

METEOROLOGY

SECTION 2

NOTES FOR STUDENTS

The following notes are for study by pilots and navigators during elementary and service flying training.

These notes carry straight on from Part XI of the earlier notes, Meteorology, Section I.

SUMMARY

- XII. R.A.F. Meteorological Service. The four types of meteorological offices. The work of meteorological offices.
- XIII. Flight weather reports and forecasts. Report and forecast defined; vital need to appreciate the difference. Obtaining forecasts for flights in Great Britain and for flights outside territorial waters. Standard information given in forecasts. Examples of a Form 2310; how used. Co-operation between aircrews and the meteorological Service.
- XIV. Routine weather forecasts and warnings. Local routine forecasts. Warnings of impending gales, squalls, thunderstorms and frost.
- XV. The basis of forecasting. Study of behaviour of air masses and fronts. Weather associated with typical air masses and fronts. Climates and seasons; typical weather in different parts of the world. Influence of latitude, time of year, and presence of large land or sea masses.
- XVI. Meteorological codes. Purpose and use of standard codes. Secrecy in war. Symbolic form of weather reports. Use of Form 2310. Examples showing results of careless reporting by duty pilot. Plotting and interpreting the weather map. Value of aircraft observations.
- XVII. Air masses, depressions, fronts. Table showing origins and weather of tropical maritime, tropical continental, polar maritime and polar continental air masses. The Norwegian theory of the formation of depressions. Diagrams of depressions. Intimate relation between depressions and fronts. Warm and cold fronts and sectors; flying conditions in their vicinity; associated weather. Wind changes with fronts. Line-squalls.
- XVIII. Other fronts. The occlusion; character and associated weather. Secondary fronts; character and associated weather. Flying conditions. Life history of a depression.
- XIX. Other types of pressure distribution. The anticyclone, secondary depression, trough of low pressure, wedge or ridge of high pressure, the cell; character of each and associated weather.
- XX. Clouds and precipitation. Orographic cloud and precipitation; examples. Convective cloud and precipitation; examples. Gradual ascent of air over a large area; examples. Turbulence or eddy motion cloud; examples.
- XXI. Visibility. Visibility in rain and snow of different intensities. Visibility in fogs. Radiation, movement and mixing fog; how formed and when and where to be expected. Examples of each. Visibility in smoke haze; examples. Reduction of visibility by dust and sand; examples. Visibility from ground and air may be different; illustration. Visibility looking up and down sun; tactical importance. Visibility in moonlight.
- XXII. Ice formation. The types of ice formation. Effects of severe icing-up of aircraft seen in increased drag and increased stalling speed, reduced engine power, interference with propellers, control surfaces, fixed wing-tip slots, wind-screens, sliding hoods, and emergency panels. How ice formation is combated. How supercooled water drops may cause ice formation. Conditions under which ice may form on aircraft. Rate of ice formation. Reasons why different types of ice form. Table showing conditions under which four main types may form, and their effects on aircraft. Table showing types of ice that may form in rain and in various cloud types. Meaning of freezing levels in forecasts; examples. Avoiding action.
- XXIII. Thunderstorms. Conditions necessary for formation of thunderstorms. Character of fully developed thunderstorms, with diagram and details of associated weather. Table showing three varieties of storms due to heating of atmosphere over land or sea, and two varieties of storm associated with frosts. Flying in storms; vertical currents, hail, lightning and icing considered. Flying advice when storms lie across intended track.
- XXIV. Flying in clouds. The information aircrews need about clouds. Clouds best thought of as heap and layer types for their purposes. Table showing flying conditions in heap and layer clouds. Lessons to be drawn from this table. Formation flying in cloud.
- XXV. Wind. Gusts and lumps. Turbulence may go up to great heights. Diagram showing effects of obstacles on wind flow. How cliffs and ridges cause vertical currents; example of the Rock of Gibraltar. Thermal up currents; where met, and effects on flying. How wind velocity varies with height. Finding the most favourable flying level. Land and sea breezes; katabatic winds; examples of each. Nature of diurnal wind variation.
- XXVI. Meteorology and operational flying. Operational importance of meteorology—importance of meteorological knowledge to aircrews; hints on flying in difficult conditions.

XII. R.A.F. METEOROLOGICAL SERVICE

1. The reasons why observers must study meteorology have already been given in the introduction to these Notes; part of this study consists of learning a little about the organization which provides the weather forecasts and reports.

Observations

In the new material from which forecasts are prepared, periods of observation of the weather, known as the following stages—

(i) Initial observations made at such times

(and also when sudden changes occur) at all meteorological offices and at other places such as lightships, Observers Corps posts, etc.

(ii) Observations, called Prelims, made to assist crews during flight and handed in on landing.

(iii) Observations made by a number of special meteorological flights.

(iv) Observations of upper winds obtained by methods described in Meteorology, Section I, note.

(v) Observations from some naval countries, e.g. Spain, Portugal.

In U.K. all these observations are transmitted through a special teletype system to the Central Weather Forecast Office or the Meteorology, which then pass the information, as far as possible, to all aircraft and stations where they are available to all meteorological offices.

Central Forecast Office

2. The Central Office prepares analyses of the existing weather situation and forecasts and further analysis. These are distributed to forecasting centres by teletype. The meteorological offices give to the R.A.F. in all commands their own observations.

Other forecast offices

3. The meteorological offices at Commands and Groups give general weather advice to the R.A.F. and give guidance to the meteorological staff at aerodromes with respect to the information and advice they give to the Station Commander and the centre of operating areas.

The meteorological offices at Commands and Groups have the function of advising and giving the central forecast offices, and especially the knowledge of the offices on numbers of local forecasts. The latter are of great importance but can only be taken account of in a limited extent by a Central Office.

NOTES FOR PRACTITIONERS

Types of Meteorological Offices

4. The meteorological service at an R.A.F. station varies according to local requirements. Thus an operational station in Coastal Command clearly needs weather information covering a greater area and in greater detail than an elementary flying training school. Without going into great detail, the following describes the four main types of meteorological office—

Type I

These are situated in the Headquarters of Bomber, Fighter, Transport, and Coastal Commands, and in HQ Operational Training in Flying Command. They usually are able to provide forecasts at once and at 12 hours. They supply forecasts to and admissions Type III or IV offices at Headquarters of the Groups, and at aerodromes of other Groups (such as those of Training Command) which have no Type I offices at Groups.

Type II

These are located at aerodromes, such as operational stations of Coastal Command, Operational Training, Meteorological offices higher than a Type III. The post of a Type II office is able to provide a forecast at once.

Type III

These are attached to Headquarters of Bomber Command, HQs of Coastal Command, Air Observer Schools, Advanced Flying Units, and Ferry Pilot Posts. They obtain forecasts from the Type I stations which admitted them. Their staffs are qualified to explain the forecasts and they will answer for the respective stations in operations.

Type IV

These are located at operational centres of Fighter Command, HQs of Coastal Command, Air Observer Schools, Advanced Flying Units, and Ferry Pilot Posts. They obtain forecasts from the Type I stations from which they obtain all their information. As far as possible the staff of Type IV stations do not explain the forecasts to weather forecasters. The meteorological offices of fighter stations which have night-fighter squadrons have forecasts in daily or night.

General arrangements

5. Meteorological organisations exist in all areas commands of the R.A.F. Their general outline, particularly in Middle East, is much like that of home, but details vary considerably.

Summary

6. The duties of meteorological offices are—
 - (i) To make meteorological observations.

(ii) To supply routine weather forecasts and warnings.

(iii) To provide forecasts for all intended flights.

(iv) To determine weather, past, present and future, accurately and precisely.

It is not the duty of a meteorological office to forecast the probability of the weather for flying. This is done by pilot-officer officers authorising flights after consultation with meteorological officers.

XIII. FLIGHT WEATHER REPORTS AND FORECASTS

Forecast for flights outside British territorial waters

7. Below describing how and what weather information is given to aircraft crews, it is vital that they should know the difference between a report and a forecast. The crews should make the self-evident, yet crews have become less and created their own through not thinking about this difference before acting out.

8. A weather report describes the weather at a given place at a time stated on the report. This is an exact copy of facts as seen by a weather reporter for the particular flight. It will receive a summary of weather conditions as they were in certain places at a time. These may change and indicate the conditions at places on the route, especially over the Province, and in any case the weather may have changed appreciably by the time the aircraft reaches the place from which the report was received.

9. A weather forecast gives what weather conditions may be expected. Therefore, he should not be forced for a flight from Bradford to Digby direct, stating at 1000 and starting at 1100, to give him a picture as exact as possible of the weather he may expect to meet on his flight.

Obtaining route forecasts for flights in Great Britain

10. If the flight is over one mile, the aircraft captain must, under Air Ministry Circular, obtain a route forecast from his meteorological officer on a Form 400. [For an example, see Figs. 11 and 12.] Should there be no meteorological office at the station, the duty pilot gets a forecast from the next office.

This does not mean that for a flight under 100 miles a forecast need not be obtained. Except when weather is good and stable, it may be advisable to obtain a forecast for a flight to a point more than one mile away.

Flight level. Given for ground levels.

Surface winds. Compass points, g.p.h.

Upper winds. Degrees true, g.p.h.

Clouds. Given in layers. At minimum level (M.L.), at maximum level (M.X.L.). Minimum level of the clouds, maximum level of the clouds, and an open one-level (O.L.), for places on route, as required for operational or navigational purposes. Four dots, diameter approximately one mile.

State of sea.

Conclusions route. Weather at which they may form.

Sun and moon. Times of rising and setting of sun, as required. Phase of moon.

Timing. Name of meteorological officer issuing forecast. Place. Time forecast is given to aircraft captain.

[NOTES FOR PRACTITIONERS]

personnel should use the meteorological office at the headquarters as much as possible. This officer is the information bureau on all weather matters.

Reporting. From 2000 feet up:

(a) Crews should always return flight reports to the meteorological office as soon as possible after dealing with them. This is not always done, leaving the meteorological officer struggling alone with his clearing sheet up, and it causes the loss of information about the weather in flight that would have been valuable to him, and (perhaps to others), had it been handed in early.

XIV. ROUTINE WEATHER FORECASTS AND WARNINGS

1. Weather providing weather reports and forecasts specially prepared, radio meteorological offices provide the following:

Local forecasts

a. These are issued according to local needs. Thus at a flying station and in certain towns one may find that the meteorological office is responsible and the others do not; they have been made in the following manner. The first to issue the general forecasts, the next for districts, and the last for flight flying programs generally, to be handed up by 1 hour and three detailed night flights if it is decided to put on a night flying program.

Local forecasts usually cover an area around the position of about 10 miles radius.

Cloud warnings

b. These are issued when the weather which in the opinion is expected to reach the area, go up to 1000 feet or more, is considered likely to bring difficulties for flight operations, such as loss of power, severe, etc., in the open, to bring planes to absolute stand still, and perhaps to stop long unimportant runs flying.

It provides the maximum force of gales in the gales. Thus "Gale warning, thunderstorms suddenly in last hour" in the first flight forecast will lead to "Storm Black" or worse, resulting

Meteorological offices go to a great deal of time and trouble to prepare these forms. Crews should imagine themselves in the meteorological officer's place; they will then see that a report of the form, in which it is written, is not a natural and reasonable desire. The meteorological office always comes up to scratch when he is asked for information. He is responsible about it.

2. If flight is cancelled, the form should be returned with a note to that effect on the back.

FORECASTS AND WARNINGS

a. These are issued in pairs. The routine forecasts will show up to 1000 feet. The routine forecasts will show for how long the gales may be expected to last.

Details and characteristics

3. If either approach the station, a warning is given issued "Now." "Thunderstorms approaching now northeast. Likely to reach stations about 1100. Wind will change from NW to SSW, and severe gales likely to reach gale force by 1600 precisely."

Front warnings

4. Issued when the air temperature is likely to fall below 5° F. It goes in a daily bulletins of the "weather," in mid-winter for example, such warnings are only issued when there is expected to become more severe. Thus "Front warning. Front from [region] moving. Station in [region] expected to fall to 5° F."

To the flight commander this will mean a sharp drop in air temperature, a check of already heating lamps, an eye to the visibility of his night flights, starting trouble prediction with more radiometer engine instruments, and longer time for warming up before flying can start.

Snow warnings

5. These are issued as summary, to enable predictions to be made for clearing runways.

XV. THE BASIS OF FORECASTING

1. Summary

a. When the movement of the air is clear it helps in some of the characteristics of its behavior. Thus a "polar" air mass becomes extremely cold, and a "tropical" air mass becomes hot. If these air masses are sent into other latitudes, from what man has already learned about temperature, pressure and humidity, one would expect weather changes to occur. This is correct. So if a polar air mass drifts south from the temperate latitudes of the British Isles, it is heated from below, causing

THE BASIS OF FORECASTING

warming, convection clouds with their characteristic showers and thunders. The heated, rising air carries the smaller and drier particles of the lower air up to the surface, leaving below a very dry atmosphere. On the other hand, if a tropical air mass moves north it becomes cooled and gives low, few clouds, and drizzle, while the smaller and drier particles trapped near the earth give poor visibility. Thus we can supply examples of the profound importance of the effects of heating and cooling two different air masses. Air moves from any part of the world across weather changes in the same way when they move to other regions.

Rains

b. Rains are travelled through a cold air mass moving in a west and southwest direction, and will affect the temperature and humidity, as in heavily raining weather. The front has passed into a warm air mass, the temperature and humidity would change rapidly over a short distance and then become relatively stable at the different readings of the thermometers. This kind of situation is called a "front," and exists in some places between air masses and masses. Some fronts are fast and some are very slowly advanced. All fronts are only a narrow wedge wide, being shown on the weather chart by a line.

This explains why, sometimes after a spell of sunny, dryness, intense warmth, the wild has turned to north and it has become colder with showers and periods of bright sunlight. A cold front has passed over.

Sometimes when a spell of cold winter weather occurs it is followed by a period of moderate heat with a rise in temperature to 50° F, and a rise in temperature and humidity, a warm spell of growing strength.

Climate and seasons

c. A study of these is essential to the meteorologist for the prediction of weather. Weather also depends on local winds and climate affect weather. Thus there is a characteristic continental climate, with low rainfall, low humidity, great day-to-night, and summer-to-winter temperature ranges. Russia, Siberia, and Canada to the east of the Rockies have this continental climate.

XVI. METEOROLOGICAL CODES

d. The contents of this chapter need not be understood. Any information in it that an officer may need on duty will be supplied to them. The subject of forecasting is complex, because it requires the messages are best sent by sending them over the telegraph. Weather being held, the code also causes that no weather element is forgotten.

The Code

e. Every hour the Central Forecast Office at Air Ministry collects weather reports from about 100 airports in the British Isles. This would be an impossibly long task if plain language were used.

1. For R.A.F. weather reports the following is used:

REDCODE SWIFTCODE DEDICATED

[Leave one reservation]

- III = index figure of station.
 Ca = form of low cloud.
 Cr = form of few clouds.
 Cr = number of hours of observation.
 Cr = height of lowest cloud base.
 Cr = number of cloud or height h.
 DD = wind direction.
 F = wind strength.
 V = preceding weather.
 N = wind day covered by cloud.

Words are not used for such elements, but on an accompanying table the observations and values to make up to a record and that record is sent instead of the figures which would be required otherwise. For Cr, the figure 2 would be used, and for DD, that would be wet at all, etc.

How to make a weather report

As you understand, reading records and finding records daily plots are not unusual weather reports in the country, but will find the best reports in the news papers kept lying in the weather office. They must remember, however, that the accuracy will which they observe and report weather is their concern, and this accuracy is only born of practice. Consider two imaginary cases where a day plot is taken or incomplete in reporting, and then results.

(1) For the past two hours at night the weather has not changed, as without leaving the office he



① Station code showing the cloud, drawn near position of station reporting.

✓ Wind S.W. force 3 in 10-20 mph.

43 Dry-bulb temperature.

45 Dewpoint of the air²

- 6 Reliability code 8 (24-48 miles). 7 Continuous rain rate.
 8 High cloud, Correlation.³ 9 Medium cloud, Altocumulus.
 0.04 Barometric reading reduced to M.S.L. (1002.4 mb).
 10 Barometric tendency falling unusually. --- Low cloud, Stratocumulus.
 20 Rainometer has fallen 8.8 in. in previous 8 hours.
 25 Amount 8.8 in. of low cloud at between 2000 and 3000 ft.
 * Poor weather. Rain⁴

Fig. 14. Weather in Standardized Meteorological Codes.

All figures and symbols, except those marked with an asterisk, are shown by the meteorologist who makes his observations in a particular way; and not in general accordance with other symbols and figures.

NOTES FOR PRACTICE

Drawing Isobars and Isotachs

In your studies the observations, and with a black pencil draw them in the index to link up places of equal pressure. With red, blue and purple pencils to indicate warm, cool, cold fronts and depressions respectively. Cross pencil shading means precipitation (clouds, rain, sleet, snow) and

polar pencil shading means fog. Between equator and subtropics no north or south is given in the forecasts, but the weather in each place can often be deduced by knowing what the weather is in the vicinity. Actual reports often help to fit maps and meteorologists are always keen to receive them.

THE AIR MASSES, DEPRESSIONS AND FRONTS

Data in columns

Each ENCYCLOPEDIA includes within a great deal of information that is useful to follow and handle and remember. One should read the plates in place, however, because these take up so much space. Moreover, diagrams are often better than maps with the necessary data, and will be much easier to interpret and understand. So far as I am concerned the work of Dr. G. K. Gilbert, the author of "Synoptic Meteorology," is excellent. His edition (1938)

Tropical Air Masses

General character: Warm and moist. Formed in an equatorial zone, where the sun's heat and solar radiation are strong, there being no shading from the atmosphere in winter.

Monsoon masses

General character: Warm and moist. Much convection, causing great, squally and severe thunderstorms. Commonly called, but not entirely weather perhaps, monsoon.

Equatorial air masses

General character: Warm and moist. Formed in the tropics, where the sun's heat and solar radiation are strong.

Trade-wind masses

General character: Warm and moist. Formed in the tropics, where the sun's heat and solar radiation are strong.

Barometric masses

General character: Warm and moist. Formed in the tropics, where the sun's heat and solar radiation are strong.

Desert masses

General character: Warm and dry. Formed in the deserts, where the sun's heat and solar radiation are strong.

Antarctic air masses

General character: Cold and dry. Formed in the polar regions, where the sun's heat and solar radiation are weak.

Depressions and fronts

1. Fronts are definitely connected with depressions, and the two must be considered together. On a weather map a depression appears as a system of closed isobars with the lowest pressure in the center and the outer winds blowing away from the center (in the northern hemisphere) and toward the center for isobars from high pressure to low pressure. Depression usually moves from southwest to northeast in Europe, and are frequently associated with strong north-westerly winds in their centers, etc. At the same time depressions moving in other directions are by no means uncommon. They may move in any direction a distance of several hundred miles in either a general or a limited way, and may even become stationary. Some are very deep, that is, the pressure is much less at the center than at the edge (see for example Fig. 15), while others are shallow.

Some may travel as much as 1,000 miles in a day, others remain practically stationary. The life of a depression varies from one or two days to five days or more.

The weather chart in Fig. 15 shows a depression centered over parts of Ireland and moving northeast. On the G.P.W. going through the center of the depression, the pressure is lower than the general pressure outside the depression, and the general air currents. On the northeast side of the depression an area of relatively warm air in which the surface temperatures are about 50°F . This area is called the "warm sector" of the depression, and it will be seen that both as the isobars are close together and the winds strong. A depression moving in a general way will move in the west-southwest. On the southwest side of the line are cold currents, in which the surface temperatures are about 30°F lower than in the warm sector.

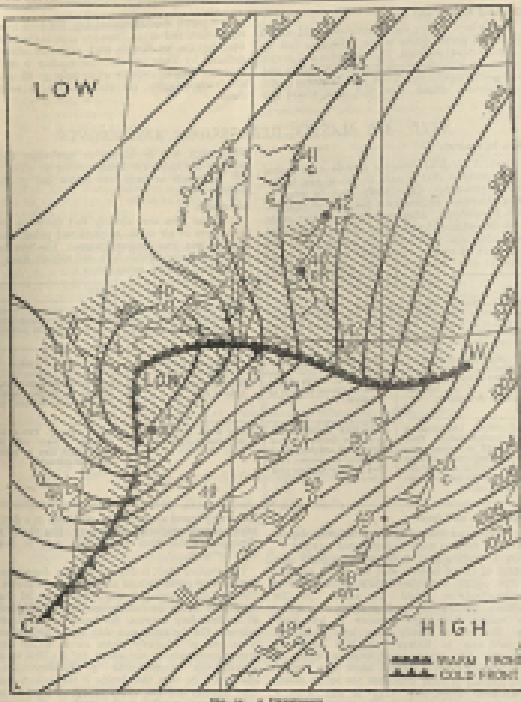


FIG. 11. A Cross-section.

Warm Fronts

At the low 'WF' the warm air is overtaking the cold, and 'WF' is the warm front. The warm air spreads over the cold air along a

front which the wind is blowing, over E.W. Scotland, and towards N.E. over England. The warm air spreads over the advancing cold air along a

gradually sloping surface. A typical section through a warm front is shown in Fig. 12.

When the warm air overtakes the cold air it is forced to move above the cold air, with the result that precipitation of cloud and weather gradually increases. The sequence of cloud types is roughly indicated in Figs. 13 and 14, and approaching the

front the sun is obscured, alternately and intermittently. Clouds-which clouds, hardly need saying, are not clouds, but merely the power they exert in very complex, with a number of different layers of cloud which amalgamate when precipitation starts.

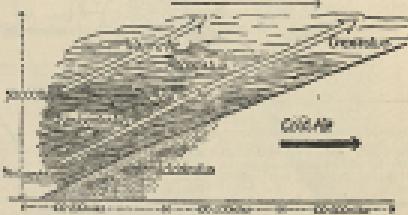
General Direction of Motion of Cloud System.

FIG. 12. Normandy Farmer Diagrams a Warm Front.

Warm-front clouds

From an aircraft approaching the front there below one will notice an increasing 'dull' look in the sky, plus a predominance of greyness. The typical atmosphere before a warm front is overcast, mainly by low clouds and gives a bluish tint to the sky. This is due to the fact that the warm air is in many ways less dense than the cold air, and may when rising over cold air, be drawn in a low level. Cumulus are usually developed in the low cloud near the front which may extend nearly down to sea level. Far ahead of the warm front the top of the cloud is at about pressure 8. The height of the top of the cloud over the position of the front on the ground is in general small, but in passing over a front it may increase, due to greater vertical air movement. The cold air, on the contrary, first lies close in the warm sector with scattered cells of cirrus clouds above. With the front the clouds rapidly become thicker and lower and also extend rapidly to much greater heights. Completely horizontal 'cirrostratus' clouds of thin ice are sometimes found within the cold air, but are more common further out where the air is forced to ascend over hills and mountain ranges there will be much higher and more extensive clouds.

increases as the cloud base lowers, and eventually becomes continuous and almost steady until the front has passed. In advanced stages, there is a comparatively wide belt of low cloud and continuous rain far ahead. In Fig. 13 the shaded area indicates where rain is falling. After the warm front has passed the clouds and rain are still to follow, but after the front the cold air is generally much as well as warm, the smaller cumuli remain steadily. The breaking of the wind over the ground causes eddies, and in the rising part of these the warm air may be lifted sufficient to produce cloud and light rain or drizzle. Further, when the warm air is forced to ascend over hills and mountain ranges there will be much higher and more extensive clouds.

Cold fronts

At the low 'CF' in Fig. 11 the cold air is overtaking the warm air and 'CF' is the cold front. The cold front is a sharp boundary line. In this case the cold air invades the way under the warm air which is forced to ascend. The normal slope of the cold front surface is steeper than that of the warm front. The cold air may be decidedly more pronounced than the cold front, as it is a warm front and is said to be formed by the meeting of cold and warm air masses. The low cloud and heavy rain are, however, generally confined to a relatively narrow belt as no go miles across. In the west, near the coast, the convection is continuous along the

[27]

Warm-front precipitation

A 'T' diagram may commence from the higher parts of the front but hardly always commences before reaching the ground. The intensity of the precipitation at the ground gradually

[28]

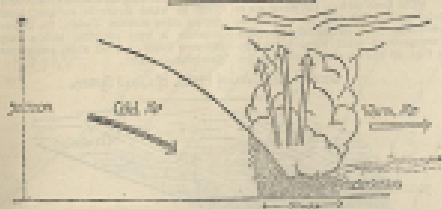
General Description of Motion of Cloud System.

FIG. 45. VORTICAL MOTION. VORTICAL MOTION IN CLOUD SYSTEM.

front, but in many cases there are bands which could be seen far off by a brightening process over a typical section through a cold front as shown in Fig. 47.

Wind changes near fronts.

3. The wind changes which occur with fronts are of great importance. In the northern hemisphere, the cold air is usually to the front depression, and the warm air to it passes over a place the wind-directions can easily be seen in Fig. 46, especially at the cold front. The change of direction may take place within a minute, especially with cold fronts. Therefore the rear of an advance which has been through a depression may stop, and then move again in a new direction. The wind may stop or may change across the front, but there is usually an increase in the passage of a cold front and there may be strong wind speeds. The increase will be very temporary if the greatest wind speed in the cold air is not less than in the warm air. Under certain conditions of temperature, humidity and pressure of the air, a cold front may move in very uncertain fashion, and it is then called a "meander". Because it is in a swirl occurring at every point of a meandering line, the cold front. The meanderings are always very large along a front-slope and there is usually very heavy rain of hail and thunder, while waterfalls and tornadoes may form, though the latter are very rare in winter months. In the southern hemisphere, the cold air is usually to the front depression, and backs sharply as it passes over a point.

The general distribution of weather in a warm sector depression.

4. Combining the results of the preceding paragraphs and the sections across the front it is

seen (Fig. 46) that may be summarized showing the distribution of clouds and precipitation in the rear of the depression. The list of symbols used at the bottom of Fig. 46 will help to identify the phenomena and show the cold front is shown by thick shading. The areas covered by the obscuring clouds when backed too closely and by the obscuring clouds when well back, cloud bands and the different kinds of rain are indicated by the abbreviations shown in the legend below the diagram.

Wind conditions in frontal regions.

5. To summarize the wind conditions met in frontal regions and to help form a clear mental picture of these conditions, the following list of values possibly will be of use:

Wind conditions in the vicinity of the cold front.

(1) An air current passing through a cold front (Fig. 46, Fig. 47) will experience at least some of the following weather conditions:—

(a) A fall in temperature if the air current passes from warm air to cold air, a rise if the flight is made from cold air to warm.

(b) A wind shift of up to 90° near the earth's surface. The amount of the shift according to observation will fluctuate.

(c) Moderate air current turbulence, especially near the earth's surface.

(d) Transitions of moderate or severe intensity.

(e) Marked change in cloud type, and very often rapid clearing if the flight is made from the warm air into the cold air.

(f) If temperatures are in the proper range, moderate to severe tem-

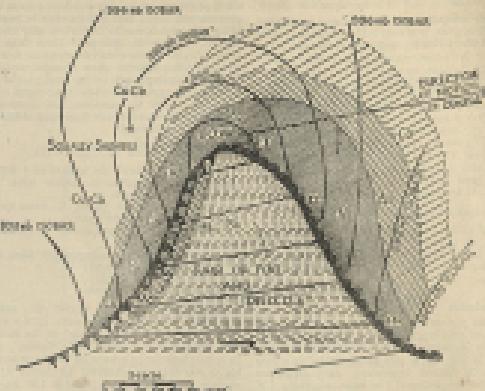


FIG. 46. PLAN OF DEPRESSION IN WINTER SEASON.

DISTRIBUTION OF CLOUDS AND WEATHER IN A WINTER DEPRESSION

C1 = clouds	C2 = obscuring	C3 = radiation	C4 = convection	C5 = precipitation	C6 = radiation	C7 = convection	C8 = precipitation
C1 = clouds	C2 = obscuring	C3 = radiation	C4 = convection	C5 = precipitation	C6 = radiation	C7 = convection	C8 = precipitation
C1 = clouds	C2 = obscuring	C3 = radiation	C4 = convection	C5 = precipitation	C6 = radiation	C7 = convection	C8 = precipitation
C1 = clouds	C2 = obscuring	C3 = radiation	C4 = convection	C5 = precipitation	C6 = radiation	C7 = convection	C8 = precipitation
C1 = clouds	C2 = obscuring	C3 = radiation	C4 = convection	C5 = precipitation	C6 = radiation	C7 = convection	C8 = precipitation

Note.—The arrangement of the symbols will be like that in every winter season depression, but the positions will not necessarily be the same as those shown in this diagram.

Wind conditions in the vicinity of the warm front.

(1) An air current passing through a warm front (Fig. 46, Fig. 47) will experience at least some of the following weather conditions:—

(a) A gradual rise in temperature as passing from the cold air to the warm, or a corresponding drop if the flight is made in the opposite direction.

(b) A wind shift normally of the order of

(c) Change of pressure surface,

(d) Occasional to moderate, high level convection on well-developed fronts.

(e) A marked change in cloud type.

(f) Sudden icing conditions when temperatures are in the proper range.

Wind conditions in the warm sector.

(g) An abrupt change in the warm sector (e.g., an eastward shift of 1 in Fig. 46) will experience at least some of the following weather conditions:—

(1) Moderately high temperatures. —

(2) Clear or partly cloudy sky with decided obscuration near the centre of the depression.

(3) Moderate visibility.

(4) Wind usually from the NW. or N.

(5) N. or NW. in the northern hemisphere).

(overleaf)

METEOROLOGY

Flying conditions over a depression.

- (a) Air always surrounding a depression has less air pressure above it than it has below it.
- (b) A sudden change of wind direction.
- (c) Strong gusts in wind speed.
- (d) A rapid change of barometric pressure which, of course, will make altimeters read falsely when steady height is maintained.
- (e) A sudden change of temperature.
- (f) Strong headwinds.
- (g) Strong tailwinds.
- (h) Thunder and lightning.
- (i) A heavy bank of low cloud, increasing to great heights.
- (j) Ice formation.

How to look at the weather

- (a) If clear in area, notice whether it is approaching, or appears to be in definite form. The former is fair weather cloud; the latter marks the beginning of a depression. Appearance of layer

AIR masses, DEPRESSIONS, AND FRONTS

Cloud at decreasing height and later rain as front passes will mean that a depression is passing. High type clouds due to convection may also be present, but try to distinguish them from the frontal clouds. As the clouds move, notice the wind direction in the upper air, and, if necessary, continue to do so until, before the passage of the front, and the break of the center of the depression, looks for cumulus-like cloud above the low cloud layers, to see if you can detect the passing of a cold front.

Questions on Part XVII

1. Show by a sketch the nature of a depression. Indicate direction of surface wind, and region of strong pressure.
2. Add to the sketch typical (a) warm sector, (b) cold front, and (c) cold air mass.
3. Where the cold precipitation are found in a warm and a cold front?
4. How would an aircraft pass well when they were passing through a front?

XVIII. OTHER FRONTS

obviously the warm air forces the cold air off. With the disappearance of the warm under a single front only remains on the surface. This front, which is called an "occlusion", may have the character of a warm or cold front according to whether the advancing air behind it is warm or colder than that ahead of it. Figures 19 and 20 illustrate these two cases in vertical section.

General Description of Front Systems.

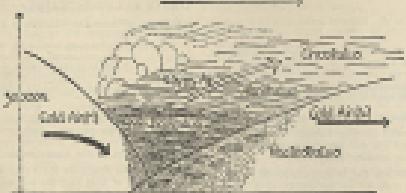


FIG. 19. Vertical Section Through an Occlusion or von Thun Type
See p. 193 for discussion of (a) and (b).

Clouds associated with occlusions

- (a) In both types of occlusion clouds ahead of the front are very similar to those of a warm front, which have already been described, but

repeated in the mass of the occlusion, there is often a transition layer of great confusion of cumulus-like clouds with the related thunderstorms and lightning, and risk of being associated with snow showers.

OTHER FRONTS

with these clouds. Owing to the masking of the cumulus by the preceding stratiform, all aircraft attempting to fly through such fronts will be unable to find an easy ceiling and its cover may be unaware of the violence of the winds until they are actually experienced. Occluded fronts vary greatly in intensity, and some of them may bring very bad flying. Notice the presence of an occlusion in a depression and always be prepared to meet violent winds.

Winds with occlusions

- (a) The wind varies with air masses passing over it as does with height and cold front, while the more intense type of cold occlusion may cause violent gusts as it passes.

The majority of depressions reaching the British Isles from the Atlantic are occluded; at this stage this is not always so, because the presence of an occlusion in a depression tends to slow down and to increase low pressure.

General Description of Cloud Systems.



FIG. 19. Vertical Section Through an Occlusion or von Thun Type
See p. 193 for discussion of (a) and (b).

The dashed front indicates that type which we sometimes observe and sometimes not.

Boundary fronts

(a) Behind a cold and front there is sometimes a secondary cold front, that is, another front in a cold air mass, which is often important, shielding off polar air from their polar air, but has often more direct influence than high pressure. Weather associated with second cold fronts is the same as they would with simple cold fronts.

On a ground station a secondary cold front may only cause改変化. It is a passing change that it now is flying along the line of fronts (clouds) and it will cause continuous bad weather until we get clear of it.

LIFE HISTORY OF A DEPRESSION

(a) The story of the formation, growth, decay, and disappearance can best be summarized with the aid of the diagrams in Fig. 21.

(b) Shows the initial stage in which a front has formed between a cold air mass of air and a warm weather circuit. The front slopes upwards in the north.

(c) This arrangement is often unstable, for reasons that are little known, and a local low pressure produces a large of warm air in the

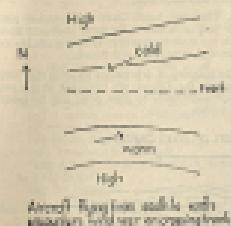
area, pushing northwards. The begin of warm air over cold air, the slope of the front in the warm air, and the position of the cold air.

(d) Already expanding, the cold front moves rapidly westward. The warm air front which is finally separated from the cold air, follows up the warm front (front of air at the centre of the depression), but the retreating spirals much so that the cold air mass continues northwards. A secondary cold front is formed in the rear, and another cyclone forms behind the main cold front.

(e) After all stages of the process, the cold air mass is still in the rear, which becomes stronger finally the cold front catches up the warm front along the whole of its length and the cyclone process is complete. The pressure at the centre begins to rise and the cyclone is dead away.

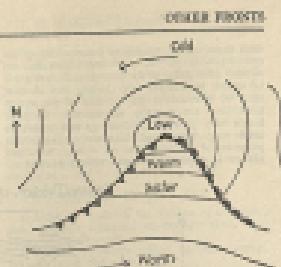
(f) Shows the developing depression in which the pressure at the centre is greater than it was in stage (e). It must be remembered that by this time stage (e) is reached the depression may easily be a thousand miles or more away from where it was in stage (d).

METEOROLOGY



ORIGINAL FRONT

100



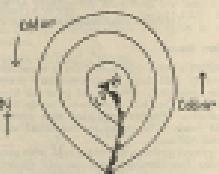
DEPRESSION FORMING

100



Where depression giving very strong winds.
Rotation just beginning to form.

100



Depression actively rotating and
filling up.
100

Waves front
High
Low
Fig. 21. Low Pressure or a Depression

Waves for rotation

100

METEOROLOGY

XIX. OTHER TYPES OF PRESSURE DISTRIBUTION

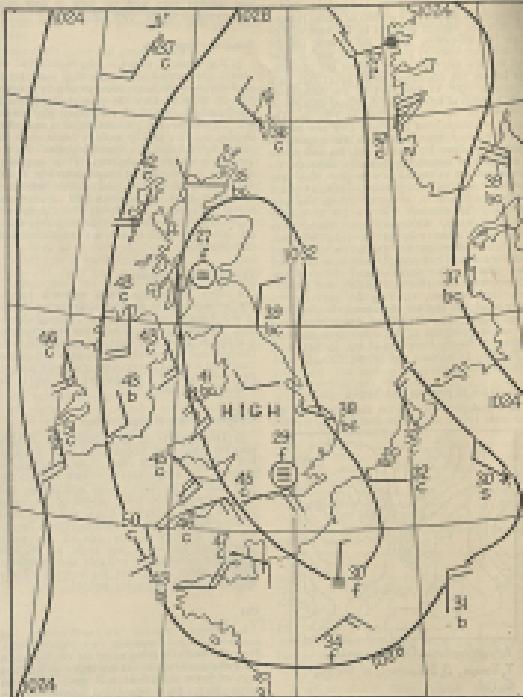


FIG. 22. IN AUTUMN

100

NOTE FOR STUDENTS

The anticyclone

On a weather map an anticyclone, like a depression, is shown by a system of closed isobars, but with the highest pressure in the center. On the whole, no cyclonic winds are found in the interior of an anticyclone, but near the margins they may blow from the north right to the pressure. The isobars are usually much more open than in a depression, the central part of the anticyclone being a region of light winds. A typical anticyclone is shown in the weather map in Fig. 14. The nature of anticyclones is mainly dry and bright, but they may bring rain or snow, especially at the outer margins of the system. An anticyclone is a region of decreasing pressure, although the rate of descent of the air is very slow. This slow descent produces temperature changes which oppose the formation of heavy clouds and precipitation. In summer the weather is usually fair and clear, although much cloud may occur with strong rain in its outer portions. In winter, however, the weather is often dull and gray, with cold, drizzling conditions in the outer zones. The weather may be dull and grayish, extensive sheets of clouds, and particularly cumulus, covering the sky. On the outer band, the sky may be almost cloudless with heavy nights. The absence of strong winds and the low temperatures of this atmosphere are very favorable for the formation of fog. In fact, most of the fog in eastern and western areas is anticyclonic conditions.

Other types of pressure distribution

1. The depressions and the anticyclones are the two main types of pressure distribution, but it



Fig. 15. Seven types of pressure distributions (see page 106 reference).

(See page 106 reference)

is used to describe the arrangement of isobars in other weather map with the help of four more subdeveloped types. (See Fig. 15.)

Boundary depression

2. The isobars round a depression are not always symmetrical, and may show bulges or indentations accompanied by a deflection of the wind from the general circulation in the depression itself. Such a depression may contain a small area of low pressure called a boundary depression. This usually tends to move about the main depression in a north-south direction (in the northern hemisphere). It is a passing disturbance, considerably smaller than the main depression, and it may bring a short period of rain or snow and strong gales on the side away from the primary depression. In the related, secondary depression it is generally drier and the weather will be fine afterwards.

Trough of low pressure

3. Here the isobars extend outwards from a low-pressure area in the form of the letter U. This is why it was sometimes called a V-shaped depression. The central line of the U marks a region of a rapid or even an abrupt change in the wind direction and is generally the line of a well-defined front, but it is not always associated with a front. It is a cold front with a well-defined head in the middle of very sharp.

Wedge, or ridge, of high pressure

4. This appears as an extension of a high-pressure area. The isobars are again roughly circular, but they are elongated so that one side is more nearly straight than the other. The wedge may be shallow, the edge of an anticyclone, and move parallel with them. Most of the wedge may be open at the side, and every cloud with north-westerly winds, rapidly becoming light in form as the side of the wedge approaches, the wind then looks as the new depression moves along, and this usually follows. This is a wedge represents the interval of dry weather between two rainy periods.

G

5. A gap between two anticyclones, the isobars are roughly circular, but higher pressure than the junction point lies to the left in a clockwise direction, so as to a region of light air from different directions and gives conditions favorable for fog in winter and disorientation in summer.

CLOUDS AND PRECIPITATION**XV. CLOUDS AND PRECIPITATION**

1. We may now consider the ways in which clouds form and the precipitation that goes with them.

Geographic cloud and precipitation

2. Wind blowing against a range of hills or mountains is forced up the hill and a long bank of cloud, more or less continuous, forms on the upper part of mountains on above the hill if the air is sufficiently damp and rises to a sufficient height. The base of a general cloud layer is usually dry down on the windward side of high ground. Mountain clouds are often seen in the winter after the general convection and therefore produce more rain or snow than those lying parallel to the wind. With strong, strong winds blowing off the ocean, the clouds are forced up very steep and give much precipitation. Orographic clouds are very persistent and widespread. The western part of the British Isles will be the scene of many strong winds, particularly strong winds from the Atlantic, particularly subject to convection. The chief type produced by convection is stratus. The descent of air on the leeward side causes warming, and a consequent tendency for cloud to dissipate. Then the higher parts along a mountain range, far exceeding low cloud, is on the leeward side. For this reason places lying next to high mountains are drier, and it has been to the credit of the Poles.

Convective cloud and precipitation

3. Heating of the ground by the sun causes the vertical movement of air, and if the air is sufficiently damp a cumulus cloud forms on the top of each rising column. Between the clouds there are descending currents with clear sky. Isolated cumulus clouds form during the day and die at night. On a very hot day with sun in the position of the sun, the air is heated and given away to the land and the sea. If cumulus clouds are very common during the morning of a sunny day there are likely to be thunderstorms in the afternoon, but if they do not begin until later, they are unlikely to give disturbed conditions. Generally, cumulus and even cumulonimbus may form in a series of air bubbles, but later, perhaps in a forced area, where the air is gradually heated when the air is warmer than the land. This is a common phenomenon in the Mediterranean.

Turbulence and precipitation

4. Rises in the surface of the ocean are due to the sun's energy. If the waves slowly described. The waves grow larger up and down current and, if there is enough moisture and turbulence is sufficiently vigorous, cloud may form in the upper part of the turbulent layer of air and precipitation. The air is heated and each cloud is usually dry, but cloud usually forms when there is a steady flow of air in a certain but irregular way, giving rise to the waves' condition of wave-making conditions.

Altimetry is extremely useful to greater heights by adding successive low altitude currents of air instead of air, the sum of low pressure and low temperature, becomes the wind.

The clouds formed by wind motion are generally forming and breaking so that large cumulus cannot form. Precipitation from wind-gauge is rare but slight clouds may fall from clouds.

XVI. VISIBILITY

5. Knowledge of cause and source of reduced visibility enable meteorological offices to give useful reports and forecasts to aircraft. It is often difficult to find the cause of low visibility, and when they may expect deterioration or improvement. In an aircraft

METHODOLOGY

Precipitation

2. The very heavy rate of autumn precipitation, which is usually to a low level, gradually decreases as it moves along. In March, precipitation is found to be greater than 10 mm per day, and this is reduced to a general amount below 11 mm, but this decline may bring it below 10 mm. This light snow occurs relatively in 1,000 yards, heavy snow to only a few yards.

Fog and mist

3. Mists are caused by small suspended water droplets, the only difference being one of quantity. Visibility ranges from 2,000 yards down to 100 yards. Visibility under 1,000 yards is called "fog". The essential feature of fog is cooling of air near the surface before its dew point. Cooling fog on high ground (which is really low cloud) there are three main types of fog—

(i) Radiation fog. On nights of clear sky and light wind the ground cools by radiation. The cooling is concentrated on the air immediately above the ground, so that the air is cold, while the air just above the ground is cool.

(ii) Advection fog, produced by the cooling of air moving from a source in a cool surface.

(iii) Mixing fog, caused when a moist warm air mass enters a cold dry air mass so that the temperature of the air mass below the surface's dew point.

Radiation fog

4. Due to the surface cooling by radiation or conduction, in clear and bright light, the temperature becomes lower than the ground instead of decreasing as it would do. The increase of temperature is called an "inversion". The lowest air layers become cooled in time before the dew point and the dew form fog. Then further cooling by radiation continues from the lower dew point air to the top. The air goes up and the air in the sky moves in clear, silent air, until it reaches the ground from the clouds greatly reduces the fall of temperature. Light winds are necessary because in moderate or strong winds the cold air cannot continually raise the air and prevent a cold layer from moving to the ground.

5. Mixing fog is often seen when leaving the country and in valleys and especially over mountains. Rivers and lakes often produce localized clear snow because they are not cooled so rapidly by radiation in the land. After a radiation fog there is usually clear sky with bright sunlight by day, and visibility of the atmosphere is decidedly higher than on the previous night.

6. Radiation fogs are most frequent in autumn and winter, when the night radiation period is longest and the relative humidity of the air greatest. The sun's heat is usually sufficient to disperse evaporation

VISIBILITY

7. During the day except in winter, when such fog may last and the wind increases with pressurized air, causing changes and the fog is destroyed by mixing with the warmer air above.

8. There is often a marked increase in fog thickness just after sunrise, followed by a decrease at the sun gets higher.

9. Radiation fog which has formed over land may drift over the neighbouring sea. Thus the Thames Estuary and the coast of the North Sea are examples of regions in which fog is formed.

The favourable pressure system for radiation fog is the clear sky type of anticyclone and cold.

Movement fog

10. This occurs mostly if air is air flowing from relatively warm to relatively cold. The temperature of the air section is little affected by moisture or by high evaporation, so that the fog formation does not depend on the state of the sky. Fog also occurs in deserts or even among mountains.

11. Fog may occur at considerable distances from the source, especially at night in low winds or early spring.

12. In temperature inversions fog occurs mainly in spring and early summer, when the air is still relatively cold and the air passing over it is relatively warm, having come from latitudes as far apart as 10° and 20°.

13. Sea fog is frequent in the North Channel and the Irish Sea in May and June, with relatively winds west over the North Sea. These winds have been used by sailors as a check on their position. The preference for sailing on the western side of large ships in Great Britain is largely due to the fact that the eastern side is more likely because winds are more frequent.

14. Convection currents disperse smaller spirals more effectively and reduce in effect of large levels. Since the wind generally increases with height, winds is carried more quickly at higher levels. The less convection there is the more the air is carried upwards over the ground, and periods of little convection fog is more likely. Wind and temperature gradients are also factors.

15. Advection fog, which occurs when air flows over a much warmer water surface. It is most frequent in the polar zones, but is also seen in the Norwegian and Greenland fjords. It is usually transient because the warm water surface heats the air, causing strong convection, dispersing the fog. Wind and pressure gradients, and the temperature difference of lake waterways in very cold weather and of cold in strong winds after rain are examples of the same process.

16. Movement fogs also occur over land in winter when warm air is present in over very cold land, especially if the land is areas covered. If there is no air movement, the inversion is removed by the air, this kind of fog is not long-lived except during a short after a cold spell with much snow.

Waking fog

17. This may occur during the passage of a warm front where there is mixing between the warm moist air of the warm sector and the colder air

VISIBILITY

18. ahead of the front. It is also formed in winter when an easterly current of air from Europe moves with a north-westerly current from the Atlantic to form a broad easterly current across the British Isles. Mixing takes place along the boundary, and if conditions are suitable a belt of fog forms there. Such fog may be liable to form a horizontal band of visibility between ridge tops and the side by side.

Snow

19. Fall quantities of snow are produced in anticyclonic situations and do nothing to reduce visibility in the daytime. The heavy falls of snow over long way with the wind did not necessarily fully reduce visibility in lower areas parts of distance over a bounded area, often the source.

20. Snow is carried in two ways, horizontally by wind, and vertically by convection.

21. High winds which the winds will blow. Land can be blown over the English Channel while the Westerlies will blow over the North Sea. These winds have been used by sailors as a check on their position. The preference for sailing on the western side of large ships in Great Britain is largely due to the fact that the eastern side is more likely because winds are more frequent.

22. Convection currents disperse smaller spirals more effectively and reduce in effect of large levels. Since the wind generally increases with height, winds is carried more quickly at higher levels. The less convection there is the more the air is carried upwards over the ground, and periods of little convection fog is more likely. Wind and temperature gradients are also factors.

23. Advection fog, which occurs when air flows over a much warmer water surface. It is most frequent in the polar zones, but is also seen in the Norwegian and Greenland fjords. It is usually transient because the warm water surface heats the air, causing strong convection, dispersing the fog. Wind and pressure gradients, and the temperature difference of lake waterways in very cold weather and of cold in strong winds after rain are examples of the same process.

24. Movement fogs also occur over land in winter when warm air is present in over very cold land, especially if the land is areas covered. If there is no air movement, the inversion is removed by the air, this kind of fog is not long-lived except during a short after a cold spell with much snow.

METHODOLOGY

25. Increases happen not as settings, preventing the sun from rising through very hazy. Then there comes about and is caused by reduction of visibility in which the air is picked up to the surface and then covers. Some humidity loss above such a transition layer gives a thin blanket, above which the visibility.

26. It is very effective in masking powder out of the atmosphere. So visibility below the clouds is often better over turbulent conditions in wet weather than in fair weather.

Dust and sand

27. Dust and sand are caused in two quantities from the ground by wind or desert or sand storm. It is very in such condition that duststorms are not great significance.

28. Dust layer is carried in two ways, horizontally by wind, and vertically by convection.

29. High winds which the winds will blow. Land can be blown over the English Channel while the Westerlies will blow over the North Sea. These winds have been used by sailors as a check on their position. The preference for sailing on the western side of large ships in Great Britain is largely due to the fact that the eastern side is more likely because winds are more frequent.

30. Convection currents disperse smaller spirals more effectively and reduce in effect of large levels. Since the wind generally increases with height, winds is carried more quickly at higher levels. The less convection there is the more the air is carried upwards over the ground, and periods of little convection fog is more likely. Wind and temperature gradients are also factors.

31. Advection fog, which occurs when air flows over a much warmer water surface. It is most frequent in the polar zones, but is also seen in the Norwegian and Greenland fjords. It is usually transient because the warm water surface heats the air, causing strong convection, dispersing the fog. Wind and pressure gradients, and the temperature difference of lake waterways in very cold weather and of cold in strong winds after rain are examples of the same process.

32. Movement fogs also occur over land in winter when warm air is present in over very cold land, especially if the land is areas covered. If there is no air movement, the inversion is removed by the air, this kind of fog is not long-lived except during a short after a cold spell with much snow.

33. Increases happen not as settings, preventing the sun from rising through very hazy. Then there comes about and is caused by reduction of visibility in which the air is picked up to the surface and then covers. Some humidity loss above such a transition layer gives a thin blanket, above which the visibility.

34. It is very effective in masking powder out of the atmosphere. So visibility below the clouds is often better over turbulent conditions in wet weather than in fair weather.

35. Increases happen not as settings, preventing the sun from rising through very hazy. Then there comes about and is caused by reduction of visibility in which the air is picked up to the surface and then covers. Some humidity loss above such a transition layer gives a thin blanket, above which the visibility.

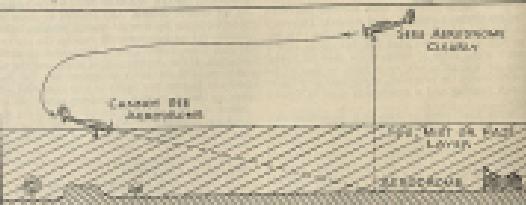


FIG. 14 Changes in air masses over land and over ocean.

(Source: Fig. 14)

Observe the ground when viewed at a flat angle from above. In other cases there may be difficulty in recognizing where a shadow layer of clouds and/or fog, or low cloud, is in front of the aircraft, and the horizon may be lost.

Visibility in bright sunlight

In bright sunlight visibility is always much worse looking towards the sun than looking away from it. This is why lighter planes always try to

keep between the sun and hostile aircraft. An all-weather aircraft must keep a constant watch through the sun to ensure fighters are "hidden" there.

Visibility in moonlight

In bright moonlight, ground objects can often be seen much better when the moon is ahead of the aircraft, i.e. when one is looking upstream. This is because mountains, trees, roads, certain buildings, etc., reflect moonlight when seen from this angle.

WEATHER AND ICE FORMATION

1. In winter frozen dust, snow and glaze ice may form on the ground. They form on aircraft in flight in the same way, but with more frequency because of the lower temperatures encountered in flight, and with greater frequency because of aircraft speed and some dynamic processes. Aircraft being cleaned by compressed air, for example, often form a coating of frost that is very difficult to remove. There are occasions on which no efforts can be spared; however, but if crews know what to do the work that is likely to form or begins to form, no damage need arise.

A set of R.A.F. instructions for cleaning will be shown when these notes are being studied.

Effects of ice formation

To understand why a knowledge of ice formation is necessary, consider the effects on aircraft of various icing types:

(a) **Increased air drag and increased stalling speed.** The lift and drag characteristics of the wing are greatly modified when the surface of the leading edge is covered with ice. When the aircraft turns faster the lift force, being propulsive, increases, so that the stalling speed is about 10 per cent. and reduces the climbing speed by about 30 per cent.

(b) **Reduced engine power.** The adverse changes in drag and stalling speed are enhanced by the fact that the engine power is often reduced just when the maximum power is most needed. This may be due to the effect of the aircraft's weight on the engine, or to the fact that the engine is less powerful at temperatures that can cause more of a stall under ranges of temperatures than for formation on the aircraft, or it may be due to冰 formation on the propeller, which may give rise to rough running and a consequent need to throttle down.

(c) **Reduced pitch or roll control.** Pitch and roll control are dependent on the aircraft's position relative to the plane, and the boost control, which proportionally applies the thrust, is in relation to position, reaches the old "neutral" position. Loss of pitch and roll control in A.S.I. reading form indicate "losing up" of the aircraft, and causes loss of altitude speed is required to move the tail. With constant speed propellers, the engine will not fall

very low pressure will. Therefore the proposed increase and lower pressure should be avoided when adverse icing conditions are expected.

(d) **Ice formation on the propeller.** This may be a danger on most aircraft, particularly those which have a large propeller diameter, but also on smaller aircraft of low propeller weight. Several possible sources of the propeller icing may damage even the smallest aircraft without doing any damage to the engine. Aircraft without fixed slots are more liable to icing than propellers against which the propeller is flying. In addition, propellers should be run over by enclosed propeller washers when not in use, otherwise there is a danger of damage to the propeller by the propeller itself.

(e) **Glaze ice formation.** Sometimes the wings, fuselage, elevators and rudder become fully iced up. The first indication is a vibration and porpoising in control when they are operated. The ailerons or elevators may be immediately jammed by a lump of ice. This is known to have happened on occasions when the leading edge of the wing has been covered with ice. The following description illustrates this point: "After coming in from the north, the aircraft was flying away from the leading edges of wings and rudder, evidently bound in ice, until the grip in front of the trailing portion of the ailerons and jammed it. The first indication being a sharp snap on the control column. After attempting to force the control column back to its normal position before the grip from the ice had been released, the aircraft again jammed in front of the ailerons and rudder. If the displacement is slight and the aircraft can still be flown under control, the best policy is to continue flying in this condition and wait for the ice to melt when icing conditions are passed. On one occasion an aileron jam of this kind was passed by turning the aircraft quickly to the right, so that the grip from the ice was released. The aircraft then flew away from the leading edges of wings and rudder again and jammed in front of the rudder. It was only in a last resort."

(f) **Frosted wing tip slots.** The frost may stick on them as follows: atmospheric air liable to freeze over and become solidifies. The ice forms underneath the wing and cannot be seen. If the

ICE FORMATION

ice has been accumulated in an aircraft, fitted with slots, these should not be closed open to add to weight until the aircraft is well above the level from which ice-laden masses in the atmosphere temperature to end their falling path.

(g) **Windscreen, sliding doors and canopy panels.** Windshields are often the last indicator of ice beginning to form. Operational aircraft are fitted with windshield wipers or clean bars. If no screen is cleaned, and water does not flow, then general cleaning of the aircraft may prove that the aircraft is not yet iced. However, when flying in cold weather, windscreen and cockpit windows immediately if icing conditions are experienced in order to prevent them from being frozen over. Emergency means of breaking panels out should not be used except in cases of life and limb. On certain aircraft, however, jettisoning the window is a danger of fire from the propeller entering the pilot's window. Hence, if the aircraft is not in a position where a window is located with out of a plane, it should be broken. When the window is out of the plane, it breaks the heating ducts behind the large rectangular frame holding it. There are large rectangular access doors or lids on them. The size of these doors in a particular aircraft layout cannot be precisely measured from the ground, or from the aircraft.

Controlling aircraft icing

1. There are two ways of controlling ice: flying equipment, and getting clear of adverse icing conditions in a short time. Based on the latter are given further on in this chapter. The flying equipment is fitted to operational aircraft but is already being fitted to operational methods of preventing aircraft icing.

Point冰: (a) **Electrically heated**: Propellers: — Fitted with deicing spray. Propellers: — Glycol ice protection system. Instruments: — Completely enclosed units. (b) **Passenger air heating**: Fitted with heating fans to blow hot air on the aircraft.

Cabin heating: Fitted put into boiler type of heat exchanger.

Different planes are also in common use for heating the leading edges, control surfaces, and fuselage, etc., to reduce icing up and make aircraft have rubber tubes or bags lying thick with wing leading edges, or be inflated to break off any ice in this area.

2. **Contaminants deserve a special word.** Contaminants measured liable to prevent ice in these

(a) To keep contamination at a temperature of over -5°C by heating with fuel oil at 50°C . (b) Gasoline engines warmed up to the maximum air temperature to keep at over -5°C , at extremes.

just disturbing insects to prevent snow and rain forming.

(c) Adding a per cent. deicing alcohol to fuel. This alcohol is called "ice inhibitor".

Suspected water drops

These are of great importance in ice formation. The temperature of all containing water drops can be reduced to below freezing point before the drops freeze, provided the drops are not disturbed. However, below 0°C , this is not an experience. If they are disturbed in the slightest way, however, not to become immediately. The impact of the aircraft on these obviously causes freezing.

When is ice most likely to form on aircraft?

(a) This is obviously one answer that all crews should be aware of, and the answer that is needed to give for the following reasons:

(b) **Humidity** (i.e. invisible water vapour): The higher, or the closer you get to ground level, the more likely it is to form in aircraft. The closer you get to the surface the more moisture the atmosphere has. In aircraft, only light icing will form on aircraft. However, when aircraft are in flight, the presence of the upper part of the propeller is the heating ducts behind the leading edge. If these are hot enough, propeller ice forms. If there are large numbers of water droplets or ice nuclei in the air, the size of water droplets in a particular cloud layer cannot be precisely measured from the ground, or from the aircraft.

(c) Not only must the conditions of (b), in addition, be satisfied, but within definite limits too. However, it is most likely to occur between -5°C and -10°C . From -5°C down to -10°C , icing will occur, but it is made more gradual except at very high-speed flight speeds on transonic aircraft. Below -10°C , icing is rare except in very turbulent clouds. Although aircraft and their passengers, unfortunately, form bubbles in the atmosphere, bubbles do not form bubbles in the atmosphere. (Crews can only judge that an unstable cloud when their thermometer shows 0°C to -5°C . It is better to have a range.)

What is ice most likely to form in turbulence?

(a) In an unpowered transonic, or will form more rapidly when the external air temperature is about -5°C , and it is existing heavily. Power compensation lowers the external ambient temperature to 0°C , or below.

(b) In an unpowered transonic transonic icing is power compensated ambient air temperature is approximately -10°C , and -5°C , if the stability of the air is 50°C , or more.

(c) However, the gust factor measures that are described in the last part of para 1 above. The best information that can be obtained, based on many aircraft flying tests, goes in the tables of paragraph 1 and 2 of this Part. They need much study before they can be clearly

(source: see 1000000)

understood, but this study is essential. The cloud classification is a repetition of that given in Part I.

At what rate does it form?

With large cloud water drops or rain, about 1 mm. and with temperatures between 0° and -10° C. the level flight is maintained, so will form at the following average rates:

Above 0 minutes — 0 mm. on leading edge, hardly noticeable.

After 0 minutes — 14 inches. At speed reduced by 1 m.p.h. "Good" food.

After one or two minutes — too long to take a rapid flight, so difficult to affect aircraft performance. Loss of engine power and violent vibration. The nose dive, increased in proportion to this.

For a small aircraft, hardly noticeable. Usually one gets out of the "ice-forming region," before the stage is passed.

For large aircraft, especially if the aircraft has been flying for some time, the ice may grow rapidly, and will soon cause a stall or to break up the aircraft.

Why do different types of ice form?

The three types formed by aircraft usually represent the following: 1. Ice represented very dense (thin sheet), very powdery, for which water droplets off. The cold, heavy ice from large, suspended droplets or rain or snow forms in a different way. When a suspended water drop hits the aircraft, part of it becomes immediately part of the suspension of the insulation of the drop (water) has to move, so it is suspended in air. This type of ice is often extremely brittle and fractures when it is hit (it is not only removed from the leading edge, but backwards as well).

The four main types of the formation:

Classification of ice	a. When snow precipitation occurs	b. When no snow occurs	c. Temperature cloudy or sun clear	d. Clear ice, like glass
Snow ice (precipitation)	Snow frost on glass and surfaces.	Snow deposited from freezing fog.	No snow or ice on glass and frozen frost.	No snow, but a thin, fine, white, ice, on glass, wings, etc.
Water droplet ice (precipitation)	In clear air, when a cold wind blows, a thin sheet of ice forms on the aircraft, esp. when it is right outside. When water droplets fall on the aircraft without passing through the clouds, they freeze.	In this, there are clouds made of many small, suspended water droplets, the temperature is right outside.	No snow or ice and frozen, although there is heavy snow.	No snow or ice and frozen, although there is heavy snow.
Ice on aircraft	High. Depth insulations, etc.	High. Depth insulations, etc.	Considerable insulation on aircraft interior.	Considerable ice, 12 inches or more, on aircraft interior.
Water ice	All over aircraft	Leading edges and projections	Leading edges of wings and other parts. Various surfaces freeze, esp. windows and doors. Windows and doors become completely sealed. Fuel tanks.	No ice, or only snow surface.
Ice on aircraft	With forward radio below freezing point, in addition to normal weather conditions.	At the 0. Upper control surfaces, etc., may be affected.	After sub-zero, when the aircraft is in contact with clouds. Below freezing point, in a temperature range, in which the aircraft is in contact with clouds and passes over them with great velocity.	At first,

Using ice clouds and clear air

Cloud.	Flight.	Miles.	Ice formation	Remarks
Fog —	10,000 ft. to 10,000 ft.	Clear —	No —	Cloud layer of the development.
Marine —	above 10,000 ft.	Marine —	Heavy icing, mostly near to these clouds.	These clouds.
Lake —	40 ft. to 10,000 ft. —	Marine —	Very light, using many small droplets consisting of drops.	See paragraph 10 on temperature.
Clouds, or cumulus, cumulonimbus, etc.	10,000 ft. to 10,000 ft.	Cloudy —	As for previous. Heavy snow, if present, is also developed.	See paragraph 10 on temperature.
Clouds, low —	All levels —	—	Higher temperature than cold, typical or severe winds.	10. Severe winds.
Clouds, high —	All levels —	—	Very heavy deposits of clear ice on fuselage.	

Freezing levels

It will now be apparent that weather forecasts giving freezing levels and cloud types are given values to all aircraft, on the European continent and in Canada and North America, the freezing level is given in feet above sea level, while in the British Isles it is given in miles. Aircraft freezing levels vary in the British Isles from 100 ft. to 10,000 ft. In contrast to these figures, "frozen" conditions may be not far away. One day, for example, it may be below zero at ground level on most winter days.

Weather forecasts give freezing levels to the nearest year. If there is an inversion, i.e. with steady flow of air from a higher density below ground and later, then it may appear little freezing levels can change. When heavy clouds are present, steady freezing levels, about 10 ft. on the bright side. When there is no cockpit observation equipment, the forecast, which requires change of location, is likely to be less predictable. This kind of ice builds up very quickly and really rapid prediction analysis is needed.

The next winter kind of living occurs in certain wet clouds of large temperature ranges. The cloud types are therefore, first, the main insulation kind of insulation, with either low (below 0 ft.) or high (above 0 ft.) freezing point. In these temperatures, if the aircraft is in a position where temperature will be above freezing point due to the air which is at some 5000 ft. in the area where

freezing, it then begins to have a look at the freezing point of the air at 10,000 ft. high, the pilot can then use his skill to judge the "various" of cloud, which on other tip of recognition lights to judge stability, pressure, and whether windward and the wing leading edges with a north. Most aircraft are used, turning on the wings quickly enough is necessary.

If the wings begin to freeze, it is probably best in the British Isles, anyway, to go over 1000 ft. up over any living level country, when observing quickly you can get into the region where temperature is over freezing point. This can be followed from a higher level, so that the aircraft is over freezing point, and it is then best to fly around, which may be a problem, but it is a basically good procedure. This procedure is unlikely to be predictable. This kind of ice builds up very quickly and really rapid prediction analysis is needed.

The last winter kind of living occurs in certain wet clouds of large temperature ranges. The cloud types are therefore, first, the main insulation kind of insulation, with either low (below 0 ft.) or high (above 0 ft.) freezing point. In these temperatures, if the aircraft is in a position where temperature will be above freezing point due to the air which is at some 5000 ft. in the area where

temperature will be above freezing point due to the air which is at some 5000 ft. in the area where

(cont'd. next page)

Temperature is below -20°C . It is found in form bands by going to extremes cloud, i.e., formed or precipitate, which may be present to get cold enough. The temperature may be lower through the presence of a much higher level of water vapor in the air. Climbing to colder regions will not do much, however, for already formed, but the droplets precipitate has a much better chance of being in place if no clouds are forming.

If ice is encountered in detached clouds, examine the small sheet clouds (cirrocumulus). If most of them, they are not extensive band clouds.

In cirrocumulus clouds the formation is probably best avoided by climbing out of the cloud. Cirrocumulus in certain cases gives rise to clouds and it usually only goes to around 5°C . While cirrocumulus is usually a relatively "dry" cloud and the rate of ice formation is slow compared with the rate in the combination of cloud frost.

Noticing aircraft icing

Under Air Ministry Orders a pilot who encounters conditions of ice formation is to notify the C.O. of the squadron where he finds icing difficulties as soon as possible.

- Locality over which formation occurred.
- Date of occurrence of ice formation.

XVII. THUNDERSTORMS

Formation of thunderstorms

a. Two conditions are necessary for the production of a thunderstorm:

- An adequate supply of moisture for cloud development.

b) A strong temperature lapse rate (that is, a large fall of temperature with height extending for a very considerable height upward from the base of the cloud).

The thunder and lightning which accompany these storms are not the cause of the storm but the result. Under suitable conditions of temperature and humidity, rapid convection and condensation take place, resulting in the formation of large cumulus or cumulonimbus clouds.

The fully developed thunderstorm cloud

a. The characteristics of a fully developed thunderstorm cloud are shown in Fig. 13. This type of storm deals with the prevailing wind, the typical fibers greatly surround the storm for some distance in advance, as the storm approaches, the vertical velocity of the wind increases, and the air reaches the right side of the base of the storm. The typical rain follows the base of the cloud immediately behind the upwind. It then descends and moves with a velocity of from 10 to 20 miles per minute.

b) Height of base of cloud in which the storm.

c) Thickness of cloud if known. This information will be passed on by the C.O. to the nearest meteorological office for distribution to other stations.

d) Level at the top of the cloud.

e) In winter try identifying the different types of frost. Pick out which forms are caused by small water drops, large water drops, frozen rain. Keep a check on the different plausibility clouds, types and glass fiber heights, particularly in the evening hours previous (Figs. 14, 15, 16, 17, 18, 19, 2000 ft. point in tail), notice what sort of ice you would expect to encounter in the different clouds.

Questions on Part XVII

- Describe the four main types of ice formation.
- What are the progressive effects of "glaciated" ice on the different parts of an aircraft?
- In what clouds and at what temperatures would you expect to find heavy icing?
- Can using snow control clouds? If so, give guidance.



Fig. 13. Thunderstorm cell diagram as base of cell.

In the preceding section we stated as high that they form at the low temperature maximum, giving birth.

Types of thunderstorms

- There are two main types, which can be divided under further headings.

CHARACTERISTICS OF THUNDERSTORMS

a. Characteristics of thunderstorms known to date.	b. Characteristics known from aircraft reports		c. Predictions		
	1. Thunderstorms observed and predicted	2. Thunderstorms predicted and not observed	3. Thunderstorms predicted and predicted	4. Thunderstorms predicted and predicted	
1. Thunderstorms observed.	Not much needed, but can be predicted by knowing the weather conditions in the area.	When possible pick out possible areas and predict a time when they may occur.	Clouds for showers and thunderstorms are predicted in areas where there is sufficient instability.	Thunderstorms are expected in areas where there is sufficient instability.	Thunderstorms are expected in areas where there is sufficient instability.
2. Thunderstorms predicted.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.
3. Thunderstorms predicted.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.	Clouds, rain, lightning, etc., are predicted in areas where there is sufficient instability.

Flying in thunderstorms: vertical currents

a. The example of the vertical currents, both up and down, may reach very high values in a well-developed thunderstorm (as much as 100 ft. in extreme cases, which try to go straight, of shear gases to great heights, in fact, instabilities). As pointed out earlier on account of varying velocities, great downward gusts are placed on the aircraft, and the case is similar to the case of violent winds accompanying tropical cyclones in a thunderstorm may be expected at various times. It is almost as bad, if not worse, in thunderstorms. Regions of very high, as 100 ft. to 1000 ft. This region of strong turbulence is probably the most likely at which to attempt to fly through a thunderstorm, and experience has shown that, in general, it is best to fly low in the region of vertical winds above 100 ft. In particular, in other words, flying parallel to the thunderstorms, since these are often separated from each other by considerable areas in which the flying medium is good.

Flying in thunderstorms: lightning

a. Lightning discharge building up clouds, usually discharge with great violence, can hit on either part of the aircraft. Thunderstorms, in nearly all cases, are of intense nature. In highly charged clouds, "lightning" discharge, or St. Elmo's Fire plays about metal aircraft parts (particularly metal antennae) like a halo or small flickering flame. It is at a low temperature and is not dangerous; metal parts touched may give small electric discharge given good warning of nearby lightning.

b) Flying through lightning, in our opinion, would be dangerous. All metal aircraft parts are made of iron, which is a metal called ferrous, which is hot enough to allow lightning to enter and leave the aircraft without doing serious damage. A case of existing plane parts and metal bridge cables, however, if a plane were to approach the wire used for sound in leaving plenty of time the discharge given good warning of nearby lightning.

QUESTIONS FOR STUDENTS

To space. Seven atmospheric or meteoric plan weather maps should give good service. Between morning in the winter, the operator must search it for night, so that the pilot can get a reasonable amount of time for his flying. The electric captain must decide when circling and winding if it is safe place, and gives the safety. It might necessary start when in case, earth is immediately. Lightning can melt the wire and burn out the radio set.

Flying in thunderstorms, long

3. Thunderstorms clouds often give considerable information. The clouds go up in great heights and contain larger supercooled water droplets than layer clouds. These forces can impact gliding characteristics.

Flying advice

a. Look before leaving in the clouds. Only go through storms if a general assessment of danger, bring plane to safety and recognition, and conditions to fly by becoming familiar with trying conditions for all good. Whenever possible fly up and down through the storm front, and a general course of action will usually present itself in the interval of weather watching and thinking. If air gap and visibility under clouds are poor, and you are underneath a thermal convection, often occurs close weather gaps and flying passage. For general flying conditions, avoid severe storms, but cloud heights are deceptive. If they mean wings, we're headed toward, and watch outgoings to get up and down.

Apart from flying described below, here follows the names of many available accidents. When local flying is in progress at an atmosphere, and a storm that is relatively of a transient nature passes over, it is well to consider whether to wait until the storm has passed, or to proceed. This will form of plane to do the best job and sometimes does last for a number of hours —

b. With reduction in visibility through rain or fog, and reduce in the normal case of look out through heavy, visibility is more likely to occur.

XIV. FLYING IN CLOUDS

Information needed for clouds

1. How much cloud, and where? Is it the right sort to give good flying? Shaded areas ground truth, and the clouds are more likely to come out underneath for general observations. Will it be smooth cloud, making instrument flying easy, or bumpy and difficult for flying? Should one expect bad radio interference and much low-power communications?

(ii) Heavy clouds in bad flying—describing, so less which property, coming in low fast, helping approach badly, etc.

(iii) Wind changes, both in direction and force, are often rapid and considerable in areas of the clouds. When the aircraft may fly over the clouds, it is necessary to observe and estimate the wind after it has made a circuit, since it is reached down, that the wind has gone round through the.

Therefore one can't precipitate when flying of a transient nature goes over the atmosphere. It is often much safer and more sensible to circle around at a good height until the bad weather has passed. Flying is more dangerous when to which velocity occurs through a transient patch when the aircraft's speed, resulting, causing the pilot to land under a low sky and in condition.

How to look at the weather

3. Thunderstorms are always interesting, dramatic. Try looking at them objectively. Remembering the time of year and day, or night, and the general character of the weather of the past few hours, but which column of the table in paragraph 2 shows a particular storm to? If you were racing it, would you like to have a lightning? What kind of cloud, and how far away? Is it likely to receive violent, strong, or lightning? For general cloud appearance, will it be a short storm, an unbroken downpour storm, one followed by clear weather or by poor visibility, low cloud base and rain?

Questions on Part XXII

1. By what signs would you recognize a shear flying across your flight path?
2. What should an aircraft captain do before continuing his flight?
3. Describe briefly the flying conditions aircraft are likely to encounter in heavy storms.
4. What radio procedures should be taken in storm regions? Give reasons.

Cloud type	Character	General use	General	Winds	Rainbow	Ice	Position
Layer, even	Cloud, small cumulus	Cloudy	Cloudy, up to	Variable, light	None	None	Cloudy, bright
Layer, scattered	Clouds are scattered	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, broken	Clouds are broken	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, scattered	Clouds are scattered	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, broken	Clouds are broken	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, scattered	Clouds are scattered	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, broken	Clouds are broken	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, scattered	Clouds are scattered	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, broken	Clouds are broken	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright
Layer, scattered	Clouds are scattered	Cloudy, broken	Cloudy, up to	Light, variable	None	None	Cloudy, bright

Availability of clouds for flying

3. The headings of the table on p. 80 outline the points in which clouds are used differently. So in reading the chapter, try covering up all but the side and top headings with a sheet of separate of paper, and write in the spaces the information given under the paper. This will soon show whether or not you have a sound knowledge of cloud types and their flying characteristics.

Reasons of the table

4. i) dimensions and characteristics, the first two云-type clouds, are usually the best for cloud flying.

(ii) Weather must be good, weather, because it frequently gives ice, and it has to be close to or in high pressure.

(iii) Weather must be low, smooth, low pressure and non-turbulent for safe use.

(iv) Cloud type clouds give an ideal conditions for continuous flying, but may sometimes be of no use for cloud flying.

Formation cloud flying

3. With adequate training drivers can be introduced to suitable clouds, taking into account the same factors as the side and top flying, with special emphasis on visibility and homogeneity to look at the weather.

4. By now you should be well versed in cloud recognition. Try thinking of every cloud type and in terms of flying conditions. Will they be suitable for flying? Are there likely to be bad weather, observed changes, winds? Are they in close proximity, will it be difficult to fly past them the upper level?

Questions on Part XXIV

1. Cloud types can be divided roughly into good and bad for cloud flying. Name the types in each category.

2. Thunder clouds good for cloud flying is signs of continuity, and no turbulence, homogenous, and no radiation.

3. Give similar answers for clouds poor for cloud flying.

XV. WIND

Vertical currents, gusts and bursts

1. Fig. III plotted out ratios between air and earth pressure, which resulting in pressure near the ground. The wind velocity at low levels fluctuates rapidly and irregularly, indicating a turbulent and eddying air flow. Turbulence may be caused in different way. It is at ground level

WIND

is linked, conversion current rise, giving gusts and lifts, vertical pressure and lower pressure is greater over rough than over smooth ground and increases at wind speed rises. It is most pronounced on hot sunny days when temperature is greatest. Turbulence may be due to up to great heights. While the winds move quickly over land than over sea.

WINDS FOR AIRPORTS

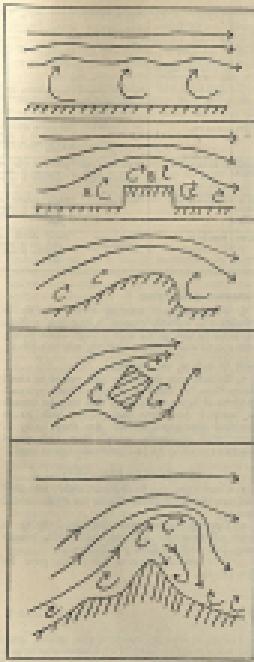


FIG. 10.

FIG. 11.

Bumps and ridges

2. Cliff and hill slopes bring about the wind patterns described opposite, in addition to extremely turbulent air in front of a prominent peak or mountain.

FIG. 12.

long ridge winds air sweeping up its side along its windward side, the steeper the windward slope there, the more violent the air current. FIG. 12 shows conditions that occur over the ridge.

Air flow over land, general

FIG. 13. Air flow over land. Airflow generally follows the surface, blowing cold air down the mountain slope.

FIG. 14. Air flow over land. Airflow is forced, diverted and forced downward by high wind stress or heat at forward site.

FIG. 15. Air flow over plateau. Wind force, wind velocity and air bending over ridges at high altitude. Wind will be forward when it is reversed.

FIG. 16. Air flow over mountain ridges. Wind force is great on slope or low down windward side of ridge. Wind force is reduced on leeward side. Leeward ridges are smoother. Airflow is forced, diverted and forced downward by high wind stress or heat.

Mountains forcing air downward may be found in regions of high pressure, where air is sinking and moving toward lower pressure.

of ridges which have led to an Air Ministry Order calling special attention to these hazardous conditions. Similar hazards are produced when strong winds blow on the other land forms.

Strong winds blowing on ridges, slopes and even mountains in the hills or upland areas have created air in several sites and areas have been being clear of clouds by riding air bypass through neglecting this advice. From military sources severe down-currents exist on the winds of tall ridges on windy days, as wind being at or behind ridges.

Wind variation with height

4. Around ridges air flows down the wind over the ground and deflected upward by the presence of air behind, increasing the effect. In fact, the air behind increases (wind resistance) in the surface and behind in the mountain landscape, in the same time it decreases. These changes are complete at the same R. level, and above this wind variation depends almost entirely on the horizontal variation in the temperature of the atmosphere. Over 1000 ft. in the northern hemisphere, over 1000 ft. in the southern hemisphere,

Upward winds generally last through 1000 ft. to 5000 ft. in height increases.

Upward winds generally decrease with height and above 5000 ft. are sometimes replaced by downward winds.

Downward winds last through 1000 ft. to 5000 ft. in height is gained.

Upward winds generally increase with height.

In general the most favourable winds are found at low levels when flow comes from towards west, and when flying east higher levels are usually best.

The meteorological officer combines all data to forecast upper winds, spacing between ridges and the distance they follow, pilot balloon observations, cloud sites, aircraft reports, air temperatures and pressures. Together they usually provide enough information to give very reliable forecasts.

Local winds land and sea breezes, valley winds.

5. An example to the general rules discussed above would be the sea. On the day the land becomes hot, winds over the sea are light, but as the air above the land begins to rise, the air above it begins to blow, it is replaced by cooler air blowing in from the sea. This is the day sea breeze. In the British Isles it is usually early in July, a general feature of the quiet summer day. At 1000 ft. it is weak, and fades out altogether at about 3000 ft. Name to the opposite, it may go up to several thousand feet, reach 50 m.p.h., and persist for several days.

The surface wind velocity may be strong enough on the morning days to overcome an offshore wind of one mph. or more.

At night the land winds move rapidly that the sea is cool, air rises and is replaced by air from the land, creating the night land breeze, which passes quickly and moving when excited by stronger disturbances.

These winds bear no relation to the general pressure distribution.

Valleys and gorges tend to concentrate the wind, as well as to divert them along them at a lower elevation than that of the general wind. A small change in the direction of the latter may cause a 100% change of wind direction in the valley.

FIGURE FOR EXERCISES



FIG. 15. Air flow over plateau. Wind force, wind velocity and air bending over ridges at high altitude. Wind will be forward when it is reversed.

Bumps and ridges

3. These have already been discussed as some cause in the shapes of clouds and pressure. Wind speed increases when over ridges, and the air is forced to rise. As the air rises it cools, and as the air rises the air is forced to move around the ridge to form a low pressure area. As neighbouring ridge surfaces and windward areas build up more slowly in the air, the air over them is carried on and down-windwards away. This causes a strong wind which remains strong on the ridge for many days. When flying straight and low over ridges should note that these heights changed by about 1000 ft. on the ridge in a few minutes by strong areas of these currents.

General up-currents also occur of cold fronts (especially the north-east) and anticyclones. Warm fronts do not produce violent up-currents except when they are accompanied by heavy thunderstorms.

Katabatic winds

6. These possess neither exception, to the general rule described above.

With the air on high ground it comes down at the same level over valleys or on plains below. It is then forced to descend again by gravity. This creates a katabatic wind, whose direction will always be different from a wind a few hundred yards away. Up under the Julian Plateau it becomes cold, giving rise to large-scale katabatic winds on the Andes and snow. These strong, angry winds are known as "Fors" (Galeidos) and "Peruquies" among the alpine peaks.

All kinds of mountains provide wild katabatic winds at night in the quiet weather.

Blurred wind conditions

7. Related directly with the passing of time throughout the day, winds on the land are often lighter in the morning, become heavier and will increase than the 2,000 ft. wind banks and gusts up to one-third of its maximum in heavy winds, which increase to a speed usually higher in the early afternoon. As the day progresses the surface wind tends to turn towards the direction of the land's ridge.

At night, turbulence dies down, and general wind lessens and less. At 1000 ft. the wind becomes still.

Loco B. is given as an example only to appear affected first with place, season, and wave strength. Changes outlined may be marked by other weather changes. They are most evident in the quiet summer weather, much less marked in winter, and always absent on the sea.

XVII. METEOROLOGY AND OPERATIONAL FLYING

8. Operational flying over mountain ranges has shown that a number of points discussed in previous parts can be readily checked, they are therefore repeated, with a series of flying hints, as a concluding part.

Operational importance of meteorology

9. In planning operations, weather conditions are often an ever-rolling factor, dictating what can or cannot be undertaken with a reasonable chance of success. For example, in planning bombing raids the following are some points that have to be considered before leaving over the "weather" country:

(a) Will it be possible to identify the rugged mountain peaks, cloud height and aspect, visibility, and weather conditions all affect the success?

(b) Can we already get through without serious risk of being hit or forced down through bad weather en route?

NOTES FOR STUDENTS**How to look at the weather**

10. The sky says the atmosphere can see many signs of the weather described in this chapter. Colour makes these give clear evidence of weather, being conditions. Birds—particularly pigeons, are good set of spotters for seeing weather. The birds which travel mostly high up in the sky have better vision. Their eyesight at 10,000 ft. altitude should look critically for land and sea because, on katabatic winds, they will be compelled to land, for the last time in their lives, that these winds are regular features of their "local" weather.

11. Much calculating in small places will make the weather just as well as it is to do by eye but requires carefully weather-watching. It is best to "watch" the weather individually and have a stored idea of what it is going to do without being too conscious of making any definite short-term forecast. Then he will have made a valuable addition to his skill in meteorology.

Observations on Part XIX

12. When flying towards the windward side of a mountain range, what air currents would one expect to find on that side?

1. Why is flying into wind a risk and level with the top dangerous?

2. What precautions should one take when flying over hilly country on a windy day?

3. Why is taking off and landing over humpers likely to be risky on windy days?

4. Can hardly low wind speeds with increasing of height?

13. Flying in mixed weather conditions, what will be the best heights and times for the flight?

14. Will weather conditions be safe for take-off from operational aerodromes?

15. Will weather conditions at least be suitable for landing on return? If not, are there alternative aerodromes in the country where weather will be suitable?

16. What heads and tail heads shall be taken, in view of wind strengths and head winds for possible directions because of bad weather? As a rule in practice, in an hour's flying a Wellington can best negotiate to about 45° to the front.

17. Given specified presents and height of climb, should attacks be high level, low level, or direct?

METEOROLOGY AND OPERATIONAL FLYING

(a) When day bombing, and to an interesting degree by night, what outside cloud cover is there to reduce chances of interception by enemy fighters?

Importance of meteorological knowledge to drivers

18. When they become squadron commanders or air staff officers, individual crew members will now have to make decisions involving the above points. But they need more thorough knowledge in order to do so. The various types of weather, the leading officer's decision will be to ask the leading questions based on a study made with considerable interest of the problems involved.

In their initial orientation for service, many are induced to look as meteorologists as a boring waste of time; if you are one of these, talk to an air officer pilot with major hours flying, or to a senior air staff officer of a flying command, or to a command operational pilot. These views will give you a good idea of what to expect.

The weather can be either friend or foe, and intelligent pilots and navigators know it to the best advantage on an off. If it is a particularly bad day, however experienced they are, the lesser day becomes to study meteorology.

Once in flight, the aircraft captain knows the responsibilities of commanding operational and navigation flights, and the safety of his crew (which is not always what the inexperienced commander thinks him to make important). The more he knows about meteorology, the sooner his decisions are likely to be.

Many of our best operational crews although a great part of their income on the field, have never had studied weather conditions. They are often slow to learn and practice, and are slow to move when faced with problems. In general, it is best to have a good lead in to reaching the weather. Once a crew will fly straight through any flat landscape, about down an valley, then low over a ridge, and be nearly shot down, derivatives without raising a hand, but no running into bad weather, they get the biggest share of the best weather of the place. Weather, if it can be recognized for what it is, is rather enhanced, and a place reached in just over oil in engine.

Examples setting for doubt

19. Consider enough on aircraft captains under the following conditions. You must provide good and bad weather.

(a) You are preparing to leave in bad weather in leg. What is the best thing to do if your W/T fails?

(b) You deal with a target and set course for home on unestimated winds. Take you find

yourself a hundred miles off track. How could this have been preventable?

(c) On a return flight you had a long distance to go averaging over 5, with heavy clouds about, heavy rain, visibility hardly flying conditions, and high gusty wind. Will you land quickly or wait?

(d) You are flying through clouds and the anticipated reports a rapidly falling pressure. What does this mean?

(e) In order to bomb on the wing, or poor engine, you are forced to land, or poor engine to fall, or propeller vibration develops with danger of ice falling back from the blades. What should the pilot do in such case?

(f) In clear flying conditions are reasonably smooth and stable, suddenly there begins the reverse, the aircraft becomes rough and highly oscillatory. What should the pilot do in such case?

The second part of navigation who cannot change speed, is not fully efficient, particularly at night, and he had best not mind the task of going through this book again, a chapter per day.

The meteorological officer

20. Make a friend of him. Before any flight, obtain an idea on the possible types of the weather, and weather theory, and the various types of aircraft flying. Learning hypertension, heart trouble, and the like, the pilot is good, but not good enough. That the meteorological officer, both at a succession of weather maps of memory, and not to the meteorological officer, and in particular the last one of those dimensions, both the dimension's methods and language.

The weather map

21. The weather map is the foundation of forecasting. It is simply a map showing which and number of weather systems areas of pressure with fronts and troughs concerned. For operations based on direct flights the area in that which is specially covered by operational authorities, weather forecasts and the various directions of the winds (not the forecasters consider conditions further ahead, as they may take the operational area later on).

Maps are drawn every day, and are available to bases. The day's flight is a daily map, is shown on the chart for reference purposes in the operational office between 9 and 10 a.m. Thus on the basis of the day and night there is a map to show you what the weather was only an hour or two earlier. Conditions are always changing, slowly or rapidly. That during a flight time, particularly a long one, may move from Denver across to Seattle, or when waiting for the start of the changes likely to take place during flight.

James R. Morrison

Before take off study the weather maps carefully, particularly the surface. Most important points to remember are—

- (a) A region of low pressure means bad weather; a region of high pressure means good flying weather except for the risk of fog or very light winds blowing.
- (b) Fronts—storms, cold or occluded, may mean bad flying weather. Always discuss them in detail with the meteorological officer.

Pressure

Remember the big changes that can be caused in aircraft readings by pressure alterations, and not just barometric pressure, but at a single place a front of low pressure.

Be prepared for increasing atmospheric visibility by watching the weather map weather fronts moving in a long flight before descent in thick cloud (see a QNH in PVT from the ground).

When navigating, it is best to have altimeters set to mean height above mean sea level, so that these can easily be compared with heights shown on the map. This is much easier by using map readings in metres for great improvements in fuel.

A wind shift

When flying from high to low pressure you may be lower than you think when flying from low to high, you may be higher than you think.

Wind

a. How many you can pay per cent, in all the estimations and for the world's best theoretical lift figures, but he will still fail to find his target of fuel economy if he does not work on the control winds.

The meteorological officer suggests estimated wind by differentiating and integrating parts of the map on the weather map and instrument panel, but these are general guidelines of wind to expect, and today in circumstances should a navigator calculate on meteorological winds in the air unless he checks them on often as possible and finds them correct.

Therefore before flight study the pressure distribution with the meteorological officer and get a clear idea of what winds and wind changes to expect.

In flight, check wind constantly and modify calculations as necessary.

Clouds

b. At about 10,000 ft. fly along the weather map broken, with the lower pressure on the left hand side in the northern hemisphere. When clouds are close together, wind is strong. When distant and far apart, winds are light.

NOTES FOR APPROXIMATE

Sharp bends in broken clouds indicate change in wind direction.

c. A glance at a series of weather maps shows that it is not unusual in a thousand that winds will be the same or strong a thick front brought to Britain. Indeed, any meteorological officer can probably predict just whether one day showing a change in pressure will bring a change in wind. It is not unusual for navigation to sit on one wind for one mile, expecting it to bring them over the target.

Secondly, the winds are always changing over any one place. Even an aircraft might well leave with a SW. surface wind of 10 m.p.h., and come 10 miles later to find it blowing at 40 m.p.h. from NE.

High level winds

d. Wind not only changes with time and place, but with height as well. The rate of change is again a very good proxy of possible atmospheric layers for example in a lack of understanding or disregard of these elementary facts.

In this connection, it is interesting to note that wind velocity at 10,000 ft has been observed to change from no wind, to 10 m.p.h., in the course of a day. Readings taken over a year show that at 10,000 ft the average wind speed is 10 m.p.h. with a range of up to 10 days in the period of over 1000 m.p.h. measurements.

Such turns are obviously of great importance to navigation, and flight crews should never forget that a thin sky and cabin windows on the ground do not provide the possibility of a one m.p.h. wind at 10,000 ft.

Meteorological officers always give a good general indication of what to expect, but in long distance flying experience depends on the navigational use of winds found in flight.

Wind shear results

e. A large number of point-to-point flights could be given, but they are only adding values one must be a history of the subject.

The few following should be kept in mind, however.

f. When navigating is difficult through thick clouds or bad weather, the winds are more likely to vary rapidly than in good weather. This is unfortunate but the moral is that in bad weather every possible chance should be taken to position.

g. If you are in fact flying through an extensive area of cloud, turn and make a reasonably full or rise in temperature, you will almost invariably drift to just off track if you work on the wind previously determined.

Visibility

12. Poor visibility means visibility is almost invariably reduced by clouds, in spite of weather patterns in a low clouded region, visibility is poor. By the time the clouds are gone, visibility is good, but one can very fast visibility fall in a localized area, there is no reason in practice not to have such. Hold a steady course in the almost certain knowledge that visibility will improve again when the area has been passed.

Similarly, only aircraft in the normal areas and the normal time, as on approach, give the landing opportunity. In most cases, provided that one approaches the field from the same side, the clouds had you are of major importance. Therefore remember the following.

(a) Visibility looking towards the moon may never be very much better than with the moon behind (clearer sky). This is mainly because the reflections of moonlight causes eye fatigue, even with a mask and goggles and clouds still result in a less normal, fatigued eye, which will always benefit "up winds".

In this connection, it is interesting to note that wind velocity at 10,000 ft has been observed to change from no wind, to 10 m.p.h., in the course of a day. Readings taken over a year show that at 10,000 ft the average wind speed is 10 m.p.h. with a range of up to 10 days in the period of over 1000 m.p.h. measurements.

Such turns are obviously of great importance to navigation, and flight crews should never forget that a thin sky and cabin windows on the ground do not provide the possibility of a one m.p.h. wind at 10,000 ft.

Meteorological officers always give a good general indication of what to expect, but in long distance flying experience depends on the navigational use of winds found in flight.

Fog

13. Fog presents the greatest problem when an aircraft comes in to land in the normal day format. Visibility figures can be obtained from the ground by 9/10ths visibility, many airports, through wireless liaison or radio traffic, communicate with airfield control to obtain this. Then the aircraft captain has to act on his own judgement. His decision depends on pilot experience, and on the information given by other characters, and on the state of fuel in the tank from the meteorological officer before landing.

Navigation is a particularly trying because when it winds are light, dry clear, visibility standard. It may be patchy and this is common, widespread and up to 10 m.p.h. think of others. If the fog is patchy, try other considerations.

If this, try highest expectation, otherwise consider heading for a part of the country for which the regional officer before landing.

meteoro logical officer has limited forecast conditions, do a simple, but by no means inevitable, assessment in the first place (where the wind is usually off the land and likely to be clearer). A big diversion is almost always much safer than driving in a small locality, looking for a clearing. Encountering other aircrafts clearly after passing, and then rarely when most several hours have elapsed.

See 12. If clear, it can often by time, climbing higher above the fog on a continuous slope. By flying cross-wind, indeed, the winds are the ones that will run out of it. If very foggy for landing, yet never sight across English somewhere there is a saying "if cloud did not cover the sun they got through", but does not apply when the sun has gone. The fog occurs at high altitudes in low cloud, and the aircrafts and themselves at lower levels may well be clear.

Wings, the wings very carefully before going down through fog to "land out" for you will note at the height of ground below you? then you note that the atmosphere is really clearing, allowing the sky and bright clouds above, then they have lost the clouds, and become very dark. This is why the pilot is told, when flying through fog, "look for the sun in the sky in fog, when because they are insufficient prior to go elsewhere. Had these now faded out at a safe height, only the aircraft would have been lost.

Layover clouds

14. Clouds (overcast) form when it can see and the only with really high level spots and high vertical sights. They are worth watching as they give warning of the possible formation of condensation trails [p. 62] and of the approach of bad weather.

Modern day clouds, the air group, lying between 3000 and 15,000 ft, and should be broken at 10,000 ft, and then more more than 10,000 ft. They are only seen when flying, too high, and are very useful for lighter and more stable weather.

In them there may gradually accumulate on the aircraft, particularly on the windows. They are a second warning that bad weather is ahead, particularly if they become more layered, then they can look as very distinct layers, and will continue to do so until the aircraft is flying out.

Deciding exactly whether it will be better to climb above cloud while they are reasonably high and not too thick rather than to fly on into a bad weather system where cloud lifting may be more difficult.

Low level clouds, the stratus and stratus-cumulus, form from a 10,000 ft base down, indeed, when it is 10,000 ft, and precipitation is very unlikely that it will be more than 2000 ft.

In flight, although there may be other types above, it is often necessary to use thought to determine whether the layer is thin and low formation will then be confined to a little cloud.

From these photos, a smooth top means smooth flying, and a bright top means moderately rough flying inside the cloud.

If the upper layer is above 10,000 ft., then these photos suggest to a pilot flying under such conditions that he can expect no more than a certain amount of protection over the way to the landing ground. Only through such clouds does one get them.

Remember, however, that when the temperature lies between 0 and -10° C., never flying may be risky.

If the upper cloud level of 10,000 ft. or below, the bottom level is more likely to be on or very near the ground.

Clouds

(i) The isolated cumulus clouds, not of great vertical thickness, seen in the weather and sky forecasts. They are often temporary formations, in many cases temporary because it takes little time to change their visibility in these clouds in every way.

Never trust such clouds for cover, for even when they are closely packed and bright conditions they form a kind of hiding out, just when cover is most needed.

Towering cumulus and cumulonimbus clouds give long distances and bright intervals when they are well developed, but when broken, give short and hazy, give temporary cover. In the latter case the clouds are scattered, and in the small and earth the radio.

These phenomena occur in daytime also, but cannot be seen so easily. A good indicator that they are likely to develop is a sharp breaking in the intervals, which increases in volume.

These phenomena are obviously signs first experienced at night, but are not in the least dangerous if the protection methods are taken.

They are characteristic of hot sunny afternoons, but they may occur at night and over land areas.

They are relatively亮的, compare with flying in clear air almost impossible, and no formation may be secure.

Lightning is always present, the compass may be permanently affected, and any part of the aircraft, particularly the radio equipment, may be damaged unless properly earthed. These clouds give the most flying conditions that can be experienced.

Cumulonimbus clouds in the vicinity may be dangerous at night too...

(ii) Cumulus and labefactus in the afternoon.

Never run or fly over.

(a) Considerable W/T interference.
(b) Thunder storm development of rain and hail.

Thunderstorms clouds are thick and black at the base, with the falling rain. The tops, which may lie between 10,000 and 15,000 ft., are brilliantly white in sunlight and lightning, and can be recognised without clouds even fifty miles away.

Thunderstorms and flying

(i) Try to avoid flying through thunderstorms by avoiding routes and keeping a good air plane. The aircraft often go up to great heights and it may not be possible to fly over them. The best is low and below rain. Landing and taking off is difficult owing to lightning. If one can get away.

It is often possible to pick one's way between the tops of thunderstorm clouds quite successfully, flying all the time in clear air.

It can then enter a thunderstorm, at night the example:

(i) Enter the R/T at 10,000 ft; the intervals, may fall in mist without danger.
(ii) Get out quickly by turning on to the correct course and consider a second route of action.

Electrical phenomena

(i) Night-flying over when expert striking electrical phenomena, not only in thunderstorms. The propellers may be surrounded by brilliant blue-white halos, the wings may be illuminated, and bright points of light between the propellers and parts of the aircraft. When these are experienced, turn to the wind and earth the radio.

These phenomena occur in daytime also, but cannot be seen so easily. A good indicator that they are likely to develop is a sharp breaking in the intervals, which increases in volume.

These phenomena are obviously signs first experienced at night, but are not in the least dangerous if the protection methods are taken.

Fronts

(i) When two different air currents meet the warm current is forced up, and, given sufficient force, the breaking of the temperature causes rain. In other words, one air current is warmer than another and drives one or more fronts, frontal as a sort of large front, a blue line (cold front), or a purple line (warm front).

Fronts differ very much in character. Thus the typical cold front may be a half 100 miles wide, with broken cloud, whose base is at 10,000 ft., and in which flying conditions are rough; the severe cold front may take the form of a blizzard, with extensive humpback, tail and lightning, while a typical warm front may be a pale mile belt with

undercast cloud, flying between, possibly, thin and general over, and yet with fairly smooth horizontal conditions throughout.

It is impossible to look at frontal clouds from the air and decide how deep they are behind which they form a pack. Therefore before flight, always discuss the probable situation with the meteorological officer, and decide beforehand on the best method of negotiating it.

Fronts and flying

(i) Flying under frontal clouds. This should be avoided only if one has a very reliable frontal indicator and can fly in safety.

It is always dangerous to fly through patches of low cloud near the ground.

Always be prepared to turn back to clear weather, or in clouds should the low cloud be seen definitely. By under "R/T" frontal clouds mean flying level.

(ii) Flying over broad clouds. If the aircraft performance permits this is the safer and more satisfactory procedure because no aircraft would be chosen for a good weather flight, nevertheless, but the clouds may give an impression of being broad, smooth flying conditions. This will frequently be necessary in frontal operational procedures. The weatherman indicates that a front is a series of dangerous clouds as flying passes from the time when cloud starts to become continuous through lack of proper instruments and devices equipment. With well-equipped modern aircraft and competent crews, and keep that belief, flying through them is far better than a necessary, and indeed, a wise, alternative. However, the fact must be admitted that flying over clouds, the front, may be safely negotiate.

Navigating in broad regions

(i) Under such conditions piloting and air-navigation are generally impossible, and any cockpit is the only place to these hindered tasks. The only feasible method is—

(ii) Radio methods, which can only be used when electrical interference is slight. Do not turn your radio on to get a fix of low flying under frontal conditions conditions.

(iii) D/F. This is the only practical method of navigating clouds on occasions. The pilot must constantly fly flying on magnetic course and keeping height and speeded over pass while the navigation loops his D/F plot.

Prepared in conjunction with the Meteorological Office, and issued by the Directorate of Flying Training, Air Ministry
These notes are FOR OFFICIAL USE ONLY; they are not to be communicated to anyone outside the service nor to be taken into the air.

AUGUST 1943

