

Working With Glider Pneumatic Air Lines And Instruments

By John DeRosa



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Thank you, John




-  ← Photos marked with this symbol are courtesy of Cumulus Soaring
-  ← Photos marked with this symbol are courtesy of Craggy Aero
-  ← Photos marked with this symbol are courtesy of Wings and Wheels

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Air line Function	Air Line Color
Pitot	Red
Total Energy	Green
Static	Blue
Capacity	Yellow
Spare	Clear



Presentation Overview

Aircraft pneumatic air lines and ports are vital to the safe functioning of critical instrumentation such as air speed indicators (ASI), altimeters and transponders.

Air lines are also very important for the proper functioning of other instruments such as variometers and flight computers used to optimize soaring flight.

This document is an attempt to help you understand these glider pneumatic systems to install, test, maintain, plus other technical details.

Any of your questions, comments or corrections are always very welcome!

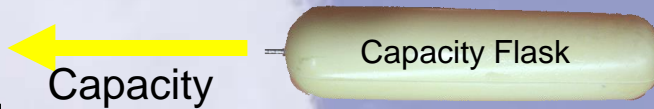
Basics of Air Lines



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Air Lines – Typical Instrument Use

**Mechanical
Variometers**



Capacity



Static or
Total Energy

**Airspeed
Indicators**

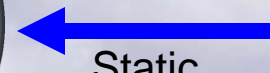


Pitot



Static

Altimeters



Static



Capacity Flask



Pitot



Static



Total Energy



**Electronic
Variometers**

Air line Function	Air Line Color
Pitot	Red
Total Energy	Green
Static	Blue
Capacity	Yellow
Spare	Clear

Types of Glider Pneumatic Sources

Note: The descriptions below provides limited physical information about each sources type but not the function of each.



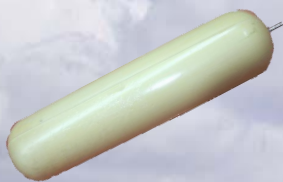
Static – These are pairs of rather small holes found on the left and right side of the fuselage. Each pair is cross-connected to one another. Most often found at a point on the fuselage perpendicular to the flow of air but may be found near the nose or along the glider's tail boom, or a combination. There may be more than one pair of static ports on a sailplane and can also be found in multi-port total energy probes.



Pitot – Typically found on the nose of a glider. May also be found in multi-port total energy probes.



Total Energy – A probe commonly found on the front of the vertical stabilizer fin, sometimes just aft of the canopy on the fuselage. This is connected to both mechanical or electronic variometers to increase their accuracy. This probe also comes in “double” or “triple” port versions which can add static and/or pitot sources.



Capacity Flask – This is an insulated and leak proof flask whose internal stabilized pressure level is used by mechanical variometers, and some older electronic versions, to be compared to that of the static port pressure. Becoming less common in modern glider systems.

Air Line Tubing

- Air lines in gliders are almost always 3/16" (5mm) inner diameter (I.D.) PVC tubing.
- Air lines are attached to instruments via barbed fittings which prevent air leaks.
- Only buy air line materials from a reputable glider equipment dealer! These will be easier to work with and will remain flexible for a very long period of time. Consider this rather cheap insurance!
- Good quality air line material is **NEVER** found in your local stores. It is not hardware store tubing. It is not automotive brake line hose. It is not medical tubing.

HOWEVER, there is one important caveat to this rule¹

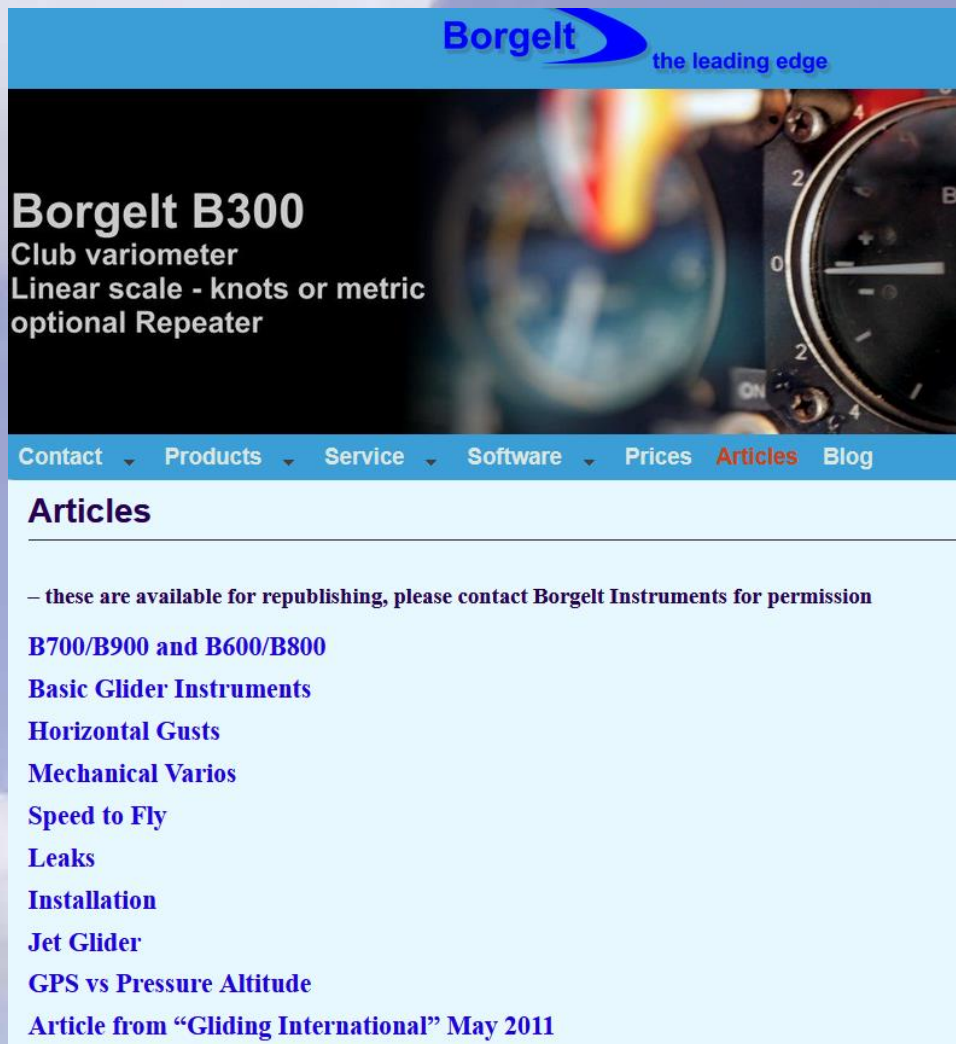
Air line Function	Air Line Color
Pitot	Red
Total Energy	Green
Static	Blue
Capacity	Yellow
Spare	Clear



¹ **Mike Borgelt states;** ***“DO NOT** use very soft wall tubing for the total energy line and make sure this line is well secured so that it cannot move under changing G loads due to maneuvering and/or turbulence. This will prevent spurious transient signals on the vario caused by volume and hence pressure changes in this line. Long lengths of tubing should be of the less flexible plastic or rigid nylon pressure hose.”* For details see http://www.borgeltinstruments.com/?page_id=252

Valuable Information from Borgelt

http://www.borgeltinstruments.com/?page_id=27



The screenshot shows the Borgelt Instruments website. At the top is a blue header with the Borgelt logo and the tagline "the leading edge". Below the header is a large image of a variometer with a red needle. To the left of the image, the text reads: "Borgelt B300", "Club variometer", "Linear scale - knots or metric", and "optional Repeater". Below the image is a navigation bar with links: "Contact", "Products", "Service", "Software", "Prices", "Articles" (highlighted in red), and "Blog". Below the navigation bar is a section titled "Articles" with a list of links: "– these are available for republishing, please contact Borgelt Instruments for permission", "B700/B900 and B600/B800", "Basic Glider Instruments", "Horizontal Gusts", "Mechanical Varios", "Speed to Fly", "Leaks", "Installation", "Jet Glider", "GPS vs Pressure Altitude", and "Article from “Gliding International” May 2011".

Borgelt the leading edge

Borgelt B300
Club variometer
Linear scale - knots or metric
optional Repeater

Contact Products Service Software Prices **Articles** Blog

Articles

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[B700/B900 and B600/B800](#)

[Basic Glider Instruments](#)

[Horizontal Gusts](#)

[Mechanical Varios](#)

[Speed to Fly](#)

[Leaks](#)

[Installation](#)

[Jet Glider](#)

[GPS vs Pressure Altitude](#)

[Article from “Gliding International” May 2011](#)

Mechanics of Air Line Instruments



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Mechanical Airspeed Indicator

Mechanism Details

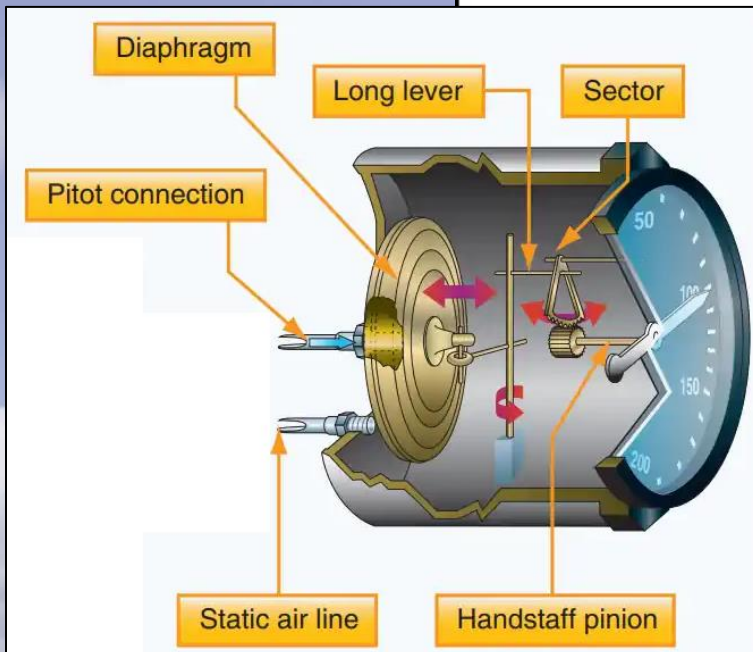
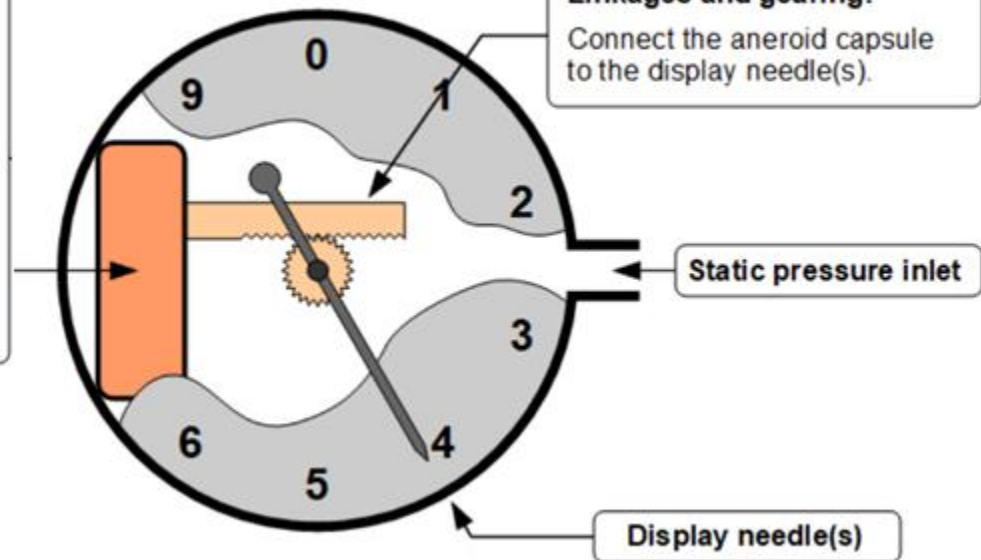
Aneroid capsule:

A sealed copper and beryllium alloy capsule from which the air has been removed.

The capsule is springy and designed to compress as the pressure around it increases and expand as it decreases.

Linkages and gearing:

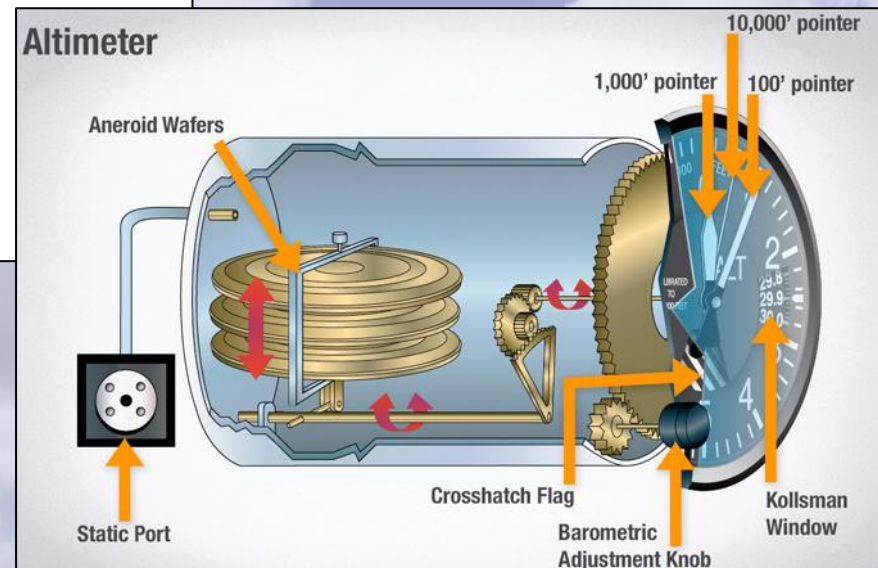
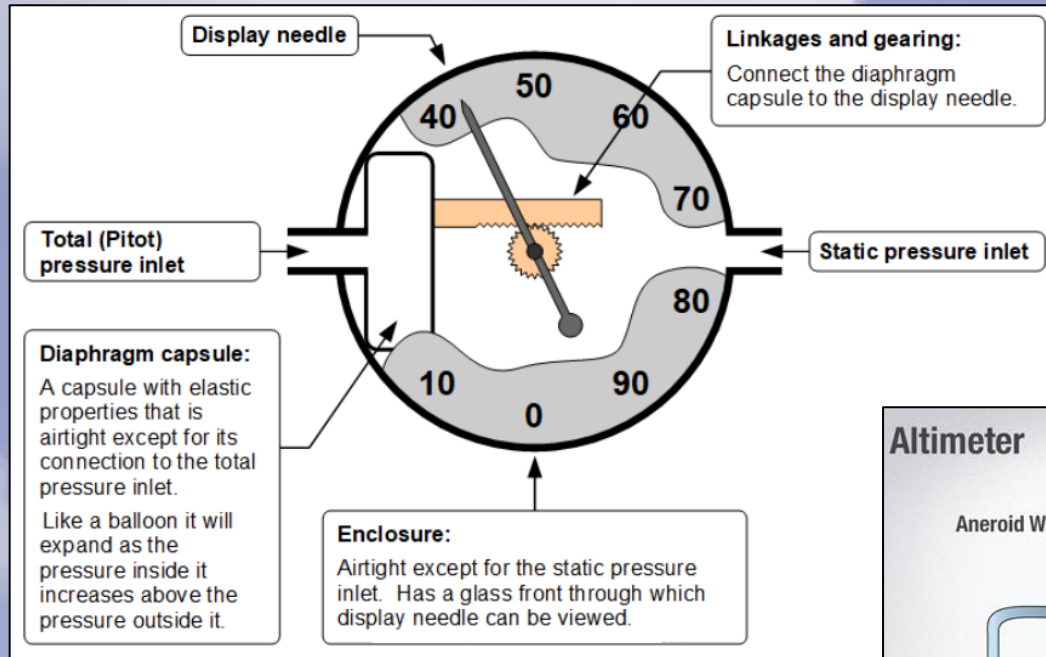
Connect the aneroid capsule to the display needle(s).



Source: Dave Rolley soar.rubber.duck@gmail.com

Mechanical Altimeter

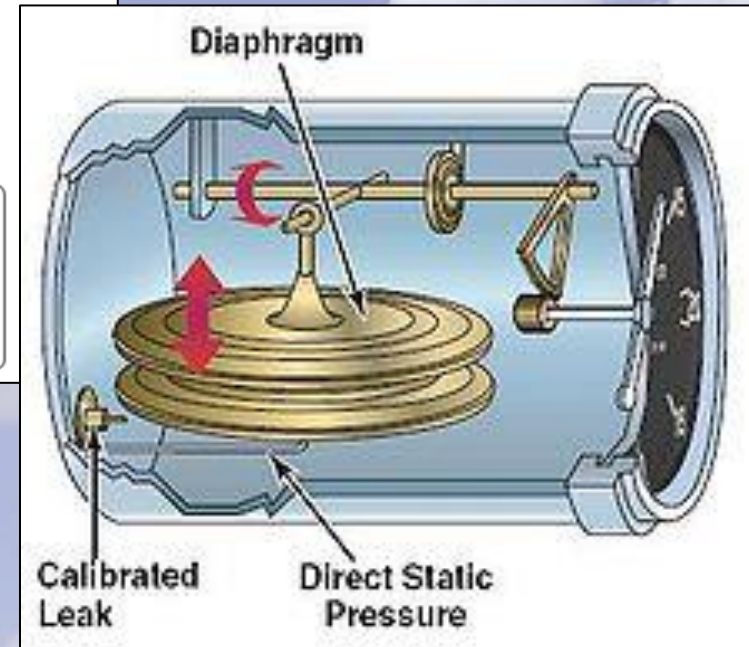
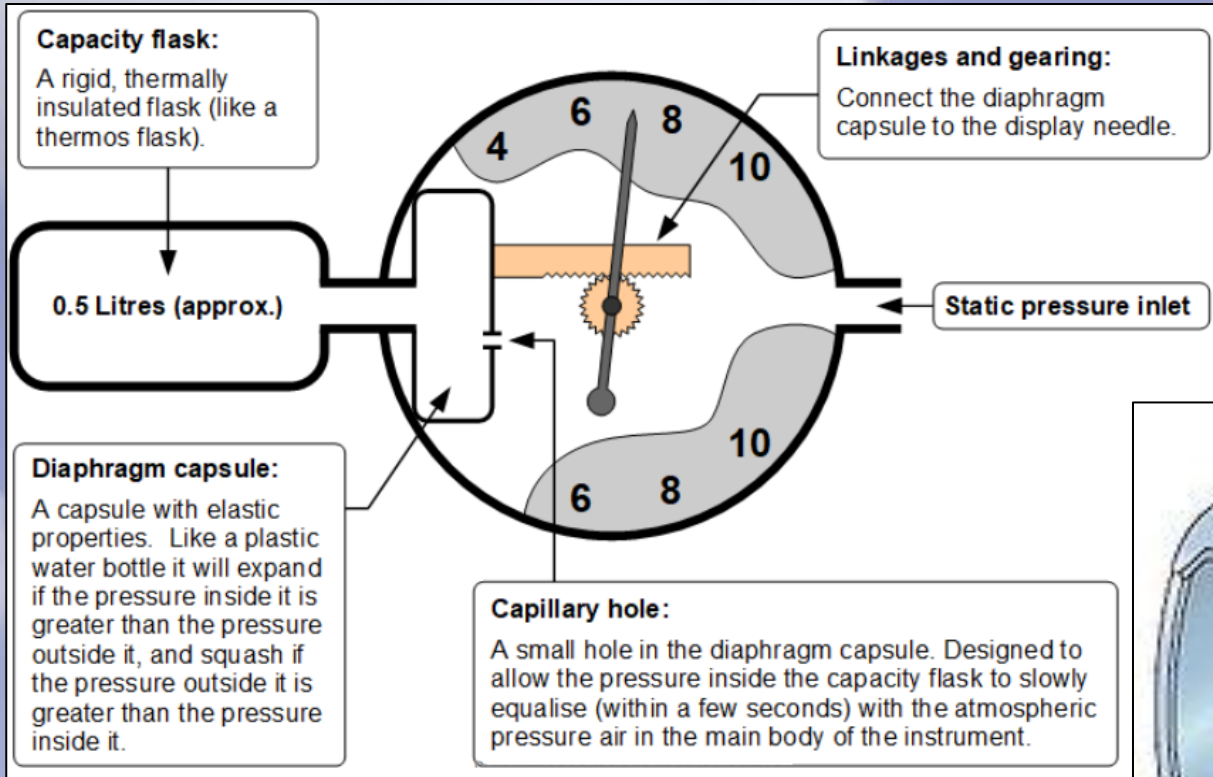
Mechanism Details



Source: Dave Rolley soar.rubber.duck@gmail.com

Mechanical Variometer

Mechanism Details



Source: Dave Rolley soar.rubber.duck@gmail.com

Mechanical Variometer Mechanism Details

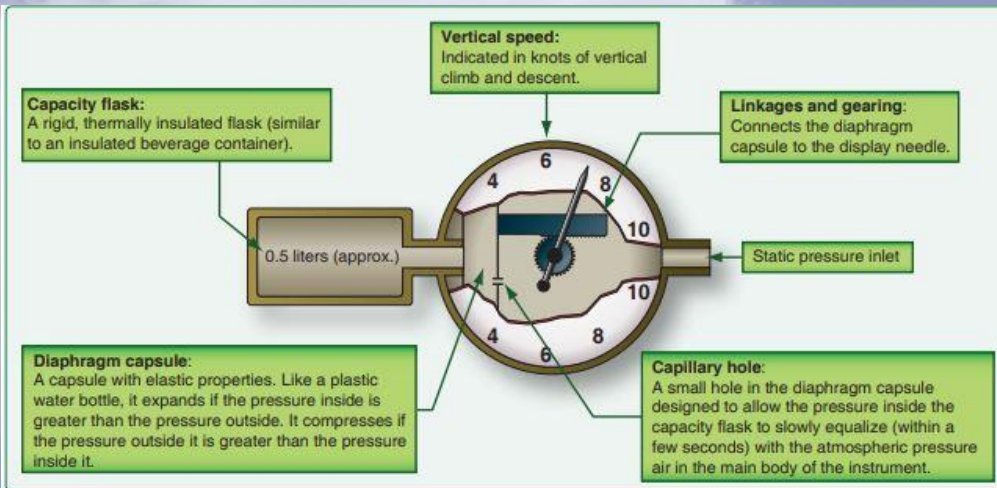


Figure 4-21. A variometer diaphragm anatomy.

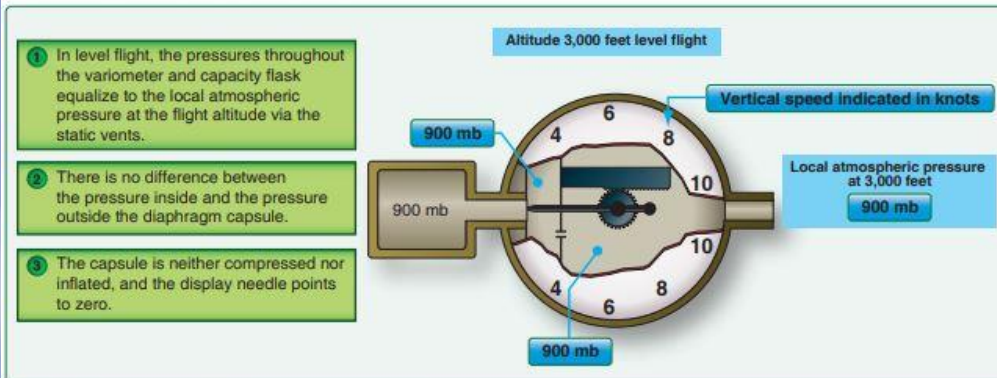


Figure 4-22. Uncompensated variometer in level flight.

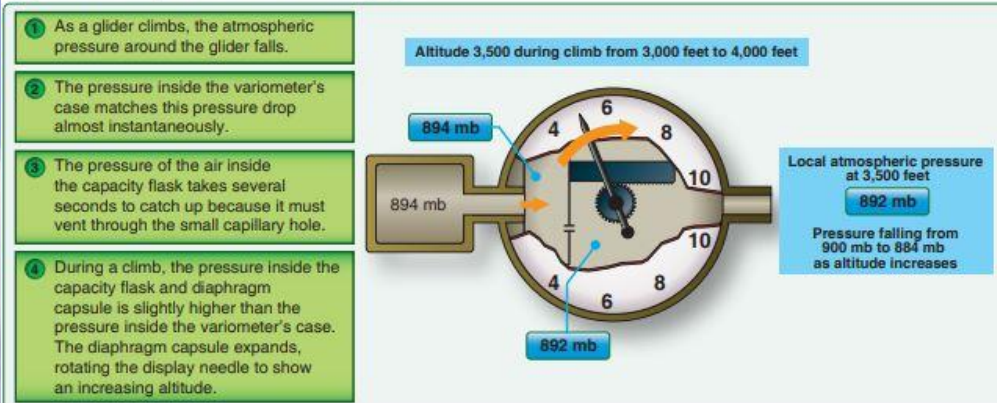
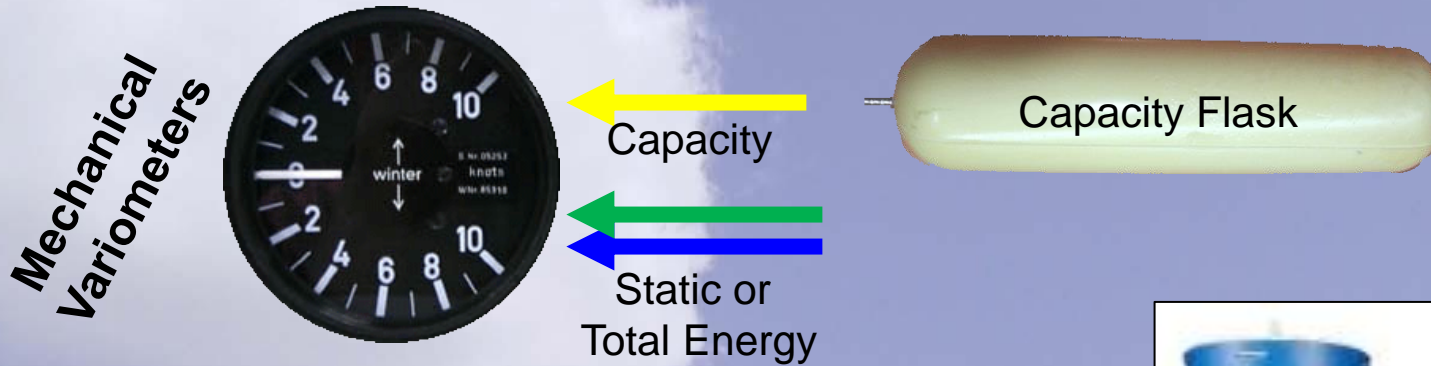


Figure 4-23. Uncompensated variometer in a climb.

Air Lines – Capacity Flasks

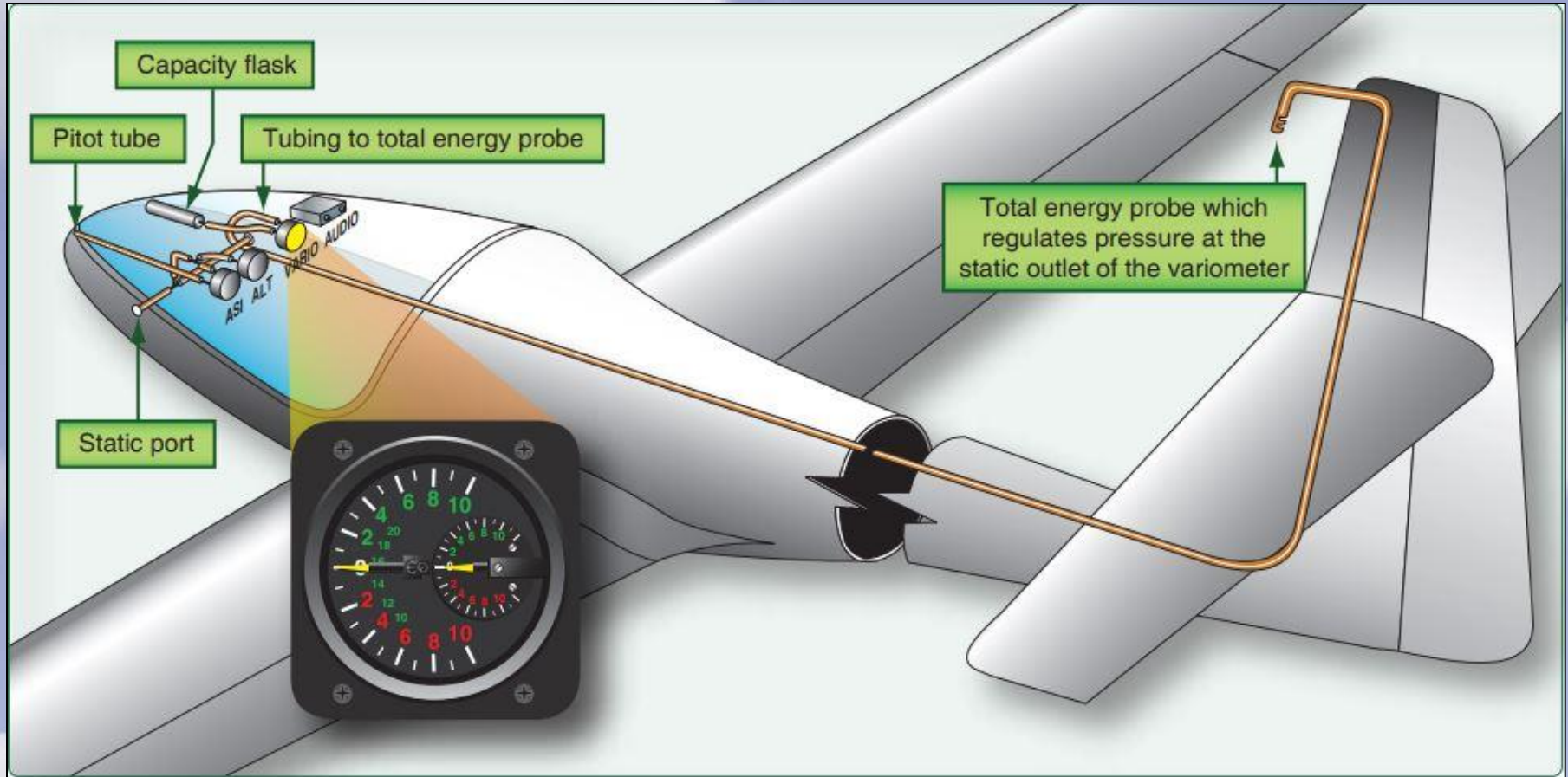


- Capacity flasks, sometimes called “bottles”, are a critical component of most mechanical variometer systems. Capacity flasks are typically not used with electronic variometers.
- Capacity flasks come in several sizes based on their volume and are specific to the variometer manufacture and model. Common internal volume sizes are 0.45 liter and 0.90 liter.
- To read more about variometers and capacity flasks refer to Chapter 4 of the FAA’s “Glider Flying Handbook” in the “Variometer” section. This manual is found online at https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/glider_handbook for technical details and information.



Mechanical Variometer

Mechanism Details

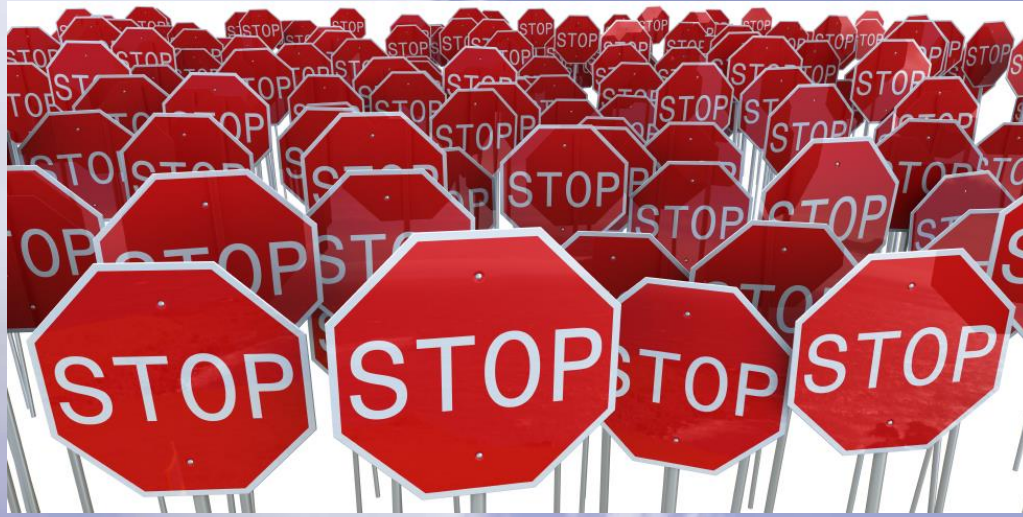


Source: <https://en.wikipedia.org/wiki/Variometer>

Replacing Air Lines



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IT'S IMPORTANT TO LABEL
EVERY AIR LINE BEFORE
REMOVING ANY TUBING FROM
AN INSTRUMENT!

Air Lines – Removing/Replacing – Part 1

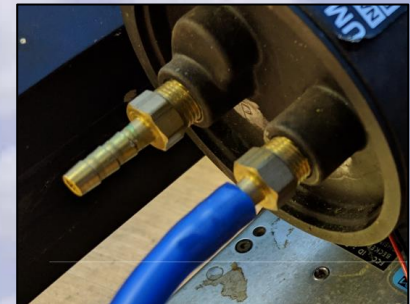
Replace old & age hardened air lines to prevent leaks. You should decide to replace all easily accessible air lines as a matter of course during a panel refit/refurbish. This is cheap insurance.

- Take pictures behind the instrument panel of all the air lines from several angles.
- The pneumatic port names are usually written on the rear of the instrument. This helps identify air lines and to prevent reversing air lines and causing unintended (and potentially dangerous) results. Sometimes instrument port names are missing, hard to read, or in a foreign language.
- The air lines imbedded in the fuselage at the factory are seldom replaced due to the difficulty in accessing them.
- Before removal/replacing any air line you **must document each line**, one at a time, as to which aircraft's instrument & port it connected to and its function if known (see later sliders to help identify the function of unknown lines).
- Hint: Write the air line's details on colored coded electrical tape – see the table below.



Automotive Vacuum Line Tool ~\$10

Air line Function	Air Line Color
Pitot	Red
Total Energy	Green
Static	Blue
Capacity	Yellow
Spare	Clear



Air Lines – Using Colored Tubing

Using color coded air lines makes it much easier to identify and trace air lines by function!

Before

After!

← **Difficult!**

Easy! →

Sage
Total
Energy
System
B-526-0777

Sage
Total
Energy
System
B-526-0777



Capacity

Total Energy

Static

Pitot

General



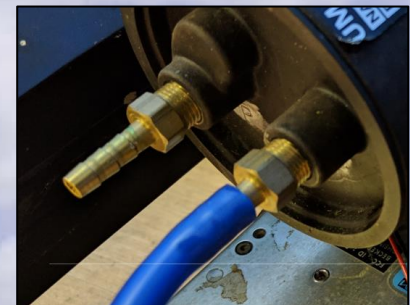
Air Lines – Removing/Replacing – Part 2

- Removing air lines from instruments can be difficult. Do not simply pull on the air line as this only tightens onto the barbed fitting which can possible damage the instrument! Try gently warming the air line at the instrument's fitting with a hairdryer.
- You can also use an inexpensive automotive vacuum line removal tool (shown below at left) to help push the line away from the instrument and off the barbed fitting. With stubborn air lines you may need to make a parallel slit or two into the air line along the length of the instrument's barbed fitting - just be careful not to damage the fitting as this can also cause leaks. Gently does it!
- Replace each air line one at a time following the color codes in the table below for ease of maintenance. Using color coded air lines eases recognition of the different air line types and to aid troubleshooting (see following slide).
- To aid inserting the new air line onto the instrument gently warm the end of the tubing with a hair dryer.



Automotive Vacuum Line Tool ~\$10

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Determining Which Air Line Goes Where?



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Air Lines – Tracing Air Lines' Path

You may find yourself losing track of which air line behind the panel is connected to which of the fuselage's various ports. Finding this out can be difficult to determine but is critically important to know.

**CRITICAL – To prevent instrument damage you must remove and label every single air line from every single instrument before beginning any testing.
See prior slides for details on removal.**

1. Follow these steps to determine which air line port at the instrument is connected to which fuselage port;
 - Locate each different air line port on the glider's fuselage. Tape a small flap of tissue paper over each port including the TE probe's outlet(s).
 - An air line is often split behind the panel into two, three or even more outlets. Plug all but one outlet.
 - GENTLY introduce air into each air line at the instrument panel end and note which flap of paper moves. Compressed air should be avoided. Pressure from your mouth is usually all that is needed.
 - Record your results. Mark each air line with colored tape and its function.
2. Some glider total energy (TE) probes have a single air line attached. However, other gliders can have a TE probe attached to multiple air line types to increase instrument accuracy. These "multi-probes" will have air lines attached for TE, and/or static, and/or pitot, and/or all three! In this case it is important to determine which instrument's port is being sourced from, either from ports on the fuselage (nose, waist, boom, etc) or from the TE probe itself.

Air Lines – Splitters & Couplings

- You may need to split an air line to be able to connect it to multiple instruments (a common example of this is the static air line) or extend an existing air line.
- Use as few splitters/couplers as possible because the air flow in glider's air lines is very slight and any interference to this flow should be avoided to maintain accuracy.
- There are several types of air line splitters and couplers;
 - Tees – Most commonly used. Splits an air line to two instruments.
 - Crosses - Splits an air line to three instruments.
 - Couplers – Joins two lengths of air lines. Avoid if possible by replacing lines entirely.
 - Elbows – Prevents kinks in air lines. Avoid if possible by replacing lines entirely.
- The air line junctions come in both plastic and metal versions. In either case inspect the ends of the fittings and remove any rough edges.
 - Plastic – This type may interfere with the air flow due to “flashing” left over from the manufacturing process. Be sure to look for this and remove it if found.
 - Metal – This type is referred type as it is more robust and less likely to have any “flash”.
- Do not allow any kinks in the air lines.

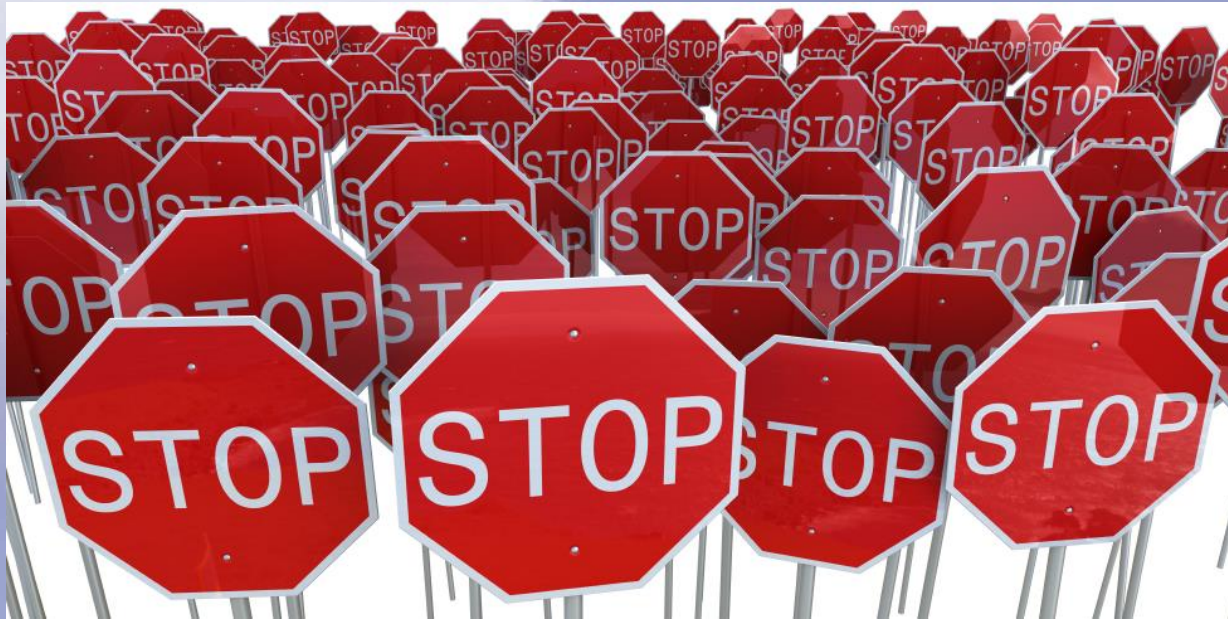


Testing of Air Lines & Instruments



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AIR INSTRUMENTS – TESTING



**NEVER BLOW INTO, OR INJECT
COMPRESSED AIR INTO, ANY
AIR LINE or INSTRUMENT!**

Air Lines – Testing

(beyond the scope of this presentation)

How's Your Plumbing? by Lee Kuhlke

No, I do not imply that you need to see an internist. But your glider may need a thorough examination.

Have you seen the classified in *Soaring* "Glider For Sale

3. Silicone lubricant (Vaseline will work but it causes the rubber to expand)

4. 2 hemostats

- Here are two good articles on testing your air lines;
 - "How's Your Plumbing?" by Lee Kuhlke (July 2005 *Soaring*)
 - "Sailplane Instrument Installation and leak checking" by Mike Borgelt (2008)
- You can find PDF copies of these two articles at;
<http://aviation.derosaweb.net/articles/airlines>

RULE OF THUMB

If you disconnect tubing from a connector, cut 1/2" from the end before reconnecting it. If the length is too short, replace the tubing or insert a straight connector and connect an additional length.

The vinyl tubing has memory. It will not reseal exactly and a leak WILL result. Secure all loose tubing. As tubing flexes, the volume within the tube changes.¹ Also, connections may distort and leak due to age.

The entire time to check a system is less than two hours. Fixing the leaks is another matter!

MATERIALS

For this exercise you will need the following items (Figure 1):

1. 3 cc medical syringe
2. 60 cc medical syringe

Fill a tube with water and bend it. Observe the water squirt out.



Tools needed to check and repair the glider pneumatic system.

PROCEDURES

Prepare The Syringes

The rubber stoppers of the syringes can be sticky. You will need precise movements of the plungers for testing. Lubricate the plunger with the silicone. Insure smooth movement. Attach a 3-foot length of tubing to each syringe and seal it with tape (Figure 2). Check the seal by clamping the tube with a hemostat and withdrawing the plunger a little. It should be pulled back into the barrel.

There are two syringes. The smaller is less sensitive to technique and should be used for the direct connection to the ASI, described later. The larger syringe allows more volume for the longer tubes. When leaks are encountered it can be further withdrawn without having to disconnect and reconnect the syringe.

Airspeed Indicator (ASI)

The ASI will be the "leak detector." The ASI consists of a

Sailplane Instrument Installation and leak checking

Updated December 2008

In order to obtain the best possible performance from your sailplane instruments it is essential that the installation be done correctly and be free of leaks.

A few simple installation rules are:

1. Use high quality tubing (Teflon based is highly recommended) to connect the variometer to the TE line. This tubing should be secured so that it cannot move during changing G loads due to the variometer's volume and hence pressure changes in this line. Long lengths of tubing can cause problems. This tubing should be secured so that it cannot move during changing G loads due to the variometer's volume and hence pressure changes in this line. Long lengths of tubing can cause problems. This tubing should be secured so that it cannot move during changing G loads due to the variometer's volume and hence pressure changes in this line. Long lengths of tubing can cause problems.

3. All tubing must be in good condition and should be a very tight press fit over the fitting to avoid air leaks. Even a small air leak will compromise any variometer's performance. For extra insurance against air leaks we supply small, thick walled elastic 'donuts' which you may install over tubing several inches past the end. After the tubing is properly attached to the fitting on the instrument, slide the 'donut' back toward the end of the tube so that it supplies extra squeeze around the tubing/fitting area. You can use two on the TE line connections. Short lengths of thick wall silicone tubing may be used instead of the 'donuts'.

4. Do not use electronic type nylon cable ties or twisted wire on tubing fittings as this will almost certainly guarantee a leak.

5. Unless all the varios connected to the TE line are of the pressure transducer type, split the line as close to the TE probe as possible. This minimises interaction between the instruments caused by flow in the line from variometers which use capacity flasks and also prevents the pressure transducer vario response from being slowed by the presence of the flask causing a pneumatic low pass filter to be formed. In practice, placing the T piece under the seat near the rear of the seat area is good enough.

The most common mistake in variometer installations is to connect two vario systems to one Total Energy line with a T piece at the instrument panel. The only

Miscellaneous Information



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Pneumatic Instrument Repair Stations (US)

- **Mechanical Instruments**
 - Keystone Instruments
320 Proctor St, Lock Haven, PA 17745
Phone: (570) 748-7083
 - Or Google “Altimeter Repair”
- **Electronic Sailplane Instruments**
 - Contact your instrument supplier or manufacturer

Pneumatic Instruments

Air Data Systems – Technical Details

http://aviation.derosaweb.net/articles/air_lines



2022
SSA Webinar Series

Black Forest Soaring Society Ground School Series

Air Data Systems

By Dave Rolley

Feb 4, 2022

Air Lines – Miscellaneous Information

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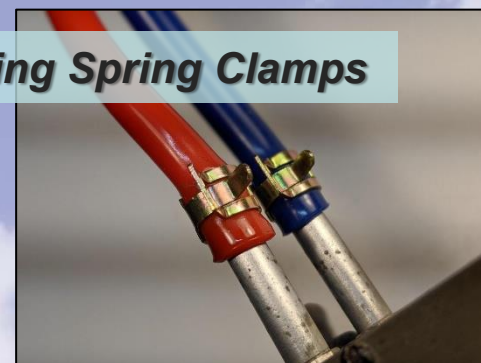
1. Tape a copy of the air line color code chart somewhere behind/under your instrument panel for quick reference! (see the next slide)
2. The Winter 5-Way quick connector (below at left) is a great way to allow your instrument panel to be more easily removed.
3. Preventing Leaks – It is not recommended using cable ties (applies unequal forces) or small livestock castration rings (weakens quickly over time) to secure tubing. Instead use 5/16" (8mm) tubing spring clamps which applies equal force around the entire tube diameter.



**Winter 5-Way Tubing
Quick Connector**



5/16" (8mm) Tubing Spring Clamps



Castration Rings



Cable Ties

air line Color Code Chart - Print this page and tape a copy behind/under your instrument panel for quick reference

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Pitot	Red
Total Energy	Green
Static	Blue
Capacity	Yellow
Spare	Clear

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Air Lines

Inline Condensation Filters

Prevents moisture from entering instruments. These may impact performance.



Air Lines - Variometers

“Flow Restrictors” & “Gust Filters”

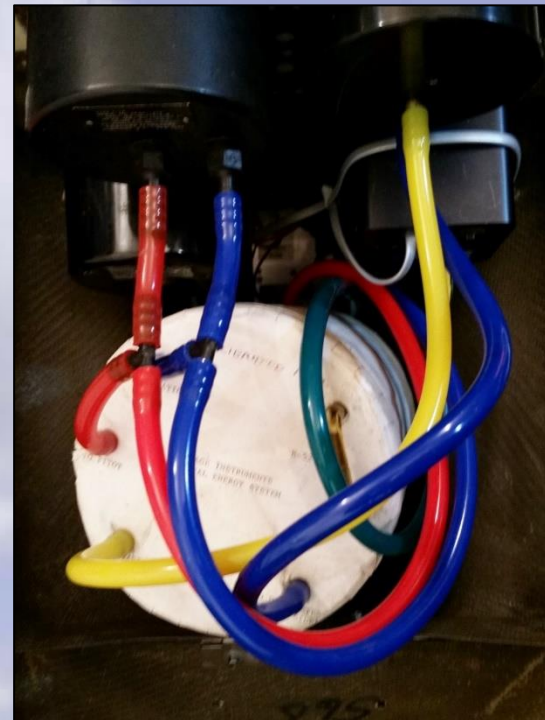
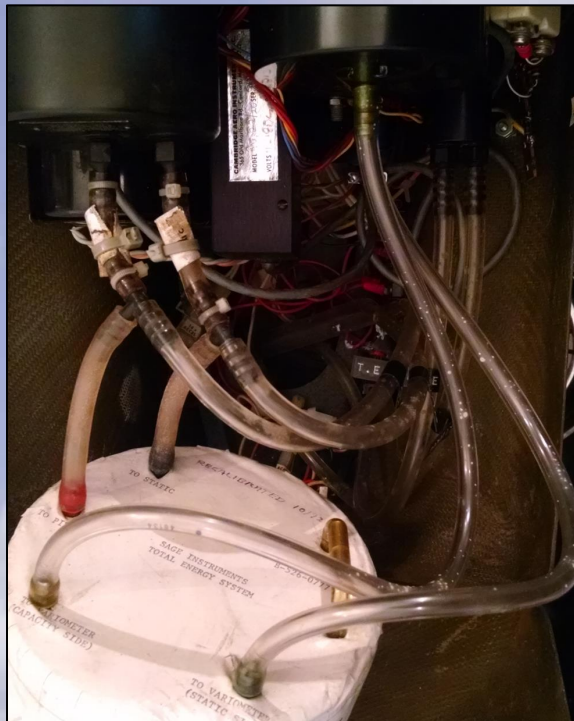
*Inserted in air lines per the instructions
from the instrument's manufacturer*



Sage Total Energy System (B-526-0777)

"What you have there is a Sage B box. The box is a total energy compensator device. When they work, there is nothing better. We do not have any calibrating technology or knowledge to support these anymore. These boxes were replaced by the Compensated static probes call TE probes. These boxes are very good to use as a second source of TE when multiple varios are installed and one wishes not to have them plumbed in parallel. There are also handy for motor gliders so one may have a vario unaffected by the prop wash. The downside is the space they take up or if they get damaged, there is no one who knows how to fix them. If you have the space to mount it, I would recommend using it. Just hook it up according to the labeled ports."

Rex Mayes, Williams Soaring (December 6, 2015)



U.S. Glider Equipment Dealers



<http://craggyaero.com>



<http://cumulus-soaring.com>



<http://wingsandwheels>

See My Other Presentations

- Glider Electrical Wiring
- Bailing Out Successfully
- Transceiver Troubleshooting
- Oxygen Systems
- Working with Glider Air Lines
- Trailer Wiring & LED Lighting
- Soaring Pilot Relief Systems
- Battery Testing
- Emergency Location Devices
- Survival Kits
- Landout and Bailout Kits
- Spar Alignment Tool
- L'Hotellier Fittings
- Carbon Fiber Panels
- IGC Filename Decoding
- Blanik L-23 Strut Work
- Removing Painted Lettering
- Open Glider Network
- Instrument Knob Extensions
- Landing Gear Warning

[**http://aviation.derosaweb.net/presentations**](http://aviation.derosaweb.net/presentations)

Let me know of any comments!