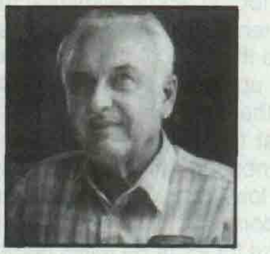
SPORTPLANE BUILDER

Tony Bingelis



THE BASIC FUEL PUMP SYSTEM

A gravity flow fuel system will not work in many aircraft designs — especially in most low wing types. As you know, a fuel pump system must be used whenever the fuel tanks cannot be installed high enough above the level of the carburetor to take advantage of gravity and the simple, efficient, gravity flow system.

Does that infer, then, that a fuel pump system is more complex than a gravity flow system? Yes, indeed, unfortunately.

We know that man's best efforts can never equal nature's simplicity and efficiency. Therefore, it's not surprising that the seemingly simple solution of adding a fuel pump only partially copes with the problem of delivering fuel to an engine without the help of gravity. Gravity never fails but fuel pumps do. So, to protect yourself from that eventuality, you will have to add a back-up pump of some sort.

Now you have two pumps — but how do you know how well they are working? That's right, you must also install a fuel pressure gauge, or a fuel flow meter (which in reality is nothing more than a fuel pressure gauge) to give you that information.

There you have it — just a hint of the added complexity that sets a basic fuel pump system apart from a gravity flow fuel system.

The Basic Fuel System Components

In all respects, the fuel pump system is quite similar to the gravity flow system. Both systems begin at the fuel tanks.

Fuel delivery starts as the fuel passes through a finger screen protected outlet in the bottom of the fuel tank. From the tank, the fuel flows through an aluminum line (at least 3/8" in diameter) to a conveniently located fuel selector valve in the cockpit.

After passing through that tank selector valve, the fuel heads for the main filter, better known as the "gascolator."

The gascolator is generally located on the firewall and should be the lowest component in the fuel system. It is always fitted with a quick drain valve so that the entire fuel system can be drained at that point. The gascolator also provides a convenient means for draining some fuel to check for the presence of water during your preflight inspection. The quick drain should be easily accessible without having to remove any cowling or covers.

Incidentally, has it ever occurred to you that when you drain fuel out of the gascolator to check for water, you are only checking the tank that the selector is set on? If you want to check any other tank, you must change the selector setting and drain some more fuel. Right?

After the filtered fuel passes through the gascolator, it enters, or bypasses, a back-up pump. This unit is usually an electric pump but could also be a hand-operated wobble pump.

Finally, the fuel reaches the heart of the fuel pump system — the engine driven pump. This mechanical engine driven pump is bolted directly to an accessory pad on the engine crankcase from whence it delivers the fuel under pressure to the fuel injector or carburetor.

NOTE: It is important to know that, although your engine driven pump is the primary source of fuel pressure, a back-up auxiliary fuel pump is a mandatory installation for aircraft manufactured under an Approved Type Certificate. Certainly, your own amateur-built aircraft should be likewise equipped.

Since these fuel pumps must provide sufficient pressure to move the fuel from the tank(s) to the carburetor or fuel in-

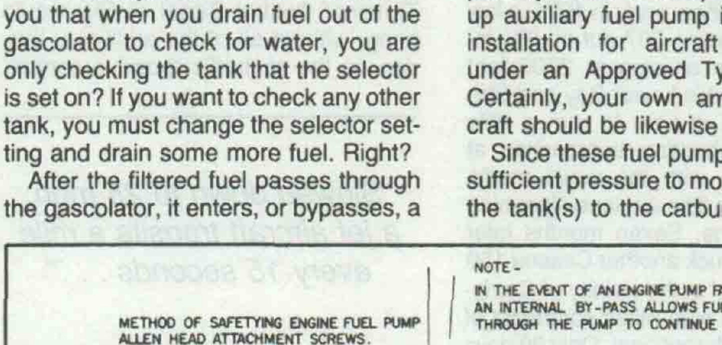


FIGURE I.
ENGINE FUEL PUMP INSTALLATION
AC DIAPHRAGM TYPE (TYPICAL)

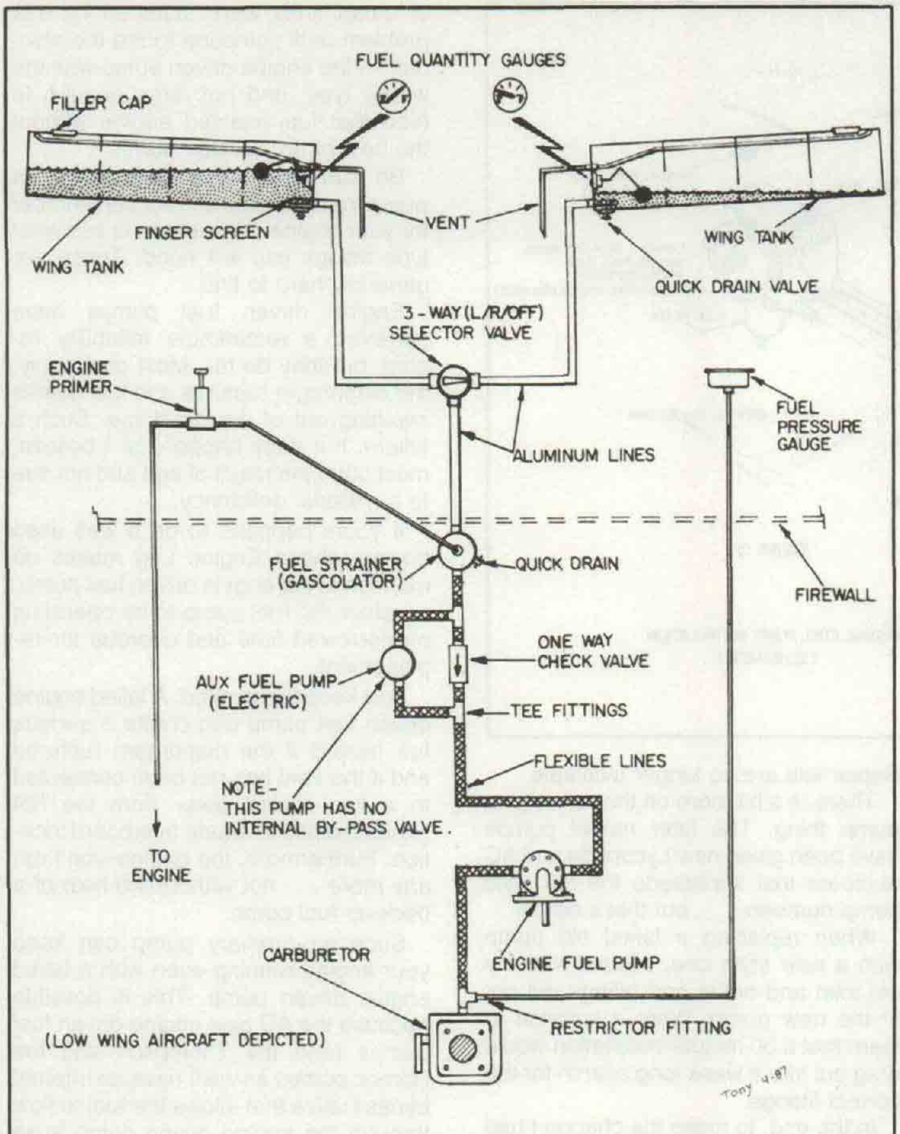
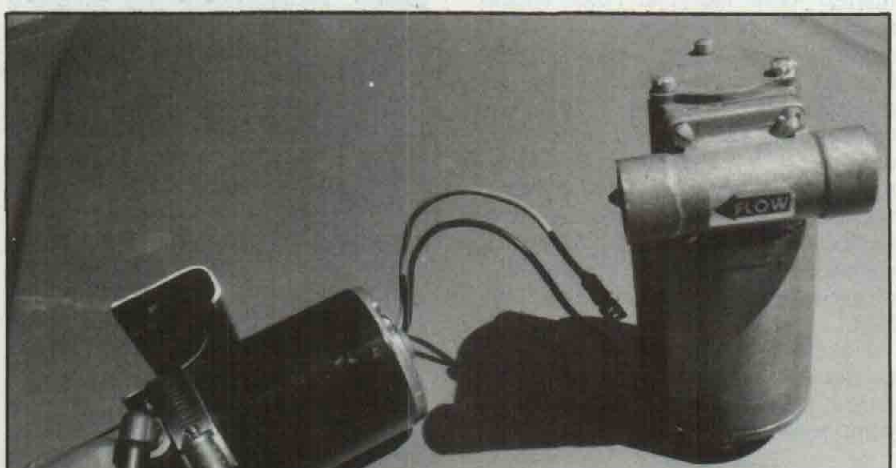


FIGURE 2.

FUEL PUMP SYSTEM SCHEMATIC

(A PARALLEL PUMP INSTALLATION)



jector, it is obvious that you should have some way of knowing that the required pressure is being produced. As already pointed out, this little matter is taken care of with the installation of a fuel pressure gauge.

The added complexity of the fuel pump system, compared to the gravity flow system, will become more apparent to you after you start your installation. Let's see what is involved.

The Fuel Pressure Gauge Installation

The fuel pressure gauge you install must be calibrated to accommodate the fuel pressure range for your system. For example, a fuel injector operates with a normal fuel pressure of approximately 24 psi while a pressure type carburetor will not require more than 15 psi. A conventional float type carburetor requires even less pressure to operate efficiently . . . about 5 psi. So you see, you should install a gauge that will read high enough for your installation. On the other hand, a fuel pressure gauge capable of registering a much higher pressure than that needed for your installation may not be as accurate as a gauge calibrated for a lesser fuel pressure range.

There is one more consideration. The typical individual fuel pressure gauge will be either 2-1/4" or 2-1/16" (automotive type) in diameter. Better check your gauge size before cutting that instrument panel hole. Fuel pressure gauges are also available as part of an "instrument cluster." These are quite popular and are used by most aircraft manufacturers. The choice is yours.

Installing a fuel pressure gauge is fairly simple. After the gauge is mounted in the instrument panel, or in some other more convenient location if need be, the instrument is connected to the carburetor or fuel injector by an aluminum tube using standard AN fittings. Since the line will be full of raw fuel all the way from the carburetor to the cockpit panel, it would seem prudent to use tubing of a smaller diameter than that used for your main fuel supply lines. After all, only pressure is being measured, and that has nothing to do with the flow of fuel to the engine. A 1/4" or even a 3/16" aluminum line should, therefore, suffice. Connect the fuel pressure line, using a restrictor type fitting, to the port in your fuel injector or

Both of these are high pressure auxiliary fuel pumps intended for installation in a fuel injected engine. The pump on the left has no internal by-pass valve and must be installed in parallel with the engine driven pump. The pump on the right has an internal by-pass and can be installed in series with the engine driven fuel pump. Which would you use?

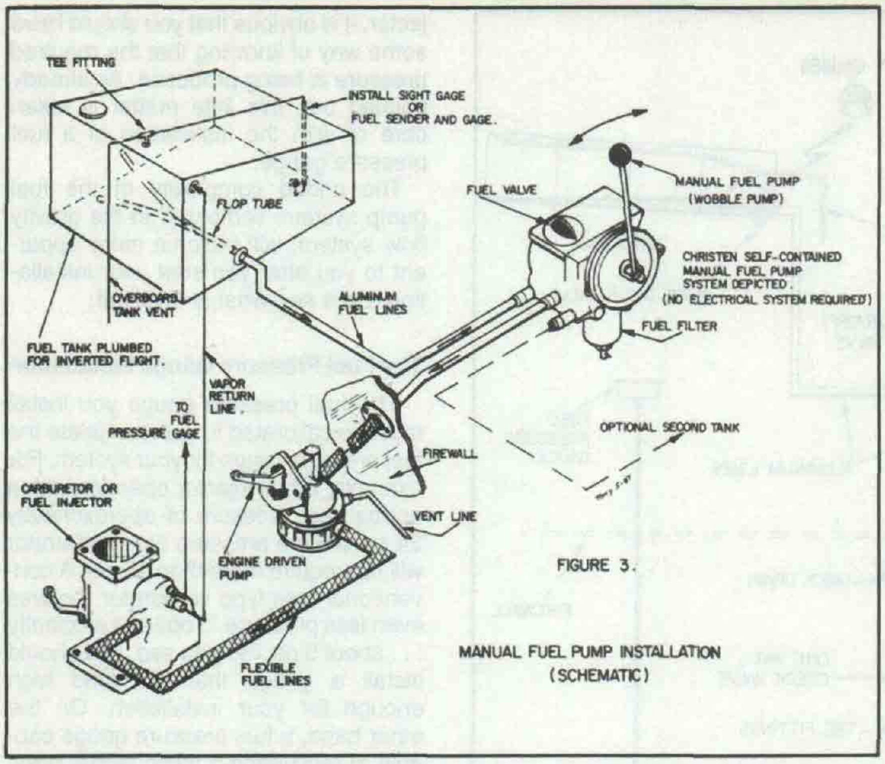


FIGURE 3.

MANUAL FUEL PUMP INSTALLATION (SCHEMATIC)

carburetor housing provided for that purpose.

While you would normally use an aluminum line from the fuel pressure gauge to the firewall bulkhead fitting, the fuel pressure line inside the engine compartment (from the firewall to the fuel injector or carburetor) should be a flexible aircraft hose fabricated with standard metal fittings (see Figures 2, 3 and 4).

In my opinion, plastic hoses and slip-on fittings secured with clamps or wire twists, have no place in the primary fuel or oil system — especially, inside the engine compartment.

Your Engine Driven Fuel Pump

During all normal engine operations, the engine driven (mechanical) fuel pump automatically delivers the fuel at the proper pressure directly to the nearby fuel injector, or carburetor as the case may be.

The well known AC diaphragm-type aircraft fuel pump is considered to be the industry standard engine pump for most small aircraft engines. It is a self-priming type pump with specially developed diaphragms that seem to be unaffected by the various exotic chemical properties making up fuels these days (see Figure 1).

Not many moons ago, the AC folks decided to cancel production of their fuel pump repair kits because too many fuel pumps were being improperly repaired. They figured that the cost difference between the repair of an old pump and the installment of a new one was not worth the problems being encountered. So, forget about overhauling your old AC type engine driven fuel pump. Repair kits are no longer available.

There is a bit more on the AC engine pump thing. The later model pumps have been given new Lycoming and AC numbers that supersede the old style pump numbers . . . but that's not all.

When replacing a failed old pump with a new style one, I found that my old inlet and outlet port fittings did not fit the new pump. What a surprise to learn that a 30 minute installation would drag out into a week long search for the correct fittings.

In the end, to make the change I had the unwelcome choice of purchasing special Weatherhead — or Lycoming engine pump fittings — complete with "O" rings (see Figure 1).

When the correct engine driven fuel pump is installed, it will discharge (pump) more fuel than your engine needs . . . actually the pump should be capable of providing a minimum fuel flow of 125% of that required for maximum take-off power. This excess capacity will not be a problem in the operation of your engine as an internal relief valve — factory adjusted to deliver the fuel at the correct pressure for a particular carburetor or fuel injector installation — prevents the development of excessive fuel pressure at the fuel inlet.

I know of an instance where the builder was unable to maintain cruise engine power unless his electric boost pump was turned on and running. A lot of smart folks were stumped by this problem until someone found the obvious — the engine driven pump was the wrong type, and not large enough to feed that fuel injected engine without the help of an auxiliary pump.

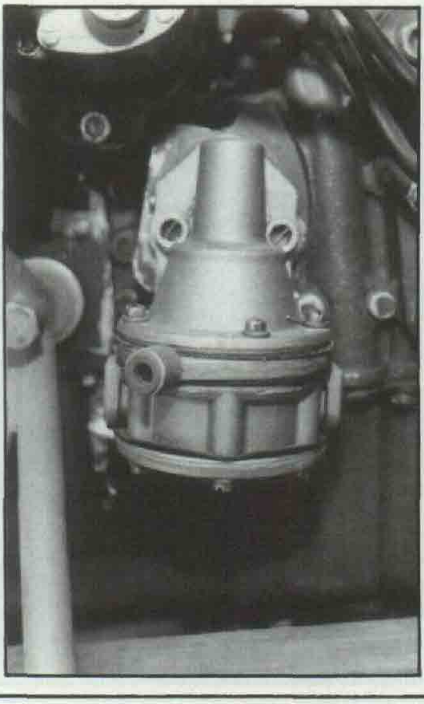
Be sure when you do buy a new pump that it has the correct part number for your engine. Also, check to see what type fittings you will need. These are generally hard to find.

Engine driven fuel pumps have achieved a remarkable reliability record, but they do fail. Most commonly, the diaphragm ruptures and fuel comes squirting out of the drain line. Such a failure, if it does happen, is, I believe, most often the result of age and not due to a material deficiency.

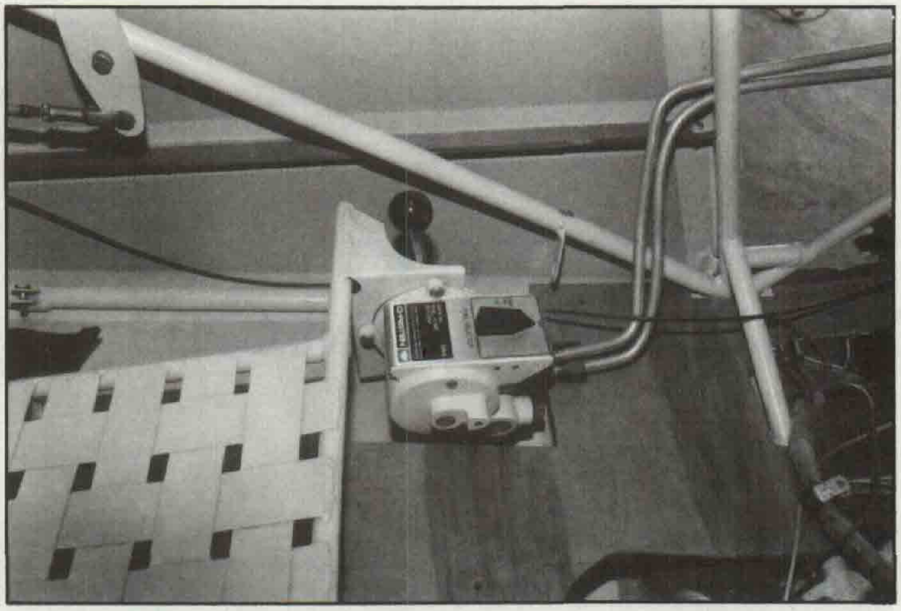
If yours happens to be a well used engine whose Engine Log makes no mention of the engine driven fuel pump, consider the fuel pump to be operating on borrowed time and overdue for replacement.

Just keep this in mind. A failed engine driven fuel pump can create a serious fire hazard if the diaphragm ruptures and if the vent has not been connected to a line routed away from the hot exhaust pipes to a safe overboard location. Furthermore, the engine won't run any more . . . not without the help of a back-up fuel pump.

Such an auxiliary pump can keep your engine running even with a failed engine driven pump. This is possible because the AC type engine driven fuel pumps (and the Thompson and the Romec pumps as well) have an internal bypass valve that allows the fuel to flow through the engine driven pump even after it has failed. Without this provision, the installation and use of a back up pump would be greatly complicated.



A rare view of an AC diaphragm engine driven fuel pump uncluttered by the usual hoses, controls, and wires that virtually hide the pump from view. Note its general location on a Lycoming O-320 engine.



The wobble pump, when installed, should be conveniently located on the left side in the cockpit where the pilot can easily reach and operate it. A wobble pump provides back-up pump capability even though the aircraft may not have an electrical system.

Back-Up Pump Options

A back-up by any other name may be an auxiliary pump, boost pump, electric pump or even a wobble pump. They all serve the same purpose — that of helping the engine driven pump or, in extreme cases, taking over its function completely.

The auxiliary fuel pump is usually powered by a self-contained electric motor which is pilot controlled by a switch on the instrument panel.

An auxiliary or boost pump can be used for a number of important functions, such as:

1. Priming a fuel injected engine prior to start-up.
2. Restoring fuel flow to the engine any time the engine driven pump fails or is unable to maintain adequate fuel flow.
3. Being used to suppress vapor formation tendencies, particularly at altitudes above 10,000 feet.
4. Helping to restart the engine after the guy flying your airplane has allowed one of your fuel tanks to run dry.
5. Using the boost pump as a safety precaution during take-offs and landings.

The back-up pump when installed is most commonly mounted in line (in series) with the engine driven pump (see Figure 4).

Now hear this, amigo. To be installed in this manner, the boost pump MUST have an internal by-pass valve which will allow the fuel to pass through the boost pump whether or not it is turned on.

Should you install an electric boost pump without an internal by-pass valve in series with the engine driven pump, anytime you turn off that boost pump all fuel flow to the engine driven pump will be blocked. In other words, the engine will quit because no fuel can pass through that type boost pump unless you keep it turned on.

Many of the small low pressure electric pumps used by builders for carburetor equipped engines do not have internal by-pass valves. These pumps, when installed to supplement the engine driven pump, must be installed in parallel with the engine pump. Depending on the installation, a parallel system may also require the incorporation of one or more one-way check valves to insure that the fuel flows only toward the engine and not escape back to the tank while the electric pump is running. At any rate, a parallel system will always be more complex than an inline installation (see Figure 2).

The Wobble Pump

Sport aerobatic pilots prefer their back-up fuel pump to be the classic wobble pump type. Its basic functions, such as aiding in starting the engine and maintaining fuel pressure on demand, is similar to an electrical auxiliary pump except that it is operated manually by the pilot . . . and requires no electrical system.

The installation of a wobble pump is like that for any of the other boost pumps having an internal by-pass. That is, it, too, can be installed in series in the main fuel line to the engine (see Figure 3).

The old WW-II surplus D series wobble pumps are getting in scarce supply and are being replaced by the superior new Christen manual fuel pump.

The Christen manual fuel pump installation is much lighter and contains a fuel valve, fuel filter and fuel pump packed into a single compact unit. If you are equipping your airplane for aerobatics, undoubtedly this is the way to go.

Vapor Problems

Protect your fuel system from excessive exposure to engine heat and you will, to a large extent, reduce the potential for vapor lock problems.

This is not easy to accomplish because the engine compartment housing most of your fuel system components is not unlike a hot box or furnace. Then, too, the engine driven pump is picking up extra heat from its physical attachment to the engine. As a consequence, the fuel pump can get hot enough to percolate the fuel.

Some manufacturers, and many builders, too, significantly reduce the heat by enclosing the engine driven fuel pump in an aluminum shroud open at the bottom. A duct from the rear engine baffle pipes cool air into an opening in that shroud to cool the pump.

Other measures that can be taken include encasing all of the flexible lines in

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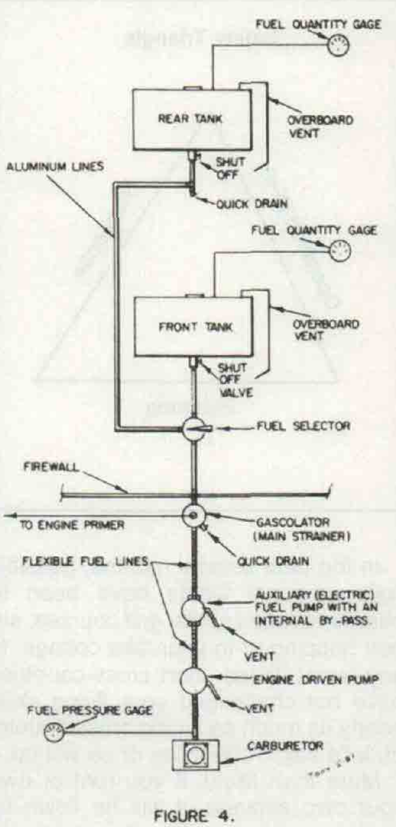


FIGURE 4.

PUMP-FED FUEL SYSTEM
(A PUMPS-IN-SERIES INSTALLATION)

TABLE 1

TAKEOFF DATA

PA Pressure Altitude ______	Landing Weight ______
Runway Length ______	Air Temperature ______
T/O Weight ______	Wind ______
Takeoff Power ______	
Takeoff Run ______	
Vx-Vy ______	
Va ______	
Landing Distance ______	

Perform Weight and Balance: Yes ______ No ______

CRUISE DATA

Pressure Altitude	Air Temp. ______	Wind ______
Weight	Power ______	Icing Level ______
KIAS	KTAS ______	
Fuel Rate	Flight Altitude ______	
Fuel Required ______		

FUEL REQUIRED	**Time**	**Fuel**	**Distance**
Runup and Taxi			
Climb			
Cruise			
Descent			
Approach			
TOTAL			

LANDING DATA

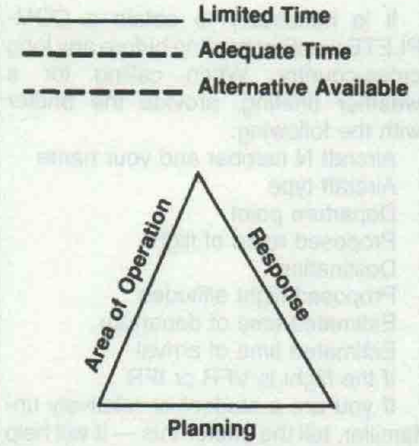
VFR/IFR APP	Runway ______	Wind ______
Ceiling	Vis ______ Altitude	Temp. ______
Weight	Vref ______	Landing Dist. ______

and fly a radial from a nearby VOR to find the alternate. Know how to navigate by both dead reckoning and pilotage.

Let's look at some other possible alternatives you might *need* to face. In serious situations, revising of your original plan could result in returning to the point of departure, an unscheduled enroute landing or a change of destination. The options are dependent upon the situation and no standard course of action is possible. Flight planning, prior to take-off on a long cross-country must include **all** possible complications and/or emergencies. Always plan for any contingencies and/or alternatives.

A well-organized cross-country flight should be systematically organized in a practical manner to include all necessary information for a safe flight from Point A to Point B. It is important for you as PIC to consider this or a similar systematic approach starting with preflight planning, followed by your personal area of operation (cross-country) and your **response** to alternative choices required during the flight.

Planning Area of Operation Response



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"firesleeves", not so much to protect the lines from an engine compartment fire as *to protect them somewhat from* the heat in the engine compartment. The gascolator, too, often is installed with a metal shroud around it for the same reason.

Depending on the type equipment installed, a vapor return line back to the fuel tank(s) may be utilized with a continuous flow type of fuel injector system (see Figure 3).

For the smaller fuel injected engines, the primary means for coping with vapor lock tendencies is to turn on the boost pump to insure a positive flow of cool fuel through the system.

I'm sure that, as a serious builder, you realize that we have only touched on the more important basic essentials for a fuel pump system, and that your own installation has to be made to suit your airplane — engine and fuel metering device (fuel injector or carburetor, that is) — and the kind of components you intend to install.

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