TOTAL ENERGY VARIOMETER

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AWHILE ago I ran across an article by Arthur Kantrowitz of the N.A.C.A. which I think deserves to be brought to the attention of our soaring pilots. The article deals with the Total Energy Variometer with which it should be possible to measure up-currents, even in rough air when the attitude of the ship is continually changing. without making corrections, in other words it will eliminate "stick thermals."

The concept of this instrument is based on the two factors of energy due to gravity: Potential, or in this instant called Altitude energy which is the weight times altitude above the point of reference. There is no absolute measure of potential energy, it is always measured with respect to say take off point, sea level or any other reference. The other factor is Kinetic energy. In a dive the Potential energy of a glider is replaced by Kinetic, the opposite takes place in a zoom the Kinetic energy is replaced by Potential or Altitude energy. For example, a sailplane weighing 400 pounds flying at an altitude of 1,500 feet has a Potential energy of 600,000 foot pounds if one converts some of the energy into Kinetic in order to have flying speed, the total energy will be the same as before the conversion was made. A Total Energy Variometer would read a constant value of 600,000 foot pounds regardless of the form in which this energy existed. If the time rate of change of total energy was measured, the instrument would read zero when the total energy was constant. If the Potential energy changed, however, it would read corresponding rates. In a sailplane all of the potential energy would not be converted into Kinetic because of some loss in the form of drag and there are also occasional gains in energy due to thermals. In his article Mr. Kantrowitz says: "Thus if we measure the rate of change of total energy instead just Altitude (potential) energy, we will have a measurement of atmospheric currents and sinking speed independent of the ships attitude. Furthermore, total energy is the quantity in which the soaring pilot is interested in increasing. The total energy of a plane mass "m" flying at a velocity "v" at an altitude "h" is: $\frac{1}{2}mv^2 + mgh$ and is thus proportional to $\frac{1}{2}v^2 + gh$.

In the usual design the atmospheric outlet of the variometer is connected to the static head where it is exposed to the altitude pressure $-pgh$ (pg is the density, "h" the altitude, and pressure is measured from sea level). Now, consider the variometer outlet to be connected to the throat of a venturi with a contraction ratio of $\sqrt{2}$ which will produce a pressure drop equal to the dynamic pressure $\frac{1}{2}\rho v^2$. A venturi tube was suggested by Mr. Eastman Jacobs of the N.A.C.A. to produce the pressure drop because it is relatively insensitive to angle of attack. In this case the variometer will be exposed to a pressure $-pgh - \frac{1}{2}\rho v^2$.

Thus the negative pressure is also proportional to $\frac{1}{2}v^2 + gh$ which is just the measure of the sailplane's total energy. Therefore if a conventional variometer were connected in this manner it would read rate of change of total energy in altitude units.

This venturi tube has to be made up specially as most of them have a much higher contraction ratio. The contraction ratio is the ratio of cross sectional areas of mouth A_1 and throat A_2 it's $\frac{A_1}{A_2}$. For use in a total energy variometer we need a venturi which gives, according to Mr. Kantrowitz, a dynamic pressure of $-\frac{1}{2}\rho v^2$, to obtain

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