GLIDE MATRIX AND FINAL GLIDE DEVICE

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When examining a number of performance polars, with the purpose of constructing my "GLIDE MATRIX range and final glide device", I noticed a similarity between the polars, which may be used to avoid the necessity of a complete polar in the preparation of the layout for the MacCready speed ring.

Figure 1 shows the polars for three very different sailplanes, 1-26, SHK and AS-W12.

The tangents A, all going thru 6 knots on the ordinate scale, are seen to touch all three polars at a point where the "polar sink" is close to 4 knots, a similarity unknown to me before.

According to the well known graphical method', the forward speeds corresponding to the tangent points on the polars, are optimum when the variometer is indicating 10 knots, (4 knots plus 6 knots).

As a further demonstration of the conventional procedure, tangent B illustrates that the figure 70 knots should appear on the speed ring of the AS-W12 at a point on the variometer scale reading 4.1 knots.

The object of the following is to show that the noted similarity makes sense and then to develop a formula by which the MacCready speed ring may be laid out, with sufficient accuracy, using only the following two speed values, relatively easily obtained from flight tests with the sailplane.

V_m: The speed at which the sink is minimum.

V_4: The speed, in air with no vertical motion, at which the sailplane is sinking 4 knots or 400 fpm or 2 m/sec.

Figure 2 shows an arbitrary polar with the adopted designations indicated. For a given sailplane, the lift L and the geometry are assumed to be constant, hence:

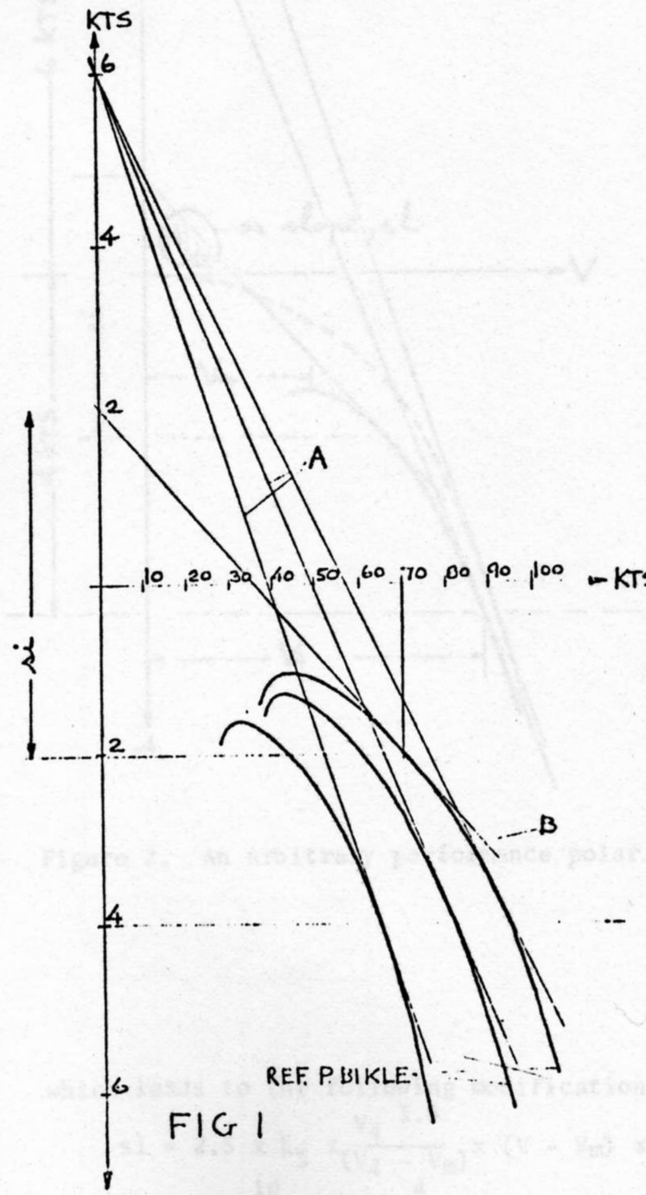

Figure 1. Performance polars for 1-26, SHK and AS-W12 sailplanes.

$$L = k_1 = C_L \times k_2 \times V^2$$

$$C_L = \frac{k_3}{V^2}$$

At high speeds, the aspect ratio effect can be neglected with good approximation ; hence, for the high speed part of the polar, C_D is nearly constant, thus:

$$\frac{D}{L} = \frac{C_D}{C_L} = \frac{k_4}{C_L} = \frac{k_4}{k_3} \times V^2 = k_5 \times V^2$$

$s = \frac{D}{L} \times V = k_5 \times V^3$, where s is sinking speed.

This equation describes the polar for an imaginary sailplane having an infinite aspect ratio and an infinitely wide laminar bucket, and is illustrated by the dotted curve in Figure 2. It has the same wing loading and high speed drag coefficient as the real sailplane.

For the present purpose, the variation of the slope of the polar is more useful than the polar itself. By visual comparison, it is easily seen that the real polar, at all common sink speeds, slopes less than the imaginary dotted one.

The equation for the variation of the slope = sl of the dotted polar is:

$$\frac{ds}{dV} = sl = k_5 \times 3 \times V^2$$

To get the information for the speed ring, we multiply the slope with the corresponding speed, thus:

$$si = sl \times V = k_5 \times 3 \times V^3 = 3s$$

Inserting the sinking speed of 4 knots in this formula, we find:

si = 3 x 4 = 12 knots

Comparing this with the finding, 10 knots from Figure 1, and the visual observation of the relationship between the imaginary and the real polars in Figure 2, it appears to make sense.

This far, the formula is only good for the imaginary sailplane, but it has all the essential features and needs but to be modified to conform to reality, i.e. to satisfy the following two conditions:

$sl = 0$ when $V = V_m$

$si = 10$ when $V = V_4$

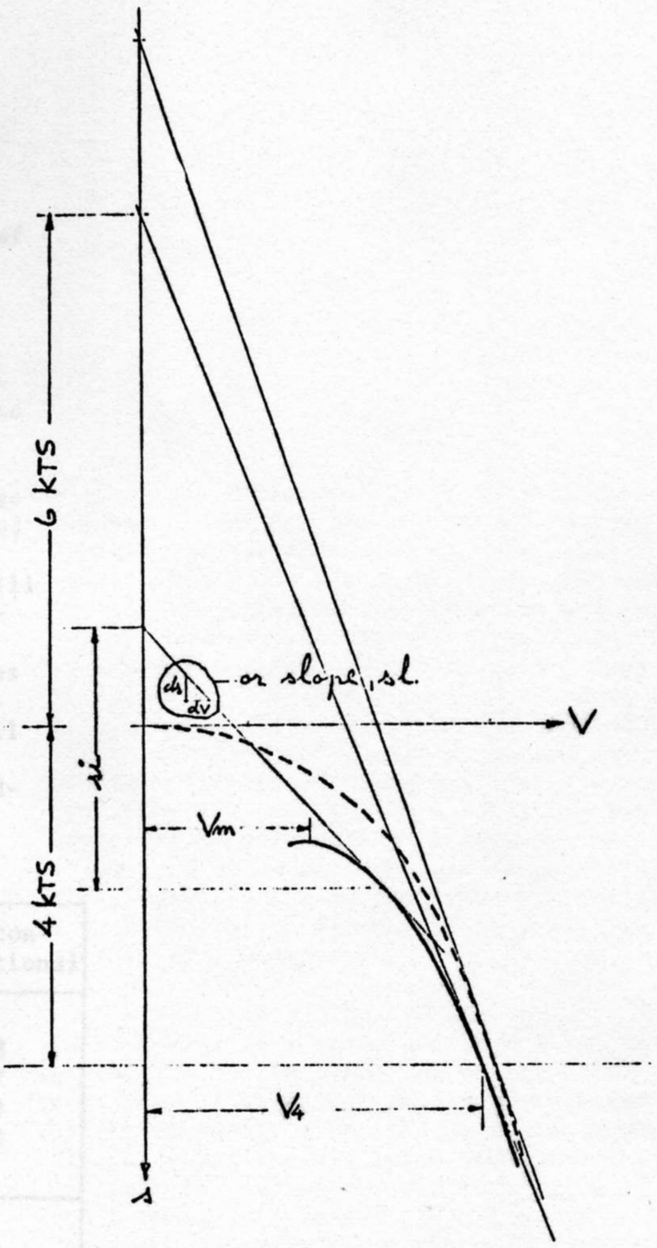

Figure 2. An arbitrary performance polar.

which leads to the following modifications:

$$si = 2.5 \times k_5 \times \frac{V_4^{1.5}}{(V_4 - V_m)} \times (V - V_m) \times V$$

$$k_5 = \frac{10}{2.5 \times V_4^{2.5}} = \frac{4}{V_4^{2.5}}$$

The sought formula then looks like this:

$$si = \frac{10}{V_4\ (V_4\ -\ V_m)} \times (V\ -\ V_m) \times V$$

To simplify the use of the formula, it is best to make a little table. I worked it out for the three sailplanes, 1-26, SHK and AS-W12, and for comparison the last column of the three tables shows the figures found using the conventional method.

The formula is particularly useful in cases when no measured polar is available, for example, for one- or few-of-a-kind home-builts, but I say, since the information used in the formula is derived from flight tests with a particular sailplane-instrument combination, that the formula has some advantage over the conventional method even when a good polar is available.

Obviously, good measured polars are still required to obtain range and final glide information.

Close scrutiny of the AS-W12 polar makes it apparent that for it and similar high aspect ratio ships, it may be better to use 11 instead of 10 in the formula.

This is also in agreement with the finding of 12 for the imaginary sailplane.

	V	$V-V_m$	$\frac{10}{V_4(V_4-V_m)}$	si	si conventional	$\frac{11}{V_4(V_4-V_m)}$	si_{11}
1-26	32.5	0		0	0		
	40	7.5	$\frac{1}{212}$	1.41	1.8		
V_4=65	50	17.5		4.15	3.7		
	60	27.5		7.4	7.0		
V_m=32.5	65	32.5		10.0	10.0		
SHK	42	0		0	0		
	50	8		1.22	1.9		
V_4=82	60	18	$\frac{1}{328}$	3.3	3.4		
	70	28		6.0	6.7		
V_m=42	80	38		9.3	9.3		
	82	40		10.0	10.0		
AS-W12	43	0		0	0		0
	50	7		0.73	1.0		0.8
V_4=94	60	17	$\frac{1}{480}$	2.1	2.5	$\frac{1}{435}$	2.3
	70	27		4.1	4.1		4.25
V_m=43	80	37		6.2	6.2		6.8
	90	47		8.8	9.3		9.7
	94	51		10.0	11.0		11.0