METAL-PROBE VARIOMETER

VW 3 SG

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1. General Introduction

1.1 Operation Details

In the following paragraphs the way the Metal-Probe Variometer works will be explained in a simple manner, together with the theory of the pneumatic OSFI. This will aid understanding of the device and prevent errors in its use.

1.1.1 Operation of the Metal-Probe Variometer

Whilst climbing with, say, 1 m/s an airstream of approx. 0,06 cm/s flows out of a 0,45 l reservoir flask to equalise pressures. With 2 m/s climb rate double the flow, 0,12 cm/s, results and so on. On sinking, the pressures cause the air-flow to reverse, i.e. into the reservoir flask. The function of the Variometer is to monitor this air-flow rate and display it as a rate-of-climb or-fall reading.

The air-stream is made to flow over two minature, electrically heated, wire coils placed one behind the other. Both are thus cooled, but the upstream coil more than the more protected downstream coil. This results in a difference in electrical resistance between the coils which is measured on a Wheatstone bridge type circuit and registered as the visable movement on the instrument display and also by the sound generator.

Our especially developed metal elements* in the detector allow the coils to have little mass but a large surface area.

* German patent DBP 1523270

Their sensitivity is comparable to a thermistors but with the considerable advantage of enhanced stability when affected by external temperature changes and fluctuation of working voltage. The current taken by the detector remains at about 40 mA within tolerable limits.

1.1.2 Operation of the Optimum Speed to Fly Indicator* (OSFI)

By turning the OSFI to the SG position the air-flow j_s flows from the pitot head (total pressure) via the capillary R_s to a junction between the Variometer and the flask. (see Fig. 1)

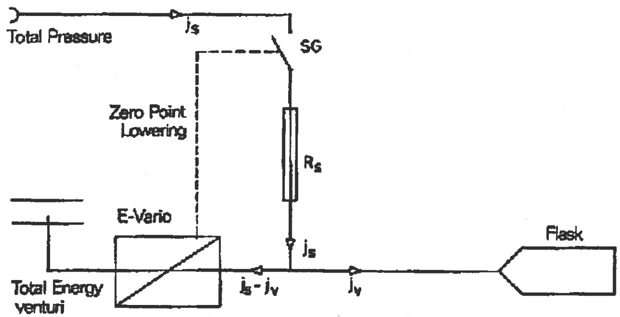


Fig. 1 The OSFI-connection.

Simultaneously, on closing this switch, the zero-point of the E-Vario is lowered by about 1 to 2 m/s — depending on the glider type. For details of the correct lowering

* German patent DBP 2 227 600

please refer to our other publications.* The electrical switch which operates this lowering is, in our OSFI, linked mechanically to switch SG.

The electric Variometer has, unlike mechanical devices, negligible air-flow resistance. Hence the pressure difference across the capillary R_s is pitot pressure minus pressure of the total energy-venturi, i.e. the dynamic pressure (doubled) $2 \times \frac{1}{2} \varrho v^2$. The flow-rate of the air current j_s is thus directly proportional to the dynamic pressure and hence a function of the flying speed.

Without the OSFI capillary R_s in operation loss of altitude causes an air-flow j_v towards the flask, via the E-Vario detector, in order to equalise pressures again. On climbing the flask pressure becomes too high and flow j_v reverses direction.

On closing the OSFI capillary the air-flow j_s divides. Part of it (j_v) removes flask pressure and the remainder $j_s - j_v$ flows away via the E-Vario (see Fig. 1).

Now, assuming gliding in calm air with the speed of the best gliding ratio, the partial air-flow $j_s - j_v$ will register as "Climbing" on the E-Vario but by an amount which will just compensate for the pre-set zero point lowering mentioned previously.

The E-Vario connected to the optimum flying speed system WILL INDICATE ZERO WHILST OPTIMUM FLYING SPEED IS MAINTAINED!

* Helmut Reichmann: Das Sollfahrt-Variometer. Deutscher Aero-Kurier 1974, Heft 5.

Egon Brückner: Vereinfachter Streckenflug mit Netto-Variometer und Sollfahrtgeber. Luftsport 1973, Heft 3.

Ingo Westerboer: Elektronische Entwicklung für den Leistungssegelflug. OSTIV-Vortrag 1972, Abdruck in Schweizer Aero-Revue 1973, Hefte 3, 4, 5.

At too high an air-speed the dynamic pressure and hence air-flow j_s and $j_s - j_v$ will be too high. The E-Vario reading will be greater than the zero lowering amount and an above-zero indication results. Conversely, flying below optimum speed produces a flow $j_s - j_v$ which fails to completely compensate the zero point lowering and the instrument reads below zero point.

Thus the E-Vario becomes an easy-to-handle Optimum Speed-to-Fly Indicator: ABOVE ZERO : PULL UP; BELOW ZERO: PUSH DOWN, until zero reading is obtained again.

The system will also operate when flying through areas of sinking air. Air-flow j_v will increase and $j_s - j_v$ through the E-Vario will decrease yielding a below zero indication. The stick must be pushed away to increase the dynamic pressure and hence j_s and $j_s - j_v$ until the higher optimum flying speed has been obtained as indicated by a zero indication again.

Conversely, when flying into rising air-masses: The air-flow j_v now changes direction so that a net flow of j_s plus j_v passes through the E-Vario giving a reading above zero. The glider is then pulled up until the minimum rate-of-sink-speed is approximately acheived. The SG switch is then opened for normal Variometer operation.

The expected average rate-of-climb and rate-of-sink experienced whilst gliding between thermals are equivalent values according to the best speed to fly theory of Mc Cready. For example the optimum flying speeds are identical for the following cases:

a) Flying with a Vario reading of −1 m/s, and a Ring setting of +2 m/s.
b) Flying in sinking air with a Vario reading of −3 m/s and a Ring setting of 0 m/s.

This is why, when setting the McCready values of the OSFI, the zero-point of the E-Vario is further lowered (in addition to the above mentioned lowering) by the value of the expected average climbing rate.

1.2 Components

The use of Intergrated Circuits in the amplification of the detector signals results in the electronics taking up little space. Thus it has now been possible to house the OSFI components in a case of dimensions 80 x 80 x 150 mm. Further, intergrated amplifiers (as bi-products of space reseach techniques) are exceptionally reliable modern electronic components.

The above illustrates the basic concept in the construction of our Metal-Probe Variometer: it must be robust and reliable for many years of service-free operation.

In the rare case of a failure in the Variometer, the sectioning of the electronics in the amplifier and sound generator into modules makes for easy servicing.

The instrument display and all necessary controls appear on the 80 mm dia. front panel, whilst all electric and pneumatic connections are made to the back panel.

2. Mounting Instructions

2.1 Mounting the Instrument on the Instrument Panel

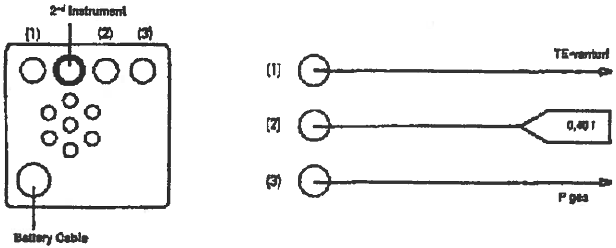
The front display panel of the compact instrument has an external diameter of 79,5 mm; the four mounting screws are on a circle of diameter 89 mm. The VW3SG will thus fit into any normal 80 mm dia. cut-out in the instrument panel (standard size of aeronautical instruments).

To fit, the four mounting screws next to the display are removed. The apparatus is held from behind the instrument panel and the four screws tightened.

The magnetic field of the linear display instrument is shielded to prevent compass error, but despite this the compass should be at least 15 cm away from the side of the VW3SG.

2.2 Tube Connections

The three hose connection points on the back panel of the VW3SG are connected according to the following scheme:



a) From hose-point (1) to the TE-venturi
b) From hose-point (2) to the supplied 0,40 l-flask
c) From hose-point (3) to the Pitot-head

The supplied material (approx. 3 m connecting hose 7 x 4 dia.; 10 cm hose 6 x 4 mm dia.; hose fixings and T-piece for standard 4 mm) enables air-tight reliable connections to be made.

To transfer to an instrument hose of standard 5 mm the supplied T-piece has the 6 x 4 hose pushed on first; the 5 mm will then fit well.

Should, besides the VW3SG, another vane type variometer wished to be connected to the TE-venturi, then, after the T-piece in each of the Variometer lines a flow-restrictor may be placed. Two of these restrictors are included with each VW3SG. See Fig. 2.

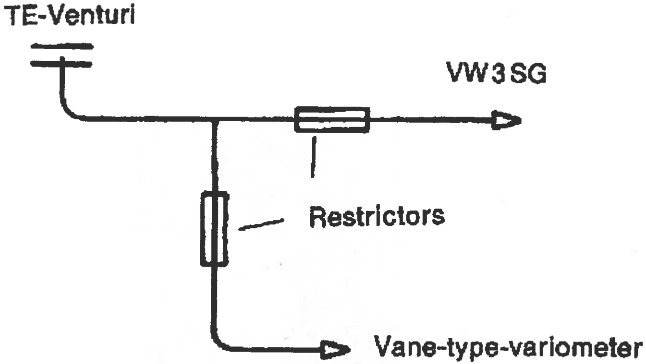


Fig. 2

Should a test-flight show that, due to the flow restrictor, the vane type variometer has too much inertia, a restrictor with reduced damping effect can be ordered from the supplier.

2.3 Electrical Supply

The shielded battery cable from the back of the VW3SG ends in a three-wire-coupling with entry clips.

The white wire (middle) connects to the positive pole of the battery and the blue to the negative pole. The third is connected with the shield on the battery cable to the casing of the VW3SG.

VW3SG CASE AND MINUS POLE OF THE BATTERY ARE INTERNALLY CONNECTED, SO THAT THE MINUS POLE IS AT GROUND POTENTIAL.

The VW3SG requires a battery voltage of 12 ± 2 Volt and uses approx. 80 mA, according to the sound volume setting.

Incorrect connection to the battery poles causes a "False-Pole-Diode" to switch the equipment automatically off.

The VW3SG IS NOT FUSED. In general the circuitry of the glider should be protected against short-circuit directly at the battery.

2.4 Connection for a Second Instrument

The amplifier of the VW3SG allows the operation of other display instruments.

The connection of a second linear instrument (± 100 µA, 750 Ohm) or a circular dial instrument with a pointer range of 250 deg, (± 200 µA; 1,8 kOhm) is built into every apparatus and can be arranged as an addition by the supplier.

The angular instrument with standard 80 mm dia. (or 60 mm dia.) has the same form and scale as the 5 m/s vane type variometer (25 deg. per 1 m/s.)

The connector of the second instrument has to be pushed into the back panel of the casing until by feel and sound it is fully home.

The angular second-instrument and the built in linear instrument are connected in series. WHEN ARRANGED FOR SECOND-INSTRUMENT OPERATION THE WHOLE INSTRUMENT CIRCUIT IS BROKEN AS LONG AS THE PLUG OF THE SECOND INSTRUMENT IS NOT IN PLACE.

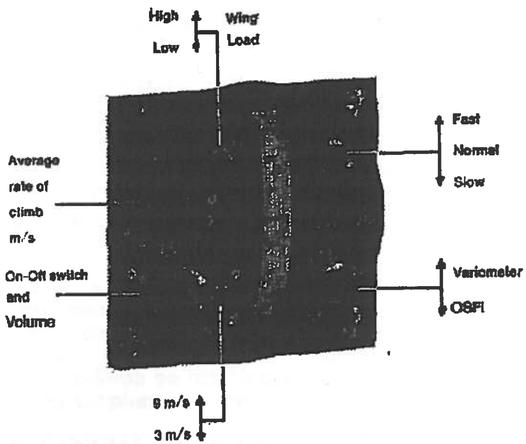


Fig. 3 VW 3 SG, Front panel.

3. Operation

See Fig. 3

3.1 Variometer

The VW 3 SG is switched on by turning to the right the volume control knob (bottom left on front panel). The sound volume can be increased until the knob reaches its stop. One sets the loudness to a suitable level over the background flight noise.

The function switch (lower right) is turned up to VAR. Now the device works as a straight-forward Variometer, the McCready-switch and the wing-load-switch being out of operation.

The Damping switch (above right) offers the choice of three reaction speeds for the display instrument:

The setting FAST (.) is generally used only in quiet thermals. (Time constant appr. 0,7 s)

The setting SLOW (...) approximates the time lag of a good mechanical Variometer. (Time constant appr. 3,5 s).

The setting NORMAL (..) with a time-constant of 1,5 s is chosen for normal thermal conditions.

Also the speed of the sound signals will correspond to the three switch positions of the Damping switch.

The Range switch (lower/left, next to the linear scale), is set normally at 3 m/s but can in extreme cases be turned to 9 m/s.

3.2 Optimum Speed-to-Fly Indicator (OSFI)

The Function switch is turned down to the setting SG. The equipment now operates, as previously described, as an OSFI.

The Wing-load-switch can be turned to High (H) or Low (N). For gliders without water ballast switching to N causes a 20% worse polar-curve (to be used when wings are wet).

The McCready switch allows the adjustment of the OSFI to rate of climb values from 0 m/s to 3 m/s.

4. Maintenance

Wire-Variometers will work maintainance – free and reliably for years, provided they are installed and operated according to instructions.

However the Metal-probe and capillary are adversely affected by dust or water. During road transport the Pitot-head and TE-venturi must be protected against dust and water.

Should a zero-error develop on the display, the zero adjustment knob on the rear of the instrument will correct it. Such an adjustment should be made after the apparatus has been left on for some minutes first. Should the limit of the zero-knob be reached, the apparatus must be adjusted by the supplier or a specialist.

IN GENERAL THE MANUFACTURER SHOULD BE CONSULTED IN FAULTS AND REPAIR ACTION.

5. Practical Hints

5.1 Variometer

All TE–venturis act, because of their pressure variations during flight, as small water-pumps.

Experience shows that considerable amounts of water can be transfered with the immediate consequence of blocked tubes and failure of the Variometer.

Should ever water get through the pipelines into the VW3SG, do not hesitate to send your Variometer with appropriate information back to the suppliers. This is the only way to avoid damage to the Metal-probe caused by slowly drying water inside it. About 80% of apparant failures have been traced to water penetration.

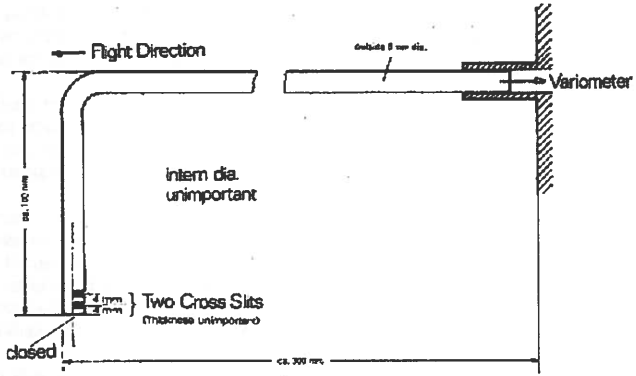


Fig. 4 Zylindrical-Slit TE-venturi

A proved method of protection against water penetration is the use of a cylindrical-slit TE-venturi with, on the lee side, two cross–slits. The TE-venturi must be fixed pointing downwards (see Fig. 4). The lower slit now acts as an outflow opening for sucked-in water.

Errors from Radio and Transmitting Station Interference.

The VW3SG has built in shielding against high-frequency interference. However experience has shown that, in a few cases, flying near strong wireless transmitters has caused false readings on the VW3SG. In such cases it is possible to install a "broad–band" shielding by the makers.

Gauge-Error

The VW3SG Variometer system has, as a thermal E-Vario, readings which are dependent and proportional to the airdensity. Thus the results are a function of flight-height. For every 1000 m of height gained the results decrease by about 8%. As the VW3SG is set for 1500 m above sea level, this height function error is of no practical importance unless heights of over 3000 m are exceeded.

Flasks

The flasks included by the makers are carefully adjusted. They are in addition, filled with wire-wool to ensure isothermal conditions for the air inside the flasks. THE SUBSTITUTION OF OTHER TYPES OF FLASKS WILL LEAD TO INSTRUMENT ERRORS WHICH MAY BE CONSIDERABLE.

5.2 OSFI

The advantages of the OSFI can only really be best taken advantage of WHEN IT IS USED WITHOUT GLANCING AT THE INSTRUMENT INDICATION BUT BY SOUND SIGNAL ALONE.

The following instructions thus refer only to the double-tone audio-signal and not to the corresponding dial readings. With some practice it will found to be possible to fly at optimum speed solely with reference to the audio signals.

A high intermittent signal indicates that the glider should be pulled up until the sound is just on the border of being continuous. A low continuous signal means the stick is to be pushed until the speed is great enough to just make the intermittence begin. This will keep the indicator within plus or minus 0,5 m/s–reading.

When training please avoid over-controlling: Pushing the stick too hard at a continuous audio-signal will easily lead to the intermitting range thus demanding now a reduction of airspeed.

Gross airspeed errors will build up if, with the system switched to Variometer use, the pilot interprets the signals as those from the OSFI mode. A continuous audio signal in sinking flight can now not be altered by increasing the airspeed. On the contrary, such a flight leads to a still further decreasing audio signal.

On the other hand, the system switched to OSFI mode but interpreted as a Variometer, cannot cause too large an error. As long as the airspeed is kept in the lower range one flies in effect with a Variometer whose zero-point is slightly shifted. The signals can still be used to center and circle thermals.

The function switch Vario/OSFI will be frequently used. Sometimes a piece of instrument tubing can be slid over the switch knob to make a comfortable extension for rapid back and forth switching.

6. Adjusting the VW 3 SG to other Polar Curves

The function switch Vario/OSFI will be frequently used. the OSFI to new polar curves takes little time.

Such an adjustment can, with the advice of the manufacturers, be made by a specialist if the change is to a similar polar curve.

In all cases it is advisable to consult briefly the manufacturers as to which way the adjustment is most easily made.

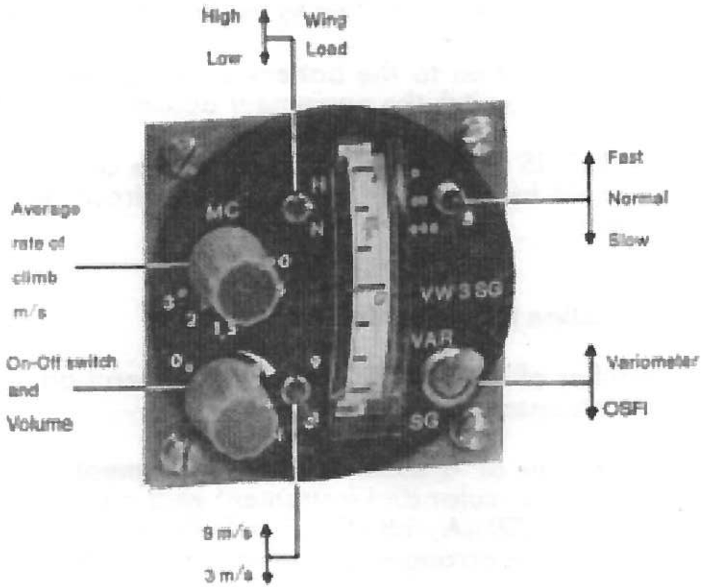


Fig. 3 VW 3 SG, Front panel.