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Cooling Systems

For Automotive Conversions

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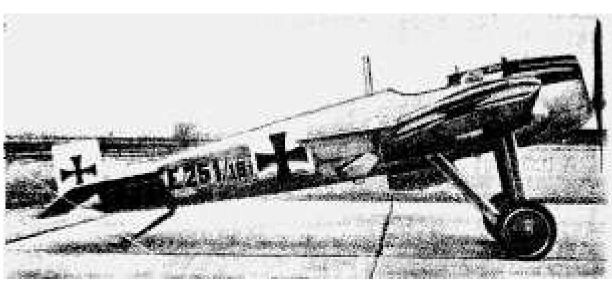
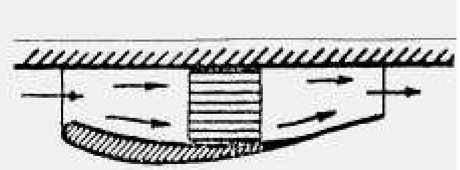
As we progress with the cooling report we look at system developments that work and why these systems work. We will also look at setups that were not so hot and why the setups were poor examples. Finally, we will take some well established and proven perimeters and dimensions for a cooling system that really works.

From the early beginnings it was clear that cooling the engine was as important as keeping the engine running. The search for an ideal location and form was a tug of war between the military and the engineer in W W. 1. The military insisted on a location that was protected from groundfire to keep the aircraft in the air as long as possible; with no consideration for the pilot or drag and cooling efficiency! The engineers, on the other hand, wanted the most effective cooling system, with performance as a top priority. The stages from the freestanding to the integrated cooling system were long. From the ear, or fin-coolers, that stuck out the side ofthe fuselage, to the standing or hanging radiators, above and below, the wing and fuselage, the front radiator developed. This most effective system (Jenny, Fokker, Junkers) was the standard for slow speed aircraft and peaked in the Ringradiator of the SPAD fighter. The V-8 (Hispano Suiza) adopted more to this shape than the in-line engines. The only drawback of this radiator shape was to manufacture the radiator, with the prop shaft sticking through the center. Because of these difficulties, the system faded out until the Germans segmented the radiator in the 4O's on the Focke Wulf 190, Ju 88 and Do 335 and developed that low drag, very efficient cooling system. After extensive wind tunnel development, Jugo Junkers patented in 1915 the ducted cooling system. This low drag and very effective cooling system was successful and problem-free installed on the world's first all metal Junkers J1 and J2. Compare the small duct installation on the J2 picture with the huge radiator on the Jenny. Unfortunately the military believed a radiator on top of or at the same level as the engine, would have better overheating protection than a radiator on the belly of and aircraft, and rejected both the ducted cooling system and the all metal aircraft.

This is the drawing for the cooling duct patent issued as Reichspatent # 299799 to Hugo Junkers on Jan. 15, 1915. The dimensions are all there and still valid today. The JUNKERS J2 was the first and only aircraft with this installation, because the advantages in cooling and aerodynamics were of only minor importance in the early days of aviation.





Towards the end of W.W. 2, the ringradiator was extensively used by the Germans because relative lightweight armourment could protect the segmented cooling system. The close proximity to the propeller and the relative thick propeller section could slow the inflowing air down by 20 percent, but a large spinner would partly compensate the problem. With the radiator mounted on the engine, a standardized powerplant hookup and exchanges between different makes and engine models could be achieved.

This cooling system is good but also very expensive (the military never cared about cost). Just try to find a Radman that is willing to make you one of these segmented installations! That eliminates this setup for homebuilders. We have lots of rectangular aluminum radiators in cars and trucks that work fine without bankrupting the project.

First let's look at the components we have to work with. The hot coolant from the engine is pumped into a radiator (heat exchanger) that should be exposed to cool air. The air flowing through the radiator takes some of the heat away and by doing so, cools the liquid in the radiator. Nothing fancy or special about that. So, why then do so many people have problems with cooling? Simply because they ignore the limitations and laws that nature put on us.

We established earlier that the coolant is a water based liquid, with additives, to avoid freezing and corrosion. We also established that an aluminum radiator is far superior to a brass radiator. That leaves the air flowing through the radiator to look at. We have lots of air, more or less cool, that we fly in. Certified aircraft engines use only air for cooling, but most of the setups are ass backwards! Hot air wants to rise, not go down! If you force cool air in on top of any hot object and push the air down to exhaust on the bottom, you need lots of energy to do that, instead of using that energy for cooling. Just compare the air inlets on Peter Garrison's Melmoth, or Burt Rutan's Defiant with the Cesna's or Moony's big holes in the cowlings. The Defiant flows the cool air in on the bottom and exhaust on the top, with very small and aerodynamic clean openings and makes use of the natural tendency of the air to rise when heated, while the latter go against the natural flow . The price they pay is big, ugly holes on the top and a just as ugly and big outlets on the bottom.

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RULE NO. 1 for our cooling system is, exhaust the heated air at the same level,
           or preferably higher, than the intake area.

RULE NO. 2 have your intake area in a high pressure zone on the aircraft and in
           undisturbed flow. Exhaust the heated air in a low pressure zone or in
           a turbulent flow area. That is very easy to do right? Think again!
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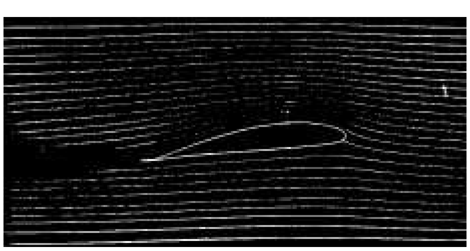
The propeller blast, you'll say, gives us high pressure and lots of flow. That is correct, but the propeller also gives us turbulent flow and pulses if we come too close to it. So, where is the clean flow and high pressure on the aircraft? Simple, on the wing! The wing and the areas under the wing have the most undisturbed and clean flow of the whole aircraft. That is the area where we should pick up the cooling air. The radiator and the exhaust area can be in the fuselage.

Figure 1 shows an airfoil in a 2 dimensional smoke tunnel at a +5 angl e of attack.



The air flows in from the right and prepares well ahead of the airfoil (up to 3 times the chord) to go around. The air going over the top surface of the airfoil has to travel faster, because of the curve and camber. That's why the lines are closer together on the top of the airfoil (the particles are spread out more) than the lines on the bottom. The high pressure on the bottom of the airfoil (denser air) forces the lines apart. Note, that the lines above the airfoil are thinned out up to one chord length high, while there is high pressure, one chord length below the airfoil. Notice also, that the high pressure lines go undisturbed back behind the airfoil.

This is the area where you should pick up the cooling air and guide it to the radiator. The choice spots for picking up cooling air are from the center of the leading edge, all the way back to the trailing edge of the wing. Even high wing aircraft can have a pick up on the fuselage sides, as long as the high pressure area under the wing is used!

Extensive testing in the 30's by the American, British, French, Dutch, Italian, German, and Russian aircraft engineers established that a ducted cooling system is the most efficient. That means the radiator is installed inside a duct, to guide the air through it. Wind tunnel and flight tests pointed to the following wing cooling duct dimensions. (Continued in Part 2).