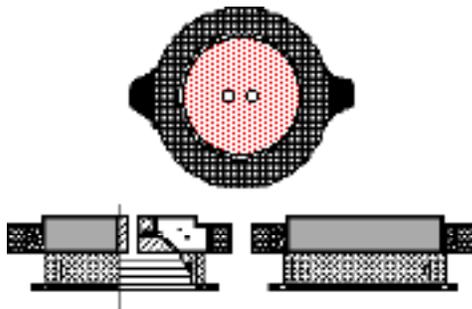




Forward Facing Gascaps, Cessna 120/140/140A

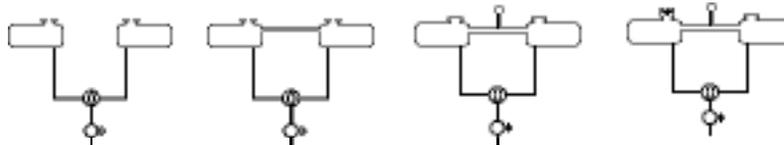
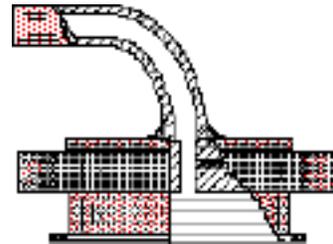
Forward-Facing Gas Caps, Effects and Penalties

The "cute" forward-facing pipes that one sees added to the vent port of the old-style gas caps on some 120's and 140's add a bit of uniqueness to the plane, a talking point. Cessna used gas caps on the 120/140's that have vertical vent holes near their centers, the vent holes having openings of a little less than 1/8 inch in diameter. That is all that is necessary to allow air into the tanks as the fuel drains during use and to allow fumes and gas to escape as the gasoline is heated and expands. In late-manufacture 120/140's, a tank-to-tank vent pipe was added, so blockage of one tank's gascap vent would be compensated for by the other vented cap. This note was expanded to include comments about the central vents for the 140A's but if you want the full story on those and the hazards they induce, see the full article titled "Gascap 140A"



On the left, the original type cap, showing the top view and the through-hole vents. Expanded for clarity

On the right, the modified old style 120/140 gascap, showing a tube that has been brazed to the cap and oriented to be forward-facing when the cap is installed (shown sectioned for clarity).



The types of tank arrangements that are supposed to be on the planes. The left was the first, with open vents in both caps and a three way selector; the next is the late-140 change with the tank-to-tank vent and the four way valve that had the first Both option, and the caps were still open; the next is the way the 140A's came from the factory, with the sealed caps, the tank to tank vent, the four way selector and the new forward-facing large vent above the wing; the right is how the 140A should be today, with the central vent, tank-to-tank vent, one original closed cap, one AD-mandated cap that lets air in but lets no pressure out if the central vent gets plugged, and the four way selector.

If there had been an advantage to have the forward-facing tubes, our planes would have had them.

Engineering features and Physics effects:

The vent pipes added to the "normal" gas caps for the 120/140's are usually 1/8 or 3/16ths inside diameter tubes brazed to the vent openings of the caps; the vents are positioned to face forward into the airstream when the caps are installed. The vent pipes do look a little racy, and they do have the attraction of making your plane a bit different. The reasons that led to using them seem logical if those reasons are the only ones you are exposed to and they would have been very reasonable in the days when they were first used on airplanes, before a lot of the present-day physics of flight were known. The reasons put forth for them are: if you add a vent pipe that faces forward, then: a) the pressure in the tank is increased by the ram pressure, so the fuel will "feed better", b) less rain water will enter the tank when the plane sits outside and c) because I, old head mechanic, say so! Many

planes of the barnstormer era had the forward-facing vents, probably based on the same false hopes, so it would be natural to make the 120/140's "better" by adding the "proven" vents. Taking a closer look at the old planes, however, the first thing that becomes apparent is that they were all different, inferring there was no consensus. Some face forward, some go forward and down, and so on.

Item b, about the exclusion of rainwater, is certainly true for the time the plane is on the ground in the open, because there would be less rain ingestion than with a vertical opening through the tank cap, but item b is absolutely wrong if the plane is flying through rain, because the forward-facing vent will ingest much, much more rain than an unmodified cap would. The forward-facing vent tube acts like a small scoop for the rain, whereas rain while the plane is in flight simply zips on by the normal cap, with no likelihood of ingestion. Like all "free" changes, this one of adding a forward-facing vent tube could be even more hazardous to your health if the rain while flying was freezing rain. Oddly, this "feature hazard" is never mentioned when discussing the "need or benefits" for the forward-facing tubes.

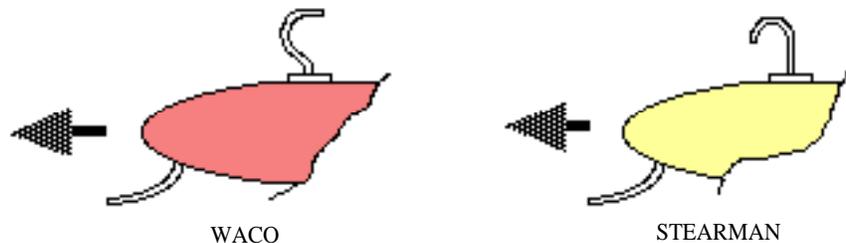
Proposition a, that the pressure in the tank would increase if the forward-facing vents were used, is true but the change is relatively tiny. Pressure increase from the actual ram effect is insignificant to our planes. It is lucky that is true, because, if the pressure change were great, an even more undesirable effect would be that the greater pressure would overpower the carburetor fuel inlet metering ability as designed---the carburetor would flood.

Assuming the 120/140 is flying at the normal cruise of 120 mph (something all except mine do), the perfect ram-to-static pressure recovery would be equivalent to about 0.26 pounds per square inch or 7 inches of water. That pressure increase equates to raising the fuel tank by 8 or 9 inches. I used "perfect" pressure recovery but the actual gain would be much less.

The down side:

The addition of the vent pipes facing forward has no beneficial effect, but it is a drastically more effective collector of rain water when flying through rain than a normally vented cap is, and that could lead to some reluctant engines in flight if enough water were ingested. If your plane metal is colder than freezing and you run into some rain, some of that rain will freeze on the front of the plane----if some of the rain hits and freezes at the front of the forward-facing vent pipe or freezes in it, then you have an effective blockage of the vent. Fuel starvation will follow as soon as the vacuum in the tank created by lack of replacement air to replace the volume of fuel used overcomes the hydraulic head of the remaining fuel. With a cold plane and cold rain, the blockage might take as long as two minutes to be created and then the time to starve and kill the engine will be what? Two or three gallons worth, probably. Realize that if a plane like ours was forced down because of this, by the time the NTSB and FAA got to the site, there could be only one conclusion....."pilot error and carb ice" because the proof of the fault would have melted, even if they had known where to look.

Way back when:



The figures here indicate some of the olden-days solutions to the venting, one from Waco and the other from the Stearman trainers—note that they make more sense in that both would be very effective in preventing the ingestion of rain, either in flight or on the ground, and neither would be likely to be plugged with ice. In the same fashion that we shouldn't seek the tiny "aid" that the ram pressure was assumed to give with the forward-facing vents, Waco was not concerned about the slight loss of fuel pressure from having the vent openings to the rear. In a roundabout way, if you must have vents with tubes, these methods are tried and true. Remember, though, that they were slow planes and "looser".

Mysterious effects:

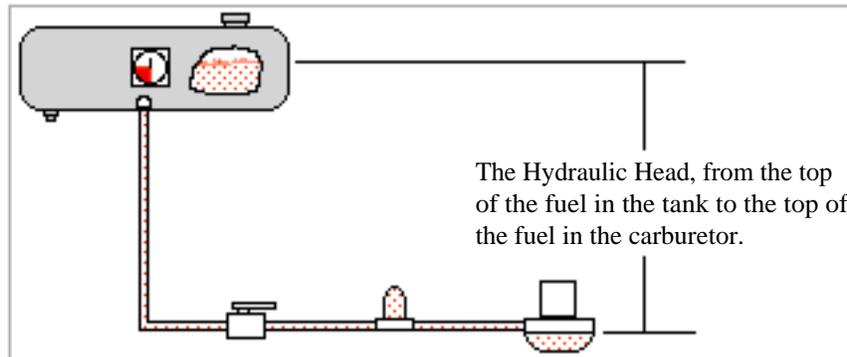
Explanations come about by people noticing "little things"; when enough little things are added, there can be a big explanation. One of our members who had the non-sanctioned forward-facing tubes on his plane had this combination: a 140, the forward-facing bootleg tube vents, a late-model 140/140A type four-way fuel control valve, and what appeared to be a leak at the top of the left tank. (The four-way selector includes a "both" position....earlier planes had no "both".)

The occasional leak on his plane, evidenced by the red streak on the top of the wing, would only occur during flight, and would occur only when using the "both" position of the fuel selector, and only when the trip was started with full tanks. Consider what he deduced after reading and understanding the pressures outlined in this note-----the propwash over the top of the right wing is greater than over the left, a phenomenon that can be seen when observing the spiral motion of the propwash. When the fuel selector is on "both" position, the two wing tanks are hydraulically connected as though they were one; if both are full, then a difference in pressure between them will cause fuel to flow, via the fuel's hydraulic interconnect at the four-way selector, to the tank with the lower pressure (as well as feeding the engine preferentially). The forward-facing vents induce enough differential pressure from the propwash to cause an imbalance in the tank pressures and the fuel from the right transfers to the left; the top-of-the-tank/wing red stain leak evidence occurred only when starting with full tanks, the fuel transferred to the already-full left tank was overboarded through the tank vent, leaving only the stain to show its going. His solution? Flying with the fuel control valve on right or left, but not on "both" since he was loath to do the right thing and forego the "cute" forward-facing vent tubes. I pity the guy who buys that plane because he won't know the "secret" either.

Per the STC which authorized the installation of the Lycoming engine for his plane, he had to use the forward-facing caps. I do not know if other STC's for the Lycoming require them.

Hydraulic Head:

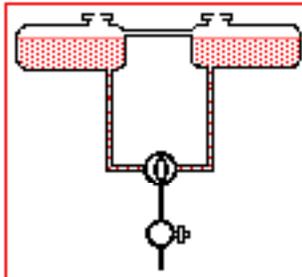
The hydraulic head created by the position of our tanks relative to the position of the carburetor is on the order of three feet.....our Stromberg carbs were designed to work with as little as five inches (some sources say three, some say seven) of head so the addition of forward-facing vents which would effectively raise the tanks another seven inches or so would never have an effect that could be noticed. Of course I know that our planes are "tilted" when on the ground and that was taken into consideration by actually measuring and getting the "about 36 inches" of head.



If the engine is the C-90 with a Marvel-Schebler carburetor (an option then) or an O-200 with the Marvel, only a few inches more of head is required for them, so again there would be no value of a slightly higher pressure. My conclusion has been that such things were not known by the people adding the forward-facing vents "way back when".

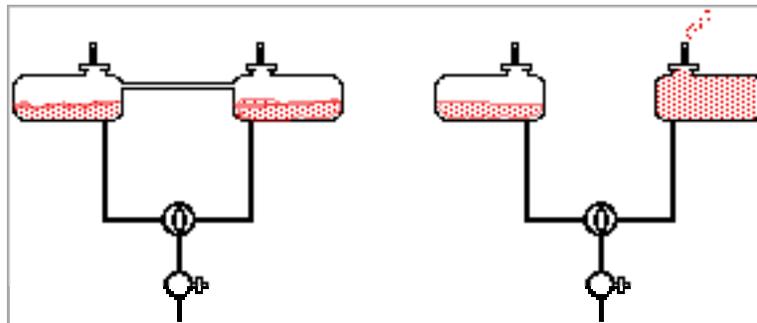
On planes other than ours, where the gas tank is nearly the same level as the engine....maybe the forward-facing vent helped. On those planes which were designed with the forward-facing vent tubes, consider that such things as tank venting was not understood, otherwise the downturned vent tubes, the rearward-facing tube, and the forward-facing vent tubes would have had a clear winner....and no new plane has used a forward facing vent tube for.....50 years? Except, perhaps, Maule, which was designed way back when....we are trying to find what they use now.

If there had been an advantage to have the forward-facing tubes, our planes would have had them.



Cessna later modified the fuel system by adding a tank-to-tank vent tube and a four-way selector so that the owner could utilize the Both position for the first time. With the tank-to-tank vent, the pressures inside the tanks were always the same, even if one cap is plugged. When the Both position was used, the tanks were "hydraulically locked" and would act as one, feeding equally. That was the intent, but practice has proven that in the Both position, one tank feeds preferentially. Nobody knows why. 150 model planes have only a Both position, and there are many complaints about the uneven feeding.

During the years since this was initially written, nature has proved over and over that the assumption of even feeding never occurs. On the Cessna 150's, with ONLY a Both position, the tanks NEVER feed equally, though every owner has wished so. The tremendous advantage of having the ability of Left or Right tank selection is that you can control the fuel usage and end up at the destination with a quarter tank of fuel in one tank and none in the other. With only the Both position, owners find that they are below the legal quantity IN both tanks before landing. 140 owners with the Both position have found the same oddities and most revert to Either tank, and avoid Both.



If you have a plane that has been modified to have the four way valve as on the left, and the tank to tank vent has been installed, the forward-facing vent gas caps don't have any bad effects on a sunny day because both tanks will have the same pressure. But, when the four way valve has been added to a plane that lacks the tank to tank vent, and the plane also has the forward-facing gas cap vents, then the right tank (remember that the figures show the airplane as viewed from the propeller) will be pressurized more than the left tank because of the corkscrew motion of the propwash. The result, when using the Both position, is as shown on the right, with the greater pressure pushing fuel into the left tank and, if full to start with, out the gas cap vent. The right tank also provides the fuel for the engine.

One of our members who bought a plane that had the forward-facing vented gas caps and it came with no warning other than: "make sure the vent always faces forward". He forgot that little admonition one night when fueling. In flight, he was shocked to see how much fuel he was losing out of one tank, the one with the cap having the vent pointed to the rear. He, too, promised to get rid of the "cute" caps and go back to the original.

Conclusions:

Even though the forward-facing vent tubes are attractive, do make the plane look different, do make it look "racy", and though they appear to add the "benefit" of increasing pressure in the tank, the pressure added is so small as to be incidental, and the pressure is never necessary. However, a terrific hazard is created if one flies in freezing rain or supercooled moisture with them. If the plane with the forward-facing vents is flown in the freezing rain, the vents could be blocked in seconds, thereby leading to engine fuel starvation and stoppage. If an engine stoppage is caused by the bootleg forward-facing vents getting plugged, no investigator seeking "why" would be able to find out because the ice would be long gone by the time the investigation started.

As pointed out by the member with the forward-facing vents plus the four-way selector valve set on "both", stained wing tops are no fun. There are others with the bootleg vents who must also have the

“leak” and be unaware of the cause of odd things and several owners have mentioned the preferential fuel usage from one tank with the forward-facing tubes. Stoppages or nasty red stains because of the forward facing caps are too high a price to pay for a “cute” cap.

The recommendation?

Get rid of the forward-facing vent tubes on the 120/140's; they are not sanctioned. They are not legal (except for some? Lycoming engine STC's). Alternatively, if you “must” have them because you live in a rain forest, shape them like the Stearman or Waco types. And don't use the half-vented caps meant for the 140A models on the 120/140's!! For a more complete explanation of that, see the story entitled *140A Gascap*. That can kill you, too. A portion of that story is at the end of this article.

Part Numbers:

The original full-vented gas cap had the part number of 0422109-1

The replacement full-vented gas cap has the part number of C 100084-5

The cap for C-140A only, a half-vented gas cap, is C 156003-0101

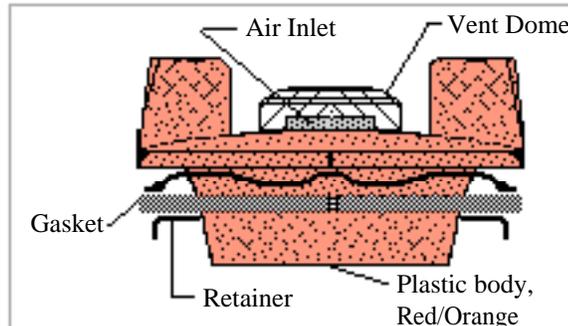
The original, fully blocked C-140A only gas cap was 0311360-4 and 0311360-5 for the gasket for it.

Be careful. Some Cessna dealers will sell the 140A only cap as a “direct replacement” for the 120/140 cap. Don't believe it. The correct part numbers are in the Cessna parts lists.

140A

In the 140A, Cessna deleted the full-vented gascaps by two changes-----they changed to non-vented gas caps and added a shared forward-facing vent scupper above and in the center of the wing. That tube is spliced into the tank-to-tank vent tube added on the late 140's. This combination makes a single common vent for both sealed tanks. Why did the designers at Cessna add the single, shared, forward-facing vents on the Cessna 140A's? We don't know, though one advantage is that, with full tanks, you can park the plane with one wing low without leaking fuel whereas the full-vented cap, tank-to-tank vent and the selector set on Both would allow fuel to escape and stain the top of the wing if the plane was tilted, full tanks, on a hot day.

The 140A parts manual shows that the planes should have the full vented caps like the 120/140's but that was because of a lazy draftsman and poor print checking. The part number listing was...originally...correct.



The central vent tube of the 140A differs from the bootleg vent tubes on the 120's and 140's in that the 140A vent tube has a much larger diameter, about a half inch. The likelihood that it would be blocked by a single bug or a little bit of ice is much reduced, but it also takes in proportionally more rain when flying because its opening to the front is so much larger. Even though the large, common vent “shouldn't get plugged”, they sometimes did and so, eventually, the hazard of a single vent and one placed in such a vulnerable position was forced to be recognized. On some, there is a tiny escape hole at the rear of the vent tube, in line with the front opening and I wonder yet if that was by Cessna or simply experience and action by owners.

Problems about blocked vents and lack of fuel feeding caused the FAA to issue an airworthiness directive (AD) in 1979 against all the Cessnas, 140A and subsequent. It called for a half-vented cap to be added to one tank or the other, thereby preventing total lack of venting if the overwing vent was plugged. Fuel usage with a blocked overwing vent creates a vacuum in the tanks and the “promised/expected” feature of the silicone umbrella-shaped valve in the new half-vented caps would allow air in once the vacuum in the tank exceeded the opening threshold of the silicone valve. The valve would not allow any pressure relief outwardly, thereby creating the “half-vented” cap.

They could not revert to a full vent because fuel would have been dumped if the AD'ed caps had been full-vent types. The secondary path vastly lowered the probability that an ice or bug-plugged central vent would bring down a plane by fuel starvation. This was, in a way, an acknowledgment that the plain, simple, full-vented caps on the 120's and 140's were safer than the forward-facing vent of the 140A because the AD did not apply to the 120/140 planes. The reason only one half-vented gas cap replacement was mandated rather than two was that the one cap doubled the inlet vents and tripling them was considered unnecessary. Great confusion was created by the usual inability of the FAA to explain the intent and the function and limitations of the AD cap and many swear that only one AD-ed cap can be used (not true) or that the AD-ed cap must be on the right tank only (not true). Neither Cessna or the FAA explained that the caps were half-vented of course or that once in a while, the caps ought to be checked for function. And, of course, there is no way to check them. And there is no published vacuum limit which would be needed to test them.

The figure above indicates the shape of the cap with the high ears and the center vent cover, meant **ONLY** for the 140A and newer planes, never to be used on the 120/140's. Some Cessna dealers will sell you the wrong caps, believing them interchangeable. They are not, and some crashes and near-crashes have proved the point.

A word of caution again. You will see some 120/140's with the AD-mandated gas cap meant only for the 140A and bigger Cessnas. To use them is to take the chance of heated gasoline unable to get out, and expanding the tanks!! In addition, some of the half-vented caps have failed in allowing inward venting, causing engine stoppages. Don't use them on anything but the 140A! Cessna agrees.

By now, it should be obvious that forward-facing caps on the A are taboo, too.

Alterations:

Planes with certain features and part sets are built in blocks, signified by the coding in the parts manuals of such as: use part x on serials 8001 to 13,333, use part y on serial 13,334 and subs. Many of our planes have parts from older/newer blocks of manufacture and that can cause odd problems sometimes. A significant number of the earlier planes now have the four-way selector, but not all of those also have the tank-to-tank vent which was a companion change at the factory. This is mentioned to point out that you don't really know what you have unless you have seen it because the log books seldom tell the truth. In days past, many changes simply were not considered significant enough to make an entry, a point made when I found that one tank had a drain of one size and the other tank had a different one entirely. Little things but sometimes important. What makes the mixture more uncertain and complex is that Cessna made so many errors (or left-outs) in their parts manuals and no one I know has every issue of the manual so many things cannot be established. For the fuel system, the 140A parts manual shows the through hole vented gas caps but the parts number listing calls for the fully blocked type, and for the parts manual I have for the 120/140's, only the four-way selector is shown with no hint that a three way was used on several thousand planes, but in an earlier page of the manual, the escutcheon and position plates for both the three way and the four way combinations are listed and coded...on different pages. Be sure you know what you have, not what a book indicates you have on the plane.

Three legal caps, five part numbers for them (at least) and different STC'ed/PMA'ed caps and mix in the forward-facing bootleg caps. It requires a scorecard!

The Killing Monarchs:

When this was written and modified over the years some FAA-sanctioned gas caps known as Monarch caps were sold by a company of that name. It has since been proven that the caps could only have been safe to use on some (the later serials) of the 120/140's and this was proven by many engine outages (on the early serial planes) shortly after takeoff. Some owners using them were lucky enough to not have an engine outage but they did hear the sound of the tanks tin-canning when pressurized with the plane in the sun, or with the vacuum caused by fuel usage. The Monarchs need to have either a vacuum to open their valve to relieve the vacuum or they needed to have enough pressure buildup so that the pressure threshold of the valve would vent outwardly.

As a result of my extensive article explaining that the FAA was wrong to have initially approved the Monarchs for all the 120/140's, and to prove that the company was hiding the reported plane downings

from the FAA's PMA office, and that the Monarch company NEVER met the criteria of the FAA-approved PMA sanction, Monarch was driven out of business. The FAA, who created the problem by sanctioning the caps, took the credit of course for curing the problem, only they caused worse with their cure.

To compound the errors, Monarch released a terribly wrong "Emergency Alert" "cure", which contains errors which can still kill people and they added a comment which is grossly incorrect....and the FAA continued in their path of not caring about little planes by passing along a version which they blessed but never submitted to anyone at Cessna or anyone of the 120/140 experts. Neither at the time of the original approval of the caps or at the time of the issuance of the "Emergency Alert" did the FAA ever make a phone call to Cessna to ask for assistance, nor did they ever ask anyone who truly knew anything about our planes. Nothing like good help. They got paid for making the gross error, got paid for not curing it for nearly 15 years, and got paid when there was no other choice than to cause Monarch to quit, and then they got paid to assure the wrong and dangerous "Emergency Alert".

Unfortunately, owners who had or have the Monarchs keep selling them to the unsuspecting who then find out the hard way that they won't work correctly and might land them in the field beyond the end of the runway, sometimes without trees. Sigh.

The Lycoming STC

The plane with the forward-facing caps which started the investigation into why it overboarded fuel was a 140 with the Selector on Both, Full tanks. When flying, a red stain would appear on the left wing top and more fuel would feed from one tank than the other. It had one other trait which was not considered at the time until November of 2001, some ten plus years after the "solution" for him, that being never to fly on Both unless both tanks had been partially depleted. That trait was that the plane had been changed via an STC to have the Lycoming engine...and the STC demanded the use of the forward-facing caps!!!

This is an indication of the difficulty one can get in when the STC creator does not investigate the change on all the versions of the planes; with the original 120/140's, before the change to the four way valve (with the Both position), the forward-facing caps would have caused no consistent harm though still dangerous for those flying in freezing rain and still dangerous flying in plain rain because the tubes are little scoops for water.

Neal

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