I

FIRST PRINCIPLES

Every day you either make or receive an *inference* of your own past, present or future weather. 'An anticyclone', you read in the paper, 'is centred over this country.' 'Turned out nice again,' you say when you see the sun.

Those are inferences. In this country you cannot do without them. Upon them may hang all your plans for the day. On their accuracy rests success or disaster, whether to health or to clothes, to picnics or harvests, work or play. You need to know both how to interpret the inferences you receive, and how to make your own more easily.

The idea of this book is to help you. It is a single observer's record of his own weather with a running commentary to explain all its changes. Whilst requiring no more elaborate instrument than a thermometer, it is quite good enough to illustrate how meteorologists in this country think of the weather, how they talk of it, how they have it reported, charted, analysed and finally forecast.

What we must learn is their language. They think of the weather in rather the same way as doctors think of your health. They *diagnose* and *prognose* it. First of all they have it reported. The report is not the whole story. It just says what happens on the surface. For the doctor it may be a rash on the surface of your body. For the meteorologist it may be rain falling on the surface of the earth. It is just the chief *symptom*. Your doctor also notes exactly your temperature and perhaps blood pressure. So do we note the temperature and barometric pressure of the air. Just as an abnormal body temperature means something wrong or abnormal inside, so an abnormal barometric pressure means something abnormal aloft. You can no more easily go up to see for yourself than the doctor can see for himself inside you. Without an operation you must learn to judge from outside. That is diagnosis. The simplest observations, in fact, are not actual measurements but mere classifications of how things look, or how you feel. The expert completes the picture, and uses the picture to size things up. His diagnosis sometimes is only of the immediate cause of the symptoms. At other times it goes deeper. Diagnosis, of course, is half-way to prognosis or forecast. Only meteorologists cannot cure! This book is of observations with diagnoses, showing how they were made for one place for one season.

For diagnosis the doctor must know how the body is built. So must the meteorologist know the atmosphere. How is the atmosphere built? It is really an ocean. It contains water, but mostly as vapour. Rain, snow, clouds, fogs—all these kinds of bad weather consist of water in liquid or solid form. As long as the water is only vapour the weather is fine. So the weather is simply a matter of water changing its state. But that means gain or loss of latent heat, for which Nature has a rationing system. The pressure and temperature determine a limit to the amount of water vapour the air can hold. Suppose they are lowered too far for the air any longer to hold all its water as vapour. The surplus water must be condensed. Into what? Into fog or clouds or even into PRECIPITATION as rain or snow. That is bad weather. The weather, you see, consisting of

precipitation
clouds
visibility
wind } familiar, non-technical elements

is determined by laws of Nature with

temperature
pressure
moisture } technical elements.

Having reported them, what do we do with them next? The best way here to use what is known, in order to estimate what has hitherto been unknown, is to plot them on charts and then draw the charts up. In experienced hands this is a remarkably rapid and accurate method, combining science with art. In effect the weather consists of certain *properties* of the air. Air is a fluid. Fluid motion has its mechanics as well as its beauty, its science as well as its art. This particular science is hydrodynamics, and has its own technical terms. Any change in any property of a particular MOVING PARTICLE or ELEMENT of a fluid is called a TOTAL change. Any change in the property, on the other hand, at a particular FIXED PLACE in the fluid is called a LOCAL change. Air which rises above hot ground, for instance, cools as it rises: that is a 'total' change of temperature in the rising air. But at the ground, a *fixed place* in the rising air, the temperature may stay the same all the time. The 'local' change is zero. A change of weather, then, at a fixed place, is simply a local change in certain properties of moving air. Obviously it can be analysed into two parts:

I. 'Total' change;
II. 'Advection', or BODILY TRANSPORT of properties by the flow.

To the weather, therefore,

total change contributes NEW properties of OLD air, while
advection contributes OLD properties of NEW air.

For total change the appropriate chart is ideally a map of the weather at all levels, one time and one place. That is an aerological or upper-air chart. For advection, on the other hand, the appropriate chart is ideally a map of the weather at all places, one time and one level. That is a synoptic chart. SYNOPTIC weather analysis, in short, tells you *where* and *what* the air is, while AEROLOGICAL analysis tells you *how* or in what state it is. The atmosphere consists of great masses of air, in each of which many properties are horizontally almost uniform, so that a new type of weather occurs with a new air mass. The line or zone of transition is called a front. So the weather is commonly analysed in terms of WEATHER TYPES, AIR MASSES and FRONTS.

Your doctor must also know how your body *works*, and so must we know the atmosphere. How does it work? Where is the air hottest? In the tropics. So there it must rise, accordingly flowing in over the ground and out up aloft. Beneath it the world is turning round. But motion is purely relative. We think of the ground as being at rest while the atmosphere does the turning. In northern latitudes as the earth turns anti-clockwise relative to the heavens, so must the air or heavens turn clockwise or always *to the right* relatively to the earth. The air, in short, when moving freely over the earth, always starts to turn to the right as if pushed by a force. Otherwise we say it is not moving freely. At any rate we always assume this force. From high to low pressure, of course, is also a force. To balance it, therefore, at any one level, the push to the right must act from low to high pressure. So keeping the high pressure always upon the right-hand side of its path the wind must blow *round* the high or low pressure according to the famous law of Buys Ballot: 'If (in northern latitudes) you stand with your back to the wind, then the pressure is lower upon your left hand than upon your right.'

Winds thus blow into the tropics not from north, but from a more easterly quarter. In southern latitudes, where the winds turn to the left instead, they enter the tropics not from south but again from an easterly

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quarter. Emerging therefore aloft from a westerly quarter in both hemispheres they presently come down to earth as ex-tropical WESTERLIES, such as the old mariners' Roaring Forties, Furious Fifties and Shrieking Sixties. The high pressure, which is then on the right-hand side in northern latitudes or the left-hand in southern latitudes, must in either case be upon the equator side. As it must be *between* the Forties and the tropical easterlies, it must be at the *edge* of the tropics. So there must be a SUBTROPICAL HIGH-PRESSURE belt. On the other side of the westerlies must be low pressure.

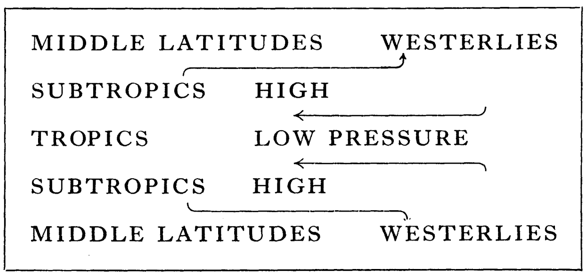

Fig. 1. General circulation.

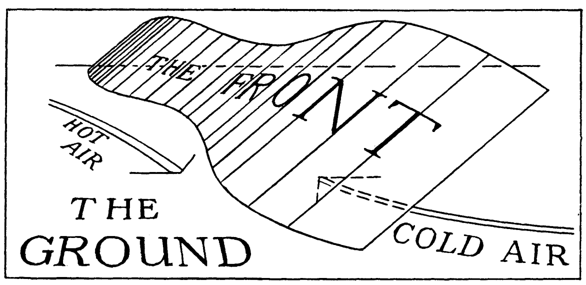

Fig. 2. Polar front.

Should the pressure be higher again beyond it towards the poles, then there must be polar easterly winds. Between these and the warmer westerlies is a kind of war. The battle front is the so-called POLAR FRONT.

What is it like? The force of gravity, as you know, makes hot air tend to lie horizontally over cold. The extra force that pushes the air to the right or left makes it lie at a slant instead. The mechanics of it are not very simple, but that is the rough idea. The 'front' is therefore a sloping surface between different air streams which you may regard as two kinds of fluid with different flow. Now when wind blows over water we also have two kinds of fluid which differ in flow: and what does the surface between them do then? As long as the two streams differ enough there are WAVES. Either short ripples or long waves, once started, they grow by themselves, and as they travel they may do damage. So does the polar front. So, in fact, does the front or boundary surface between *any* two sufficiently different air masses. We are most concerned with its big long waves that develop DEPRESSIONS, extensive bad weather and immense power.

Under water we can make the pressure uneven at any one level by having some hot and some cold, as we do in the bath. In the same sort of way we have average pressure low over land in the summer and high in the winter. But in the bath to get really low pressure you pull out the plug. Quiet at first, the flow is nevertheless unstable, as it may change to a whirl. Quiet frontal air-flow may likewise rapidly change to a CYCLONE or circulation round a low-pressure centre, tending to move with the warmer air until it has so distorted the original wave as to have destroyed it. Others follow,

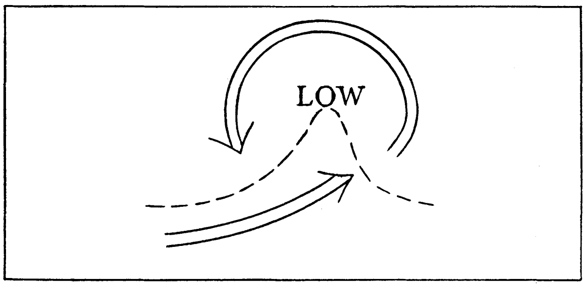

Fig. 3. Air circulation round a wave in a front.

often successively farther away from the poles until the cold air breaks right through the region to reign in peace with high pressure. Victorious in its final battle it sweeps all the old air away to the tropics and settles itself in sole occupation. Surging into the tropics, in fact, it feeds the sub-tropical high-pressure zone with its fresh high pressure, so that it may make its influence felt all the way to the equator. Meanwhile, of course, being strongly heated over the tropics it becomes tropical air and rises well laden with moisture over tropical seas to return to a new polar front. So the rest of the world gets its rain.

That is the shortest possible outline of HOW THE AIR-FLOW ALTERS THE WEATHER BY BRINGING OLD PROPERTIES OF NEW AIR. Now what, on the other hand, brings *new* properties into *old* air?

Air is HEATED by (1) descent and compression,
(2) warmer land or sea,
(3) condensation of water.

It is COOLED by (1) ascent and expansion,
(2) colder land or sea,
(3) evaporation of water.

Sufficient ascent of air over fronts or mountains, for instance, makes water vapour condense into clouds or even rain. We also say that hot air rises. If it is hotter than the air *beside* it, that is true enough. But if merely hotter than the air *above*, then it does not necessarily rise. For in rising it cools itself at a standard rate, for which we have to allow. It is only *potentially* hot air that freely rises. This free rising is CONVECTION, which always goes on in the air over warmer land or sea. Any clouds formed by it tend to be of the puffy CUMULUS type. Any rain or snow from them tends to be of the SHOWERY type. Inland they normally only develop by day when the earth is warmer than all the air, but at sea (and therefore also on windward coasts) they may go on almost equally well day and night until a warmer air mass arrives.

Descent or SUBSIDENCE of air, on the other hand, normally has to make up for horizontal outflow over the ground or sea, such as in a region of high or of rising pressure. At sea-level itself, of course, the descent must stop, so the air aloft is warmed more than the air at the bottom. This tends to raise the upper-air temperature even higher than the temperature of the air underneath. The result is called an INVERSION or temperature. 'Inversion', in fact, means not merely this abnormal state of affairs but the actual layer of air that is warmer above than below. It is important because, like a kind of ceiling, it stops air rising. In clear air it cannot be seen, but in hazy air it appears as a haze top, while in damp air it is the top of a layer o cloud. Similar in effect is *any* layer of air *potentially* warmer above than below. If too low for clouds to be formed below it at all, it must tend to make the weather FINE (unless there are clouds higher up). If the air is damp enough to make clouds below it, the weather will be of the CLOUDY or overcast type. If the layer is higher, however, so that the clouds have room to begin to dry out, the weather may be of the FAIR type. There you see, are three main weather types already partly explained.

Having outlined it, we must consider what weather analysis really is. To-morrow's weather, for instance, is forecast from to-day's. How? Ideally by applying all the laws of Nature to all to-day's weather conditions. In practice we may know more of the laws than of the conditions, or *vice versa*, so that we just have to do our best. THEORY tells us what laws to apply, while OBSERVATIONS tell us to-day's conditions. The idea of weather analysis is to express them in the same language; for only then can the laws be applied. What is the language to be?

Our analysis of total change, namely of the way in which properties change as the air goes along, is largely a matter of thermodynamics, the theory of heat flow. That is part of physics. It speaks of temperature, moisture, pressure—physical terms. Analysis, on the other hand, of advection, namely of the way in which properties are bodily carried along by the air-flow, is largely a matter of aerodynamics which is a branch of hydrodynamics, the theory of fluid flow. That is part of mechanics. It speaks of density, pressure and circulation or flow—rather more mathematical terms. Air density, however, can be expressed in terms of pressure and moisture and temperature, circulation or flow being a matter of wind. *Both* parts of weather analysis are thus boiled down to the same elements, MOISTURE, PRESSURE, TEMPERATURE and WIND—the ABCD of the language. If theory and practice are to talk the same language, then we must express observations in the same terms as these. Wind is already one of the four weather elements we have observed. Moisture, pressure and temperature can equally well be measured. All that remain are PRECIPITATION, CLOUDS and VISIBILITY to be described in figures too.

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II
THE CODES

Synoptic weather reports describe

(i)	*precipitation or general weather*	capable of adequate description in figures by mere classification, requiring no instruments,
(ii)	*clouds*	
(iii)	*visibility*	
(iv)	*wind*	
(v)	*temperature*	requiring instruments.
(vi)	*pressure*	
(vii)	*moisture*	

Our reports (see e.g. pp. 22, 23) use (i)–(v), tabulated in thirteen columns. Instruments are often required elsewhere for some of the first four elements, particularly for wind, but have not been used for reports in this book.

Column 1 gives the Observation Station Number. The weather partly depends on PLACE, which must therefore always be stated, preferably by a simple number. The following table explains the place numbers used in this book.

No.	Name	Latitude N	Longitude W	Height (ft.)
01	West Norwood, London	51 26	00 06	270
02	Streatham Common	51 25	00 07	250
03	Merstham, Surrey	51 17	00 09	400
04	Norbury	51 24	00 07	100
05	Wandsworth	51 27	00 12	100
06	Mortlake	51 28	00 16	20
07	Kew	51 29	00 17	20
08	Upton, Hants.	51 17	01 29	400
09	Andover	51 12	01 29	250
10	Brookwood	51 18	00 38	150
11	Tooting	51 26	00 10	50
12	Wimbledon	51 25	00 12	100
13	Malden	51 24	00 15	50
14	Kingston	51 24	00 17	40
15	Hampton Court	51 24	00 20	30
16	Mitcham	51 24	00 10	100
17	Addiscombe	51 23	00 04	150
18	West Dulwich	51 26	00 05	125
19	Upper Norwood	51 25	00 05	350
20	London (the City)	51 30	00 05	20

They were assigned by the writer himself, as you yourself might, starting at home with No. 1 and then adding one to the list every time a change of weather was noted from some place not already numbered. All but a few observations, however, were made near London, so that the changes of place do not make much difference. The *idea* of numbering observation stations, however, is universal.

Column 2 gives the DATE.

Column 3 gives the TIME, G.M.T. This book's reports, unlike standard Meteorological Office ones, were made not at fixed hours but just whenever changes were noted. That seemed the best way, though restricted by other duties as well as by every night's sleep. If your reports are made for a central office with hundreds of others to add to the picture, then naturally you report at regular times; but to complete the picture yourself you note the weather just whenever you can. That is what the writer has done.

Column 4 describes the WEATHER by standard abbreviations, thus:

b=blue sky: fine weather
bc=blue sky with clouds: fair weather
c=cloudy
d=drizzle (moderate, or unspecified)
dd=drizzle (moderate), continuous
d_0=drizzle (slight)
d_0d_0=drizzle (slight), continuous
D=drizzle (heavy)
DD=drizzle (heavy), continuous
e=wet air, wet fog
f=fog
F=dense fog
g=gale
h=hail
i=intermittent...
j=...in sight, though not occurring at your place itself
k=storm of...(e.g. sand) arising with violent wind
l=lightning
m=mist
o=overcast
p=passing showers
q=squalls
r=rain
rr=continuous moderate rain, and so on as for drizzle
s=snow
ss=continuous moderate snow, and so on
t=thunder
u=ugly, threatening sky
v=unusual visibility
w=dew
x=frost
y=very dry air
z=haze

Capital letters thus mean a heavy or intense variety; suffix '$_0$' means 'slight'; repetition denotes continuity, while prefix 'i' stands for intermittence. '+' denotes increase, '−' means decrease, and (in this book only) '>' means 'becoming'. '/' (oblique stroke), followed by any weather abbreviation, means that that weather has arisen *since* the time of the last recorded observation although it may now have ceased. SHOWERS are distinguished from 'intermittent' or 'occasional' rain or snow, not because

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they are any less wet, but because they come from quite different upper-air types, with different causes, different accompaniment such as bright intervals or squalls, and different development, such as a tendency to die out inland at night.

Column 5 gives the total CLOUD amount in OKTAS or eighths of the sky (as seen from the ground).

Columns 6–8 describe the forms or types of clouds, low (L.), medium (M.), and high (H.). Notoriously hard for beginners to describe correctly, they are nevertheless our most valuable information. 'Show me your tongue' says the doctor; or 'Let me see your rash'. A glance at those outward signs is often enough for his diagnosis. Likewise a glance at the clouds is often enough for a diagnosis of how all the upper air is, if not indeed to tell what type it is and whence it has come. Just as the doctor looks only for certain signs as symptoms of certain disorders, so we classify clouds by certain features as symptoms of certain weather types. Readers are recommended to learn the standard international classification illustrated in a cloud atlas, of which a useful summary is the Air Ministry's Meteorological Office handbook of *Cloud Forms* (H.M.S.O., 1949 edition), from which some definitions will now be quoted as well as those used by the writer. The writer himself had originally no more guidance than the bare definitions published in the quarterly *Introduction* to Meteorological Office *Daily Weather Reports*, so that again he departed slightly from Meteorological Office standards, and these in turn have since been slightly altered, with the result that the cloud-type numbers in this book do not quite correspond to those you will nowadays find in *Daily Weather Reports*. As far as possible, however, they have been brought up to date. Here are the main types:

HIGH CLOUDS

(GENERALLY ABOVE 6 KM. OR 20,000 FT.)

1. CIRRUS (abbreviated to CI), the wispy type made of crystals of ice, with blue sky showing.

Officially defined as

DETACHED CLOUDS OF DELICATE AND FIBROUS APPEARANCE, WITHOUT SHADING, GENERALLY WHITE IN COLOUR, OFTEN OF A SILKY APPEARANCE.

Cirrus appears 'in the most varied forms such as isolated tufts, lines drawn across a blue sky, branching feather-like plumes, curved lines ending in tufts, etc.; they are often arranged in bands which cross the sky like