NACATM 613

TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 613

ELMIRA SOARING CONTEST, 1930

By Wolfram K. E. Hirth, Martin H. Schempp, and Jack Herrick

Prepared originally for and at the request of the
National Glider Association

Washington
March, 1931

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM NO. 613

ELMIRA SOARING CONTEST, 1930*

By Wolfram K. E. Hirth, Martin H. Schempp, and Jack Herrick

The first American national soaring contest held at Elmira, New York, was a bigger success than anybody had anticipated. This was due to the quality of the pilots and airplanes and also to the very favorable terrain and prevailing wind directions. I think that the terrain has only one disadvantage, in that, for every wind direction, a different starting point must be chosen. These points are often more than an hour's drive apart. The hills toward Big Flats (field No. 6), and especially South Hill, are so favorable in their position and contour that utility or primary training gliders are able to soar in a very slight wind. The fact that the two hills lie across the valley down which the wind blows, closing it like a dam, creates very strong up-winds. In addition to this we find that these hills are heavily wooded and therefore store up heat during the first part of the day. This energy is released toward evening, causing thermal up-currents. There is an additional up-current on South Hill that is not very strong but still can be felt. I refer to the rising heat of the city of Elmira, which lies right in front of the hill. On top of both hills there are starting places which can be used without any particular inconvenience. However, it

*Paper originally prepared for and at the request of the National Glider Association.

would be still better, were it not for the trees from thirty to forty feet high at the end of the runway. If a misstart should happen, perhaps caused by the failure of an anchor rope, a crash would be almost certain. To remedy this condition, the trees should be cut down or at least a shock cord should be stretched across the runway, two feet above the ground, at a safe distance from the trees. This would act as an elastic stop for the sliding glider. Such a safety device might be unnecessary for a utility glider with air wheel and brake. One can execute a quick turn on the ground in such a case, but it is dangerous to turn a high-performance glider or soaring plane with its large wing span. If one wing is held on the ground, the outside wing will swing around at such a great velocity as to raise the fuselage off the ground and perhaps crash it.

One of the main advantages of these two hills is that both are long. Only 180-degree turns are necessary after a long straight flight. This does not make flying so strenuous and tiring. Such a condition is an especially important aid to beginners. In addition, there are plenty of landing fields not only below but also on top. These are sufficient and convenient for utility gliders as well as for soarers. This was demonstrated during the contest by many good landings with both types. While the two above-mentioned hills are suitable for the prevailing north and northwest winds, the hillside east of the city must be used for south and southwest winds. There are several good starting places on top of East Hill. Though the landing possibilities at the foot of the hill are not ideal, yet several large fields farther out in the valley make up for this lack. The up-wind zone on East Hill is not so ideal as the one at South Hill and Big Flats (No. 6), (Figs. 1 and 2). The very best soaring terrain is found on the steep and high ridges east of Horseheads. A high-performance glider can be soared on East Hill without any effort with a wind of 12 to 15 m.p.h., while a utility glider requires at least 18 to 20 m.p.h. In comparing Elmira with Germany's famous gliding center, the Wasserkuppe, it is noticeable that Elmira is never hampered by fog. This condition usually spoils four or five days of the annual two-weeks' contest on the Wasserkuppe.

Up-current maps.- To fill up the time occurring during my many flights extending from 30 minutes up to several hours, I made quite a number of up-wind surveys by this method (Fig. 3). I marked on my contour map several prominent points - some close to the slope and others far out in front or to one side of it. This surveying was done during fair weather in air not disturbed by thermal up-currents. I flew my plane over these points at an exact speed of 30 m.p.h., as shown by my air-speed indicator. This was equivalent to a sinking velocity of approximately 2.6 ft. per sec. Flying above the marked spots, I noted the climbing or sinking velocity of my plane by my "sustentometer." At the same time I noted my altitude, which, of course, could not be determined exactly, due to the fractional lag of the altimeter. By this method I measured 25 different strong up-currents in three flights at field No. 6, and 72 up-currents in seven flights at South Hill (See sketch and table). Since the different points could not be studied at the same time, we cannot get an exact picture of the up-current conditions. Therefore, my work should be valued more as a well-meant experiment, than as a finished test. The results could be improved during another contest, if more gliders should participate in the survey. The greatest accuracy would be obtained if two-seat gliders were used and if, at the same time, the wind direction and velocity were determined from the ground by balloons and instruments. Since the pilot, on his endurance flight, has nothing else to do but to stay in the up-current zone, it would be worth while to get good up-current maps of different soaring terrains by the above-mentioned method. The study of these maps would be of great interest, particularly to beginners in soaring flight. That I had some thermal up-currents during the period of these tests, at least at times, was shown quite clearly by the flight over Elmira (from South Hill over points 2, 10, 17, 11, and 7). I gained altitude even farther out than point 17. Because Hastings also gained some altitude after passing the airport on a flight toward Elmira, I believe that the heat radiated in the afternoon from the city (stored sun heat from buildings plus heat from heating plants, automobiles, factories, etc.) plays quite a helpful part when there is a low wind velocity. Of course this factor should not be overestimated. It can never be strong enough alone for soaring, but it can add to the actual hill up-current.

Experiences in endurance, altitude, and goal flights.- Due to the prevailing weather conditions, a systematic gain of altitude was out of the question. The one exception was my distance flight on the fourth of October. The altitude flights were simply parts of endurance flights. On almost every flying day the air was very gusty during the noon hours, an indication of the existence of many small thermal up-currents. Since the air was apparently very dry, its saturation point was never reached. Hence, no clouds were formed, which would have deprived us of all indications as to where to look for these up-currents. It was more or less accidental when one flew into a larger up-current zone. This happened several times during the endurance flights of Backus, Hastings, O'Meara and others. In this event it is obvious that the slow utility gliders had a certain advantage over the faster high-performance gliders. They were compelled to remain longer in the up-wind zones, while the faster planes continued on. Of course the former also stayed much longer in the next down-current area, thereby ascending and descending all the time, while the high-performance gliders could hold a more nearly uniform altitude. This may easily be seen from the barograms. The barograms of the flights in the late afternoon and the ones in the evening were different. The continual up-and-down motion ceased as soon as the radiation from the sun became weaker. The up-wind zone became more stationary, so that its height could be determined, as well as its limits on both sides. Only the steady up-current from the woods, which held the heat somewhat longer, assisted the actual hill up-current to keep the gliders in the air. At this time of day, no utility gliders were able to climb above a soaring plane. Not much needs to be said about the spot-landing flights, for they do not depend upon the terrain. A self-evident fact is that, for this purpose, the slower - equipped with wheel and brake - were superior to the faster planes.

Endurance flights are generally dependent on two factors:

1. Duration of the wind;
2. Endurance of the pilot.

There was an additional factor at Elmira - the early arrival of the darkness. Since the planes had no navigation lights, the regulations allowed them to stay up only a short time after sunset. During the contest there were three days when, I believe, a new world's endurance record might have been made, if the flights could have been extended into the night.

There are three factors which affect the endurance of the pilot:

1. The comfort of his seat;
2. The gustiness of the air;
3. Tedium.

While points 1 and 2 are most important for younger pilots, tedium is the danger for experienced soaring pilots. It requires no effort nor concentration for them to fly in a sloping up-wind. It is helpful to occupy oneself by observing the instruments, the other competing machines, and what is happening on the ground below. The feeling of hunger is not often very bad. It was demonstrated for the first time that food could be passed between gliders. Twice during the meet one glider passed sandwiches to another. Therefore the endurance pilot need not stay hungry. However, there may arise a real urgent necessity for which the machine should have proper hygienic equipment. In this respect, one of the Franklin gliders had a very practical provision.

Distance flights - Experience and possibilities.- We can classify four different types or distance flights with soaring planes:

1. Pure slope flight; that is, along a mountain range or a chain of sand dunes on the seashore. This is the easiest type, if there is enough wind and a continuous slope. The direction of the flight is perpendicular to that of the wind.
2. Flight in a sloping up-wind, but varying the routine by slipping from one slope to the next one, usually in the tail-wind direction.
3. Cloud-hopping or, better yet, distance flying made by taking advantage of thermal up-currents.

4. Flight in hilly country having sun radiation.

The latter type is composed of flying from a slope into cloud or thermal up-currents, then again into a slope up-wind zone, and so on. All four types were used during the Elmira contest. The first distance flight of Bowlus and Jack O'Meara belong to type No. 1; Backus' distance flight was made by means of thermal up-currents; Haller's flight was like type 2; and my 33-mile distance flight was of type 4. A distance flight along a mountain range can even be made successfully in a primary training glider. In order to make a long-distance flight according to the three other types, one must use a high-performance plane, unless there should be extraordinarily favorable wind conditions.

The difference in the flying qualities between the utility gliders and the soaring planes used at Elmira consists, as is well known, in the difference in their actual gliding angles, their sinking velocities being about the same. An excellent distance performance, in powered planes as well as in gliders, depends only on the gliding angle of the plane.

Due to the late season of the year, there was not a single day during the contest that had summer-cloud weather. Therefore, we cannot speak about pure cloud up-winds. Yet one day we had a perfect corresponding up-wind without clouds, because the rising air was too dry for cloud formation when cooled off. This one day was October 4, on which, during my long-distance flight, I was lifted several times to an altitude of 2500 and

3000 feet (according to my altimeter). I gained my first remarkable height above the east ridge of South Hill and hit the second very strong up-wind shortly before Waverly at an altitude of about 1600 feet above my starting point. My plane climbed to 3000 feet in about 8 or 10 minutes. The prize for the best distance flight was national and therefore could not be won by me. Yet the prize for flying to Norwich, New York, was in sight and I purposed to cover the distance from Elmira to Norwich. After a short time, I realized that, due to the unfavorable wind direction, I would not be able to complete this flight, since I had to fly against the wind for quite a time. Between Waverly and Owego I lost my high altitude, coming down to 400 feet, and was getting ready to land. Suddenly, in a terrain over which I expected a down-draft according to air-flow rules, I felt a strong up-wind and was able to climb again to a considerable altitude. Though I passed several times through strong down-draft zones and thereby lost altitude, I easily reached a beautiful slope above the golf course of Owego. There I soared for half an hour in a steady, safe up-wind and had time to think over my position. It was clear to me now that I could not reach Norwich, but I then made a false move. From my new altitude I tried to fly south into Pennsylvania. I soon realized that my altitude was not sufficient to cover the distance to the next mountain range and I turned to get back to the Susquehanna Valley, flying toward Endicott. But it was too late. Shortly before I could reach the lift-giving slopes, I had to land near Appalachin. Still I had on this flight new and instructive experiences. I believe it was the first time that such a distance flight was accomplished under a blue sky without the help of a single cloud. Yet I flew the entire distance to Owego by almost exclusive use of thermal up-winds and far behind the slopes of the valley. Surprising to me was the sharply defined limit of the up-currents which had an astonishing velocity. My machine was pushed upward with such a force that the wings bent and I was pressed into the cockpit. This was the case in the up-wind zone beyond Waverly. I only touched with my left wing the limit of the up-wind channel and it put me in a sharp side slip. This caused me, of course, to turn my machine immediately back right into this channel where I could use its lifting energy to gain a considerable height. It is too bad that I did not first continue my flight from Owego in the old direction. Endicott certainly could have been reached and perhaps even Binghamton.

It is equally as important to stay the longest possible in the up-wind area, as it is to be able to pass through the down-wind drafts at high speed. The high-performance glider is therefore so designed that in a slightly tail-high flight, it is gaining greatly in speed without greatly increasing its small gliding angle. The pilot is thereby enabled to shoot over an unfavorable terrain. Soaring that could be counted in the long-distance class was hardly begun in this year's contest. It is not too difficult to make world's records for altitude and endurance at Elmira. There is also the possibility of making a distance record not only in the direction of Binghamton, but particularly, with a start from South Hill, by flying toward the south to the Bald Eagle Ridge, over the Towanda mountains and the Burnell Ridge, where distances of more than 200 miles might be covered. This is considerably more than is possible in a flight from the Wasserkuppe in Germany under like weather conditions. Of course, we must have cumulus clouds or a cold-air front, which might be expected earlier in the year (perhaps in July or August), in order to make the hop from the Elmira hills to these mountains.

The near future of gliding in the United States belongs undoubtedly to the utility gliders, mainly because of their splendid suitability for automobile towing and their lower cost. To improve them, particularly for distance flying, several methods may be employed. Before going into these practical aspects any further, I would like to explain a few theoretical points, with which every soaring pilot should be acquainted.

The terms.- Gliding angle, or better, glide factor and sinking velocity can be expressed by simple formulas. The ratio $\frac{C_d}{C_l}$ is equal to the gliding factor, for instance, on the soaring plane (Fig. 4) "Musterle" $C_d : C_l = 1 : 22$, where C_d is the coefficient of drag and C_l is the coefficient of lift. One can see here very plainly that the low air resistance and the great lift play a large part in obtaining this good gliding ratio. This is still more apparent from the formula for the sinking velocity which, in its simplest form, is

$$V_s = 4\sqrt{\frac{W}{A}\frac{C_d^2}{C_l^3}}$$

W = weight of plane, A = wing area, V_s = sinking velocity. Since everything in this formula that is squared or cubed is much more important than the simple factors, it is clear that the wing loading $\frac{W}{A}$ does not signify so much as $\frac{C_d^2}{C_l^3}$ in order to make V_s as small as possible. Next to the increase in the lift, the reduction in the drag is the most important factor. The weight may be somewhat greater and the area smaller without having much effect on the sinking speed. To increase the lift and at the same time to keep the drag small, is possible through an improvement in the aspect ratio, or simpler by increasing the span while keeping the same airfoil and not taking trifles into account.

I am giving these explanations chiefly because I was asked several times by pilots at Elmira how it was possible for my soaring plane to perform so well, though it was heavier than the other planes besides having a smaller wing area. My plane had better flying qualities because it had a better aspect ratio and a very small total drag. By a further increase of the span the gliding angle and sinking velocity might be still further improved, but there would be some other disadvantages. The plane would be still more expensive, heavier, more difficult to assemble and to transport, not quite as easy to curve, and harder to handle in landing. As in many other cases, nature gives us the best example. Soaring birds with a large aspect ratio live on the wide ocean. The soarers on the continent which have to alight on trees and fly narrow curves and circles to take advantage of small up-currents, have a low aspect ratio, but make up for this by having a small wing loading.

Syracuse, N. Y.,

October 15, 1930.

Up-wind Survey at Elmira, N. Y.
Made by W. K. E. Hirth with his soaring plane "Musterle"

4 examples at South Hill

Point	1				2				3				4			
	V_c m/s	V_c ft./sec.	Altitude m	Altitude ft.	V_c	V_c	Altitude m	Altitude ft.	V_c	V_c	Altitude m	Altitude ft.	V_c	V_c	Altitude m	Altitude ft.
1	0.5	4	120	360	0	2.5	250	750	0.5	4	220	660	0.5	4	300	900
2	0	2.5			-0.5	1	250	750	0.2	3	220	660	0.2	3	300	900
3	0	2.5			-0.7	0.3	220	660	0.2	3	250	750	0	2.5	320	960
4	0.25	3			0	2.5	250	750	0.25	3.5	250	750	1	6	150	450
5					-1	-0.6	250	750	-0.5	1	300	900	-1	-0.6	300	900
6									-0.5	1	280	840	-1.2	-1.2	280	840
7													-1	-0.6	380	850
8					0	2.5	200	600					-0.5	+1	220	660
9	-0.5	1			-0.2	2	200	600					0	+2.5	220	660
10													0.5	+4	320	960
11													-0.5	+1	350	1050
12					-0.2	2	220	600					-1	-0.6	250	750
13									-1	-0.6	180	540	-1.7	-3	280	840
14									-1	-0.6	150	450	-1	-0.6	250	750
15									0.5	4	150	450	0.7	5	220	660
16									0.3	3.5	150	450	1	6	250	750
17													0	2.5	350	1050

It is: V_c - m/s = ascending velocity of the up-wind in meters per second.
V_c - ft./sec. = " " " " " " feet per second.
altitude m = altitude in meters.
" ft. = " " feet.

The ascending velocities seem high, which may possibly be due to inaccuracy of the sustentometer which may have suffered in a drop of my instrument board in a start from Sullivan's Monument.

Up-wind Survey at Elmira, N. Y. (cont'd)

2 examples at Big Flats

	1				2			
Point	V_c m/s	V_c ft./sec.	Altitude m	Altitude ft.	V_c	V_c	Altitude m	Altitude ft.
1	1	6	120	360	0	2.5	100	300
2	1	6	150	450	0.5	4	100	300
3	0.5	4	150	450				
4	0.5	4	150	450	0.25	3	120	360
5	0	2.5	100	300	-0.5	1		?
6	0.25	3.5	150	450	0.25	3	120	360
7	0.5	4	150	450	0.25	3	120	360
8	0	2.5	250	750	0.25	3	150	450
9	-1	-0.6	200	600				
10	0	2.5	250	750	-0.25	2	200	600
11	0.2	3.5	250	750	-0.25	2	150	450
12	-1	-0.6	200	600				
13	-1.2	-1.2	220	660				
14	-0.5	1	250	750				
15	-0.5	1	200	600				

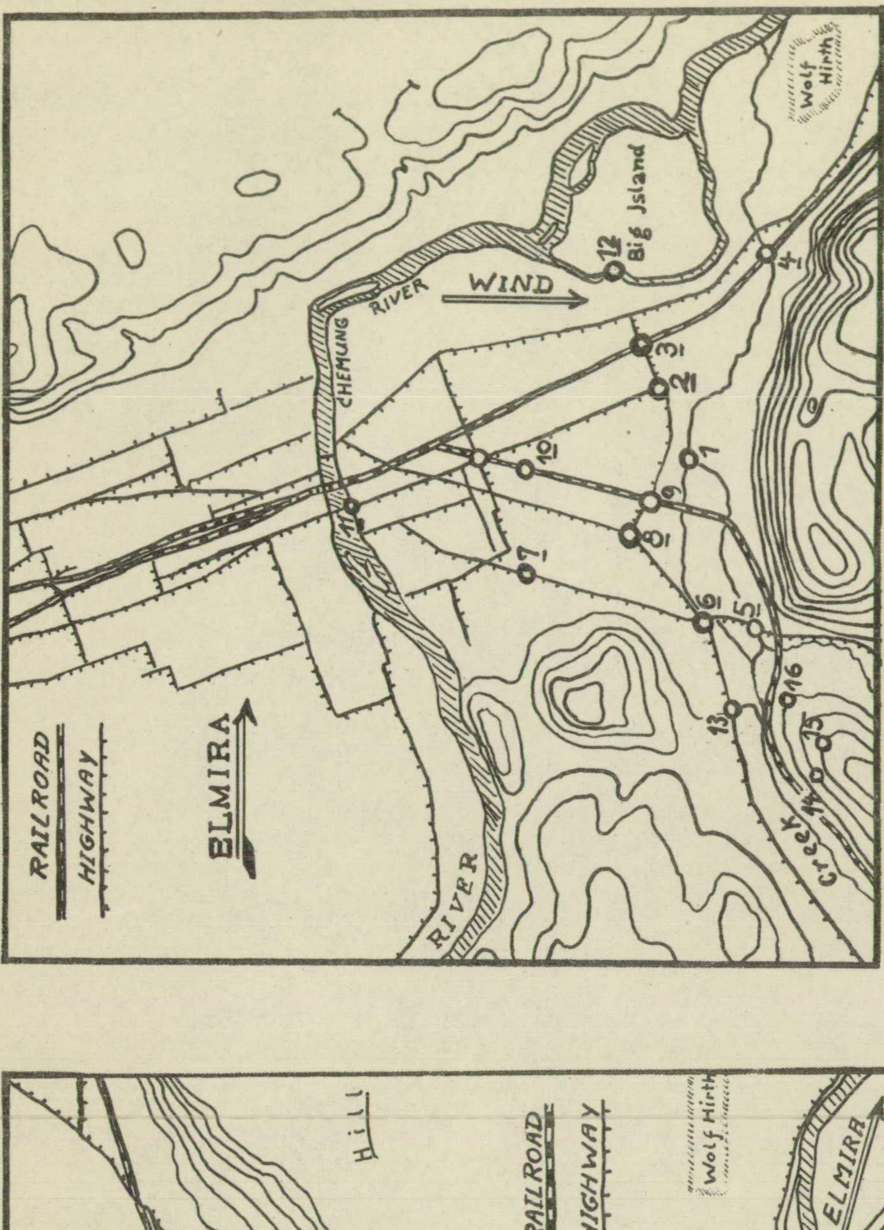

Fig. 2

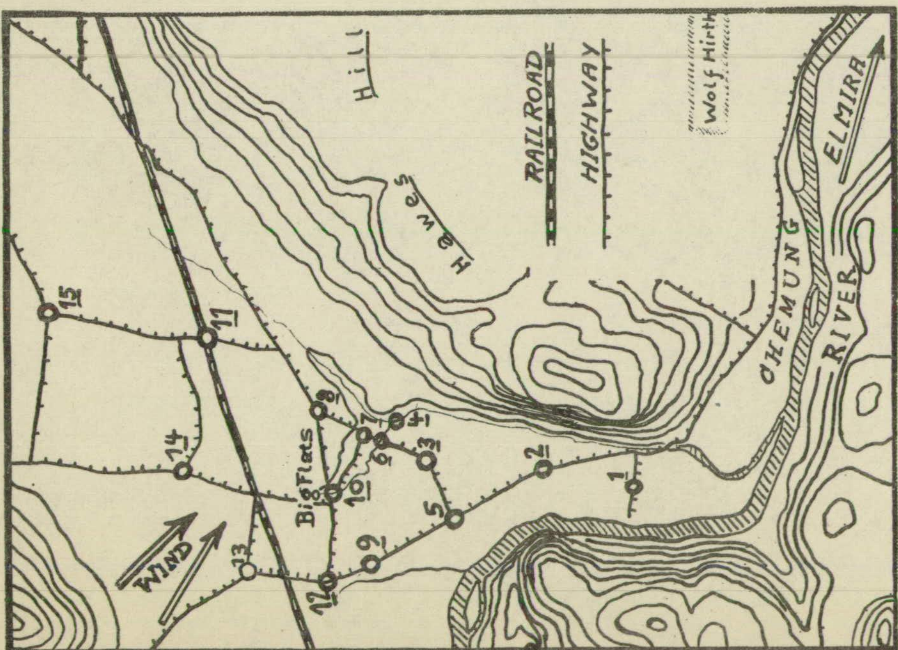

Fig. 1

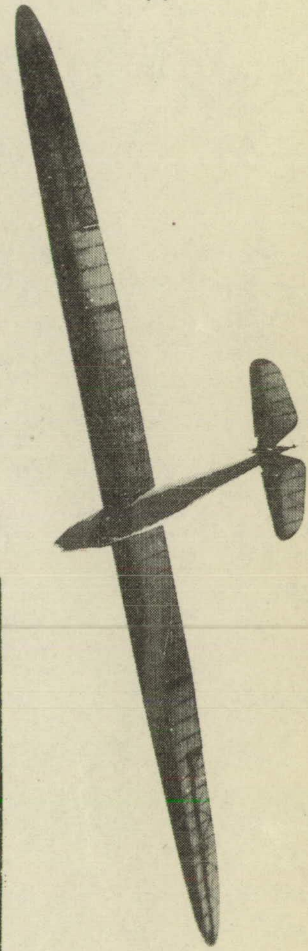

Fig. 4 The Musterle glider

Sketches illustrating the different types of distance soaring flight.

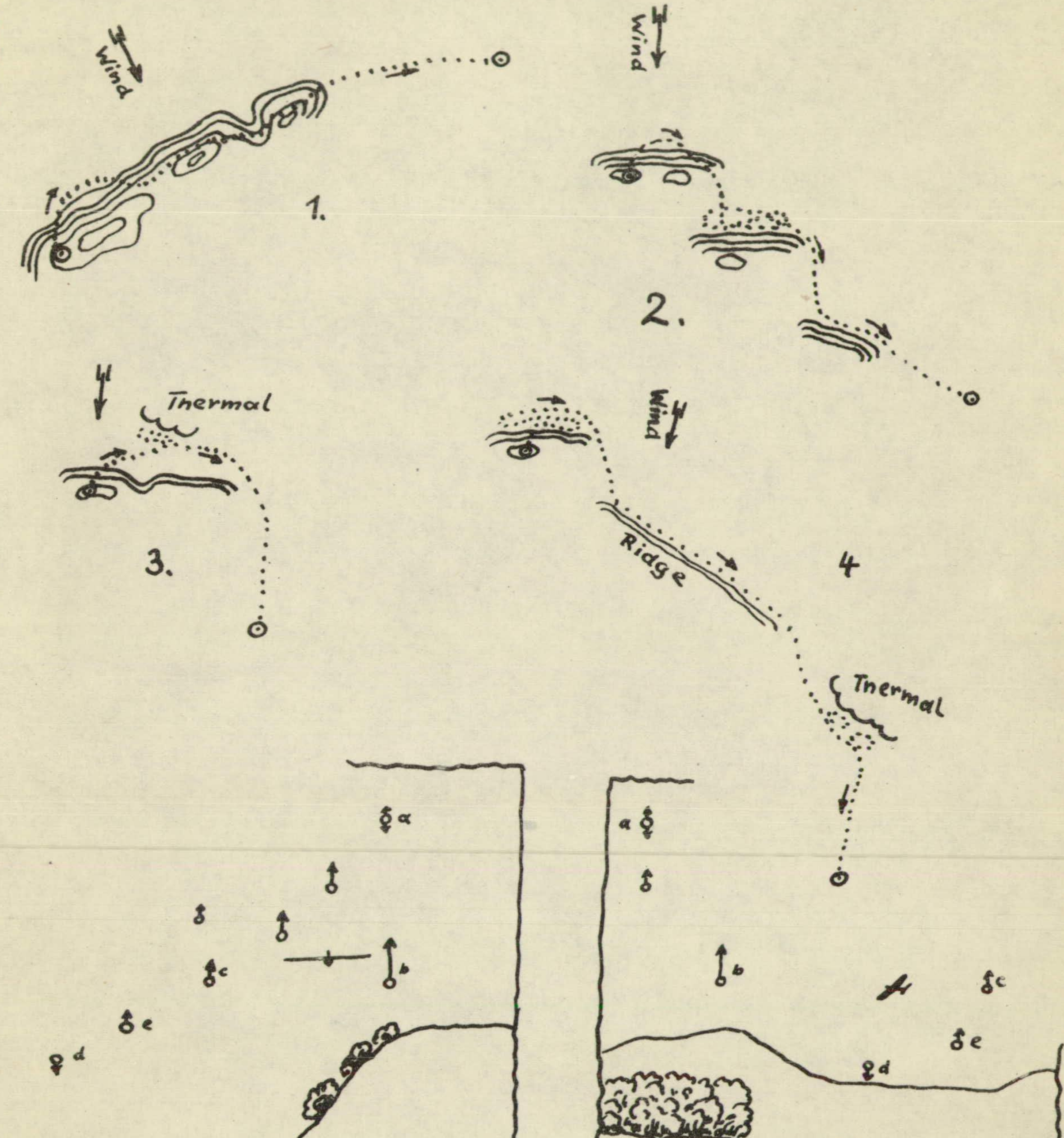

Fig. 3
An example of how the results of an up-wind survey can be used for making a plain up-wind map.