A new nozzle for total-energy-compensation having low drag

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Modern high performance sailplanes with great span of velocity afford a good instrumentation too. High speed flight velocities of 150 km/h and more are customary. As these sailplanes have only very few drag they can gain a lot of height by reducing flight velocity. Energy of motion is then transformed in potential energy. The total energy, sum of energy of motion and potential energy remains constant if there is no vertical motion of air. A variometer which is not compensated would indicate a high rate of climb owing to the gain of height. A variometer compensated correctly for total energy only indicates the sinking speed resulting from the polar of the sailplane at the corresponding speed of flight. It shows another reading only if the total energy of the sailplane is changed, that is when it is raised by an upcurrent or pushed down by a downcurrent. Rates of climb or sink caused by variation of flight velocity the so called "stick-thermals" are compensated out.

The mechanical compensation by diaphragms affords a diaphragm which renders a linear variation of volume over a wide range of flight speeds. The magnitude of variation in volume by variation of pitot-pressure must be adjusted to the volume of the variometer flask. This adjustment is only correct for one certain height of flight. Apart from the difficulty to build diaphragms with the characteristic needed this characteristic may alter by aging.

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The simpler and cheaper method of the pneumatic compensation has been worked out already in 1948 by Irving, who even constructed a suitable nozzle, the so called Irving-nozzle (OSTIV Publ. III).

A nozzle suited for total energy-compensation must have a suction factor of -1.00 that means it has to deliver a suction which is equal to the pitot pressure but of opposite sign. It is fitted to the static side of the variometer. The magnitude of the flask does not matter and the compensation works correct for all flight levels.

As the venturi constructed by Irving has a big drag it is merely not suited for use at a sailplane of high performance. By this reason a new nozzle with low drag which is shown in the picture 1 was developed. For comparison there is a cigarette shown too. Picture 2 shows a sketch of its construction. In the upper part there is shown the well known Irving nozzle with its big end plate. Both nozzles are drawn in the same measure.

The new nozzle consists only of an outer tube which contains two little zylindrical protuberances one of these is a tube delivering the suction pressure. Between the two zylinders a high suction peak is generated by the air flow. Behind them laminar separation takes place as the Re-number is low. Since laminar separation conditions do not vary with Reynoldsnumber the suction of the nozzle does merely vary with flight speed. The magnitude of the suction generated by the nozzle depends on the distance of the two little zylinders. This distance is individually adjusted in a wind-tunnel to gain the suction factor -1.0.

The suction factor of the nozzle is -0.98 at 80 km/h, -1.00 at 120 km/h and -1.02 at 200 km/h flight speed. This little variation does not affect the compensation it is masked by variometer errors. Within an angle of yaw between $+10^{o}$ and -10^{o} the factor remain constant. At correct adjustment of the nozzle to the sailplane this range of angles is sufficient in any case as the practic has shown.

To get a rough idea about the drag of the two various nozzles without shaft one can assume a drag coefficient C_D=1 with respect to the front area for the Irving nozzle with separating flow at its end-plate. Assuming the same drag coefficient for the new nozzle too, the drag will be reduced by 80% where as the actual drag coefficient surely will be smaller than 1.

At the sailplane the nozzle has to be installed at a place where is no interference with any part of the plane. The best location is at the upper thirth of the fin. The nozzle is fixed by a tube parallel to its axis. As the air-flow is nearly parallel to the tubing shaft it has only a small parasite drag. It is also possible to fix the nozzle on the upper side of the fuselage between the wing and the tailplane say 2/3 of their distance behind the wing. At sail-planes on which the canopy is not contoured in the fuselage (Ka 6) the nozzle can be fixed some 10 cm before the canopy.

As at the last mentioned possibilities of installing the nozzle the shaft is vertical to the flow direction it should be of a small diameter as possible. A shaft with a diameter of 10 mm will produce the same drag as the airfoil drag of a part of the wing with the same span. The axis of the nozzle must be adjusted to lie within the tolerable angle of yaw of $\pm 10^{\circ}$.

All tubing and especially the housing of the variometer will have to be leak proof to grant reliable function of the whole installation. It is possible to fit 2 variometers to one nozzle and a "Sollfahrtgeber" may be also compensated. A normal poor mechanical variometer compensated with a nozzle is a cheap installation and works very good for soaring.

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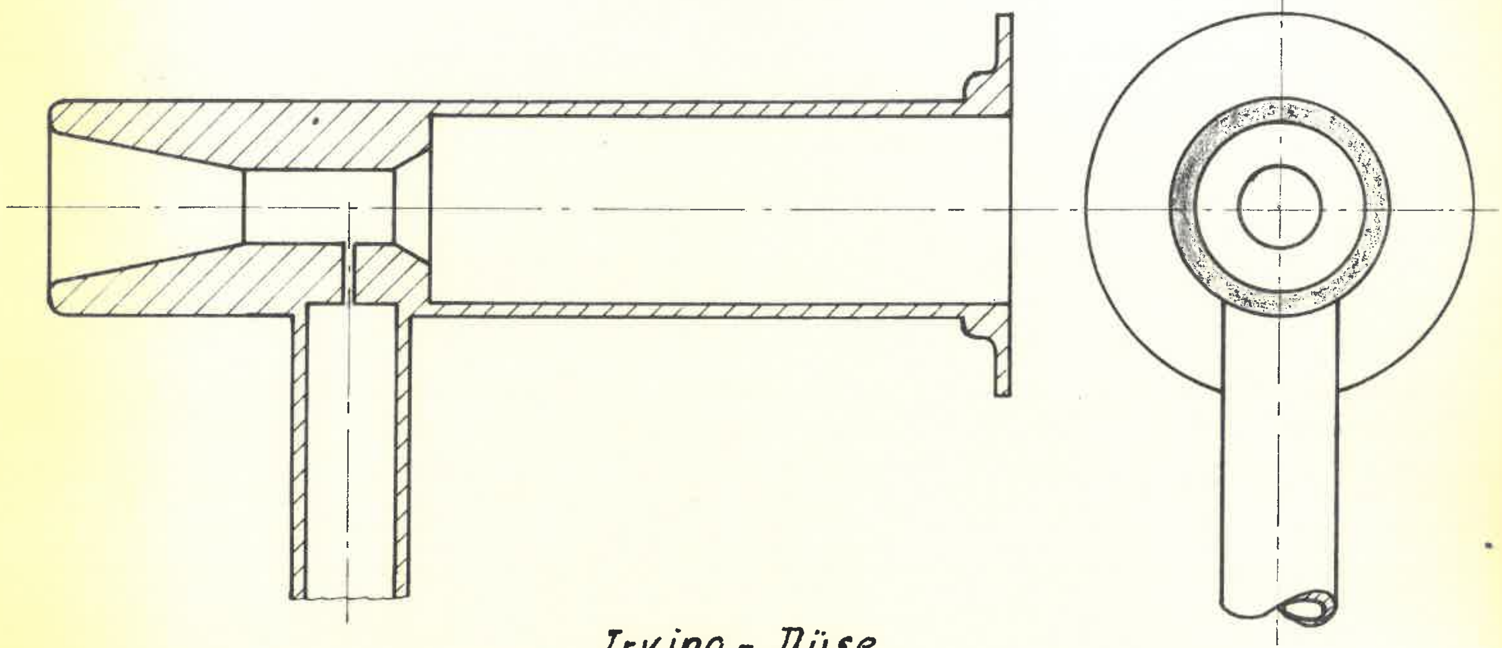
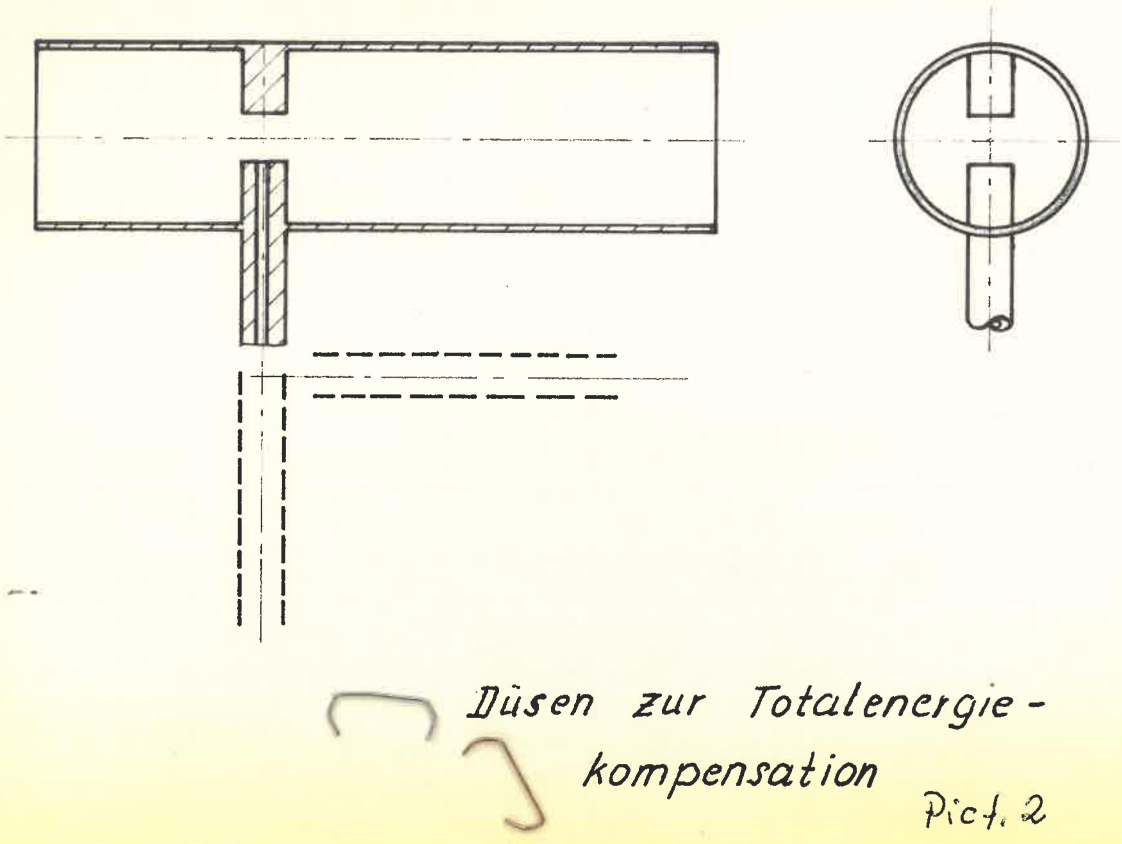
Picture 1: The new nozzle with a cigarette for comparison



Irving - Düse



Düsen zur Totalenergie-
kompensation

Pict. 2