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Cooling Systems

for Automotive Conversions

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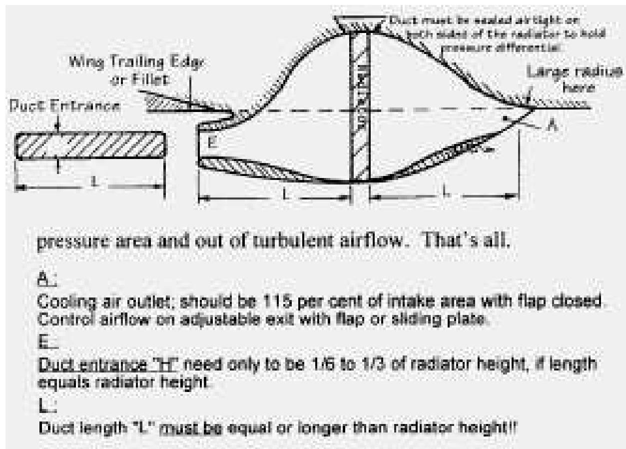
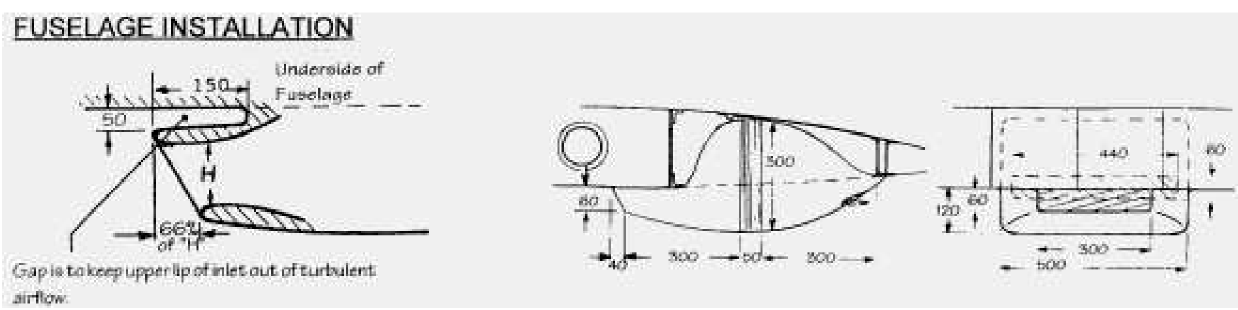
Part 2: COOLING DUCT DESIGN



The dimensions on the cooling ducts were developed in early stages of W.W.2 and are so efficient that even modern race cars have them installed today. The airduct entrance has to be in a high pressure area and out of turbulent airflow. That's all.

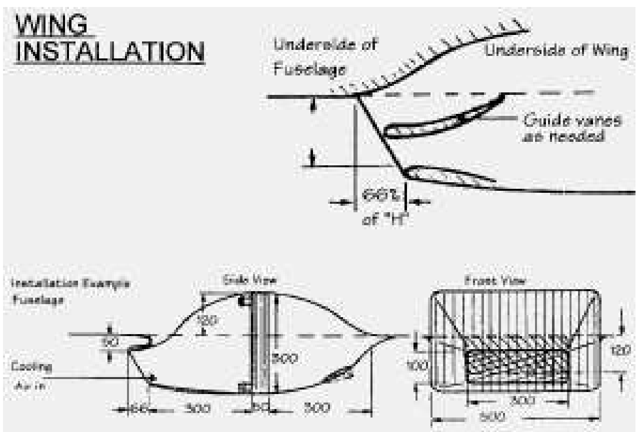
Keep inlet leading edge of duct on or ahead of trailing edge of wing or wing fillet. The 66 per cent top lip extension will increase airflow with the exit flap closed by 10.25 per cent. The increase with exit flap open is 12.6 per cent!! Guidevanes, horizontal or vertical will improve airflow in the cooling duct.



The radiator in this examp1e is from the VW Fox. The cooling area is 300mm x 500mm, the radiator is 50mm wide. The cooling air inlet is 300mm wide (the same dimension as the rad height) x 100mm height, (1/3 of rad height) for an intake area of 300em2.

The top lip is 66mm extended forward to make use of the increased airflow . The duct in front, as well as behind the radiator is 300mm, the same as the rad height. The overall length of the cooling duct is 716mm. The duct widens in center to 500mm to match the length of the rad. The cooling air outlet is 300mm x 120mm in closed position and opens to 150mm if more airflow is required. The duct is 120mm inside the fuselage to reduce drag. With the 50mm gap between fuselage and upper lip of the duct, we have the cooling air outlet above the inlet, which helps with the airflow .

The wing installation below has the same radiator for a Zenith CH 200 installation. The distance between the spars is 500mm. The radiator protrudes 118mm below the wing. The wing is 300mm in front of the rear spar 182mm deep. The air inlet is 60mm deep x 300mm. The duct sides are slanted 40mm, to increase airflow into the duct. This installation will cool the 100 HP engine for this aircraft, with only minor modifications to the wing. Only 2 rear ribs need to be changed. The cooIing air outlet is 60mm x 440mm with the flap closed and 80mm wide in the open position.



The duct dimensions in these examples are the minimum you should have. Lengthening the duct will increase the cooling, a shorter duct will make things worse.

Now, go back and look at the Junkers Patent from 1915. All the dimensions are right there. Talk about re-inventing the wheel.

What about the chin radiators that were so common in W.W.2 aircraft? They were real bad compromises to keep the radiator as close as possible to the engine and were poor setups. There are lots of examples of what I am talking about.

First the JUNKERS JU87.. The prototype (JU87V 1) had a 525 HP supercharged Rolls-Royce Kestrel V engine with a chin radiator. The radiator intake was nicely slanted, to improve cooling, (later you find out why) but the engine was overheating. Figure 2 shows the side and front view of the plane.

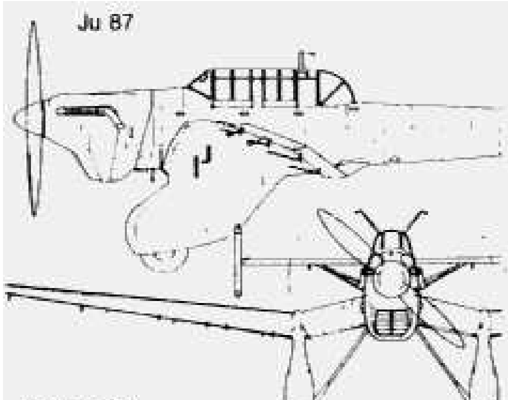


Figure 2

The solution to the problem was a big, ugly forward set radiator. In Figure 3 moving the radiator made things worse, not better!!

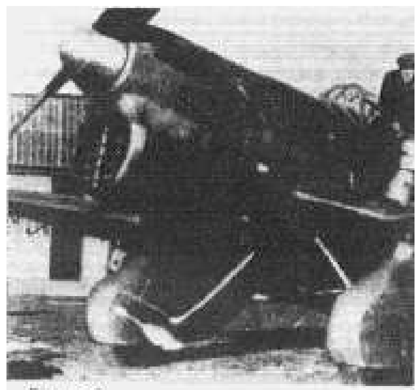


Figure 3

The propeller is forcing the air back, but by thrashing through the air it creates a lot of turbulence and strong flow around the fuselage. Every blade creates a pulse when it comes by the radiator. Go back to Fig. 1 and look at the trailing edge of that airfoil. The air behind the airfoil is turbulent and disturbed, at least three chords wide behind the airfoil. So anything three times the chord ofthe propeller blade, away or closer to the propeller, is in that turbulent area and gets the pulse of the blade. If you do not understand what I am trying to tell you, park your car on a windy day, on the down-wind side of a multi-lane highway and open the windows. You will notice the wind blowing throhgh the car. Imagine the car being the radiator. Every time a car goes by you will notice a pulse of air going through the car, even from cars four lanes away. You will also notice that the cars in the lane closest to you create a re verse flow in the car, (if you spread small pieces of paper on the dashboard they get sucked out on the up-wind side). The same thing happens in a radiator duct. Everytime a proprller blade sweeps by, a pulse is pushing in the duct, instead of good continuous flow. Beside losing a lot of air flow , the pulses can fatigue the fins and ruin the radiator.

After the crash of the prototype, the new JU 87 got a Jumo 210A engine, with 610 HP and a large radiator on the chin (Fig. 4) but still failed to cool the engine.

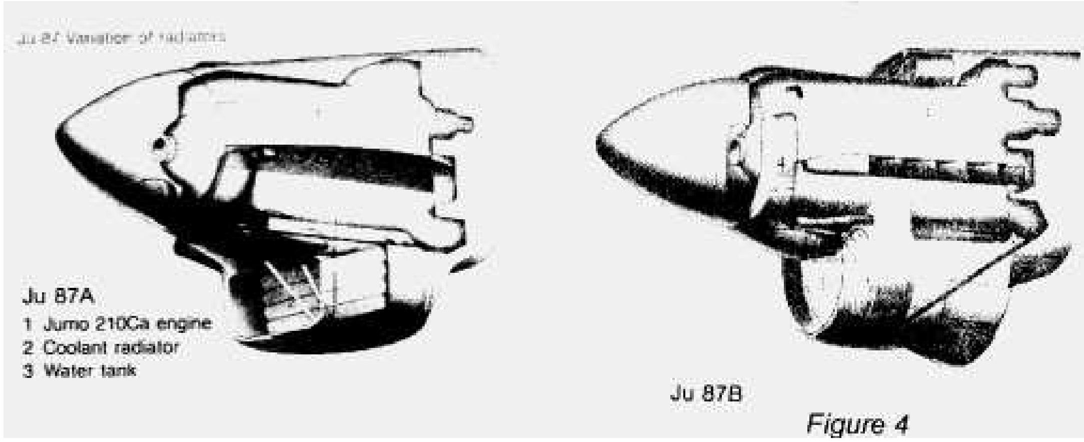


Figure 4

Production started anyway and the pilots had to cope with the problem. (That's the reason why the A and B models were mostly used in the cooler Russian climate). On the B model the oil cooler was set on top of the engine with the enlarged chin radiator still too close to the propeller. The engine continued to overheat. The Jumo 211D had 1,200 HP and produced lots of heat. To help with the oil cooling, an offset intake was designed for the oil cooler.

The geared propeller turned clockwise, so the engineers fabricated a low lip on the left side of the oil cooler intake and put a high ridge on the right side to force the prop blast into the oil cooler (Figure5). That helped somewhat, but did not eliminate the problem.

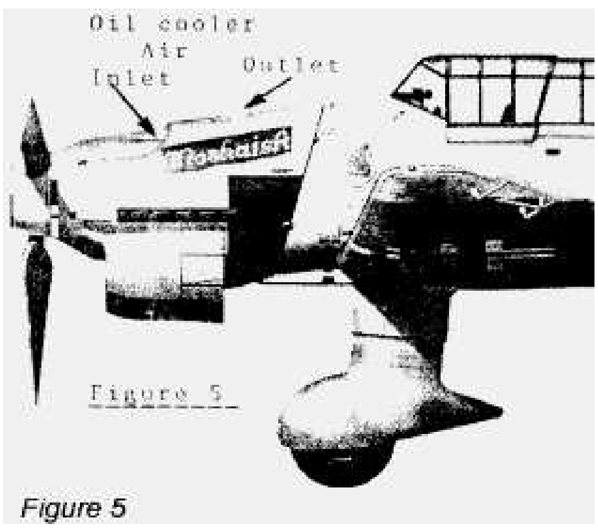


Figure 5

Finally, on the D-Model, with the 1,420 HP Jumo 211J engine, the designers located the radiator under the wing, and the oil cooler far back on the chin, out of the propeller pulses. Fig. 6 and 7 show the nice aerodynamic clean setup.

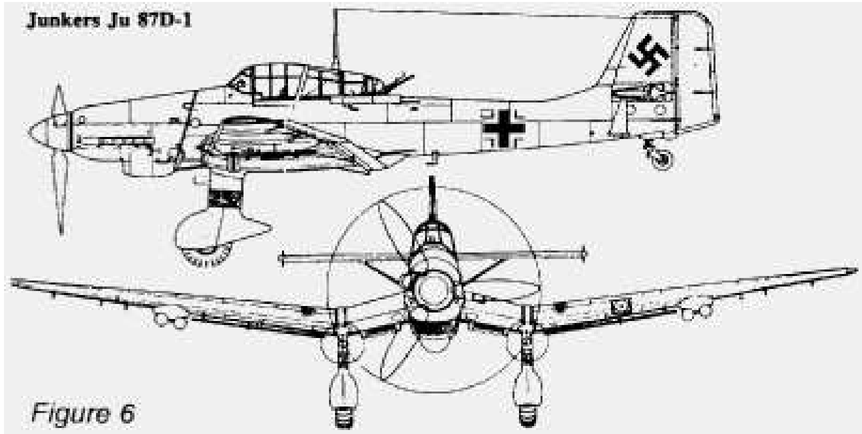


Figure 6

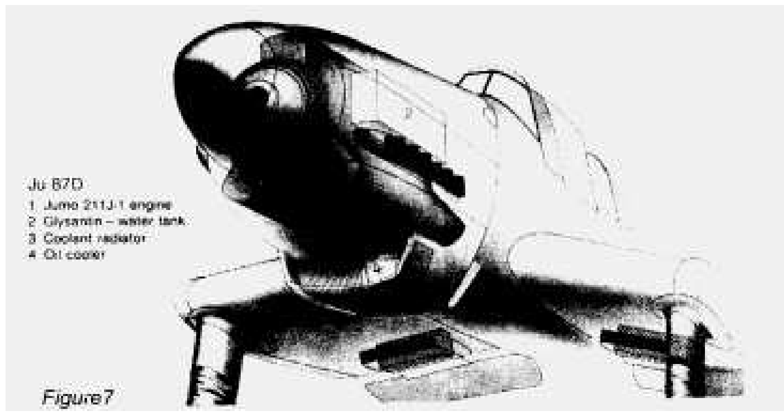


Figure7

This cooling system worked well, even in Sicily and North Africa. The second example is ME 109. The prototype V1 had just like the Stuka, a Rolls-Royce Kestrel with the chin rad too close to the prop. Fig. 8 shows the setup. This otherwise superb fighter had cooling problems.

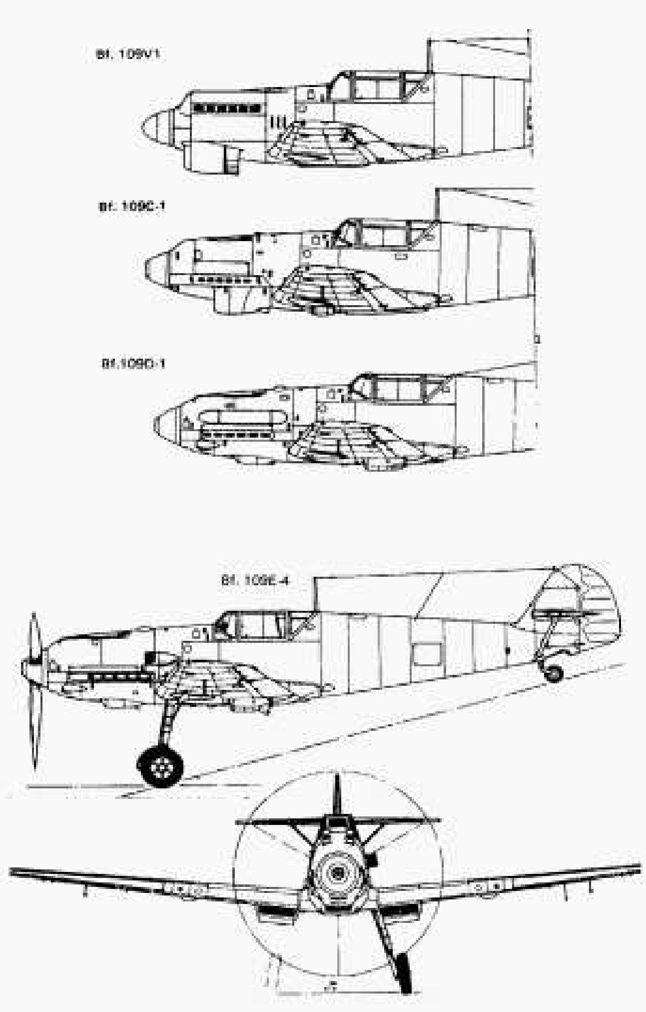


Figure 8

The introduction of the B-Model, with the Jumo 2lOD with 68O HP, brought the change to a rearward chin radiator and the oil cooler under the left wing.

Fig. 9 shows the huge and ugly radiator very clear . This is not an aerodynamicly clean setup and totally unsuitable for a fighter aircraft !

Figure 9

Finally Messerschmitt smartened up and put things where they belong. The oil cooler under the chin. but far enough back to keep it out of the propeller pulses and the radiator under the wings. Figure 10 shows the clean installation on the ME 1O9K with the 1,800 HP DB605 engine. (This engine had 1,550 HP supercharged. but with water-methanol injection the power was boosted to l,800 HP.) This low drag installation worked well, even under severe conditions.

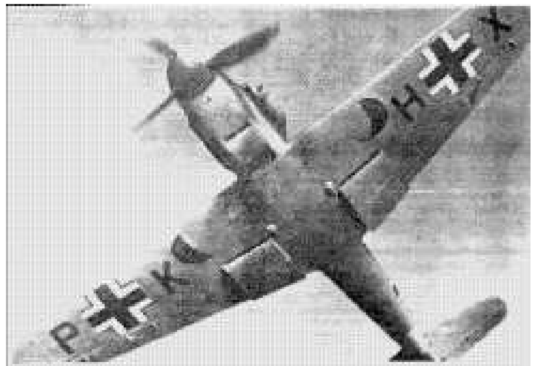


Figure 10