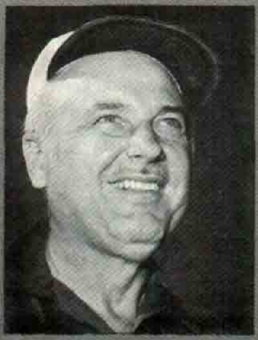

THE SPORTPLANE BUILDER

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INSTALLING A SUBMERGED INLET VENTILATION SYSTEM

COCKPIT VENTILATORS NEED not be noisy, high drag protuberances. Not at all.

There is a better way to get ventilation than by deliberately affixing a clam-shutter or scoop over a large hole to force the outside air into the cabin.

And yes, there is a better way to get ventilating air than by cutting a large gaping hole in the side of the windshield or canopy and inserting one of these inelegant plastic bubble scoops.

Not only are such installations primitive, they have to be rated among the noisiest ways possible to ventilate a cabin. Furthermore, those plastic inserts (in addition to being ugly and unmanageable) tend to warp and curl up under the scorching heat of the summer sun.

Well, ponder your ventilation options no longer for I would remind you that good ol' NACA (now NASA) showed us years ago how to modernize aircraft ventilation with submerged inlets. The NACA tested a number of inlet configurations and shelved among their archives all but two of the more efficient ducts. These have achieved recognition and acceptance by race car designers, homebuilders and aircraft designers . . . but only on a limited scale.

The two flush inlet designs that are in current vogue are the parallel ramp wall type as installed in Mooney aircraft and NACA's scientifically derived diverging ramp wall duct. Of the two, it appears that the NACA duct has the edge on popularity, efficiency and elegance.

Builders seem to prefer the NACA duct design over the parallel wall ramp type in spite of the fact that the Mooney type inlet is easier to make. It has no compound curves and can be easily formed of aluminum. Of course, if an inlet is to be made of fiberglass anyway, that attribute is not too significant. What is significant, however, is what NACA found out about the relative efficiency of the two ducts many years ago.

The NACA discovered, for example, that the parallel ramp wall (Mooney type) submerged inlet, in wind tunnel tests, showed a sharp decline in pressure recovery at the inlet at Mach numbers between 0.75 and 0.82 while this did not occur with the NACA divergent wall inlet until a free stream Mach number of 0.90 was exceeded! How about that?

It is therefore obvious that when going subsonic, any homebuilt (or Mooney) would be better off with a NACA diverging ramp wall submerged inlet than with a parallel wall job. Well, so much for the scientific analysis.

Actually, both flush duct designs have been around a long time and, for the most part, those homebuilders who have installed them for cabin ventilation or engine cooling purposes are satisfied with the results.

Should you be a builder who is disappointed or unimpressed with his results, you might want to reexamine your inlet profile and installation to determine if it is properly designed and located.

Essentials of the NACA Duct Design

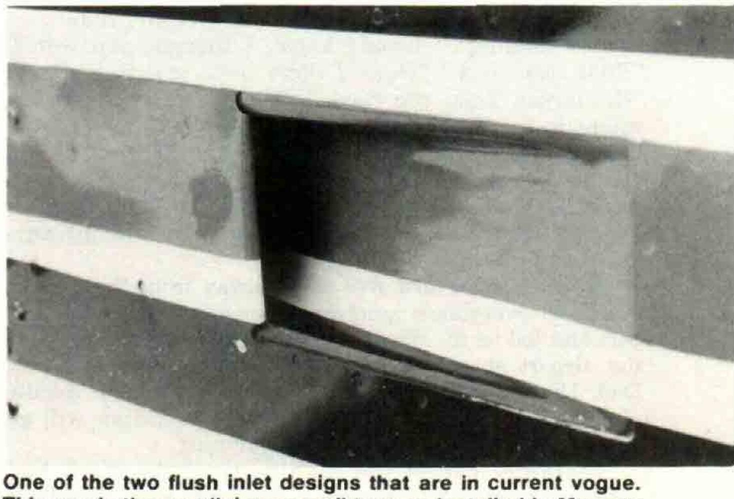
The design, that is, the profile and shape of the submerged NACA duct (inlet) is quite critical and the layout data provided in Figure 1 should be used to obtain the proper configuration.

Although a noticeable reduction in wind noise may be expected with either the NACA inlet or the parallel ramp wall inlet compared to the ram air variety, we will limit our attention to the installation of the NACA duct primarily, although the installation details would also be compatible with parallel wall type vents.

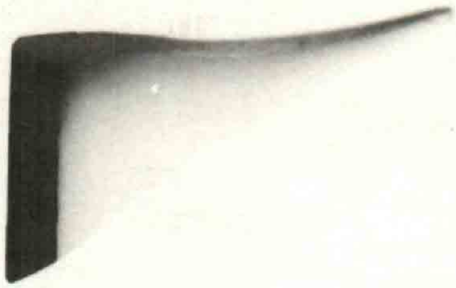
Of course, the air pressure recovery in a cabin will not be equal to that obtained with an external scoop but except for the louder noise level of ram air vents, the difference in the cockpit ventilation achieved would be hard to differentiate. Actually, the difference is really not too great as a well designed submerged duct can provide a pressure recovery of up to 90 percent of the outside free stream pressure.

Naturally, the size of the inlet opening determines the mass flow of ventilating air you will get. To avoid getting into a mess of mass flow and pressure recovery calculations (and believe me I will avoid it), a sagacious builder will always find a more practical approach . . . like profiting from the experience of others who have built and used submerged inlets for ventilation.

If you would, therefore, walk down most any flight line you will see at least a few aircraft equipped with flush inlets. Most of those installed, you will notice, are similar in size (about 3 inches wide) and uniformly located.



One of the two flush inlet designs that are in current vogue. This one is the parallel ramp wall type as installed in Mooney aircraft.



The NACA duct as it is called is a scientifically derived diverging ramp wall air inlet. Simple yet elegant and efficient.

The shape of the inlet opening is as important as the gentle 7 degree ramp slope that allows the air to flow smoothly into the cockpit. The diverging wall design of the inlet allows the entering air to expand, thereby decreasing in velocity. The beneficial result of that is a decreased noise level.

Figures 1 and 1A provide you with the essential details for laying out a NACA duct opening. You can work out your own layout from the Table of Coordinates in Figure 1 or copy the layout graph given in Figure 1A . . . the easy way. By making the layout squares ¼", ⅜" or even ¾" you will be able to obtain a larger or smaller duct at will.

The size duct shown in Figure 1A is 3" in width with an overall ramp length of 6¾". Unless your aircraft is very small, the 3" opening should be just about ideal. The only other factor affecting the amount of air entering is the height of the opening. However, the recommended range limits this to a ratio of 3 - 5 (height divided by width). Don't alter the 7 degree slope as it too apparently is an optimum angle for the ramp.

The shape of the lip over the opening is equally important and the early data dwelled on its shape and function in detail. Most builders, however, simply round off the lip smoothly to insure that a smooth attached air flow is maintained both inside and outside of the opening along the external surface aft of the opening.

Finding A Good Location For The Inlet

To be effective not only must the NACA flush inlet be properly profiled, it must also be located in an area of positive slipstream flow. Most frequently you will find it located on either side of the fuselage (just ahead of the windshield post area) or on top of the fuselage near the base of the windshield. This latter location is common to most VariEze and Long-EZ aircraft. Other locations, however, could be as well or better suited for a particular aircraft.

For my part, I have always installed two submerged ducts for cabin ventilation — one on each side of the fuselage just ahead of and below the bottom level of the instrument panel. This particular location in conventional aircraft has proved to be quite effective and convenient as well.

Your aircraft's structure will probably influence the location selected for the submerged duct or ducts. A location on top of the fuselage nose section can lead to complicated installation efforts if your aircraft has a nose tank, or if the panel instrumentation is so compact that little space remains for the installation of a cabin air inlet. On the other hand, a duct low in the side of the fuselage may pick up exhaust fumes or may have to be located further forward or aft than you would like due to structural obstacles. Each aircraft design presents different inlet location problems (and advantages), so the first step is to visualize the proposed location from both inside the aircraft and outside. It very definitely is helpful to look over a few aircraft to see where the manufacturers and other builders have positioned their inlet ducts.

Making the Installation

Installation of any type of ramp is quick and easy. You can rivet it in place, or glue it in with epoxy . . . use both if you like.

It doesn't matter whether you install the NACA duct during construction or later as a retrofit, the procedure will be the same. That is, after you have decided on a location, a template will be used to outline the opening which is then cut out. (The cut-out in the skin can be started with a hole saw and roughed out with a hand held hacksaw blade.) Be sure that the centerline of the duct is aligned with the top longeron or the line of flight for a normal cruise attitude. Be sure, also, that the opening will be just behind a bulkhead and not astraddle one. Don't cut a bulkhead away to make room for the inlet!

The submerged inlet can be installed in any kind of structure be it wood, metal or composite. The main core of the installation is the 7 degree sloping ramp which may be made of metal, wood and plywood or of fiberglass. I believe you could even hammer out a diverging inlet from soft aluminum sheet . . . first around a male form and then in a female form to bend down the flanges.

These ramps are not structural and need not be built so thick and heavy that they will withstand sledge hammer blows. Sheet aluminum (soft) .030 - .040" should be heavy enough. A fiberglass ramp is easily built up by overlaying a foam form attached to a temporary base. Don't forget to include the flanges in your lay-up.

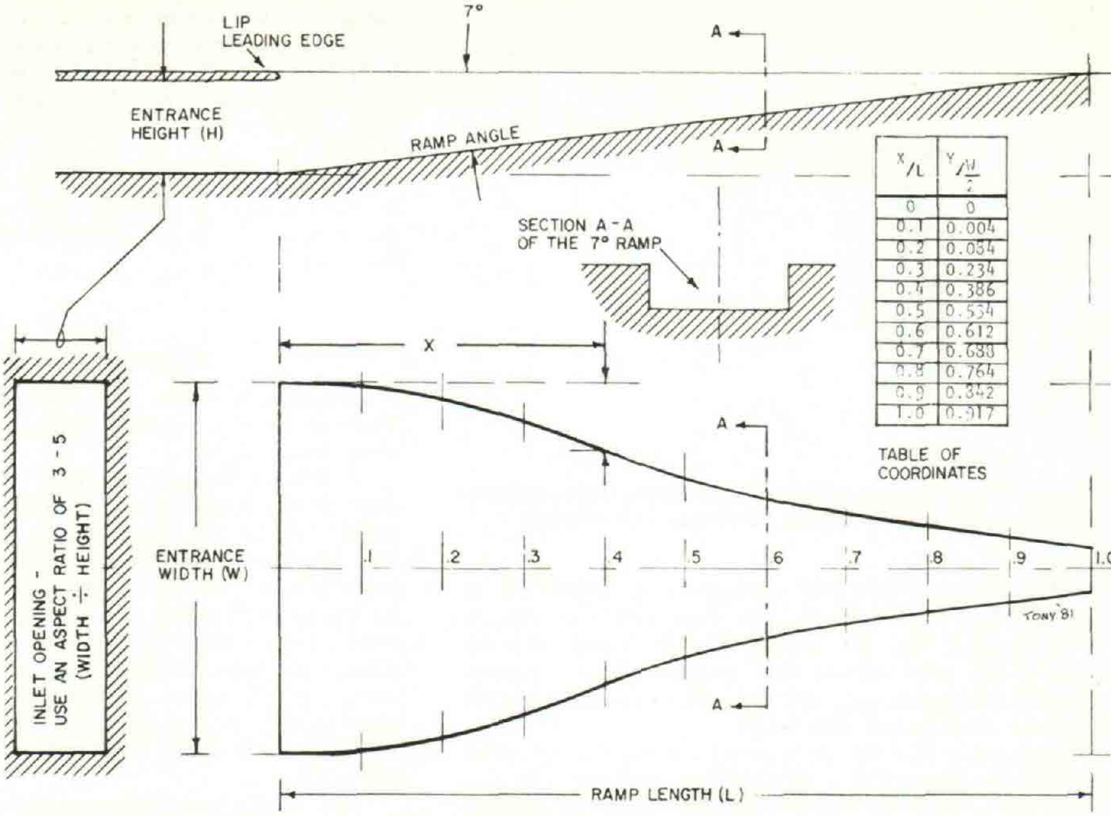
After the ramp is glued or riveted in, the job is only half done. You still need to fabricate a way to open and close the vent.

Control Ventilating Air With A Sliding Shutter

Most VariEze owners, I've noticed, use a piece of foam or sponge-like material poked into their vent opening when no ventilating air is wanted. This is, essentially, an all-or-nothing-at-all control and I think most of us would prefer something a bit more sophisticated than that.

The simple slide shutter illustrated works effectively in controlling the amount of air allowed into the cabin. It can be used to obtain a full range of control over the incoming air or it can be used to close off the vent completely when the aircraft is parked, or in flight when the outside temperature is far too cold for air to be allowed on board. Your installation should include a screened deterrent to entry by unwanted varmints, bugs and other nocturnal trespassers. The screen can be epoxied in at some convenient position inside the throat of the inlet.

The shutter is a marvel of mechanical simplicity, easily reached and controlled by the pilot or his passenger — much simpler than the drawings would indicate. No complex ducting is needed or desired for this type installation. A slightly modified version would be as effective in an all-metal aircraft structure.



X/L	$Y/\frac{W}{2}$
0	0
0.1	0.004
0.2	0.034
0.3	0.234
0.4	0.386
0.5	0.534
0.6	0.612
0.7	0.688
0.8	0.764
0.9	0.842
1.0	0.917

TABLE OF COORDINATES

FIGURE 1. NACA SUBMERGED INLET LAYOUT DATA

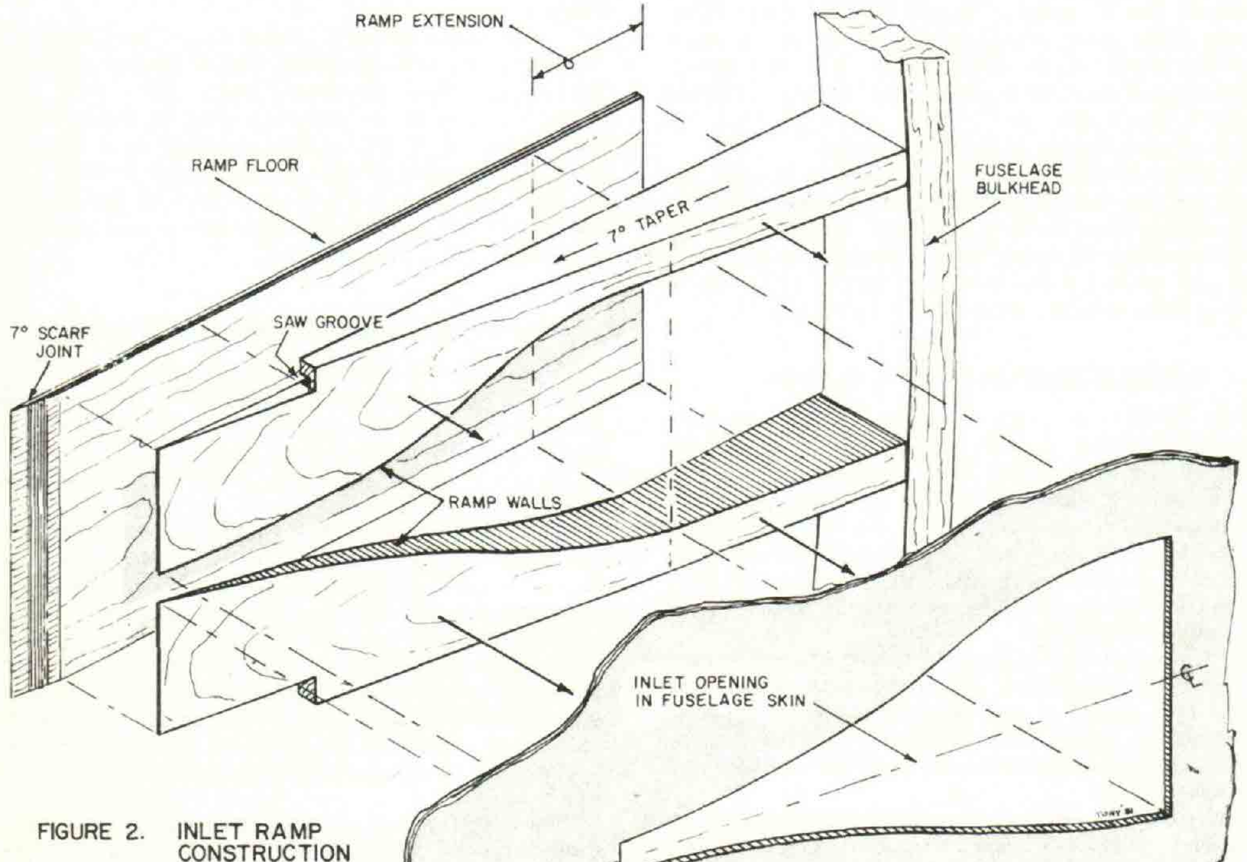


FIGURE 2. INLET RAMP CONSTRUCTION

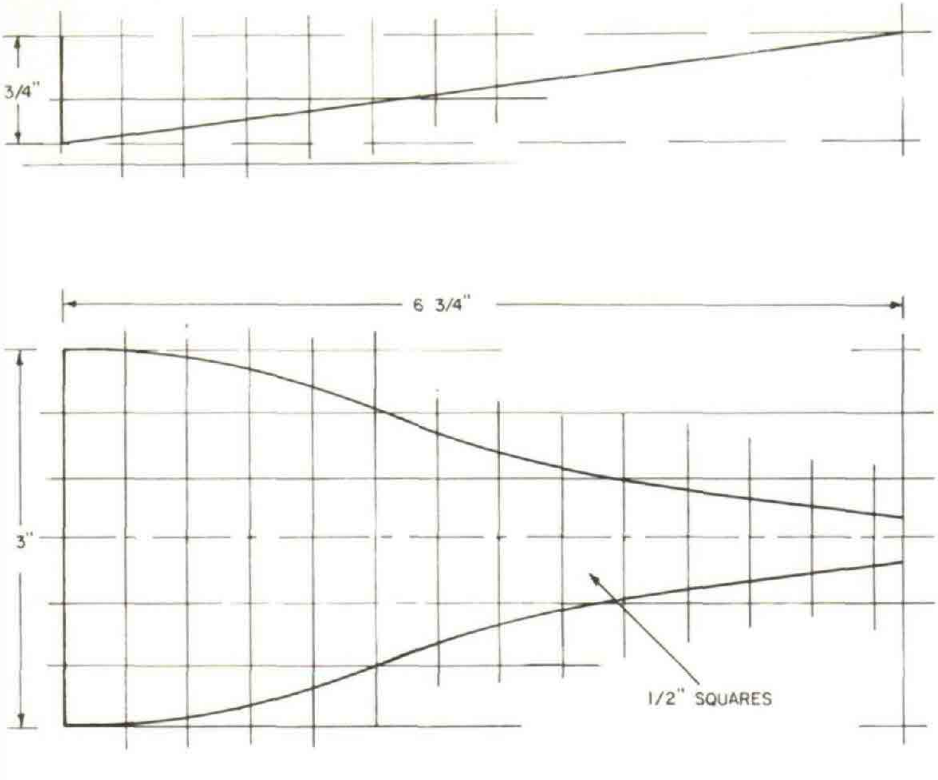


FIGURE 1A. ALTERNATE LAYOUT METHOD

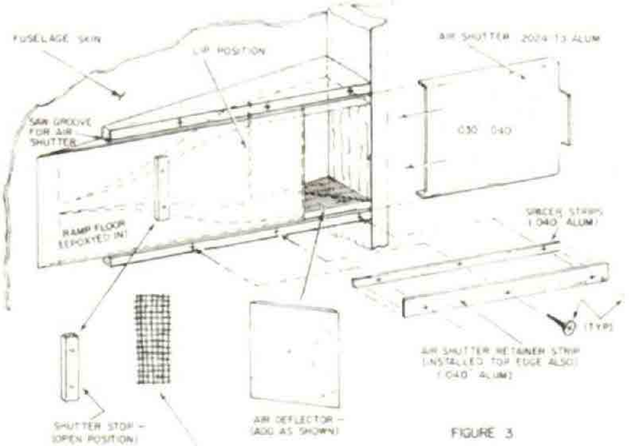
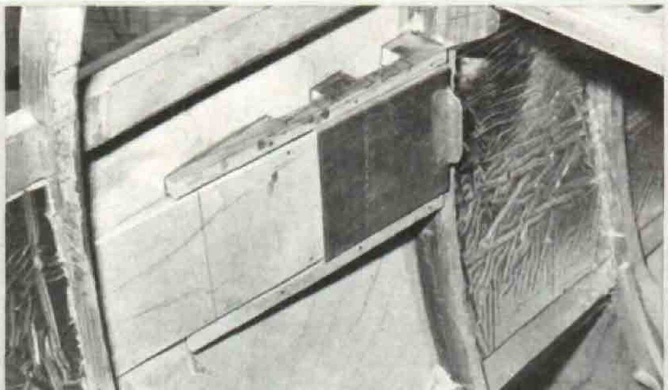


FIGURE 3

INLET RAMP AND SHUTTER DETAILS (INSIDE VIEW)



(Dick Kinchloe Photo)

This view of the sliding shutter is from the firewall looking toward the backside of the instrument panel. The shutter is fully closed. *Metal retaining strips not yet installed.* See Fig. 3. Note sound insulation being installed.

If you prefer to route the cooling air to some specific part of the cabin or to instrument panel vents, the installation will become heavier and complex.

You should realize that those store-bought eyeball control vents, although impressive, are less efficient because they usually restrict the flow of air, particullarly when it's forced to change direction. A little vent like that does not have as large an opening as the submerged inlet. If the eyeball controllable vent is to be used, try to route the flow of air from the inlet to the unit with as little change in direction as possible.

What About Air Outlets?

If air comes in . . . it must also get out.

It used to be that this was no problem because the typical airplane leaked more air than a sieve. However, this drafty condition is no longer always true. Composite aircraft, for example, are built devoid of the usual openings and connections found in, say, a biplane or a tube and fabric aircraft. Ordinarily, a separate outlet for ventilating air in such an aircraft will improve the effectiveness of cabin breezes wafting through curly hair or bouncing off a bald pate. (Select one!)

An outlet often need not be much more than an opening in the aft end of the pilot's compartment. For something a bit fancier, you could use a vent assembly from one of those fancy foreign cars (obtained through your favorite junkyard broker). This type vent can be opened or closed at will although the chances are you will ignore that featured luxury and leave the outlet vent always open.

Reminder

As with anything installed in an aircraft, your ventilation system should be as simple and as light as possible for trouble-free operation . . . and this sliding shutter flush inlet vent installation has it all.