The Cosim variometer is the most suitable instrument for T.E. variometers, because it is inexpensive and it works on a comparatively small capacity, which is less difficult to compensate.

The following information is only applicable for Cosim variometers with one pint capacity.

Required expansion of bellows at one inch W.G. pressure differential and altitude of 2000 ft. A.S.L.:
$V_o - V_1 = (1.0 \times 568)/(1.4 \times 378) = 1.07$ cubic cm.

These requirements are almost met by two bellows obtainable from War Surplus and specified as follows:

Link Trainer Part No. 23953
Dimensions: 2¼" O.D. × 1⅜" I.D. × approx. 3" long.
Number of convolutions: 12
C = 11½ active convolutions.
Wall thickness: estimated .005".
Effective area: Ae = 2.59 sq. in.

Obtained from Ae = pi R^2 = pi $D^2/4$ = (pi/4) × [(O.D. + I.D.)/2]^2 = .1963 (O.D. + I.D.)^2.

Bellows deflection (tested on scale) = 1.0"/5.7 lb.

Deflection per convolution per P.S.I.:

delta ℓ per P.S.I. = delta L × Ae/C
= (1.0"/5.7 lb.) × (2.59 sq. in./11.5)
= 0.0395"/P.S.I.

To test the bellows deflection, place bellows on a scale and depress until a desired load or a desired deflection is reached.

From the above, the volume expansion of 2 bellows is calculated:

at pressure P_d = 1.0" W.G. or 0.03613 P.S.I. and where 1 cubic in. = 16.39 cubic cm. and C = 11.5 active convolutions,

$V_o - V_t = P_d \times$ delta ℓ × 2 × C × Ae × 16.39
$V_o - V_1 = 0.03613 \times 0.038 \times 2 \times 11.5 \times 2.59 \times 16.39 = 1.395$ cm^3

The required expansion to compensate a 1 pint (568 cubic cm.) capacity had been found to be 1.07 cubic cm.

1. Modification of bellows to suit a 568 cubic cm. capacity:

The number of convolutions required is 2 × 11.5 × 1.07/1.395 = 17.6 convolutions. Use one bellows with 11.5 active convolutions and one bellows modified for 6 active convolutions (see illustrations).

2. Modification of capacity to suit existing bellows:

It is not advisable to make alterations on the bellows because they are extremely delicate.

The Hungarian R-23 "Gebics," the Schweizer 1-26 of that country. All metal, it features simple construction, rib spacing is one meter, leading edge skin is beaded. Span is 13 meters (42.6 ft.); wing area, 13 sq. meters (140 sq. ft.), aspect ratio 13; empty weight 348 lb; minimum sink, 2.79 ft./sec.; and maximum L/D, 22.5 to 1.

To install bellows in a capacity, it is best to start from scratch and make up a new metal capacity, insulated with fiberglass (see Fig. 5). The dimensions of the capacity can easily be changed to suit the existing bellows. To determine the required capacity at 2000 ft:

$V_o - V_1 = 1.395$ cubic cm.
$V_o - V_1 = (P_d \times V_o)/(n \times P_s)$
$1.395 = (1.0 \times V_o)/(1.4 \times 378)$
$V_o = 738$ cubic cm. = 45 cubic in.

With the capacity 1.3 times larger than the standard Cosim variometer capacity, the indication will be more sensitive. The following results can be expected with a 738 cubic cm. capacity used on a Cosim variometer:

Indicated rate (ft./sec.)	1.0	2.0	3.0	5.0	10.0
Indicated rate (knots)	0.5921	1.185	1.78	2.98	5.921
Expected true rate (ft./sec.)	0.75	1.55	2.3	3.85	7.5
Actual data, calibrated at 750' A.S.L.					
True rates of climb (ft./sec.)	0.6	1.0	2.1	3.3	6.3
True rates of sink (ft./sec.)	0.85	1.5	3.0	5.0	9.2

Discrepancies will exist with most Cosim variometers and if accuracy is desired, each instrument should be calibrated for the true rate of climb and sink, especially if one takes the trouble to convert it to a T.E. variometer.

It would not be economical for an individual to buy special bellows, as they are not stock items and are only made to specification. Manufacturers quotation for brass bellows of size desired indicated that if 20 were purchased, each would cost $112.00, whereas by using the War Surplus Link trainer bellows, complete T.E. units can be assembled for less than $30.

T. Goodhart describes, in *Sailplane and Gliding*, an excellent method for testing T.E. variometers and their calibration. In the same article he advises to calibrate the T.E. variometer and the A.S.I. in knots, thus showing quickly the glide ratio in flight.

To convert ft./sec. and m.p.h. to knots, multiply by 0.5921 and 0.8684, respectively.