Tony Bingelis

YOUR PITOT/STATIC SYSTEM AND ALTITUDE ENCODERS

Just what does it take to develop a reliable pitot/static pressure system for your airplane? Not much, really, because in its simplest form, all you need are a pitot tube assembly, several feet of plastic (or aluminum) tubing and four fittings with matching connectors for the instruments.

Simple? Yes, it can be, but only if you get the installation right the first time. If not, trouble shooting your way out of a pitot/static pressure problem could drag on and on.

Simple as your pitot/static system may be, don't lose sight of the fact that it will have to provide reliable sources of pressure (both pitot and static) for the operation of two of your mandatory - and most important - flight instruments - the airspeed indicator and the altimeter. Although the vertical speed indicator (VSI) is not a mandatory instrument, it is considered to be almost so by many builders. Anyway, it, too, requires a good static pressure source.

When it comes to pitot/static installations, trusting to luck doesn't always yield satisfactory results. It is far better to organize your thoughts and rely on a bit of advance planning before you start drilling holes in the airplane.

What a Pitot/Static Pressure System Does

You really can't tell very much about a pitot/static pressure system looking at it from outside the aircraft and, really, there is not much to see inside, for that matter. Outside the aircraft you will see the pitot tube, and if you search long enough and look closely, you will also find the static pressure ports.

The pitot tube, no matter where it is mounted, is designed for one function only and that is to pick up the ram air or dynamic air (pitot) pressure it encounters in flight.

This ram air pressure enters the pitot tube through a small opening up front and is conveyed by tubing directly to the airspeed indicator's pressure port ("P") where the internal mechanism converts the ram pressure to a readable airspeed indication . . . and that's all the pitot tube does.

The small static ports, on the other hand, regardless of where they may be located, pick up the ambient or still air (static) pressure found at the aircraft's flight altitude, and conveys it to the airspeed indicator's static port ("S").

As you know, the airspeed indicator is the only instrument that requires both pitot pressure and static pressure for its operation. So it is only logical that the first static pressure connection be made at the airspeed indicator. There, a "T" fitting is usually screwed into the "S" port to branch the static pressure to also route it to the altimeter, and, if installed, to the rate of climb indicator (VSI) auto pilot, altitude encoder and to any other instrument or device that has to have static pressure for its operation.

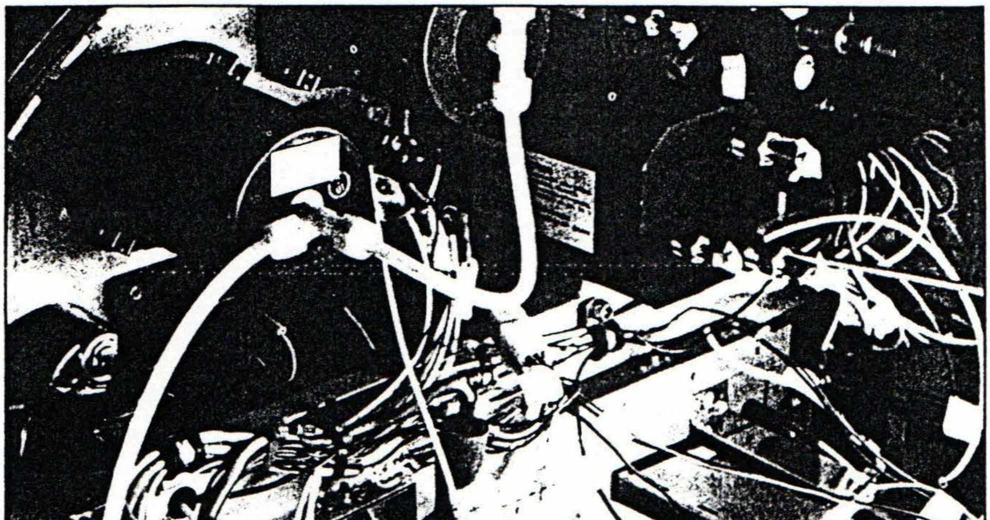
Your Static Source Options

As a builder, you have 3 basic static source options to select from (see Figure 1).

Option 1 - Co-locate the static source with the pitot tube assembly which may be mounted out on the wing someplace, in the nose, on the sides of the fuselage, on top of the vertical stabilizer, or wherever. Co-locating the static source with the pitot tube is possible only if the pitot tube assembly is designed with separate static ports. Such a unit is more accurately referred to as a pitot/static tube assembly.

Option 2 - Remotely locate the static source ports in the fuselage sides. Usually the static ports are installed on both sides of the fuselage, or both sides of the nose section just ahead of the entrance to the cockpit. When installed in the fuselage sides, the most common location appears to be at a midway point between the stabilizer and the trailing edge of the wing - roughly in line with the thrust line. There are plenty of variations as each builder tries, sometimes more than once, to find a location that yields a reliable static pressure.

Option 3 - Use the air inside the cabin



This RV-4 has just had its altimeter and Vertical Speed Indicator plumbed. Next in line will be the Blind Encoder (A). Note that it is necessary to use "T" fittings in each instrument to complete the static system.

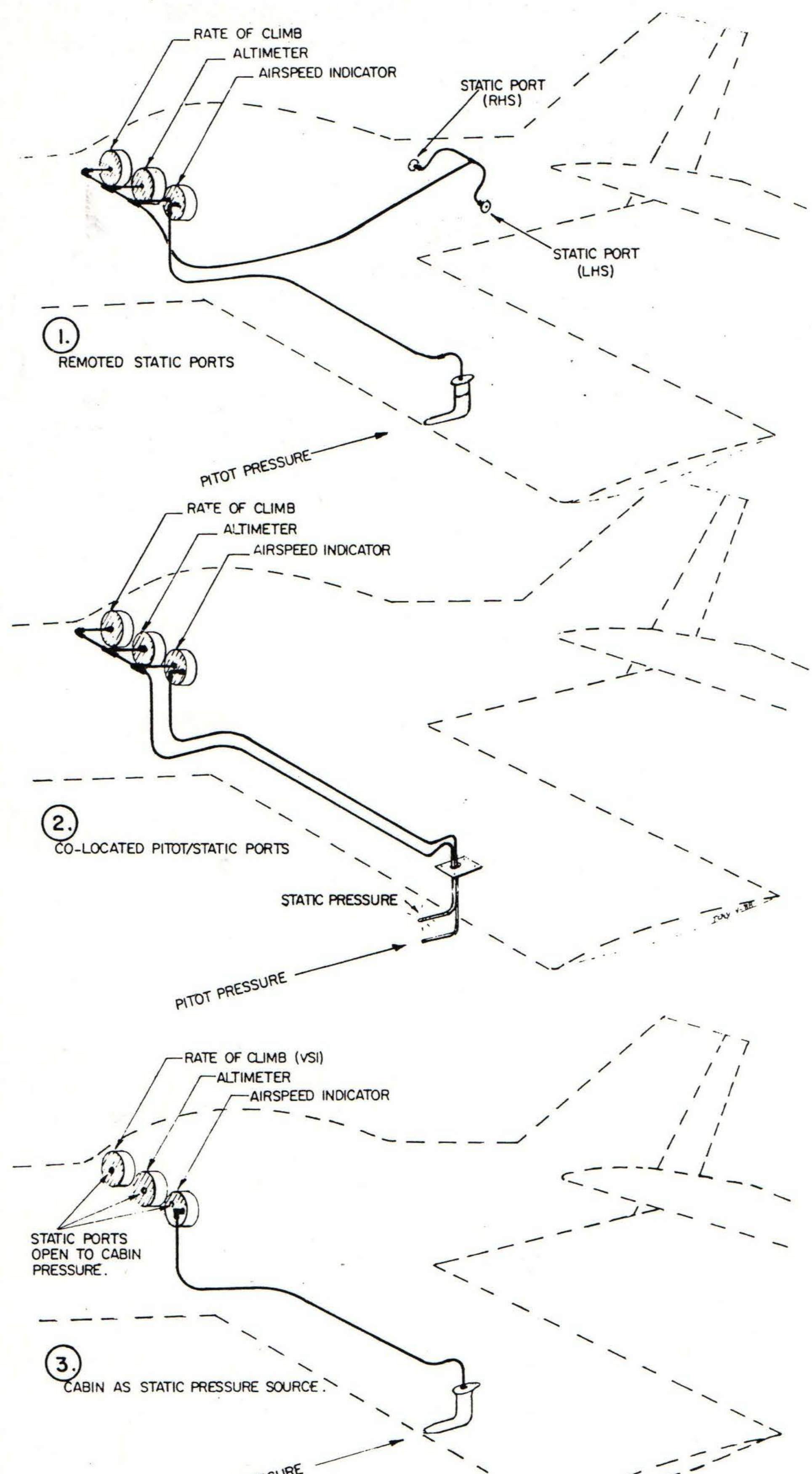


FIGURE I.

TYPICAL STATIC PRESSURE SOURCES

(SCHEMATIC VIEWS)

as a static pressure source by simply leaving the static ports (connections) in the airspeed indicator, altimeter and the VSI open. This option may not be very practical as every time you open or close a ventilator, the needles (hands) in your instruments will dance a merry jig. Then, too, this static source could be considered to be less than reliable should you want to install an altitude encoder or an auto pilot. On the other hand, maybe not.

Of the three options, the co-located pitot/static pressure source generally proves to be the most efficient arrangement, and consistently provides reliable pressures.

The remotely located static ports will be somewhat more difficult to fabricate and install, and will weigh and cost slightly more. And there's another drawback. If the first static port location you pick proves to be an unreliable static pressure source, you will, naturally, be most reluctant to drill more holes in the fuselage sides looking for the "best" location.

The third option is the least desirable of all. And yet I was surprised to learn that a highly experienced avionics gent, frustrated in his search for a good static source for his auto pilot, found his cabin air pressure to be the best acceptable source for his plush, IFR equipped biplane. As he pointed out, this was all quite proper and legal because he, as the manufacturer, simply designated the cabin as the approved static source for the design. I also learned that his former organization sometimes had difficulty in obtaining a reliable static source in large certificated aircraft, no less.

All these things considered then, here are a few pointers which might be useful in making your own original pitot/static installation, or perhaps, in improving the one you have now.

Static Source Installation Tips

First, be sure to select a location for your pitot/static pressure tube assembly that is outside of the turbulent propeller disc area.

Also, take note that while the leading edge of the wing is a very good location for a pitot/static tube installation, it is also the most vulnerable to damage on the ground.

When installing a pitot tube assembly under the wing be sure that its ports will be well below the accelerated and compressed (?) slipstream that hugs the wing undersurface. Usually about 6" to 8" below will get it into unruffled air.

If you are using a Piper blade-type pitot/static assembly, you should note that these units are installed much further to the rear than other types of pitot tubes. Actually, on laminar flow

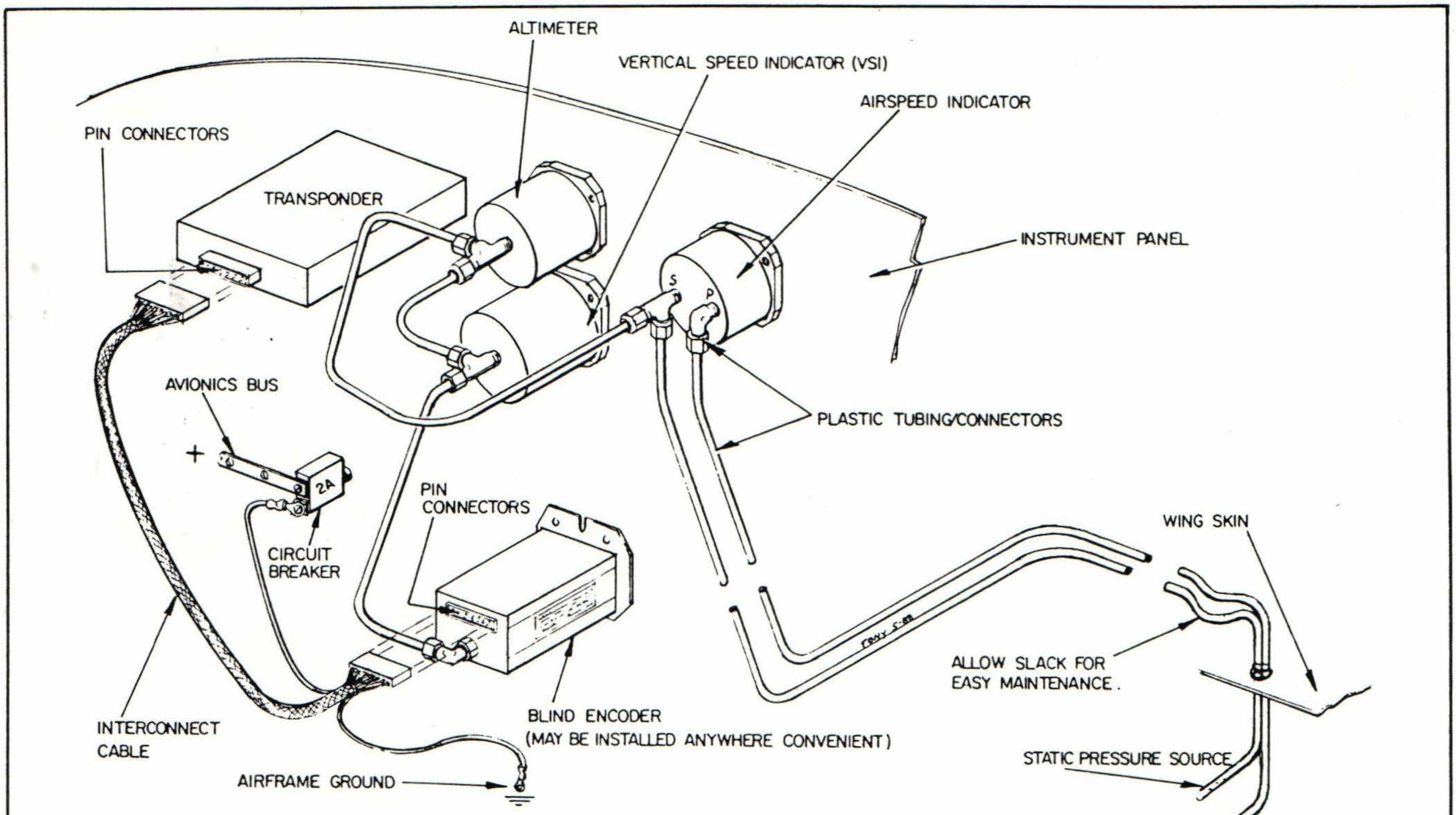


FIGURE 2.

ALTITUDE ENCODER INSTALLATION

(TYPICAL)

type airfoils the blade-type pitot/static unit is mounted close to the point of maximum airfoil camber.

Be sure to allow plenty of excess tubing (slack) at your pitot and static connections to facilitate future static testing and maintenance.

Since only low air pressures are involved, most informed builders make their pitot/static line installations with plastic tubing and fittings. Aluminum lines and aluminum fittings are much more difficult to fabricate and route, and as a consequence, are currently as rare as fabric covered bamboo fuselages. Almost any kind of plastic tubing will make a satisfactory installation but I recommend the use of 1/4" O. D. Nylo-Seal or Poly-Flo tubing for the instrument connections - and the automotive type compression fittings for the pitot/static tube connections. These will virtually guarantee you a leak-proof static system . . . especially important if you ever expect to install an altitude encoder, auto pilot or whatever. Incidentally, some blind encoders have a plastic static port connector already installed. However, it takes a 1/4" I. D. tube so you will have to replace it with a smaller diameter fitting if your other instruments are plumbed with the smaller 1/4" O. D. tubing. Be careful in removing the fitting . . . use two wrenches to keep the inner core from twisting and ruining something inside the unit.

Altitude Encoders Et Al

The hottest avionics offers at the Sun 'n Fun Fly-In this year were the Blind Encoders (Digitizers). I saw at least three different brands offered at prices ranging from just under $300 to about $425. It pays to shop around, doesn't it? On the other hand, I also heard one builder say, "Sure, I got one of those bargains and I don't even need it . . . yet."

Well, as you are well aware, the most frequent topic of conversation these days is the threat potential for a mandatory Mode C capability for all aircraft operated in controlled airspace. That's O. K., I guess. But that designated airspace is spreading like wildfire, gobbling up more and more of our free sky . . . and that's not O. K.!

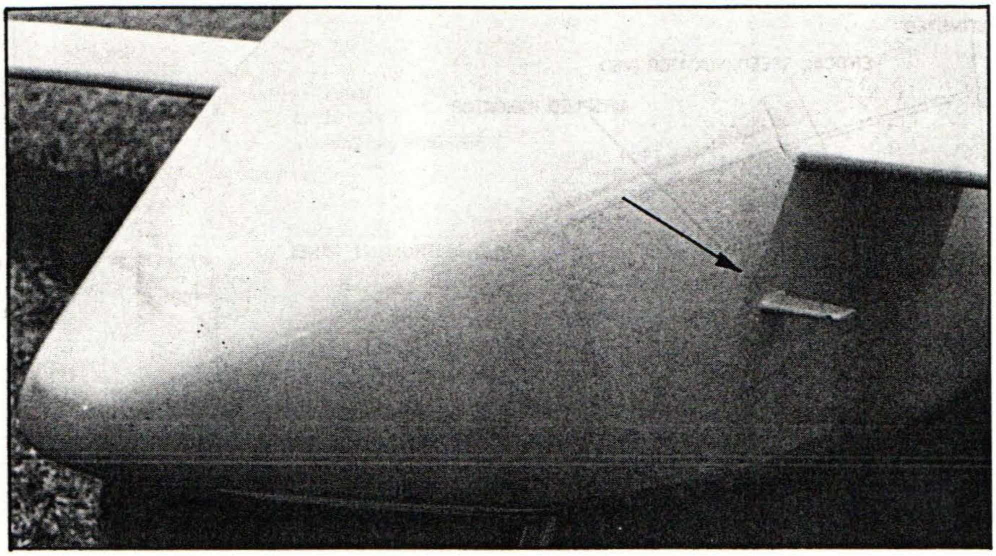
Well, what does this Mode C and Mode A business mean to us? As I recall, we were first confronted with a proliferating, non-mandatory transponder requirement for aircraft operating in, over or through an ARSA (figure that out if you can).

A Mode A transponder, they said, would enable the Controller on the ground to "see where you are" when you respond to his command to "squawk" whatever code (4 numbers) he gives you. After you dutifully enter this code in your transponder and punch the "Ident" button . . . sure enough, he "sees you" where he thought you were. He is so pleased he allows you to keep that code number all the while you are in his area.

No transponder? That was O. K., too. The Controller would, instead, give you a heading to turn and fly to to see if the blip he has on his screen is really you, and that you are where you say you are. They call that "Positive Identification." Since you are VFR, and probably only passing through his area, he would, after verifying your position, instruct you (sooner or later) to "resume navigation." By that time you are almost lost . . . certainly, you are no longer headed in the direction that you were originally going.

A little bit of that sort of thing can become very irritating. Consequently, more and more homebuilders are capitulating and are reluctantly equipping their aircraft with transponders for those occasional and necessary passages into or through the limits of ARSA airspace.

This basic transponder capability is called Mode A. From the point of view of the Controller on the ground, it had



An unusual location for a pitot/static tube. It is just ahead of and below the canard.

one major drawback. The Controller could "see" where you were, but could not tell at what altitude you were. This, of course, was a handicap, especially to those Controllers working a high density airspace.

Incidentally, if you are transponder equipped you must, after allowing your transponder to warm up for a few minutes in the standby position (SBY) and after take-off, switch it to "ON" so that the transponder will be "transmitting" the 1200 code during flight . . . no matter where you are or where you are going.

In order to have an altitude reporting (Mode C) capability, your aircraft must, first of all, be equipped with a transponder.

Both encoding altimeters and blind encoders operate through a transponder and, furthermore, neither will work unless your altitude encoder is connected to the aircraft's static source.

An encoding altimeter is a very expensive altimeter because of its dual function. That is, the pilot can look at it and see what his altitude is. The Controller on the ground can look on his display and see that same altitude being reported by your encoding altimeter.

A blind encoder, with the help of the transponder, permits the Controller to see where you are and your flight altitude as well. On the other hand, your blind encoder has no dial or indicator for you to read so you don't know what altitude the thing is allowing the Controller to see . . . it may not be the same altitude showing on the face of the altimeter in your instrument panel. This is the blind encoder's biggest shortcoming.

Obviously a reliable static system is most important for both the altitude encoder and the blind encoder because an accurate reading of the pressure altitude is the basis from which all the information stems.

If you have an aircraft under construction and are going to equip it with a Mode C capability, you might well consider purchasing an encoding altimeter to install in your panel. That way, you, too, will see the altitude that the Controller is getting.

On the other hand, if your airplane is already in service and is equipped with a good altimeter, it would be less expensive to add a blind encoder to enable your transponder to operate with the Mode C altitude response capability. A nice thing about a blind encoder is that it can be installed anywhere. It does not have to be installed in the instrument panel.

Installing a blind encoder is simple. connect the port on the encoder to a good static pressure source. In most installations this is the back side of the altimeter where the installation of a "T" fitting will permit you to connect the line from the encoder.

Of course, there are the electrical connections between the encoder and the transponder that will also have to be made. Most outlets selling the encoders will make up a harness to match your brand of encoder for the going price of $60 to $87. However, the encoder comes with a very detailed manual that includes the wiring diagrams. Anyone who can build his own airplane certainly should have no trouble soldering a few wires to pin terminals.

To enable your encoder to respond to altitude queries, switch the control knob on the transponder from ON to ALT. However, there is no use in switching to ALT unless you do have an encoding altimeter or a blind encoder on board.

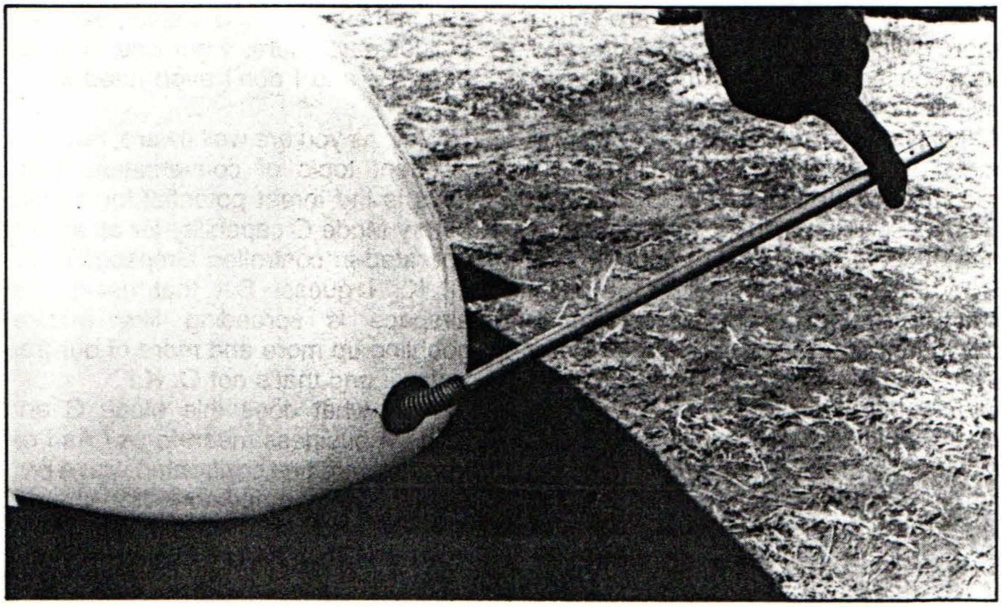
After you install your blind encoder, you should have the unit checked by an avionics shop to verify the interplay between the blind encoder data and that displayed by your altimeter.

Those of you with an IFR capability already know you must obtain a static check every two years (FAR 91.171).

Of course, your static system should also be checked for leaks during the installation of any kind of altitude encoder. Leaks can occur at the connectors or maybe even in the altimeter, VSI or airspeed indicator, necessitating replacement or repair.

I guess you will agree that this information is, at best, only a brief simple language introduction to the increasing complexities facing new builders. Hopefully, it will encourage you to keep yourself better informed.

If you wish to contact the author for additional information, please write to Tony Bingelis, 8509 Greenflint Lane, Austin, TX 78759.



For pusher designs like the Mini-Imp, the perfect location for the pitot/static tube assembly is in the nose. It is also a perfect location for getting the thing broken off by careless folks. This one won't break . . . I wonder how Molt Taylor did it?