ENGINE COOLING TIPS

During that first exciting test flight of a new aircraft or the initial flight for a freshly overhauled engine, it is not at all uncommon to experience a high oil temperature indication, an excessively high cylinder head reading, or both.

What to do? Well, for one thing, fly the airplane and keep calm. Sure, it is easier to say than to do but try anyway. Concentrate your thoughts on possible courses of action.

If your oil temperature is extremely high but you don't smell anything unusual and your oil pressure is "in the green" (that is, within limits), the threat of an immediate engine seizure, due to oil starvation, is most unlikely.

Nevertheless, as a prudent pilot you will immediately head for the stable. At the same time, attempt to bring the engine temperatures under control by:

1. Reducing power . . . and leveling off.
2. Allowing airspeed to increase if altitude and conditions permit.
3. Increasing the mixture to full rich.
4. Opening cowl flaps (if installed).

Under the circumstances, these are the best initial actions you can take. And as long as the oil pressure reading is normal, there is no immediate risk in continuing your flight provided the redline oil temperature is not exceeded.

But How Hot Is Too Hot?

It depends, of course, on the engine design and type. But most aircraft engines operate pretty much within the same permissible temperature range. The limits established by the engine manufacturer for your particular engine should always be observed.

The following engine instruments are important in monitoring engine temperatures. They will alert you to the onset of a heating problem and will enable you to better cope with it should one develop:

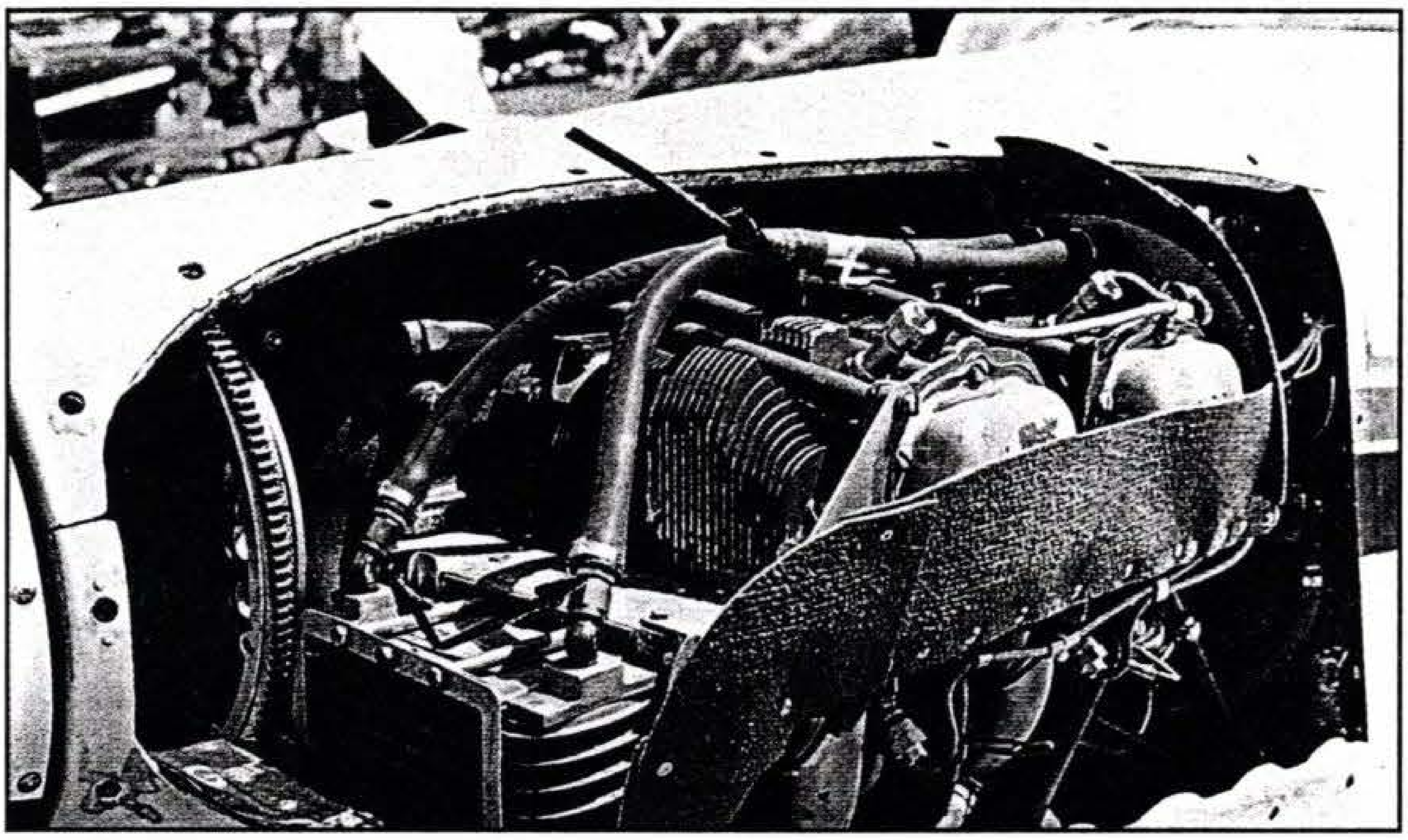
Oil temperature gauge (OT) - mandatory.

Oil pressure gauge (OP) - mandatory.

Cylinder head temperature gauge (CHT) - optional.

Exhaust gas temperature gauge (EGT) - optional.

In order to be as specific as possible, let's examine the manufacturer imposed temperature limitations for most small 4-cylinder air-cooled aircraft engines . . . engines like the Lycoming O-320 series, for example.



An effective front-mounted oil cooler installation. Cool air enters the radiator and the heated air exits easily and harmlessly into the lower engine compartment. The primary drawback is the need for two long oil hoses running all the way back to the engine accessory section.

Cylinder Head Temperature (CHT) Limits

According to the engine manual, the maximum allowable cylinder head temperature (red line limit) is 500 degrees F.

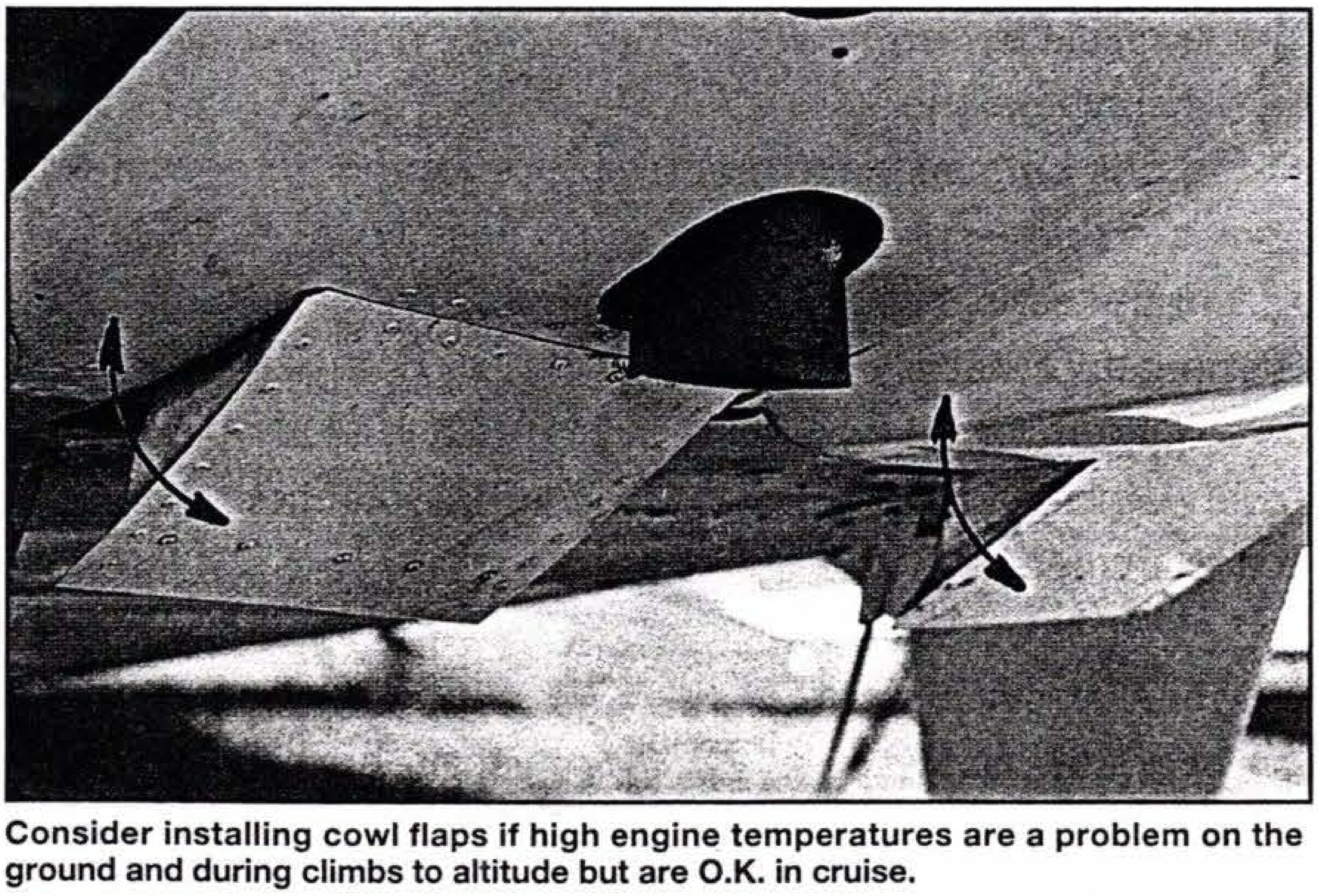
Lycoming states flatly that the maximum redline cylinder head temperature limit must never be exceeded. For a longer engine life, the recommendation is that a maximum 435 degrees F. should not be exceeded during high cruise power.

In my opinion, however, a somewhat lower 360-400 degrees F. CHT is more reassuring for normal cruise conditions.

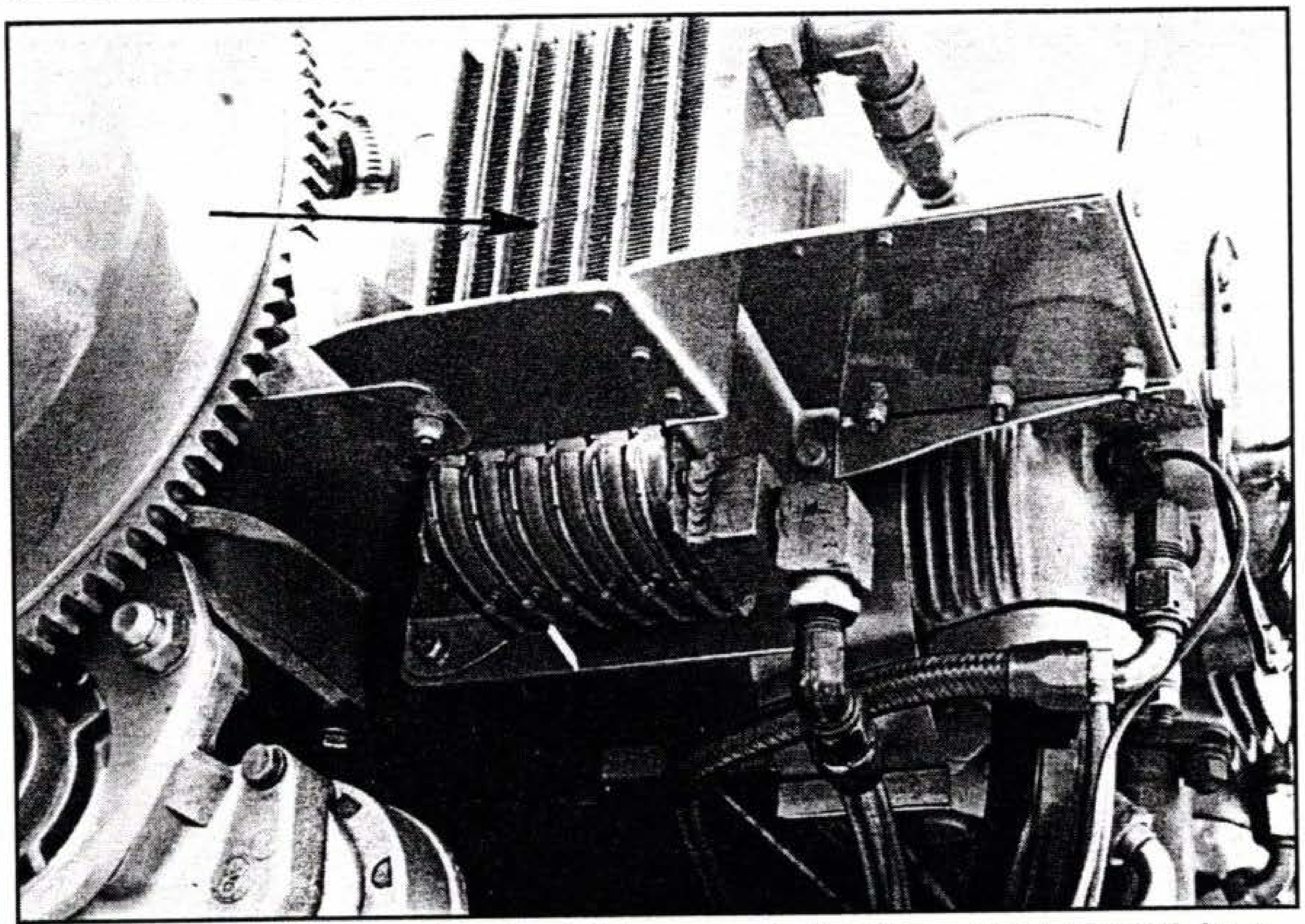
Oil Temperature Limits

Here's one for you. The maximum oil temperature (red line limit) is established as 245 degrees F. when the average ambient air temperature is above 60 degrees F. and as 225 degrees F. when the outside air temperature is 0 to 70 degrees F.

So, what would you consider to be



Consider installing cowl flaps if high engine temperatures are a problem on the ground and during climbs to altitude but are O.K. in cruise.



With the oil cooler mounted up front, it is assured of getting cool air through its radiating fins. Unfortunately, in an installation like this one much of the hot air exiting the oil cooler is blown down through the engine, thereby, considerably inhibiting engine cylinder cooling effectiveness.

the proper redline for your oil temperature gauge?

More pilots seem to accept the 225 degrees F. as being the limit. (Incidentally, the small Continentals also peg 225 degrees F. as the oil temperature redline.)

At the lower end, the recommended minimum operating oil temperature is 160 degrees F.

The desired oil inlet temperature is about 180 degrees F., however, don't lose sight of the fact that these are heat engines and a normal oil temperature range between 190 degrees F. and 200 degrees F. is not at all unusual . . . besides, that 200 degrees will definitely get rid of any condensation (moisture) present in the engine's oil system.

Since high oil temperatures do have an effect on oil pressure . . . and vice versa . . . let's review the oil pressure operating limits established by Lycoming for its engines.

Oil Pressure Limits

The oil pressure during normal cruise power settings should range between 60 psi (min) and 90 psi (max).

However, an initial start-up and warm-up oil pressure of 100 psi is O.K. Cold oil offers a greater initial resistance to flow.

And don't be surprised if, on occasion, your idle oil pressure drops as low as 15 psi.

Those Troublesome High Temperature Symptoms

The suggested in-flight corrective actions previously mentioned may, or may not, alleviate the high temperature problems experienced.

Keep this in mind. Your high oil temperature is not the culprit! Actually, it is the victim. Something else caused or is causing that condition.

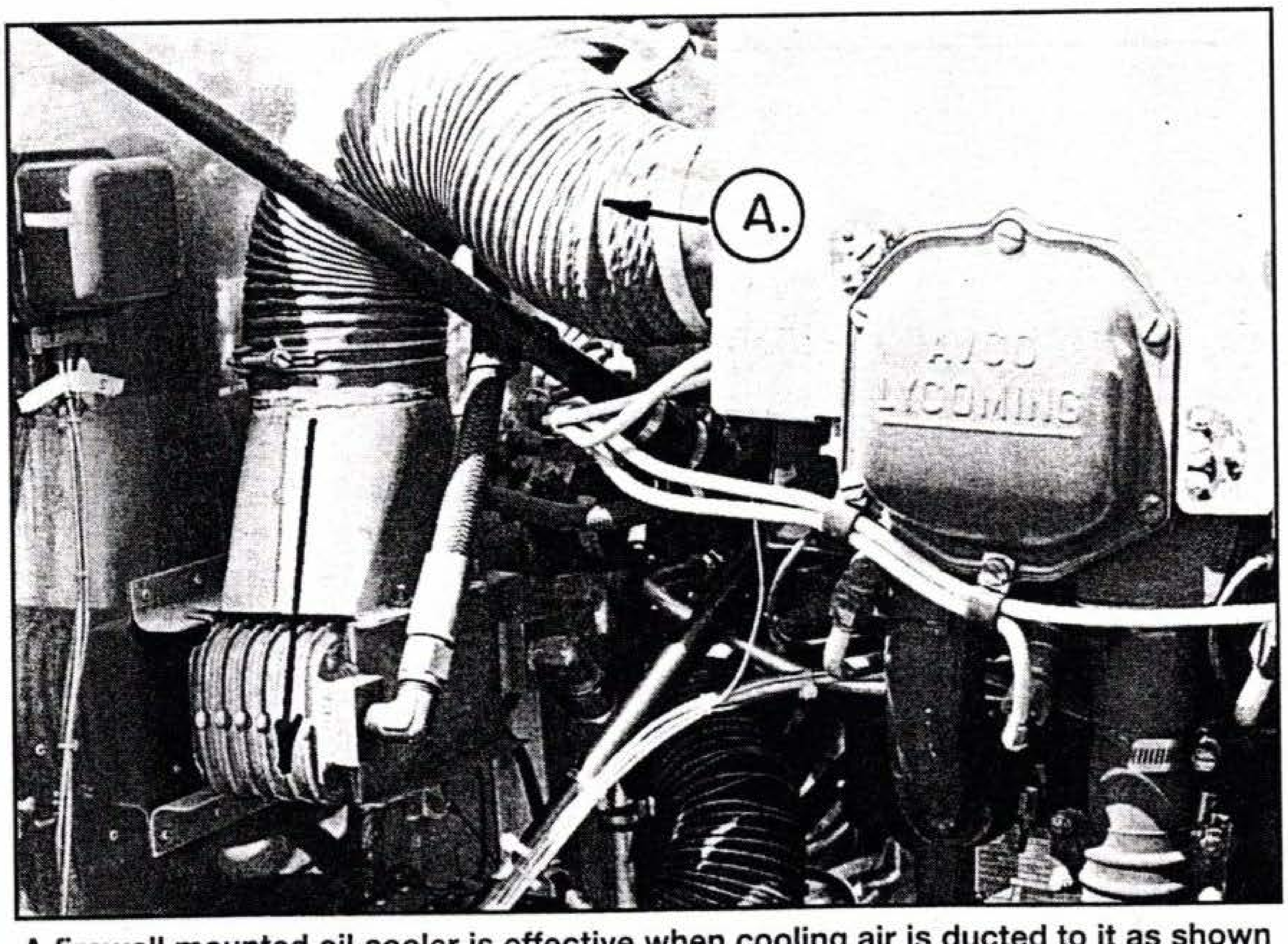
One or more of the following may be the cause of your high oil temperature problem:

- Oil supply insufficient
- Low grade of oil
- Malfunctioning oil temperature gauge
- Clogged oil lines or strainers
- Inadequate air for cooling (cowling inlet/outlet areas)
- Ineffective engine baffling installation
- Improper oil cooler installation
- Excessive blow-by (worn or stuck rings)
- Failing or failed bearing

Similarly, a high cylinder head temperature condition can be caused by some of the same things that affect your oil temperature.

A few additional possibilities may also have to be explored:

- A malfunctioning CHT gauge
- Inadequate air for cooling
- A poor baffling installation
- Improper ignition timing
- Wrong grade of fuel



A firewall mounted oil cooler is effective when cooling air is ducted to it as shown here. The heated air easily exits through the bottom cowling air outlets.

So, What IS Causing That High Engine Temperature Problem?

Up to now you probably don't know what is causing your high temperature indications but you do know the best place to solve the problem is on the ground.

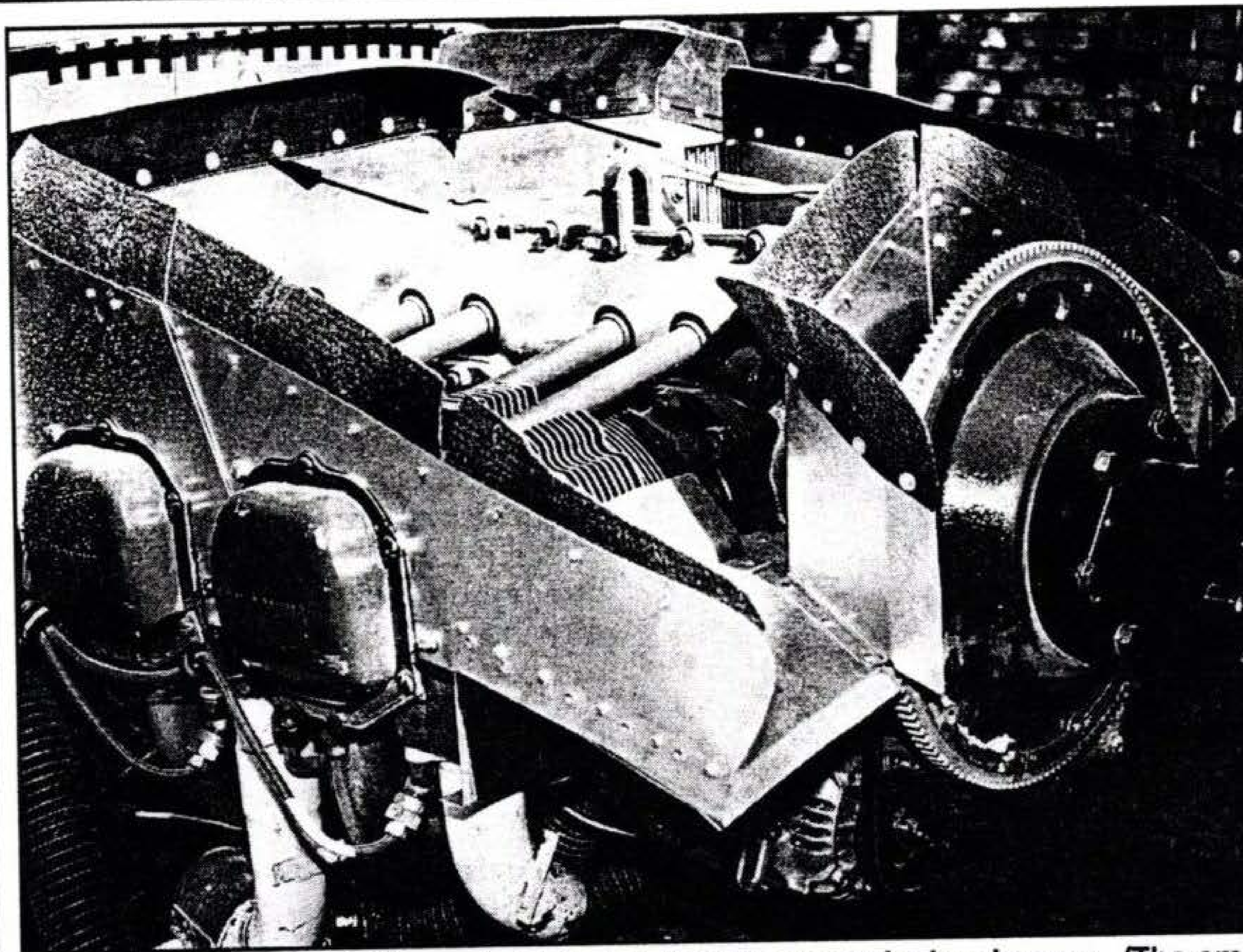
Before the next flight, begin to systematically check out each potential trouble source.

Always check out the obvious and easiest things to do first.

Quite often, this process of elimination will lead to a readily correctable minor problem without probing into the engine's inner workings or making some major modification to your engine installation, therefore:

1. Check your oil level.

Wouldn't one of your very first checks be to verify that you are using the correct grade of oil and that the sump is being maintained at the recom-



A 160 hp engine should have air inlets totaling 56 square inches in area. (The empirical formula is .35 x hp - 56 sq. in. total area.) This would provide for a 3" x 8" rounded (approximately) inlet each side of the spinner.

mended level?

Although you can safely operate your Lycoming with as little as two quarts in the sump, a generous supply of oil, nevertheless, helps the engine run cooler.

The sump capacity is 8 quarts but I try to keep my oil at a more efficient 6 quart level.

2. Check engine gauges for reliability.

The next, obvious action is to check your engine temperature gauges to verify that they are not lying.

You can check the oil temperature sensing probe by removing it from the engine and dipping it into a small can of boiling water.

No need to remove the gauge from the aircraft.

The oil temperature gauge should show an indication of approximately 212 degrees F. (100 degrees C.).

If either the oil temperature gauge or the CHT gauge is inaccurate, replace it with a reliable unit.

Don't forget to check out the new gauge before installing it!

Did you know that the behavior of the oil temperature and oil pressure are often interrelated? That's right. A high or rising oil temperature has the effect of causing the oil pressure to decrease.

For example, when the oil supply is quite low, the engine will run hotter and the oil pressure will tend to read lower.

On the other hand, if you are confronted with a slow steady increase in the oil temperature, with no evidence of engine roughness, check the oil pressure. If it is low and dropping, you could be facing a total loss of oil situation.

An oil leak developed in flight (ruptured oil cooler hose, loose connection, etc.) could, of course, be quickly followed by an engine seizure. This situation calls for an immediate discretionary landing. The decision is yours - either an immediate discretionary landing, or a seized (ruined) engine, and a forced landing.

Incidentally, when installing the oil pressure line fitting in your engine, be sure to use a restrictor-type fitting. This is a safety precaution. If your oil pressure line should fail, the tiny orifice (about .060-.070" dia.) in the fitting will slow down rate of oil loss drastically, and give you more time to get down.

3. Check the cowling.

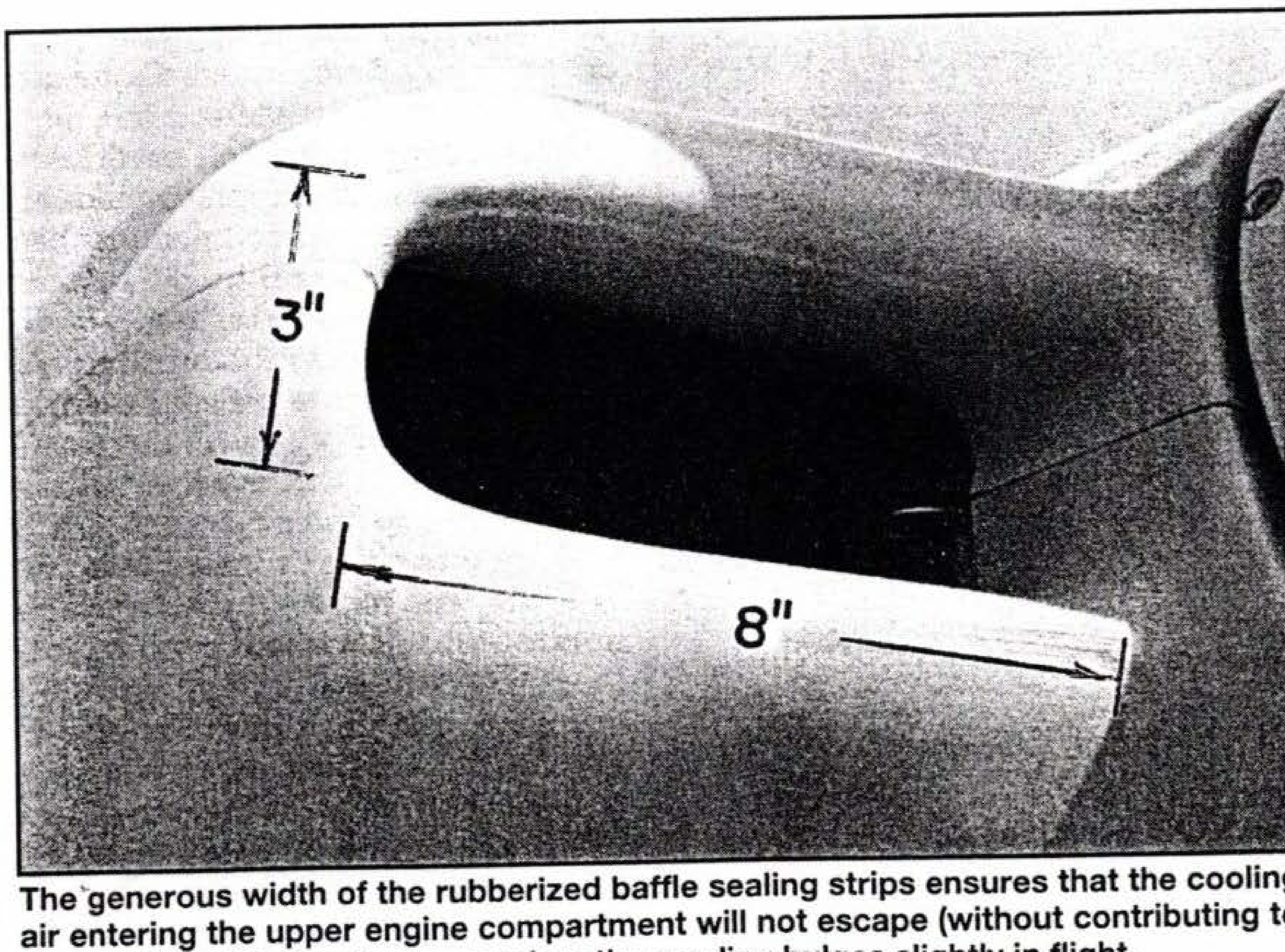
If yours is a stock kit cowling, the inlet and outlet areas should be about right for your engine installation. On the other hand, if the cowling is your own design, verify that the inlet areas are properly located, and are approximately the same size used in other aircraft having a similar performance.

Of course, there is more to it than that.

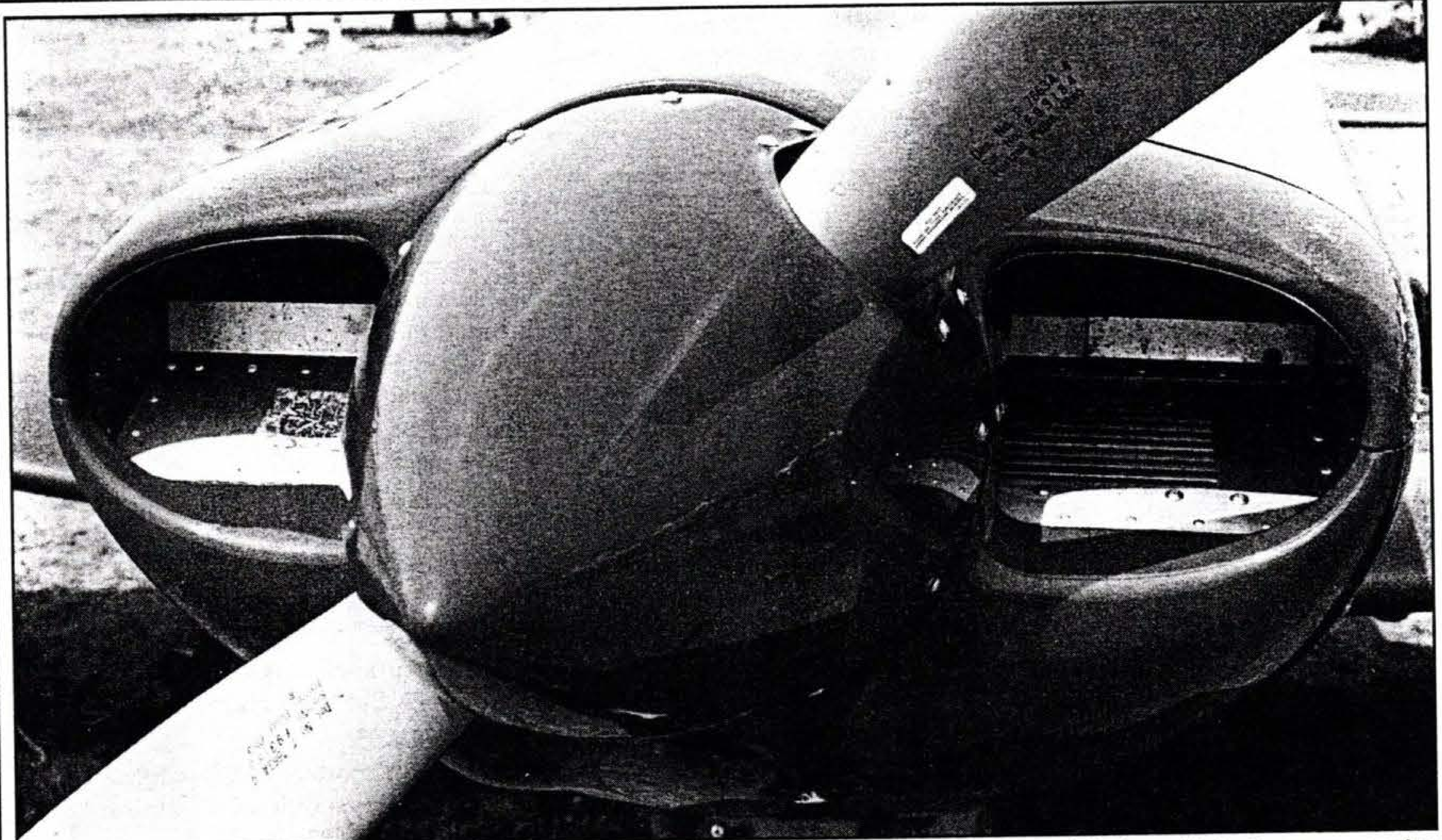
For example, the cowl inlet openings must also be smoothly rounded and, perhaps, located slightly below the thrust line to take advantage of a better transitional flow of air into the cowling when the aircraft is in a nose high climb attitude.

The smaller your cowling inlets, the faster the airplane will be. Unfortunately, if you cut down the inlet areas too much, the oil temperature will peak before you realize much increase in the airspeed.

Homebuilders have been using a simple formula for about 30 years to determine the size of the cowling air inlets. Simply multiply the hp by .35. For example, a 160 hp engine should have an inlet opening of 160 x .35 or 56 square inches. Since we normally have an opening on each side of the spinner (propeller), a 23.5 square inch opening on each side is necessary. This would give you a fairly small opening . . . approximately 3" x 8" with rounded corners. Larger air inlets in a high performance aircraft would merely result in so much useless cooling drag.



The generous width of the rubberized baffle sealing strips ensures that the cooling air entering the upper engine compartment will not escape (without contributing to the cooling of the engine) even when the cowling bulges slightly in flight.



Extra large cowling air inlets produce considerable cooling drag, especially if more cooling air is forced into the upper engine chamber than can exit out the bottom of the cowling. Of course, the larger the engine horsepower, the greater the volume of cooling air needed.

Finally, the air outlet areas should be somewhat larger than the total inlet area. The reason for this is that the outlet air will have been heated and expanded as it passes through the engine.

Of course, there is more to cowling design than this brief explanation would indicate.

If you feel yours is a cowl inlet/outlet problem I suggest you look up and read the article, "Cowling and Cooling of Light Aircraft Engines" by John Thorp in the November 1963 issue of SPORT AVIATION. A copy of the article can be ordered from the EAA Aviation Foundation's Boeing Aeronautical Library, 414/426-4800.

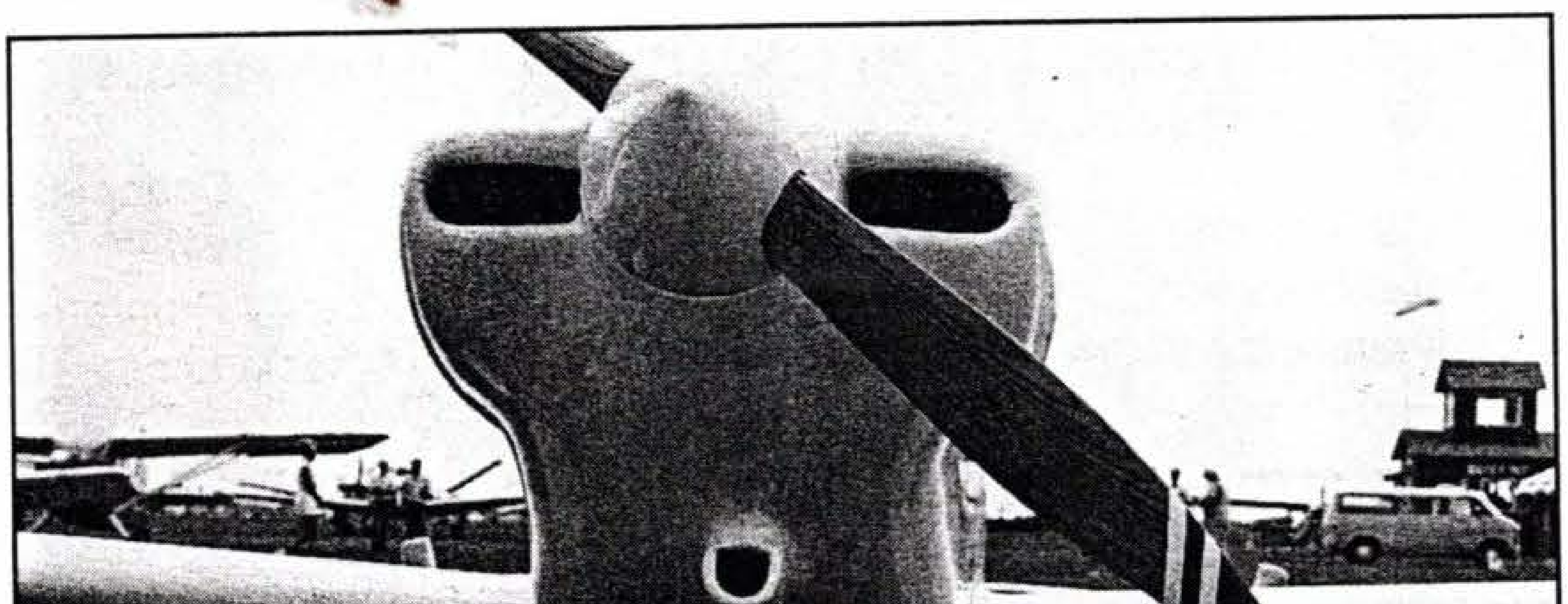
4. Check the baffles.

Your baffles must fit tightly so that all the air entering the upper engine compartment is forced through the engine where you want it to go.

Any air leaking past the baffles is not cooling the engine and is creating unnecessary cooling drag. Even gaps as small as 1/16" in the baffles, especially in the corners and adjacent to the crankcase, should be sealed with a high temperature (it's red) silicone adhesive (Permatex, Dow Corning, etc.).

Another baffle leak source area is along the top of the cowling. At cruise speeds the air pressure in the upper engine compartment is quite high. This might cause the cowling to bulge and allow the cooling air to escape between the cowling and engine baffling because the rubberized seal strips are no longer effective and air leaks past. Persistent high oil temperatures are the consequence.

On the ground the seal strips look effective but in flight they may not be. Double check this possibility.



If yours is a stock kit cowling, the inlet and outlet areas provided should be just about right for your engine installation. However, be sure your exhaust pipes, braces and other parts don't reduce the total effective area of the air outlets. The air outlet areas should be somewhat larger than the total inlet areas.

Examine Your Oil Cooler Installation

Your Lycoming needs an oil cooler to help keep the oil temperature within limits.

However, the oil cooler will cool the oil adequately only if it has a sufficient capacity and it is located where an adequate amount of cooling air can flow freely through the oil cooler's radiator fins.

Where your oil cooler is located is not as important as confirming that the cooling air can flow freely through it.

Engine compartments are quite crowded and sometimes the heated air exiting the cooler may be partially blocked or severely restricted. This will certainly inhibit the proper cooling of the oil and the engine.

The three most popular locations for the oil cooler are:

1. Up front somewhere in the front baffle deck.
2. On the left aft baffle. Occasionally you will find the cooler installed on the right rear baffle but the oil lines will have to be longer.
3. Remotely mounted, usually on the firewall.

The simplest and lightest installation is the one with the oil cooler mounted in the left rear baffle. A mistaken belief prevails that the cooling air reaching the oil cooler in this location will have been heated somewhat in passing over the cylinders. This is not so . . . not when there is a balanced flow of air through the cowling inlets and outlets.

Cowl Flaps?

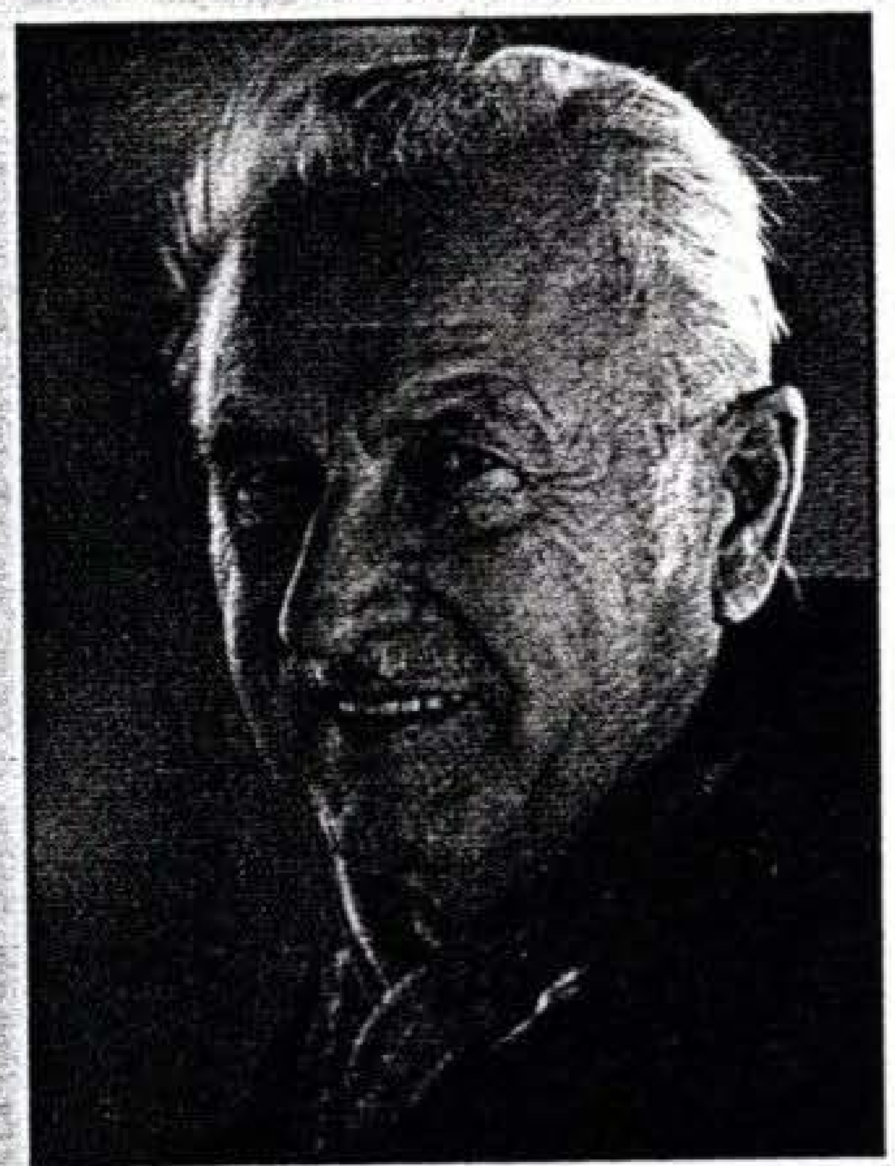
The cooling benefits realized from the installation of cowl flaps are the greatest for high performance aircraft. Without cowl flaps the engine temperatures run very high during climbs to altitude and tend to run very cool in cruise.

Cowl flaps provide a cockpit controllable low-drag variable cooling air outlet. They can minimize the high percentage of cooling air drag otherwise present in a clean fast airplane.

Cowl flaps result in a heavier, more complex installation. It also becomes necessary in most installations to disconnect the cowl flaps before removing the cowling. In spite of these minor annoyances, cowl flaps can be essential in controlling engine temperatures . . . especially on the ground, and during climbs to altitude. Furthermore, cooling drag at cruise can be reduced.

A newly overhauled engine will often run hotter the first few hours. If this situation is applicable, take this into consideration. If your oil temperature does not actually reach the redline in flight, you should be able to closely monitor the engine oil temperature's behavior for a few flights before undertaking more drastic measures.

Here is something else you should know about aircraft temperature gauges in general. Some are temperature compensated, some are not. What difference does that make? It could be quite significant. In fact, your engine may be running hotter (or cooler) than the temperature gauge indicates. Check that out, too.



If you wish to contact the author of this column for additional information, please send a SASE to Tony Bingelis, 8509 Greenflint Ln., Austin, TX 78759.

BOOKS BY TONY

The following books by Tony Bingelis are available from the EAA Aviation Foundation, EAA Aviation Center, Box 3086, Oshkosh, WI 54903-3086, 1-800/843-3612. Major credit cards accepted.

-Sportplane Builders (Aircraft Construction Methods, 320 pages) - $19.95

-Firewall Forward (Engine Installation Methods, 304 pages) - $19.95.

-Sportplane Construction Techniques (A Builder's Handbook, 350 pages) - $20.95.

Add $2.40 postage and handling for each publication ordered . . . or order all three for **$52.97 plus $6.95 postage and handling.** Wisconsin residents add 5% sales tax.