MEASUREMENTS OF VERTICAL CURRENTS

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Abstract

The vertical velocity of the surrounding air is of vital importance to a glider pilot, who ordinarily utilizes a variometer (sensitive rate-of-climb indicator) to ascertain the vertical motions of the glider. To find the vertical air motion from the variometer reading it is necessary to correct for (1) the rate of change of airspeed and (2) the sinking speed due to the drag force on the glider. This paper reviews the types of variometers available and the method of correcting for "(1)" with a total energy venturi; it describes a new simple way of correcting for "(2)" and shows how the resulting readings permit the use of an improved Ringscale Airspeed Selector for between thermal flights; and it describes a method of substituting audio for visual sensing of the variometer indication to improve the ease, efficiency, and safety of thermal flight.

Introduction

This paper is intended chiefly as a practical summary of the equipment used by soaring pilots to measure vertical air motions, and a resumé of the underlying principles involved. The quality of variometers has long been as good as needed. The major improvement recently has been in their use, primarily in the adoption of a venturi device to correct the variometer for "stick thermals" and thus make it a better measuring device for vertical air motions. Very few powered craft are equipped with the variometers (sensitive rate-of-climb indicators) used in gliders, but many could benefit from them, for safety in mountain flying, economy in daily flying, altitude in research flying, and enjoyment in sport flying.

Types of Variometers

A variometer is essentially a pressure altimeter with a leak which tends to make it read the altitude relative to the altitude of a moment earlier. It consists of a container vented to the outside air in such a way that the pressure inside the flask lags slightly behind the outside static pressure (see Fig. 1). The rate-of-climb measurement comes from the measurement of the rate-of-air inflow or outflow from the container.

The following are representative types of variometers:

1. *Discontinuous Venting:* The Temple[2] variometer has an air capacity which is momentarily vented to the outside air whenever the pressure inside differs from the pressure outside by a certain amount (equal to a 6-foot altitude change at sea level). Simultaneously, a light is flashed (green for up, red for down). The rate of flashing is proportional to the rate of mean air inflow or outflow, which in turn is proportional to the rate of descent or ascent. The instrument has virtually no time lag, and is as accurate for infinitely slow climbs as fast climbs. It is fairly easy to distinguish between higher and lower rates of climb but it is difficult to interpret the flashes as the actual "feet per minute" number which is often needed.

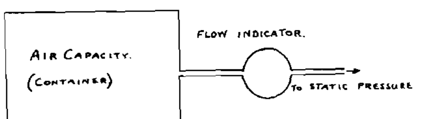

Fig 1

2. *Continuous Venting:* All these types have an air leak which operates continuously causing the air capacity pressure to lag smoothly behind the outside pressure.

(a) *The constant area leak type* is well represented by the Aircraft Indicators Company sensitive rate-of-climb indicator.[3] (This is a more delicate variety of the most common rate-of-climb indicator.) This has a capillary or porous plug air leak on the air capacity; the difference of pressure between the inside and outside static pressure is measured by means of a metal bellows coupled to the indicator needle. The friction of the instrument is so low that the indicator needle will move if the instrument is raised or lowered one foot. Like all continuous venting types, this unit has a characteristic time constant which is, roughly, a measure of the time lag of the instrument. The time constant is approximately one second for this variometer. The scale is non-linear.

Another variation of the constant area leak type has been developed at the General Electric Company by Mr. Richard Ball. The outflow from the air capacity is directed against a heated wire (a hot-wire anemometer), and the resulting cooling and resistance change noted. Reverse flow back into the vent tube does not cool the wire as much, since the flow pattern out of the tube is different from the flow pattern back into it. A second tube and wire in the same vent are used for inflow, and the two wires form elements of the indicator bridge circuit. Time lag can be extremely low—even lower than desired, since the mind can assimilate an indication best if it is integrated over a period of a second or so. This electric variometer is extremely non-linear—it can handle large rates of climb far better than the other types mentioned, and still has all the sensitivity needed.

(b) The constant pressure-difference type refers to the "*pellet*" types, such as the Robinson or the Cosim.[4] The flow meter which measures the outflow or inflow from the air capacity (one pint or larger) is based on having a pellet set in a gently tapering vertical hole in a transparent plastic. Air issuing from the air capacity blows through the hole raising the pellet a certain amount depending on the flow rate. A green pellet indicates "up" and a red pellet in a second hole indicates "down;" the holes are interconnected in such a way that each pellet forms a seal against reverse flow. These variometers are simple and inexpensive; some pilots make their own. The time constant compares favorably with the constant area leak type. Their main disadvantage, other than an occasional sticking of the pellets, is that the reading is affected by the weight of the pellet and, therefore, by the vertical accelerations or G's of the glider.

(c) A third type, of which the most famous example is the German "Horn" variometer, combines the constant pressure-difference and the constant area leak types. Airflow causes a vane to be rotated one way or the other inside a closely fitting chamber, which comprises a section of the air capacity vent. The in-

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