The Peebles Computer

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At the 12th OSTIV Congress, Alpine, USA (1970), two papers* on the Peebles Computer were submitted, by Patrick Peebles and Francesco Moretti, both of Centro Nazionale di Volo a Vela, Rieti, Italy. The authors being unable to be present, a review of the papers was made by Paul Mac Cready jr. who has combined them into the following article.

Introduction

The Peebles Computer combines both rate of climb and airspeed instruments into one. On its face is a dot which moves vertically to show the rate of climb and horizontally to show the airspeed. Special grids on the face permit the pilot to interpret at a glance how the sailplane should be flown to take best advantage of the local upcurrent-downcurrent situation.
The instrument was developed and tested at the Centro Nazionale di Volo a Vela in Rieti, Italy. Theoretical help came from Plinio Rovesti, while technical help came from Mr. Ernst Tross (a specialist on windows). The CNVV provided two gliders for the tests, a M-100 and a CVV8 Buonaventura two-seater. Tests were carried out in the spring of 1969 and went on through the summer when Ing. Francesco Moretti of the CNVV used the computer during the Italian soaring championships. The computer is very easy to use; most pilots find themselves completely at home with it after one or two hours in the air. The prototype of the computer had a limited ASI scale (50 to 150 km/h), but the model that will soon be in production will have a graphic ASI scale of 60–170 km/h and a digital ASI scale of 170–300 km/h.

The Instrument

The diagram shows the mechanical setup of the prototype unit. The pressure diaphragms for rate of climb (7) and airspeed (8) are interconnected in such a manner as to move the white dot (2) just behind the transparent instrument face (1). Since the pressure is proportional to the square of airspeed, the airspeed linkage must actually be nonlinear so as to make the dot move horizontally linearly with airspeed. The rate of climb must also have a linear movement, which is the conventional situation. Peebles connects the rate of climb transducers to a total energy venturi to minimize horizontal acceleration errors. The computer concept is the same whether or not total energy is employed.
On the face there are four sets of lines. One set, the orthogonal grid (25, 26), permits the dot position to be read in terms of rate of climb (w_t) or sink (w_s) and airspeed (v). The other three grids are for the three distinct applications of the Peebles Computer: (1) when the pilot flies at high speed through a thermal, the computer tells him how fast he would climb if he returned and circled; (2) in flight between thermals, the device displays the optimum airspeed for achieving maximum cross-country average speed; (3) the computer aids the pilot in estimating the glide angle with respect to the air or ground. All of these functions are performed so directly and simply that the computer is a real aid rather than a distraction. Its display and applications are intuitively obvious to the pilot.

Assessing Thermals

For the first application, assessing thermals, the instrument display face has scribed on it dashed lines (29) which represent the w_s vs. v curves in air with various upcurrent or downcurrent strengths. The thick line (32) is for still air; it is the standard performance curve of the particular sailplane. As airspeed is changed, the dot moves along one of these ws vs. v curves, or parallel to it. At a glance the pilot can easily see the value of the local upcurrent or downcurrent, no matter what speed he is flying at. Further, by moving his eye parallel to the scribed lines, he can see how fast he would be ascending or descending if he changes to some other speed. When flying through a thermal at high speed the pilot can observe whether its strength is enough to be useful for circling in. When predicting his climb rate, he should make an extra ½ m/sec or so correction to take account of the fact that the sailplane sinks more in circling flight than in straight flight.

Optimum Airspeed

For a predicted climb rate of the next thermal ($\overline{w}_t$) and a given local downcurrent strength, there is one airspeed which maximizes the average cross-country speed. This speed is found by the procedure given by Mac Cready in developing the Speed Ring (see «Soaring», March/April 1954, or Swiss «Aero-Revue», November 1949).
On the diagram the heavy solid line is the optimum airspeed line for $\overline{w}_t=0$. For $\overline{w}_t = 2$ m/sec, the line should be moved down by 2 m/sec and so on for other predicted thermal speeds. This can be accomplished by scribing on the face a grid of appropriate parallel lines, or having a single line on a separate transparency which can be slid vertically.
To use the optimum airspeed selector, merely set the optimum airspeed line at the right height corresponding to the expected next thermal and then vary the airspeed so that the dot moves to a position on the line.
With the commonly used Speed Ring method of selecting the airspeed, a ring is set around the rate of climb indicator and rotated to a position depending on the expected thermal strength. The ring is marked with airspeeds and so when the rate of climb needle points to a sink rate it simultaneously indicates an airspeed. If you are flying at that airspeed, you are in the optimum condition. If you are at another speed, you should speed up or slow down appropriately. However, as you change speed your sink changes and the reference airspeed does also, and so, until you are right at the optimum airspeed, the Speed Ring actually gives you only the information 'faster' or 'slower' rather than the exact speed to attain. The Speed Ring method requires noting the airspeed being indicated on the ring, then noting the airspeed indicated on the airspeed indicator, then adjusting speed accordingly, next observing the new airspeed being indicated on the ring, again observing the actual airspeed and repeating the process until the desired accuracy is reached. In practical application the Speed Ring does serve as a simple and adequate guide to help the pilot fly efficiently. Exactness is not required; being off-optimum by ±5K is of little consequence. However, the Peebles Computer does the Speed Ring job in one step. When you are off-optimum, one glance shows you the optimum speed you should change too; the process is not iterative. The pilot can devote more of his time to observing events outside the cockpit.

* Patrick Peebles: A mechanical computer for use in gliders; Francesco Moretti: Flight impressions on the use of the Peebles computer at the 1969 Italian soaring championships.

Glide Angle

The position of the dot shows glide angle with respect to the air. Some scribed lines (28) converging at the origin where $w_s = 0$ and $v = 0$ provide a convenient reference. It is easy to see whether accelerating or decelerating will improve the glide angle, by following from the dot parallel to the w_s vs. v lines. To get the more important information of glide angle over the ground, one must include wind speed along the line of flight. This is readily done if the scribed glide angle lines are on a transparency which is shifted left or right by an amount corresponding to the tailwind or headwind component.

Feature and Design Aspects

For clarity the three main applications have been presented separately. There are many configurations which an operational instrument could take. A logical configuration is to have the parallel w_s vs. v lines scribed on the fixed face of the indicator, have a single optimum airspeed line on a superimposed transparency which is adjusted down or up to correspond to the expected thermal strength and have another superimposed transparency adjustable left and right for glide angle reference. The two latter functions can be accommodated on a single transparency since they are not used simultaneously, if the required two dimensional motion can be effected. As another alternative for the moveable transparencies, one can use fixed lines and bias the dot vertically or horizontally. This is especially easy to accomplish if an electronic version of the computer is made. Peebles notes in his paper: 'The relatively large size of the instrument (11×11 cm) is amply compensated by the fact that it substitutes for two 8 cm instruments. The computer provides more information than the ASI and the variometer, so it can be seen that we have a gain in information display per surface area.'

In the discussion we have ignored density (altitude) effects. All grids would serve universally if all scales and sensors were in terms of 'indicated' values with a density ratio factor involved. Then the w_s vs. v curves would be applicable at all altitudes. Airspeed measured with a pressure transducer has exactly this desired density scaling factor, but unfortunately rate of climb does not and in fact variometer sensitivity often increases with altitude while airspeed indicator sensitivity decreases. From the practical standpoint the computer could be designated for best accuracy at an intermediate density, say an altitude of 2 km in standard atmosphere conditions, and it would still retain adequate accuracy over the range of most normal lfights. For more precision, alternative grids could be provided or density corrections could be automatically introduced into the mechanism. However, such complexity is hard to justify for this type of device which is used only as an approximate guide and where small variations in speed from the optimum have only secondary effects on net performance. In the discussion following the review of the papers it was brought out that the optimum airspeed computation was based on standard concepts of spiraling in thermals and then flying straight to the next, but we are now entering an era of superships which may often avoid spiraling by merely slowing down when crossing thermals. This suggests the need for a different airspeed optimizing procedure in future computers or Speed Rings.