MEMORANDUM REPORT

for

Army Air Corps

DRAG ANALYSIS OF THE LOCKHEED YP-38 AIRPLANE

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INTRODUCTION

At the request of the Army Air Corps a drag analysis of the Lockheed YP-38 airplane has been conducted in the NACA full-scale wind tunnel. The drags of the various components of the airplane, such as the Prestone radiator and oil-cooler ducts,supercharger installation, armament installation, etc., were measured in the original and in several modified conditions. The Prestone radiator and intercooler installations were modified so as to simulate the installations on the P-38E airplane. Air quantities and pressure drops for the oil-cooler and Prestone radiator ducts were measured for several different outlet-flap deflections. The wing profile drag was determined at three sections on the wing by the wake-momentum method.

AIRPLANE AND TESTS

The YP-38 airplane is a single-place, twin-engine, low-wing monoplane with a 52-foot span and wing area of 327.5 square feet (fig. 1). The gross weight of the airplane is 14,500 pounds.. The 11.5-foot diameter, 3-blade, Curtiss constant-speed propellers are driven through 2:1 gear ratio by Allison V-1710-27 engines supercharged to 25,000 feet altitude.

Engine cooling is provided by means of four Prestone radiators located in ducts on the inboard and outboard sides of the booms (fig. 2). Each radiator has an area of about 1.5 square feet. On the original YP-38 airplane the cooling ducts have an inlet area of 0.70 square foot and an outlet area of 0.38 square foot and are provided with an adjustable outlet flap which enables the outlet area to be increased to 0.76 square foot. Modified duct inlets were provided by the Lockheed Company which are similar to those to be used on the P-38E airplane and differ from the original YP-38 scoops in that the inlet area is somewhat smaller and the nose shape of the inlet is more rounded (fig. 3).

The oil coolers are located in a duct at the nose of the booms beneath the engine with an adjustable flap outlet provided at the rear of the duct (fig. 4). Two 9-inch-diameter oil coolers are provided for each engine. The turbo-superchargers are located on top of the booms near the wing trailing edge and, although the wheel and turbo-cooling cap are exposed, the entire installation is dropped below the level of the top of the boom (fig. 5). In the original installation for the YP-38 a large air scoop is located ahead of the super-charger installation which provides cooling air for the exhaust shroud. During the tests the supercharger installation was modified so that it was similar to the one to be used on the P-38E in which the large forward scoop is removed and replaced with two smaller scoops and the exhaust-stack shroud is exposed to the air stream (fig. 6). The intercooling is provided by passing the heated charge air through a heat exchanger connected to the inside of the wing surface and utilizing the external wing surface as the cooling surface. A small amount of additional air is provided on the inside of the wing for intercooling, which is taken in through a small hole in the wing leading edge near the boom and exhausted from a small outlet at the wing tip (fig. 2).

The armament on the airplane consists of two 30-caliber and two 50-caliber machine guns and a 37-millimeter cannon, which are located in the nose of the fuselage (fig. 7). Large ports were provided in the fuselage nose to enable the guns to be zeroed for different ranges. The gun installation was tested with these ports sealed over and with small fillets provided at the junctures of the protruding gun barrels and the sealing plates.

Pressure distributions at the front faces of the oil coolers and Prestone radiators were measured by means of total-head tubes and the air quantities were measured by means of rakes of total- and static-pressure tubes mounted in the duct outlets. The special technique and apparatus used for the determination of profile drag by the momentum method are described in reference 1.

The method of testing consisted of measuring the drag of the airplane in a completely faired and sealed condition and then progressively opening the cooling ducts and exposing the various installations. The order in which the progressive modifications to the airplane were made has a slight effect on the drag increments measured due to interference effects. In some cases the more important increments were measured for several different airplane configurations with no large differences in the drag. The detailed test program and airplane drag coefficients are given in table I. All of the tests were made at a tunnel speed of 100 miles per hour except the momentum measurements which were made at a tunnel speed of 78 miles per hour.

SYMBOLS

C_L	lift coefficient
C_D	drag coefficient
C_{D_P}	drag coefficient corresponding to useful power = $\dfrac{\frac{Q}{60}\Delta p}{Sq_oV_o}$
ΔD	drag increment, lb
S	wing area, sq ft
α_T	angle-of attack of thrust axis, deg
V_o	velocity of free stream, ft per sec
Q	quantity of air flow, cu ft per min

q_0	dynamic pressure of free stream, lb per sq ft
H_r	total pressure at radiator, lb per sq ft
H_e	total pressure at exit, lb per sq ft
Δp	pressure drop across radiator, lb per sq ft

RESULTS AND DISCUSSION

The measured airplane-drag coefficients at the lift coefficients for high speed and minimum drag are given in table I for the YP-38 in the original and modified conditions. These coefficients have been corrected for wind-tunnel jet-boundary and buoyancy effects. The drag increments for the various components tested are given in table II. The high-speed lift coefficient of 0.27 corresponds to the calculated value at the critical altitude of 25,000 feet. The drag coefficient of the airplane in the original condition was 0.0293 at the high-speed lift coefficient (run number 11) and 0.0222 in the fully faired and sealed condition (run number 27). The difference in drag coefficient of 0.0071 between these conditions represents the maximum possible decrease in the drag of the YP-38 airplane without a major change to the airplane arrangement. The attainment of this drag reduction is not possible due to certain irreducible cooling drags. Major rearrangement of the cooling units and supercharger installation might enable a substantial portion of this drag to be eliminated.

<u>Prestone radiator installations</u>. - The drag increment of the four Prestone radiator installations with the outlet flap in the closed high-speed position was 0.0021. This value was obtained as the difference between the drag of the airplane

with the Prestone duct installed and removed. The booms were smoothly faired in the latter condition. The measured air-flow quantity through the outboard Prestone duct on the left boom was 1147 cubic feet per minute which, corrected to an estimated high speed of 400 miles per hour at 25,000 feet, corresponds to a flow of 7270 cubic feet per minute. With full deflection of the outlet flap the air quantity at altitude was increased to 15,700 cubic feet per minute and the drag-coefficient increment to 0.0043. With the revised inlet for the P-38E installation (fig. 3) the air-flow quantity in the high-speed condition was increased about 9 percent, but the quantity with the outlet flap full open was decreased 6 percent. The drag-coefficient increments for these two conditions were 0.0024 and 0.0051, respectively.

As a means for comparing the two installations, the duct efficiency factors defined as

$$\eta = \frac{\text{useful work}}{\text{total work}} = \frac{Q\Delta p}{\Delta D V_o}$$

were calculated and are presented in table III. The efficiencies with the revised duct inlet with the closed outlet flap are about 18 percent as compared with 8 percent for the original inlet. Both of these efficiencies are low, indicating that the expenditure of cooling power is some four to eight times as much as for an efficient installation. With the outlet flap in the full-open position the duct efficiency for the original inlet was higher than that for the revised inlet, that is, about 49 percent as compared to 38 percent. The extremely low duct efficiencies of the Prestone radiator installations in the high-speed condition are attributed to large internal and external losses. The origin of the internal drag is shown by the total-pressure measurements taken at the face of one of the radiators (figs. 8 and 9). Average values of the total pressure from integration of these surveys are shown in table III. With the original scoop inlet the total pressure at the radiator was only about one-half of the free-stream dynamic pressure since the air entering the duct included the low-energy air from the wake of the wing-fuselage juncture and the boundary layer on the boom. An additional decrease in the total pressure at the face of the radiator was caused by the separation occurring on the inner wall of the scoop due to the thick boundary layer and the low inlet-velocity ratio of the scoop. The pressures adjacent to the inner wall (fig. 8) are somewhat lower than the average pressure over the radiator face.

The internal cooling losses are increased whenever air with low initial total pressure is utilized for cooling since the total internal drag largely depends on the total pressure of the air leaving the duct outlet. If the total pressure at the face of the radiator were equal to the stream dynamic pressure, the internal drag of the Prestone installation would have been reduced to one-third of its present value.

The gain due to increasing the duct inlet velocity is demonstrated by the larger total pressures at the face of the radiator and the higher duct efficiencies that are realized with the smaller P-38E inlet. Increasing the inlet velocity through the original inlet by deflecting the outlet flap also increased the total pressure at the face of the cooler (table III); however, in the revised P-38E inlet the total pressure at the radiator is not appreciably changed with higher inlet-velocity ratios. In the latter case the gain due to the improved flow stability at the higher inlet velocity was counteracted by the increased kinetic energy loss resulting from the more rapid expansion of the air from the duct inlet to the radiator. This criterion defines the limit at which improvement in the duct flow can be effected by increasing the inlet-velocity ratio.

The magnitude of the external drag is illustrated by comparing the duct efficiencies obtained with the outlet flap closed and opened. With the opened cowl flaps, duct efficiencies from 40 to 50 percent were realized for the original scoop, whereas with the cowl flaps closed the duct efficiencies were about 8 percent. The difference between these duct efficiencies may be largely attributed to the external scoop drag. Higher proportionate external losses always occur with exposed scoops for cases in which relatively small air-flow quantities are utilized for cooling. Due to this high external scoop drag for the present Prestone radiator installations, it is not believed that minor modifications to the P-38 installation will provide significant drag reductions. To reduce the drag of the installation, it is recommended that wing-duct inlets be provided in an extended wing leading edge between the booms and the fuselage on the airplane (fig. 10). With this arrangement, both the internal and external drags can be realized in the high-speed condition with flaps closed. The effectiveness of the extended wing leading edge to house the Prestone radiator installation and to decrease the serious buffeting problems occurring in the airplane dives has been discussed in reference 2. It has been estimated that a drag reduction of $\Delta C_D = 0.0020$ can be effected if the Prestone radiator and oil-cooler installations are installed in the wing leading-edge duct.

Oil-cooler installation. - The measured drag coefficient for the oil-cooler installations with the outlet flaps in the closed, high-speed position was 0.0008 higher than that measured with the inlets and outlets sealed. This is not the entire increment for the oil-cooler installations, since the extra drag of the increased boom depth due to the installation was not determined. The air flow with the closed-flap setting was 447 cubic feet per minute at the test speed, which extrapolates to 2860 cubic feet per minute at the assumed high speed of 400 miles per hour. Changes in the airplane angle of attack from -2.5° to 1.4° had a negligible effect on the quantity of air flow. Lowering the outlet flap to the full-open position increased the drag-coefficient increment to 0.0026 and the cooling air flow to 11,320 cubic feet per minute. The efficiency of the oil-cooler duct was 3 percent. This low efficiency is directly attributable to the extremely poor recovery of total pressure at the face of the oil cooler (fig. 11). With the outlet flap shut, in which case the inlet-velocity ratio is very low, the flow tends to overrun the duct inlet due to its slanting position. The flow that enters is further ~~debilitated~~ by separation occurring over the reentrant lines behind the lower lip of the inlet. The internal duct losses could be largely eliminated by extending the lower lip of the duct forward so that the inlet is more nearly perpendicular to the local air-flow direction and by eliminating the reentrant shape at the front of the diffuser. The center dividing passages through which the engine compartment air is taken are detrimental to the pressure recovery at the face of the oil cooler and should not be extended forward to the inlet. The drag of the present installation could be further decreased by fairing over the drain lines located in the outlet (fig. 4).

An improved oil-cooler installation which would largely eliminate the drag increment due to the present oil cooler would result from inclusion of the oil cooler in the leading-edge wing duct described in the preceding section. (See fig. 10.)

Intercooler installation. - The airplane drag coefficient was increased by 0.0005 due to the two holes located in the wing leading edge near the wing roots and the outlets at the wing tips, which provided air to the inside of the intercoolers. This increment in drag coefficient is excessive in comparison with the useful cooling obtained from the air flowing through the intercooler. By properly rounding over the intercooler duct inlets and smoothly fairing the outlets, it is believed that the drag from this source can be reduced to an unmeasurable amount.

Supercharger installation. - The supercharger installation on the YP-38 airplane (fig. 5) increased the drag coefficient of the airplane by 0.0034, whereas the modified installation as proposed for the P-38E airplane (fig. 6) increased the total drag coefficient by only 0.0014. This large reduction in drag with the modified arrangement was effected primarily by removal of the rear shroud air scoop and the shroud air exit louvers in the wing-nacelle fillet.

The drag of the supercharger can be still further reduced by sealing the installation and providing cooling air through a wing leading-edge inlet similar to that shown in figure 10 and by ducting the cooling air through the wing boom fillet. A drag saving of approximately 0.0008 is estimated for this modification.

Armament installation. - The original armament installation (fig. 7) of one 37-millimeter cannon, two 50-caliber machine guns, and two 30-caliber machine guns increased the airplane drag coefficient by 0.0008, of which 0.0003 was added by the cannon, 0.0003 by the two 50-caliber guns, and 0.0002 by the two 30-caliber guns. Sealing the gun ports with all the guns installed reduced the increment in drag coefficient from 0.0008 to 0.0005. A further reduction of 0.0002 was made by fairing the gun-fuselage intersections. The drag coefficient of the installation including sealed gun ports, faired gun-fuselage intersections, and rounded gun tips was 0.0002.

Wing profile drag. - Momentum measurements made in the wake at the three spanwise stations shown in figure 12 gave section profile-drag coefficients of 0.0084, and 0.0089, and

0.0081, respectively, for stations 1, 2, and 3 for the high-speed attitude of the airplane.

SUMMARY OF RESULTS

1. The duct efficiencies for the oil and Prestone radiator installations on the original YP-38 airplane and the modified P-38E airplane are extremely low. It is estimated that a drag coefficient reduction of 0.0020 can be effected by locating the Prestone and oil radiator installations in a wing leading-edge duct.

2. The modifications to the YP-38 supercharger installation reduced the drag coefficient by 0.0020. A still further reduction is possible by completely enclosing the supercharger and providing cooling air by means of ducts with wing leading-edge inlets.

3. The drag due to the flow through the inside of the intercooler should be reduced about 0.0004 if an efficient inlet and outlet are provided.

2

220

4. The drag coefficient of the armament installation was reduced 0.0006 by sealing the gun ports, fairing the gun-nacelle intersection, and rounding the ends of the gun barrels.

4

5. The high speed of the YP-38 will be increased approximately 28 miles per hour if all the foregoing modifications are adopted. This conclusion is qualified by the assumption that the compressibility effects on the airplane propeller do not prevent the attainment of higher speeds.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
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REFERENCES

1. Goett, Harry J.: Experimental Investigation of the Momentum Method for Determining Profile Drag. T. R. No. 660, NACA, 1939.

2. "Recommendations for Modifications to P-38 Airplane to Reduce the Tail Buffeting and to Increase the High Speed." Preliminary Analysis for Army Air Corps, March 18, 1942.

TABLE I. - DRAG ANALYSIS TEST PROGRAM FOR P-38 AIRPLANE AND MEASURED DRAG COEFFICIENTS

Item	Run number																																						
	10	11	12	13	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
Aerial	R	I	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
Canopy and hatch																S	S																							
Cockpit ventilator															S	S	S																							
Intercooler vents														S	S	S	S																							
Prestone scoops	N	N	N	N	N	N	N	N	N	F	R	R	R	R	R	R	R	N	N	N	N	N	N	F	N	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Carburetor scoop						R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R																		
Turbo deck																	S																							
Shroud air exhaust on boom												S	S	S	S	S	S	(none for P-38E installation)																						
Shroud air scoops (front)					R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R		R														
Engine compartment air entrances				S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Oil radiator	N	N	N	S	S	S	N	F	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	N	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Shroud air scoops (rear)													S	S	S	S	S	(none for P-38E installation)																						
Shroud air exit louvers			R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	(none for P-38E installation)																						
Engine compartment air exits							S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		S	S													
Turbo bearing air scoops (inboard)	(none for YP-38 installation)																	S																						
Turbo bearing air scoops (outboard)	(none for YP-38 installation)																	S	S																					
Intensifier tubes	(none for YP-38 installation)																	S	S	S																				
Open section of exhaust stack	(none for YP-38 installation)																	S	S	S	S																			
Spark plug cooling tubes					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		S	S													
Rear view mirror	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	I	R	—	—	—	—	—	R
Ejection chute smoke deflectors	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	I	—	—	—	—	—	—	—	R
37-mm cannon	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	I	I	I	I	I	R	R
Two 50-cal. machine guns	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	I	I	I	I	I	I	I
Two 30-cal. machine guns	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	I	I	I	I	I	I	R
Remarks (see note)																		a	a	a	a	a	a	a	b a	a	a	a	c a	cd a	e a	e a	e a	e a	fe a	ge a	he a	ie a	e a	e a

Note:
- a YP-38 turbo-deck replaced by P-38E turbo-deck installation; revised Prestone scoops installed
- b represents P-38E in normal flying condition
- c hatch open 1/4 inch
- d nose wheel door open 1/2 inch
- e fuel drains faired
- f gun ports sealed
- g gun ports sealed and fuselage gun intersection faired
- h gun ports sealed and fuselage gun intersection faired; end of guns rounded
- i gun port lips faired

Legend:
- I installed
- R removed; cover plate on
- N flap in normal position, 0°
- F flap full open
- S sealed and faired

Blanks in columns indicate original condition.

Run No.	C_D at C_L=0.27	$C_{D_{min}}$ -
10	0.0292	0.0272
11	.0293	.0273
12	.0288	.0270
13	.0280	.0263
14	--	--
15	.0274	.0257
16	.0272	.0253
17	.0280	.0260
18	.0298	.0281
19	.0273	.0255
20	.0295	.0276
21	.0252	.0230
22	.0248	.0228
23	.0237	.0214
24	.0232	.0213
25	.0232	.0212
26	.0229	.0210
27	.0222	.0203
28	--	--
29	.0257	.0237
30	.0257	.0237
31	.0258	.0239
32	.0259	.0239
33	.0259	.0238
34	.0261	.0243
35	.0288	.0268
36	.0277	.0258
37	.0257	.0219
38	.0244	.0223
39	.0246	.0225
40	.0247	.0226
41	.0248	.0228
42	.0243	.0224
43	.0246	.0225
44	.0244	.0224
45	.0251	.0231
46	.0248	.0225
47	.0246	.0225
48	.0245	.0225
49	.0251	.0231
50	.0248	.0229
51	.0246	.0229

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TABLE II. - DRAG ANALYSIS OF P-38 AIRPLANE

Item	Runs	ΔC_D at $C_L=0.27$	ΔC_D at $C_{D_{min}}$
<u>YP-38</u>			
Shroud air exit louvers	12 - 10	0.0004	0.0002
Forward shroud air scoops and spark-plug cooling tubes	13 - 15	.0006	.0006
Rear shroud scoops	21 - 23	.0015	.0016
Sealing shroud air exhausts on boom	21 - 22	.0004	.0002
Prestone radiator installation, outlet flaps full open	20 - 21	.0043	.0046
Prestone radiator installation, outlet flaps normal, 0°	19 - 21	.0021	.0025
Turbo decks	26 - 27	.0007	.0007
<u>P-38E</u>			
Turbo decks	26 - 27 - 19 +29 + 21 - 23	.0006	.0005
Turbo bearing air scoops	31 - 29	.0001	.0002
Intensifier tubes	32 - 31	.0001	.0000
Forward shroud air scoops	38 - 37	.0007	.0006
Open section of exhaust stacks	33 - 32	.0000	-.0001
Spark-plug cooling tubes	39 - 38	.0002	.0000
Prestone radiator installation, outlet flaps full open	35 - 37	.0051	.0049
Prestone radiator installation, outlet flaps normal, 0°	34 - 37	.0024	.0024

TABLE II. - DRAG ANALYSIS OF P-38 AIRPLANE - Cont'd

Item	Runs	ΔC_D at C_L=0.27	ΔC_D at $C_{D_{min}}$
Armament			
One 37-mm cannon, two 50-cal. machine guns, two 30-cal. machine guns with:			
Gun ports unsealed	45 - 42	0.0008 ✓	0.0007
Gun ports sealed	46 - 42	.0005	.0001
Gun ports sealed and fuselage-gun intersection faired	47 - 42	.0003	.0001
Gun ports sealed, fuselage-gun intersection faired, and end of guns rounded	48 - 42	.0002	.0001
Gun ports unsealed and lips faired	49 - 42	.0008	.0007
Two 50-cal. machine guns and two 30-cal. machine guns; gun ports unsealed	50 - 42	.0005	.0005
Two 50-cal. machine guns; gun ports unsealed	51 - 42	.0003	.0005
Ejection chute smoke deflectors	43 - 42	.0003	.0001
Miscellaneous			
Aerial	11 - 10	.0001	.0001
Oil coolers, outlet flaps normal, 0° (includes drag of accessory cooling air)	12 - 13	.0008	.0007
Oil coolers, outlet flaps normal, 0°	17 - 19	.0007	.0005
Oil coolers, outlet flaps full open	18 - 19	.0025	.0026
Intercooler vents	23 - 24	.0005	.0001
Carburetor air scoops	34 - 33	.0002	.0005

TABLE II. - DRAG ANALYSIS OF P-38 AIRPLANE - Cont'd

Item	Runs	ΔC_D at C_L=0.27	ΔC_D at $C_{D_{min}}$
Cockpit ventilator	24 - 25	0.0000	0.0001
Canopy leakage	25 - 26	.0003	.0002
Hatch open 1/4 in.	40 - 39	.0001	.0001
Hatch open 1/4 in. and nose wheel door, 1/2 in.	41 - 39	.0002	.0003
Rear-view mirror	44 - 42	.0001	.0000
Fuel drains	39 - 42	.0003	.0001

TABLE III. - SUMMARY OF PRESTONE DUCT DATA

[All data taken in outboard duct on left boom]

α_T (deg)	C_L	V_o (fps)	Q_{test} (cu ft/min)	$Q_{400\ mph}$ (cu ft/min)	H_r/q_o	H_e/q_o	$\Delta p/q_o$	C_{D_P}	[a]ΔC_D	η
Original scoop, flap closed										
-2.5	0	92.8	1147	7,250	0.50	0.43	0.07	0.00005	0.00063	0.08
-1.4	.090	92.6	1140	7,225	.51	.43	.08	.00005	.00063	.08
-.5	.175	92.5	1147 ←	7,270	.51	.43	.08	.00005	.00060	.08
1.4	.360	91.8	1179	7,530	.55	.45	.10	.00007	.00050	.14
Original scoop, flap full open										
-2.5	0	92.9	2468	15,750	0.65	0.24	0.41	0.00056	0.00120	0.47
-1.4	.090	92.6	2488	15,780	.65	.25	.40	.00055	.00113	.49
-.5	.175	92.3	2468	15,700	.65	.25	.40	.00055	.00113	.49
1.4	.360	91.5	2449	15,710	.67	.26	.41	.00057	.00105	.54
Revised scoop, P-38E, flap closed										
-2.5	0	92.9	1292	8,160	0.60	0.45	0.15	0.00011	0.00063	0.16
-1.4	.090	92.9	1269	8,020	.60	.44	.16	.00011	.00060	.17
-.5	.175	92.4	1250	7,930	.58	.43	.15	.00010	.00060	.17
1.4	.360	91.1	1218	7,850	.57	.42	.15	.00011	.00060	.17
Revised scoop, P-38E, flap full open										
-2.5	0	93.3	2356	14,810	0.56	0.21	0.35	0.00045	0.00120	0.38
-1.4	.090	93.1	2304	14,530	.57	.21	.36	.00046	.00125	.37
-.5	.175	92.2	2317	14,220	.58	.21	.37	.00047	.00125	.38
1.4	.360	91.8	2225	14,220	.58	.20	.38	.00047	.00127	.37

[a] For one duct only.

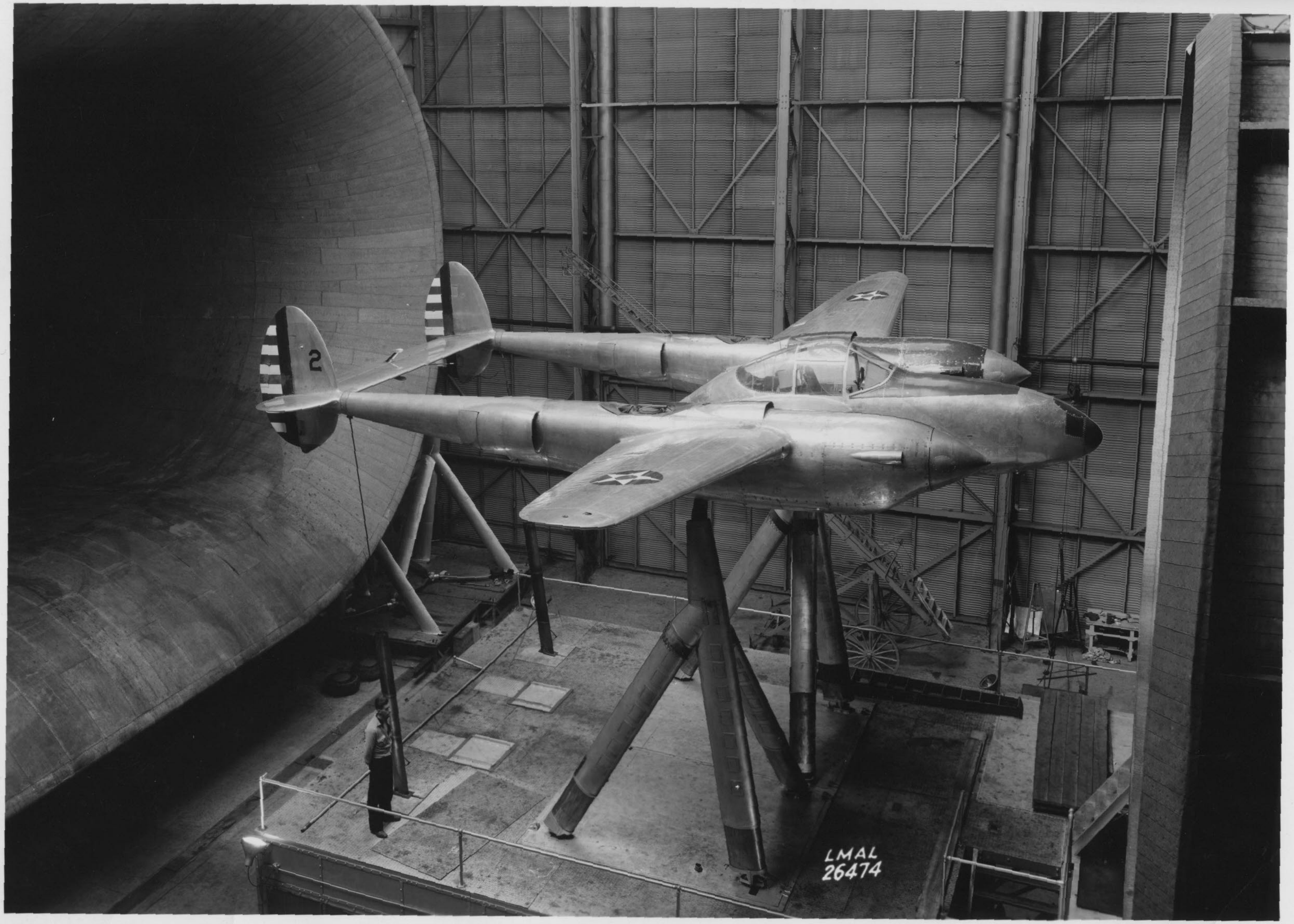


Figure 1. - General view of the airplane mounted in the NACA full-scale wind tunnel.

Figure 2. - Various components of the YP-38 airplane.

Figure 3. - Prestone duct entrances modified to those of the P-38E airplane.

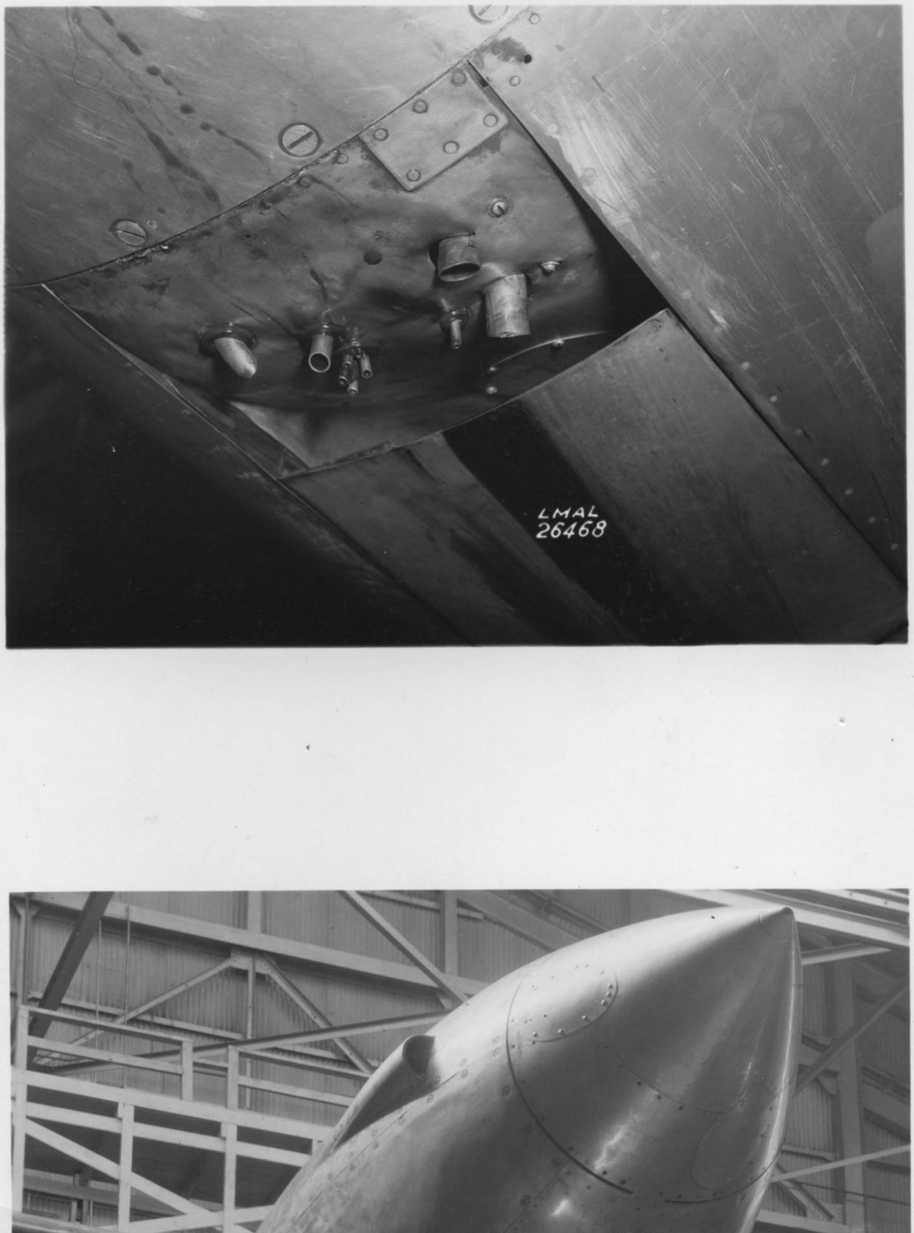


Figure 4. - Oil-cooler inlet and outlet of the YP-38 and P-38E airplanes.

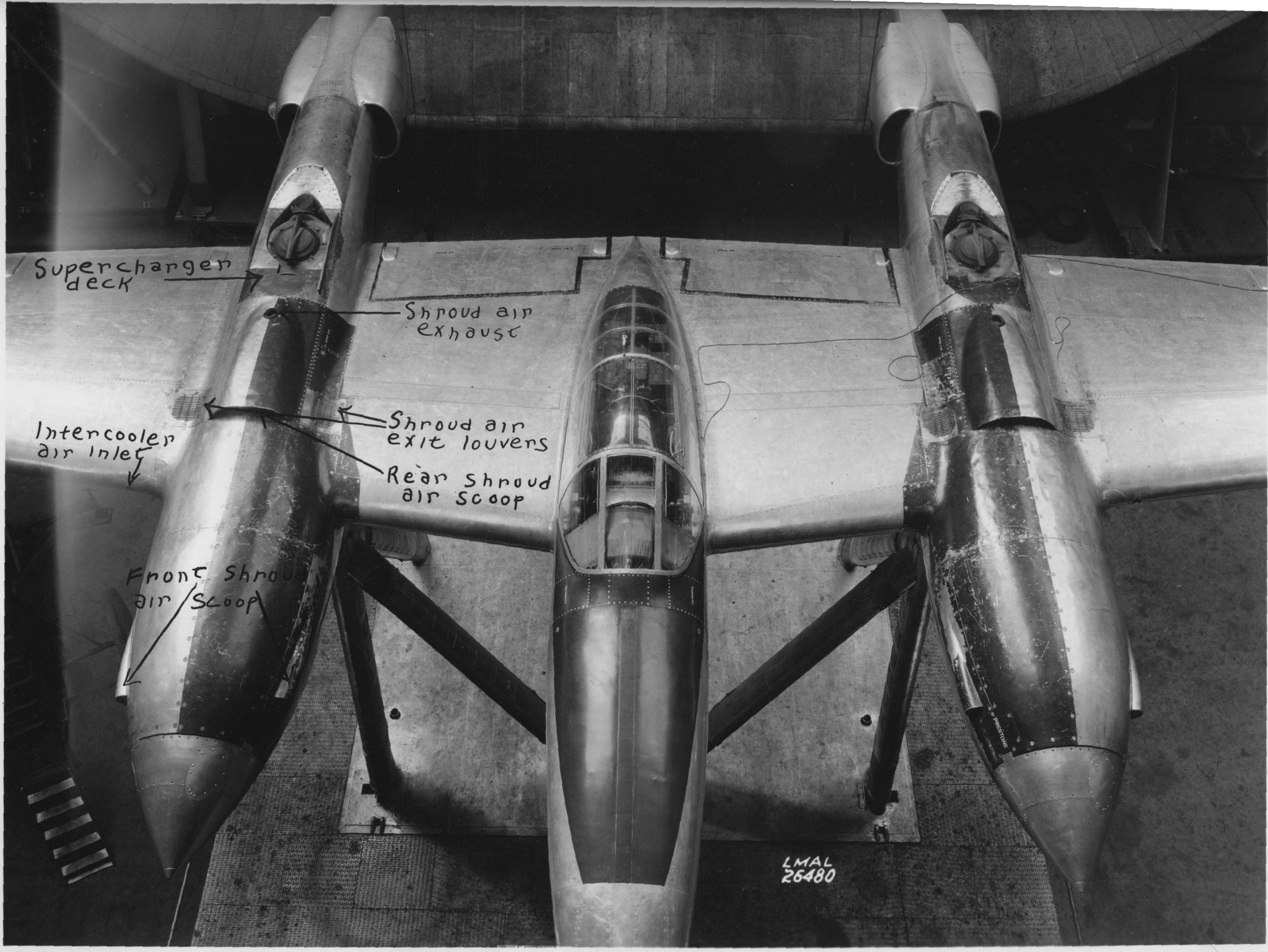


Figure 5. - Supercharger installation of the YP-38 airplane.

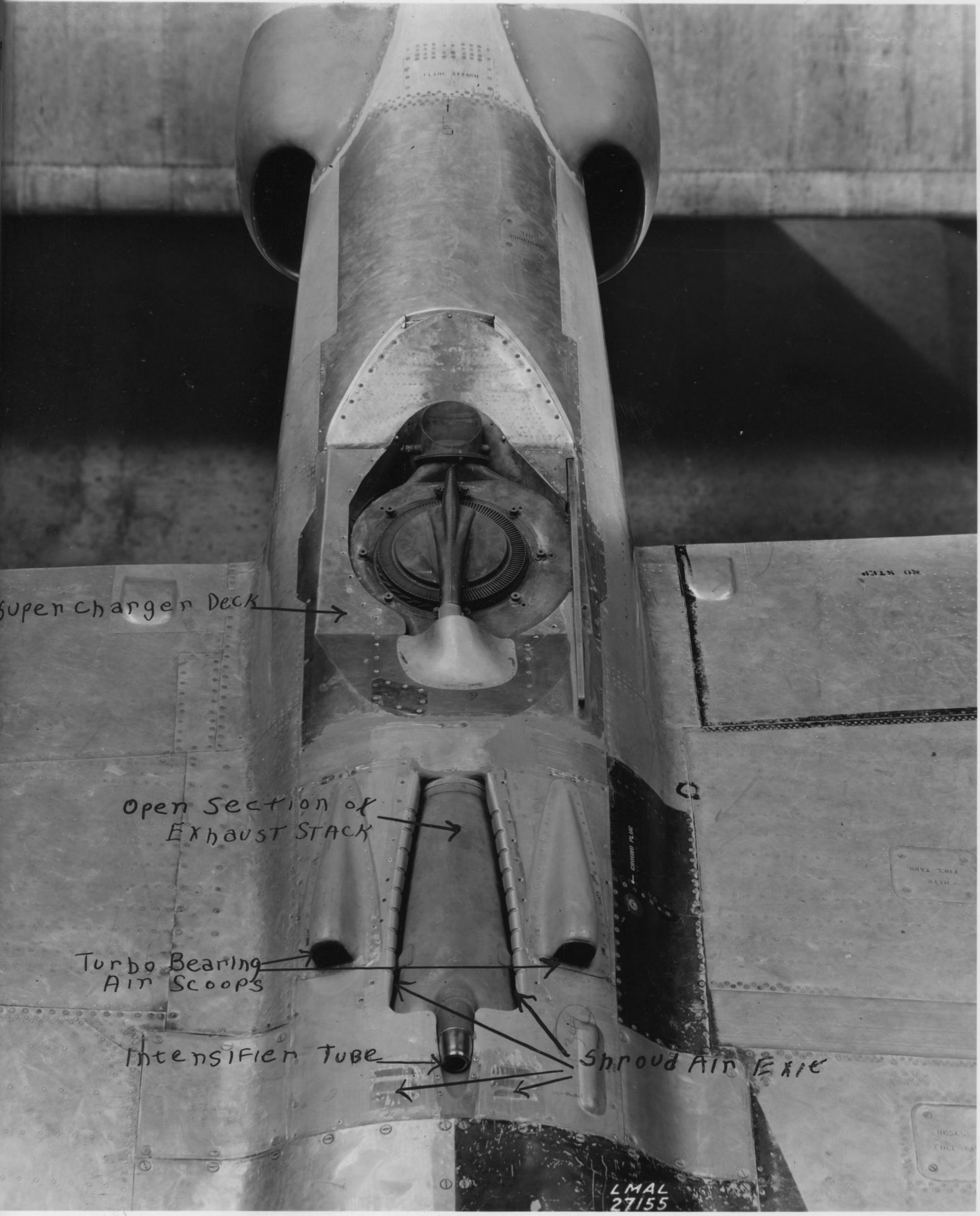
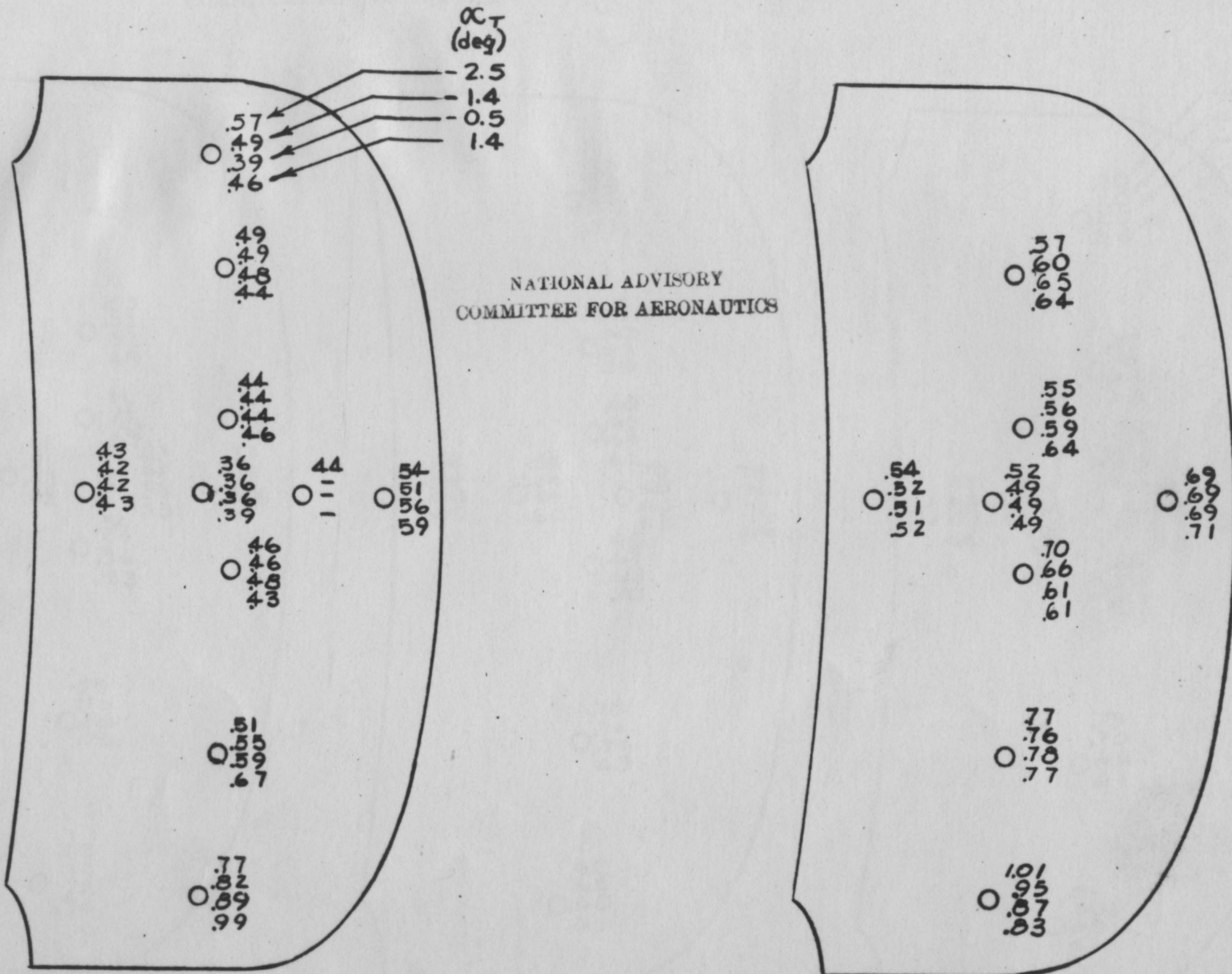


Figure 6. - Supercharger installation modified to that of the P-38E airplane.

Figure 7. - Armament installation of the YP-38 airplane.



Flap normal

Flap full open

Figure 8.- Total pressure at front face of radiator in YP-38 Prestone scoop; values given in terms of q_o.

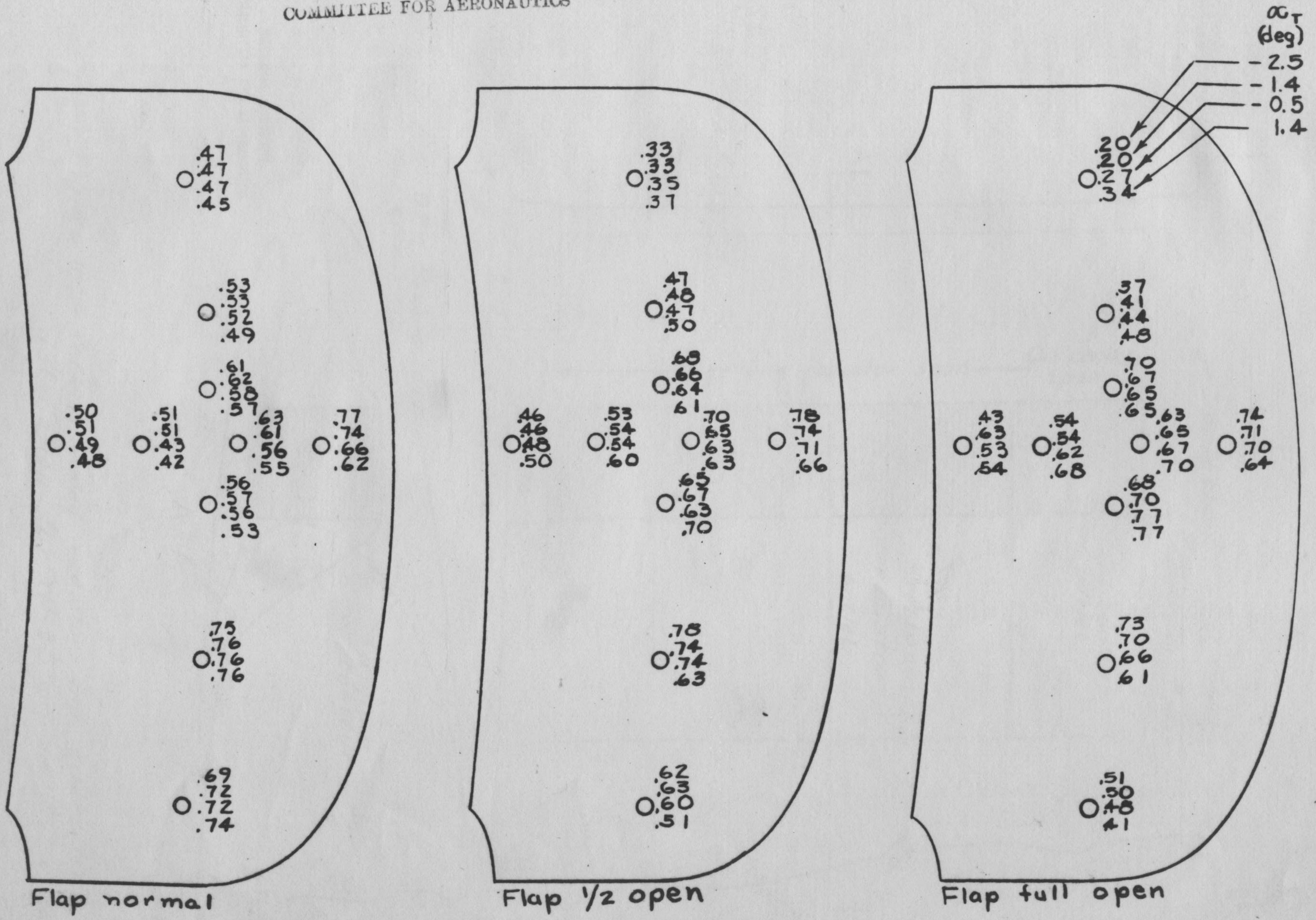


Figure 9 .- Total pressure at front face of radiator in P-38E Prestone scoop; values given in terms of q_0.

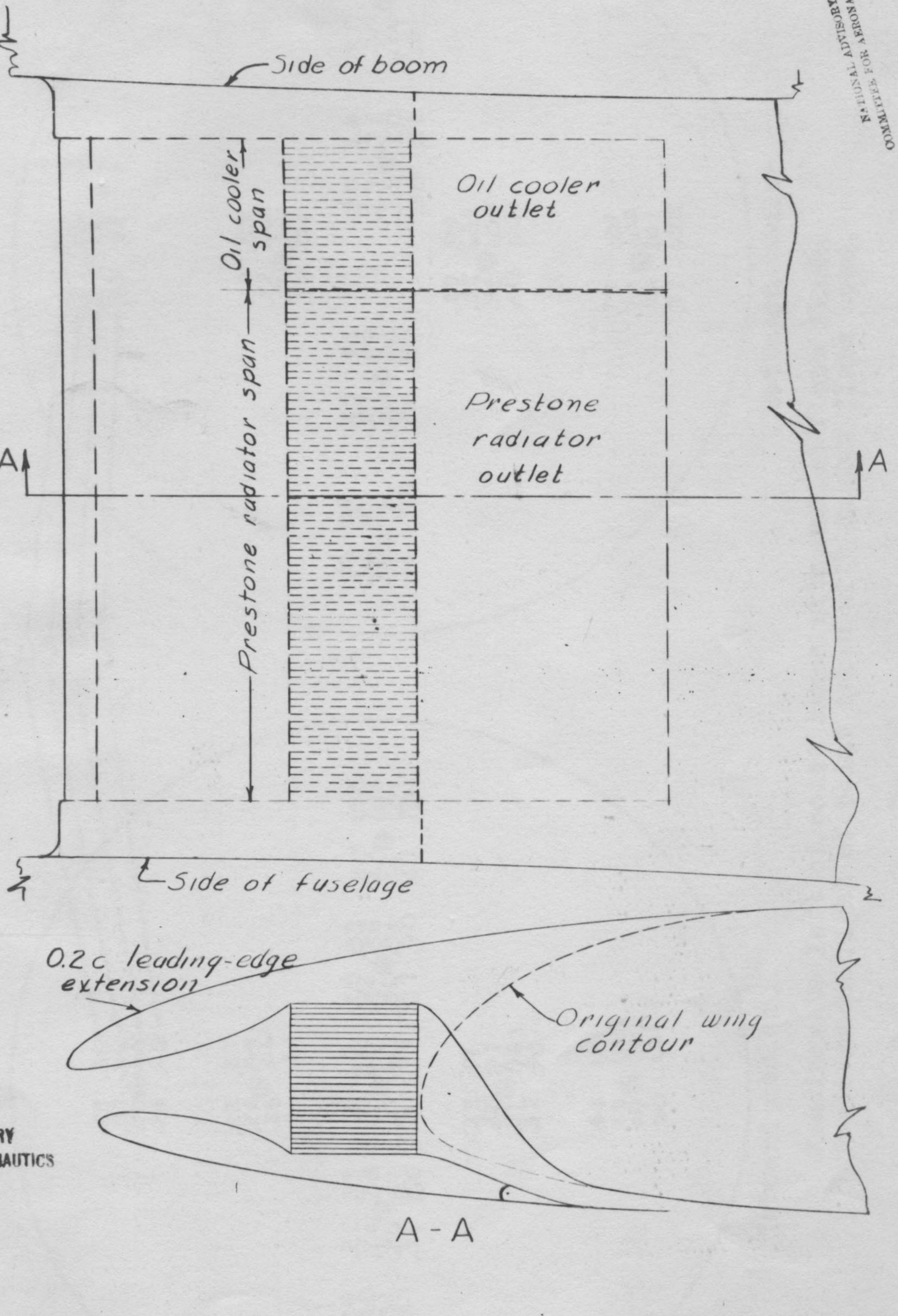
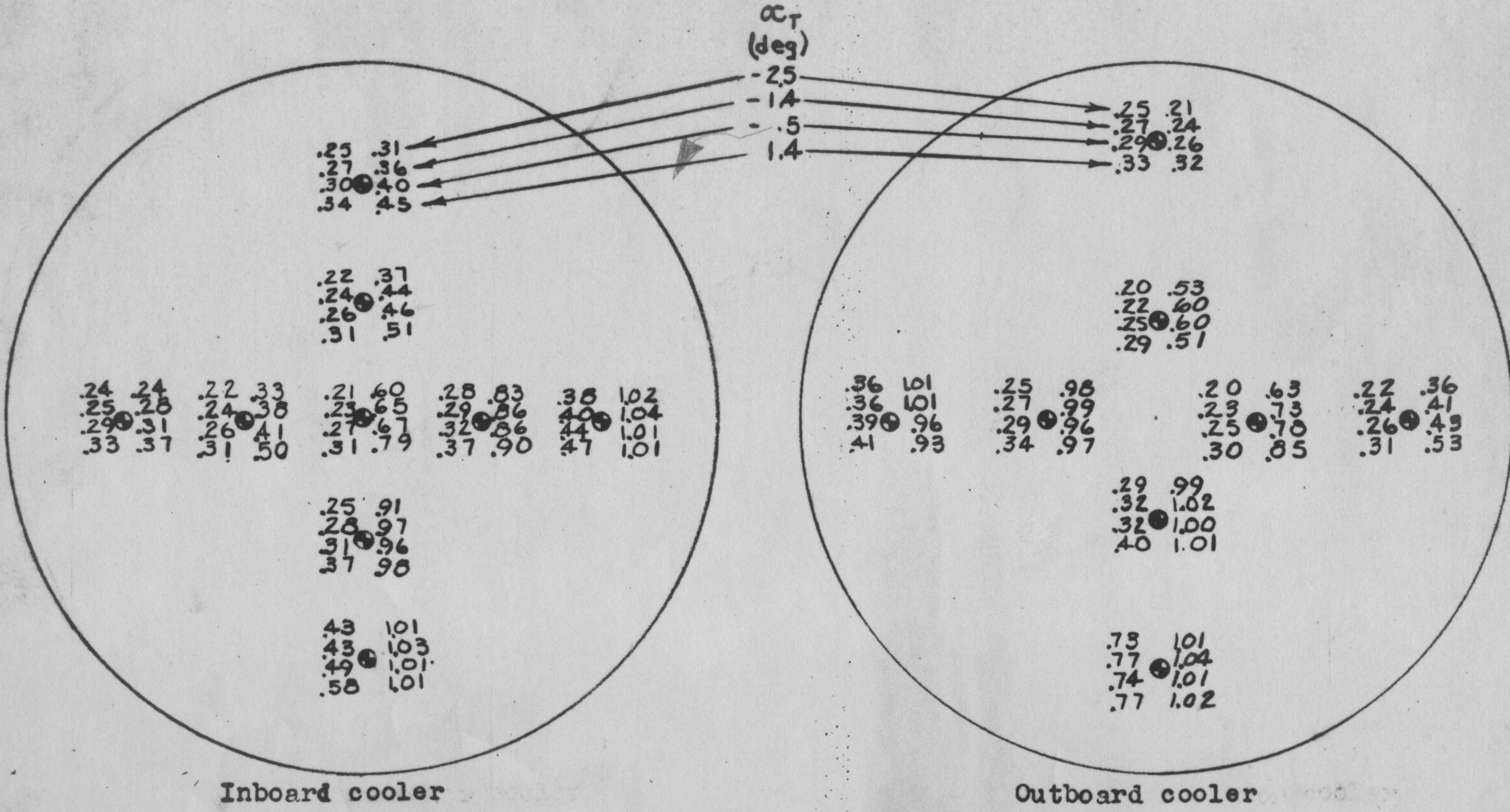
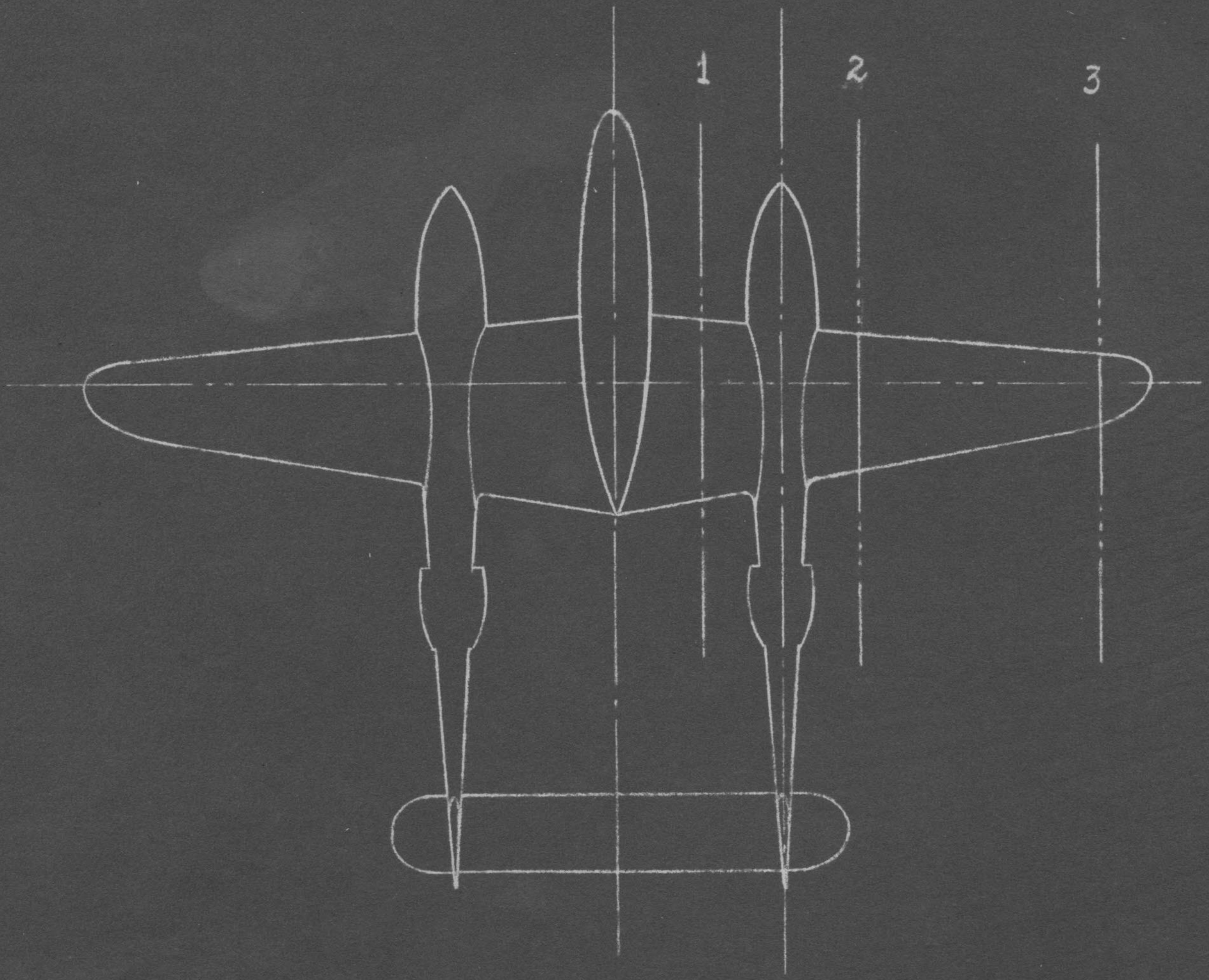


Figure 10.- Recommended radiator and oil-cooler installation for YP-38 airplane



Readings to left of point taken with outlet flaps flush.
Readings to right of point taken with outlet flaps open.

Figure 11.- Total head at front face of oil cooler; values given in terms of q_o.



Station	Section drag coefficient
1	0.0084
2	0.0089
3	0.0081

Figure 12.- Profile drag of three wing stations; high-speed attitude.