METEOROLOGY for Glider Pilots

C. E. WALLINGTON

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Preface

No other sport is so interwoven with the ways of the weather as gliding. Very early in his career the glider pilot finds meteorology infused into his initial instruction. Often his early lessons materialise from irritating delays in his training programme; the wind is either too light or too strong, or it rains on the wrong day, or convection is too weak and sporadic. But natural curiosity whetted by minor frustrations prompts him to learn more about the element in which he flies, so from conversations with his instructors and club colleagues and from his sharpened interest in the weather forecasts disseminated by the press, radio and television he gleans something of the practical significance of depressions, fronts and anticyclones.

As his flying ability progresses, however, the pilot's meteorological interest tends to be directed from the broad scale weather features towards the local phenomena which can present both hazards and opportunities for soaring. He experiences the effects of rugged terrain on hill lift and local eddies; he cavorts around in convection currents and, if lucky, he finds himself soaring in lee waves. At this stage his task is not so much to understand or forecast the phenomena in which he soars as to visualise the pattern of lift and to fly correctly within it. At first it is difficult to decide how much of any failure to stay in lift is due to his handling of the aircraft and how much is due to the natural capriciousness of the atmosphere. Flying ability normally improves with experience, but the rate of progress made in understanding the atmosphere varies considerably among the individuals who comprise the gliding fraternity. For some pilots meteorology is a science akin to their own professions, while for others the weather is no more than a topic for casual conversation before their introduction to gliding. Whatever their initial scientific standards, however, most pilots acquire their meteorological knowledge through clubhouse conversation and books on general or aviation meteorology—and as their flying experience increases they begin to find such sources of information inadequate. Casual advice and hints from clubhouse conversation can easily be misinterpreted by the trainee, and semi-experienced pilots are sometimes loath to seek guidance on aspects of meteorology they feel they ought to know already. Elementary books on meteorology usually treat fronts, low level winds, sea breezes, convection and lee waves at too elementary a level for the glider pilot; advanced level books cater mainly for the meteorological specialists and books on aviation meteorology are designed primarily for the power pilot who is likely to attend a formal training course.

The glider pilot's thirst for meteorological knowledge is usually made obvious to any meteorologist, like myself, involved in gliding affairs by the numerous questions he asks at opportune moments. The substance and level of this book is based mainly on such questions put to me by glider pilots in recent years. In the first nine chapters the aim is to cover the necessary meteorological groundwork without specific reference to gliding. Then, having set the broad meteorological scene, the remainder of the book elaborates on those aspects of the subject particularly relevant to soaring flight. Here there has been ample opportunity to incorporate the findings of modern research into the varied facets of convection, sea breezes, lee waves and wind flow in mountainous regions. To help the reader new to meteorology to acquire more familiarity with meteorological charts and real weather situations, actual case histories rather than hypothetical examples are used wherever practicable.

A few facts, figures and rough and ready formulae are interspersed in the text, not so much to enable the reader to forecast for himself as to provide numerical teaching aids for the reader to juggle with in his spare time. Some sections on fronts and the tephigram may also call for thoughtful study rather than perfunctory reading, but in general the level at which the book is pitched has been considered with three main requirements in mind. First and foremost, most gliding club members need a textbook suitable for self-tuition. Secondly, the glider pilot needs to acquire a mature appreciation of the actual weather he encounters; he cannot turn a blind eye to observations which do not fit oversimplified concepts, and if he cannot explain these observations then he should at least understand why they are difficult for his (and perhaps the expert meteorologist's) comprehension. Thirdly, there is a growing need for a textbook suitable for the lectures and short courses on meteorology for gliding which have been inaugurated in recent years and which are envisaged for the future.

Although gliding is an international sport, the accent here is on the gliding meteorology of the British Isles. Material from other lands has been included but to cover too wide a geographical field would have meant sacrificing detail for generality, and it is the details of certain local phenomena which make soaring possible. Nevertheless, although the characteristics of weather and climate vary from country to country, the basic physical processes involved are the same the world over and, once these processes are understood, it is not too difficult for the pilot to adapt his meteorological repertoire to foreign climes.

The international aspect of gliding also poses the problem of selection of units; knots, kilometres per hour, metres and feet should all be familiar to the truly international pilot. To help foster this familiarity I have given a liberal selection of approximately equivalent Continental values alongside the units used in English meteorological practice. This practice entails the use of two temperature scales: degrees Fahrenheit for most ground level observations and degrees Celsius (centigrade) for upper air temperatures, but a familiarity with the approximate conversion from one scale to the other is soon acquired with a little usage.

A sound appreciation of meteorology and of the forecasting services does not, of course, automatically raise a pilot to top class in the soaring world, but it can add considerable interest to his sport, it can forestall many potential hazards, it can help him to perceive and use extra soaring opportunities and it can make him feel more at home in the air. It is not for me to advise on the handling of aircraft on the ground or in the air, but my hope is that by elaborating on the strictly meteorological aspects of gliding I may help literally to broaden the glider pilot's horizons and at the same time reduce whatever worries he may have about his personal knowledge of meteorology.

Much of a practising meteorologist's work entails collecting data or literature from various sources and passing it on to his customers in a suitable form. Therefore, I am indebted to many of my friends in the gliding world for recounting to me their various flying experiences. I have also made use of many scientific papers and gliding articles, and by way of acknowledgement (as well as to

provide references for further study) the authors and a selection of their articles are listed at the end of the book.

I must thank Dr R. S. Scorer for introducing me to gliding meteorology and for his guidance particularly in those early days when modern views on lee waves and thermals were just beginning to emerge from post-war research. John Findlater, with his practical enthusiasm, has inspected the script and made suggestions for which I am also grateful, and last, but by no means least, I want to thank my wife for being secretary extraordinary.

C. E. W.

January 1960

CHAPTER 1

Pressure and Wind

We live at the bottom of an ocean—a great ocean of air encasing the earth and effectively about 200 miles deep. We call this ocean the atmosphere. We feel its undercurrents as winds, sometimes as gales sweeping across the countryside, sometimes as light breezes gently filtering through the trees, but always driven by an illimitable supply of energy—energy from the sun. The linkage between this energy and wind can be described briefly, though rather loosely, as follows. Heat rays from the sun give rise to an uneven distribution of temperature changes over the globe; the tropics receive more radiant heat than the poles, and temperature is quick to rise over desert sands whereas much of the heat received by a marshland is used for evaporation; snow surfaces and the tops of thick cloud layers reflect rather than absorb much of their incident heat rays. This uneven distribution of temperature changes leads to variations in atmospheric pressure and it is these variations which are directly linked with winds over the earth. But the winds themselves affect the temperature distribution by transporting warmth, or cold, or layers of cloud from place to place, and the whole mechanism is geared to the spinning motion of the earth and lubricated by the evaporation and condensation of water in the atmosphere. So the weather we experience can be considered as the by-product of interwoven cycles of events into which the sun injects a daily supply of energy. A convenient starting point for dissecting and understanding the weather machine is an appreciation of atmospheric pressure.

Atmospheric Pressure

The air in the atmosphere is fairly light, but its weight is by no means negligible. At low levels the air is compressed by the weight of the air above it, and the total weight of a column of air extending from the ground to the top of the atmosphere amounts to almost one ton for every square foot of ground it covers—or, in metric units, about one kilogram per square centimetre. This weight of air per unit area is called the *atmospheric pressure*, or sometimes *barometric pressure*, "baros" being the Greek word for "weight."

A vital duty of most meteorological services is to measure the atmospheric pressure at frequent intervals at a large number of observing posts scattered throughout the territories they serve. The most commonly used measuring instrument is the mercury barometer. It is a simple device consisting in principle of mercury

Fig. 1.1. The mercury barometer is a form of balance; the weight of air resting on the mercury surface at *A* exactly balances the weight of mercury in the column between levels *A* and *B*.

in a U-shaped glass tube which is open at one end and closed at the other. As shown in Figure 1.1, the tube is held vertically to form a sort of balance; the weight of air resting on the mercury surface at level *A* exactly balances the weight of mercury in the column between levels *A* and *B*. If the pressure on the exposed surface of the mercury increases, then level *A* is pushed down and *B* rises. Thus the atmospheric pressure can effectively be measured in terms of the length of the mercury column *AB*. In all but freak weather conditions this length lies somewhere between 28 and 31 in. (between about 70 and 80 cm.) at places at or near mean sea-level (M.S.L.). Since horizontal pressure gradients are of primary interest to meteorologists, barometer readings are "reduced" to a standard altitude. In all but generally high level territories M.S.L. is taken as the standard reference level and mercury barometer readings are modified by simple calculation to yield the probable atmospheric pressures at M.S.L. Meteorologists and aviators find it more convenient to talk of pressure in terms of millibars rather than lengths of mercury. By definition a millibar is a pressure of 1,000 dynes per square centimetre, but we need only remember that the range 950 to 1050 mbs. corresponds roughly to the more familiar 28 to 31 in. of mercury.

Taken throughout the year, the mean atmospheric pressure over the British Isles is about 1014 mbs., while the highest and lowest recorded in these isles during the past 100 years are 1054·7 mbs. and 925·5 mbs.

The Pressure Map

As soon as pressure measurements from a number of observing stations are available a pressure map can be plotted. Figure 1.2 shows a typical map for Europe and part of the Atlantic. The observing stations, some of which are ships at sea, are indicated by small circles.

To the right of each "station circle" are the last three figures of the pressure in millibars and tenths of millibars. In other words the 15·0 at Dublin denotes a pressure of 1015·0 mbs. and the 96·4 at the ship near Greenland means 996·4 mbs. This is an international system of plotting pressure on weather maps. In practice there is seldom any doubt in deciding whether "9" or "10" should precede the three plotted figures.

The first step in diagnosing the pressure pattern is to draw *isobars* on the map, isobars being lines joining places having equal pressure. Drawing these lines for the values 996 mbs., 1000 mbs., 1004 mbs. and so on yields the pressure map for 06 GMT 19 May 1957. The pattern reveals two areas of low pressure which we label "*LOW*." They may be referred to as *depressions*, or simply *lows*, while the suitably labelled high-pressure area has the alternative name of *anticyclone*. The pressure map also shows a *trough* (of low pressure), a *ridge* (of high pressure) and a *col*—that is a region of fairly uniform pressure between two highs and two lows. It is difficult to measure the precise dimensions of these features labelled on the pressure map but, roughly speaking, the depression over the North Sea is about 600 miles in diameter and the anticyclone west of Spain covers an area of approximately 1,000 × 500 miles. Meteorologists would consider these dimensions as quite normal. Depressions or anticyclones of less than about 300 miles in diameter would probably

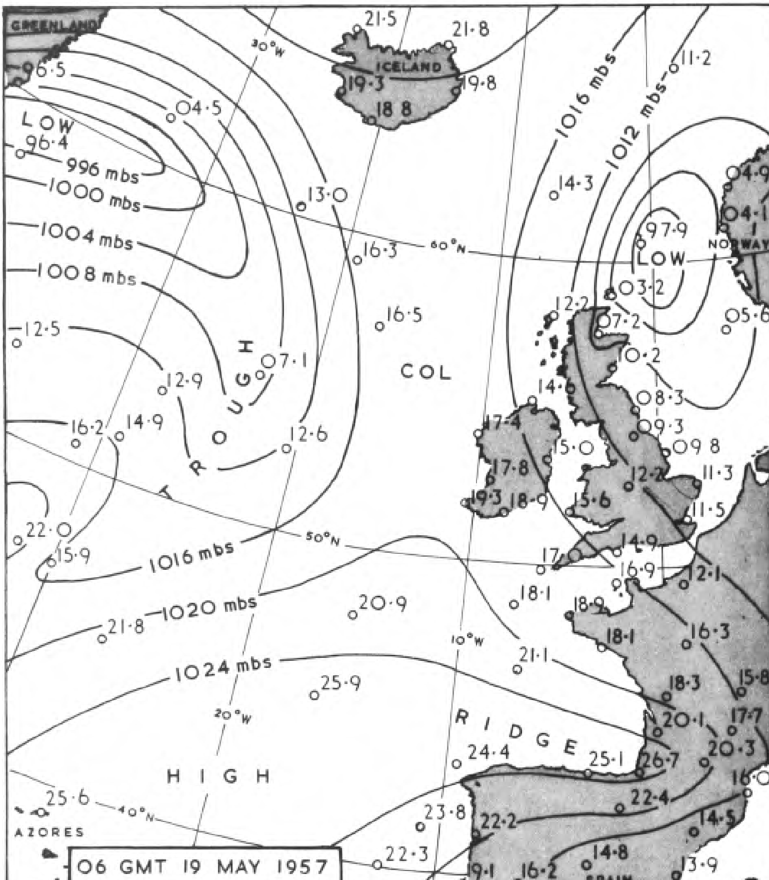


Fig. 1.2. The atmospheric pressure map for 06 GMT 19 May 1957. To the right of each "station circle" are the last three figures of the pressure in millibars and tenths, e.g. 25·6 at the Azores denotes a pressure of 1025·6 mbs. while 96·5 in Greenland means 996·5 mbs.

be described as small but the figures quoted in this chapter should not be taken to define rigid limits; they merely serve to acquaint the reader new to meteorology with the magnitude and character of pressure systems in general.

At most meteorological offices pressure maps are prepared at regular intervals throughout the day and night, the conventional chart times being midnight, 6 a.m., 12 noon and 6 p.m. GMT (or,

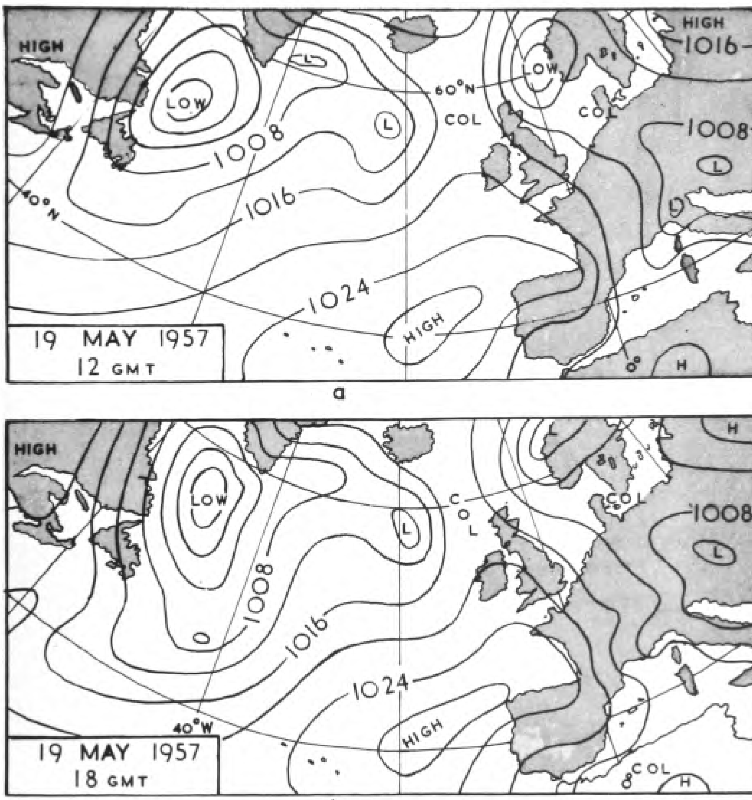
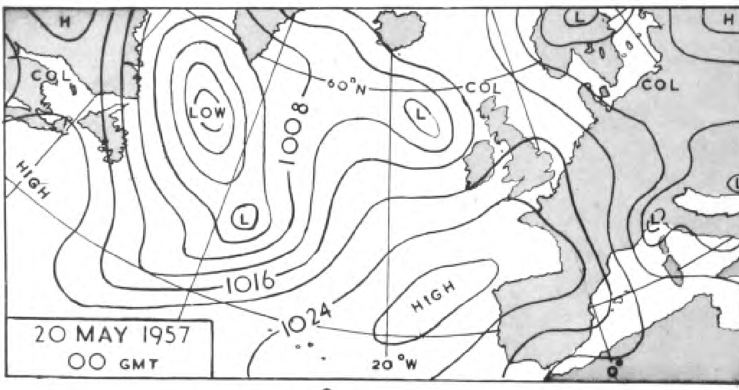


Fig. 1.3. The sequence of six-hourly pressure maps shows the development of a secondary depression over the Atlantic. The last three charts show the tracks of the principal lows and highs with dots to indicate the positions every six hours. *See also* pages 6, 7.

more professionally, 00, 06, 12 and 18 GMT). A number of stations supplement these main charts with intermediate 3-hourly or even hourly maps, and once a sequence of charts is available the movement of current depressions and anticyclones can be measured. For example, in the sequence of charts shown in Figure 1.3 we can trace the movement of the lows and highs by noting their positions every 6 hours. The western half of the first chart, 12 GMT 19 May 1957, is dominated by a large depression from which a trough extends towards the south. By 18 GMT a small new depression had appeared



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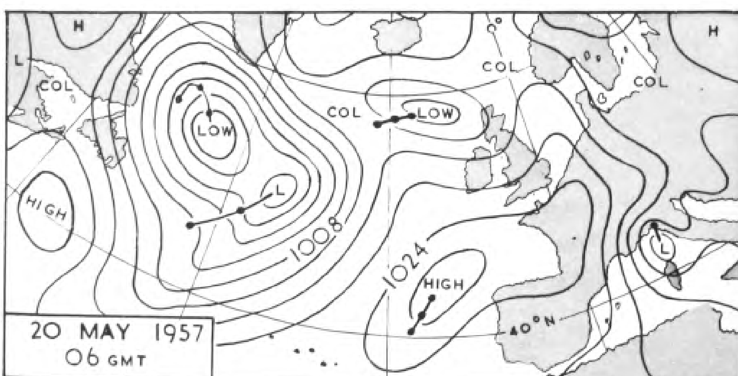

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Fig. 1.3—*continued*

in this trough, and during the next 24 hours this *secondary depression* deepened and moved on a curved track towards Iceland. At first it moved along this track at over 40 knots but a gradual deceleration brought the speed down to 20 knots by the end of the sequence. Meanwhile the "primary" depression turned from its northerly track towards the south-east so that the two depressions over the Atlantic showed a tendency to rotate about each other.

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Abbreviations :

G — *Gliding* (to Summer 1955)
SG — *Sailplane and Gliding* (from October, 1955) } Official organ of the British Gliding Association.

MM — *The Meteorological Magazine*—Published by the British Meteorological Office.

W — *Weather*—a monthly magazine
QJ — *Quarterly Journal* of the R.M.S. (An advanced level journal) } Published by the Royal Meteorological Society, London.

SAR — *Swiss Aero Revue*—Official organ of the Swiss Aero Club containing contributions from the Organisation Scientifique et Technique Internationale du Vol à Voile (OSTIV).

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