A FUEL SYSTEMS REVIEW

Most fuel systems in homebuilts have been surprisingly trouble-free. For the most part, more so than some builder-pilots.

Mechanical and fuel management problems do, of course, crop up, but no more frequently than they do in commercially produced certificated aircraft.

True, the average homebuilt fuel system is more likely to be simpler than that of a large or multi-engined aircraft. Nevertheless, I believe the homebuilders are producing some good reliable fuel system installations.

I attribute this success mostly to the technical guidance made generally available by the EAA for more than 40 years through its publications, forums, Technical Counselors, and the free exchange of information among member homebuilders themselves.

This dissemination and exchange of information has, in effect, resulted in a sort of standardization of amateur-built engine installations and in fuel systems in particular.

That is to say, builders today quickly learn what a good fuel system is and how to duplicate a proven system for their own aircraft.

Not too many years ago, this sort of information was quite scarce and the average homebuilder had to do his own research, and figure out for himself what he needed to install a functional fuel system.

He had to worry about what size fuel lines to install, about vented and non-vented fuel caps, about where and how to install fuel filters, and lots of other details that have since become common knowledge in homebuilder circles.

Here is an opportunity to check your own fuel system installation to see how it compares with current applications.

If your fuel system has been reliable and trouble-free, don't be too quick to change it unless you understand the need for doing so . . . after all, it could be that your way is better than those I'll be describing.

On the other hand, if you have not yet installed your fuel system, this will be a good time to make a few notes.

GRAVITY FLOW FUEL SYSTEM ESSENTIALS

A gravity flow fuel system is a good reliable one. It is simple and inexpensive to install providing you can obtain the necessary fuel head pressure with your installation (see Figure 1).

A few example aircraft using gravity flow fuel systems include the RV-3, T-18, Emeraude, Sonerai, the venerable Pietenpol, Kitfox and many other fine aircraft.

Here's what is needed for a gravity flow fuel system:

1. The fuel tank(s) in a gravity flow fuel system must be at a higher level than the carburetor to ensure adequate fuel flow. It is an ideal system for high wing aircraft but just about automatically rules out low wing aircraft with wing tanks.

2. Each fuel tank must be vented, otherwise the fuel will not flow. Usually some attempt is made to increase the head pressure on the fuel. For example, a curved tube facing the slipstream is sometimes soldered to the filler cap. This type of installation can be risky if the cap is improperly installed with the tube facing backwards. A better arrangement is to run the vent line from the fuel tank to some point below the fuselage. Its outlet opening, too,

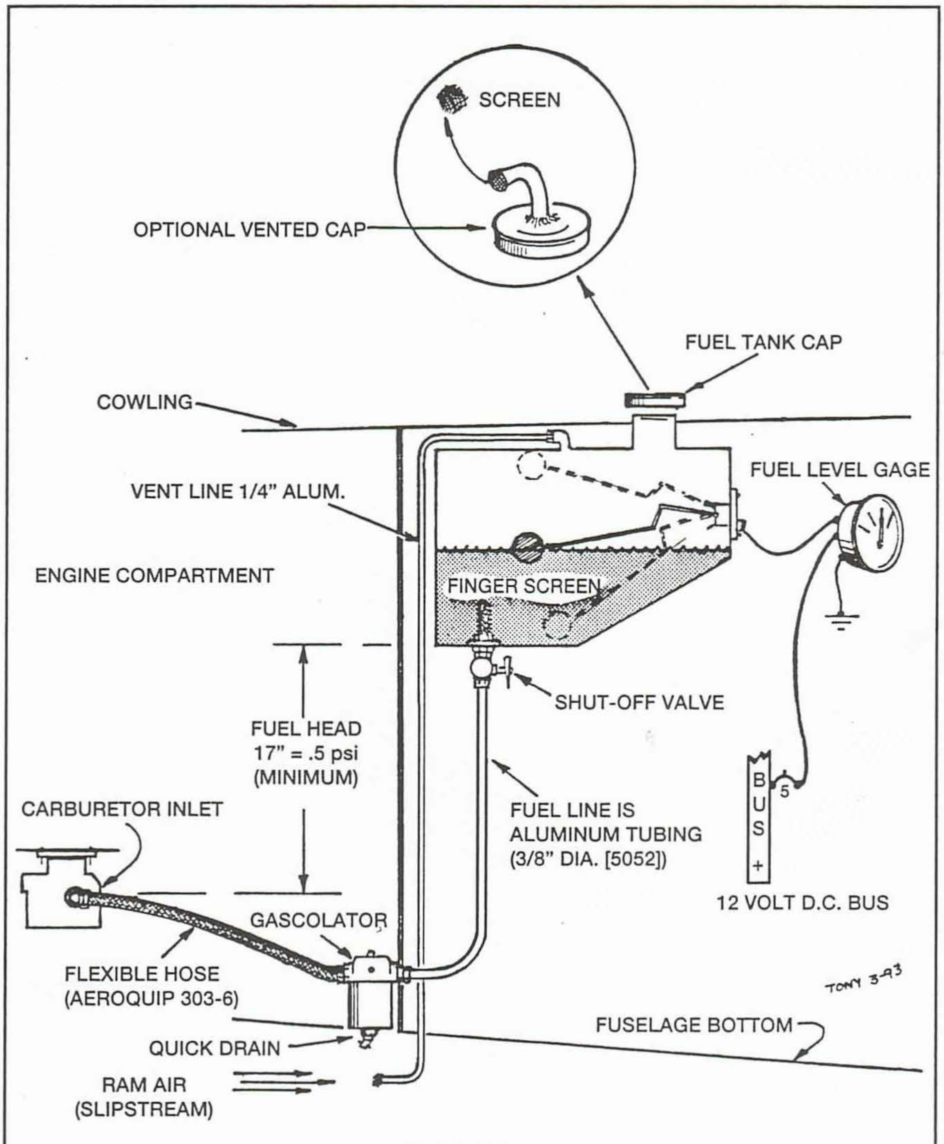


FIGURE 1
GRAVITY FLOW FUEL SYSTEM ESSENTIALS

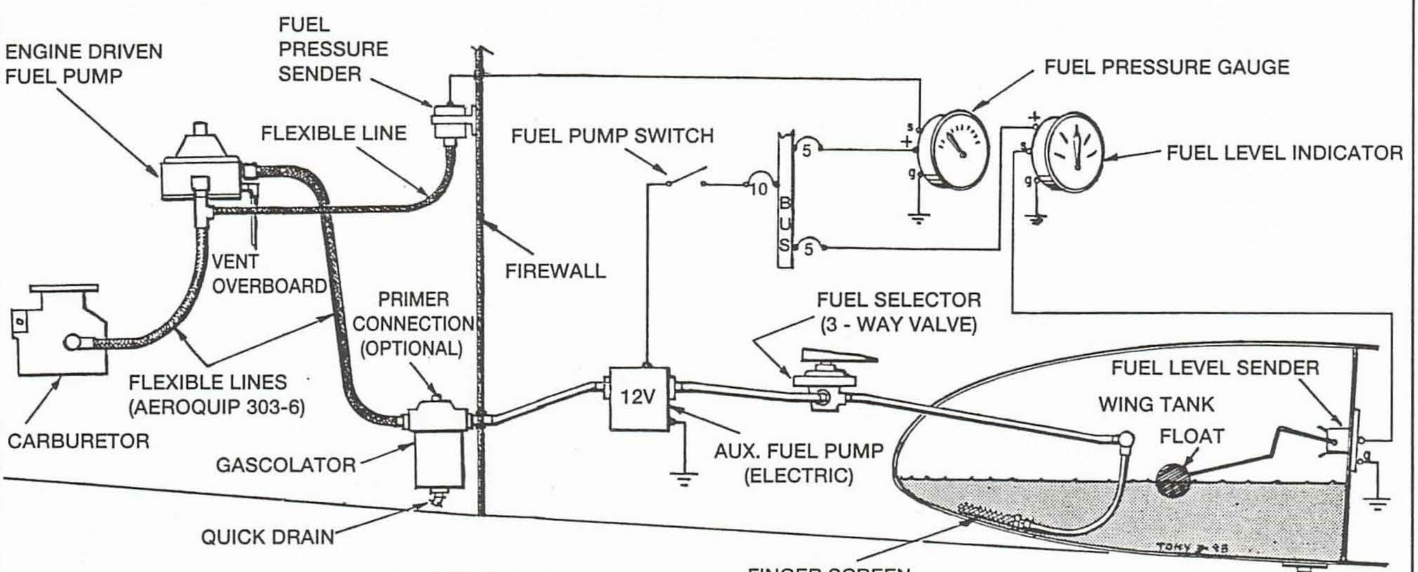


FIGURE 2
FUEL PUMP SYSTEM SCHEMATIC
(LOW WING INSTALLATION)

faces forward to take advantage of the ram air effect. The ram air, in effect, increases the fuel head pressure and helps gravity move the fuel to the carburetor.

3. A "finger screen" (about 16 mesh/in.) or a strainer of some sort, must be fitted into the bottom of the fuel tank at its outlet. Its function is to screen out debris and impurities which might have found their way into the fuel tank.

4. Next in line is a fuel shut-off valve for the fuel tank.

5. The rigid fuel line between the fuel tank and firewall is made of 5052-0 aluminum tubing and should be fitted with flared AN fittings. The minimum acceptable outside tubing diameter is 3/8". The fuel line will run downstream from the fuel tank shut-off valve to the gascolator.

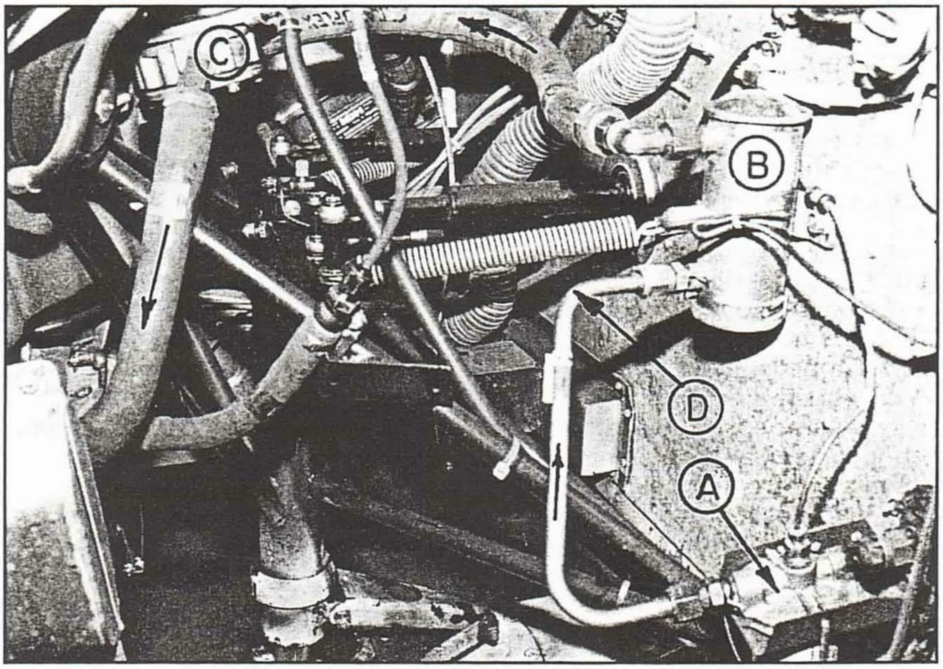
6. The gascolator is the second fuel strainer in the system. Its screen is finer than that of the finger screen (about 60 mesh/in.) and its job is to screen out smaller particles which may escape past the finger screen. Any water in the fuel will also settle to this point. The gascolator is mounted on the firewall in the lowest part of the fuel system, if possible, and should be fitted with a quick drain valve.

7. Because the engine moves and vibrates on shock mounts, a flexible fuel hose, such as an Aeroquip 303-6, must be used for the fuel line between the gascolator and the carburetor. Its minimum inside diameter is 3/8" and its size is identified as a -6.

8. A fuel quantity indicator (fuel gauge) of some sort for each tank is mandatory.

9. A primer pump may be installed as an aid to starting the engine . . . especially for cold weather starting where the temperatures are known to drop below 40 degrees F or so.

Incidentally, the third fuel filter, or screen, in the fuel system is the one located in the carburetor. It has the finest mesh of all (200 mesh/in.).



In this installation the electric fuel pump (B) is located downstream between the gascolator (A) and the engine driven pump (C). The use of an aluminum line (D) as shown is O.K. as both units are rigidly secured to the firewall.

FUEL PUMP SYSTEM ESSENTIALS

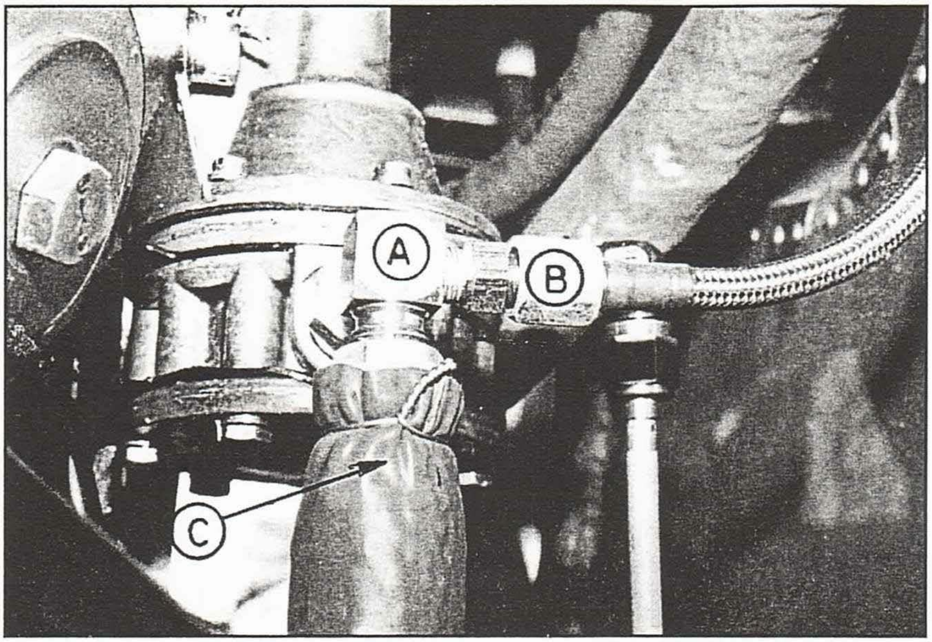
A few additional components over and above those required in a gravity flow fuel system will be needed:

1. An engine driven fuel pump becomes an essential part of the fuel system. The fuel pump becomes necessary when the fuel tank(s) cannot be installed high enough to ensure a reliable gravity flow of fuel.

2. Since the engine pump can fail, a back up pump, usually an electric self-priming pump, MUST also be installed.

3. A fuel pressure gauge is necessary for monitoring the fuel system pressure.

4. A fuel selector becomes essential when two or more tanks are installed.



The engine driven fuel pump outlet fitting (A) is drilled and tapped to provide a source for the fuel pressure line (B). Note how the ends of the firesleeve (C) encasing the fuel outlet line are secured.

These 4 items are in addition to the 9 essentials described for a gravity flow fuel system.

FOR A TROUBLE-FREE FUEL SYSTEM

1. Use new aircraft quality components, if possible. Even so, check each component and part to verify that it is free of defects and functions properly.

2. Route your fuel lines as directly as possible avoiding sharp bends, rises and descents. Keep them away from hot exhaust pipes. The fuel lines may slope up or down but should not have a sag or low point between connections.

3. Use aircraft AN type aircraft flare fittings. These flare fittings utilize a 37 degree flare angle. Automotive/plumbing fittings use a 45 degree flare. The two are NOT compatible and are NOT interchangeable. Mixing a brass automotive 45 degree flare fitting with the standard AN aircraft fittings will result in a great leak potential and, possibly, a failed flare in the tubing. AN aircraft aluminum fittings are blue (AN and MS specifications are the same). However, both aircraft and automotive brass and steel flare fittings look the same and are difficult to tell apart, so be very sure you know which is which.

4. Slip-on fittings secured with hose clamps may be all right for ultralights but should not be used in Certificated aircraft . . . this includes Experimental category aircraft as well.

5. Be sure, absolutely sure, that your fuel lines do not rub against any structure, sharp edges, or are routed where they can be stepped on or otherwise abused.

6. All your fuel lines from the firewall forward should be flexible hoses (Aeroquip 303 or equivalent) with standard aircraft quality fittings.

7. The gascolator should be mounted to some structure and not merely hung, unsupported, from the fuel line.

8. If the gascolator is not at the lowest point in the fuel system, it will function primarily as a fuel filter and not as a point where water will collect and can be drained. In that case, the bottom of each fuel tank should have its own quick drain where you can check for the presence of water in each tank.

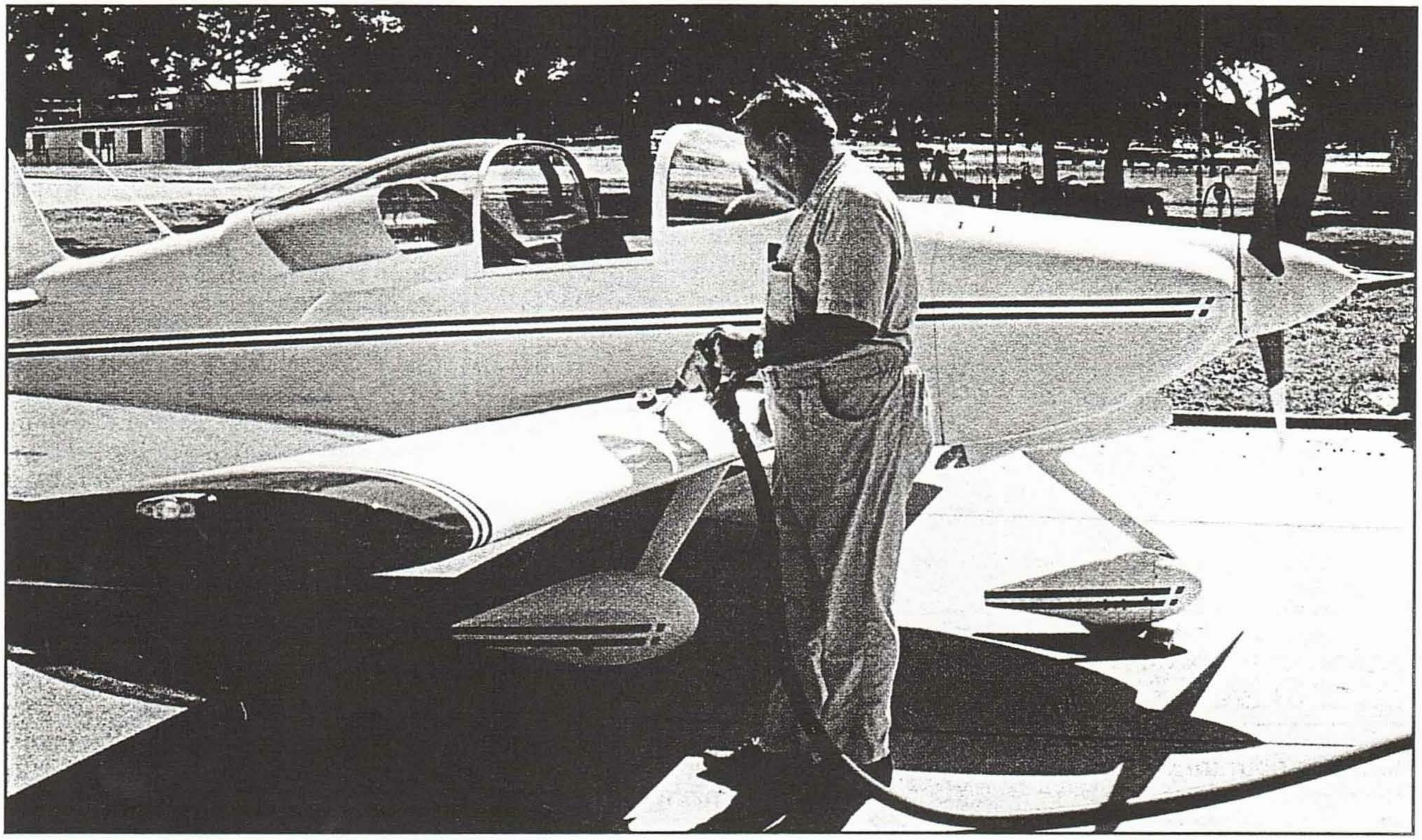
9. In a fuel pump type system, make your connection for the fuel pressure line at some point between the engine pump outlet and the carburetor inlet using a restrictor type fitting to minimize the loss of fuel in the event of a failed hose.

10. If you use direct reading pressure gauges for the oil pressure and fuel pressure, remember you are introducing hot oil and volatile fuel into the cockpit area. Should a leak in either develop you will have an untenable situation in the cockpit.

Electric gauges, although more expensive and complicated, are worth the peace of mind they afford.

11. A primer pump is not gener-

This primer line installation is properly fabricated and well secured, although the brackets could be smaller and lighter. Note the classical 2" loop in the 1/8" copper lines to absorb vibration and enhance the service life of the tubing.



If you allow someone else to refuel your airplane, it would be wise to visually verify the fuel level and to reinstall the fuel cap yourself.

ally required with a Lycoming installation as the Marvel carburetor has a built-in accelerator pump that squirts fuel into the carburetor throat when the throttle is "pumped." It's not as good as a primer pump but it is quite effective in temperatures above freezing . . . say, above 40 degrees F.

Well, so much for the basic fuel system installation.

Now, what about the various fuel system problems we hear about so often?

FUEL STARVATION

Fuel starvation, at the very least, means a forced landing or, worse, a crash landing which may or may not be fatal. There are a number of causes for this problem. The most mortifying being that the pilot simply allows the engine to run out of fuel.

Why in the world would any pilot allow such a thing to happen? Well, it is never intentional. And seldom is it due to mechanical failure.

So, who or what is to blame? Believe it or not, sometimes the fuel system installation or the design of the individual component parts may trick the pilot into jumping to the wrong conclusion or taking the wrong corrective action.

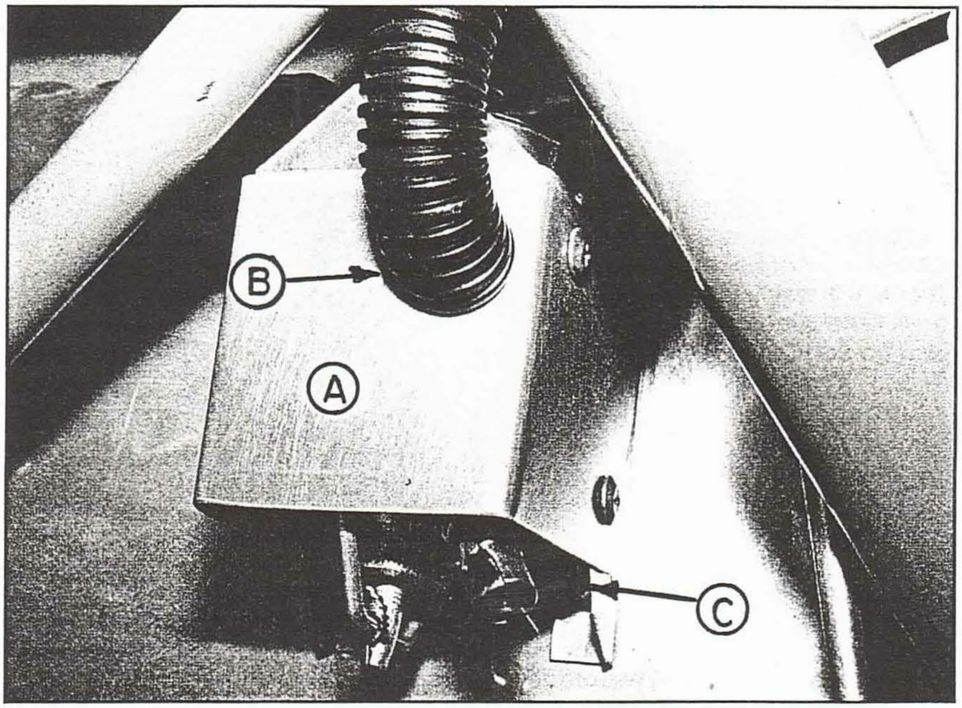
Here are the most frequently cited causes for fuel starvation:

1. Taking off without knowing exactly how much fuel you have on board. This is foolhardy and, besides, it is against regulations.

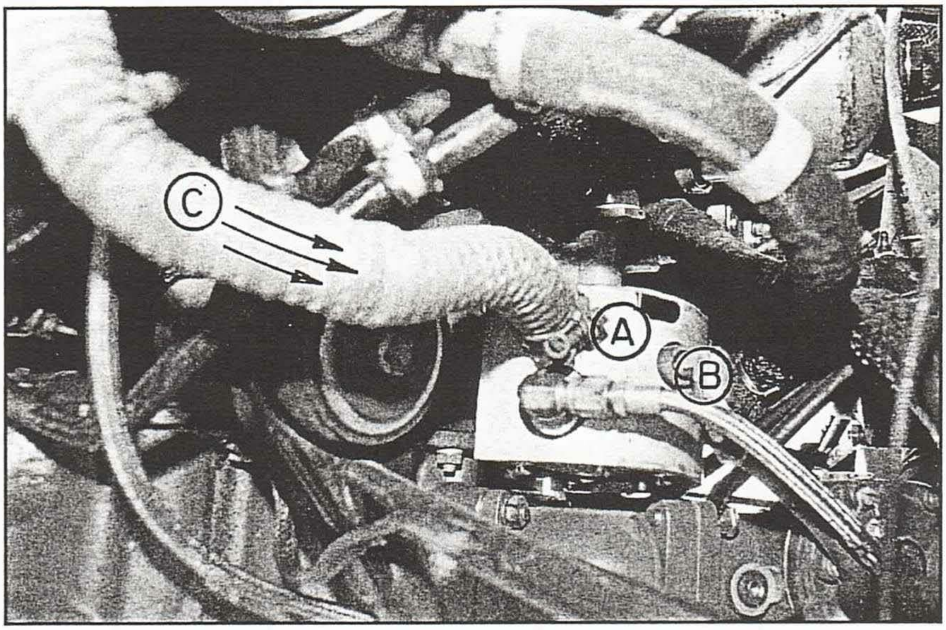
Your preflight should include the removal of the fuel cap(s) for a visual check for the presence of fuel and its level. Verify your eyeball calculation with a dipstick reading (provided you had the foresight to make and calibrate one in the first place).

2. Believing your fuel gauges. You can't rely on fuel gauges. Most of them are inaccurate, at best . . . and like other instruments they can fail to function when you need them the most.

NOTE - I log my tach time when I refuel. Then, before each following flight I check the hours flown since refueling. Knowing that I burn 8 gal-



This gascolator is protected from the engine heat with a simple aluminum cover (A) into which cool air from the rear engine baffle is fed through the ducting (B). The quick-drain valve (C) is more useful if it can be reached from outside without having to remove the cowling.



Encasing the engine driven fuel pump in a simple aluminum shield is another way to help minimize fuel vapor problems in the fuel system. Cooling air is ducted in through (C). (B)? . . . that is the engine driven fuel pump's overboard vent.

lons per hour (or whatever), I start looking for a gas station after I have flown 3 hours. My tanks hold 38 gallons. Too conservative, you say? Go ahead and say it . . . but don't try to confuse me with high tech mathematics.

3. The fuel selector valve has caused many an engine-out situation.

For example . . . after the fuel selector is installed, initially its operation should be viewed with suspicion. What if the handle was installed so it points to the wrong tank? Also, the design of the handle may make you wonder which end is really the pointer. Or worse, what if it is really off and not on any tank position? To play it safe, run the engine long enough on each tank position to allay all doubts. Anytime you have to remove the fuel selector handle, mark it so that it can be reinstalled with the correct alignment. Some handles can go on only one way. Hopefully, that is the way yours is.

4. The pilot forgot to switch tanks and couldn't restart the engine.

5. The fuel tank vent was plugged. Fuel cannot flow if the vent or vent line is plugged with insect larvae accumulations.

You can verify that your fuel tank vent is clear by slipping a short length of plastic tubing over the vent outlet and blowing in it to see if the vent is open.

6. Carburetor ice can do a good job of starving your engine for fuel.

7. Vapor lock is another form of fuel starvation. Due to the formation of vapor and foam bubbles in the fuel lines, insufficient fuel reaches the engine to keep it running even though there is plenty of fuel in the tank.

Hot weather combined with high engine compartment temperatures can be conducive to the formation of vapor lock in the fuel lines.

You can minimize the risk of vapor lock taking place in your fuel system by:

a. Enclosing the gascolator in a simple aluminum enclosure (shroud) and ducting cooling air through it.

b. Enclosing the engine driven fuel pump in the same manner. The cooling air can be taken from the rear engine baffling.

c. Enclosing engine compartment flexible fuel lines in firesleeves. These will help protect the lines against the high engine compartment temperatures.

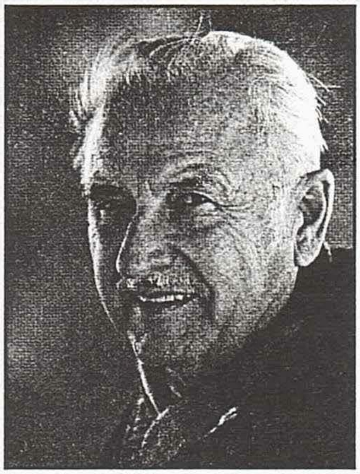
d. Protecting fuel lines that pass close to an exhaust stack with simple aluminum heat shields.

The FAA seems to believe that fuel starvation and the forced landing, or crash, that follows are brought on by a lack of proficiency, a lack of familiarity with the fuel system, a lack of attention, a lack of good judgment, or all of the above. In short, except for a few instances of mechanical failure, they are quick to assume that fuel starvation mishaps are due to pilot error.

IT'S TRUE

Finally, if the engine quite, immediately switch to the other tank . . . if you have one. A logical procedure, if you stay calm, cool and collected, isn't it? Maybe that tank has fuel and/or its vent is not plugged.

Would it surprise you, however, to learn that there have been pilots who have experienced engine failure due to fuel starvation, made a forced landing, or a crash landing, only to be informed later by the FAA that they found evidence that the other tank still had fuel at the time of the incident?



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