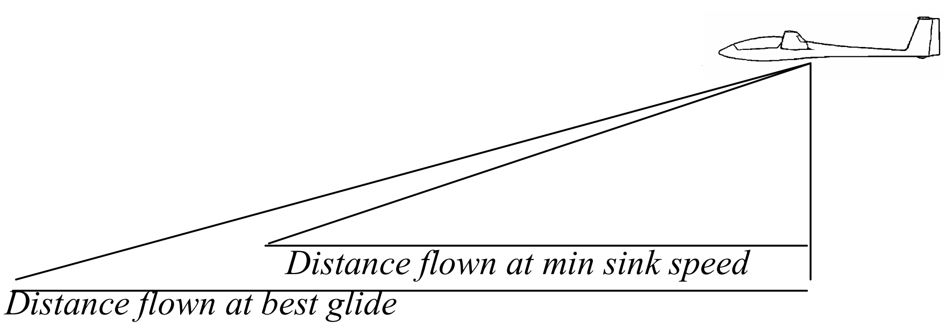
MODULE FIVE

SPEED TO FLY THEORY

The basic glider performance will be discussed to see how a speed to fly theory can be applied, in order to obtain the maximum possible cross country speed.

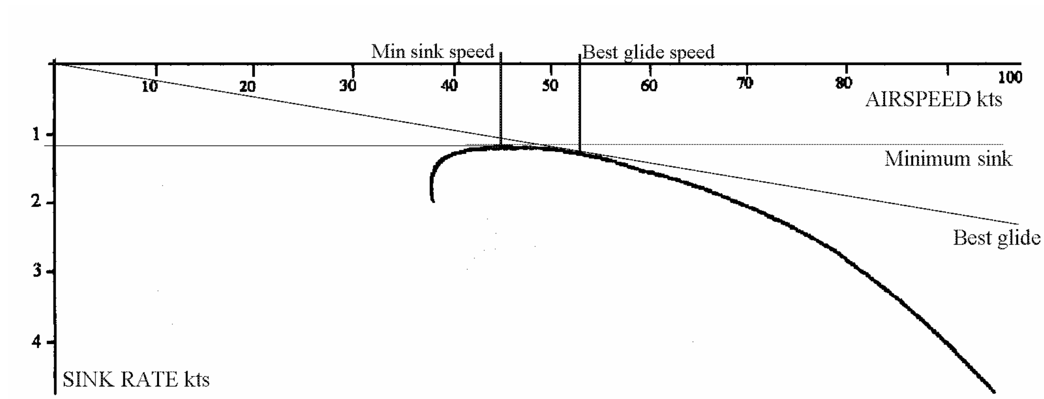
First, the relationship between the speed of the glider and its sink rate should be considered.

It is a common misconception that if a glider is to be flown for maximum distance in still air then it should be flown at its minimum sinking speed, this is not the case. It is true that if you want the glider to sink as slowly as possible then this is the correct speed to fly at, even though the glider is sinking slowly its forward speed is quite slow. If the speed is increased a small amount then the sink rate also increases,



however not by the same ratio and it is this maximum ratio of forward speed to sinking speed that gives the best glide ratio. Above is shown the total distance flown and height lost for a glider flown at its best glide speed and its minimum sinking speed for a given time period.

Beyond this optimum speed then the sinking speed increases at a greater rate than its forward speed, and a graph can be plotted of glider sink rate against its airspeed. This graph is called a polar curve and is shown below.



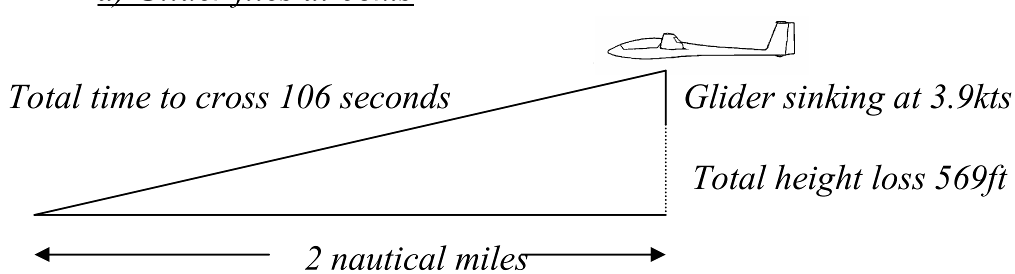
Also shown in the above graph is the minimum sinking speed, which is about 1.1 kts at 45kts airspeed

The best glide speed is about 53kts and gives a sink rate of 1.2kts. Therefore the best glide angle is, Airspeed / Sink rate

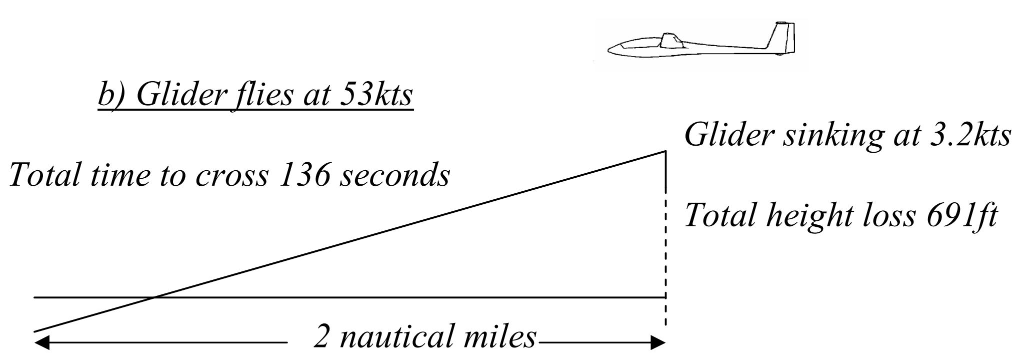
53 / 1.2 = 40.8.

In the previous example the glider was flying through still air, unfortunately in real life the air is rarely still so a new case needs to be considered. Assume two identical gliders gliding through air sinking at 2kts, one flies at 68kts and the other at its best glide speed of 53kts.

<u>a) Glider flies at 68kts</u>

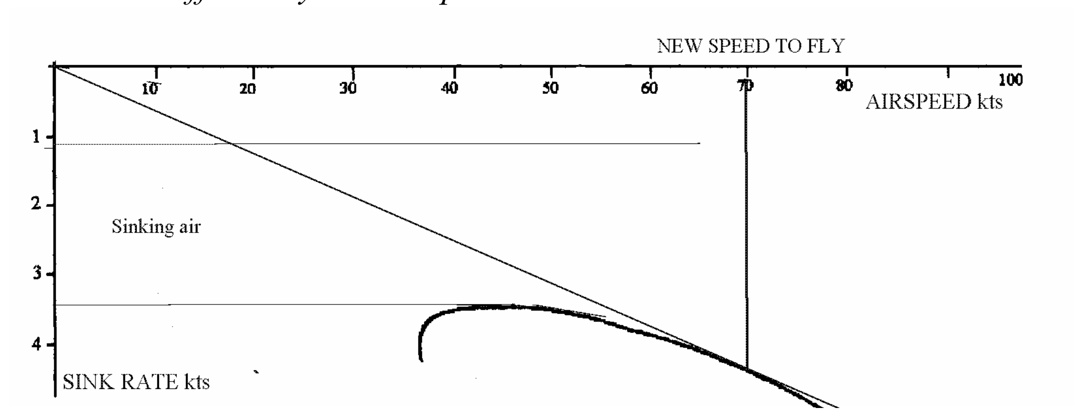


<u>b) Glider flies at 53kts</u>



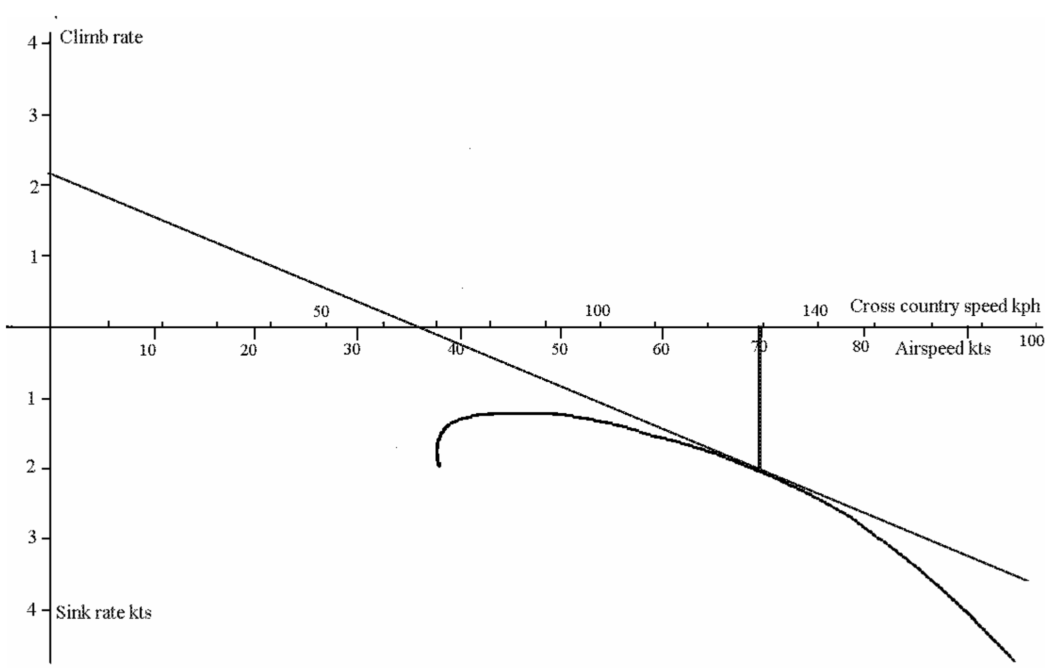
When looking at the two examples it can be seen that the glider flying faster than best glide looses less height than the other. This is because it is spending less time in the sinking air than the slower glider despite the fact that it is sinking faster by flying faster. Once again this principal of flying faster in sinking air for maximum distance can de shown on the polar curve and the cruising speed optimized for each set of conditions.

There are two ways of reproducing a glide through sinking air on the polar, either the curve itself can be moved down the Y-axis, or the X-axis can be effectively moved up.

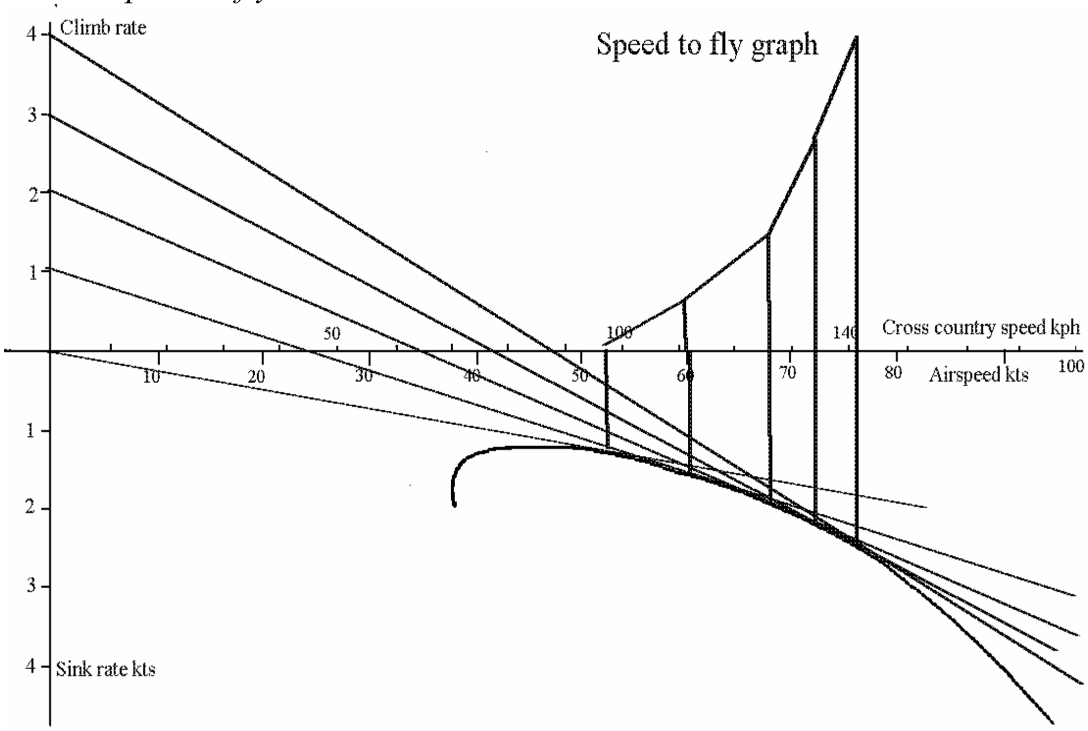


This polar shows a glider flying through air sinking at about 2.2kts; the new speed to fly for best glide is now 70kts. Moving the polar curve down the Y-axis 2.2kts has simulated the sinking air.

The other way of arriving at the sane answer is to move the 0,0 point up the Y-axis to the desired sink rate.



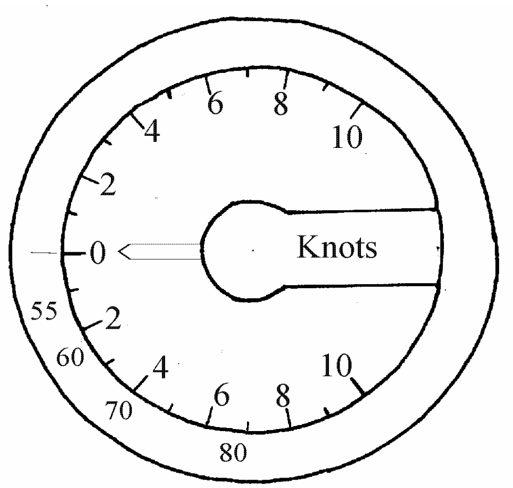
If all these points are plotted on the graph then we can form a new chart of correct speeds to fly for different sinking airmass conditions. For instance if the glider is flying in an airmass that is sinking at 3kt then the correct speed to fly would be 72kts.



This graph was used by Paul McCready who placed this information onto a ring that neatly fits around the face of the vario. The device is of course known as the Mc Cready ring, and tells us the optimum speed to fly for any given sink.

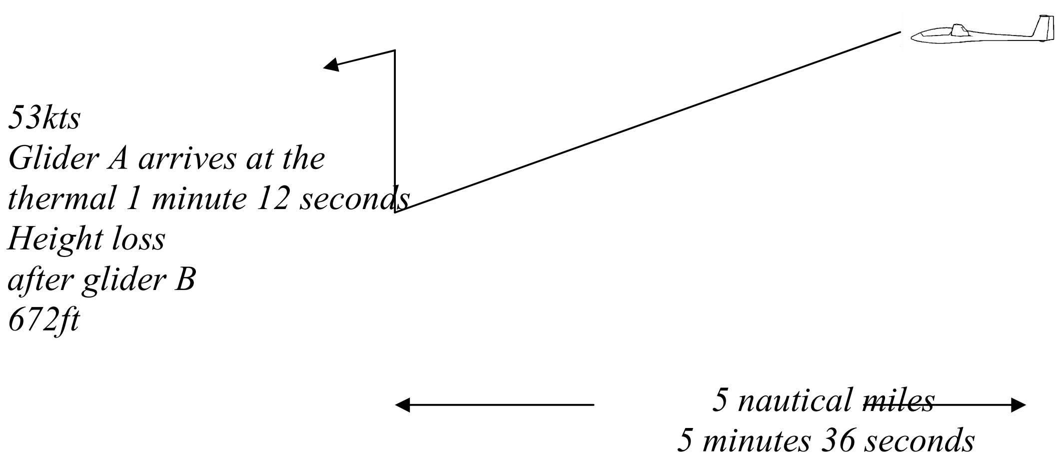
When constructing a McCready ring then not only the sinking airmass but also the gliders polar sink rate must be included, unless the vario is of the NETTO type.

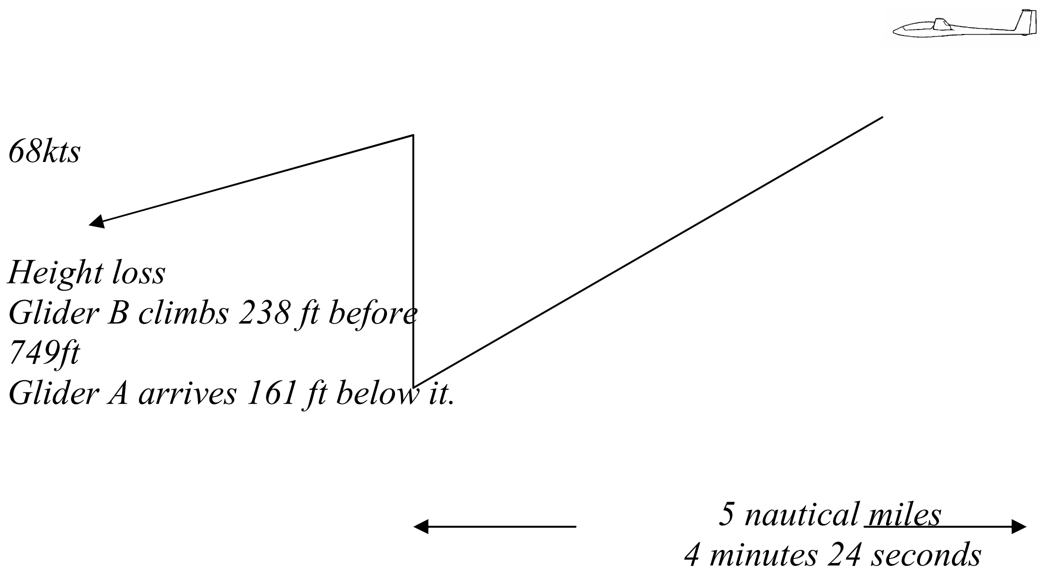
Below is a diagram of a McCready ring and vario correct for an LS 4 at wing loading 32kg per square meter. Note that when the vario is reading 0 the glider should be flown at min sink speed, when the vario is showing 1.2 down then the glider is actually flying in still air, so best glide speed should be chosen.



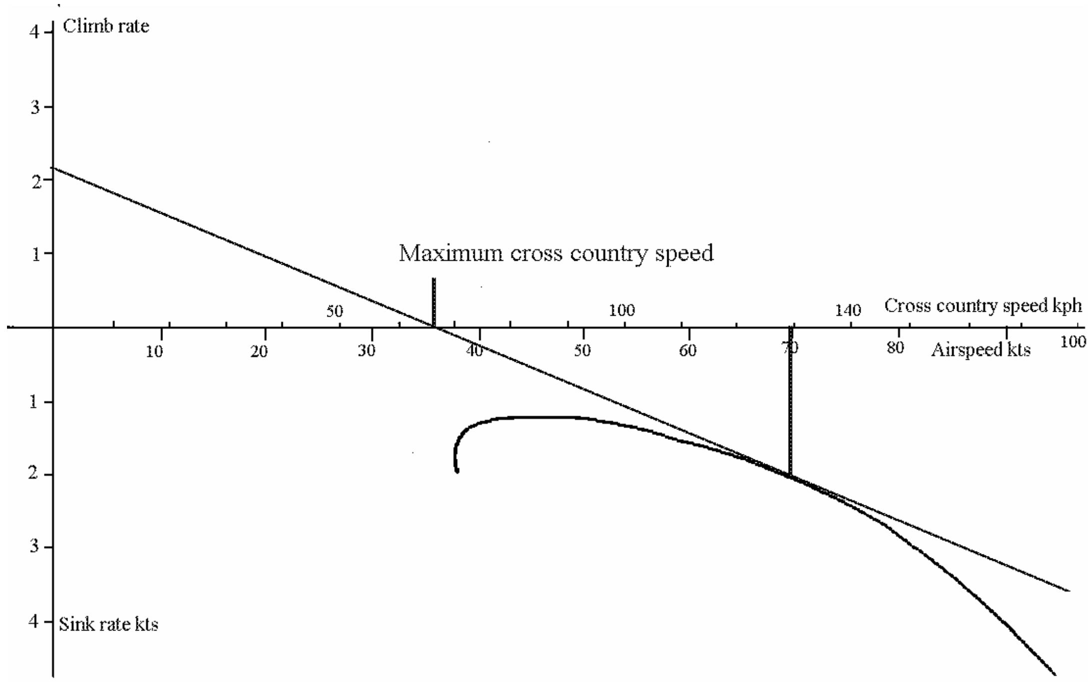
If you have ever flown with a vario fitted with a McCready ring then you may have noticed that the ring is not fixed, but is free to rotate around the face of the dial. This is because the device has a second function, in that it will provide the optimum speed to fly if the next climb is known.

To understand how this works we need to consider two gliders flying through still air towards a thermal that will give them a 2kt climb.



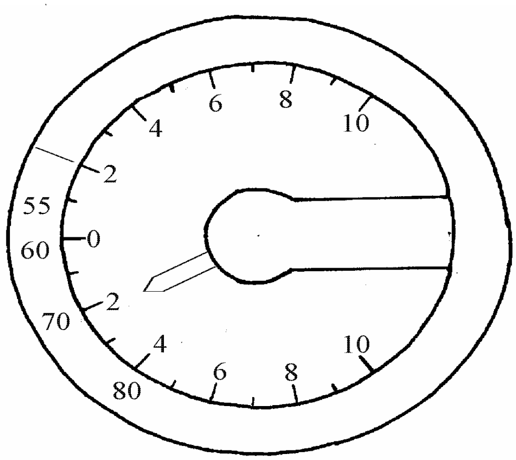


In the last case it can be seen that the glider flying faster towards the thermal will reach it first, and start to climb in it. By the time the second glider arrives, it will not only have made up the extra height loss but also have gained a significant height advantage over the first. In this way the average cross-country speed will be increased. To find out exactly how fast a particular glider should fly in any set of conditions then reference should once again be made to the polar curve.



In this diagram the climb rate is plotted on the positive Y-axis and a line drawn from this to a point where meets the polar tangentially. At the point it crosses the X-axis is shown the maximum theoretical cross-country speed; in this case it is 68 kph.

You may recognize this graph as being identical to the way the correct speed to fly in sinking air is worked out, indeed it is, which is why the Mc Cready ring is free to rotate around the vario dial. In the above case the ring should be moved so that the datum is on the 2kt climb and the indicated speeds flown.



Mc Cready ring set for optimum speed.

Mc Cready theory works for predicting the optimum speed to fly in sinking air, however there are limitations to the theory when it comes to speeds to fly towards rising air and makes some assumptions, which are,

1) *The next climb will be the same strength as set on the ring*
2) *The climb will be achieved instantaneously*
3) *The climb will be of a continuous strength up to the time it is left*
4) *The height available is infinite; i.e. there is no ground.*

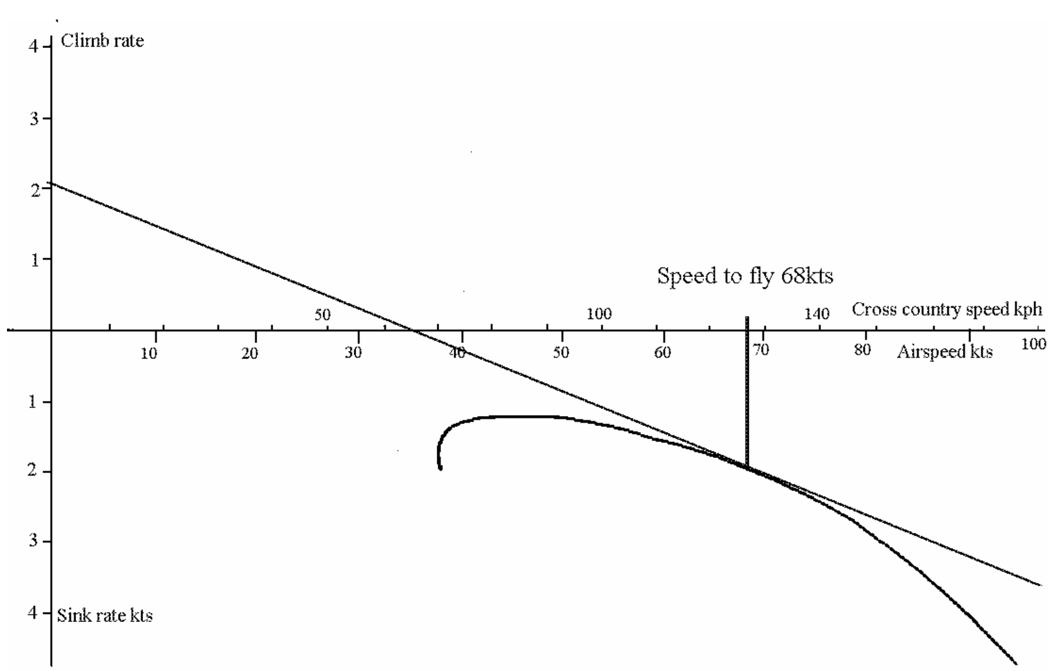
It is true to say that if conditions permit then flying at the correct Mc Cready speed will produce the maximum possible cross country speed in classic climb and glide conditions. Unfortunately real life does not always allow this, so the loss in cross-country speed due to variations in achieved rates of climb and predicted climb should now be considered.

Losses due to incorrect Mc Cready setting.

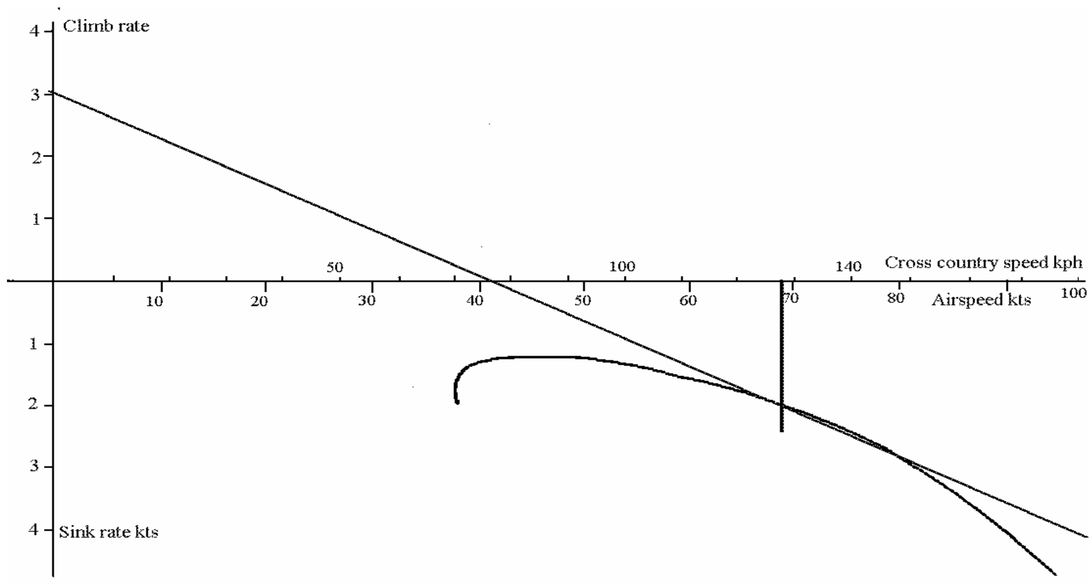
Let us now consider a situation where the thermals on the day are producing regular climbs of 3kts, and two pilots are flying, one with a ring setting of 3 and the other with a ring setting of 2. In order to discover the differences in cross country speed between the two pilots we must look at the second pilot and discover how to simulate a pilot flying on a 3kt thermal day with a 2kt setting.

Once again we must refer back to the polar curve for the answers. To create this situation a line must be drawn from the positive y-axis at 2kt, to where it just touches the polar. This gives us the correct speed to fly for 2kt thermals whilst gliding through still air.

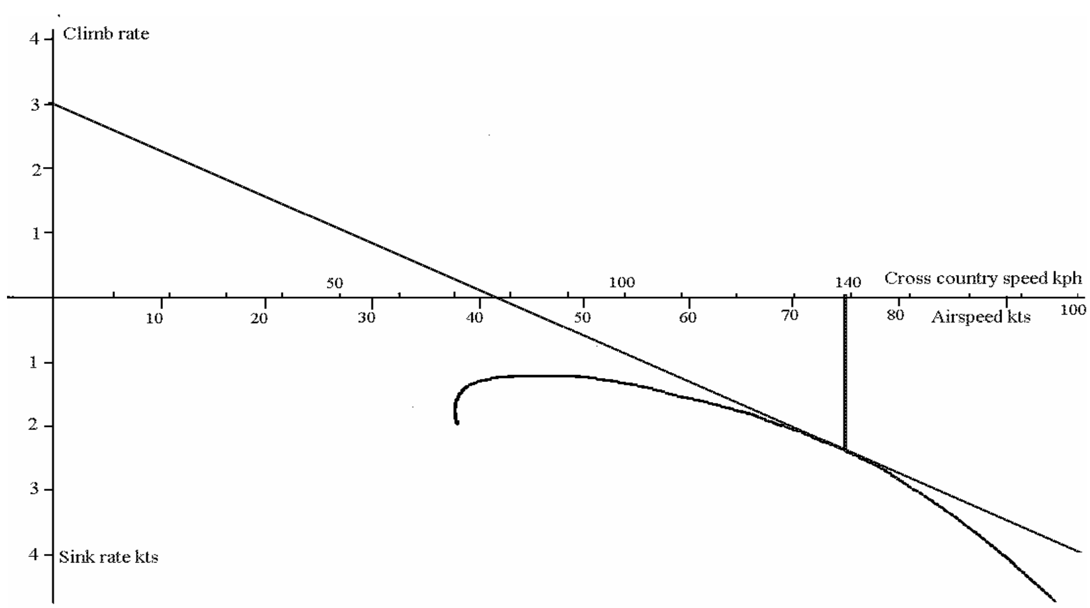
This tells us that with the Mc Cready set on 2kt then the glider should be flown at 68kts in still air.



To find out what the cross country speed will be with this 2kt ring setting in 3kt conditions, then a new line should be drawn from 3kt on the positive y axis down to a point on the polar such that it crosses the polar at 68kt on the positive x axis.



This now shows us that flying in conditions that produce 3kt thermals and still air glides, then using a 2kt ring setting will give us a cross country speed of approximately 76kph. This speed should now be compared with the pilot who flies with a ring setting of 3kt.



It can be seen that this pilot will achieve a cross-country speed of about 78kph by flying at the correct Mc Cready speed for these conditions.this shows an improvement of 2kph or 2.6%.

However Mc Cready's fourth assumption should be considered, the height available is infinite.

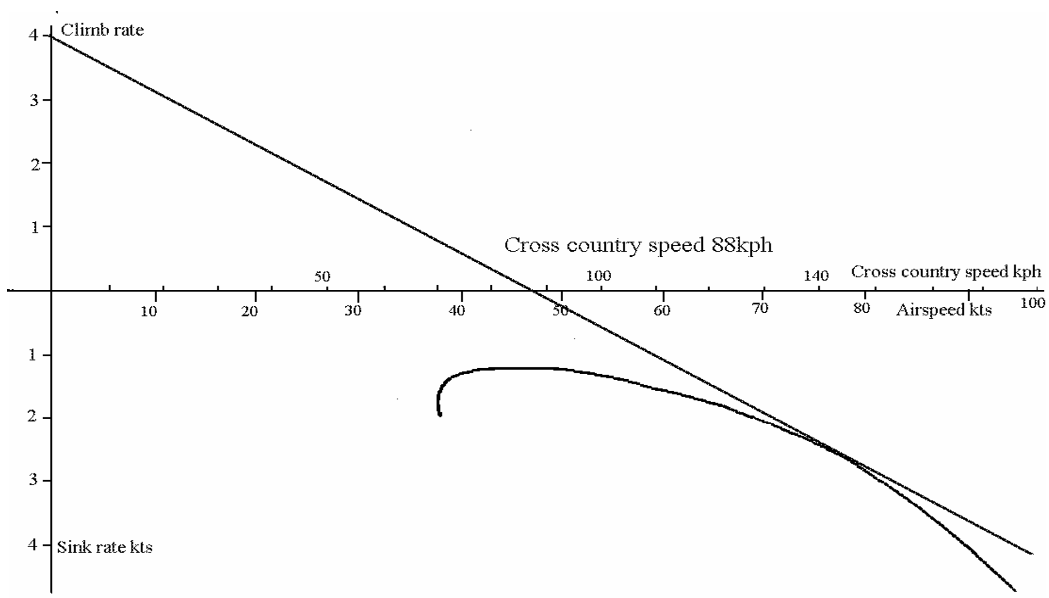
In the first case the glider was being flown at 68kts and was sinking at 2tks. This would give a glide angle of 34 to 1.

In the second case the glider was being flown at a faster speed of 75kts but sinking at 2.6kts giving a glide angle of 28 to 1.

The conclusion so far, with the two examples we have looked at. Flying the correct speed to fly for those conditions increased cross-country speed by 2.6% with the penalty of 18% greater height loss between climbs.

Climb rate considerations.

In the above case the very best speed a pilot could achieve whilst flying in 3kt conditions with a 3kt Mc Cready setting was 78kph. Now consider a pilot that consistently climbs at 4kt.



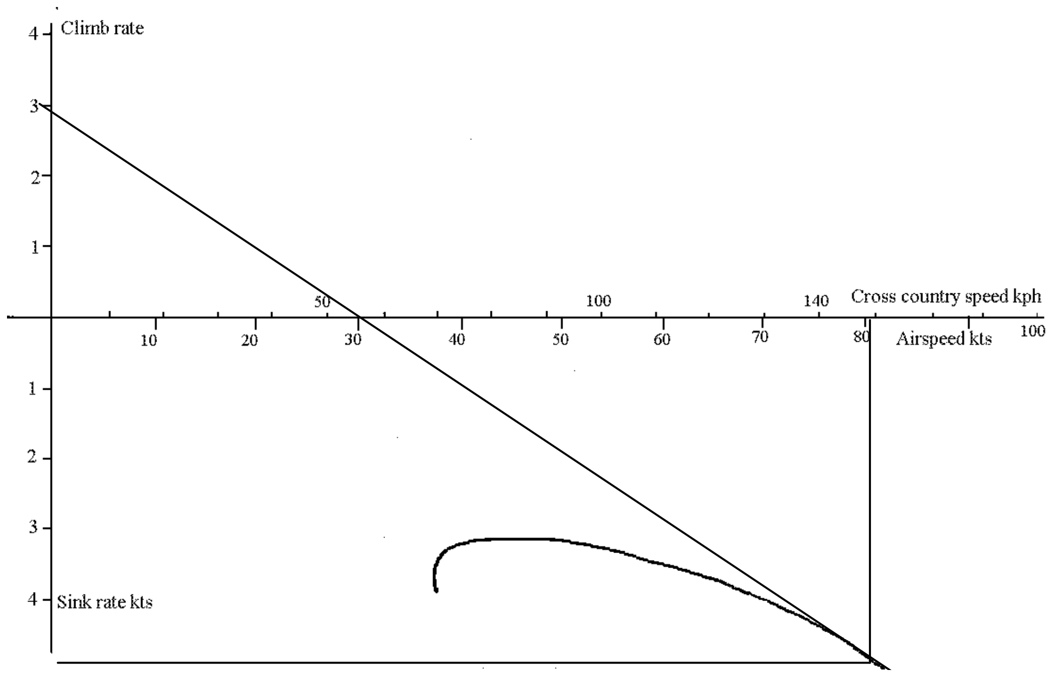
This shows clearly that increasing climb rate is highly beneficial when maximum cross-country speed is required. In this case an increase in speed of over 11%. Even if the pilot used a conservative 2kt ring setting his cross-country speed would be 85kph.

Glides in a sinking airmass.

So far all the examples have been concerned with climbs and glides in a still air mass. Once again real life rarely behaves like this, so the effect of gliding through an air mass sinking at 2kts with climbs of 3kts being used.

In order to simulate a sinking air mass then the gliders polar must be moved down the negative y-axis to the same extent that the air is sinking. The achieved cross-country speed can then be worked out as before.

Below is the polar curve simulating a climb rate of 3kts and glide in a sinking air mass of 2kt.



As was demonstrated earlier Mc Cready theory demands a higher cruising speed when flying through sink, and if this is done then the glide angle will be optimized. In the above case not only is a higher speed demanded due to the sinking air mass but also due to the climb rate being set on 3kts.

These settings demand airspeed of 81kts and the glider is sinking at a total of 4.9kts, which gives a glide angle of a mere 16.5: 1

Also the maximum possible cross country speed is 55kph, a reduction of about 30% from that achieved whilst gliding in still air.

Conclusions.

Now that we have looked at some examples of speed to fly theory it is possible to draw some conclusions about Mc Cready theory validity, uses and limitations. In order to do this climb, glide and route selection should be examined.

1) Climb.

Climb rate is probably the most important factor for achieving high cross-country speeds.

Whilst climbing only the average rate of climb is important, and this is taken from the moment the glider slows down until, at the top of the climb, it has set off on the cruise again. This means that if a long time is spent trying to center the core of the thermal or if time is wasted at the top of a climb then the overall average climb rate will be reduced.

When selecting which thermals to climb in then an overall picture of the typical climb rates for that day should be known and at what altitude these occur. Only thermals better or at least as good as average should be used, or if a weak thermal is used then it should only be used until something better can be reached. Similarly if whilst climbing the rate of climb deteriorates then it should be left if there is enough height to reach stronger lift.

2) Route selection.

In the last example it was shown that cruising through sinking air reduced the cross country speed significantly, for this reason choosing a route down track that avoids areas of possible sinking air should be chosen. Occasionally the maximum theoretical speed can be bettered if the pilot chooses routes between climbs that not only minimizes the sink but may indeed provide extra energy.

As the rate of climb is important then if the pilot can sample as many clouds as possible down track then the chances of finding a stronger than average climb is increased.

When climbing it is important to have a route planned before you reach the top of the climb, for several reasons.

a) At cloud base it is impossible to see any clouds that may form a good route.
b) The thermal should be exited swiftly and decisively in order to minimize dawdling.

3) Cruising.

When looking at achieved cross country speeds then choice of cruise speed made only small differences, and only when large cruise speed *errors were made then any significant change in cross country speed is noticed. As route selection and following energy lines reduces the gliders sink rate, then monitoring the sky ahead is more important than trying to fly at precisely the correct speed, or following a flight director to within a few kts. Flying at block speeds is normally sufficient, i.e. 60, 70, 80kts. However speed should always be increased if sink is encountered.*

Cruise speed chosen is also dictated by the available height. If high cruise speeds are chosen, then large amounts of height will be used up between climbs, this is particularly important on low cloud base days.

4) Mc Cready ring setting.

Given that the high ring settings require high speeds and height loss, then you should be sure of finding good lift.

Moderate or low ring settings will increase the gliders range and a larger number of climbs can be sampled. The low ring setting will have only a small effect on cross country speed, the 0 ring setting should be avoided unless the gliders maximum L/D is required to avoid an out landing.

Remember that the Mc Cready ring should only be set to what you expect and NOT to what you have just climbed in.