THE THEORY OF MODERN CROSS-COUNTRY GLIDING

Fred Weinholtz

D. HOPE-CROSS

THIRD EDITION

F. W. WEINHOLTZ

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Translated from German
by Ing. (grad.) D. H. Hope-Cross

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INTRODUCTION

There are two grounds that led me, a wandering preacher as it were, over the airfields and then finally to my writing desk to produce this work.

The first is that, world wide, there has been a considerable increase in distance flying, yet gliding clubs, and therefore the majority of the pilots have chosen to ignore this.

The progress in distance flying can be shown by a few figures:— In 1958 E. G. Haase won the World Championships in Leszno in grand style in the HKS 3. In this contest he set two new German records which I would like to compare with the 1966 German Gliding Championships in Roth.

On the 14.6.58 Haase flew a 300 km triangle at a record speed of 61 kph (38mph). On the 10.6.66, exactly 8 years later, 32 pilots flew 369 km at a higher speed, and in May, 1966, over a course of 306 km. 35 pilots exceeded. that record.

A little clearer is the position concerning the 200 km triangle: 66.4 kph (41.5mph) was the record set in Poland. On the 10.6.66, 50 of the 64 competitors at Roth flew even faster over a course of 246 km.

No one should get the impression that Haase's record is being underestimated, he had done his best at Leszno — how else could he have won the World Championships? — but I am using this as an example of the progress of Soaring during the last eight years.

Should the performance of today be attributed to better aircraft? A comparison of the HKS 1 with the HKS 3, the record breaking aircraft of 1958, shows this to be untrue. We should not forget that at Leszno many Ka 6 aircraft were present. It is also difficult to believe that the talent of the pilots has improved so much. The unbelievable jump in performances can be attributed alone to the extension of knowledge, of the science — of distance soaring.

If this development continues, and this work should help towards that end, then the 300 km triangle will no longer be the reserve of the pundits, but belong to the repertoire of every good glider pilot, of which there are a great number. Soaring is in the position of being able to free itself from the confines of the airfield and the opportunity of doing so should not be missed.

The main reason, however, for writing this book is to be found in the person and works of Heinz Huth of Hamburg — twice world champion.

For many years I had planned to do research into the theoretical background of distance soaring.

Only a tiny fraction of the information have I been able to gather through bitter experience and a little through eavesdropping and questioning. Only when I had the opportunity of taking part in Heinz Huth's lectures did the relationship between my scattered bits of information become clear. I discovered the extent of the knowledge of Heinz Huth, and the way in which he mastered the trickiest problems and I suddenly understood why he had been able to "Fly away" from all other glider pilots.

Two world championships were the fruit of his concentration on theory and the way in which to get the optimum out of any given situation. What impressed me was the way in which he was prepared to share his knowledge with any one who was interested, in order to establish distance soaring on a wider basis. It is a fact that the present prominent position of German soaring pilots would have been unthinkable without Heinz Huth, and the considerable competition that surrounds him is the result of his own efforts.

An attempt has also been made in this work to make it easy to follow, so that the reader can think out the problems on the way, rather than having to discover the answers for himself later. I must mention that no guarantee of infallibility can be given that this book contains the last gems of knowledge in this field. I will be satisfied when this work forms a basis for all followers who can build further from their own experience and knowledge, so that finally we can say

Soaring is distance flying!

F. W. WEINHOLTZ

TRANSLATOR'S NOTE

Few glider pilots will question the fact that Germany has contributed a great deal to the art and science of soaring flight in recent years. High on the list of those responsible for this development stands the name of Heinz Huth, twice world champion. No less important is this work by F. W. Weinholtz which has made available in concise form much of the information contributed by Huth. Glider pilots, in the English speaking world can learn much from this work particularly those at club level and those just entering competitions for the first time.

The greater part of this work has been translated as it was written by F. W. Weinholtz. However a few passages which applied only to the country in which the book was originally written have been changed somewhat, although the sense and spirit of the original work has been maintained.

I hope that this translation will prove to be of as much benefit to the pilots of the English speaking world, as the German edition is to German glider pilots.

D. H. HOPE-CROSS

1. GAINING HEIGHT IN A THERMAL

In order to carry out a distance flight it is first of all necessary to gain height — height can be converted into distance. With few exceptions, height for such tasks is gained in thermal currents. Anyone wishing to try his hand at distance flying must possess the basic knowledge of how to use a thermal air current in order to gain the best possible rate of climb. "Staying up" is today less a basic part of distance flying.

1.1 THE POWER IN THE THERMAL

First a small example to increase the faith of the sceptics in the power of the thermal. Confidence in the thermal, in the aircraft and in oneself is an important essential for success in cross country flying.

Consider a normal thermal column 200 yards across, 6,500ft high (with cloud) and an average rate of climb of 2.5 metres per second (8.2 f/sec.), which will show as an average rate of climb on the Variometer as 1.5 m/s (4.9 f/sec.) One cubic metre of air (59,000 cu. in.) weighs of course 1.3kg (2.85lbs). From the volume of a cylinder (r^2 x 3.14 x height) it is but a simple matter to calculate that in this thermal there are 62,800,000m^3 of rising air and in terms of weight that represents 81,640,000kgs (180,000,000lbs), or 80,000 tons of rising air! There is a lot of power in an everyday thermal! It may be that with our few square feet of wing area, we use only a very tiny fraction of this power, but it should always be our aim to use as much of it as possible.

1.2 THE FORMATION OF THERMALS

From old text books we learn that Cornfield = thermal, Forest = sink, Towns = thermals and that water means sink etc. Can, however, a town or a cornfield give rise to such a rising mass of warm air, of the proportions of the example that we have just calculated? How many pilots have circled hopelessly over a town in the forlorn hope of finding lift and then when on a landing approach have over a forest discovered the thermal of the day?

Consider for a moment a water pipe in a cool basement. The water drops hang in long rows on the pipe and yet their weight is sufficient to cause them to drop to the floor but adhesion keeps them in place. If we disturb one of them with a finger then it will run along into the next drop and the next, until finally a waterfall descends to the floor. A thermal behaves in exactly the same way. The sun's rays cause a large mass of air above the earth to be warmed and because of continued heating, to grow in size, and because this mass of air has become lighter than the air above it, it should rise up. Yet adhesion keeps it fixed to the earth, while the wind makes it swing to and fro. Finally an impulse at any point is sufficient for the bubble to be set free. The warm air then rises column-like upwards until its progress is halted by an inversion or an isotherm. The column will be fed with warm air from the bubble until it becomes exhausted.

The triggering impulse can take different forms. It is possible that strongly heated air from places such as quarries, industrial plants, or similar areas forces a way clear, through which warm air can flow from the surrounding area. Edges of forests, and mountain ridges against which the warm air is forced by the wind, are also capable of triggering off thermals.

Frequently, disturbances caused by movements from trains or cars are sufficient to start a thermal. It is not uncommon for the winch on gliding fields to provide the necessary impulse.
It should also be noted that the frequency of impulses rises with increases in wind strength, although the bubbles cannot grow in size as much as under still air conditions, and that a bubble can supply many columns of rising air.

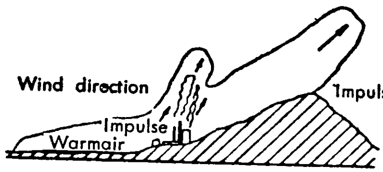


Diagram 1

A warm air bubble.

1.3 THE FORM OF THE THERMAL

1.31 TURBULENCE IN A THERMAL

In our thermal air column the air shoots out in a fountain-like fashion, the rising air forming a current within the surrounding air and giving rise to a reduction in air pressure, resulting in a suction effect on the surrounding air. At the same time the surrounding air acts as a brake on the edges of the rising column, causing turbulence. A simplified section is shown in diagram 2.

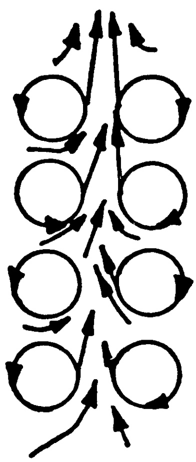


Diagram 2
Turbulence in a Thermal (diagramatic)

It is therefore necessary for us to fly within the core of the thermal in order to make use of the smoother, more even lift. When we discover "negative sink", the safest method is to continue circling carefully. The negative sink" will gradually improve and the aircraft will be drawn slowly but surely upwards.

1.32 EFFECT OF THE TEMPERATURE GRADIENT

It frequently happens that we find at different heights greatly differing rates of climb within our thermal. The rate of climb of a body in a fluid or a gas depends first of all on the difference between the specific gravity values of the body in question and the surrounding mass. In our thermal the specific gravity of the air changes according to the temperature. (The influence of pressure will be ignored here). The greater the difference in temperatures between the rising and the surrounding air, the greater will be the weight difference and the greater the rate of climb.

Dry rising air loses exactly one degree centigrade in temperature for every 100 metres (328ft) of height gained. This is known as the dry adiabatic lapse rate, and can be explained by the reduction in air pressure with increasing height. In still air the temperature loss with increasing height is considerable, but it can remain the same over several hundred feet (Isotherm) or it can increase (Inversion). The temperature curve of the rising air is called the adiabatic curve, the curve of the still air gradient.

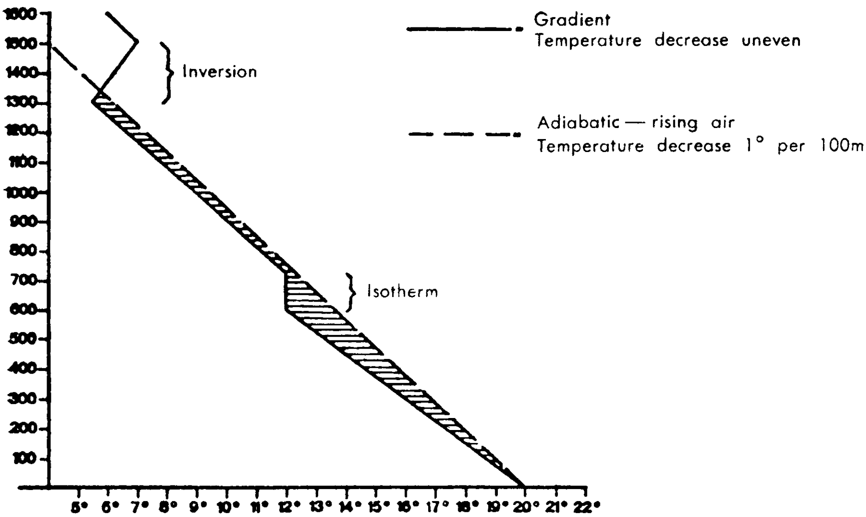


Diagram 3
Gradient and adiabatic curves.

In diagram 3, between the range of 600m (1970ft) and 1300 metres (4250ft) the temperature difference and therefore the rate of climb, is

at its greatest. At 1500 metres (4900ft) the thermal is halted by an inversion. The air here is about one degree centigrade warmer than the rising air.
If, however the temperature of the ground increases by more than 1°C then the thermal can climb through the inversion. The adiabatic curve must in this case be moved to the right, according to the change in ground temperature.

1.4 THE TECHNIQUE OF THERMAL FLYING

1.41 CENTERING

The next problem is to hold the thermal in such a way that one flies with as few control movements as possible around the core of the thermal. The technique of finding the best place to fly in a thermal is known as "centering". After a little practice the pilot learns upon entering a thermal where the best lift is to be found. This is to be found on the side where the wing was pushed up by the thermal. If the rate of climb (determined best of all with a sensitive Variometer) increases evenly, then the aircraft is in the centre of the thermal. However if one wing is lifted suddenly and the Variometer shows little or no increase in the rate of climb, then the thermal has in all probability been approached from the side only.
It is to be recommended that the course is then changed as quickly as possible to about 45° in the direction of the raised wing. When the rate of climb increases somewhat unevenly, together with an increase in flight noise, with changes shown on the Variometer, and best of all from the upward surge of the aircraft, wait about one second. Then with about 40° of bank, fly in the direction of the raised wing. If after several thermals we have counted the seconds delay between the edge and centre of the thermals, we can determine when to begin circling simply by counting.

If we are lucky, then we will find ourselves right in the centre of the thermal, and the Variometer will show an even rate climb right around the circle. If after about ten seconds the rate of climb on the Variometer becomes less and the surge becomes less, the best rate of climb has been lost. Now the centering begins. The practice of reducing bank for a short time and moving the circle in the direction of the core is by no means a sure one. Attempting to bring the aircraft in the direction of the best lift with rudder only may produce results, but is by no means sure because the exact position of the core is unknown, and there is the chance that one will fall out of the thermal altogether.

Heinz Huth has a much more effective method. Should one fly out of the thermal during the first turn, then the degree of bank and rate of turn should be maintained until the stronger lift is found again. After a short pause the rate of turn and bank is increased and then after 300° shortly before the turn is completed, the aircraft is returned to its normal turning pattern. As a result the centre of the circle now being flown will also be the core of the thermal. If no mistake is made then the centre will be found, at the latest on the second turn.

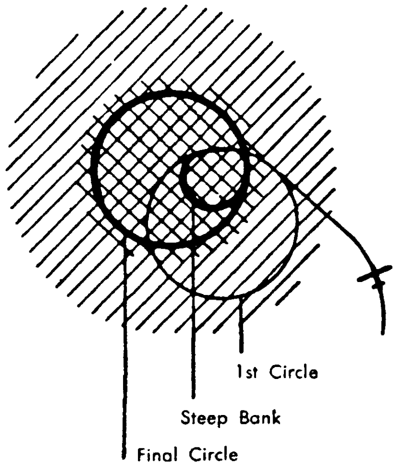


Diagram 4
Centering

Naturally a little practice is required in order to be able to carry this out successfully but the results are amazing. The requirements are that the pilot is capable of flying accurately. It is also extremely important not to enter the thermal at a slow flying speed. The correct speed with which to fly out the thermal is that of the best glide angle as with that speed the pilot will have sufficient reserve for sudden and important changes in the flight pattern.

1.42 BANKING

A good bone of contention amongst glider pilots is the question, "With how much bank should the thermal be flown out?" There are the "steep-bank" fanatics who swear by 60° and more. Others stagger around like butterflies in a thermal with full rudder in the direction of turn, at near stalling speed with almost no bank and the aircraft shuddering on the edge of the stall. What the first loses through excessive bank, the other will also lose when he falls out of the thermal and because of the low flying speed, lacks the use of the rudder to correct the situation. There is, therefore, no such thing as the correct bank for all situations. Thermal conditions can vary infinitely in the strength, diameter, width of core, in the degree of turbulence and in the rate of climb from the edge to the centre, so that one should never adopt a set pattern for all thermals but rather adjust the flight path to suit the prevailing conditions. The requirement is, again, accurate flying.

In diagram 5 two thermal columns are shown graphically above the horizontal axis with their strengths given in metres per second. The curves show the rate of climb at corresponding distances from the centre of the thermal. Curve No. 1 applies to an average thermal and curve No. 2 is that of a type of thermal such as is found in the evening.

Under the horizontal axis there is shown a calculated circular-flight polar curve and the rate of sink of a high performance sailplane. If we draw in, every ten metres, the difference between the rate of sink of the glider and the meteorological rate of climb of the thermal, then we get a new curve which shows us the rate of climb or sink of the aircraft at different rates of bank.

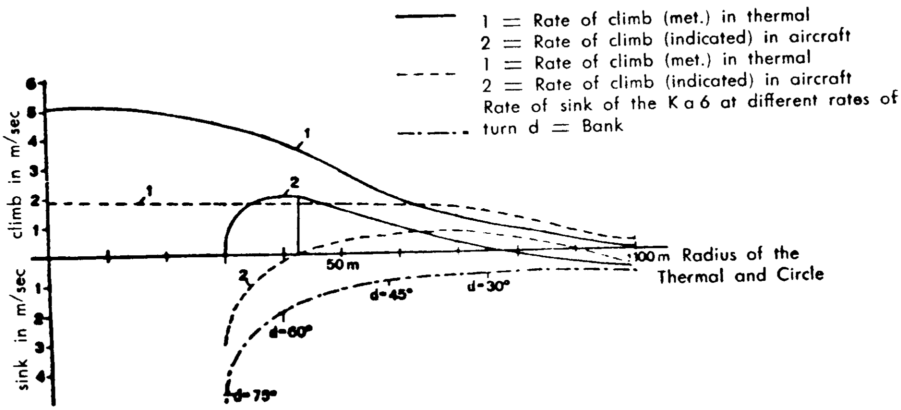


Diagram 5

Rate of climb in a thermal.

The curve belonging to thermal No. 1 shows that with about 55° of bank and a radius of about 45 metres (143ft) the best rate of climb is achieved, and in the second curve the best rate of climb is achieved at a circle radius of 70 metres (225ft) and 35 degrees of bank. This shows us that the thermal determines the attitude in which the aircraft is flown, and therefore the thermal must be re-assessed at frequent intervals. As we saw in the previous paragraph, entry into the thermal with about 40° of bank gives us a favourable rate of sink at a comparatively small turning radius. After centering we can increase or decrease our rate of bank gradually according to the best rate of climb shown on the Variometer. This rate of bank is then the best for the prevailing conditions in that area. If a change occurs in the thermal activity then a new flight pattern should be worked out.

1.43 ACCURATE FLYING

As has been said previously, it is of basic importance that one flies cleanly in a thermal, that is, one should fly correctly in the aerodynamic sense. In one case the performance of any sailplane falls off rapidly when flown incorrectly and of equal importance is the fact that inaccurate flying in the thermal will result in a displacement of the aircraft in relation to the core of the thermal and the effort taken to establish that position will be wasted. An unmatched aid in maintaining the correct attitude is the woollen thread. It reacts even more quickly than the liveliest slip indicator. It is important that it is arranged vertically over the longitudinal axis of the aircraft and that it is not influenced by turbulence.

1.44 TO WHAT HEIGHT SHOULD A THERMAL BE FLOWN

There is still a great deal of discussion taking place over the question of height to which a thermal should be flown out. In the case of cloud the VFR rules determine the limit of 1000 feet vertically. However even without this limit it would be wrong to climb directly to the base of the cloud since forward view is restricted. Also we found that at different heights in the thermal differing rates of climb were found. For the pilot who wishes to make fast progress there is only one course of action, to remain within the height band where the best lift is found. When the rate of climb falls off with increasing height then it is time to leave and to fly to the next thermal. If, of course, the best rates of climb are to be found low, 400-600 metres (1250-2000 feet), then of course one should climb higher in order to be sure of reaching the next source of lift and so avoid straining the nerves too much.

1.45 AN EXAMPLE

The importance of getting the best rate of climb is shown by the following example. Over a distance of 300km (186 miles) with a glide angle of

20 it is necessary to gain height totalling 15,000m. (49,000ft). Pilot A gains this height at an average rate of climof 1.5 metres per second (4.9 f/sec.) and Pilot B does so at an average of 1 metre per second (3.3 f/sec.). A will have saved 5000 seconds over B, and that is 1 hour 23 minutes! Such is the difference that ½ a metre per second (1.6 f/sec.) makes.

2 GLIDING OVER A DISTANCE

2.1 DOES IT PAY TO FLY ACCORDING TO THE McCREADY RING?

A short example at the beginning will show how important it is to fly at a speed appropriate to the average rate of climb. Consider a good day on which the average rate of climb is 1.5 metres per second (4.9 f/sec.). Pilot A is cautious and fliesat the best glide angle of the Ka 6, 80 kph (50 mph). Pilot B uses his McCready ring and flies at the figure shown to be appropriate to an average rate of climb of 1.5 m/sec. (4.9 f/sec) — 107 kph (66 mph.)

Consider a glide over a distance of 10km (6.2 miles) and then a climb back to the starting height.

Pilot	Glide angle	Gliding time	Height loss	Climbing time	Total time
A	30	7m. 30s.	330m (1008ft)	3m 40s	11m 10s
B	25	5m. 37s.	400m (1300ft)	4m 27s	10m 4s

Pilot A is already more than one minute ahead of B. This example assumes that the glide took place through still air and without any climbing or increased sink occurring, something which never happens in practice. So we can easily triple the difference because for every vertical movement of the air Pilot B will fly according to his Variometer and reset his McCready ring. A time difference of 90 minutes over a 300 km triangle would not be too great.
How else could it be explained that at the 1966 German gliding championships at Roth, on good days, speeds of 70 kph (43.3 mph) which would enable a 300 km (186 miles) triangular course to be flown in 4 hours 20 min. were sufficient for only a medium placing in the results? The machines taking part were not so very much better than club machines, and the pilots were not supermen either! The pilots simply flew according to their McCready rings — that is the secret.

2.2 THE SPEED TO FLY

2.21 THE INFLUENCE OF THE RATE OF CLIMB

First of all we should understand perfectly the relationship between the rate of climb and gliding speed.
The longest distance is flown from a definite height at the "best speed to fly." If one flies faster then one does not fly so far, since the glide angle falls with the increase in speed. More height has been lost but time has been won. Should it be possible through good climbing techniques to regain the lost height before the pilot flying at the best gliding angle reaches the thermal, then despite the poorer glide angle, one is then above and ahead of him, and in the end effect reaches the goal first. The faster one regains lost height then the more one may reduce the glide angle and so increase flying speed or in other words, the better the rate of climb — the faster the glide.

2.22 RISING AND SINKING AIRMASSES, DURING THE GLIDE

We could of course for every rate of climb determine the appropriate flying speed or of course read it from the polar curve, and then fly according to those values. In section 2.1 we saw that, under thermic conditions it is not possible to fly through still air since all the air masses are either all rising or falling.

Diagram 6

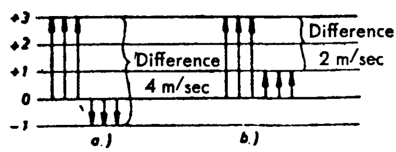


Diagram of rising and falling air masses.

Diagram 6 illustrates this problem very simply. If we leave a thermal with a strength of 3 metres per second (9.8 f/sec) and fly into a region of air that is sinking at 1 metre per second (3.3 f/sec.) then the difference between the two is 4 metres per second (13 f/sec.). If we fly from the same thermal into an area of air rising at 1 metre per second (3.3 f/sec.) then the difference is only 2 metres per second (6.5 f/sec.). When gliding over a distance we consider only the airmasses through which we wish to fly as quickly as possible — the ground is ignored for the purpose of this discussion. From diagram 6a we take a rate of climb of 4 metres per second (13.0 f/sec.) and fly therefore faster, in 6b we fly at a speed appropriate to an average rate of climb of 2 metres per second (6.5 f/sec.).

In order to understand this a little better here is a further explanation: We want to leave the sinking air masses in 6a as quickly as possible. The loss of height which results from the higher flying speed is not as great as that which we would have to accept if we were to stay in the region. In the air mass shown in 6b we can afford to fly at the "best speed to fly" and gain height as a result. However we expect to find thermals that will help us gain height at a rate of 2 metres per second (6.5 f/sec.) faster than the air through which we are flying at present.

Sacrificing the small rate of climb that can be made at the moment, we fly at the speed which is given by the difference between the rate of climb of the air through which we are flying at the moment, and the rate of climb of the air that we expect to find in the prevailing thermals.

To summarise section 2.21 we can say that one should fly more quickly through sinking air and more slowly through rising air than the figures indicated by the average climb for the conditions.

2.23 INFLUENCE OF THE WIND

"What should be done about a head wind?" — a common question. During a glide, head or side winds should not be considered. When choosing the course, calculating it and when gliding to a goal, the wind plays an important part. At the moment we are flying on course and we are concerned with getting through the air masses ahead of us as quickly as possible. As a result it makes no difference whatever, whether these airmasses, in relation to the ground, push us along or whether they slow us down. To fly more quickly in such cases, through the air is simply not feasible.

2.3 THE McCREADY RING

The theoretical considerations that we have just been making have already been thought out by the American Paul McCready and used in practice. Heinz Huth seized upon the ideas, developed them further and has encouraged their use in practice.

During my lectures and classes I found to my dismay that the term McCready ring, although known to many pilots, was of little use because of ignorance and that very few glider pilots indeed had even the remotest idea as to how it was constructed and used. I am of the opinion that this knowledge is to be expected of every cross country glider pilot. The next few sections are intended for those who wish to construct a McCready ring for themselves.

2.31 THE POLAR CURVE AND GLIDE ANGLES

First of all we need a legible polar curve for our aircraft. Polar curves such as they are found in pamphlets are inadequate for our purposes because they are too small and are cramped in the speed range. It is necessary therefore to transfer the polar curve onto a sheet of graph paper, preferably ruled in centimetres and measuring 40 x 50cm (16 x 20 inches). On this sheet we construct first of all two axes, the vertical, 15cm from the left hand edge and the horizontal, 18cm above the lower edge. From the intersection point of the two axes which is labelled "O" and on the vertical axis we mark off the rate of climb in metres per second above the "O" point and the rate of sink in a similar manner below. 50mm (5 spaces) should represent one metre climb or sink. On the horizontal axis working from "O" outwards we mark off the speed, 10kph (0.62 mph) every 20mm (or two spaces) up to 150kph (92.5 mph) or even up to 200 kph (124 mph) for fast aircraft.

Now the performance figures for our aircraft are marked off — and for the Ka 6 it will look something like this:—

At 58 kph (35 mph) the airflow breaks away and the aircraft is no longer flying.

So from the speed of 58 kph we drop a line down to the rate of 1.5 metres per sec. (4.9f/sec). At 60 kph (37 mph) the rate of sink is 0.86 metres per second (2.8f/sec.). At the intersection of these values a point is marked. At 65 kph (40.5 mph) the sink rate is 0.7 m/second (2.3 f/sec.). This point is also marked. At 70 kph (43.5 mph) the Ka 6 sinks at 0.67 m/s (2.2 f/sec.), at 75 kph (46.5 mph) — 0.68 m/s (2.2 f/sec.), at 80 kph (50 mph) 0.7 m/second (2.3 f/sec.) etc. In this way the values from the small polar curve are transferred very carefully to the larger drawing. Finally the points are all connected to each other so that we have a legible polar curve, from which the rate of sink for any given airspeed can be read off. Even the glide angles are easy to determine.

Of course in this case both the airspeed and the sinking speed must be expressed in the same units, either metres per second or feet per second. With a slide rule this is a very simple matter. An example: 90 kph (56 mph for those who still haven't got used to the metric system!) is exactly 25 m/second. At this speed the Ka 6 sinks at 0.84 m/sec. (2.75 f/sec.) so at a rate of sink of 0.84 the Ka glides

$$\frac{25 \times 100}{84} = 29.76$$

that is, the glide angle of the Ka 6 at 90 kph is 29.76 — for every metre of height lost it moves forward 29.76 metres.

At 108 kph (67 mph) which is 30 metres per second flying speed the rate of sink is 1.22 m/sec. (4.0 f/sec.) that is:

$$\frac{30 \times 100}{1.22} = 24.6$$ the glide angle has fallen to 24.6.

2.32 THE McCREADY CURVE AND THE POLAR CURVE

The higher our polar curve lies in relation to the axis the better will be the sink speed and the glide angle. The flying speed of the best rate of sink is in no case the speed of the best glide angle, since the glide angle is dependent on the ratio of the sinking speed and the flying speed. Let us now determine the best flying speed for still air conditions. We place a ruler at the intersection of the axes and using this as a turning point, we move the ruler until it intersects the polar curve. The tangent so found gives us the best ratio gliding speed to sinking speed and with it, the best gliding angle. With the Ka 6 the point of intersection lies exactly under 80 kph (50 mph) at a rate of sink of 0.72 m/second (2.35 f/sec.) From these values it is possible to determine the best glide angle of the Ka 6 — 30.8.

Under still air conditions, the greatest distance can be achieved only by flying at exactly 80 kph (50 mph). If we have just left an area with a rate of lift of 0.5 m/s (1.6 f/sec.), or if we are now flying through an area with a sink rate of 0.5 m/second (1.6 f/sec.) after previously flying through still air, then the difference between then and now is 0.5 m/second (1.6 f/sec.) We must therefore consider the polar curve as being 0.5 metre lower in relation to the axis. This, however, is not a simple matter, so instead we simply move the ruler up the vertical axis by 0.5 metre, find the new tangent to the curve. In this case it is at 89 kph (55 mph) at a rate of sink of 0.83 metres per second (2.7 f/sec.). The best speed to fly at after leaving an area of 0.5 metres per second (1.6 f/sec.) lift, or when entering an area of 0.5 metre sink is therefore 89 kph (55 mph).

In this manner we determine for all rates of climb, or differences between still air and sink, the best speed to fly for every 0.5 metres per second change. From each speed so determined we draw a line vertically into the upper right portion of the graph and mark in this area a point exactly horizontal to the intersection of the ruler with the vertical axis. All the points joined together give a new curve which is needed for the production of the McCready ring. The closer together the points chosen on the vertical axis, the greater will be the accuracy of the curve.

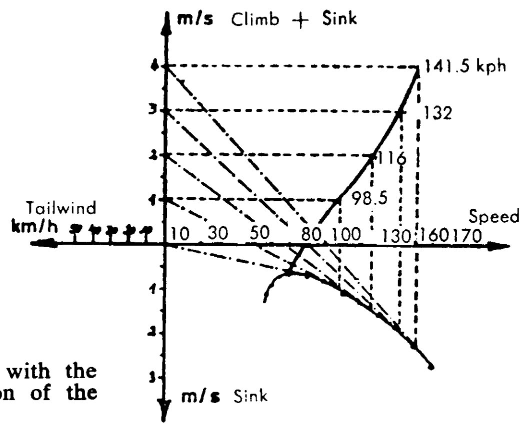


Diagram 7

Speed curve of the Ka 6 with the curve for the determination of the McCready values.

2.33 DETERMINATION OF THE McCREADY VALUES FROM THE POLAR CURVE

From the graph paper we now cut a strip of paper 2cm (4/5 inch) wide and at least 40cm (15.8 inches) long which will be used as a layout ruler. At the very top of this strip on a heavily printed line, we draw an arrow pointing right and label this point 0 (zero). Moving down from this arrow, we then mark off divisions in metres per second which correspond to the divisions on the vertical axis of the graph. (50mm for 1 m/second, 5 squares per 1 m/s). If possible at least 8 such divisions should be made.

On this strip of paper from which the values for the ring will later be taken, we now mark off the different speed values which belong to the different rates of climb, or to the differences in the rate of climb or sink found during the glide, and which are contained in the glide angles.

During the flight it is not very practical to use the speed values from the curve as determined in section 2.23 but rather to go to the nearest 5 kph.

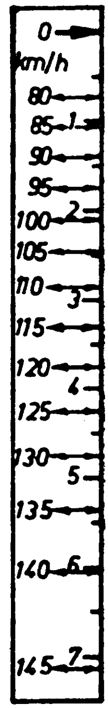


Diagram 8

Paper strip with the McCready values taken from the polar curve.

We then lay the paper strip on the graph so that the right hand side of the strip is vertically above the speed of the best glide angle (80 kph - 50 mph), and slide it so that the arrow touches the new curve in the upper right hand part of the graph. At the best glide angle this point is at the intersection of the curve and the speed axis. The point at which our ruler touches the polar curve is marked and the speed 80 kph is marked alongside. That is at a sink rate of 0.72 m/second (2.3 f/sec.). At a McCready setting of "O" in still air conditions we must fly at 80 kph (50 mph) and the variometer will show a rate of sink of 0.72 m/s. (2.3 f/sec.). Now we slide the paper strip up to the right so that the arrow intersects the curve, and the strip in a vertical position cuts the speed axis at 85 kph (52.5 mph). At the intersection of the strip and the polar curve, we make another mark and label it 85 kph. This mark lies at 1.07 on our strip, from which 30cm lie over and 77cm lie under the speed axis. This means that after a climb of 0.3 m/second (0.9 f/sec.) or in a sinking airmass of 0.3m/sec. (0.9 f/sec.) the best speed to fly is 85 kph (52.5 mph) and the variometer will show as the difference between the starting point and its present position at a sink rate of 0.72 m/s (2.3 f/sec.) If we had had a rate of climb of 0.3 m/s then the variometer will show a rate of sink of 0.77 m/s (2.5 f/sec.) and if we had left still air then the same speed would give us a sink rate of 1.07 metres per second (3.5 f/sec.). Continuing with the paper strip, then we get the following differences 1.40m/second (4.6 f/sec.) at 90 kph (56 mph), 1.73 m/s (5.7 f/sec.) at 95 kph (59 mph), 2.10 m/s (6.8 f/sec.) at 100 kph (62 mph), 3.70 m/s (12.2 f/sec.) at 120 kph (74 mph) etc.

2.34 RING DESIGN POSSIBILITIES

When all the values have been transferred to the paper strip, then we can progress to the making of the ring itself. We need next of all, a not too erratic, fine variometer with + — 5 m/second (1.64 f/sec.) in linear divisions.

There are now two possibilities of mounting the ring. The most commonly used method is to mount the ring around the scale of the variometer. A ring made from plywood, metal or plastic must be cut in such a way that it can be turned around the variometer. A couple of holders can easily be fixed to the instrument retaining screws.

The ring can also be made from clear plastic such as Perspex and mounted on to the glass of the instrument. A steel spring which can be kept in place by the instrument screw can hold the disc in contact with the face of the variometer.

The second method saves a certain amount of space, but the first method has the advantage that the figures can be written larger and more clearly. Also we can add to the ring the appropriate flying speeds for the average rates of climb.

When this stage has been reached, we transfer from the variometer the divisions between the rate of sink or climb.

When the ring has been finished, we transfer from the variometer the divisions between the rate of sink or climb for at least 7.5 m/secs (24.5 f/sec.). On this scale we write in the speed values from the paper strip. The upper- most marking is marked with an arrow, and at 0.72 m/s (2.35 f/sec.) the speed 80 kph (50 mph) is written, and at 1.07 m/s (3.5 f/sec.) stands 85 kph (52.5 mph) etc.

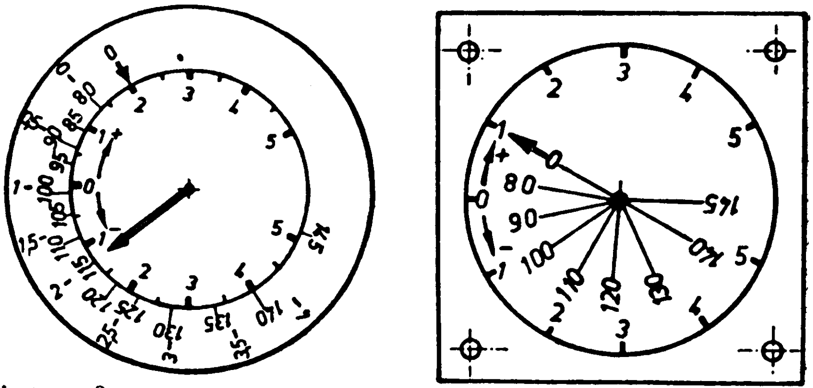


Diagram 9

Ring design possibilities

On the ring in Diagram 9 the rate of climb values have been marked to which the various speeds belong. These rate of climb values enable us during the last circle in thermal to decide on the airspeed for the departure. It also has the advantage of allowing us to determine at any time during a glide whether we are flying through rising or sinking air.

2.4 THE USE OF THE McCREADY RING

If you have taken the trouble to construct the ring for yourself and have understood its function, then its use in flight should not present any problems.

2.41 THE AVERAGE RATE OF CLIMB

First of all the average rate of climb must be determined. The invariable fluctuations of the average variometer are not very satisfactory for this purpose. One should never make the mistake of determining this figure from only part of the thermal. Many pilots, because of simplified reckoning, measure this rate over a period of time of 100 secs. Everything that is not a genuine glide over the course must be reckoned with, even the time taken to centre in the thermal and eventually the time spent searching for a thermal. That means with an indicated rate of climb in a thermal of 3 metres per second (9.8 f/sec.) that the average climb rate may be only 2 metres per second (6.5 f/sec.) or even less.

The best means of finding the average rate of climb is the slide rule from the development group of Bolkow and thought out by Nagele, Eppler and Lindner. When the glide is terminated the stopwatch is started, and if necessary the height is marked on the altimeter. When the thermal is left the time taken is set out above the gain of height on the calculator and the average rate of climb is read off the lower scale.

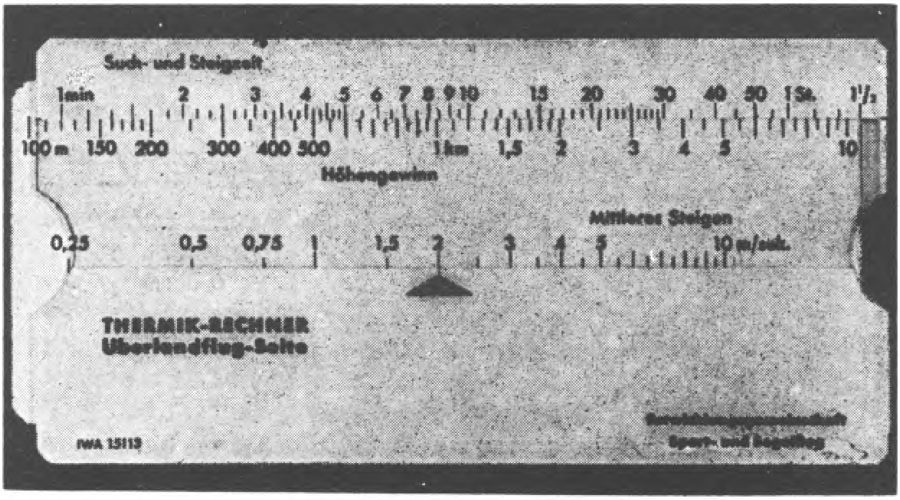


Diagram 10
Thermal calculator from the development group.
"Sport and Soaring flight."

TRANSLATIONS:
Such- und Steigzeit — Search and climb time. Hohengewinn — Height gain.
Mittleres Steigen — Average climb rate.

2.42 ADJUSTMENT OF THE RING AND FLYING ACCORDING TO THE RING

If a genuine rate of climb of 2m/second (6.5 f/sec.) is found, and which we expect to find in the next thermal as well, then we set the arrow on the McCready ring at the figure of +2m/sec (6.5 f/sec.) on the Variometer. The rate of climb scale on the ring tells us that this rate of climb we must fly at a speed of 116.6 kph (72 mph) and that the rate of sink will be 1.25 m/second. We increase the airspeed during the last circle in the thermal to 116.6 kph (72 mph) and leave the thermal. Only seldom will the needle of the Variometer remain at the sink rate of 1.25 metres per second (4.1 f/sec.). If it shows more, then we carefully increase the speed until the indicated speed on the airspeed indicator agrees with the speed to be flown figure indicated by the ring opposite the rate of sink being experienced.

An example for the Ka 6:
During a glide at 116.5 kph (72 mph), the figure on the variometer falls to 2.25 m/second (7.4 f/sec.). The difference between the previous rate of climb of 2 m/second (6.5 f/sec.) and the sinking air mass of 1 m/sec. (3.3 f/sec.) is 3 m/sec. (9.8 f/sec.) The speed to be flown is then 132 kph (82 mph). If we now fly faster in order to catch the pointed which is at 2.25 m/sec. (7.4 f/sec.) and 126 kph (78 mph) then it will sink further until the speed of 132 kph (82 mph) is reached, when the speed to fly and the real airspeed coincide. After a little practice one will find that one automatically flies at the right speed. It is very important that the change in air speed as dictated by the Variometer pointer is carried out

smoothly. Sudden back pressure on the control column results in a performance loss and in erratic readings by the Variometer.

If in the course of gliding, the Variometer pointer continually moves up, then we must fly at the speed shown to get the best performance. Should the pointer reach or even pass the "O" arrow then it is time to begin circling in order to gain more height. The average rate of climb should be checked at frequent intervals, so that the ring always shows the best speeds to fly at. In weak lift, flying too quickly can result in a loss of time.

If at any time we lose more height than is considered good, in fact even a forced landing may be threatening us, then it is time to change the ring setting in order to fly at the speed which gives us the best gliding angle. Important as it is to fly quickly, there is little to be gained by landing out.

2.5 DOLPHIN SOARING

In recent times fantastic world records have been flown with the super-ships made from either synthetic materials or from metal. The times achieved for the 100 km triangle — 148 kph (93 mph) and 137 kph (85 mph) for the 500 km triangle cannot be achieved by many powered aircraft of 100 horsepower. That such flights are not restricted to the best gliding areas of the world was proved by Alfred Roehm when he flew his BS 1 over the Schwabian Alps and the Black Forest on a 300 km triangle at a record of 138.3 km/h (86 mph).

How is it then that such flights are possible with sailplanes? Even with an average rate of climb of 7 m/sec. (23 f/sec.) it would not be possible to reach an average speed of 120 kph (74 mph). Further the maximum possible speed of the aircraft imposes a clear limit on us.

According to this, world records can no longer be won with our traditional aircraft. Yet despite this it is possible to fly faster than the given McCready values. If for instance the thermals are so arranged in their strength size and distribution that they permit us to regain lost height by simply flying straight ahead, then we can achieve very fast times by means of the Dolphin soaring technique.

This method gets its name very appropriately from the sea-mammal which by means of its graceful up and down movements moves forward with the speed of an arrow.

Weather conditions, which, even for aircraft with glide angles of 30, permit one to refrain from circling flight are not as rare as one would generally believe. On many cross country flights there are at least sections that can be covered by Dolphin soaring when the pilot recognises and uses the situation. Every cloud street demands this type of flying.

Now because no generally applicable rule for the best speed to fly has been found for the Dolphin technique, it is usual to fly according to the rule of thumb, in "sink — faster and in lift — slow". I have worked out a large number of examples and made some practical tests. Although I

am a long way from being able to offer a patent answer for the use of the Dolphin technique I am able to prove that the rule of thumb quoted here is not the best answer.
With a distribution of thermals and still, or for example sinking air, in a ratio of 1:1 and with a genuine climb rate of 2 m/sec. (6.5 ft/sec.), we would, with a Ka6 flying at its best glide angle (McCready 0) under the best conditions reach a cruising speed of 94 kph (58 mph). In this case we regain, flying at 80 kph (50 mph) our starting height within the first third of the thermal area. In the next two thirds the climb must be used up, so the speed is increased to 150 kph (93 mph). According to this example, we would without using thermals, fly two thirds of the distance at 80 kph (50 mph) and one third at 150 kph (93 mph). Thus, for 200km (124 miles) at 80 kph (50 mph), we would take 2hrs. 30min. The remaining 100km (62 miles) can be finished in 40min. which represents a total time of 3hrs. 10min. for 300 km (187 miles). The average speed is then 94 kph (58.5 mph). If however we set the McCready ring at 1.5 and maintain the given speed of 108 kph (67 mph) even when climbing we can raise our average by 14 kph (8.7 mph). In this case we regain our starting height almost exactly at the end of the thermal field. With a climb of 3 m/sec. (9.7 ft/sec.) the cruising speed differs from 99 kph (62 mph) at the best glide angle and 127 kph (79 mph) at a McCready value of 2.5 by a whole 28 kph (17.5 mph). If the rate of climb is lower, or there exists an unfavourable thermal distribution, then the differences will naturally be smaller. We must therefore where possible, seek to organise the flight in such a way that we never find it necessary to convert climb into horizontal speed. First of all we have been forced to accept an unnecessary loss of time and in addition the limits of the aircraft are too easily reached One should not overlook the fact that the Ka6 must be flown at 160 kph (100 mph) in order to convert a climb rate of 3 m/sec. (9.6 ft/sec.) into the appropriate forward speed.

3. NAVIGATION

There are many publications available on navigation. However one frequently finds that glider pilots with cross country experience lose themselves and land in some large unidentified area. This can be partly due to the fact that some pilots attempt to use powered flying navigation techniques for gliding purposes . They forget that there are considerable differences between the two.

3.1 PREPARATIONS FOR CROSS COUNTRY FLYING

Before a glider pilot attempts a cross country flight certain important conditions must be fulfilled.

3.11 THE MAP

A pilot needs a good map, on which the important landmarks have been printed. Contours, forests, railways, roads, canals and rivers are

not always shown clearly. Especially recommended are the aeronautical charts with a scale of 1:250,000 and 1:500,000. It may happen that a particular map may be heavily overprinted to the extent that it is confusing, and where possible a simpler version of the same map should be obtained and the appropriate control zones and landmarks drawn in during the preparations.
The cross country pilot must be absolutely familiar with the map before starting the flight. That demands either a lot of cross country experience or many hours of homework beforehand. It should never be that a pilot has trouble reconciling the surrounding landscape with the map or vice-versa.

3.12 THE COMPASS

A further, frequently ignored condition is that the aircraft is fitted out with a corrected compass. Unfortunately one sees, time and time again, aircraft equipped with electrical variometers, radio, artificial horizon, oxygen, etc, in value well over $1000, fitted with a compass with an error of 45° and more. Such things should never be!

3.13 NAVIGATION EXERCISES

No glider pilot should begin on the day of the flight to work out a course over which to fly. He should always have several prepared. A good pilot will work quietly at home making himself familiar with all details of the course and working out a course of action to meet all eventualities.

3.14 COMPASS COURSE AND DRIFT

When the course has been determined and drawn on the map, it should be divided into sections. Guide marks should be placed around landmarks etc. en route and lines crossing the course should also be noted and even marked. Prior to the flight, after receipt of a reliable weather forecast, the compass course should be determined and a timetable worked out — something which is usually forgotten, then the low flying speeds of gliders make allowance for drift and the headings against wind especially important. During cross country flights the strength of the wind is frequently greater than the pilot realises. A cross wind of 30 kph (18 mph) is not uncommon. Suppose we are flying a Ka6 with an average rate of climb of 1.5 m/sec. (4.9 f/sec.) at a calculated flying speed of 60 kph (37 mph), and therefore at a flying speed of 60 kph (37 mph), then with a cross wind at right angles to our course of a strength of 30 kph (18 mph) it will be necessary to head exactly 30° into the wind. When such a drift is ignored then the results can be disastrous.
One frequently hears the opinion that a glider pilot should simply fly at an angle to the course which compensates for the drift. However that is not so simple, unless one is flying straight ahead just as the power aircraft do. Appropriate to our rate of climb at 1.5 m/s (4.9 f/sec.) we fly at a speed of 110 kph (68 mph) and with a correction of 14° which is correct for these conditions. For the whole distance however, we must

base our speed on 60 kph (37 mph) and at this speed the drift is more than twice as great at 30°. Over a distance of 100 km (62 miles) an ignored 15° of drift will result in an error of more than 25 km (15.5 miles). There is no other solution than to allow for drift when determining the compass course.

3.15 THE AVERAGE CRUISING SPEED

For such calculations we need to know our average cruising speed. This is where the speed polar curve helps once again. When we place a ruler on the average rate of climb on the vertical axis and on the polar curve, then the point at which it cuts the horizontal axis is the speed value sought after.

The speed at the point of intersection is the average cruising speed through the air. With the Ka 6 we get the following speeds:

Average climb rate (m/s)	0.5	1.0	1.5	2.0	2.5	3.0	3.5
	(1.6 f/sec)	(3.3 f/sec)	(4.9 f/sec)	(6.5 f/sec)	(8.2 f/sec)	(9.8 f/sec)	11.5 f/sec)
Average cruising (kph)	34	50	60	70	75	80	85
(mph)	22	31	37	43	46	50	52

Every glider pilot should have such a table prepared for his aircraft. During preparation of course the average rate of climb will not be known to us. After receiving the weather forecast, and from experience, it is possible to gauge such values fairly accurately.

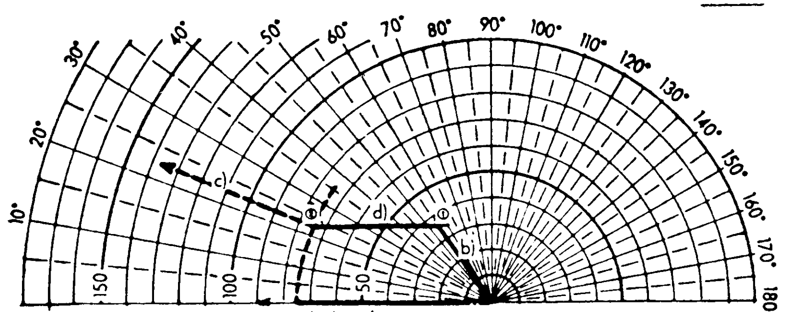
3.2 COURSE CALCULATOR AND NAVIGATION CALCULATOR

The calculation of the drift can be found in the same way as power pilots find it, with a calculator or by means of the famous triangle. However Heinz Huth has found an ideal solution (Diagram 11).

Calculate wind angle (from left — from right +) from intersection wind angle — wind strength (1) go horizontally to left and at intersection (2) with average cruising speed circle (2) read off drift.
Groundspeed is the distance between (1) and (2).

Example:

ð) Right-hand course	285°
b) Wind	340°/35kph
Wind angle	+55°
a) Average cruising	75 kph
c) Drift	+22,5°
d) Groundspeed (1) — (2)	= 49 kph



Average cruising + right-hand course.

Diagram 11

Course calculator from Heinz Huth.

This course diagram is really so simple that one can only wonder why it was not developed earlier. From the centre out, the semicircles are arranged at a distance of 10mm (0.4" approx.) from each other and represent the speeds for aircraft and wind. 1mm = 1 kph (0.62 mph). Also arranged from the centre out are markings in degrees in divisions of 5°. With this diagram we can determine all amounts of drift and all possible variations in drift, and therefore compass courses, as well as the resulting speed over the ground. Let us take an example from Heinz Huth which is given in the diagram. We have a course of 285°, and a wind with a strength of 35 kph (22 mph) from 340°. Now between 285° and 340° there are 55°. That means that the wind affects our course at an angle of 55° from the right. This +55° is our wind angle. If the wind comes from the left it is labelled minus (—). The average cruising speed is appropriate to the average rate of climb of 2.5 m/second, that is 75 kph (46 mph), on the diagram we follow the "right-hand" course to the left, to the point 75 kph (46 mph). On the 55° line we draw a line from the centre with a strength of 35 kph (22 mph) to intersection point No. 1. From there we construct a horizontal line to meet the speed 75 kph (46 mph) at point No. 2 exactly in between the lines of 20° and 25°. The drift which is then 22.5° must be allowed for in the heading to the right.

The compass course is then, ignoring compass deviations due to the aircraft and the earth's magnetism, 307.5°. The distance between the points of intersection 1 and 2 (measured in mm) gives the ground speed — in this example 49 kph (30 mph). As a further example — a course of 170°, the wind has a strength of 30 kph (18 mph) from 40°. That gives a wind angle of minus 130°. The average cruising speed, at an average rate of climb of 1m/sec, is 50 kph (31 mph). With these figures we can calculate the drift at minus 27° and a ground speed of 63 kph (39 mph). (Diagram 12).

Calculate wind angle (from left — from right +) from intersection wind angle — wind strength (1) go horizontally to left and at intersection (2) with average cruising speed circle (2) read off drift.
Groundspeed is the distance between (1) and (2).

Example:

a) Right-hand course	170°
b) Wind	40°/30kph
Wind Angle	— 130°
a) Average cruising	50 kph
c) Drift	— 27°
d) Groundspeed (1) — (2)	= 63 kph

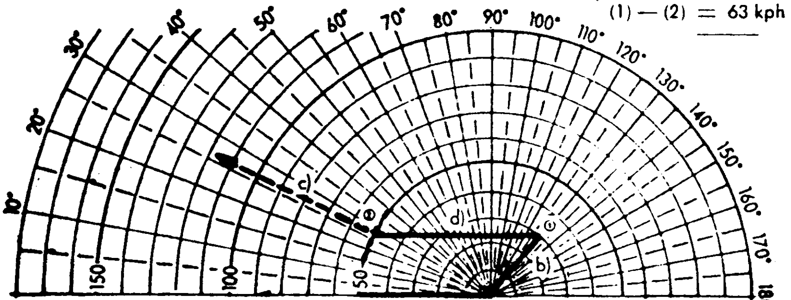


Diagram 12
Course calculator from Heinz Huth.

Finally the errors in the compass caused by the aircraft (deviation) and by the earth's magnetic field (declination) must be allowed for and we will then have our final compass course.

Starting with the basis of the Huth course calculator, Jurgen Holtkamp has developed a very elegant system for determining compass course and ground speed. On the flight calculator he has combined on the front side the goal flight calculator, flight time calculator and the calculator for the average rate of climb. The resulting free side has been taken up for the navigation calculator.

From the centre point of the transparent slide, average speeds in steps of 10 kph are arranged in circular form and for speeds above 40 kph, sectionwise only. In the same centre there is a rotatable disc on which wind speeds are arranged in four circles from 10-40 kph.

On the same disc degrees have been marked. Under these two transparent parts there is a slide with speed lines arranged vertically, from 0 kph to 170 kph in intervals of 5 kph. The horizontal lines are to assist in reading off the compass course and speeds over the ground.

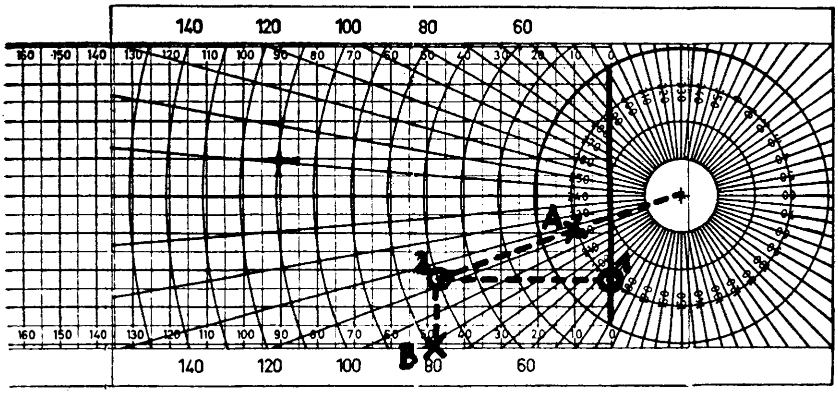


Diagram 13a

NAVIGATION AID — HOLTKAMP

1. Exercise. 240° at 70 kph. Wind from 190° at a strength of 30 kph.
01 = Base line slide under the windpoint.
20 = Intersection of the horizontal with the average speed.
AX From 20 to disc centre = Compass course 222°
BX From 20 downwards — speed over the ground = 48 kph.
Headwind component = 22 kph (for goal flight).

Working with this calculator requires only the determination of the wind angle and the drift since the compass course can be read off directly. Deviation and declination must also be allowed for.

The circular disc is turned so that the degrees of the course lie on the centre horizontal line e.g. 240° — Dia. 13a. The wind is expected from 190° with a strength of 30 kph (19 mph). The wind point is then the intersection of the 190/30 line of the disc. The base line of the slide is then set on this point of intersection. Take an average cruising speed of 70 kph (44 mph). Follow the horizontal line from the windpoint

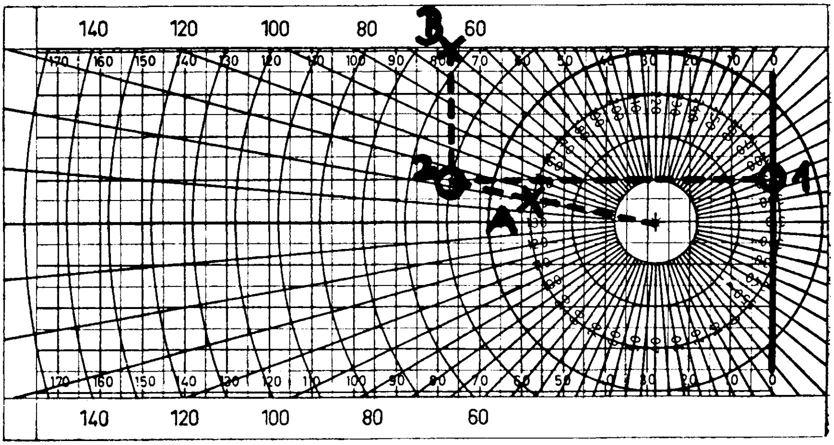


Diagram 13b

2. Exercise. 130°. Speed 50 kph. Wind from 290° at a strength of 30 kph.
01 = Base line slide under the windpoint.
20 = Intersection of the horizontal with the average speed.
AX From 20 to disc centre = Compass course 141°.
BG From 20 upwards — speed over the ground = 77 kph.
Tailwind component = 22 kph (for goal flying).

to the 60 kph circle. From there following the follow line to the centre of the rotatable disc and read off 222°.

That will be the course to steer. From the point of intersection moving vertically upwards we find the speed over the ground, in this case 48 kph (30 mph). The difference between the average cruising speed and the ground speed which is in this case 22 kph (14 mph) is also the head wind component which must be allowed for during the final glide. After a little practice a surprising degree of accuracy will be possible. Once more briefly the procedure:

1. Set the course on disc opposite centre line of the slide.
2. Windpoint is intersection point of wind direction and wind strength to be determined on rotatable disc.
3. Base line of the slide set on windpoint.
4. From the windpoint move horizontally to the left to the intersection cruising speed-circle.
5. From there to the centre of the disc read off the compass course.

Finally move vertically either upwards or downwards and read off the speed over the ground. We now have a method which cannot be improved upon. However producing such a piece of equipment is considerably more difficult than the Huth calculator, but of course this navigation calculator with the slide for calculating average rates of climb and final glides is obtainable from the Wirtschafts Dienst GmbH, DAeC Landesverband NRW, 433 Mulheim, Flughafen at a reasonable price.

Before every triangular task, each stage should be prepared according to this method, in which the weather map also plays an important part. Naturally for this purpose an accurate forecast for the course is necessary, and for glider pilots the general weather forecast is totally inadequate. If the probable wind speed over the ground is known, then the preparation of a time schedule should not present too great a problem. On the map stages at intervals of one hour can be marked off, or points marked which should have been reached after flying a certain time. Such a time schedule allows us to determine whether a planned flight can possibly be carried out in the time available.

It is not surprising that such careful and exact preparations should be regarded as unnecessary by pilots with little or no experience in flying against head or side winds. Every pilot who in the course of flying a triangle in strong winds and in weak thermals and who after an hour or more of hard work finds himself well inside, or perhaps outside, the triangle will know that how important such preliminary work is. Even many out landings can be avoided, when, after exceeding the time limits set for the exercise, the pilot can see that completion of the course is no longer possible, and that an early decision to cease means an assured landing at the home airfield. Furthermore, attempting to link up the drift and the ground speed during flight is unpardonable.

3.3 NAVIGATION IN FLIGHT

When a cross country flight has been planned as described in the manner here, then little, from the navigational point of view, should go wrong. The most important part of the work consists of controlling the flight, checking the time schedule and correcting the drift. Naturally one should watch for possible wind changes, seen best of all by cloud shadows and drifting during turns in thermals, or by their announcement over the radio. Of the greatest importance is co-ordination during the flight, that is, the maintenance of the time plan and the pre-arranged course should be continually checked. If one flies over a large area without any obvious navigational landmarks being seen, or, as is so simple in industrial areas, the visibility deteriorates, then any tendency to lose one's head must be avoided. Many cross country pilots have sunk to the ground in good conditions because they temporarily lost their sense of direction, became nervous, flew wildly around the region searching desperately for a landmark and then have been forced to land out.

The only help here is calmness and dead reckoning. When orientation has been lost, then the pilot will still know up to which point the time plan and course has been maintained. If he has flown accurately according to the ring and plan, then with help from his watch he can say "I must be in this area on the map!" Accordingly, he can work out when he should have reached a certain point which may possibly still be some considerable distance away. This knowledge will reassure the pilot and enable him to continue flying on with confidence. Anyone who has not had this experience will be surprised how accurately it is possible to fly in a sailplane. Every pilot should understand that successful navigation and the resulting calm during the flight are the results of careful preparation.

4. METEOROLOGICAL NAVIGATION

A comprehensive guide to meteorology is beyond the scope of this book and cannot therefore be handled here. However this necessary knowledge can be obtained by any glider pilot so inclined, from the very good books "Meteoroligsche Navigation" by Georgii (in German only) or from "Meteorology for Glider Pilots" by Wallington. Two better books on this specialised subject would be hard to find.

4.1 THE CROSS COUNTRY WEATHER FORECAST

The power pilot has fewer problems here. When he expects wind, poor visibility, low cloud and possibly rain he can decide whether or not the flight should be carried out. Only in this way are the automatic weather reports of the airports to be regarded. Glider pilots who are satisfied with a call to the automatic telephonist will remember this when they find themselves prematurely on the ground because of poor thermals.

The cross country glider pilot must have more details on the weather if the flight is to be properly prepared. Our Austrian friends are to be envied because their weather forecast that is broadcast daily provides a good starting point. Unfortunately there is not only this service missing in many countries but many a meteorologist has been unwilling to answer the somewhat awkward questions put to him by a serious enquirer.

We should, however, have some sympathy for the weather man who, while endeavouring to cope with the demands from power pilots and commercial pilots is frequently called by glider pilots wanting to know something quite different. What is at fault here is the system and many attempts to organise such have been doomed to failure because they have been organised on a local basis only.

The following is an attempt to list all the details required by the glider pilot under one heading.

Cross country flight weather on:

1. General situation (highs, depressions, changes in air pressure).
2. Cloud cover
2.1 Cloud cover in eighths
2.2 Type of cloud
2.3 Lower and upper limits
2.4 Precipitation
2.5 Visibility
2.6 Inversion (height and strength)

3. Wind direction and strength
3.1 On the ground
3.2 Details per 2000 feet up to the inversion
4. Temperature
4.1 Release temperature (time)
4.2 Expected maximum temperature
4.3 Dew point
5. Gradient for every 1000 feet to the inversion limit.
6. Further outlook
7. Further remarks on the weather.

The general introduction of this form by the weather service would be ideal. It could be filled out by the meteorologists in the morning and handled over the telephone by assistants in reply to each number being called out.

However before an official ruling is made glider pilots should help their own cause by always referring to this form. The meteorologists will appreciate having a system to work to. An attempt should also be made to have these details transmitted by teleprinted to all branches of the weather service. A considerable reduction in work for the airfield authorities would be the result.

That every cross country glider pilot is familiar with the need for the details listed here, is taken for granted. If this is not the case then the help of more experienced comrades should be sought. No one should underestimate the importance of the details concerning the gradient.

From these details a diagram similar to that in No. 3 is drawn on graph paper which can then provide useful information for the planned cross country flight.

4.2 CROSS COUNTRY FLYING UNDER CUMULUS CLOUD CONDITIONS

By the term good weather, every glider pilot thinks of a deep blue sky and from 10.00 or 11.00 hours' white, puffy, cumulus clouds. Surprisingly enough, one frequently hears the opinion from glider pilots that a sky covered to the extent of 4/8 or even 6/8 is desirable. They should understand that a sky that looks like a chess-board, that is with 4/8 cumulus, is for our purposes over-convected. The ideal for cross country flying is 1/8 to 2/8.

4.21 FLYING IN THE THERMAL

Right at the beginning of the flight the first thermal found should be flown in because the conditions found initially are likely to be repeated right throughout the region When flying in a thermal the question — which side of the cloud provides the lift? must be answered. It is not necessarily true that the upwind side of a cumulus cloud or the sunny side of a cumulus cloud provides the best lift. That can vary from one set of conditions to another. Secondly, the glider pilot must determine the heights in between which the best rate of climb is to be found. As described in chapter 2, it pays to fly within their height band. Climbing higher under a cloud when the rate of climb has fallen off costs unnecessary time. If however, the thermals are weaker at lower heights, then the McCready ring must be reset to a lower figure, so that the next thermal will be reached while still flying within the band of the best lift. The next and third point is the importance of determining the strength, width and turbulence of the thermals, so that entering the thermal is done with the appropriate ring setting.

All of these values can of course change in the course of a day, and with changes in landscape, and for this reason they should be frequently checked.

4.22 FLYING ON COURSE

One also hears of glider pilots who, presumably flying in thermic conditions, have spent many hours in the air and yet cover only a short distance. A check on the ground speed reveals 20 kph (12.4 mph) or less even though an insignificant wind was blowing.

This is usually due to a mistake that is frequently made by the inexperienced. The pilot flies around under a cloud and fails to find the expected rate of climb. Looking up he sees a grey hazy foggy mass. A few miles away however, and not on course, there appears a wonderful white puffy cumulus cloud of increasing size. The pilot allows himself to be led too easily. Instead of seeking the better rate of climb under his present cloud, he flies to the better looking one. Here is the same picture as before, above him, a foggy haze and in the distance, another picturesque cloud. And so the poor pilot flies here and there, from cloud to cloud, finding perhaps not a single really good thermal. Because of poor thermalling techniques, he loses height slowly but surely, and is finally satisfied with a miserable rate of climb in order to stay up in the air. Especially bad, is the fact that these unsuccessful efforts have strained his nerves to the limit, especially when he hears over the radio that his friends have been enjoying good lift.

Every glider pilot should know that the nearer one flies to a cumulus cloud, the hazier and more useless it appears.

Heinz Huth frequently uses a good example in his lectures. He compares the air space in which the thermals occur, with a forest, and shows that it is impossible to move through the forest with one's eyes closed without hitting a tree. So he recommends that one stays on course.

With a McCready ring setting of the expected rate of climb one must stick to the course, and only when the Variometer needle reaches the "O" arrow of the ring should one begin to circle. How right this theory is and how much time can be gained are now shown by Huth's results in competition flying when he alone flew according to these rules. Today of course, through his generous sharing of knowledge he has succeeded in drawing competition from those who fly as he has taught. Fantastic average flight times during recent competitions have been the result. In no case of course, should one fly according to these rules until one hits the ground. An early reappraisement of the ring setting enhances the safety factor and saves the nerves considerably.

4.23 CLOUD ELEVATION AND DISTANCE ESTIMATION

When distances between clouds are considerable, e.g. 15-20 km (9-12 miles), which can happen toward evening, and we are sure that no thermals are to be found between the clouds, then we should not continue flying according to the "forest theory". In such cases it pays to fly to the next cloud lying approximately on course in order to be sure of finding lift.

"Young", developing clouds are always to be preferred since their life expectancy is greater and the lift under a developing cloud is always better. Of course experience is required in order to determine the age of a cloud. If from a distance the contours of a cloud look frayed, then the cloud has already begun to decay.

A distant cloud, probably unobserved, which in the course of three turns by the glider has grown in size is guaranteed to still be developing. The estimation of distances is also not exactly simple. Under conditions of good visibility, the cloud shadows are of use, but one must allow for a high cloud base and the angle of the sun. Care is also needed because forest areas at a distance look just like cloud shadows.

4.24 OPERATING HEIGHT AND RING SETTING

As suggested by the explanation of the "forest theory" every cross country pilot should be guided by reason and not by blind faith, that the previously established average climb rate will always be found and so avoid being caught with an excessively high McCready ring setting. At which heights the ring should be reset to a lower value depends on the weather and the pilot's nerves. I would recommend that below 500 metres (1500ft), one flies with a ring value of "O".

4.3 DISTANCE FLYING IN BLUE THERMALS

Good soaring weather may be had even when no clouds are visible in the sky, that is when so called blue thermals provide the lift.

Under a high inversion, when humidity it low, and the sky is blue, good cross country weather is still possible. In such a case one can only fly according to Heinz Huth's "Forest theory", with, of course, certain limitations, that poor areas for thermals are either flown around, or across, with care. For the nervous and unsure pilot, such conditions have the advantage that the pilot will not be attempted to fly zig-zag around the countryside after good looking cumulus.

4.31 EQUIPMENT AND TACTICS UNDER BLUE THERMAL CONDITIONS

In blue thermal conditions a white sun hat and a pair of sun glasses are especially important. Many a pilot after hours of flying under a merciless sun has suddenly begun to "see stars" and has been forced to terminate the flight. Good quality polarised sun glasses offer a further and not to be underestimated advantage.

If we climb in a blue thermal up to the level of the inversion, it is possible to see billowing vapour. To the unprotected eyes, these cotton wool balls are invisible. They show us places where the thermals break through the inversion, tumble through the vapour layer and burst through into the air above. In this way, the glider pilot can see the frequency of the thermals, and flying to the next billow there is a very great chance that he will arrive at the thermal responsible. However, we must understand that this phenomenon is to be observed only in the vicinity of the inversion. It is also important here, that just as with weather conditions, with clouds a pilot should not be tempted from his course unless absolutely necessary.

4.32 ARRANGEMENTS OF THERMALS UNDER BLUE THERMAL CONDITIONS

It can easily happen that we experience extreme rates of sink while flying on course under blue thermal conditions.

That is mostly due to the fact that blue thermals can arrange themselves in rows just as cloud streets. In such cases the best course is probably to alter course 45° until a normal rate of sink, or even a thermal, is found. From there, one continues on the old course. Under no circumstances should one use the common practice of flying around in circles in heavy sink because the old theory says "Where there is sink there is also lift!"

4.33 MINIMUM HEIGHT UNDER BLUE THERMAL CONDITIONS

Should, in the course of a cross country flight under blue thermal conditions, more height be lost than is thought good, then we cannot rely on the clouds to point the way to lift. The only possibility is to observe the ground closely in the hope of finding impulse producing areas or ridges that promote lift. Smoke clouds, dust clouds from vehicles or agricultural machines, or even the amazingly common soaring bird can save the pilot from landing out.

4.4 MISCELLANEOUS

4.41 CLOUD FREE AREAS UNDER CUMULUS WEATHER CONDITIONS

It frequently happens that a cross country pilot having flown through areas of good cumulus, suddenly finds himself confronted with a large cloud free area. Not even the smallest cloud indicates signs of lift. There may be several reasons for this. One possibility is that the ground is so wet that the "triggering temperature" has not been reached. In such cases no thermals can be expected. Perhaps the ground temperature is especially high as in very dry areas, which in addition may be protected to windward by mountains. In such a case the ground can be expected to produce good blue thermals, clouds being unable to form because the rising air is halted by the inversion before the condensation level is reached. Whatever causes have been responsible for the absence of the clouds, the question for us is the way in which the area is to be crossed. Should cumulus clouds be visible on the other side of the cloud free area, and there is a good chance that they can be reached, then the only way is to fly with the greatest possible height and a conservative ring setting towards them.

If our height is insufficient, then it will be necessary to consult the map in the hope of finding out why the cloud development is prevented. If no thermals can be expected, then it becomes necessary to determine where, according to ground details, the clouds in the distance are to be found, or where the cloud free area is narrowest. A deviation in such cases can not be avoided.

If after consulting the map we decide that the area lying in front of us can only contain blue thermals, and we discover during the climb right up to the base of the last cumulus cloud that the vapour billows, so characteristic of blue thermals, are to be seen in the inversion, then we can fly cautiously into the "hole." If our supposition is correct, and we find acceptable lift, then the ring can be set at the average rate of climb and the flight continued on course.

4.42 SINKING CLOUD BASE

Many cross country pilots have found with dismay that in the course of their flight the cloud base has begun to sink in a step-like manner. Areas with a high humidity or the advance of cold air can be responsible for such changes. In the second case, when a noticeable increase in wind, especially at ground level, is discernable, then continuation of the flight is not worthwhile when the cloud base sinks below 700m (2000ft). Should however the wind speed remain at a reasonable level, then an increase in cloud base height can reasonably be expected after crossing the damp region. River valleys, swamps, or other areas with a high water level can give rise to such phenomenon.

4.43 THERMALS IN HILL COUNTRY

What is obvious for the practised mountain soaring pilot is often left unnoticed by another, soaring over hill country. It is a fact that above valley centres, lift is seldom to be found. Occurrences such as mountain and valley winds make themselves noticeable even in the lower hills. The ridges onto which the sun falls vertically are warmed more quickly than the flat valley bottoms.

On such ridges, the warm air creeps upwards until it is triggered by an impulse, and rises to the upper levels as a thermal. A supplementary push is given to the warm air by the air from the valley centre which is continually sucked downwards, and so a circular movement of the air takes place. In the diagram this process is shown in a rather ideal form since it is usually displaced downwind over the hill tops (see diagram 14).

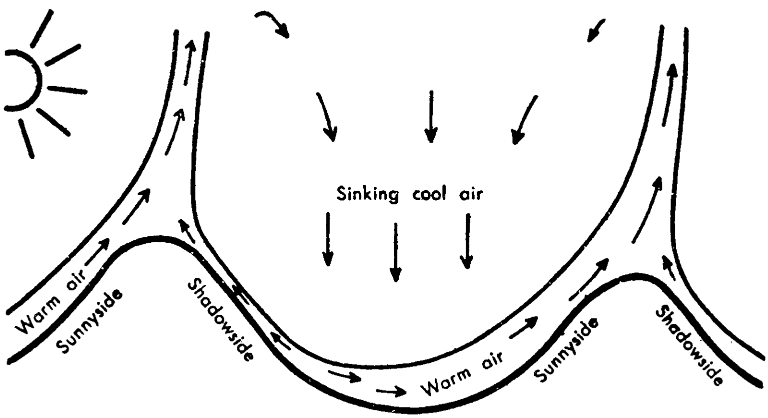


Diagram 14

The warm air from the valley centre is drawn up by the sun warmed ridges. Above the valley only sinking air masses are to be found.

Especially to be preferred are the sunny slopes at an adequate height, without consideration for the wind, although it may be blowing at ground level at 30-40 kph (18-25 mph). In such cases of course, one should not underestimate the lee effect of the ridge. If a forced landing threatens and the wind is strong enough to soar on the upwind side of the ridge, then naturally this can provide that last possibility of staying up.

4.44 WET RIVER VALLEYS

Wet and particularly wide valleys often have their own problems. Many pilots have confidently crossed a valley at low height, with a tail wind, to the other side of a river, in the hope of finding lift on a ridge. In some cases they stayed for an interminably long time at low levels in ridge lift, slowly gaining height in a laborious manner. River valleys can, after a series of cold days resulting in the necessary cooling, have the same effect as a long stretched out mountain range. On the weather side where the wet and cold ground begins, a cold air layer forms from which the arriving warm air separates itself. In the valley itself,

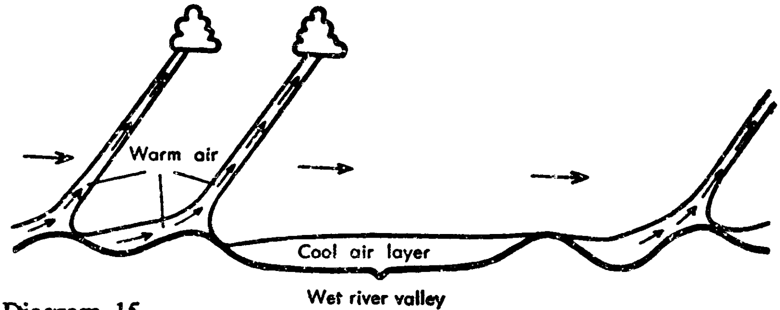


Diagram 15

In the lee of a wet river valley, thermals cannot be expected.

the release temperature is not reached and the necessary warm air formation does not occur, so that on the lee side no thermals can be expected.

One should always be careful of rivers and on the weather side of rivers, making sure of having sufficient height available for crossing.

If there has been a period of warm weather before the day of the flight and the temperature of the river valley is relatively high, then the previously mentioned effect will not occur. In this case the damp ground can have a considerable advantage in store for the cross country pilot. In the evening, when the air temperature falls, the valley will surrender its stored heat and produce evening thermals of considerable strength. The same phenomenon can occur in all damp areas.

4.45 CLOUD STREETS

A great deal has already been written by meteorologists about the formation of cloud streets. It can be shown that these "streets" originate from the interaction of the thermals and wind sheer above and below the inversion. Now, unfortunately, these cloud streets seldom lie exactly over the course on which we want to fly. In such a fortunate case it is only necessary to find the upwind side of the cloud and then flying straight ahead, to cover a considerable distance over the ground in a short time. It pays, too, to follow cloud streets which deviate a little from the preplanned course.

Helmut Kiffmeyer from Gutersloh has resorted to a diagramtic illustration of this problem. In the diagram 16a an example is given in which a glider covers a course of 40km (25 miles) from A to B with an average speed of 40 kph (25 mph). The pilot finds a cloud street at the beginning of the flight which however deviates from his course by 40° under which he is able to fly straight ahead at 80 kph (50 mph) without losing height. The ratio of the average cruising speed on a direct course to the speed under the cloud street is then 40 kph (25 mph) to 80 kph (50 mph) or shortened 1:2.

Diagram 16a

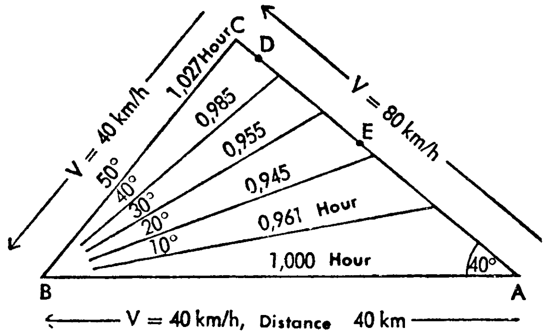


Diagram 16b

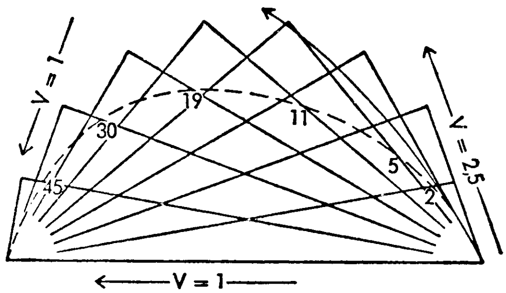


Diagram 16c

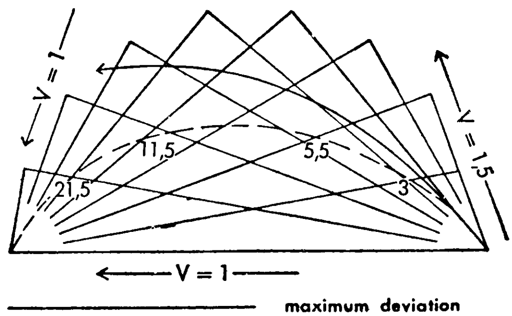
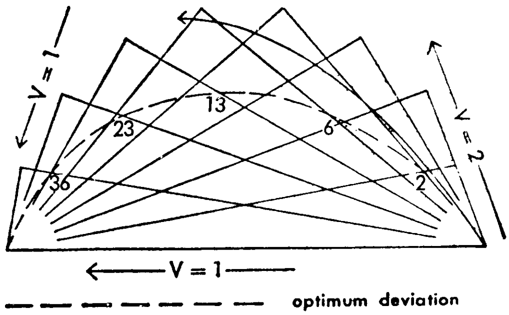


Diagram 16d



Only this proportion is used as a basis in the diagram. This applies to all flights of which the speeds are in this ratio, at 50 kph (31 mph) to 100 kph (62 mph) and from 60 kph (37.5 mph) to 120 kph (75 mph) etc. Regardless of which point the pilot left the cloud street to fly to the goal he may from this moment on expect only half the average speed that he was able to achieve under the cloud street. Here it is necessary, as with the ring setting to make allowance for the future.

From point B of the diagram, that is from the goal of the flight there are drawn lines every ten degrees on which the flight time is noted according to the length of the cloud street used. The point E on the cloud street is the point from which the goal must be approached in order to achieve the shortest possible flight time. In our example 6% of the flight time can be saved under good conditions. If, however, the cloud street is followed further to point D then there is in comparison with the direct flight from A to B, nothing to be gained. A 6% saving in flight time may be very little, the effort of the calculation and the risk in moving far from the course is hardly worth while. We should not however forget that a deviation from the course of 40% at a speed ratio of 1 to 2 is indeed considerable.

The diagram 16b starting at point A shows seven possible cloud streets with deviations from the course of 10 to 70 degrees. The ratio of the average cruising speed on course to the speed under the cloud street is accepted at 1:2.5 and can be 50 kph (31 mph) to 125 kph (78 mph) or 60 kph (37.5 mph) to 150 kph (93.5 mph). For every cloud street point E, the best point for leaving the cloud street is worked out and marked. All of these points joined together produce the bow-shaped dotted line e. This gives us for all speed ratios from 1 to 2.5 the point at which we must leave the various cloud streets while flying straight ahead in rising air, in order to make the greatest time saving. It does not pay to follow a cloud street which deviates from the course by 70 degrees. With a deviation of 60 degrees the flight time can only be shortened by 2%. A 5% time saving is possible when the street lies 40 degrees from the direct course. In this case we must set course for the goal when, measured from point B, we are 15 degrees from the direct course. If however the cloud street deviates from the course by 40 degrees then one should continue to fly straight ahead in the lift until the angle between A-B and B- position of the aircraft is 27 degrees in order to save 11%. From there the goal is approached on a course that differs from the direct course by 27 degrees. If we are to the right of the direct course then we must steer a course of 27 degrees less and if we happen to be to the left of the direct course then we must steer a course of 27 degrees more.

If perhaps the cloud street deviates from the course by only 30 degrees then the time saving becomes very interesting in that we can by means of the route via the cloud street reach the goal some 19% or approximately 1/5 sooner than by flying on course.

43 degrees is in this case the angle by which we may, seen from the goal, deviate from the course. With a deviation of the cloud street from the course by 20 degrees we can save 30% of the flight time when we approach the goal from an angle of 55 degrees, but should there only be 10 degrees between the course and the cloud street then the time can be shortened by 45%. From 65 degrees the goal flight must be started. The other diagrams show actual cases for flights where the average cruising speed on direct course compared with the average cruising under a cloud street for 1:2 and 1:1.5. With the ratio of 1 to 2 the cloud street may lie up to 35 degrees from the course and at 1:1.5 only 20 degrees from the course in order to be of use. The curved arrow drawn above the dotted line e shows the points D for the different cloud streets. If the cloud streets are followed to the arrow then no further shortening of the flight time is made. The diagrams are read so that moving from the course line to the line e, the time saving becomes greater ever greater. Past the line e to the arrow d it diminishes and past the arrow d the flight takes longer than on the direct course. Helmut Kiffmeyer has used different colours for the lines e and d for the speed ratios 1 to 1.5, 1 to 2 and 1 to 2.5 on the same diagram which is quite legible and a great help. It can be used not only for cloud street conditions but also whenever thermals occur in rows, in ridge lift, wave lift, cold fronts and sea breeze. Such a diagram can easily be made by every glider pilot. It may be an advantage to add the percentage of time saved at the intersection of the line e with the cloud street.

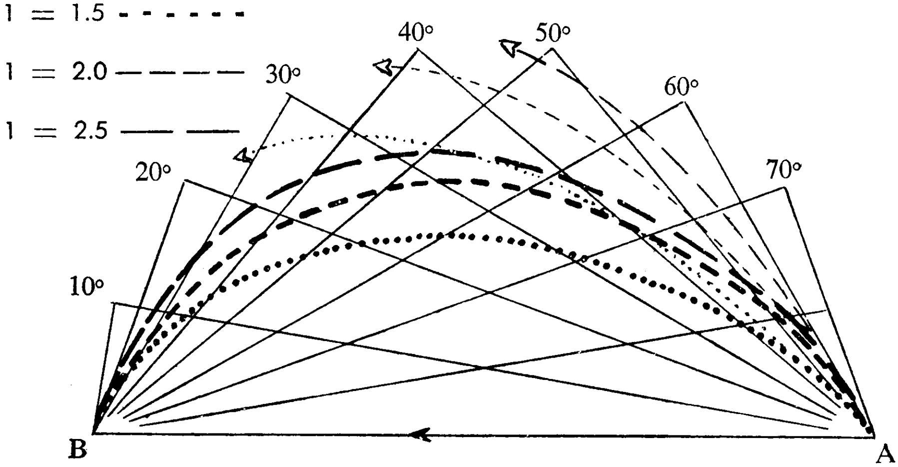


Diagram 17

In practice it often happens that the glider pilot is unwilling to fly so far from the course as may be prescribed by the diagram. Especially on competition flights this is not to be advised when an out landing off-course may result in a penalty. Best of all the course line is best of all reached by flying to it the angle given by the point E on the diagram, should the rows of lift lie parallel to each other as is often the case with

cloud streets, then the glider pilot should approach the goal in a zig-zag fashion according to the diagram. In order to achieve the shortest possible flight time. If the goal is also the landing point then the straight and level flight must cease when the goal flight altitude is available before reaching the point E.
The values on the table cannot be flown with extreme accuracy although variations of about 5 degrees make little difference in time and even cruising speeds are calculated approximately. However if a noticeable reduction in the lift occurs then the cloud street should be left before the point E is reached, and if the lift increases in strength then one may fly a little beyond this point.
Finally, it should be said in this chapter that the correct evaluation and the best use of the weather conditions is just as important to success, as accurate flying, correct gliding speed and correct navigation.

5. THE GOAL FLIGHT

5.1 THE MEANING OF GOAL FLYING

It is not intended that the term goal flight should be taken to mean the approach from 100m height (300ft) to touch down, but rather every glide from the last thermal on the quickest route to the goal.
The opinion is often voiced that the calculation of this final glide may be of some use for competition purposes, but that for normal cross country purposes it is sufficient to arrive at the goal with adequate height. However I must point out that such opinion ignores the meaning of optimum performance, and that is the fastest and most sure way of getting there.

5.11 WAYS AND MEANS

Next of all, we must understand that the calculation of a final glide under no circumstances is limited to the final glide before landing. The following examples prove this:
Perhaps we find a control zone in front of us, which must be flown over at a safe height, because we have been unable to obtain a clearance to pass through it, or
There may be an area devoid of thermals ahead of us.
Perhaps there may be a row of hills between us and the goal that we are flying towards.
A solid bank of cloud lies on our path but we know from information received by radio that thermal conditions are usable 30-40 km (18-25 miles) ahead.
A change in weather conditions forces us to terminate the cross country flight prematurely, but we still wish to reach an airfield.
Such situations show the value of the possibility of being able to calculate a goal flight exactly. In all of these cases, everything depends on

the attainable height, the rate of climb, the distance lying ahead and the available time being weighed up correctly so that we get the best solution.

5.12 TIME SAVING DURING GOAL FLYING

Let us consider the all embracing problem of the goal flight to the landing field. In this exercise, all the appropriate factors must be combined with each other. The answers to other types of goal flight can all be derived quite simply from the last example. If a cross country pilot exploits the conditions from minute to minute then he will have the chance during the final glide to shorten his flying time. Let us work out the following example: (Diagram 14).

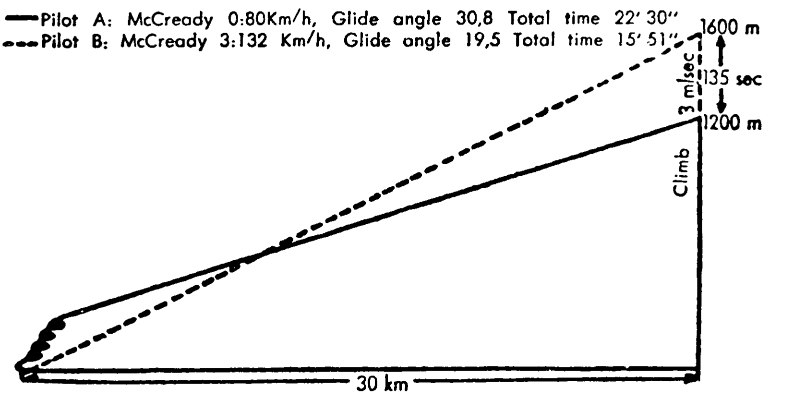


Diagram 18

Goal flight according to the best gliding angle (A) and after a rate of climb of 3 m/second. (B) Two pilots, each with a Ka 6, find themselves after a flight together in calm conditions, 30 km (18.5 miles) from their goal, at 1000m (3280ft) altitude. The rate of climb has been improving and at 1200m (3950ft) it is 3 m/second (9.8 f/sec.). Pilot A says "I have 200m (60ft) safety height, what am I doing playing around when I will reach the field safely?" He then flies at his best gliding speed 80 kph (50 mph) and 22m. 30s. later is on the ground. PilotB toys with his glide calculator, and then climbs to the calculated height of 1600m (5250ft). The extra time taken for the 400m (1300ft) in the three metre thermal is 135 seconds. Finally he sets off and flies according to the McCready ring setting of 3 at an airspeed of 132 kph (82 mph) dashing to the airfield in just 13 minutes and 36 seconds. Climbing and gliding time have cost him together 15 minutes 51 seconds or roughly 16 minutes. He arrives at the field 6.5 minutes ahead of pilot A.

The time difference can be even greater when a glider pilot, as so often happens, out of ignorance climbs far above his necessary goal height and then arrives at the field with excessive height in hand.

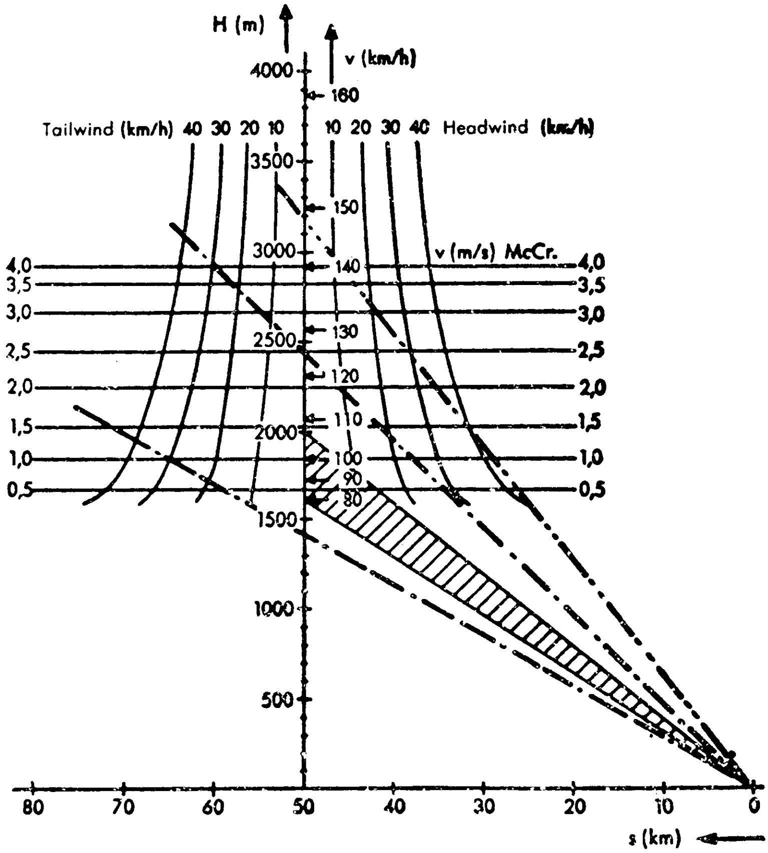
Take this example. The attainable height in a thermal is 1800m (5900 ft) and the rate of climb 1 metre per second. From 1100m (3600ft) pilot A flies with a McCready ring setting of 1 averaging 100 kph (62 mph) to the field. In 18 minutes he has covered the 30 km (18.8 miles) distance. Pilot B, over cautious, climbs to 1800 metres (6100 ft) and needs for this 700 seconds longer. Flying at 80 kph (50 mph) he suddenly notices this, and pushes the speed up to 140 kph (87 mph). The average speed is then 120 kph (74 mph) with which he reaches the field in 15 minutes. There he arrives with around 400m (1300ft) under his wings, which he does away in the most radical manner by pulling out the dive brakes. That costs him a further two minutes. Pilot B needed 12 minutes more than pilot A, whose aircraft is probably in the hangar when Pilot B first arrives. Unfortunately, I have seen such cases occur frequently. Especially bad is the case where the pilot with adequate height, e.g. 600m (1950ft) and 15 km (9.3 miles) from the field is overcome with confusion and anxiety because he is unsure as to whether he can reach the field or not. Then it happens very easily that he is tempted from the course in order to gain a couple of feet in height, even though he could have reached his goal, is however unsuccessful, and miserably lands out. Such things happen frequently to inexperienced pilots when the field is covered by a ridge or, because of poor visibility, cannot be recognised. In such cases, only a goal flight table, or goal flight calculator, can provide the necessary safety and help.

5.2 THE GLIDE CALCULATOR

Once again Heinz Huth has shown the way with his goal flight table and I think that I can safely say that all devices known today for goal flying are based on the Huth system, be it the disc calculator from Stocker or the slide rule from the (Bolkow) Sport und Segelflug development group. Because the Huth table is basic, and therefore the system can be easily understood, it shall be explained at length. (Diagram 15).

5.21 THE CONSTRUCTION OF THE GOAL FLIGHT TABLE

As a starting point for the table the polar curve is used again, from which we take gliding angles for all McCready speed values of 0 to 4 from 0.5 to 0.5. For example, with a McCready value of "O" the speed to fly is 80 kph (50 mph). At this speed the Ka 6 sinks at 0.76 m/second. (2.5 f/sec) 80 kph represents 22.2 m/sec. (73 f/sec) the ratio of forward to sinking speed is 22.2:0.72/30.8:1. The glide angle of the Ka 6 at 80 kph is therefore 30.8. When we have all the glide values together then we must take a sheet of graph paper 22 x 22 cm (9 x 9 inches), draw a horizontal line at the base which is divided from right to left, and which covers a distance of 80km. (50 miles). Each 2.5 cm equals one kilometre (0.6215 miles). At the 50km point (31 mile point) we then draw a vertical line which is divided up every 5 millimetres for 100m (328ft) height up to 4000m (13,100ft). From the previously determined glide angles,



Goal flight calculator with 3 imaginary settings

—•—	No wind McCready 2,5;	Glide Angle 20,5;	for 30km = 1450m Height
—••—	30Km/h Headwind McCready 2,5;	Glide Angle 16;	for 30km = 1900m Height
—•——	30km/h Tailwind McCready 1;	Glide Angle 35,5;	for 30km = 850m Height

Diagram 19

The goal flight calculator from Huth for the Ka 6

it is now necessary to calculate for all McCready speed values 0.0, 0.5, 1.0 etc. up to 4.0, the starting height which we will need for a flight in calm air over a distance of 50km (31 miles).

An example for the Ka 6: McCready "O" (80 kph) gives the glide angle 30.8

For a distance of 30.8 km (19 miles) =

For a distance of 1 km (0.6 miles) = $\frac{1000\text{m height} \times 50}{30.8}$

For a distance of 50 km (31 miles) =

= 1623m (5330ft)

That is, at a McCready value of "O" we must have a height of 1623m (5330ft) in order to cover 50km. The height so calculated is then marked on the height line. Then we draw a horizontal line from each such marking, 80 mm left and right of the height line, and label it with the appropriate McCready number.

On both sides of the height line several curved lines are drawn mirror fashion, the wind strength curves for every 10 kph (6.2 mph). To work these out should not present any hardship. We must determine the time which will be necessary to cover 50 km at different McCready speed values. Here is an example for 80kph:

for 80 km (50 miles) =
50 km (40 miles) = $\frac{60 \text{ min.} \times 50}{80}$ = 37.5 min.
1 km (0.6 miles) =

So for 37.5 minutes the wind affected our flight. A head wind of 10 kph during this time held us back over 50 km by 6.25 km and tailwinds of similar strength push us 6.25 km further. On the McCready line "O" we must mark 6.25 km left and right of the height line 10 kph head and tailwind. After the wind effect for the different McCready values, up to a value of 4, has been calculated and marked in, we join the dots together from top to bottom and get the curved wind-effect line. The higher the McCready value, the nearer the wind curves will lie to the height curve, the sooner we will reach our goal and the less chance the wind will have of affecting the flight. From the curve for 10 kph head and tailwind we can now double, triple and quadruple the values and then draw the curves for 20, 30 and 40 kph (for 12.4, 18.5, and 25 mph). It is of course only human to expect a little safety margin in any undertaking. This safety margin can be built into the goal flight table. During a long gliding flight unexpected occurrences can arise and take away precious height. About 20% should be sufficient to cope with any eventualities. So we add to the starting height of the best glide angle, 20%, and draw from the intersection of this height with the height line a straight line to the "O" of the distance line.

The second straight line is drawn from the starting height McCready "O" and to the "O" on the distance line. The result is a wedge which must be shaded in or can be marked in red. Within this so called safety zone, no flying should be done. As can be seen very easily, the safety is reduced as we near our goal, and the excess height can be used up appropriately by carefully flying faster.

How wide the individual pilot draws this safety zone and how much use he makes of it during the flight depends on his experience and not least of all on the state of his nerves.

The drawing is now finished. For use it should be mounted on a card, or best of all on the reverse side of the course calculator and protected with clear foil. Exactly on the "O" of the distance scale, a 20mm x 28 cm guide is now mounted, which has been made from perspex or Astrolon in such a way that it can rotate. This guide must have a line engraved along its length which later during use will show the course. Finally we can start to use the calculator.

5.22 THE USE OF THE CALCULATOR

It was unavoidable that in the course of explaining the construction of the calculator, I had to deviate a little, mainly because derivation and use are a little difficult to separate from each other. Nevertheless, I would like to explain the use of the calculator a little further. First of all there is one point: The term average rate of climb is, for goal flying, completely unimportant. Only the rate of climb that is being experienced at the moment, according to the Variometer, is to be used for the goal flight. We will not be counting on the expected rate of climb in the next thermal but rather be intent upon using the height just gained in order to reach quickly and surely, a previously determined point on the earth.

5.221 GOAL FLYING IN STILL AIR

Next of all we shall simulate a goal flight in the Ka 6 in still air. A glider pilot finds himself 45 km (28 miles) away from the goal, and in a thermal of 2 m/sec. (6.5 f/sec.) The cloud base restricts his height to 1500m (4900ft). The middle line of the moveable pointer on the calculator is set on the McCready value of 2 on the height line. From the 45km mark on the distance scale we move vertically up to the middle line of the pointer and from there horizontally to the left we read off 2020m (7200ft). The final glide cannot be started yet. So according to the practice of gliding over a distance, we set off in the direction of the goal.

30km (18.6 miles) from the goal the pilot finds another thermal, also with a rate of climb of 2 m/second. From 30km he reads off the height of 1340m (4400ft). When he has reached that height, he sets of with a ring setting of 2 for the goal. A row of cumulus clouds prevents him from losing as much height during the glide as he expected, so that during a check 20km (12.4 miles) out he finds that he still has 1100m (3600ft.) He is therefore about 200m (650ft) above his planned glide path which is shown by the centre line of the pointer. The pointer is now reset at the intersection of the 20km distance and the 1100m height lines and then the McCready value of 3.5 is read off. This value is then set on the ring and dictates the new increased speed. It is very important to check that the correct height is being maintained during the glide, preferably every 5km, so that every variation can be immediately corrected. For this reason, it is recommended that a very accurate map be used for the final glide, say to a scale of 1:200,000 or 1:300,000 on which, prior to the flight, the distances of 5km to 5km from the goal have been marked off with a compass and which permit a fine degree of orientation.

Should the pilot find that he is losing more height than he allowed for in the setting of the calculator, then he must determine immediately the reasons for the loss. An increase in the head wind or large areas of sink could be the cause.

First of all the ring setting must be reduced so that a better glide angle is obtained. Then through a change in course and a new setting on the goal flight calculator the error is corrected and the flight continued.

5.222 GOAL FLYING IN WINDY CONDITIONS

The system when flying under windy conditions is basically the same. The first condition is naturally that we know the direction and strength of the wind. Calculated guesses from cloud shadows are of course possible, but much more certain is information obtained by radio from the weather service.

Unfortunately the wind seldom does us the favour of being exactly a head or tail wind. Therefore our first job is to determine the tail or head wind component in the prevailing conditions. That can be done on the course calculator, as described in the chapter on navigation. We must not, however, set the average ruising speed, but rather the McCready speed which was determined by the rate of climb in the last thermal. We then set on the course calculator the difference between the ground speed and the airspeed, and have then the effect of the head or tailwind. As an illustration: The airspeed of the Ka 6 with a McCready value of 2 is 116.5 kph (72 mph). The wind is blowing from an angle of 50° on our right, at a strength of 30kph (18.6 mph). The drift is then +12° and the ground speed that we read off is 93 kph (57.5 mph). The difference between the airspeed and the wind component, is therefore 23 kph (14.3 mph). With all wind directions less than 30° to our course a calculation is unnecessary because the wind component is approximately equal to the wind strength and it is sufficient to determine the drift only.

For reasons of safety, it is advisable to round off head winds to the next highest 5 kph and tailwinds to the next lowest 5 kph. The resulting excess of height is insignificant and can be easily cancelled out during the final glide.

Should we, when considering the wind, set the pointer on the rate of climb McCready value, then the intersection of the McCready line with the wind curve is to be taken as the guide. The stronger the head wind blows, the greater must be our departure height for our final glide and with an increase in the tailwind the less it will be.
With the Ka 6 it looks like this: McCready value 2 and still air demand for a 50 km (31 miles) glide, a starting height of 2240m (7300ft). At the setting for 20 kph (12.4 mp.h) head wind we read from the height line for the same glide, 2700m (8800ft), and with a tailwind of 20 kph, 1900m (6200ft).

When the values for the final glide have been determined then the pointer remains unchanged other than for excessive gains or losses which make corrections necessary. The execution of the final glide is, after the setting has been made, the same as for still air. After a little and simple. Every pilot will be amazed at the precision with which a final glide can be calculated.

5.223 INFLUENCE OF THE WIND ON THE FINAL GLIDE

One problem seems to trouble all pilots particularly and that is gliding speed in windy conditions. With a head wind it is argued, a goal can be reached more quickly when one climbs above the McCready starting height of our calculator in order to fly more quickly, and with a tail wind starting lower and flying at a slower speed.

To illustrate, the following example will be discussed. We fly with a Ka 6 at 80 kph (the best glide angle) — against a wind of 80 kph. Compared with the ground we make no progress. If we increase the speed, then the glide angle will suffer but we will move forward. In the following lines I will attempt to refute this argument, at least for a cross country flight under thermal conditions.

Because the final glide to a goal on the ground must not be regarded as gliding through the air but rather as gliding over the ground, then the speed over the ground must be the starting point. The values will be taken once again from the Ka 6 polar curve. When determining the speeds for the McCready ring, we laid a ruler on the rate of climb on the vertical axis to the polar curve, in order to read off above the point of contact of this tangent, the appropriate speed. However, we want to start with the ground speed and we must therefore consider the head and tail winds.

A head wind of 40 kph (25 mph) reduces, for example, our gliding speed about 40 kph over the ground. We must then consider the polar curve to be placed 40 kph further to the left. We achieve the same affect when we go from the point of 40 kph on the speed axis vertically upwards to the appropriate rate of climb. We will assume here a rate of climb of 2 m/second (6.5 f/sec.)

From the point of intersection the ruler is laid as a tangent to the curve. Above the point of contact we then read off the best speed for this glide of 143 kph (88.5 mph). On the goal flight calculator however there stands, just as on the ring, opposite a McCready value of 2, the best speed to fly of 116.5 kph (72 mph), because the wind is used here for the determination of the starting height and not for the determination of the speed. Theoretically, therefore, the glider pilot who flys faster arrives sooner even though he needs a greater starting height. That would be the case when only the glide and not the climb was influenced by the wind. In the time in which the pilot remains longer in a thermal in order to reach his departing height, he will be blown further from his course. At 40 kph (25 mph) that will be 11 metres per second (35 f/sec.) — in a circle lasting 15 seconds it will be 160 metres lost from the previously flown distance.

As a contrast on the goal flight I deliberately took a distance of 50 km in order to make the time difference more obvious. In practice, such a final glide would hardly be carried out, because it would be impossible to reach the necessary starting height.

In column 1, the values have been read off from the Huth table. In column 2, the values have been calculated according to Heinz Huth's system. The column No. 3 shows the values which have been worked out according to the theory discussed here.

The problem: 50km flight with a Ka 6, rate of clim 2 m/second (6.5 f/sec.), head wind 40 kph (25 mph).

Airspeed (Ve)	116.5 kph (72 mph)	116.5 kph	143 kph (91 mph)
Headwind	40 kph (25 mph)	40 kph	40 kph
Groundspeed (Vg)	76.5 kph (47 mph)	76.5 kph	103 kph (64 mph)
in m/sec.	21.2	21.2	28.6
Sink in m/sec.	1.45	1.45	2.37
Glide angle	15	14.7	12.2
Required height	3400m (11,100ft)	3400m (11,100ft)	4150m (13,600ft)
Climb time from 1000m (3280ft)	20 min.	20 min.	26 min. 15 sec.
Gliding time	39m 10s	39m 10s	29m 10s
Total time	59m 10s	59m 10s	55m 25s

After this demonstration it looks as if the pilot who flew faster was some 3 minutes 45 seconds quicker.

In the flight in column 3, the pilot had to climb 750m (2450ft) higher than those in columns 1 and 2, and at a rate of climb of 2 m/sec. (6.5 f/sec.) that will take 375 secs. A head wind of 40 kph (25 mph) which is 11 metres per sec. (6.55 f/sec.) pushes the aircraft 4.125km (2.55 miles) back along its course. In order to bridge this gap another 340 metres (1100ft) is necessary, which costs 170 seconds. This calculation must be continued until finally the starting height of the distance to be covered has been reached. But already sufficient time has been lost to make this system of little value.

Gliding time over 4.125 km at 103 kph (64 mph)	= 2 min. 25 sec.
340m extra height at 2 m/second (6.5 f/sec.)	= 2 min. 25 sec.
Total extra time	= 5 min. 15 sec.

We already need, without having reached the necessary starting height, a total flight time of 60 minutes 40 seconds compared with the goal flight time according to the Huth table of 59 minutes 40 seconds. Similarly with other wind strengths and climb rates, and of course with a tail wind, the time gain is an illusion. The theory that higher speeds against head winds and slower speeds with tail winds help one to make the flight shorter, does not hold true on flights carried out under thermal conditions.

5.23 FURTHER USES FOR THE GLIDE CALCULATOR

Right at the beginning of this chapter I showed how circumstances can arise which require the use of the calculator.

Let us assume that our course takes us over a control zone which has an upper limit of 1000m (3280ft). Its width is 10km (6.2 miles). For some reason or another it is not possible to get a clearance to cross the zone. We now proceed just as we did with the last final glide. The far side of the control zone can be regarded as the goal. 1000m (3280ft) is regarded as 0. With a greatest attainable height of 1400 metres (4600ft) under calm conditions we must set the pointer to 400m (1300ft) over 10 km. It is then possible to determine that with a ring setting of 1.5, we can cross the zone quite safely without having to use thermals. A higher ring setting, even when the average rate of climb gives a better value, should not be used.

During flights over extended areas without lift, due perhaps to local cloud or to a mountain range, we simply add the height required at the point that we wish to reach, to the starting height. In such a way, we can determine whether or not the distance can be covered, or whether a deviation will be necessary. In a similar manner we can determine whether the flight should be terminated because of deteriorating weather, and whether a nearby airfield can be reached. If after setting the calculator, having safely allowed for the wind and the best gliding angle, the intersection of the distance to the goal and available height lies below the pointer, then the field cannot be reached but if it lies above the glide path, then we can confidently begin the final glide according to the process described.

A fact worth mentioning is that with any setting of the calculator, the glide angle over the ground can be read off by following the height line of 1000 metres (3280ft) horizontally to the right and from the centre line of the pointer vertically downwards to the distance line, to determine the kilometre distance which can be reached from 1 km (0.62 mile) height.

5.24 OTHER SYSTEMS OF GOAL FLYING

As already suggested all other systems of goal flying are based on this calculator. Heinz Huth himself some years ago applied certain values to the "Aristo-Rechner" disc which had the advantage of being smaller and handier.

Captain Stocker took over the circular form and mounted a perspex disc with engraved values on top of the card, with the centre of the disc over the goal, so that his position on the map is combined with the appropriate values on the disc. The slide rule from the Sport and Soaring (Bolkow) development group combines the system in a slide rule calculator. (Diagram 20).

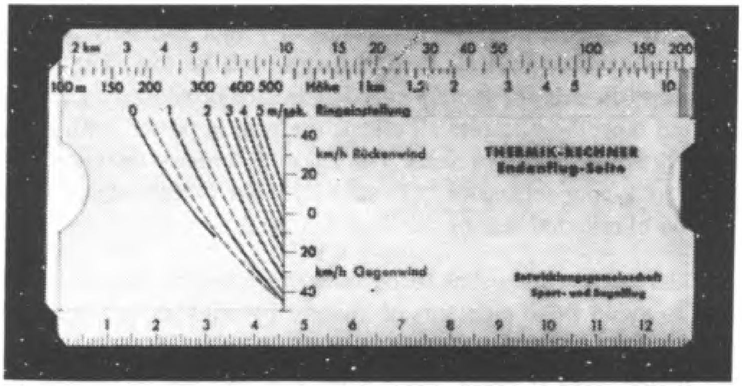


Diagram 20

TRANSLATIONS:

Ringeinstellung — Ring setting. km/h Ruckenwind — km/h Tailwind.
km/h Gegenwind — km/h Headwind

Goal flight calculator from the development group "Sport and Soaring" for the "Phoebus". Setting: Almost McCready value 3 with a 20kph (12.4 mph) head wind.

The great advantage that I see in the calculator from Huth, described here, lies in its ease of use. Height and distance are arranged as they are in reality. Head and tail winds either shorten or lengthen the gliding distance, and the glide is shown by the moveable pointer in its correct relationship. Too much, or too little height, show the position of the aircraft to be either above or below the line of the pointer. For the first few thousand kilometres and the the purpose of gathering experience I would recommend this calculator.

5.25 ADVICE FOR PRACTISING GOAL FLYING

For the glider pilot who makes his first final glide according to the values on the calculator there will probably be moments of anxiety. To fly from a height of 1200m (3950ft) with a ring setting of 1.5 is not difficult. Only when the aircraft is 20 km (12.4 miles) from the field and the height has sunk to 800m (2625ft) does the matter become serious. Then, even after a short check which probably shows everything to be in order, do the first real anxieties appear.

With a perfectly normal variometer reading, the rate of sink seems to grow to enormous proportions, the horizon climbs higher and higher, the aircraft apparently creeping along. Should the loss of height continue then the newcomer will be absolutely convinced that a landing 5 or 10 kilometres short of the airfield will be necessary. Here occurs the same optical illusion as that which occurs in mountainous country, namely the feeling of being below the mountain ahead, although the altimeter shows different values. It is certain that the pilot has long since set the ring back to an "O" value without being convinced of the effectiveness of this measure. Then having flown almost 20km (12.5 miles) towards the goal and now 350m (1800ft) high and only 5km (3.1 miles) away is appears that no further height will be lost. The airfield comes rushing towards us, the air speed indicator winds up to 130 kph (82 mph) and more, but despite all efforts the goal is passed with a good 100m (328 ft) excess height in hand. The 15km (9.3 miles) distance which were flown at a ring setting of "O" saved 1550m (490ft) which simply could not be eliminated during the last 3-5 kms.

For the glider pilot who wishes to become proficient in the art of goal flying and to avoid these moments of anxiety I would suggest beginning with 300m (980ft) safety height. One simply imagines that the airfield lies 980ft higher than it really does. That also has the advantage that one can simply zoom back up high again in order to practise more goal flights.

If after sufficient training the necessary safety margin remains, then it will be found that not only does goal flying save a great deal of time, but it also gives one confidence in the aircraft and is a great deal of fun in itself.

6. GENERAL ADVICE

A cross country flight does not consist of just a take-off, flight and landing, but begins rather with the theoretical preparation in winter and with the choice of equipment, and is finished only when the hangar doors have closed behind the aircraft.

Many factors, some of which lie beyond the art of flying, help determine the result. The advice gathered together in this chapter is intended primarily to help the newcomer avoid the mistakes already made by others before him. I hope, also, that from time to time it will be possible to give even the experienced pilots a few tips.

6.1 THE AIRCRAFT

For the execution of a cross country flight we naturally will want to have as good an aircraft as possible. What do we mean by good? With that question we are already confronted with the problem on which glider constructors have spent a great deal of effort over a considerable period of time. Every product is a compromise between performance and handling qualities. Years ago I heard a well known aircraft constructor say despairingly "Of course I can build an aircraft with a glide angle of 50 but who will be able to fly it?" Now, today, thanks to further research and constructional methods, this dream has almost been realised, but nevertheless, performance and handling qualities stand opposed like two deadly enemies.

6.11 PERFORMANCE AND FLYING CHARACTERISTICS

It is basically wrong to judge the performance of an aircraft by its glide angle alone. In order to achieve this angle, the pilot must first of all gain the necessary height. In thermal flying, the glide angle itself is of little use. Other qualities are the deciding factors — the handling properties

At the top of the list is manoeuvrability. When one flies into a thermal at 25 metres per second (82 f/sec.), then one second's delay before the full circling position is reached means a distance of 25 metres (82ft.). If in this thermal, the best rate of climb is to be achieved with a 15 second circling pattern, which is equal to a radius of approximately 60 metres (197ft), then 25 metres (82ft.) too far can make quite a difference. In the end, the more manoeuvrable aircraft will already be circling in the best rate of climb while the other less manoeuvrable machine has still to centre properly. The smoother the thermal the greater will be the difference.

Of great importance for thermal flying are the slow flying qualities of an aircraft. The higher the stalling speed, the faster one must fly, the greater will be the diameter of the circle and the greater the distance from the best lift. If the pilot of such a glider wants to fly in even smaller circles, then he must increase bank and airspeed with the result that the rate of sink increases greatly. Faster aircraft are, in a thermal, at a distinct disadvantage.

The question as to how an aircraft behaves at a slow speed should never be under valued. Certainly a good pilot with his knowledge and experience can make up for a great deal, but an aircraft which slides all over the sky when flown near its stalling speed and which cannot be controlled with the rudder is, even for the best pilot, a considerable handicap. His nerves slowly give, his concentration gradually fails and the flight is forced to an early end because it is not possible to hold the thermals.

Suppose that we have an aircraft with a very good glide angle, around the 32 mark, but the qualities of the machine permit only a rate of climb of 1m/sec. (3.3 f/sec.), while a second machine with a glide angle of 27 achieves a rate of climb of 1.5 m/sec. (4.9 f/sec.). Both gliders cover the same course together.

Aircraft A according to the polar curve at McCready 1.0
= 100 kph (62 mph) at a glide angle of 29
Aircraft B according to the polar curve at McCready 1.5
= 90 kph (56 mph) at a glide angle of 25

	A	B
Gliding time to the next thermal in 10 kms	6' 0"	6' 40"
Height loss recovered A= 345m (1100ft)	5' 45"	
B = 400m (1310ft)		4' 27"
Time over 10km	11' 45"	11' 07"
Over 300km (30 x 10) A =	5hrs 52' 30"	
B =	5hrs 33' 30"	
Plus 1000m climb to starting height	16' 40"	11' 10"
Total Time		
A =	6hrs 9' 10"	
B =	5hrs 44' 40"	

So according to popular theory the poorer glider is faster than the better glider. The values shown are not, by the way, theoretical, but taken from the polar curves of available aircraft types.

Naturally the good glide angle of A with better rates of climb will be worth more but we have to fly in weak conditions, too.

The difference does however become more noticeable when on the route there is an area without lift and when aircraft B with a ring setting of "O" can hold out until lift is finally reached, whereas A, despite the skill of its pilot sinks to the ground. How good the so called "poorer" aircraft with their glide angles of around 27 are, is made all the more difficult to determine because in the "racehorses" there are usually more experienced pilots. If skill and experience were a little more evenly distributed, then the pilots with the machines with glide angles less than 30 would be able to cause anxiety amongst the "Pundits" especially in weaker conditions. These explanations are intended to show clubs and their pilots just how good their machines really are for cross country flying, so that they can free themselves from their wrong impressions and the desire to own a "supership."

6.12 THE SURFACE OF THE AIRCRAFT

After pondering all the points, and having come to the conclusion that a cross country flight is possible with our machine, then the first and most important job is to obtain the best possible performance from the aircraft. Of no small importance is the surface of the aircraft. Runs in the paint or dope, tears, scratches, holes or similar flaws must be removed before the hard work of rubbing down begins. Under no circumstances should a coarser paper than 400 be used, and even the finest sandpaper does a good job and is considerably cheaper than wet and dry paper. Whether the near perfect finish should be polished or not must be determined by the pilot. There are points for and against polishing. One thing is certain, water droplets on a polished surface are much larger than otherwise and this cannot help the airflow.

Frequently the airbrakes stand proud of the wing surface by a millimetre or two. If this cannot be altered by adjustment of the pushrods then one must resort to using a wood plane and sandpaper. Also proud ailerons and poorly fitting canopies give rise to drag and turbulence. Turbulence of considerable strength occurs in the airbrake boxes and in the surrounding slits, which leads to considerable amounts of induced drag.

One often sees pilots resort, with very good reason, to applications of grease on the top side of the brakes. The idea is that the airflow from the pressure side of the wing undersurface to the lifting surface of the upper wing will be prevented. Should however our friends be forced to open their airbrakes at any stage in flight then this advantage becomes a disadvantage. Then in the vicinity of the airbrakes there will be millimetre high ridges of grease in the airflow. However there is one thing that can be done.

Because an absolutely airtight fit of the brakes within the wings is not possible it appears to me that the answer may lie in some form of flap that acts like a ventilator. On the brake stop within the wing a plastic or textile band of appropriate length is fixed up to half its width. Then the part that is not cemented is bent in such a way that the resulting angle points towards the middle of the shaft. Finally any remaining cement is removed with acetone or a similar solvent. With closed brakes, the free part of the strip will be pushed against the underside of the brake surface according to the amount of suction on the top surface of the wing. Any airflow and therefore turbulence is therefore simply and effectively prevented.

Fairings should also be made airtight with a good quality sticky tape so that no airflow can set up disturbances in this region. However please do not under any circumstances let anyone go so far as to seal up the canopy in this way as has actually been done. No cross country flight is so imoortant that one should risk one's life. A strip of foam backed tape between fuselage and canopy seals off the opening wonderfully, which can be shown by the reduction of noise and the absence of draught.

In all modern aircraft the induced drag from the edges of the wings due to changes in profile is kept as small as possible.

If the wing has a lifting tip, then that should be altered during the next overhaul, possibly by means of a new tip or even with a tip plate to hinder the airflow from the underside around the tip to the top side of the wing.

6.13 THE PILOT'S SEAT

One should not imagine that the suitability of an aircraft for cross country flying depends only on its performance and handling qualities. How many cross country flights have been suspended because the pilot simply could not remain sitting any longer, because the parachute was causing pain, or a bitterly cold stream of air coming through the nose hook slot was slowly freezing the pilot.

A contoured seat in the aircraft is an important accessory to enable the pilot to last out the flight and finish it in a fresh and alert condition. Unfortunately it appears that this fact does not appear to be recognised throughout the industry. A resourceful club or pilot can however find a remedy. With a little resin and a couple of glass mats it is possible to make a comfortable form in a negative mould of plaster of paris in which even the most sensitive of rear ends will be comfortable for hours. Parachutes with thick and hard straps can result in pains due to pinching.

Before purchasing rescue equipment one should consider such things. Even poorly packed parachutes are capable of giving the pilot the feeling that the small of his back is about to collapse at any second. A short talk with a parachute packer may be of help, and even as a last resort a layer of foam rubber can be a good remedy.

That the nose hook attachment has to be sealed off, is obvious. For a skilled pilot the solution should present no problems so that the entry of air is prevented without affecting the functioning of the release. A piece of rubber the size of the hand cut from an inner tube is especially suited to this purpose. Even a controllable form of ventilation for the cabin can make the flight a great deal more comfortable. An ice cold stream of air in the face which at 2000m (6500ft) can result in considerable agony must be made controllable. If the pilot is however low down and must fly around and around in a very laborious manner in negative sink or 0.1 m/sec (0.3 f/sec.) lift then he will be very grateful for a stream of fresh air to ease his labours.

The pilot, who starts off on a flight in short trousers and a short sleeved shirt and is nearly overcome by cold, deserves little sympathy. He should know that the rising air cools 1° centigrade for every 100m (328ft) gain in height and that under most circumstances a considerable part of the flight will be carried out in the shadow of clouds. The pilot should not only be sufficiently warm but also comfortable. Tight collars, belts, garters and similar items can change from being slightly uncomfortable to being really painful and in this condition are not beneficial to the efficiency of the pilot.

Concerning the interior of the cabin, one must add that the instrument layout is also of importance.

The variometer should be placed in such a position that it can be observed without all view of the world outside the aircraft being lost. An electric variometer with an audio attachment is naturally to be preferred. The variometer with the McCready ring and the airspeed indicator should also be in a position where they can be easily found. A compass that is close to any electrically driven instrument is badly placed because of the effect of its electrical field, which can lead to considerable errors. Operating switches conveniently placed will also save the pilot from having to perform gymnastics. The correct adjustment of the rudder pedals is more easily carried out on the ground than in the air. Even the humble woollen thread correctly mounted above the horizontal axis of the aircraft and free from the influence of turbulence should not be forgotten.

That the pilot should also spend a few hours flying time in the aircraft in order to adjust himself to his surroundings before setting off on a cross country flight, should be obvious.

6.2 THE CROSS COUNTRY PILOT

Just as the aircraft should be maintained at the peak of its performance, so must the pilot take care that he is in top condition.

A cross country flight carried out with the determination to succeed, makes considerable demands on the body and spirit of the glider pilot. We know from well known competition pilots that many of them keep themselves fit by taking part in light athletics, swimming and cycling. In any case such methods are not to be considered wrong. The concentration that the pilot must maintain for hours on end can no longer be available when the body is exhausted and incapable of carrying on. Now because every glider pilot can not be an athlete, then he should at the very least fulfil the condition that he has rested well and had a good night's sleep before the day of the flight.

Even a contented state of mind should not be overlooked. Just as motorists are warned against driving after a disagreement at home, so I would suggest that after a day which has brought nothing but trouble, a planned cross country flight be postponed.

A good night's sleep, a good breakfast, and then either a leisurely walk to the aircraft or up a hill after which the preparations are carried out, is the way to prepare for a flight. The ideal is that one's comrades carry out as much ot the work as possible. On the following day, another will have the chance and today's pilot will have the opportunity to work with enthusiasm, show his gratitude and so prove himself to be a good friend.

Every bit of haste, every drop of sweat, and every angry word endanger the flight and not only that of the gentle natured.

The preflight preparations have already been described under the heading on Navigation. The preparations before the launch are of no less importance. With a check list, it is possible to determine at an early stage whether everything is in order or not. This check list should cover everything from safety clips to adjustment of the altimeter, from switching on the barograph (why should a barograph with a running time of 10 hours not be turned on half an hour early?) to sunglasses for the pilot, that is necessary for the launch and the flight. The check should be carried out by one person alone and each item ticked off in turn. Anyone who has had ratification of a flight withheld because the barograph was not switched on, or because the camera was not to be found at the turning point or who could not use the radio because the antennae had not been fitted will not laugh at the slight inconvenience that a check list involves.

What refreshments should be taken along depends on the pilot alone. I enjoy acid drops, peppermints, or a little chocolate. Drinks in corked bottles are not recommended because there will certainly come the moment, when with the reduced external pressures, the cork leaves the bottle with explosive force to be catapulted around inside the cockpit. It also seems a little unwise to me to take liquid refreshments during the flight, because somehow the fluid will need to be eliminated. Even though there may be quite functional toilet devices, the whole business can be rather difficult. Drink little, is probably the best recommendation in this case. Fruit stored under the seat becomes very cold at height and can easily lead to stomach ache — I would not recommend it.

The attitude of the pilot throughout the flight should be a sporting one, that is, the performance and the end result should be uppermost in his mind. That can only apply of course, so long as safety is not jeopardised. Deliberate lawbreaking, as well as risking the aircraft and pilot is equally objectionable. Should any glider pilot not wish to take so much care, then please have a thought for your comrades and for glider and sports pilots in general who all stand to suffer as a result of undisciplined actions.

As wrong as it is to fly without consideration of the risks and to press on regardless, it is also just as wrong to alter one's decisions continually. Endeavour is to be encouraged, but not at the expense of common sense.

6.3 TURNING POINT PHOTOGRAPHY

Turning point photography is an international and widely accepted means of proving that one has actually been around the turning points of a triangle. It is however, disturbing to see the quality of some of the pictures that are presented. I am myself not a great photographer, but I have never once been troubled by faulty pictures. A supercamera is quite unnecessary, something around the $20 price fulfils the purpose admirably. The normal black and white film with sensitivity of 17 DIN (40ASA) should be kept as short as possible so that material is not wasted unnecessarily. An exposure meter is of little use in the air, because the light in the aircraft is completely different from that on the ground which we will be photographing. The problem of depth of field does not occur here either since the object being recorded is a long distance away. The exposure time should be kept as short as possible, I normally use a 1/250 second, since movement of the aircraft, especially in turbulence, is greater than generally appears. The apperture is opened as far as possible and the range set at infinity.

Because of possible haze an orange filter pays for itself and does no harm under normal conditions. With such a set-up we have all that is needed for photography under all weather conditions. The specialists in photography may be of another opinion when considering the artistic side, but in my case I have not lost one picture after taking several hundred in the air. All turning points were clear and easily recognisable, and that should be the purpose of photographic evidence. One other problem should also be considered. The camera should have a fast wind-on knob, as when one photograph is taken as proof, a second is of course better for reasons of safety, and who wants to stare at a little window in the back of the camera until the next frame number is visible?

The shutter release should also be simple and easy to operate since one handed operation is a necessity. Best of all is a shutter release on top of the camera, so that the camera can be held with one hand and the index finger used to release the shutter.

The viewfinder, with which the turning point must be viewed should operate directly through the camera in the same way as the lens. Reflex cameras in which the image is visible on a ground glass screen on top of the camera can be difficult to use under such circumstances. The direct vision panel in the canopy can of course be used to give better picture quality, but one should not be afraid to photograph through the canopy itself when it is clean and transparent. It is much more important to ensure that the camera is held high enough. It has happened on many occasions that the turning point was visible through the range finder but that the lens was partly covered by the cockpit edge. It also frequently happens that part of the hand or a finger is left in front of the camera lens during first attempts.

One difficulty is always underestimated — flying with the left hand. How many right-handed people have really practised it? The camera is used in the more practised hand and the other remains for the stick. And then the aircraft leaps and bounds all over the sky like a rowing boat on the high seas. I know of cases where pilots have lost more than 200m (650ft) of height in attempting to take their first aerial photographs. The only solution is to practise taking photographs of one's own home airfield.

Some pilots, skilled with their hands, have constructed pistol grips for their cameras, which are steady when held in the hand, and on which the shutter release is coupled to a trigger mechanism. I am not however, greatly impressed with the idea of building the camera into the aircraft and then pointing the wings in the direction of the turning point. When the camera is mounted under the canopy near the pilot freedom of movement and vision are reduced. When mounted remote from the pilot, trouble with the film transport can easily arise. And what is meant to be done when the camera is mounted on the left and the turning point is on the right of your aircraft? We lose both time and height doing one full circle for the sake of a photograph.

The approach towards the point to be photographed should not be made too far to one side. If after a steep bank, it is found that the goal is under the aircraft then the camera is prepared for shooting, the aircraft turned on its side and the photograph taken in the same movement.

After winding the camera on to the next frame a steep bank onto the new course is made and at the same time the second picture is taken as a safety measure. Excessive height and time losses need not be expected with this method. As to the choice of turning point, it should be remembered that not everything is as clear and obvious as it is on ground level. Hills and mountains for example when photographed from the air, do not often appear as such. Rural localities can look very similar. Large differences between light and dark, canal intersections, river-mouths, bridges, highway and railway intersections, turn off fork in the roads and—not to be forgotten—airfields with take off and landing areas and typical buildings are suitable objects to be photographed.

6.4 RADIO

A great deal has already been written about servicing and using radios. For that reason only a few tips that are normally overlooked will be discussed here.

Before starting, every pilot should check on the frequencies available to him, and where they can be found. If he intends to contact other airfields during the flight, he must know how these places are to be contacted. When arrangements are made to contact other pilots during flight prior agreement must be reached concerning the frequency to be used.

If a radio operator's certificate is not available, then it is advisable that a little practice is carried out on the ground beforehand, so that the pilot will be familiar with the equipment. One basic rule that all pilots should learn by heart: All messages in the air must be kept as short and clear as possible. No one should forget that many others, perhaps with weaker equipment, also using the air, are forced to listen to nonstop mono- or dialogues. Their important messages, perhaps to notify an out landing, cannot get through as a result.

It happens very easily that one's radio is left turned on to "transmit." That takes a lot of power and then perhaps towards the end of the flight when an important message is to be sent, the accumulator will be exhausted. One should fly with the radio tuned to "receive", and then when after receiving a message, only seconds need pass before the apparatus is ready to transmit and the short delay will be of no consequence. The most important knob on the radio is the "on/off" switch. When conditions are difficult and the ground is drawing nearer with every second, and then a light bumpiness shows the presence of lift which has to be accepted initially as negative sink, then the radio can become trying on the nerves and upset one's concentration.

If the situation becomes desperate, then only position and possible landing place are transmitted before the radio is turned off. Alone and quiet within the aircraft are the conditions which will best enable a pilot to "scratch" away with any hope of success.

The most simple form of transmitting appears to be with a throat microphone and with the transmitting switch mounted on the control stick because this arrangement is the least distracting.

Where a hand microphone is used it should not be simply packed into the cockpit pouch. How easy it is for the transmit button to be pressed as a result and then the whole frequency is blocked for miles around. Many tests have been carried out to determine the best place for the antennae, which is preferably kept out of the airstream. The best position appears to be in the fin. Placing the anntenae in the fuselage when it is constructed of steel tubing is completely senseless and even in wooden fuselages the aileron and airbrake pushrods absorb a great deal of energy. In such cases it is better to mount the thin steel rod on top of the wing fairing.

6.5 OBSERVING THE LAW

On every cross country flight we come into contact with the law. We must make sure that we know precisely what is expected of us and behave accordingly. Never forget that the case of a seventeen year old aircraft pilot before the courts will be treated in the same way as an airline captain who flies through the air in an airliner with one hundred passengers on board. That alone should be obligation enough to know all the rules precisely and to stick to them at all times. Imagine just how great the consequences for us could be if a collision or similar accident occurred in which military or commercial traffic was involved because a glider pilot was pronounced guilty for having failed to keep to the law.

Only through painstaking adherence to all of the rules, can the law makers and other users of the air, be convinced that we are to be taken seriously. Every offence and oversight of the law can only weaken our position.

6.6 HIGH SPEEDS

To the beginner the speed of 120 kph (75 mph) may seem very high and yet to the experienced cross country pilot it is quite natural to fly according to the McCready ring, at 150 kph (93 mph) and even more. It happens very easily then, that the feeling for height and dangerous speeds is lost. The pilot must make a conscious effort to remember the flight limitations of his aircraft and appreciate the considerable forces at work on the airframe and wings when a 4 m/sec. (13 f/sec.) thermal is entered at 150 kph and more.
The glider pilot should take care to set himself a safe limit at an early stage. It may be that avoiding high speeds costs a little time but bailing out of a wrecked aircraft costs a great deal more.

6.7 THE OUTLANDING

Every experienced glider pilot fears the moment in which, before reaching his goal, he is forced to make the decision to land. Whether it was due to the weather failing to keep its promises or due to tactical errors or a silly decision on the part of the pilot or whether the pilot was simply exhausted, the feeling of failure is just as painful.

6.71 THE CHOICE OF FIELD

The choice of field is one that must be approached with care. Even at 700m (2300ft) and at the very latest 500m (1600ft) the pilot should know in which field he can land his glider in safety. But not only the choice of field allowing for vegetation, furrows, gradients and wind direction are of importance. These problems should have been discussed during training. Just as important are the problems of access to a telephone, road access and possibly even storage for the glider. On airfields everything is of course arranged, they are the ideal landing places for out-landings but in the open countryside all sorts of problems can arise. In my experience, one is best cared for in small farming villages. For the people there, the newly arrived glider pilot makes a welcome change. The telephone is available, free labour to help with derigging and storage in a barn and good food can all be found, and when circumstances so demand a free bed is ensured.

In any case the time spent waiting for the retrieve crew will be spent enjoyably.

How different that is from the pilot who lands a long way from the nearest village perhaps in a hollow, is forced to run for about one hour to the next telephone and then perhaps soaking wet as a result of a cloud burst is forced to spend the rest of the night lying on the wing of the aircraft shivering with cold because the retrieve crew are unable to get through muddy roads. Any further comment should be un necessary.

Even a landing on the outskirts of a large city is not to be recommended because, amongst other things, there will be little interest and even less enthusiasm to help. Added to this is the danger caused by groups of children, who quite naturally want to examine everything. However more on children later.

And when it is intended that neither farmer nor insurance company is to be upset, then cultivated and farmed fields are best for out landings. There is less chance of finding things like drainage holes, stones, electric fences, which are frequently to be found in non-cultivated areas. Freshly mown grass areas can be used with little cause for anxiety and especially if one lands along the tracks of the cutting machine. One should not however, land without care in ploughed field. Asparagus fields from the air look just like freshly harrowed fields, also young vines and french beans which are supported by poles while growing, can from a height look very like potatoes.

Grazing fields should also be avoided where possible. Apart from the fact that the ground itself can be quite unsuitable, cows are quite capable of behaving in an erratic manner. I learnt from a Ka 6 pilot that he carefully landed his machine in an enclosure that was decorated in one corner by some thick bushes. At the end of the landing run, a steer charged out, snorting. The pilot saved himself by bravely leaping over the fence and the Ka 6, after some rather expensive repairs was christened "Torero."

6.72 AFTER THE LANDING

After the aircraft has finally come to rest, there is a wonderful feeling of quiet and a stillness prevails over all until the first inquisitive spectators stream along. First of all children in their early teens arrive, followed closely by smaller children and then last of all by the adults. The first two groups are kept at bay with a promise of later explanations, but one must be prepared to talk and answer questions for the adults. First of all one asks for assistance to pull the glider to the edge of the field in order to avoid damage to crops etc. When that has been done with the active participation of all present, one should explain briefly where the flight started, where it was meant to finish and that news of the landing is to be telephoned through, perhaps to air traffic control and certainly to the retrieve crew.

From the spokesman for the adults, we ask for assistance in caring for the aircraft during our absence and in keeping the public well away from the machine. In all probability he will be proud to carry out this request to the best of his ability.

The telephone call should be well planned before it is carried out in order to avoid unnecessary questioning by the receiver and so avoid expensive delays. For this purpose, there should be a standard form of a "Landing advice." It is also necessary to determine beforehand the best route for the retrieve crew, also the name of the farmer and other important details because it can take a long time to squeeze such details out of Grandma who is probably the only one left behind in the house. If the police station is some distance away from the landing field then it is advisable that they be informed of the landing. Sometimes it may be that the police have been informed by air traffic control and they can feel somewhat ignored when left out, not called by the pilot. If however, the guardian of law and order lives in the vicinity he will in all probability know of the landing, if not then an alert youngster should be sent as messenger. Should the officer, unaware of the facts, ask if petrol is needed, or whether the landing was due to engine failure and why the aircraft has no propellor, then he should be given a polite and friendly explanation.

When all formalities have been taken care of, and only then the pilot should devote his attention wholly to the onlookers.

We can never have too many friends amongst the members of the public. How many present pilots have had their first introduction to gliding through an out-landing of a glider? The pilot must have patience because the same old question "Did the wind stop blowing?" and others can be a strain on the nerves. Despite this he should explain clearly and precisely about the price, type of construction and importance of the various instruments and the pleasure of gliding. He will have grateful listeners and he will forget with certainty part of the strain of the out landing. When the children, with their playing around want to innocently rest their bicycles against the glider and with buckles and buttons on clothes endanger the aircraft then there are various possibilities.

One can either sit them all at a safe distance from the glider and allow them to sit in it one at a time or one can sit with them and talk about gliding. I have, with good results, adopted the following practice during the last few years. A sponge, drying leather, and a little soap powder are always carried in the aircraft. The children get several buckets of water and together we begin to carefully wash the glider. The previously suggested possibilities of parking the aircraft safely, a good evening meal, a bed for the night will eventuate either when bad weather approaches or when one apologetically informs the farmer that the retrieve crew will be rather late in coming and may not even arrive until the following day. The problem of damage to property is easily solved when the owner is told that insurance is carried and that payment will be made by the insurance company.

The owner is asked to have the extent of the damage determined by an assessor and have the report sent either to the club or the pilot who will then pass everything on. Under no circumstances should a glider pilot attempt to settle the damages with cash on behalf of the insurance company, because he may never see his money again. From my away landings, there has never been an assessment made, because the extent of damage to the field has been too limited. Despite that, I have developed the best friendships with all of my hosts and have not infrequently been told "Land here again sometime!"

6.8 THE RETRIEVE

When the retrieve crew roars up, it should never happen that the trailer has to be extensively modified by the village blacksmith before the aircraft somehow fits securely and can be safely transported away. Both trailer and vehicle should be maintained in perfect condition.

Special care should be devoted to the electrical system. Circumstances can arise which could lead to delays and expense in the form of fines when one first finds that at sundown everything at the rear is unlit. I have for my trailer an extra set of 12 volt bulbs even though I drive a 6 volt car. One can never know . . . perhaps the trailer lighting may be required to work from another private car.

Even a spare wheel for the trailer is extremely important because it is not always possible that the spare from the car will fit. This spare must be so arranged that it can be used without having to put the whole aircraft in the dirt on the road. The simplest answer, it seems to me, is to mount the wheel on the outside of the trailer. It may not look pretty, but it is very practical.

Anyone who values his glider should not allow it to become too wet. A waterproof cover either over a light metal framework or laid directly over the glider may not be exactly cheap, but it will pay for itself. Practical glider pilots should not have to pay more than the material costs, the labour costs should be earned by the pilot. The aircraft will in any case return this favour with a finish that will last longer as a result. Cautious and sensible driving with the trailer should be obvious. One hour's driving time won can never justify the risk of damage during the retrieve, and consider how many aircraft have already finished their lives on the roads.

A whole book full of tips and advice could be written, which even though on the fringes, would help to bring success. I hope that I have succeeded in illustrating a few of them here. There remains sufficient for the pilot to learn in the form of experience and this he must gather for himself.

Anyone who is prepared to follow the theories described here and to build up his experience on them, flying ability assumed, can expect many pleasurable hours of cross country flying.

Success heightens the pleasure of gliding, and it is for pleasure that we glide!