Cooling Systems

For Automotive Conversion

Part 4

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Part 4

The last example is Reg Mitchell's masterpiece

The Spitfire

This aircraft is my personal favorite for a brilliantly executed cooling system. The most efficient wing (elliptical platform) is mated to the fuselage with large fairings. The fuselage, from the large spinner to the elliptical tail feathers (naturally with fairings) is so clean that even a fly could not stick to it. No large blisters or sharp corners to screw the airflow up. The original Rolls-Royce proposal for the engine had a chin cooler installation. Let me explain the situation. In those days the engine manufacturers were trying to sell a whole package to the airframe people - engine, radiator, oil cooler and propeller. That was the reason the JU87 and B 109 had chin radiators on the prototypes. But Mitchell was not willing to let some yahoo mess up his carefully streamlined airframe so he designed his own system. Look at the front view of the 1000 HP Merlin powered MK1 (Fig. 16A).

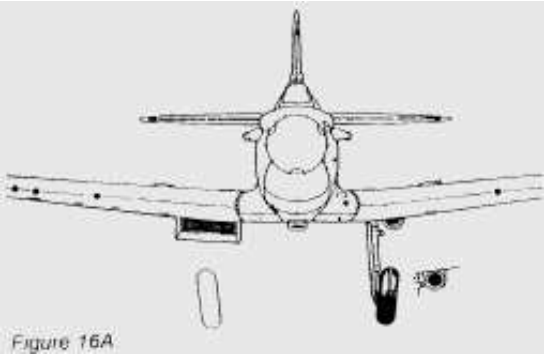


Figure 16A

One relatively small radiator under the right wing and the oil cooler tucked away under the left wing. Very low drag and still close to the engine, which results in short coolant lines. This superbly executed design worked in the Sahara desert just as well as at high altitude. The outlet flaps on the radiator housing helped to keep the needles in green, even in severe conditions. When RR came out with more powerful engines, like the Merlin 61 with 1,565 HP on the Mk IX, Mitchell simply added one more radiator under the left wing (Fig. 17).

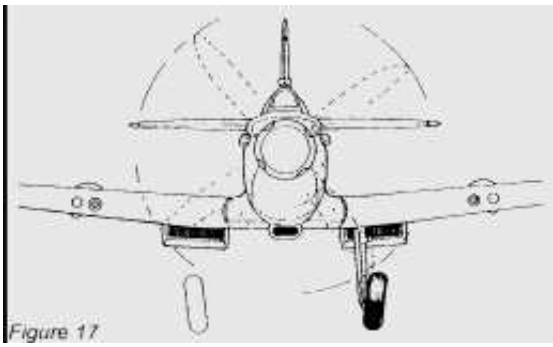


Figure 17

Later the RR Griffon 61 with 2,045 HP produced lots of heat! But all that was needed to keep things cool was a deeper radiator with a little more frontal area, like in Figure 18.

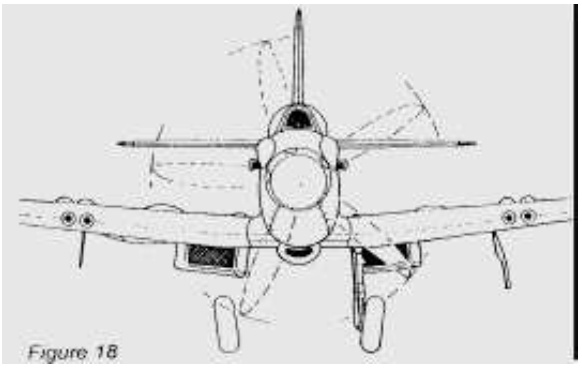


Figure 18

These aircraft flew all over the British Empire, from Egypt to Persia and India, with no cooling problems. All of these examples prove that if you do things right the first time around, you don't have to do it over again. Figure 18 clearly shows the widened radiator, with the slightly enlarged intake area.

Here are more examples, including race cars. The race cars (Fig. 19) go the same speed as fast homebuilt aircraft, which makes them good examples for comparison.

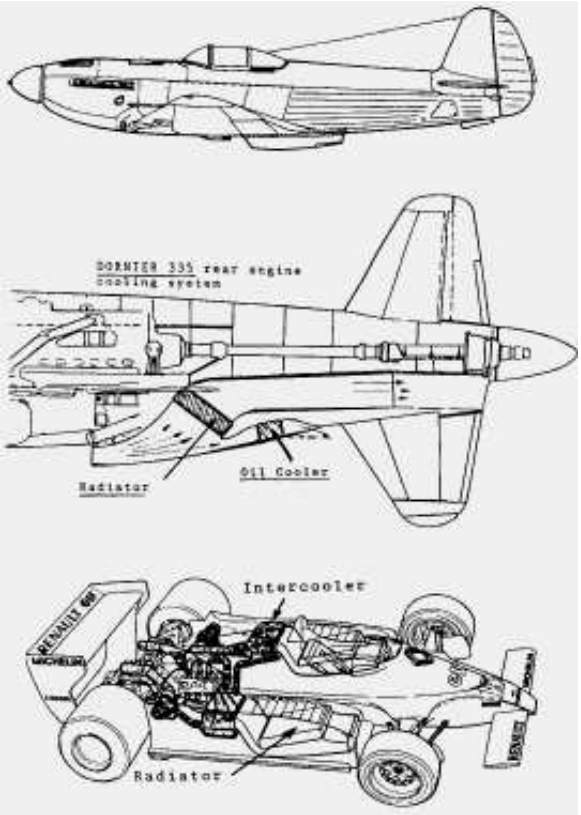


Figure 19

Figure 20 is the 4 segment ring-cooler of the Ju 88 for the Jumo 211F engine (1340 HP), It is a copper-brass unit with 1190 MM diameter that is 150 MM deep. The oil cooler is 250 MM deep with a 4, 6 square decimeter frontal area.

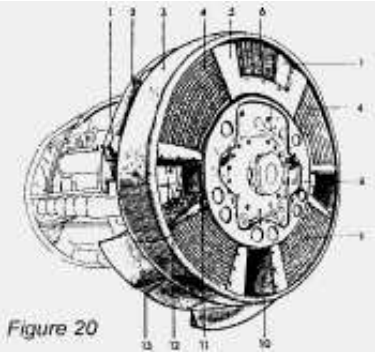
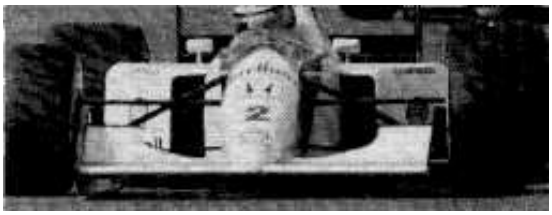


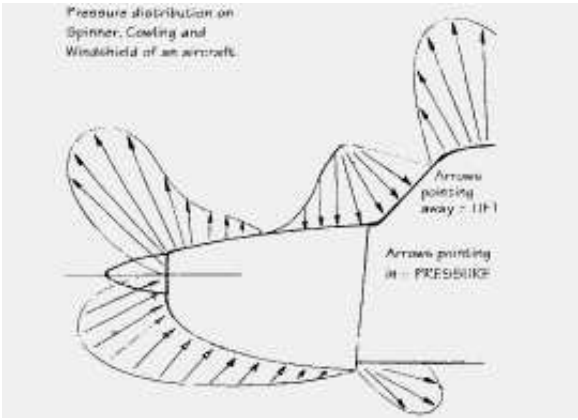
Figure 20

This Mclaren (Fig. 21) makes use of aircraft cooling technology by installing 2 radiators in the high pressure airflow on the front of the racecar.



Notice the cutout in the centre of the front spoiler to allow undisturbed airflow into the vertical air intakes. Compare the size of the drivers helmet with the inlet area. That proves again that if all things are in the right spot everything works well without being large and heavy!

That is all fine and dandy you say, but what if I have a high wing tail dragger with a welded steel tube fuselage, with lots of diagonal tubes on the bottom of the 4 frame. In other words no place or room to put a belly duct with radiator without a major rework and redesign of the steel tube frame. The radiator (or radiators) have to go into the engine cowling. This naturally is a less than ideal location and can give you some dandy problems. The drawing below shows wind-tunnel results on a front engine installation.



Everybody has at one time or another come across this cowling shape (Fig. 22). Notice the split between the pressure and lift on the spinner! This is one reason why you should have a good spinner bulkhead in front of the propeller. The forces on a large spinner can be substantial. Notice the lift on the front part of the cowling which is trying to suck the front end open. This is a good place for some exhaust louvers or openings for venting hot air out of the engine compartment. Further back on the cowling and in front of the windshield we have high pressure air. A good place to install an air intake. That is exactly where most cars have the fresh air pickup. It is also the place where Porsche and other sports cars pick up the cooling air for the turbo intercooler.

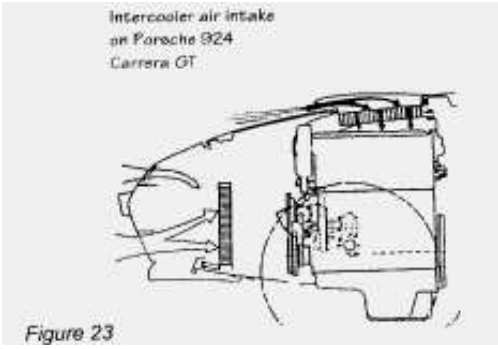
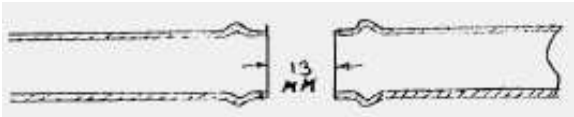


Figure 23

A scoop with good seals around the radiator will work. Not ideal and not very efficient, but workable. The hookup and plumbing of the cooling system is simple. Make sure that all metal lines have a good bead on the ends. Leave a minimum gap of 13 MM (Figure 24) between the ends of metal lines connected by rubber hose.



A gap length equal to the hose diameter is preferable. Use only spiral wound and fabric

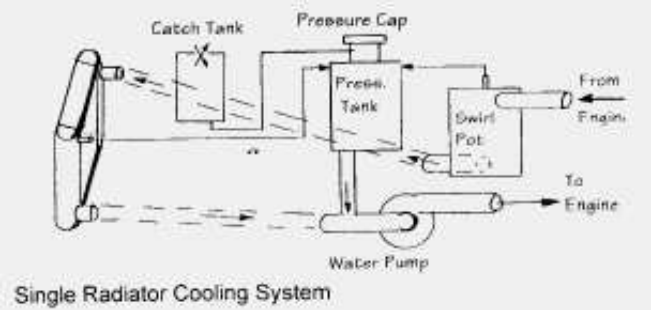
cored hoses. Aeroquip and Dayco, as well as Goodyear have good quality hoses.

Use a silicone based grease on installation. You'll be glad you did when the time comes to remove the hose. Use only good quality stainless steel worm gear hose clamps, with slots cut through the band. Get the type with a screwdriver slot as well as a hexagon head for a wrench. Make sure the clamp is installed after the bead On the tube end and leave a minimum of one clamp width of rubber hose beyond the clamp. Tighten all clamps with the cooling system hot. A weldable aluminum tubing with .040" wall works fine as a rigid line. Clamp the tubing at least every 36" and at each end. 5052 Alloy tubing in the annealed condition bends easiest. It is a good idea to use vinyl heat shrink tubing over the aluminum for abrasion protection.

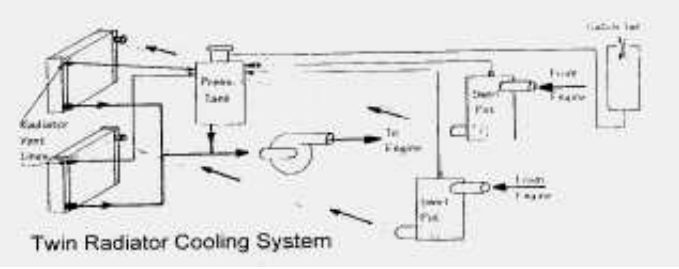
The pressure cap has to be on the highest spot in the cooling system!

The catch tank Can be located anyplace below. Even below the radiator. Or below the whole cooling system. The swirl pot should be as close as possible to the engine installed. It is important to bring the return line from the pressure tank close to the water pump.

Make sure that the header tank is above any circulating lines. the engine coolant level and the radiator. A Corvette header tank is very light and probably cheaper than the one you can make. The use of an aerator tank in the outlet line from the engine (2 tanks on V-engines) will cure all steam problems. The top of the swirlpot must be bled to the header tank above.



Single Radiator Cooling System


Twin Radiator Cooling System

Radiator cores fill up with dust, dirt and insects. The fins get bent easily. It is essential to keep the fins straight and clean. It is also essential to have the radiator boiled out and flushed periodically (every 300 hrs!). Painting will reduce the cooling efficiency and make repairs difficult. Use only Aeroquip, or AN840 fittings. They cost more but are worth the money. It is your life that depends on their quality. Caterpillar dealers have also some lightweight, plotted, quality steel fittings. Check them out. Use common sense, don't try to reinvent the wheel unless you like unexpected excitement (and brown spots in your underwear). A cloud of steam from your engine compartment shortly after takeoff can give you both.