

METEOROLOGY

NOTES FOR STUDENTS

THE following notes have been prepared for pilots and observers before they start elementary flying training. Their purpose is described in the introduction given below.

SUMMARY

- I. **Introduction : Meteorology and Air crews.** Growing importance of meteorology. Reasons why air crews should study it. Personal weather observations. Co-operation with meteorological staff.
- II. **Atmosphere, pressure and temperature.** Composition of atmosphere. Nature of air pressure. Measurement by mercury and aneroid barometer. The Mk. XIII aircraft altimeter. Vertical and horizontal pressure changes. Vertical and horizontal temperature changes. Height, temperature and air density. The five temperature zones.
- III. **Wind.** Wind velocity. Terminology for surface and upper winds. Wind changes with height. Value of accurate wind estimation in navigation. Gustiness and bumpiness, particularly near surface. Effects on flying.
- IV. **Cloud and Fog.** Cooling of rising air. Dewpoint. Water-deep and ice-crystal clouds. How rising air currents may be set up. Heap and layer clouds; examples of formation and associated weather. Fog in relation to flying. Fog formations by night cooling over land, and air movement at sea. Fog thickness variations.
- V. **Weather.** Rain formation; light and heavy rain. Formation and nature of snow, sleet and hail. Thunder and lightning; cloud types and weather associated with thunderstorms. Flying conditions and precautions to be taken in thunderstorms. Glazed frost; favourable conditions for ice formation on aircraft.
- VI. **Clouds.** Reason for using technical terms in meteorology. Importance of knowing cloud types and associated weather. The ten fundamental cloud types. Meaning of prefixes and cloud-names. Cloud heights. Set of cloud photographs and notes from Cloud Atlas for Aviators. Cloud reporting; amount and base height. Cloud observation; balloons and cloud searchlight observation, comparing with high ground, and observing from aircraft. Judging cloud height by eye. Estimating cloud thicknesses.
- VII. **Visibility.** A definition. Measuring visibility by day. Visibility Scale, 27 yards to 31 miles. Measuring visibility at night.
- VIII. **Wind.** Vearing and backing. Measuring surface-wind velocity by instruments and by eye. A condensed version of the Beaufort Scale. Measuring upper wind velocity by pilot balloons and cloud observations.
- IX. **Pressure, temperature, humidity.** Pressure readings; the millibar unit is used. Average millibar pressure at mean sea level in British Isles and average pressure increase with height. Effect of horizontal pressure variation to forecast wind velocity. Pressure corrected to sea level. Use of mercury barometer by duty pilots. Measurement of temperature on ground and in aircraft. Aircraft thermometers, etc. Relative humidity; saturated air; dewpoint. The wet and dry bulb thermometer and its use in forecasting.
- X. **Altimeters.** Example of pressure change effects along a flight track; effects of changes of pressure on altimeter readings, and some rules to remember. Need for a sensitive altimeter. The Kollsman Sensitive or Mk. XIV altimeter described. Setting and reading the altimeter. Temperature allowances.
- XI. **Introduction to the weather map.** The Beaufort weather notation, general character. Wind force. How weather maps are constructed. Information extant on weather maps; a simple map, Isobars; meaning, how drawn, how they change. Wind force and isobars. Buys Ballot's law.

I. INTRODUCTION : METEOROLOGY AND AIR CREWS

1. As soon as flying began pilots started to ask the meteorologist questions—frequently questions he could not answer. But usually pilots avoided flying in bad weather. Affairs have marched with rapid strides since then. Our bombers go five or six hundred miles from their bases to raid Germany; several times they have crossed the Alps, twelve to sixteen thousand feet high, to raid Italian targets a thousand miles from home. Every day new aircraft are ferried non-stop from west to east across two and a half thousand miles of Atlantic ocean to be handed over to the R.A.F.

2. Such flights are never carried out regardless of weather. Skilled crews, it is true, can fly in weather which would defeat a beginner; but all crews, from those newly teamed up to the seasoned hands, study the weather closely and plan their

flights on deductions made from such study. This presupposes that they can speak the same language as the meteorological officer. He reduces the information he has to the simplest possible terms, but there is a stage beyond which he cannot go. *A depression, a cold air mass, a trough of low pressure* are the best and simplest ways of describing certain meteorological features unless one is to have a lesson from first principles every time each is mentioned. If such terms do not conjure up to the crews a mental picture of the weather associated with them, they cannot get full value from discussions with meteorological staffs. Nor can they ask the right questions to draw out special information that they may need.

3. Before the war it was possible to give more exact and detailed information than it is to-day

Inasmuch there was no standard system for broad weather data at frequent intervals from a central location, the author did not feel the way he chose to do it was a plan of any value. His own personal experience clearly will show that unorganized meteorologists tend to do reports on developments on the high seas to assist weather data by wireless because this would disperse their patients to all over-bringing storms. Thus a symphony chart of weather changes shows little information for the Atlantic or the continent. To fill such gaps of course was being held information of great value.

4. What information do we see being had? An application of physics as they can be of the weather elements can be seen in a running commentary given in the first place by those below. While the data may be good, the author has no access to them. If they know what to look for, how to recognize what they see, and how to record it, in fact, they need have a working knowledge of the principles of meteorology. These short lectures can be put in practical use. Within a few months except these papers are also shown in detail, given in the first place. Here they are described in words more under-standing than in the running bulletins in a chain of evidence plus take advantage of the fundamental operations. By taking this bell and action the weather that was packed of clouds, they cannot correlate with visibility and help make flight safe to improve their markings on the weather comment of each of these comments.

5. Is summaries, air crews need to study meteorology...

6. For their own efficiency and safety.

7. In understanding the mission in which they will operate, since this will apply to all who have to live in the atmosphere from the advantage, convenience in correlating all ratings, over those who are ignorant of it.

b) to enable them to discuss weather information with meteorological staff;

(c) to bring back flight weather reports that will be of value to others.

5. This is much that can only be learned in the school of experience, and crews should make every chance to add to their book and increase their knowledge by observations from the general and flight, and from other meteorological staffs.

A habit of looking at the weather cannot be acquired too early. If in one of the parties of good citizenship, a man who the author knew the direction of travel he observed in it, in the short, or prison, or hospital, he would have in his habit of looking at the weather. He should have a mental picture of the weather he sees, and he can make more than may be to him. This will be found particularly useful record pictures of what the weather caused him to see and what it likely to be in the near future. While in the wind shearing—looking or looking, decreasing or increasing in strength. By these should increase their reactions to flight to determine the best time of night to land. When to land, when to fly. When to fly high, when low. When to land on the ground, when to descend vertically upwards for himself. To keep him safe, have been made at the end of each chapter on "How to look at the weather".

6. Discussions with the meteorological staff are available. They welcome visits from air crews because it gives them a wider understanding of flying, positions and larger than in touch with the practical purposes of their work, while by hearing teachers, and among scholars, can learn and apply to their weather knowledge.

7. There comes at the first several chapters of A.P. 1911, Meteorological Handbook, for Pilots and Observers. The following chapters are intended for study during the flying training period.

J. THE ATMOSPHERE, PRESSURE AND TEMPERATURE

The Atmosphere

a) The atmosphere consists of a mixture of nitrogen and oxygen together with small and negligible but very minute amount of residual water vapour. It also contains relatively small quantities of liquid and solid matter in water drops, ice crystals and small dust and minute particles and solid crystals. All these which have been seen very readily and are not uniformly diffused throughout the atmosphere are air and water vapour. They are however, very important for without them there would be no creation.

b) Atmosphere

c) The atmosphere is a fluid with depth, and can exert a pressure just as water pressure is exerted by a body of water. It is true that air is relatively very light, but the atmosphere is very deep and its pressure at the earth's surface is considerable, being equivalent to that caused by a depth of 30 ft. of water.

d) The pressure of the air is usually measured for R.A.F. purposes with a mercury or an inverted barometer. In the former the pressure of the air is balanced against the weight of a column of mercury

ATMOSPHERE, PRESSURE AND TEMPERATURE

BIRTH OF DAY

carried inside a glass tube; in the latter it is balanced against the expansion of the flexible lid of a box. The box is hermetically sealed and almost entirely exhausted of air, and the movements forwards or backwards of the centre of the lid move a needle over a recording-dial. Since there is almost no pressure inside the box, the centre of the flexible lid is moved inwards, while the centre of pressure moves it by three scale sets.



Fig. 1. Simplified Diagram of Altitude

When air pressure is lost distance, i.e. increasing altitude in pressure of air, from sea level, and either above or below sea level, causes gain in density.

The mystery disappears in the more accurate of the two, but it is not so easily possible, as the second instrument is considerably an early piece of apparatus. The pilot will use the primary barometer in taking pressure readings during his course of flying pilot.

Pressure and Altitude

a) Pressure decreases with increase in the atmosphere, because of the relative load of air. This is used to indicate in the case of an aircraft with considerable altitude, their height above the ground level from which they take off. The aircraft has altitude when in motion are carried by air, and the air is lighter, so that height is measured by pressure. The variation of pressure with height depends on a small factor as the temperature of the air, and its densities must be made for this for private work, particularly at great heights. Each altimeter has a handle to set the scale to zero as the height of the aeroplane before the flight begins.

b) It is important to note that the altimeter does not necessarily measure the height of the aircraft above the earth but actually beneath it. Given the same air and even with the same temperature, one can measure his position by setting the scale height as the ratio in an aeroplane flying close to the mountains and at the same level as the top.

Horizontal Change of Pressure

a) Besides varying vertically, pressure also varies horizontally, though the change is not horizontally in nearly thousands of miles smaller than the change in space it vertically. The horizontal change comes, however, to replacement. In aircraft flies with its altimeters keeping the same reading of height above sea level, the thin height above sea level will change. As such a flight is to start lower pressure the aircraft will actually be descended, and towards higher pressure the aircraft will be ascended. The important point will be discussed in more detail later.

Temperature

a) The air temperature in the lower seven miles of the atmosphere nearly always decreases with height, normally by the rate of about 1° F. per 1000 ft. It is possible for the temperature above about seven miles to increase again by as much as 1° F. per 1000 ft. in a range of height. This often leads to bad conditions when at a level of about seven miles in the atmosphere the temperature becomes almost constant. The lower part of the atmosphere where the temperature normally falls as the altitude is called the "Troposphere", and the upper part where there is little or no change of temperature with increase in height the "Stratosphere".

b) Air temperature also changes horizontally. Equally as the air passes over the edge of the earth or a hill side, the rate of change horizontally is far smaller than it is vertically.

Height, Temperature and air density

a) Expressed loosely, just as liquid flows in a lot of air in every cubic foot of space, while at great heights there is very little air in an equal space. More exactly, the greater the altitude the less dense the air.

b) Imagine a gas ruler with one end cold and is fixed in the top. If we heat it at the bottom end, the air will expand and rise up the ruler. Let us to feel that in the case of a plane and the air is heated, the air in a navigation, the air expands and rises, makes air flows in and is cooled, and eventually to have a cold, heavier volume of air in the tail.

Generating thermometers

a) The student will consider how it is that air density decreases with height, since in the preceding paragraph it has been shown that a decrease in temperature causes density to increase and as air is denser, and that temperature almost always decreases with height. The fact is that the increase in density with fall of temperature only occurs when pressure is constant.



2. The Mark XVII altimeter fitted in Elementary Flying Aircraft.

(a) An increase in height is accompanied by a rise in pressure; the air then becomes less dense.

(b) An increase in height is accompanied by a fall in temperature. This is due to the atmospheric change called the 'adiabatic effect' (i.e. that density, the pressure, decreases upwards).

Temperature Zones

8. The earth's surface may be divided into four zones of temperature. The inland areas round the equator, the low temperature areas between about latitudes 30° and 40° North and South, and the two high areas around the poles. Large differences of temperature also occur between sea and land at the same latitude. In summer the land is warmer than the sea, while the reverse holds in winter.

III. WIND

Wind description

9. The surface wind is described by the direction from which it blows and by other its speed (m.p.h. or knots), its force (on the Beaufort scale, see page 22).

which will be described later, or less definitely by its strength as light, strong, etc. Thus—

S.W. 12 m.p.h.	100% in terms
S. force 3.	E.C. moderate.

Wind which is described in a similar manner, using compass degrees measured from true north, and its speed in miles per hour or knots. Both must be written 'p.h.'.

Wind speeds

10. The wind is not the same in speed and direction at all heights. A brief description of clouds, which of course move with the wind at their level, will now show how the direction of the wind at a height is opposite in direction to the wind at the surface immediately below.

Wind and navigation

11. The more accurately wind velocity at various levels is known, the more reliable navigation becomes. The following table gives some information to guide the wind navigation student in practice. Imagine an aircraft flying for 4 hours at 100 m.p.h. from an airport on a calm day.

(a) If there were no wind it would travel a point five miles from its base.

(b) Flying against a 30 m.p.h. wind it would reach a point six miles from its base.

(c) Flying with a wind 30 m.p.h. direct from the front it would pass 10 miles from its base after 4 hours.

(d) Flying with a wind 30 m.p.h. abeam it would fly 10 miles to one side of the track made good in the previous paragraph.

Wind gusts

12. Not only does the wind change with height, but the wind at any one level is continually varying in velocity. The variations are caused by

waves in the air set up by obstacles on the ground, just as the waves of a holiday come suddenly to a sandy beach. Some variation in wind speed occurs in the air just above ground near the ground. Over the soft tops of a lawn, for example, where wind is very gusty, an average wind of 32 m.p.h. from SW. may be fluctuating between 20 m.p.h. and 40 m.p.h. in speed and between W. and S. in direction. The eddies also contain up and down currents, which makes gusty air feel lighter, so the crew of an aircraft (high winds and gusts) and passengers have difficulty in getting current and becoming fatigued easily. Precautionary guidance at altitude levels calls for greater cautionness when taking off and landing as in many cases sudden changes of altitude altitude.

How to find air direction

13. Whenever you are in the open, check the wind direction by the way in which barrage balloons float, smoke drifts, flags make off and point them against a 30 m.p.h. wind a would reach a point six miles from its base. (d) Flying with a wind 30 m.p.h. direct from the front it would pass 10 miles from its base after 4 hours.

(e) Flying with a wind 30 m.p.h. abeam it would fly 10 miles to one side of the track made good in the previous paragraph.

Directions on Part III

1. There are eastern and upper-wind fully described.

2. What is the effect of wind on an aircraft in flight?

3. What causes eddies and gustiness? What makes the crew have bad flying?

IV. CLOUD AND FOG

CLOUDS

Cloud formation

1. When the air inside a bubble pump is compressed by pressing down the plunger it becomes hotter than it was before. The reverse happens when the pressure of a bubble of air is suddenly removed. This is because the air is compressed when it is being heated and expanded when it is being cooled. If we look this with our other scientific fact, we shall understand how cloud is formed. This other fact is that the higher the temperature of a column of air the more water vapour it can hold. That is to say, an invisible vapour (H. 2 O) is a mass of air containing water vapour is cooled in a temperature called the dew point,

which depends on the amount of water vapour in the air. When the water will begin to condense out in visible drops.

Therefore if a mass of air plays sufficiently in the atmosphere, its temperature will fall till the dew point, water vapour will condense out as visible drops and a cloud begins to form. Now when the breaking point is passed, the cloud will rain down water in meteorological words it is 'precipitated water'. But according to hydrologists it is 'falling water'. Thus the crystals will grow larger, the snow type. The falling crystals of ice can be predicted immediately, as when the wind is blowing across a chain of mountains, or by convection when the air is being forced from above, just as falling currents are produced in water in a bath on a flame.

Source for students



3. Fog Cloud



4. Layer Cloud

Fog of Cloud

It is a notable fact that the same terms of cloud are used all over the world. They may very frequently be described as fog-banks and layers.

Hazeous clouds are hazy in appearance and show no vertical development. The fog clouds are the clouds consisting either of clear air in suspension and droplets of water. These may be tiny or form miles thick vertically and are formed in the up-currents which occur when sufficiently deep air is strongly heated from below. The heating may be due to strong sunshine even though indirectly, the air is not directly heated by the sun, but by the air being heated by the ground and the pressure flow heating the air above. As moving from a cold surface to a warm one, fog comes from the Arctic Ocean northwards over the Atlantic, will also become heated and thus hazeous clouds give changeable weather. However, and when well developed, hazeous clouds are often very steady patterns of fine day known as bright banks.

Layer clouds are clouds lying in nearly level sheets, often covering a wide area. The sheets may be in the form of very broken, but, however, in some cases, completely continuous to top. The sheet, however, sheet clouds, will be broken over the British Isles in winter, say, in 1930. Layer clouds give less changeable weather than hazeous clouds. Any rain or clouds from them is liable to be fog clouds.

The reader should now begin daily practice in distinguishing fog clouds from layer clouds and note the different kinds of weather associated with them.

NOTE FOR APPENDIX

General

3. Small, near-surface instruments and wireless radios enabling them to operate in reduced visibility. Indeed, highly reduced eyes, with special audio aids can take off, the red and green light fog. Every day training, research and experiment continue to improve the methods of an airman to fly in bad visibility. This adds to his efficiency of flying and (not to mention efficiency in flying) but visibility still has considerable tactical effects—sometimes advantages in providing needed cover, at other times disadvantages in hampering observation, and visibility for landing may be important in giving a certain special value rôle on the tactical and the aerialman.

The main types of poor visibility over flying areas is fog. On high ground, cloud is more important as a cause of poor visibility.

Fog, like cloud, is composed of small water drops, but the drops are produced by condensation of water vapour due to cooling without vertical movement of the air.

The two main types of fog will now be described.

Fog on over land

4. This is produced by the cooling of the air near the ground. It occurs when the dry air is cold and the wet heat. It is a condition in which the air is cool and below its dew point. Dense air and damp ground are therefore both favourable for night fog.

The cooling is most pronounced in valleys and head depressions, and it is quite common for fog

to form in these places when there is no fog on surrounding higher ground. This kind of fog is often called local or secondary. Except in winter, it usually clears in the morning owing to radiation heating, but in winter it may last day and night until it has been blown away or mixed it with warmer air over the top of the fog and driven it to dissipate.

Fog due to air movement

5. Fog arises to identify this type, forming in air currents blowing from a warm to a cold sea if they blow in strong winds, not under cloudy skies. When air moves from a warm sea eastward, the lower parts of air are cooled, and of their temperature is brought below dew point, fog will form, the best example of this kind of fog being the fogs of the North Sea Banks. These in fact are in fact the cold German waters moving over the cold sea current between Labrador and Greenland. Fog may also be formed in this way when winds in winter move over cold ground.

Fog thickness

6. Night-falling fog which forms from the air over early and night may be only a few feet thick, but gradually extend up to 100 ft. The depth increases with time; for example, winter fog over the sea may extend up to 100 ft. (see Fig. 1), and 1,000 ft. in the case of a valley depth, sometimes deep and narrow as shallow as the width of ships normal officer staterooms.

F. WEATHER

Hail

1. Hail consists of hard pellets of ice of various shapes and sizes produced by falling raindrops being caught by cold descending currents of air and carried up into air at a temperature below freezing point by a sufficient time for them to freeze. The ice pellets grow by accumulation of water droplets until the number of droplets is sufficient, when because of the adhesion between the falling air is impeded so far because the air cannot rise. Hail can only be formed in clouds of great vertical extent containing violent descending currents, i.e. the large cumulo-nimbus clouds.

Thunderstorms

2. The large cumulo-nimbus clouds are very powerful electrical machines generating huge electric charges. Ultimately the electric discharge may become so great that the resistance of the air breaks down and the electric spark leaves as a

(cont'd. on reverse)

Hour to look at the weather

2. Learn to distinguish fog and layer clouds from each other, and to look up all water knowledge of the subject. I have

It was a fine sunny day in April with showers, and winds with a light northwesterly breeze. It became much lighter during the morning and layer clouds began to form. By afternoon they had become very large and a band distant thunder. There were five clouds of heavy rain with a wind blowing from all directions. In the evening the clouds gradually grew smaller.

Another example:

It was still, excepted with low cloud, drizzling and blowing land from SW. Wind force. The wind soon quickly went round to NW. and when it has been blowing strongly from that direction, there have been a few showers, long periods of sunshine and visibility has been much better than it was this morning.

Questions for Part IV

- How is cloudiness measured in flying sky?
- How are clouds named?
- All wind forces of the year are the prevailing uppermost ones?
- Describe briefly the weather associated with each cloud type.
- Describe the two main types of fog.
- What may these fog be expected to form?
- What would prolonged fog do to a shallow tank?

METEOROLOGY

Look at lightning areas. Thunder is the noise produced by the lightning sparks. It is not possible to predict where lightning will strike. However, certain areas do seem to be more likely during the interval between seeing the first lightning and hearing the resultant thunder. The sound of thunder travels one mile in five seconds while the light is seen practically instantaneously. Very heavy rain, and often hail, falls in thunderstorms, and the violent vertical air currents inside the clouds give extremely 'bumpy' flying conditions which are dangerous to inexperienced pilots.



Ground at the same time.

- Region of violent pressure going two-thirds total height.
- + Region of increased pressure going one-third total height.

g. Airflow around wing is slowed and causes icing conditions.

The most important type of icing is called 'planing frost'. This forms on over an aircraft flying in air at a temperature below 0° F., though which rises in altitude. Frost takes some time to form when flying through air at a temperature below 0° F. and above -10° F. It is very difficult to see in this case, and it is very hard to tell which is which. The most important forms of icing occurs on an aircraft flying through a cloud of suspended water droplets. If the temperature of circling water drops is reduced below freezing point, and the drops are not disturbed, they do not freeze for a long time. Any disturbance, or strong air current from an engine, will cause them to rapidly freeze. In this case, the cloud provides the necessary difference and the drops freeze on to it, forming a transparent coating of ice. Such icing is more dangerous than the first type and often found in large clouds.

How to look at the weather

8. This chapter, elementary though it is, should open up many new interests, looking at clouds

flown in aircraft for no long while, such as a window seat or a cabin forming a large balcony from it, the dangers from lightning are surely obvious.

Lightning

a. Ice may form on an aircraft in flight. Devices which will be described later exist for preventing ice formation, but in their absence it may form a danger, owing both to the increased weight and to the change in wing section shape.



Airflow around wing with heavy coating of ice on leading edge causing distortion of flow and reduction loss of lift.

that gives clouds, steady rain, heavy showers, short, sharp and fast; having no wind changes with each weather; weather, both a wind angle, weather change when thunder, lightning and hail occurs; trying to guess when aircraft icing would be likely at low levels.

Questions on Part V

1. Why does water fall sometimes in fine drizzle and sometimes in heavy rain?
2. What temperature conditions give snow and sleet?
3. How is hail formed?
4. Are thunder and lightning dangerous to aircraft?
5. Describe briefly the conditions under which ice can form on aircraft.
6. Does ice interfere with flying, and if so, can interference be reduced?

WEATHER

P.F. CLOUDS

Description

1. In Part IV the main elements of meteorological information were concerned in very broad terms. They will be treated in greater detail, but the various elements make an almost infinite precipitation area so interesting that it is not possible to deal with each once and for all. For instance, it is impossible to know all about clouds without knowing something about wind. Clouds and wind will then be dealt with separately in successive parts and then fitted together to give the complete cloud picture.

Clouds for understanding cloud types

4. (a) Fresh clean air gives regular high cloud.
- (b) Fresh air gives thin, wispy, broken cloud.
- (c) Any other place means low cloud, or cloud of great vertical extent.
- (d) Clouds and cumulus come from the Latin for a lump.
- (e) Stratocumulus and altocumulus are from the Latin for a layer.

Cloud heights

4. These given are average figures. They may vary considerably, e.g. in very cold weather or in the polar or tropical regions.
Actual heights vary greatly from the average values, the top of stratosphere may be well above 50,000 ft.

Cloud photographs

5. The following are taken from the 'Cloud Atlas for Aircrews' used in the R.A.F. Note that there is no corresponding point there not yet mentioned, and it is best to refer to Part IV. They are dealt with later in the notes. Refer back to Table I when studying the photographs.

Table I - Cloud Classification

NAME	MAIN CLASS	SECONDARY	THIRD	CHARACTERISTICS OF THE CLOUD
Cloud	Fusiform Cumulus Cumulonimbus			
Clouds	Horizontal plates and strands	Low and High		Clouds in plates & clouds in strands

HIGH CLOUDS**Cirrus (Cs.)**

Precious wisps of delicate white cloud formed of ice crystals and stretching up against the blue background of the sky, "cirrus" known as "Moorish," these clouds are very high in the atmosphere, between 20,000 and 30,000 ft.

While it may have no direct operational significance, cirrus may be of great importance, as it is generally at the high stage of the approach of a depression or of low pressure, and earlier when these wisps become longer and more compact until they become cirrostratus may expect to be-



Fig. 3 (a). Cirrus in the form of straight and curved filaments ending in hooks with pointed edges. These pointed edges frequently indicate that the winds are in favorance of a warm front.



Fig. 3 (b). Cirrus without clearly developed, pointed edges frequently indicating that the winds are in favorance of a warm front.

Cirrocumulus (Cc.)

A layer or patches of small white flakes or of very small globular masses, without shadows, which are arranged in groups or lines or more often in ripples, resembling those on the sea shore.

Cirrocumulus in thin and high, about 20,000 to 30,000 ft. No appreciable icing will occur in this cloud.

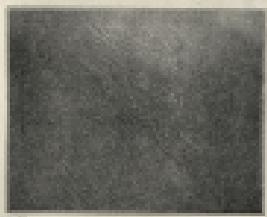


Fig. 3. A typical field of cirrocumulus, showing a plain a rippled formation and distinct small globular masses.

WINDS AND PRECIPITATION

HIGH CLOUDS**Cirrostratus (Cs.)**

In this, which will through which the sun or moon can be seen with the outline still except at the edges, there is a few minutes. The cloud gives rise to halos, which prove it to be composed of ice crystals.

The cloud is usually part of a great cloud sheet extending from the equator to the north or south, where it has a very long tail, a cirrostratus. The circulation is usually moving away from the low-pressure region. The base of the cirrostratus is at about 20,000 to 30,000 ft.

The cloud sheet is divided broadly into three sections:

(a) the stratosphere, base 20,000 to 30,000 ft.



Fig. 3 (a). Cirrostratus forming a sheet. Light shadows shown as darker bands below.



Fig. 3 (b). A cirrostratus sheet with patches above the edge.

MEDIUM CLOUDS

Nimbostratus (Ns.)

A layer or pack has composed of a great number of small cumulus. The cumulus are arranged in groups, in lines or in waves following one or two directions and are sometimes so close together that their edges join.

Altocumulus is definitely a layer cloud and not a group cloud.

Altocumulus forms between 5,000 and 10,000 ft. When it is low it is broken into patches, which will not give complete screening by clouds, and the cumulus-like formation too small to be of much value for screens. It will, however, be frequently possible for aircraft to make an alternative of clouds which will be overpassed by a dense stratus, thereby emerging from the cloud in an unpassed direction.

Occasionally altocumulus may be a thicker type of clouds previously in contact. The banded type of altocumulus often indicates the approach of rain. The condition of the head may be judged from the thickening of the cloud. Drizzle is usually to meet in this cloud.



Fig. 10. The altocumulus clouds are here arranged in a fairly regular pattern with numerous small cumuli.

ALTOCUMULUS (Ac.)

A thin veil of clouds, mostly grey, sometimes white or bluish, in colour. Generally it covers the whole sky. The sun or moon may usually be seen through the cloud at first, but gradually disappears. This cloud generally changes into nimbostratus.

Altocumulus is of greater importance. It often forms cover and intercepts it will be best to make observations of clouds which will be unobscured by the altocumulus. If the cloud is thin and scattered, the visibility will likely be good and may be 10,000 ft., but when the cloud becomes too thick the visibility will decrease rapidly, and in thick altocumulus it may fall as low as 1000 ft. It is of great extent and of very considerable vertical thickness which may reach across or across its flanks the base and the top of the cloud are often not poorly defined. The base of the cloud often shows some irregularities, but the top is smooth. The presence of the cloud indicates the cold approach of a warm front and precipitation may occur in this cloud.



Fig. 11. This unbroken altocumulus veil, rugged cloud fragments below, has dark clouds from ground, cloud streaks, and dissipates and subdues the sun's deadly rays.

LOW CLOUDS

Stratocumulus (Sc.)

An extensive layer of pleated masses or rolls; the clouds are arranged in groups, in lines or in waves running in one or in two directions. Very often the rolls are so close that their edges join together.

Figs. 12 (a) and (b). This is of great operational

value, not only for continuous flight by single aircraft, but also for the maximum flying journey time.

Stratocumulus is a thin cloud layer which is

most common in summer by aircraft which are descending over its surface. On most occasions it has a vertical thickness of about 2000 ft above M.L.H., though occasionally either lower or higher. The higher types often have cumulus clouds below them and reaching them. Frequently there is an area of low pressure just above the cloud layer and the air there is dry, remaining very dry.

The visibility in it is usually about 10 to 15 miles, but sometimes it is 10 miles, and sometimes only

10 miles. Slight or moderate turbulence is usually found in and below the cloud, but when there is a layer above the cloud when the air is very smooth.

There is frequently a decided difference in the speed and in the direction of the wind between the layers above and below the cloud.

It may form when the temperature in the cloud is between -6°C . and -7°C , but the rate of freezing is not usually rapid.

Figs. 12 (c) and (d). Stratocumulus and cumulus.

When independently occurring clouds constitute a stratocumulus, an aircraft flying through it in the stratocumulus cloud may often suddenly find itself in the cumulus cloud without visual warning. In the cumulus cloud it will encounter very much worse visibility, greater turbulence and possibly rapid ice formation. Even just above the cloud it may be possible to see the cumulus head preceding, and so be forewarned that strong vertical currents may be experienced.



Fig. 12 (a). Typical under-side cell formation of stratocumulus. Sometimes the cells are broken up by strong air moving running in a different direction.

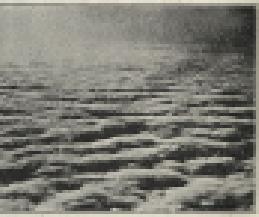


Fig. 12 (b). A typical example of the top of a stratocumulus layer, showing the wavy upper surface of the cloud.

LOW CLOUDS

Stratocumulus (Sc.)

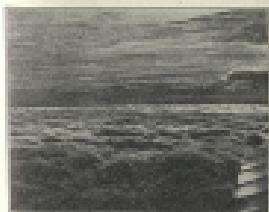


Fig. 11 (a). Stratocumulus lying just above the sea surface; but the high clouds indicate distant rain approaching. As such conditions approach there can be seen from the air, but are hidden from the ground.



Fig. 11 (b). Cumulus breaking through stratocumulus. The morning cumulus is beginning to break through the stratocumulus layer, the top of which is at ground level. The layer does not extend to the horizon. The photograph was taken around one, and an aircraft flying constant would soon have caught up with the only cumulus cloud.

Source: R.A.F.

14

Nimbostratus (Ns.)

A dense layer of dark grey colour, nearly uniform appearance and great vertical thickness; it usually gives precipitation—rain, sleet or snow. It is of great importance both operationally and meteorologically. This cloud is only practicable for single aircraft and care is essential to keep well above any hills as they are likely to be completely enveloped in it at low levels, but its visibility is generally better than in fog and often less than in rain. The vertical thickness of the cloud is very great, extending to between 6,000 feet; it then becomes very thin at the base of passage of the front and will generally cover even low hills. Over the sea the base of this cloud is at the horizon, and because it is often right against the horizon, it may be easily overlooked, very few clouds may be discerned quite suddenly; at first they may be isolated or ragged and separate from the main cloud mass, but near the land these break clouds join up with the main cloud mass so that the cloud is usually continuous from a very low level in a great height. In the transition cloud becomes definitely rain-bearing, and in this form it is likely to pass over land and make all very little. Rain may occur in this cloud, except being obscured there may occur drizzle if the temperature is below freezing point where. This cloud cannot be photographed satisfactorily.

Ns., Nimbostratus is implied here because it is continually a part of the more dense nimbus system.

Stratus (St.)

A uniform layer resembling fog and generally at a very low level. The upper surface of stratus may look like stratocumulus if an isolated area of stratus begins to develop. If the cloud extends to the sea so that it is right down to the surface of the land, or sea, in that case we should call it fog. If the cloud overlaps a number on the ground, we should call it fog, but if the base of the cloud is above him he should call it stratus.

Fog is usually too shallow and too low in for great importance for operational use except as seen from observation from the ground. It is apt to overlap the summits of low hills, and on this account may be dangerous to aircraft.

Under certain conditions in winter, fog may occur in stratus. It will, in general, take the form of nimbostratus.

This cloud cannot be photographed satisfactorily.

CLOUDS OF GREAT VERTICAL EXTENT

Cumulus (Cu.)

Cumulus clouds have almost horizontal bases of moderate height, the tops are rounded, white to the eye, in contrast to the dark grey colouring, but from below it may look dark. It may be vertically stratified for example, green in wet conditions, but it may present undivided colour and height almost alike.

Cumulus comes generally in fair weather the clouds are usually numerous but shallow; at other times they form great masses reaching up to about 11,000 feet, the colouring being green, blue, yellow, red, etc. When heavily stratified, and moist, cloud can be seen forming behind within a line of the ridge, while sky over the sea is clear.



Fig. 11 (c). Cumulus clouds not of great vertical development, seen from high above.



Fig. 11 (d). Isolated cumulus cloud with fog base and rounded top.

Clouds in Great Britain. Visibility inside is usually under 100 yards, and outside under 10 miles.

Clouds may form quickly in summer, particularly when temperatures are of 70° to 75° F. In and before sunrise particularly when large clouds, vertical currents give violent tempests.

Over land, cumulus is most frequent in day and least frequent by night. Over the sea this variation is less, and in summer, cumulus and green, blue, yellow, red, etc. When dry, blue, white, etc. When moist, cloud can be seen forming behind within a line of the ridge, while sky over the sea is clear.



Fig. 11 (e). Large cumulus, green, blue, yellow, red, etc. Great vertical development shown by clouds in foreground and towering in background.



Fig. 11 (f). Isolated cumulus, formerly the type given this classification and mostly cloudy, broken.

Source: R.A.F.

CLOUDS OF GREAT VERTICAL EXTENT.

Cumulonimbus (CB.)

Heavy masses of cloud with great vertical development, whose summits extend to the incrustations of clouds, the upper part having fibrous texture and often spreading out in the shape of an oval.

The Thunder cloud. The vertical size of this cloud is greatly limited by the excessive buoyancy experienced in it and also the effect of temperature and time. It is impossible for them to grow high and remain long. The vertical extent of these clouds may be anything from three to sixteen ft., and their bases may be at ground level. Indeed, over the sea the bases have been observed almost down to the water. Particularly, the clouds usually develop for some miles, but under certain conditions may be only a short distance above the ground. They may be experienced about the time extending from the rise of the sun to a small cloud with extremely large bases may be found under the main cloud mass and often joined to it. Even when there is no small cloud, fragments of low cloud are often found below the main mass. In the rear of a shower, rain may fall from such

cloud at a considerable height and lightning discharge may occur in the area.

The visibility is often poor, but, as may occur, being too thin to be seen. Below the cloud also the visibility is very much limited by the turbulent showers which occur. Both in and below these clouds there are very violent vertical currents giving rise to intense turbulence.

Under suitable conditions of temperature difference of $C.$, and of deg. F. in the cloud, very rapid growth is liable to take place in the cloud.

The pressure which governs these clouds may be one, half or more.

These clouds usually occur during the latter part of the afternoon or early part of the night over land; over the sea far from shore they are not the same varieties. The thunder will at the top of the cloud be composed of two types.

Now if in a cumulonimbus the vertical winds should be strong in I.A.M.O. A. category II, operational needs require the need to be evaluated aircraft should first get away from the cumulonimbus (see).



Fig. 13 (a).-In front is a large towering cumulus, with, behind, a fully developed cumulonimbus with its oval of fibrous bases spreading out.



Fig. 13 (b).-Upper half of photograph shows out of a large cumulonimbus, part clear-cut and part fibrous. In the lower half is a band of towering cumulus.

CLOUDS OF GREAT VERTICAL EXTENT.

Cumulonimbus (CB.)



Fig. 13 (c).-Large cumulus and portion of small cumulus (CB.). The cloud above the cumulus on the left consists of a series of small waves on the top of a developing cumulonimbus. When a fibrous and fibrous cumulus are close, a cold winter phenomenon is noticed.



Fig. 13 (d).-This illustrates the spreading out of the top of a large cumulonimbus into the classic fibrous shape.

CONDENSATION TRAILS FORMED BY AIRCRAFT.

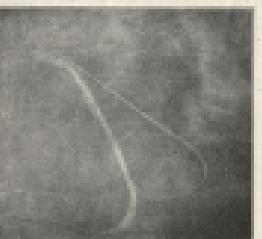


Fig. 14.-The aircraft trails, showing the way they spread. The atmosphere at that level was filled with minute ice particles which reflected the sunlight so much that even though mostly over land, fibrous precipitation had given place to a very dry and warm jet, defined they seemed CB. in character.

The condensation of engine exhaust under varying circumstances results in fibrous streaks flying in clear air. They may be faint and invisible from any great distance; on the other hand they may be long, wide streaks, carrying aircraft position and flight and speed and for no minutes or hours really stay visible. This is the contrail, also known as cirrus cloud.

These trails rarely form under about $10,000$ ft. in summer and up to $15,000$ ft. in winter. They always occur in about one-half, crossing the stratosphere. They are in any case between $11,000$ and $12,000$ ft., $11,000$ ft. in average figure.

These trails may therefore be avoided by cross-sphere flying. Otherwise the pilot should seek clear air outside (and just above) a cloud-layer. If a small aircraft cannot do this, a descent when the temperature falls sharply again. If uncertain about this, or above, it is generally best to descend.

Flying aircraft should normally avoid levels where cloud-walls give evidence of high humidity.

METEOROLOGY

At night special care must be taken in measuring visibility, particularly that it is a measure of the situation at the time of observation and not the night, which is normal. Fixed lights may be used, but even without them it is usually possible with pointers to give a fair estimate of the visibility at night. When using lights, care is needed as ordinary lights can usually be seen at night at greater distances than objects would be seen through the same air by day. Visibility is subject to fact only holds for a particular strength of light.

Scales

a. This table gives the scale figures used for estimating visibility objects and defining fog, mist, and visibility. One need not try to remember them in detail. They are given because air mass will always tell visibility measured and defined on its basis. But below 1000 yards they will be given the actual observed distance in hundreds of yards.

Scale	Description
0	Distance fog
1	Tint fog
2	Mist
3	Fog
4	Obscurating fog
5	Obs. fog, or very poor visibility
6	Poor visibility

0	Nominal visibility
1	Minimum visibility
2	Good visibility
3	Very good visibility
4	Excellent visibility

The distance in yards must also be added because the scale must originally shown up using distances measured in metres and hundreds.

How to look at this weather

1. The code says has all the information he needs for doing visibility observations. So longer need for that. If it is a short day - or a long day', but 'that factory chimney is visible' is measured on the map. I can see it but can't see the hill to its right, so visibility is between 6 and 10 miles?

Look around. Notice that visibility may be very good in one direction and very bad in another. That is, if I stand in the middle of a valley, visibility may be excellent vertically and poor horizontally—a fact of some importance in aircraft, as may be present. Roads self-shading will be of value when, as a pilot or observer, the code is given a position forward predicting visibility, say, of 4 miles, and he finds that he can visibility what the code.

QUESTION ON PAGE 71

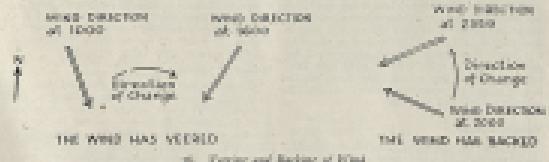
- What do meteorological offices mean by "visibility"?
- How does a meteorological office obtain visibility readings by day?

VI. WIND

Wind change

1. Part III described the way in which wind velocity is measured. Meteorologists had a need to know another detail about wind behaviour—in what manner it has changed or will change direction.

Such knowledge helps them in preparing weather forecasts. The two details below show the two terms commonly used to describe change.



NOTES FOR INVESTIGATORS

WIND

METEOROLOGY

Investigator No.	Estimated wind velocity in metres per second	Sea level winds	For land or sea	Measurement or state of air mass, per metre per second (approx.)
0	Calm	Smooth sea normally	Sea level or more	Less than 1
1	Light air	Smooth, but not calm waves, short wind direction	Sea level ripples	1-2
2	Light breeze	Wind felt on face, leaves rustle, wind from several	Small ripples, glassy water	2-3
3	Gentle breeze	Leaves and small twigs moving continuously, small clouds scattered	Large ripples, small boats begin to float freely	3-4
4	Moderate breeze	Leaves and larger paper moving readily from hands	Small waves, boats fairly combed	4-5
5	Fresh breeze	Small body feels cool	Moderate waves with pronounced crests, many white foam spots appear	5-6
6	Strong breeze	Large bushes in motion, felt paper waves rattling	Large waves, white foam more extensive covers face	6-7
7	Moderate gale	Whole trees in motion	Sea breaking up and white foam covers breaking waves in shore	7-8
8	Fresh gale	Heavy spray of rain	Moderately high waves with positive breaks, edges of crests break into spindrift; waves break in well-defined crests	8-9
9	Strong gale	High sustained damage occurs; distance poor measured	High waves, crests crests of wind along the direction of the wind spray may affect visibility	9-10
10	Whole gale	Very high waves with long lasting spray; crests of waves in great parallel rows in certain directions occur; spray from waves edges of crests become heavy and visibility is severely affected	Very high waves with long lasting spray; crests of waves in great parallel rows in certain directions occur; spray from waves edges of crests become heavy and visibility is severely affected	10-11
11	Mixing	Very poor; widespread damage	Exceptionally high waves, sea completely covered with foam; visibility reduced	11-12
12	Hurricane	Very poor	Sea filled with foam and spray, sea completely white with spray and spray	Above 12

Measuring surface wind velocity

4. Most meteorological stations measure wind velocity with anemometers which have constant records on special charts. Estimates accurate enough for practical needs can be made by eye observation. With experience, at an arm's length one can look at the wind, shunting, leant, goes, etc., and judge the wind strength within a few minutes. In general, however, one can apply their judgment to the appearance of the sea with equal proficiency. Estimates are a compass or points lying in a known direction from given the wind direction. They judge various wind directions with similar accuracy by comparing with a compass the direction of darkened lines in clouds of smoke ("wind lines") raised by the wind, the direction of motion of the waves, blown by the wind (and swell), and of spray blown by the wind. Careful learning to estimate wind strengths will find it useful at first to check such results against combined version of the above methods.

Measuring upper winds (Pilot balloons)

5. The meteorologist looks the upper wind by releasing small free balloons filled with hydrogen. These rise at approximately a steady rate and drift with similar accuracy by comparing with a compass the direction of darkened lines in clouds of smoke ("wind lines") raised by the wind, the direction of motion of the waves, blown by the wind (and swell), and of spray blown by the wind. Careful learning to estimate wind strengths will find it useful at first to check such results against combined version of the above methods.

with the wind. The balloon is waybored through the atmosphere at a steady rate and because of its motion it carries with it air from below and above. From successive readings of the elevation and altitude, the height of the balloon being known from the rates of change of the ratios, the upper winds can be found in speed and direction. The balloon eventually either disappears into cloud, bursts or gets so far away as to become invisible.

Wind-sounding balloons

4. At a few special stations special balloons carrying wireless transmitters are used and their position is found by direction-finding apparatus. This method needs an observer to ground organisations but has the great advantage of enabling the wind to be taken above clouds and of much greater distances from the station than are possible with the other methods.

Finding wind from cloud movement

5. By observing the motion of cloud nearly always, the speed and direction of the wind at the level of the cloud can be found. The direction of the cloud is obtained by which the drift point (fixed object) such as the top of a building, etc., moves in relation to the cloud. As meteorological stations a special instrument is used which, pivoting the

bright or the cloud is known, gives the speed as well as the direction of the upper wind from the cloud drift.

In the air one can often gain a useful idea of wind velocity at cloud height by watching clouds moving across the ground. Speed can be gained with practice and direction checked against the above compass.

How to look at the weather

6. Try estimating wind velocities by use of the shadow cast by a stick. Hold a stick vertically. Watch how cloud drifts in often in a different direction to that of the surface wind. Try to guess from the rate of cloud movement the wind speed drift, noting that the higher the cloud the more slowly it moves in general.

QUESTION on Part III

1. What do the words 'back' and 'over' mean?
2. How do aircraft crews estimate roughly wind velocity at ground and sea level? (a) by cloud drift;
3. Give three ways by which the meteorologist measures upper wind.

X. PRESSURE, TEMPERATURE, HUMIDITY

1. Before considering how weather maps are constructed one must have a little idea about the ways in which air pressure, temperature and humidity are measured and denoted.

How pressure is measured

2. Pressure is measured in millibars (mb), millimetres (mm) or inches (in). The name barometer is derived from the Latin word *baro*, meaning to load, and *metrum*, meaning to measure. In the British Isles a varying millibar rise to about 8 mm, above mean sea level, per million difference of pressure corresponds to a difference of height of about 1 ft. The height interval corresponding to a one difference of pressure increases with height and around 800 ft. it is 1 ft.

Horizontal change of pressure

3. It is very important that the weather forecaster should know the horizontal variation of pressure across the area for which he is forecasting, as this is the deepest part of the wind system.

To find the horizontal variation of pressure it is necessary to have pressure readings at all one level. This is achieved by finding what the instruments would read if it were at mean sea level, now for seconds:

Reading the barometer

4. Should the reader be given a plot of an average barometer in his notes he will find himself called upon to read it immediately to read an altitude corrected to an incoming aircraft. Full instructions are given on a card which hangs by the instrument. This shows how to convert the scale reading for index error, temperature, and height of instrument above sea-level level, so that an accurate reading of pressure can be read out.

Temperature

5. Temperatures are given in either degrees Fahrenheit or Centigrade. Almost every thermometer calibrated in degrees Centigrade, and found on the principle shown in the sketch.

Such thermometers are not really accurate unless they have been tested at least two points. Change of height causes temperature changes which cannot be registered in either this form:

or in this form:



6. Thermometers are also calibrated by a standard standard of mercury in both centigrade scale to which are attached to degrees Centigrade.

13. Air-temperature thermometers, Mark II

Humidity

7. Consider a cold, poor of air containing no visible water vapour. We can go on adding water vapour until the air becomes saturated. If we add no more, the water vapour continues to add air to air until it is saturated, there is no evaporation and condensation, and both thermometers give the same reading. The dew-point and relative humidity can both be calculated from the difference between the readings of the dry-and-wet bulb thermometers by the use of tables. These quantities are of great importance in the prediction of day.

In the British Isles average relative humidity is about 80 per cent.

8. Relative humidity

9. How does an R.H.T. dry plant measure air pressure? What standard corrections are made to the scale reading?

Measurement of humidity

10. The meteorological officer measures relative humidity with wet and dry-bulb thermometers. There are two identical thermometers placed side by side, the bulb of one being covered by a single layer of muslin, kept moist by awick dipping into a narrow vessel of water. When the air is dry, evaporation from the wet bulb causes a decrease in reading of the wet-bulb thermometer. If the air is saturated, there is no evaporation and condensation, and both thermometers give the same reading. Both point and relative humidity can both be calculated from the difference between the readings of the dry-and-wet bulb thermometers by the use of tables. These quantities are of great importance in the prediction of day.

In the British Isles average relative humidity is about 80 per cent.

QUESTION on Part IV

1. How does an R.H.T. dry plant measure air pressure? What standard corrections are made to the scale reading?
2. Why does the meteorological officer find pressure readings over sea air essential?
3. How does an aircraft thermometer work?
4. Why are humidity readings useful?

X. ALTIMETERS

11. Part II showed that the altimeter is nothing but an inverted barometer graduated in feet instead of inches of mercury, or millibars. The instrument described was the one used in elementary gliding aircraft, in which a very sensitive altimeter is incorporated as it is used mainly for tail-wind flying.

Altimeter "inaccuracy"

12. Careless at the R.F.T.S. will soon notice that when they get into aircraft at the beginning of the day the altimeter rarely reads zero, but some deviation above or below. As first they may think this is due to faulty calibration of the gauge itself, but as they will readily find that the pressure changes from day to day at the same time that which the altimeter reading is affected, it is therefore likely that it is the observer that is either a pilot or observer might set his altimeter to particular reading, as in long cross-country flights, and then hand back to his own cockpit in the afternoon to find it is too low for him that the altimeter now read and yet the meteorological officer could show him that the variation was due to the

fact that during his absence the pressure had gone down. By a climb over 1,000 ft., the reduced air pressure being able to support only a shorter mercury column. As every 1 in. change corresponds to about 30 ft. (the on the altimeter dial, 30 in. = 1000 ft.) that 1 in. change of the 30 cm Hg scale, 1000 ft. climb corresponds to about 30 ft.

Consider another case, in which a flying boat comes from Farnborough to Filton at 1000 feet (Leeds), taking off at the time for which the weather map in Fig. 11 was constructed. Imagine that the pressure given on the map remains unchanged throughout the flight.

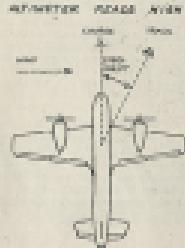
Altitude at Farnborough = 1000 ft.
Altitude at Filton = 500 ft.
Difference in pressure = atmospheric
and surface air density
and surface air density
which, deep compression is not a problem
increases in height is increased.

Therefore as Earth's atmosphere will allow just a 10 ft. in 100 ft. when the best aircraft, imagine what might happen when there is a great if meteorological information was not available.

Answers for exercises

Altimeter scale

1. "Scale of flight" may be given to show what altitudes may be expected to the pilot, and then adjusted for one set of altitudes, and then transferred to another set of conditions. The examples quoted here show the high altitude scale in inches, and may take "Scale of flight" as applied to weight measurements, however, we try to think intelligently of what is happening in flight.

a. *Aircraft Flying into Low Pressure*

(1) Standard barometric pressure is known about than that obtained. The pressure at any level which is lower than at the same level below it. Therefore if I fly by the standard pressure, i.e., keep a constant altitude reading, I shall really be descending. From this it follows that flying into a low pressure reading, my altimeter will read too high unless I read it.

(2) I am climbing to starboard. Therefore the wind is from the port side. Walking back to the wind I find P.D.P. low pressure to the left, i.e., to the west of me. Altimeter will read higher." (See fig.)

Apply Intelligently intelligently reading these by logic rules. The point to remember here is that an altimeter set at X to read one the standard height may not read exactly with such read just for several heights at another point Y. Many aircraft have the ground of the set which the pilot was least expecting to because he had forgotten or not allowed for this highly important fact.

Setting and reading the altimeter

4. The Mark XII altimeter carries inside the height scale, a small dial graduated in inches.

NOTES FOR STUDENTS

which reads the altitudes at which the hands read zero. When the barometer is connected with the aircraft so the pressure will not change pressure, the pointer indicates exactly the atmospheric level pressure, which can be verified by the meteorological office. It is done over the instrument serial adjustment by the meteorological office.

Before taking off, the hands is turned so that the hands read the height of the pressure above mean sea level. In flight the altimeter will then read approximately heights above mean sea level. In the course of flight, as the aircraft passes over points of different air levels pressure the altimeter will be required. Every time the aircraft passes through points of different air levels pressure will be at different points on the scale, and the altimeter setting can be changed on route by turning the hands so that the altitude scale reads the appropriate value of sea level pressure. When coming in to land at an airfield not at sea level, and when an altimeter reading is taken at sea level, note the necessary to read the dial, taking early warning in avoidance of good visibility, when visibility is poor and landmarks are being used by house approach, it would be dangerous to have an altimeter reading heights above sea level, so a reading of sea-level level pressure is obtained by wireless, and the hands turned so that this pressure appears on the pressure sub-scale. The altimeter will then read above the landmarks, as when the aircraft touches down the hands will read zero.

Temperature allowances

5. So far only consider the change of pressure of mean sea level force has been considered. Another, in general, much smaller source of error is caused by the fact that, even when correctly set sea level pressure, the altimeter is only accurate if the temperature of the air conditions is a certain rate. Details of this will be given in the lectures, but in order to give you here this is only to warn you that when you have set your altimeter to read zero at sea level, the error of 10 per cent. of the indicated height due to this cause will surely be exceeded. It is possible to make a very good correction for this effect by using the appropriate scales on the navigational computer, Mark III D.

QUESTIONS ON PART X.

1. Why do altimeter readings vary from day to day in a sounding circuit?
2. How can an altimeter indicate "increasing" in flight? What could be the result of ignoring such changes?
3. How are altimeter corrections given in aircraft and carried out in flight?



Fig. Mark XII altimeter

XI. INTRODUCTION TO THE WEATHER MAP**General weather notation**

1. **Aerial Doctor.** who derived the code given. For VIII, also produced a list of abbreviations, that are used in code electrical weather conditions in a log. These abbreviations will often be seen by air crews when studying the meteorological officer's records with him. As far as possible the initial letters of words have been used in the notation. No attempt need be made to learn the following example; they are given for interest only.

I	—	blue sky	I	—	rain
—	—	cloudy	—	—	drizzle
—	+	partly cloudy	—	+	snow
—	-	overcast	—	-	fog
—	—	haze	—	—	ice
—	—	rain	—	—	sun shower
—	—	hail	—	—	hail
—	—	lightning	—	—	lightning
—	—	thunder	—	—	thunder

GENERAL CHARACTER

I	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	+	—	—	—	—	—	—
—	-	—	—	—	—	—	—
—	-	—	—	—	—	—	—
—	-	—	—	—	—	—	—
—	-	—	—	—	—	—	—
—	-	—	—	—	—	—	—

Clouds. The first four columns give the various types of clouds, the last four columns give the various types of precipitation.

Wind flow notation

2. This need not be learned. It is given for interest. The figures are which are allotted numbers in boxes, and arrows drawn on weather maps carry boxes to represent the number of the wind force.

[see page 100]

INTRODUCTION TO THE WEATHER MAP

Wind direction indicated at a height of 20 ft.	Buoyancy Number.	Impression.
True North	+	◎
112°	-	—
135°	+	—
158°	-	—
180°	+	—
202°	-	—
225°	+	—
248°	-	—
270°	+	—
283°	-	—
306°	+	—
330°	-	—
343°	+	—
360°	-	—
373°	+	—
396°	-	—
410°	+	—
433°	-	—
450°	+	—
Over 45°	-	—

provide the information to meteorological offices by the telephone described in equal letters.

3. Information carried on weather maps
 Pressure, reduced to mean sea level.
 Pressure-change in last 1 hour, + millions.
 Temperature.
 Humidity.
 Cloud types and amount.
 Visibility.
 Wind force and direction.
 Weather.

This map is not detailed enough for use in practice forecasting but is a sample one to show the idea. For each station wind force and direction, temperature and weather have been plotted using the symbols for wind and weather described in paragraphs 1, 2 and 3 of this part. Figures on the map are called lobes and are described in the next paragraphs.

Lobes.

4. Just as on a geographical map we can join up several longitude points with latitude lines, so on a weather map we can join up equal pressure readings with latitude circles, our equal pressure network. It is always found that under certain conditions the pressure gradient is greater than the gradient on wind. On a pressure map we find high pressure, low pressure lobes, and constant lobes are given to regions of different pressures.

The contours in this specimen are plotted at 4 millibar intervals. The interval of pressure for which contours are drawn depends on the scale of the chart, just as contour lines are drawn on geographical maps at different intervals depending

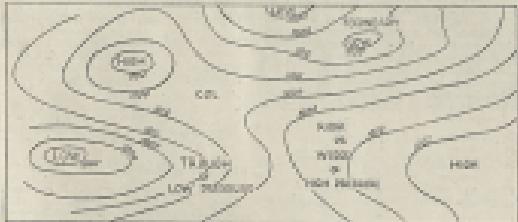


FIG. 10. Types of Cyclone Systems.

SOURCE FOR STUDY NOTES

INTRODUCTION TO THE WEATHER MAP

METEOROLOGY

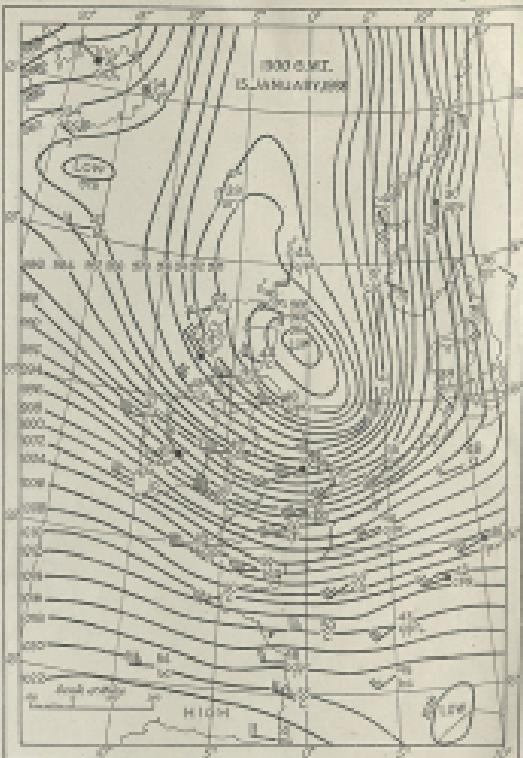


FIG. 11. A single Synoptic Weather Chart.

SOURCE FOR STUDY NOTES

on the scale. On the charts used for aviation forecasting intervals of 2 mb. or 1 mb. are used.

Hour by hour these isobar systems slowly change, moving and altering shape, deepening or fading out.

Isobars and wind

7. Notice on the map, Fig. 21, that wind arrows tend to follow isobars, inclining towards the region of lower pressure; also that where the isobars are close together the wind arrows have more fleches than where they are wide apart.

The map reveals two laws:—

(i) *If one stands back to the wind anywhere north of the equator, lower pressure is on the left.*

(ii) *The steeper the pressure gradient (i.e. the closer the isobars) the stronger the wind.*

In the southern hemisphere if one stands back to the wind, lower pressure is on the right.

How to look at the weather

8. By daily use of the weather lore given in this chapter, one can sometimes get an idea of what the pressure system in one's locality is doing.

Yesterday, the wind was about 25 m.p.h. from N.W. Therefore the isobars here were reasonably close together and pressure was lower towards the north-east. To-day

the wind is from W. at 10 m.p.h., so the isobars must be further apart and the pressure is lower towards north. It may be that a wedge has passed over and that a new low is coming from the west.

All manner of complications that occur in pressure systems may make this only partly true, but often the guess will be correct, and at an aerodrome one can check up on these observations and thoughts by seeing the meteorological office weather maps.

9. Form a habit of looking critically at the weather every day. Try making your own weather reports on "present" weather, because this will train you to notice many things you will have missed altogether before. In the morning try to guess what the weather will be like by midday and by the evening; later on check up to see how wide of (or close to) the mark your estimates have been.

Weather is either friend or enemy to the pilot and navigator; the more they know about it, the less they need meet it as an enemy, and the more they can use it as a friend.

QUESTIONS ON PART XI

1. How is wind force shown on a weather map?
2. What can one discover by joining up places of equal pressure on a weather map?
3. What do (a) close (b) wide apart isobars mean?
4. By knowing wind velocity what deductions can one make about the local pressure system?

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