A Liquid Indicator for Vertical Speed

by L. D. Montgomery

IT is deemed advisable to state at the outset that the variometer or rate of climb indicator to be described in this article was developed without searching through available literature on the subject. It is, therefore, possible that others have made use of all the designs embodied in the present instrument. An attempt will be made to describe the instrument and its calibration in the hope that a few glider pilots may find the information helpful for constructing easily and cheaply an aid of prime importance in soaring.

At elevations encountered in the Great Lakes region a change of height of one hundred feet is accompanied by a change of the pressure of the atmosphere of slightly more than one-tenth of an inch of mercury. Thus it should be possible to obtain almost one and one-half inches change on a water manometer for one hundred feet change in altitude. Consideration of these facts led to an experiment consisting in riding up and down on the elevator with a quart bottle and a U tube to see if there really was such a great indication. Forty feet change in altitude caused a separation of one-half an inch between water columns. One meniscus moved up one-quarter of an inch and the other moved down one-quarter of an inch. The bottle must be tightly corked and, in order to avoid obscuring the result due to temperature change, the change in altitude must require considerably less than a minute.

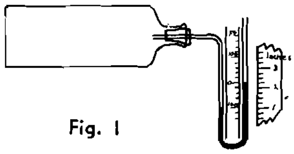

Fig. 1

A tube was constructed having two side branches and with the indicator column in the center so that tipping would not cause shift of the zero; the side branches were made of relatively large cross-sectional area in order that most of the liquid change would occur in the indicator tube; and a thermos bottle was used in order to make temperature changes slow. The altimeter was then converted into a rate of climb indicator by introducing a leak. The leak was first formed by heating a piece of glass tubing in the bunsen flame and drawing it out to a very long fine point. Air entered the bottle through the small capillary opening and this opening could be adjusted by breaking the tube off to the desired amount.

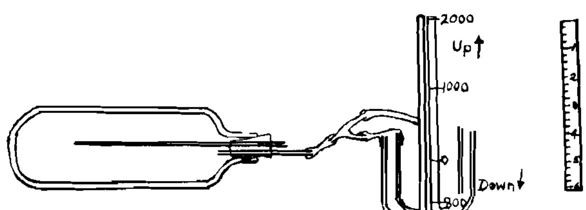

Fig. 2

The indicator tube used was a capillary of 2 mm. diameter and the side tubes were each 6 mm. in diameter. Our Glassblower was delighted to have the honor of making the tube and maintained that the process was quite a simple matter. Prestone colored with red ink was used as indicator liquid. This furnishes a non-evaporating, non-freezing indicator of less density than water.

Calibration of the rate of climb indicator proved to be easy and the method used should be a reliable standard. Two bottles were half filled with water and a syphon was established between them (See Fig. 3). One bottle was equipped with a tight two-hole stopper to carry the syphon tube and an extra. The extra tube was connected by means of side branches to the altimeter and the top of the indicator tube of the rate of climb indicator, then continued to the vacuum bottle where it was connected to the end of the calibrated leak which had been allowed to extend for this purpose. Thus the two parts of the rate of climb which would normally be left open were connected to a system in which the pressure could be reduced, just as reduced pressures would be encountered if the instrument were carried aloft. The altimeter had to be calibrated before it was possible to proceed further.

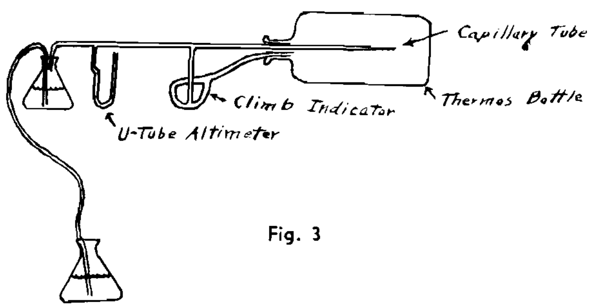

Fig. 3

Let us digress for a moment to consider this point. The altitude at the laboratory was 900 feet above sea level and 100 feet additional would produce a water head of 1.47 inches. We could have calibrated for this altitude; but at 2,000 feet above sea level 100 feet additional would produce 1.38 inches of water head and at 3,100 feet the same change would give an indication on the water manometer of 1.29 inches. If then we expected to soar from this location and sometimes to reach 3,100 feet above sea level, we would calibrate for 2,000 feet. The error near the ground would be 6½% in one direction and at 3,100 feet it would be 6½% in the opposite sense. Such an error is not considered serious and in fact all the computations have been made from an approximate formula so that it is not advisable to try to carry the results out to so many significant figures. The values given here for 900, 2,000 and 3,100 feet were computed from the easily remembered fact that at three and one-half miles above sea level the barometric pressure is very nearly half that at sea level. At seven miles up the pressure is one-fourth that at sea level. This means that at three and one-half miles up, half the atmosphere is below and the other half is above; while at seven miles up three-fourths is below. Let us use 29.94