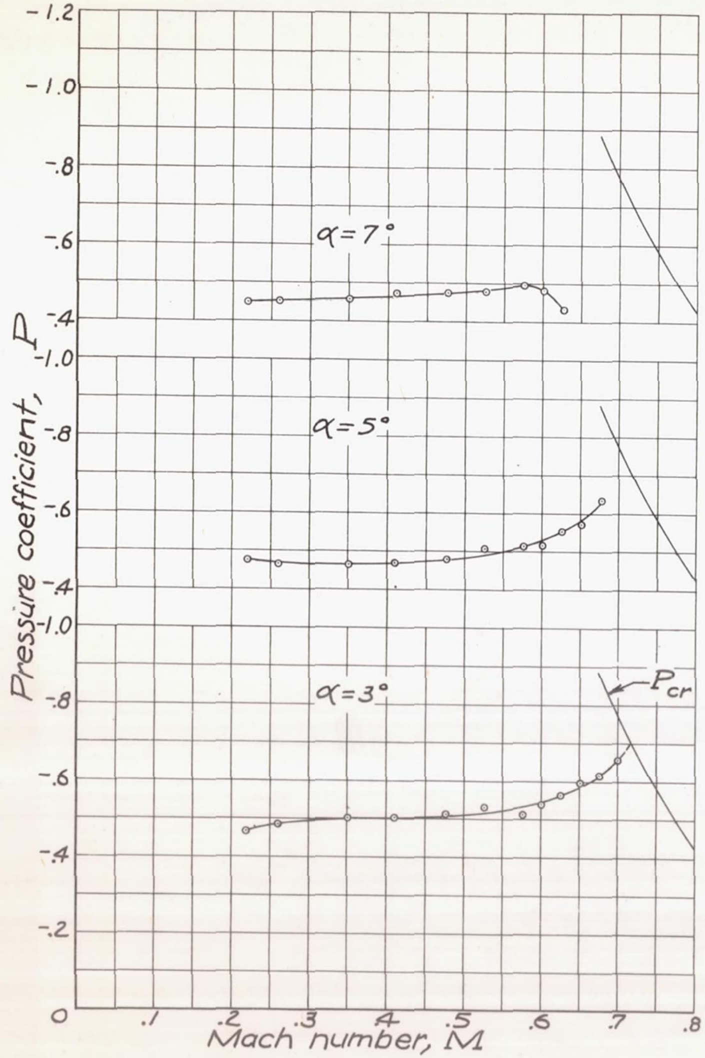

Figure 8.- Side-orifice pressure coefficient plotted against Mach number for turret A located at 59.0 percent of fuselage length.

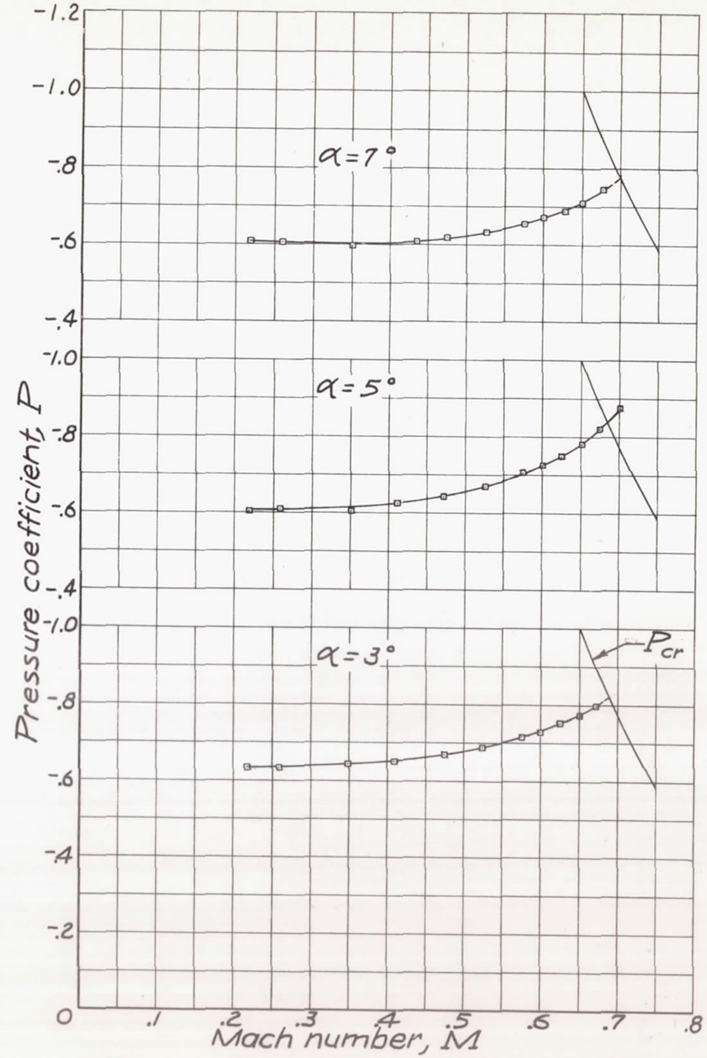

Figure 9.- Side-orifice pressure coefficient plotted against Mach number for turret B located at 59.0 percent of fuselage length.

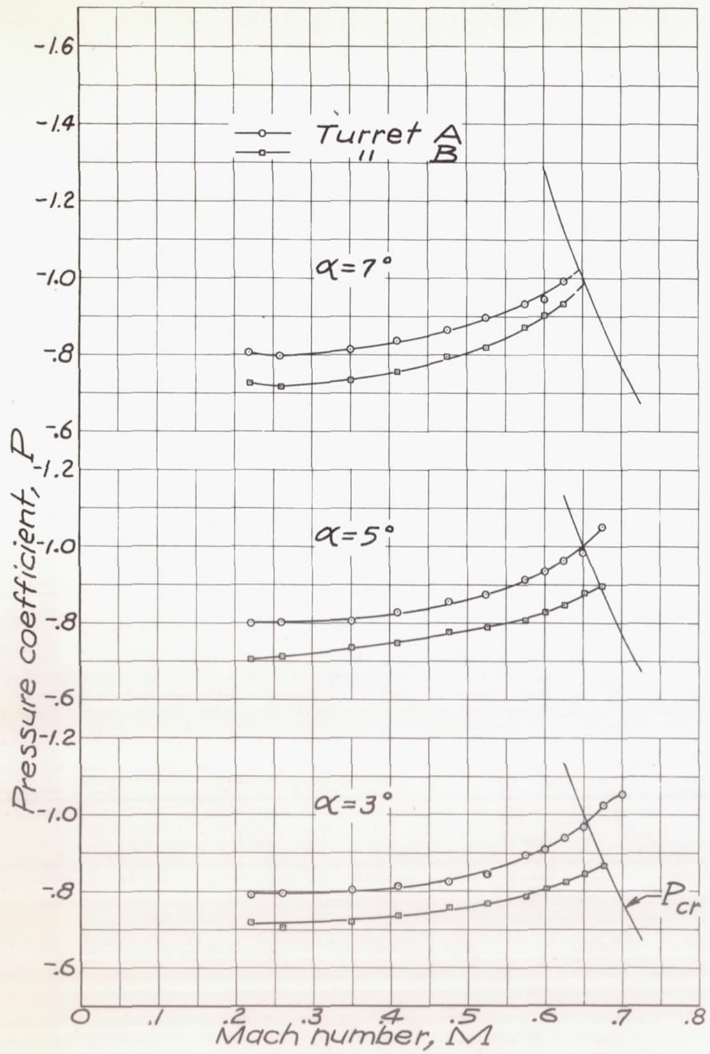

Figure 10.- Maximum pressure coefficient recorded on top of turrets A and B at 59.0 percent of fuselage length plotted against Mach number.

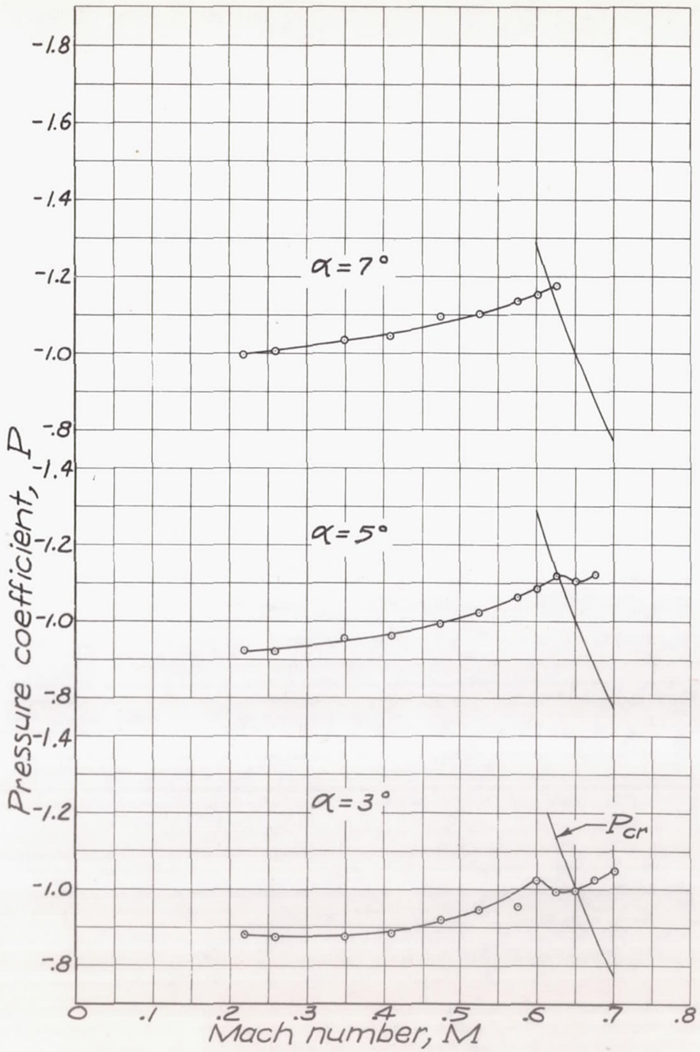

Figure 11.- Maximum pressure coefficient recorded on top of turret A at 24.9 percent of fuselage length plotted against Mach number.