INSTALLATION INSTRUCTIONS

FOR MODEL B

TOTAL ENERGY SYSTEM

Wil Schuemann 3/11/76

UNIT LOCATION AND MOUNTING

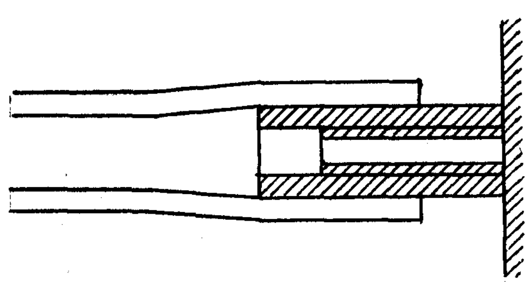
There is no preferred location or orientation of the unit in the sailplane except that it should not be exposed to direct sunlight in flight to avoid variometer errors due to heating and cooling of the unit.

PITOT, STATIC AND VARIOMETER CONNECTIONS

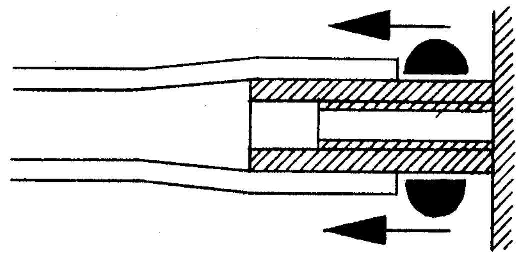
Tubing connections to the unit are self-explanatory. Pitot and static lines are 3/16 inch inside diameter tubing, colored red and blue respectively. Length of the lines is not critical though lengths should be no longer than necessary. The lines to the variometer are 3/16 inch inside diameter yellow and 3/16 ~~1/8~~ inch inside diameter green tubing. The yellow line goes to the capacity side of the variometer and the green line goes to the static side of the variometer. The unit is calibrated with the yellow and green lines each 0 feet long. However, in the typical installation the yellow and green lines are of equal length and 5 feet long. The length of these lines has a small effect on compensation and this fact is utilized to adjust for small effects which are discussed further at the end of this instruction sheet.

TUBING INSTALLATION

To install the tubes on the total energy system, spread the end of the tubing to approximately twice its normal diameter with the tip of a needle nose pliers. Then quickly work the expanded tube 5/16 inch or more over the appropriate port on the total energy system. Moistening the inside of the 3/16 inch tube and the outside of the port on the total energy system with saliva will increase the ease of fitting the tubing over the ports. ~~The 1/8 inch green tube can be installed using the same technique though admittedly with more difficulty. It is also possible to connect the 1/8 inch tube to the appropriate port using a short piece of 3/16 inch tubing as a splice. This is not as desirable an approach as using a direct connection.~~



To remove the tube, place the tips of the needle nose pliers behind the end of the tube and push the tube off of the port on the total energy system. Pulling the tube off will be almost impossible because the harder you pull the tighter the joint becomes.



USING TWO VARIOMETERS SIMULTANEOUSLY

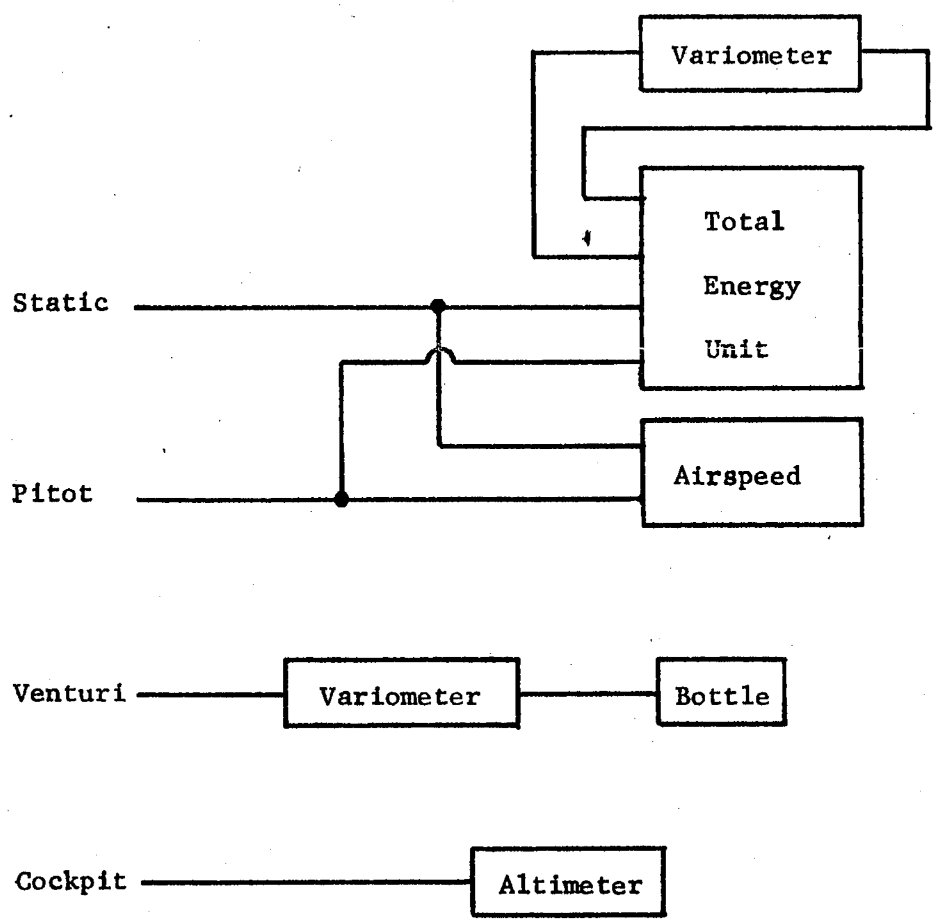
One mechanical variometer and any number of electrical variometers can be used simultaneously on one total energy system. Connect the proper length of 1/8 inch inside diameter green tubing from the port on the total energy system marked TO VARIO (STATIC SIDE) to the port on the mechanical variometer marked STATIC. Connect a short piece of 1/8 or 3/16 inch inside diameter tubing between the port on the mechanical variometer marked CAPACITY and the port on the electrical variometer marked STATIC. Connect the proper length of 3/16 inch inside diameter yellow tubing from the port on the ~~mechanical~~ electrical variometer marked CAPACITY to the port on the total energy system marked TO VARIO (CAPACITY SIDE).

The Ball electric variometer cannot be used with the total energy system because it uses a non-standard reference flask volume. There are ways to adapt the Ball for use with the total energy system but the techniques are well beyond the scope of this instruction sheet.

INSTRUMENTATION CHECKOUT

A syringe of approximately 10 cubic centimeters capacity is supplied with the unit and should be used in the following tests. After all instrumentation is connected the tubing to the static side of the airspeed indicator should be cut near the airspeed indicator and a tee inserted between the two open ends of the cut tubing. Plastic tape is placed over the static ports to seal them. The syringe plunger is pushed all the way into the syringe body. Connect the syringe to the open end of the tee. While watching the airspeed indicator, delicately start to pull out the syringe plunger. The airspeed reading should increase (do not exceed 100 knots), and the variometer should deflect upwards. The airspeed reading should very slowly return to zero after the motion of the plunger is stopped.

Instrumentation Schematic



If the airspeed moves less than halfway back to zero in 15 seconds there is no leak in the static system worth worrying about. If the airspeed drops faster than specified above, a serious leak exists and a drawing of the static system should be made. (Note that the variometer is connected within the total energy system to the static system) To check for the location of the leak the syringe should be disconnected from the system, the plunger pushed all the way in and the syringe then reconnected to the tee. By referring to the drawing select a location in the static system which when kinked shut will isolate some branch of the system. Again, while watching the airspeed indicator, delicately start to pull out the plunger. If the airspeed drops more slowly this time, a leak is indicated in the area of the static system isolated by the kinked tubing. By repeating this test, the exact location of the leak or leaks can be found. Leaks must be elimimated until the airspeed reading drops less than halfway to zero in 15 seconds after the motion of the plunger stops. Replace the tee in the static line with a coupling. This completes the checkout of the static system.

REMOVE THE TAPE FROM THE STATIC PORTS

The checkout of the pitot system is similar to that described above for the static system. Cut the tube going to the pitot side of the airspeed indicator and insert a tee into the two open ends of the cut tubing. Plug the pitot tube. Pull the syringe almost all the way out and them connect it to the open side of the tee. While watching the airspeed indicator, delicately start to push the syringe plunger in. The airspeed reading should increase (do not exceed 100 knots), and the variometer should deflect upwards. The airspeed reading should very slowly return to zero after the motion of the plunger is stopped. If the airspeed moves less than halfway back to zero in 15 seconds, there is no leak in the pitot system worth worrying about. If the reading drops faster than this, then a serious leak does exist and a drawing of the pitot system should be made. The syringe should be disconnected, the plunger pulled out,and the syringe then reconnected to the system. By referring to the drawing select a location in the pitot system which when kinked shut will isolate some branch of the system. Again, while watching the airspeed indicator, delicately start to push in the syringe plunger. If the airspeed reading drops more slowly this time, a leak is indicated in the area of the pitot system isolated by the kink in the tubing. By repeating this test, the exact location of the leak can be found. Leaks must be eliminated until the airspeed reading drops less than halfway to zero in 15 seconds after the motion of the syringe is stopped.

THEN UNPLUG THE PITOT TUBE

WARNING

FAILURE TO OPEN THE PITOT TUBE AND STATIC PORTS PRIOR TO FLIGHT WILL PROBABLY CAUSE IRREPAIRABLE DAMAGE TO THE UNIT

SPEED RING CONSTRUCTION

Because the total energy system contains the sailplane polar compensation feature it will not provide the proper speed to fly if a conventional speed ring is used. But, given the table of airspeed and sink rate values from which the conventional speed ring is constructed it is easy to adjust these values to make a speed ring which will work with the total energy system.

Given that speed rings are at best a very crude guide as to what speed to fly, it is true that a speed ring on a system which has been sailplane polar compensated is much more useful than a speed ring on a conventional variometer. The speed ring on the sailplane polar compensated variometer reads the "correct speed to fly" directly while on the conventional variometer the indicated "correct speed to fly" continuously changes as the actual airspeed is adjusted toward the indicated "correct speed to fly". The indicated "correct speed to fly" does not stop changing until the actual airspeed and the indicated "correct speed to fly" are in agreement. Of course, by that time the air through which the sailplane is flying has changed and the pilot is obliged to start the search for the new "correct speed to fly". This is a never ending process and very fatigueing. With the speed ring on the sailplane polar compensated variometer the indicated "correct speed to fly" does not change with actual airspeed and the pilot sees at a glance what speed he should be flying if he wants to follow the advice of the speed ring.

First tabulate the airspeed and sink rates used to construct a normal speed ring in the first two of four columns as shown in columns one and two below. Column one should contain the airpeed values and column two the sink values. In column three the actual sink of the sailplane from the sailplane polar should be tabulated against the airspeed values in column one. Column four is obtained by subtracting column three from column two. By using columns one and four a new speed ring can be constructed which will work with the total energy system. The distances between the airspeed markings on the new speed ring should be about one half as far apart as they were on the speed ring built for use on a conventional variometer.

Airspeed Knots	McCready ft/min	Polar ft/min	Speedring ft/min
40	-20	-125	+105
50	-145	-145	0
60	-290	-160	-130
70	-510	-230	-280
80	-790	-320	-470
90	-1150	-470	-680
100	-1600	-580	-1020
110	-2160	-770	-1390

Reference arrow is at 0 ft/min and corresponds to actual achieved rate of climb. Although I did the above McCready calculation in a hurry and have not checked it, it should represent a standard class sailplane at about 6.5 lbw/ft^2.

FLIGHT TESTING

In most cases the performance of the system will be satisfactory if the preceeding instructions are followed. If for some reason system performance is not satisfactory, then a flight test should be performed.

Flight testing must be done on absolutely calm air. Two separate tests should be performed. The first test checks the polar compensation feature. The second test checks the total energy compensation performance of the system.

SAILPLANE POLAR COMPENSATION

The variometer when used with the total energy system reads only the motion of the air through which the sailplane is flying. This type of display is far more valuable to the soaring pilot than displaying the motion of the sailplane as is usually done.

By displaying the motion of the air, a 500 foot per minute thermal gives the same variometer indication at 50 knots and at 100 knots. By comparison, using a conventional variometer, a 500 foot per minute thermal indicated at 50 knots would indicate only as sink at 100 knots because of the sailplanes much higher sink rate at that airspeed.

When thermalling,the variometer will read about 100 feet per minute up if the sailplane is in "zero sink" because the air has to be moving upward past the sailplane that much to cancel the normal sink rate of the sailplane. About 100 feet per minute will have to be subtracted from the indicated climb rate to obtain the sailplane climb rate. The difference between the reading of a conventional variometer and the polar compensated variometer is essentially a constant while thermalling hence there is no difference in the usefulness as regards the ability to center the thermal. A conventional variometer with a small upward bias of the zero point would give almost exactly the same imformation while thermalling as the polar compensated variometer. However, the polar compensated variometer gives a much better picture of the shape of the thermal and the lift and sink distribution,as the readings are not depressed downward by the sink rate of the sailplane.

To test the sailplane polar compensation feature, fly at a steady 100 knots in still air. Record the variometer indication and then slow the sailplane to 90 knots. Again record the variometer indication and slow up to 80 knots. Continue taking data until the steady state variometer reading for all speeds from 40 knots to 100 knots in 10 knot increments are obtained. The variometer should be within 50 feet per minute of zero at all speeds to 80 knots and within 100 feet per minute of zero at 100 knots.

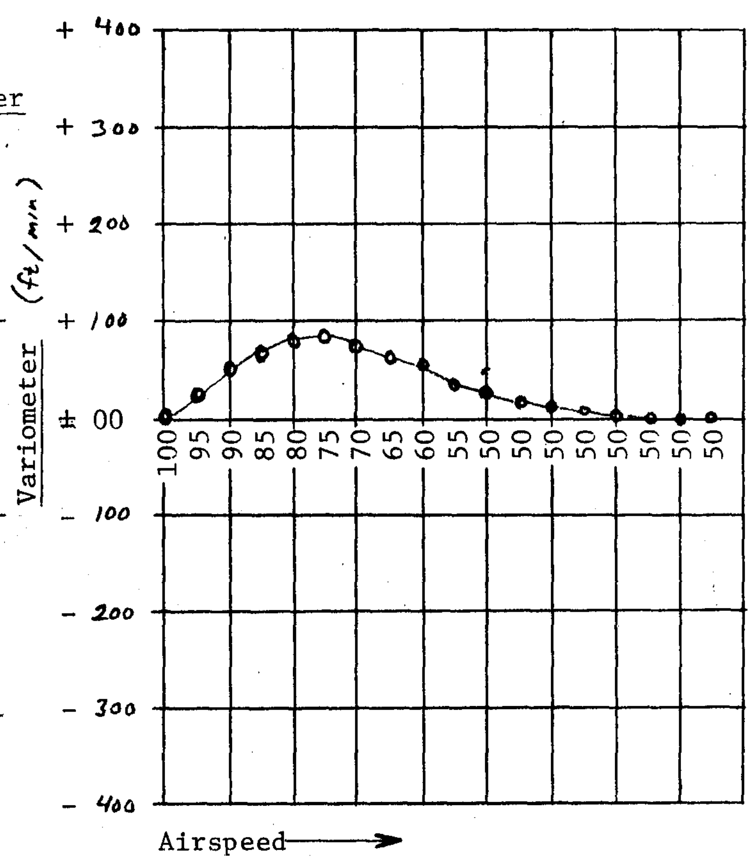
When no water ballast is carried the variometer will read slightly below zero and with water ballast the variometer will read slightly above zero. The error is in all cases small and insignificant compared to the strength of the lift which is being sought.

TOTAL ENERGY COMPENSATION TESTING

The best technique for testing total energy system compensation is with gentle zooms and dives. Violent zooming and diving seriously distort the pressure field around the glider causing variometer signals which are meaningless.

Tow to about 5000 feet above the ground in absolutely still air. Stabilize the airspeed at 80 knots (or 100 knots) for at least 15 seconds. Perform a gentle zoom to an airspeed of 50 knots. The transition to level flight at 50 knots should be very smooth. The time for the zoom is at least 10 seconds (15 seconds if the zoom is performed from 100 knots). Record the readings of the variometer each 5 knots during the zoom and tabulate the results. The easiest technique to acquire this data is with a small tape recorder either in the cockpit or on the ground recording the radio transmission of the data. The only numbers which need to be spoken are the variometer readings if it is understood ahead of time which airspeeds they correspond to. At the end of the zoom the variometer reading should be taken about every 2 seconds for about the next 14 seconds. The data can then be tabulated as shown below. The tabulated data is then plotted on a graph like the one shown adjacent to the table. Hypothetical examples of typical runs where problems of various sorts are illustrated are shown below. The hypothetical examples are only generally illustrative of the types of curves and their associated causes. The exact shapes are a function of the type of zoom, speed of response of the vario and the degree and type of the problem affecting the total energy system. But they should be descriptive enough to permit some insight into the problems which occasionally are found to exist.

Airspeed	Variometer
100	0
95	+25
90	+50
85	+70
80	+80
75	+80
70	+70
65	+60
60	+40
55	+35
50	+30
50	+25
50	+20
50	+15
50	+10
50	+5
50	+0
50	+0
(knots)	(ft/min)



SAILPLANE STATIC ERRORS

Static pressure errors on factory installed statics, when improperly located, can approach 20% of the dynamic pressure. The most common example of such a problem is the Standard Cirrus equipped with nose statics. All modern sailplanes equiped with tail statics commonly have static errors of less than a few percent. The model B total energy system will function properly only when used with good tail statics unless a special calibration is asked for prior to manufacture.

There is,for any given model of sailplane, some variation in the static error. This is most commonly the result of variations in the shape of the static holes themselves. Some manufacturers pay very little attention to the static port shape. The PIK people are particularly careless when they place vinyl registration numbers over the static ports and then punch through the letters with a pocket knife thereby creating a ragged edge around the static hole. Generally the size of the hole and the chamfer of the corner affect the static error. The chamfer is especially significant if it is not uniform around the perimeter of the hole. The best all-around compromise, if one uses a single hole per static port, is a 3/32" inside diameter hole with no more than a 0.020" chamfer, which must be symmetric around the perimeter of the hole.

COMPENSATING FOR SMALL STATIC ERRORS

Small static errors which cause small compensation errors were unnoticable in the past because the model A total energy system changed its compensation with altitude. It was not possible to tell whether a small unexpected static error was present, since the altitude change from one zoom to the next would produce as much a change in compensation as the small static error would. Since the change in compensation with altitude of the model B total energy system is very small, if there is a small static error it will show up consistently zoom after zoom and therefore be noticed eventually. Such small static errors can be compensated for by changes in the length of the yellow and green tubes. If the variometer indication is steadily up during a zoom the error is called undercompensation and the length of the yellow and green tubes should be shortened. If the variometer indication is steadily down during a zoom the error is called overcompensation and the yellow and green tubes should be lengthened. Typically 3 feet each of yellow and green tubing must be installed to adjust for the small amount of overcompensation which seems to be the most common situation found in competion sailplanes.

COMPENSATING FOR LARGE DIFFERENCES IN THE LENGTHS OF THE PITOT AND STATIC LINES

Sailplanes which have a nose pitot, tail statics, and mount the total energy system near the nose will sometimes exhibit another type of small compensation error. In this case the pitot signal effectively leads (arrives sooner inside the compensator) while the static signal lags (arrives later). This situation, if it is serious enough, causes the vario to move somewhat down (below zero) during the early part of the zoom and then move somewhat up (above zero) during the later part of the zoom. The cause of the effect is that the longer static line can have more resistance than the short pitot line which naturally slows the static signal down a small but noticable amount. The solution is to add a small diameter tube (restriction) to the pitot line between the pitot tube and total energy ststem. This small diameter tube is most easily constructed from a piece of 1/4 inch aluminum rod (or most any other material). Drill a 1/32 inch from one end of the rod to the other. Seldom is more than one inch of rod length necessary. This 1/4 inch outside diameter and 1/32 inch inside diameter tube is inserted in the pitot line between the pitot tube and the instruments. Filing the corners of the tube will permit the 3/16 inch red plastic tubing to be slipped over the metal tube more easily. The optimum length of the tube must be determined by flight testing. If the tubing is too long the variometer will move upward for the early part of the zoom and downward at the end of the zoom, exactly the opposite response as occurs when the tube is too short.

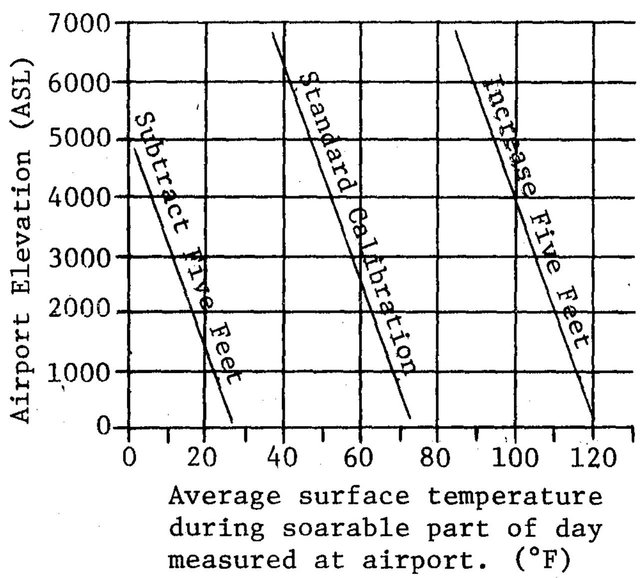
COMBINATIONS OF THE ABOVE EFFECTS

It is possible to have both a static port error and line length error simultaneously. In such a case trim the length of the lines between the variometer and unit until the variometer goes both above and below zero during the zoom. Then add or subtract some tube (restriction) to the pitot line until the variometer stays above or below zero during the entire zoom. Alternate these two adjustments until the performance is satisfactory. Usually, no more than two cycles are necessary.

EFFECT OF TEMPERATURE ON THE PERFORMANCE OF THE TOTAL ENERGY SYSTEM

There is a small temperature effect inherent in the mechanism of the model B total energy system. The slight temperature dependence of the model B system can be cancelled by adjusting the lengths of the yellow and green tubes between the variometer and the total energy system. Using the graph on the next page, plot a point corresponding to the elevation of your airport and the average surface temperature during the soarable part of the day. This point is located within the slanted lines which are labeled with how much length is added to each of the yellow and green tubes to trim the model B total energy system to your normal operating environment.

There is no reason to be continually changing the length of the yellow and green tubes between the variometer and the total energy system because the expected average temperature will be different this week than it was last week. It is quite difficult to see the effect of a five foot error in yellow and green tubing length when soaring. Even an error of ten feet will not seriously impair soaring capability though with close observation the total energy errors will be noticable. However, the pilot who goes from a flying site in Maine which is near sea level to Minden at a time when the average daily temperature might be 90° fahrenheit will obtain better performance if he corrects the length of the yellow and green tubes.



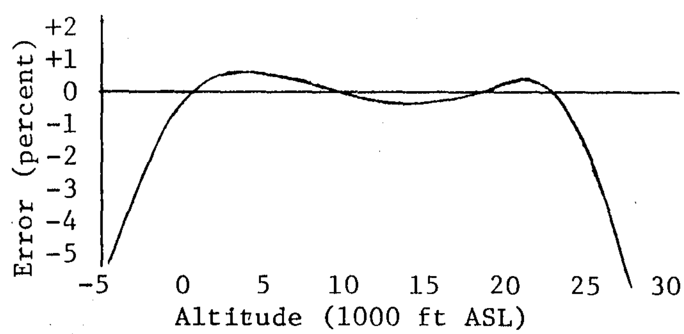
TYPICAL LENGTHS FOR THE YELLOW AND GREEN TUBES

The unit is calibrated with the yellow and green tubes 0.0 feet long. The actual length of each of these lines when the total energy system is installed in the sailplane is the sum of the line length needed to correct whatever static errors are present (usually 3 feet) and the line length obtained from the altitude versus temperature graph (anywhere from 0 to 10 feet). The typical installation usually requires about 5 foot lengths of yellow and green tubing to provide optimum performance. There is a small element of black magic in sailplane-static-pitot-total energy system interactions and do not be alarmed if the best tubing length for your ship will be somewhat different than what is predicted from the preceeding paragraphs.

COMPENSATION ERRORS VERSUS ALTITUDE

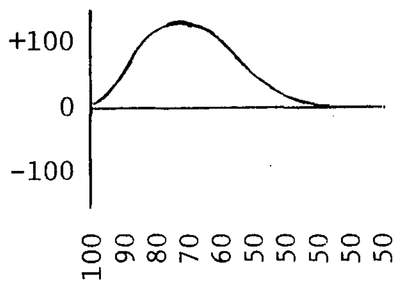
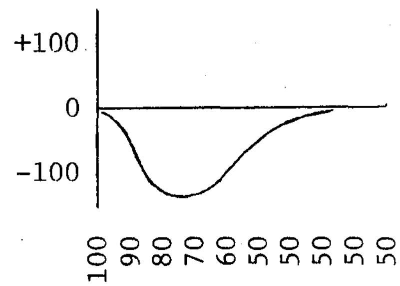
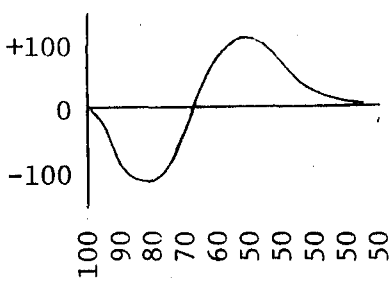
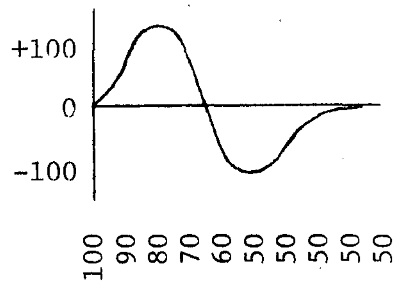
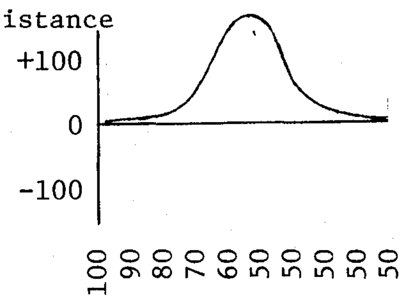
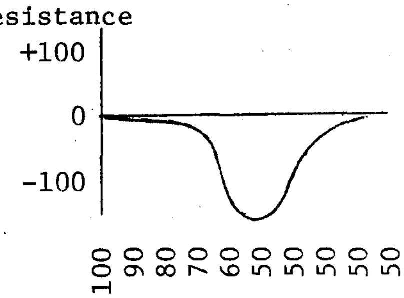
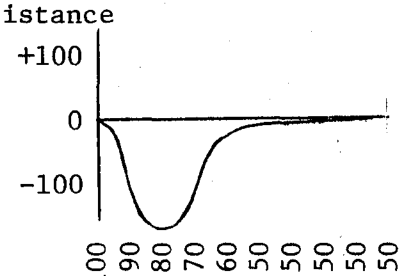
The model B total energy system provides accurate compensation to over 20,000 feet. The graph below shows the typical performance of a model B total energy system plotted as compensation error in percent versus altitude in 1000's of feet above sea level.

For comparison, a 1% error in compensation is equivalent to a variometer reading of less than 20 feet per minute for a normal thermal entry from 80 knots.



ONE FINAL WORD

The total energy system combined with a properly functioning pitot and tail static system should provide essentially flawless performance. If you are having any difficulties please get in touch with with me. The problems are always solvable and worth solving. I want your system as installed to deliver essentially flawless performance but if I don't know you're having difficulties I can't help solve them.

Undercompensation (subtract tubing) 	Overcompensation (add tubing) 
Pitot Resistance Smaller than Static Resistance 	Static Resistance Smaller than Pitot Resistance 
Undercompensation plus Pitot Resistance Smaller than Static Resistance 	Overcompensation plus Static Resistance Smaller than Pitot Resistance 
Overcompensation plus Pitot Resistance Smaller than Static Resistance 	Undercompensation plus Static Resistance Smaller than Pitot Resistance