Gliding and Soaring Flight*

By Prof. D. Brunt

THE early history of gliding is the early history of flying in heavier-than-air machines of any kind. The machine was projected into the air either from a hill-top or from flat ground, and came down slowly while moving forward. Lilienthal described in his book on "Bird Flight as the Basis for Aviation" how in some of his earlier experiments in gliding over slopes the machine actually soared, or gained in height, being carried upward by the air current flowing up the slope. But the early pioneers soon became absorbed in the problem of developing a power unit, and the development of the petrol engine, by making the aeroplane possible, diverted attention from the possibilities of pure gliding. In Germany gliding was taken up as a sport soon after the Great War, and in 1922 the achievement of Martens in soaring for an hour gave a new impetus to the movement. The *Daily Mail* organized a gliding meeting at Itford Hill in 1922; but this failed to produce any permanent interest in gliding in England. It was only at the end of 1929, after the Germans had shown that the glider need not be bound to a hill-slope, but could soar under and into clouds, and could ride the front of an advancing storm, that interest was at last aroused in Great Britain, and that there came into existence a real British gliding movement. After undergoing the usual pangs of adolescence, this movement is now approaching the adult stage.

There has not been any very revolutionary change in the design of sailplanes in recent years, and it may be said that in appearance the modern sailplane resembles the power monoplane, without an engine, but with a more closely streamlined form. Differences occur in the wing-structures used, the strutted wing being generally lighter than the cantilever wing. Perhaps the most important change made in recent years has been in the direction of increasing the strength of the structure, in order to make it capable of standing the strains to which it may be subjected during flight in clouds. The stoutness of the fuselage is dictated, not by the demands of flight, but by the necessity of the structure being able to stand up to the strain of handling when on the ground.

In the early stages of training, the machine is launched by means of an elastic catapult, the ends being drawn by teams of men. Alternatively, the human power may be replaced by a horse or

motor-car. Another method is to attach a cable to the front of the machine, and to wind it rapidly on a winch, thereby dragging the machine into the air, while another method is to tow the machine into the air behind an aeroplane. Sailplanes can fly at very low speeds without stalling, and consequently can be landed with safety in fairly small fields.

The modern sailplane has a sinking speed in still air of about 2-3 ft. per second, and so will soar in any vertical current the vertical component of which exceeds this modest value. The pilot of a soaring sailplane is in the position of an old lady trying to go down the up-escalator at a tube station, the escalator carrying her up faster than she can descend the steps.

For our present purpose we can define the problem of soaring flight as the problem of finding upward air currents of the necessary magnitude, that is, exceeding the sinking speed of the sailplane in still air, usually 2-3 ft. per second. For practical purposes, we can say that there are three classes of ascending currents in the atmosphere. First, when the wind blows against rising ground, it follows the contours of the ground, and if the upward component of the wind is sufficiently strong, soaring will be possible over the sloping ground. Secondly, when the air is unstable, convection currents may attain sufficient speed to make soaring possible. Thirdly, at the cold front in a depression, where a wedge of cold air pushes under a warm current, there is often sufficiently rapid ascent of the warm air to make soaring possible. Sometimes thunderstorms occur at cold fronts, and long flights have been achieved in the ascending currents in thunderstorms.

When the wind blows up the side of a hill the horizontal flow of the air is disturbed up to a height of about three times the height of the hill. A sailplane launched into the ascending current from the top of the hill can, by circling in the ascending current, attain a considerable height. If the pilot's aim is to make a flight of long duration, he can go to and fro above the ridge of the hill, and the duration of his flight is limited only by the duration of the wind in direction and strength, the pilot's physical endurance, or possibly the dangers of darkness. During the 1937 international competitions, two members of the English team, Messrs. Fox and Murray, flying the Falcon III two-seater, made a duration flight of 9 hours 48 minutes.

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Long-distance flights cannot be made by hill soaring alone, but even when long-distance flights are attempted, they usually start with a gain of height over a slope, and on the way across country any slopes facing into the wind direction may be used to maintain or increase height, while the pilot waits for other types of ascending currents to turn up.

The second type of ascending current, the convection current, occurs when the air is unstable, that is, top-heavy. Instability in the atmosphere requires a rate of decrease of temperature with height in excess of $5.6^{\circ}\text{F. per } 1,000\text{ ft.}$ When this limit is surpassed, as is frequently the case when the sun is shining, and particularly on bright afternoons, convection currents (or 'thermals', to give them the name usually applied by the gliding men) are set up. Every convection current which carries warm air upward must be compensated by a descent of air somewhere. In other words, convection currents must possess some kind of structure.

In the laboratory it is easy to set up convection currents in a liquid or in a gas. The simplest illustration is afforded by pouring cheap gold paint into a shallow tray such as a mince-pie tray. The evaporation of the volatile liquid cools the upper layers, and so makes the liquid top-heavy. Looked

Fig. 2.

THE SAILPLANE *Hjordis* WHICH FLEW 104 MILES ON JULY 5, 1936.

at from above, the liquid is seen to be divided into a number of small cells, in each of which the liquid ascends at the centre, flows outward over the upper boundary, and descends at the margin of the cell. Similar effects can be readily produced in air. A convenient chamber for such experiments with air has a metal base, which can be heated electrically from below, and a glass top through which the motion can be observed, the motion being made visible by tobacco smoke. Such experiments may be regarded as reproducing conditions similar to those in the atmosphere when there is no wind. To simulate the effects of wind varying with height, the top glass plate must be capable of being moved across the chamber, dragging the air with it. It is then found that, if the instability is great, the bottom of the chamber being considerably warmer than the top, a slow motion of the top plate only distorts the shape of the cells obtained previously. If the bottom plate is not much warmer than the top plate, a slow motion of the top plate gives long rolls at right angles to the direction of motion of the plate. Such rolls are called transverse rolls. When the top plate is moved rapidly, the chamber is filled with long rolls in the direction of motion of the plate, and these are known as longitudinal rolls. The rolls, whether longitudinal or transverse, are in pairs, the two rolls in a pair

Fig. 1.

CUMULUS CLOUD CONSISTING OF A SERIES OF CUMULI JOINED UP IN ROWS.

spinning in opposite directions. Thus, when in the atmosphere conditions are unstable, the rolls of cloud formed by the upward motion of damp air will be at right angles to the wind if the wind speed varies only slowly with height, but along the wind direction if the wind speed varies rapidly with height. When damp air rises through a sufficient range of height, it produces cloud, and the cloud may be taken as an indication of the existence of the ascending current. If the wind does not vary with height, or if there is a calm, the clouds will usually be cumulus clouds, each forming the cap of an ascending current. When the wind increases rapidly with height, the cumulus clouds will form long irregular rolls (Fig. 1). Under any of these clouds the soaring pilot can find an ascending current, and under the long streaks of cumulus he can go the whole length of the cloud

cornfields surrounded by meadows. He will sometimes find thermals over land near the edge of any large body of water, and an asphalt road, which can heat up in the sun to as much as 25° F. warmer than surrounding fields, will very readily become a source of thermals when the sun shines on it. In the evening, thick woods on the side of a hill will produce thermals by the release of the warm air trapped within them during the day. Then the pilot will in the course of time find that there are certain spots in the neighbourhood of his usual soaring ground at which thermals are frequently formed.

Thus even in the absence of clouds, the sailplane pilot has certain principles to guide him. But, as Kronfeld once stated in a lecture at Darmstadt, the soaring pilot must fly with his head. By so doing he finds the thermal he needs.

When once he gets into a thermal he can circle round in it until he has gained as much height as possible, during which time he will drift down with the wind. Alternatively, he can fly fast when he finds no ascending current, and slow down the moment he finds himself ascending, so as to gain as much height as possible in the ascending current.

As an example of what can be achieved, first consider that flight by Mr. Philip Wills on July 5, 1936, which holds the British distance record of 104 miles [see p. 745]. This flight was made in the sailplane *Hjordis* illustrated in Fig. 2. During the afternoon the sky showed scattered clouds, with short cloud streets here and

Fig. 3.
BAROGRAPH RECORD OF MR. PHILIP WILLS'S FLIGHT. THE FIGURES SHOW THE SCALE, NOT THE ACTUAL HEIGHT. THE LEVEL TRACINGS AT EITHER END WERE MADE BEFORE AND AFTER THE FLIGHT.

almost as readily as a car can go along a road. For this reason, such long cumulus clouds are generally known as 'cloud streets'.

When the air is too dry to form cloud readily, it is not so easy for the soaring pilot to find the ascending currents. He then has to consider what types of ground are most readily heated by the sun, since it will be over the hottest ground that the ascending currents will form. Now it is possible to arrange types of ground in order of readiness with which they will heat up in the sun, as follows: sand, light soil over chalk, light loam, heavy loam, clay, water-logged soil, water. Any type of soil will heat up more readily when dry than when wet, more readily when bare than when grass-covered. The roofs of houses are heated more than grass fields, and the air trapped between the stalks of corn will be heated more than the freer air over a meadow. The air in woods will remain warm longer than air outside them, when the sun is low. Thus on a sunny day the pilot will look for thermals over villages, over large buildings, over any sandy or chalky patch surrounded by heavier soil, over

there, a mile or two long and in series staggered relative to each other. The barograph chart (Fig. 3) shows how the pilot had to struggle to maintain height. The cloud base was very constant, at a height of about 3,600 ft., and so the pilot could never afford to lose much height. The lowest point on the chart, showing a height of about 400 ft. above the height of launch at Dunstable, and a height of about 800 ft. above the ground then immediately below, appeared to make a landing imminent, but at the critical moment a slight lift was found, and in 15 minutes the sailplane had gained 2,000 ft. This is an example of a flight made by circling in thermals, and staying in them as long as height was being gained.

The weather chart on that day showed no special indication that convection would be unusually active. There appear to be relatively few days on which it would be impossible for a sailplane to make a flight, if once it had achieved sufficient height to be able to wait for thermals to turn up. Distance flights are rarer than they need be in England because most of the soaring sites from

which a start can be made have their soaring slopes facing westward into the prevailing wind, and so a start cannot be readily made when the wind is not westerly. Longer flights could frequently be achieved if the start were made by aero-towing.

The alternative to circling in thermals, variation of speed so as to go slowly in thermals, and fast when out of them, is exemplified by the flight from Berlin to Kiel, carried out by Ludwig Rotter on August 12, 1936. Rotter's sailplane, the *Nemere*, which has a sinking speed in still air of only 2 ft. per second, can fly at 87 miles per hour. During nearly the whole of the flight, the speed was maintained at 75-87 m.p.h., being reduced to 37 m.p.h. when flying through thermals. It was only in the later stages of the flight that the pilot did any circling in thermals. There was little cloud in the sky, but Rotter's barograph record shows that he was never in much danger of having to land from the time he was launched by aeroplane tow at a height of 1565 ft. The distance achieved was 203 miles, and the landing point was 138 miles off the direct line of the wind from Berlin. This flight illustrates the ability of a sailplane to travel across wind. Within the limits allowed by the strength of the machine, a sailplane can travel at any speed by gliding downward at a sufficiently steep angle. Thus by sacrificing height it can even travel against the wind, but it is not possible to achieve any considerable distance against the wind unless ascending currents are frequent and vigorous.

During a flight in South Africa, Mr. Philip Wills found that at times the convection currents were astonishingly vigorous, on one flight a height of 5400 ft. being gained in less than seven minutes. Wills has described how he shared thermals with the vultures, who treated him as one of themselves, flying in formation with him. It appears that the vultures partition the ground, each bird taking a territory of about a half-mile square, and that their existence is devoted to the search for two things, ascending currents, and food on the ground.

There remains to be discussed the third type of ascending current in the atmosphere, at the cold front in a depression. The Norwegian scheme of the anatomy of a depression shows on the weather chart a warm sector, separated from the cold air in the rear of the depression by a line which is known as the 'cold front'. This line is simply the intersection with the earth's surface of the upper boundary of the cold air, which lies in the form of a wedge with its nose some distance above the ground. The cold air pushes under the warm air, and forces it to rise over the nose, and, in some depressions at least, some of the warm air becomes unstable, so that it then rises freely to great heights, often giving a cloud which extends as high

as 20,000 ft. The ascending current is often sufficiently vigorous to lift a sailplane to great heights, and once a sailplane has got into this current, it can fly along the direction of the front while being carried along with the front in its drift across country. Some remarkable flights have been achieved in this way.

We may note in passing that the fact that gliding is possible at a cold front, at heights of many thousands of feet, throws some light on the meteorology of the cold front. The slope of the upper boundary of the cold air averages about 1 in 50, and since we may assume that the ascending current must mount at a rate of at least 5 ft. per second if a sailplane is to gain height at a reasonable rate, it follows that if the ascending air were merely flowing up the slope of the upper boundary of the cold air, it would have a speed of 250 ft. per second, or about 166 m.p.h. This is far in excess of the winds in which cold front flights have been carried out, and so we may conclude that the ascending currents in which the flights were made were not due to ascent up the slope of the wedge. An examination of upper air temperatures measured just in advance of the cold front has shown that in some depressions the air is in such a state that if pushed upward through a relatively small distance, it will then rise freely.

When a sailplane pilot soars into the ascending currents below cumulus clouds, or near a cold front, he does not always find it easy to go just where he wishes. He is frequently drawn into the cloud, whether he wishes to enter it or not. Inside a cloud the air currents are frequently very irregular and violent, and the machine needs to be stoutly built if it is to stand this rough treatment. Further, the machine must then be piloted by the use of instruments which show any deviation from the horizontal, otherwise there is a risk of its coming out of the cloud in a nose-dive, or even upside down.

During the 1937 international competitions in Germany an English pilot, Flight Lieut. Watt, achieved a gain of height of 8,000 ft. in a cloud, taking about one and a half hours to do so. This is probably the best achievement in cloud flying which stands to the credit of a British sailplane pilot. Cloud flying has for some years been part of the normal advanced training of German pilots, but in Great Britain it is a recent development.

In Great Britain, gliding and soaring flight is purely a sport, while in Germany and Poland it is part of the normal early training of the power plane pilot. In the latter countries, gliding and soaring flight is highly organized. It is perhaps invidious to make a direct comparison between the achievements of British and Continental sailplane pilots. The longer period during which gliding has been organized in Germany and other Continental

countries, added to the fact that far stronger financial support is given by the Government in these countries than in Great Britain, makes a direct comparison at the present time a little unfair to British gliding. A comparison of distances achieved is particularly misleading, since Great Britain is, after all, a small country. For example, starting from Dunstable with a westerly or south-westerly wind, it is impossible to outdistance Wills's record flight of 104 miles by more than a few miles at most. At the international competitions last year, out of 297 launches for distance flights forty flights exceeded 100 miles; on the first day of the competitions three competitors flew from the Wasserkuppe to Hamburg, a distance of 351 kilometres (218 miles). Again, at the Polish National Competitions in 1937, the distance flights *averaged* more than 60 miles, the longest flight being nearly 200 miles. These competitions were held in the flat country in the north-west of Poland, in order

to test the possibilities of soaring in flat country with launching by aero-towing up to heights of 1600–2000 ft.

The world's distance record for cross-country soaring is held by a Russian pilot, Rastorguyev, who set up three new records consecutively, of 335, 374 and 405 miles, all made during May 1937.

Enough has been said to show that long-distance flights can be made in sailplanes without serious difficulty. Gliding is a safe and healthy sport, and forms a useful preparation for training in power-plane flying. It also offers a means of adding to our knowledge of the processes of convection in the atmosphere, the glider being the only instrument which can be used for a thorough investigation of convection currents. While this may not help in the problem of forecasting tomorrow's weather, it is difficult to believe that increased knowledge will not eventually lead to increased wisdom.

Science, Logic and Philosophy*

By Dr. Harold Jeffreys, F.R.S.

SO long as an idealist confines himself to the description of sensations and to the construction of his ideal world, he can dispense with the theory of probability, but at the cost of having to reconstruct his world with every observation that does not happen to fit his laws exactly. An idealist that does not accept the theory of probability could expect the sun to rise in the west to-morrow, and nobody believing otherwise could make the slightest contact with him such as could alter his opinion. But he has no basis for inferring new sensations without it, because an infinite number of laws can always be made to fit any finite number of data. Without some rule for selecting the most suitable laws there is no reason to prefer any one prediction to any other, whether one is an idealist or a realist.

The naive realist is in an even worse position, because his strict causality leaves him with no margin of uncertainty at all; any random variation must either lead to a complete reconstruction of the laws, to a causal theory to account for the random variation itself, or to abandonment of science altogether. The first and third alternatives are seldom adopted; and the second merely points to some hypothetical causes as explanation—which is no explanation at all (1, pp. 244–248).

*Continued from p. 676.

I conclude that naive realism as a scientific philosophy is simply wrong because it will not work in practice. It requires that we should know everything before we can say anything. Idealism and critical realism will work; the latter demands the notion of probability in any case; idealism also requires it if any inferences beyond the original data are to be made. Accepting the theory of probability, we can test the need to introduce any new parameter by comparison with the observations. The theory therefore gives an account of the actual process of successive approximation, the outstanding variation at any stage being taken as random until there is evidence to the contrary. This variation is as essential a part of the law as the systematic part. Thus we have the statement of Ockham's razor, in the form: Variation is to be taken as random until the contrary is shown*. This is the form needed for scientific purposes*.

The term 'unobservable', discussed in Prof. Dingle's recent article², is itself a legacy from naive realism. An observation, strictly, is only a

* It incidentally solves the problem of "scientific caution". Everybody agrees about the need for caution; but people differ about what caution means. Granting the possibility of inference from experience in any circumstances at all, we must begin with the hypothesis of randomness and test successive possible modifications of it. It is sometimes said that it is dangerous to apply a law far beyond the original data; but that is the best possible way to find out whether any modification is needed.