THE SPORTPLANE BUILDER

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FUEL TANKS . . . COMPONENTS AND ACCESSORIES

Part II

IT DOESN'T MATTER what your tank is to be made of or how it will be made . . . all fuel tank components are uniformly similar. The components we speak of are filler necks and caps, finger screens, vents, shut-off or selector valves, aerobatic flop tubes, quick drains, fuel quantity indicators and floats. Not really a fuel tank component but an essential accessory to any tank installation are the tank straps and installation hardware.

Depending upon the complexity of your airplane fuel system, you will be concerned with the proper location and installation of most of these components regardless of whether your tanks will be made of fiberglass, aluminum or some other material.

Filler Neck and Cap

We generally assume that the filler neck and cap will be built into the top of the tank. Filling a tank in a homebuilt from below would be difficult although not impossible if you would prefer to emulate airline practices.

A filler neck should have a large enough diameter to easily accommodate the standard fuel hose nozzle used at most airports. This means the opening will be at least 1½" in diameter. Anyhow, that size provides a little peeking space when the nozzle is inserted, besides that is the sized opening of most stock filler neck units sold to builders.

Fuel filler caps are either vented or non-vented and you must be aware of the difference. They can also be of the type that screws on to the top of a filler neck of some length or be of the type that is secured to a low profile or flush adapter assembly. Then, too, there are the flush-fitting variety as well as the familiar pressure fuel cap kind that looks like it might have been appropriated from someone's thermos bottle.

A fuel tank fitted with one of those long necked filler caps sticking out of the cowling of a biplane may look natural and in keeping with the design atmosphere for the airplane. However, the same type filler neck, with

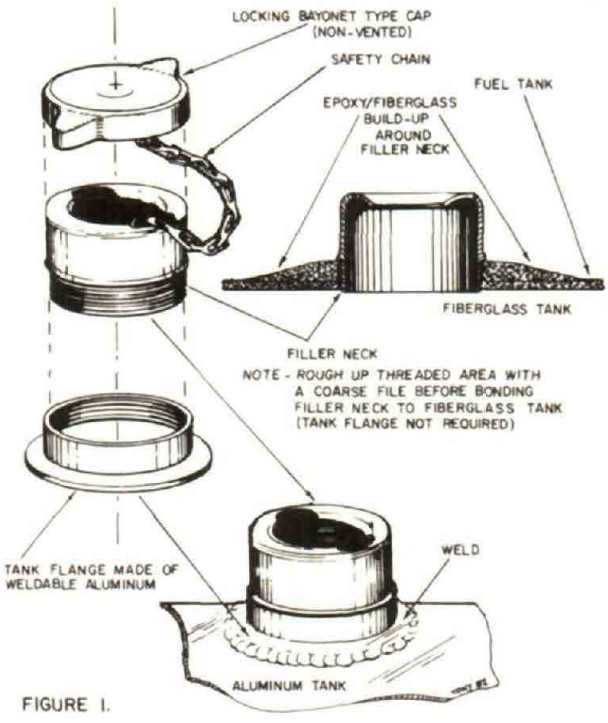
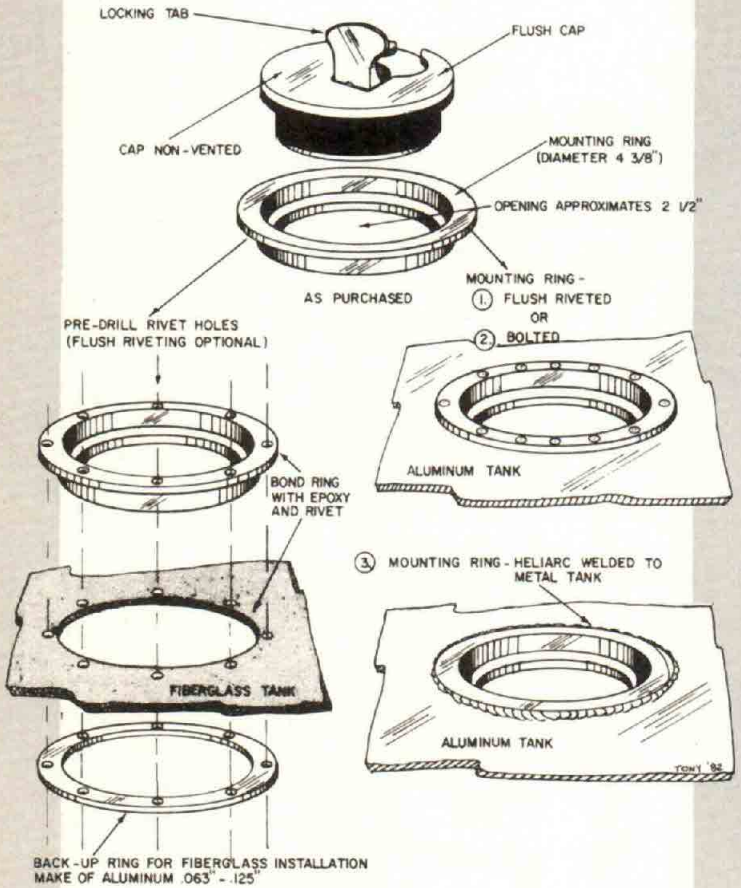


FIGURE 1.

TYPICAL PROTRUDING FILLER NECK ASSEMBLY



FLUSH FUEL CAP ASSEMBLY
(INSTALLATION METHODS)

FIGURE 2.

cap perched on top, would look very much out of place on an advanced concept airplane like the Dragonfly, Long-EZ, or, yes, even a Falco. Not only does a protruding filler neck create drag, it spoils the appearance of an otherwise clean (streamlined looking, that is) airplane.

Installing a flush type fuel cap assembly in a fuel tank is no more difficult than installing the protruding neck variety. It, too, may be welded or riveted to an aluminum tank or bonded with epoxy and glass cloth to a fiberglass tank. Where the extra work comes in is when you have to build an access door in the fuselage or wing skin for it. In addition, a small corral needs to be built up around the filler opening to keep overflow fuel, during servicing, from leaking into the aircraft. This little compartment must seal perfectly and be fitted with a drain overboard. The extra effort is generally worth it.

When deciding on the exact positioning of the filler opening you should visualize the aircraft in its normal ground attitude. Place, or locate, the filler opening on the high point of the tank as it rests in that attitude. This will minimize the likelihood that your fuel will seep out of a full tank on a hot day. Ah, you say the fuel would, more likely, leak out the vent line? True, if a vent line were installed. But what about an installation where the vent is in the filler cap?

Vents

Most aircraft fuel systems are vented, either through separate vent lines from each tank, or less frequently, through vented fuel caps.

The vented fuel cap installation is most frequently found in gravity-flow fuel systems. This type filler cap ordinarily has a curved length of tubing soldered or brazed into its top. The tube opening points into the slipstream so that the entering air pressurizes the tank. This is a very important proviso for gravity flow systems as many low wing aircraft can only achieve a marginal fuel head pressure without the assistance of the ram air effect generated through a ram-air inlet. There is a risk incurred when the ram-air vent is installed in the filler cap. It is the likelihood that someday the line boy (line person?) will install it facing aft. It may look more streamlined that way but without the ram-air boost you could experience the startling effects of fuel starvation. This blunder, however, would be difficult to overlook as the fuel cap in a single tank installation is generally right in front of your windshield.

CAUTION: If you must depend on a ram-air vent, be it in the filler cap or a separate line running from the tank to some point outside the aircraft, it must be the sole vent or the ram-air effect will be lost. A ram-air vent line must be used in combination with an unvented cap. Likewise, a ram-air tube fitted into a cap cannot develop ram-air pressure in the tank if a separate vent line is open in the tank elsewhere. In either event, the consequence can be engine malfunction or failure.

Vent lines and ram-air inlet tubes are generally ¼" or ⅜" tubing. There inlet opening must face the slipstream and must be located in an area of positive undisturbed flow. A tube secured to the firewall, even though it projects well below the aircraft, may still be in the disturbed air turbulence of the exiting engine compartment air. If so, it will fail to develop the ram effect you need. Think your installation through thoroughly.

When a vent line is used, its positioning in the tank is very important. Improperly installed, you would lose some of your fuel capacity through overflow. Another thing, mud daubers and insects can plug up your vents and you may not even notice it. Play it safe and fit the ends of all vents with screens.

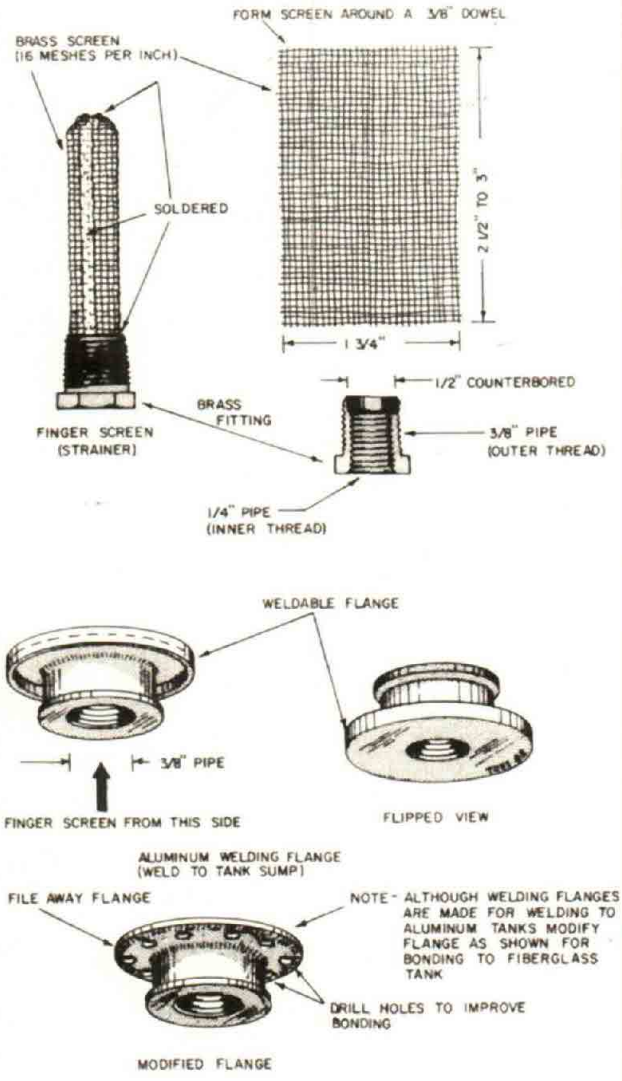


FIGURE 3.

TANK SUMP FITTINGS DETAILED

Finger Screens

Perhaps the most important element of the fuel tank is its finger screen. It is located in the bottom of the tank and should filter out any foreign matter or debris that might be in the tank, or be introduced into the tank while the aircraft is in service.

The screen is a slender (finger-like) filter made of a fairly coarse wire mesh (about 16 meshes/inch) . . . brass or galvanized.

You can easily make your own finger screen by cutting a piece of wire mesh and forming it around a dowel or fountain pen. The end is then crimped and all edges soldered. The completed unit, about 3" long, is soldered to a brass fitting which screws into the fuel tank sump opening.

NOTE: Do not use acid-core solder in aircraft work. Use the resin-core variety to avoid creating a corrosive condition in the vicinity of the soldered unit.

If you prefer, you can purchase ready-made finger strainers through most any homebuilder supply outlet. These finger strainers have a standard ⅜" external male pipe threaded portion which screws directly into the fuel tank sump flange. The fittings internal thread is a ¼" pipe thread into which a fuel line fitting or shut-off valve may be inserted.

Although some builders of composite aircraft are permanently bonding in their tank screens, since it is easier and cheaper to do so, I believe a removable screen to be the superior installation. For one thing, you can remove it for inspection and cleaning if necessary.

Recently a local VW-powered homebuilt suffered fuel starvation in flight, but luckily a successful deadstick landing was completed as the aircraft was but a couple of miles from the airport and high enough to make it. Its fuel line was clogged with debris. Unfortunately, in blowing the line out, no attempt was made to capture the offending matter so we don't know what it was. The finger screen in the fiberglass tank was a non-removable one and made of a very coarse mesh hardware screen. By running your fingers around the inside of the filler neck you could feel a pronounced roughness inside the tank. Since the tank screen cannot be removed the owner is unable to determine if debris is building up around his screen just awaiting another opportunity to do what inanimate objects do best to us humans.

Fuel Valve Vs. Selector Valve

Call it what you like, "selector valve" or "shut-off valve" . . .both do essentially the same thing, because when you operate either one you are selecting an option, even if it is just to shut off the fuel flow.

Each tank should have a valve to shut off its fuel flow so that you can work on the fuel system. A shut-off valve really serves no other functional purpose during the life of the aircraft because most of us leave the valve on all the time.

In theory, the fuel shut-off valve might have to be used during an in-flight emergency so you must locate it where it can be reached. In a two-tank installation a shut-off valve could be used to control the flow of fuel from a transfer or auxiliary tank. It all depends on your installation.

Fuel valves are made of brass and they are HEAVY. Because they are heavy, you should consider mounting the valve on the aircraft structure rather than screwing it directly into the sump flange of the tank. Heavy fuel valves have been known to cause fatigue cracking in aluminum tanks due to prolonged vibration. It has happened more than once or twice!

If you intend to remote the fuel valve control to the instrument panel or to some point you can reach easily,

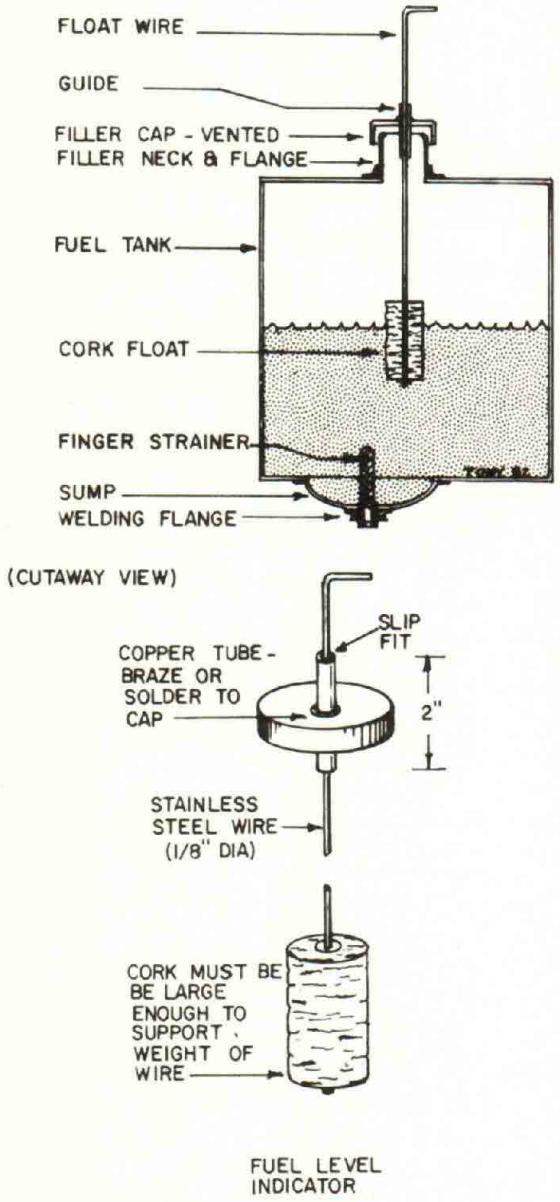


FIGURE 4.

FUEL TANK ELEMENTS - SIMPLE SYSTEM
(SCHEMATIC)

orient the handle so that vibration cannot cause it to work down and shut off the fuel flow. The ON position, therefore, is best situated in the down location. Incidentally, if your fuel valve takes much more than 5 pounds of force to operate, you had better take it apart and check it out. Don't be too picky, however, most vavles work easier when they are wet with fuel in their natural environment.

Fuel Quantity Indicators

Most fuel quantity indicators are of the magnetic type activated by a mechanically connected stiff wire arm on which a cork float is impaled. As the fuel level changes, the cork float rides with the fuel level operating a variable resistance transmitter attached to the upper end of the float wire. When the float rides to the top, as when the tank is full, the minimum resistence is produced through the tank-mounted transmitter. This generates the maximum current flow to the fuel quantity gauge installed in the instrument panel. As the fuel level falls, the resistance in the transmitter increases, producing a lesser current flow to the fuel quantity gauge. The pointer reflects this with a proportionately small deflection.

The sender unit, consisting of the cork float, wire arm and the mechanically attached transmitter, is installed through and secured to the top of the tank by means of a circular plate.

Are you planning to install an old unit you happen to have? Or maybe install a used fuel quantity transmitter on an aircraft being rebuilt? Be advised that old fuel gauges may give erroneous fuel quantity indications because of broken and/or corroded wires in the fuel quantity transmitter unit. At any rate, before you install the unit permanently, first determine if the fuel quantity gauge and the transmitter you have are compatible with each other. Then check the units out by performing a continuity or resistance bench check of the indicating system.

Carefully follow any wiring instructions that are included with a new instrument or it may be damaged.

Shorten (cut) the float arm wire and adjust the float so that it swings freely through its entire range of movement. You want accurate EMPTY to FULL instrument needle deflections. Once adjusted, do not bend the float arm. Insert the assembly in the tank and check again that the cork float does not stick or wedge against the tank bottom (EMPTY position).

Calibrate each of your gauges to read zero in a level flight attitude with the amount of fuel remaining down to the unusable level. Remember, in some tanks a lot of fuel is unusable.

If internal baffling is present, assure yourself that the float will not snag on it and be prevented full movement. If EXPLOSAFE material is used to fill the tank cavity, be sure that the float and arm are protected by an enclosure, or chamber, that provides at least ½" to 1" clearance all around the float for all levels.

Finally, a good separate ground wire connection is essential, particularly for a fiberglass (non-metal) gas tank. Oh yes, use a new gasket under the transmitter mounting plate when installing that old float assembly in the tank.

Some aircraft have a separate gauge for each tank. Others share one gauge among several tanks by utilizing a switch to obtain the reading for the level of fuel in each tank in turn. Still other aircraft have fuel tank selector controls with a fixed relation between the selector and the fuel quantity indicator, making it necessary to switch fuel flow to a particular tank to obtain a reading of the amount of fuel remaining. Confused? Who wouldn't be. Your fuel tank system needn't be that complicated.

Remember those wire-and-float fuel gauges on the old

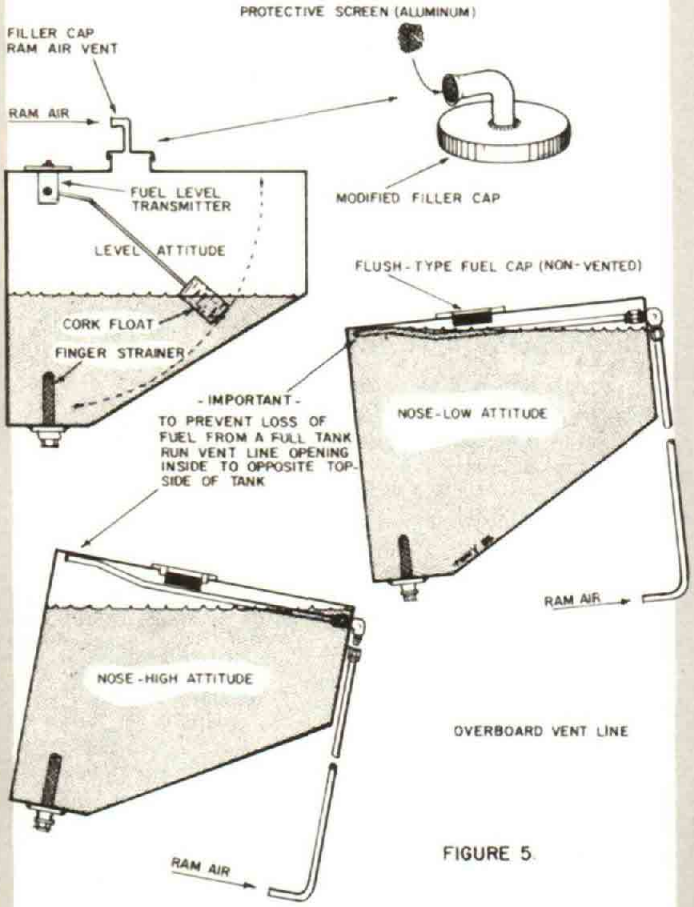


FIGURE 5.

FUEL TANK VENT INSTALLATIONS
(RAM AIR)

J-3 Cubs? Simple, eh? Reliable, too, when properly constructed because they required no switches, no selectros and no mathematics to mess with. They were totally trouble-free. It seems to me that an improvement is no improvement at all if it imposes additional requirements on the pilot.

Flop Tubes For Inverted Flight

If you are building your aircraft with the avowed intention of flying it inverted for prolonged periods of time you should install a "flop" tube. This is a length of specially fabricated flexible (limp) hose that flops down when the aircraft is inverted so that its pick-up end remains in the fuel supply and the engine never misses a lick. These units are available, prefabricated, for a number of popular aerobatic aircraft. The units, as sold, require a pick-up tube adapter for installation. The inverted pick up tubes vary in length for different size tanks. Check your catalogs for guidance. The thing to remember is that you must install the assembly before you close up your tank. Should you decide to purchase your fuel tank, you should specify that you want it fitted for inverted flight . . . if that is your best suit. Is it true that some folks resort to aerobatics because they have trouble holding the airplane straight and level? (Don't write, I'm only kidding!)

Quick Drains

If you cannot drain all of the fuel from your tanks through the gascolator on the firewall, you must install a separate drain in the lowest point of each tank. Otherwise water could accumulate in the sump area of the tank and never drain out until so much water builds up that it eventually enters the system. It is possible for that much water to build up from condensation alone over the years. Inflight maneuvers can cause this water to get into your fuel lines and may cause engine failure without too much warning.

Tank Steps and Tank Security

It doesn't seem possible that a couple of skinny straps could be capable of supporting large tanks full of fuel . . . but they can and do.

The ideal tank strap is made of stainless steel approximately .050" x 1" wide with the length to suit the installation. Usually some means must be fitted to the strap which will permit it to be tightened around the tank to better immobilize it.

It might seem like a good idea but forget it, amigo. Aircraft tanks never have tabs welded to them for bolting directly to the aircraft structure. Vibration will usually terminate such an installation with leaky cracks or broken lugs as your reward.

Fuel tanks, you will find, always are suspended or cradled in padded straps. The padding is neoprene or a material that is, preferably, fire resistant and non-absorbant. However, many builders are using felt strips stuck to the steel straps with plyurethane varnish, contact cement or some other readily available adhesive.

No part of the steel strap should ever be permitted to touch the tank lest it damage it.

Taking Stock

If you intend to fabricate your own tank(s) you ought to obtain or make all of the components you will need before you start fabricating the tank. Then you will know what size openings you will need and if you can get the proper orientation and clearnaces for the various units that go both inside and outside the tank.

Next month we get into fuel tank construction methods.