METREOLOGY

Index.

1. Introduction.

Aircrews need to follow Metreology for the following reasons.

a) For their efficiency and safety.
b) To understand the behaviour of the atmosphere.
c) To understand the weather forecasts and maps.
d) To bring back accurate and usefull information and therefore assist in the planning of future Operations.

2. The Atmosphere.

As well as Oxygen and Nitrogen, the atmosphere consists of Water Vapour, Water Drops and Solid Particals.

3. Pressure.

Pressure is the weight of air per unit area, pressing down on that point.

Pressure allways decreases, as we ascend. It is measured in millibars - 1 millibar is approx. 1 gram on 1 square centimeter. Pressure decreases with height at the rate of about 1 millibar every 30 ft near the ground, gradually becoming 1 millibar per 60 ft at about 20,000 ft. The average M.S.L. pressure - 1013.2 mb.

a) Types of Pressure Distribution

1) Depression or Low.

→ Winds at 1,500 ft.
→ Wind at Surface.

Winds at 15,00ft. follows the Isobars and blow in an anticlockwise direction around the centre of Low.
The speed of the wind is estimated by the nearness of the Isobars.
Due to friction and the uneven surface of the earth the wind at the surface will move round the centre at an angle of about 20-30 degrees to the Isobars. The surface wind blows inward to the Low pressure at a speed of about ½ that of the wind at 1,500 & 2,000 ft.
Over the sea the angle is 10°-15° and the speed is about ⅔ of the 2,000 ft wind. Therefore when we ascend from the ground up to 2,000 ft. the wind will always VEER and increase.

There are 3 kinds of Depressions.

a) Deep Depression. - one which has a barometric reading at the centre of the Low of 960-970 mbs.
b) Intense Depression. - one which has Isobars very close together and therefore has very strong winds.
c) Shallow Depressions. - one which has Isobars a long way apart and therefore relatively light winds. - Bad weather system, plenty of cloud and precipitation.

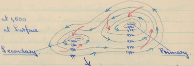
Kind of Weather from a Depression.
Bad weather system, plenty of cloud and precipitation. The depressions can move in any direction and at any speed. More than 50% of the Depressions in this part of the world travells from S.W. across the British Isles towards Russia. The speed varies from 5 to 30 mph. - some may travell up to 50 m.p.h. and some have been known to be allmost stationary.

2) Secondary Depression.

Has the same properties as the ordinary Depression.

P.T.O.

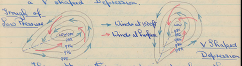
Winds at 1,500
Winds at Surface



A Secondary Depression is a separate area of Low Pressure within the Primary. It tends to rotate round the Primary in an anti-clockwise direction while the system as a whole moves forward.
The Primary or Old Depression may be moving slowly whilst the Secondary or New Depression is moving quicker. The secondary may have a Lower or Deeper Pressure in the centre than the Primary, also it may be more intense.
Weather with a Secondary Depression is similar to the Primary but the winds due to the Secondary are usually much stronger.

3) Trough of Low Pressure

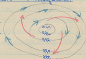
The main system is a Low Pressure System but instead of more or less circular Isobars, you get a nose of Isobars being developed.
Sometimes the nose develops and forms a 'V' shaped trough in which case it is called a 'V' shaped Depression.



The worst weather is experienced along the line of the trough or 'V'.

4) High Pressure - Anticyclone.

Wind at 1,500 ft.
Wind at Surface.



The Isobars are more or less concentric curves, winds are light. The highest pressure is at the centre and the Isobars are not so close together as in a Depression. The wind at 1500-2000 feet follows the Isobars flowing in a clockwise

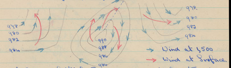
direction round the centre of High.
At surface level the winds blow outwards at an angle of 20-30 degrees to the Isobars.
It indicates good weather and allthough it can move in any direction with a speed of usually less than 3 m.p.h., it can stay put in any one region for a long time.
A system of light winds (Isobars far apart.).
The winds at 1,500-2,000 ft are in the neighborhood of less than 10 to 15 m.p.h.

Two main sorts of weather.

1. Fine weather.
2. Anticyclonic Gloom. - may be caused by.
    a) 10/10 of Stratus ~~or~~ Strato-cumulus cloud, or.
    b) By Radiation fog.

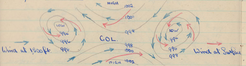
In Winter-time a) & b) will persist throughout the Day and Night.
In Summer-time a) & b) will form at night and disperse in the daytime. Owing to very light winds, these conditions will not be swept away but will linger on.

5.) Ridge of High Pressure.



A Ridge of High Pressure is a bulge towards the POLE in a High Pressure System usually situated between two Low Pressures.
The wind at 1,500-2,000 is clockwise round High and round the two Low Pressures in an anticlockwise direction and given in the direction of the Isobars.
A fine weather system but differs slightly from that of the High Pressure System itself in the time it persists
On each side of the wedge there is likely to be a Depression moving South Eastwards at 30 m.p.h. therefore the wedge is tended to move in the same direction and at the same speed therefore the fine weather of the wedge cannot last very long.

b) The Col.



The Col is the neutral area made up by 2. Low Pressure Areas and 2 High Pressure Areas. No Isobars cross it.
The winds are therefore are indefinate and very light. There may even be a dead calm.
Two main sorts of weather from a Col.
a) Winter Time. - Fog or overcast sky due to the mixing of air.
b) Summer Time. - Thunderstorms due to the Cumulo-nimbus Clouds which develope over the area due to the excessive heating of the Earth's surface beneath it, and as there is no cooling wind thunderstorms will develope. Not likely to last for more than 12 hours.

b) Pressure and Temperature

Temperature.
Is measured in degrees Centigrade or Farenheit. The volume of the air depends upon its absolute temperature which equals Centigrade plus - 273°.
Horizontally temperature from the Equator to the Poles, giving Temperature Zones.
a) 1. 25° N or S of the Equator is called Tropical.
b) 2. 25° - 70° N & S of the Equator - " " Temperate.
c) 3. 70° - Pole N & S. " " " " Polar.
3 Zones
Vertically, temperature usually decreases, the average rate being 3° F or 1.98° C per thousand feet, but Temperature ceases to decrease at the Tropopause, the height of which varies in this country from 23,000 ft in the Winter to 43,000 feet in the Summer. The mean height of the Tropopause over the Poles is 4½ miles and over the Equator 11 miles.

Air Density decreases as we ascend because of the decrease of pressure and in spite of the decrease of temperature.

The effects on an Aircraft are.
a). Decrease Lift.
b). Decrease in Drag.
c). Decrease Thrust.
d) Decrease in Engine Power. (Lack of Oxygen)
e) Decreas of Indicated Air Speed.
Therefore the A/c has a "ceiling" and also optimum height. (An height of maximum performance)

The main source of Atmospheric Heat.
Heat is obtained from the Sun by Radiation. This radiated heat warms the earth to varying degrees, dependent upon the specific heat of the substances of which the earth is composed. (Some is not absorbed but re-radiated back into space.)
The layer of air next to the surface of the warmed earth is heated by Conduction, this warmed air rises to the upper layers of the Atmosphere by Convection.

The Relation Between Temperature and Height.
Normally temperature diminishes at height above the ground. The rate of "fall off" is called the LAPSE RATE

Normal Lapse Rate is 3°F every 1000 ft, but the actual temperature Lapse Rate may differ considerably from this average.

c). The INVERSION.
Occasionally temperature increases with height over a short range especially near the ground, this is called an Inversion.
Near the ground an Inversion is not readily produced during a clear Winter night when the Earth radiates its heat into space and hence becomes cooled, cooling the air in immediate contact with it to such an extent that the air at some distance above the Earth is warmer than it. An Inversion is then established.

d). The Adiabatic Lapse Rate.
When a mass of air is heated, it expands and rises and arrives at an area of Lesser Pressure and as a result it expands. Due to this expansion the temperature drops but there is no loss of temperature to the outside surroundings.
The fall in temperature is due to the

internal expansion of the mass of air and is called Adiabatic Cooling.
The Dry or Adiabatic Lapse Rate is 5.4°F per 1,000 feet.

The Wet Adiabatic Lapse Rate
On cooling, wet or saturated air, excess moisture condenses into Water Droplets. The latent heat thus released stops or prevents the air from cooling off at the same rate as previously. This is the Wet Adiabatic Lapse Rate which is 2.7°F per 1,000 ft.

c) Conditions for Stability in the Atmosphere
a) Atmospheric Stability
When the normal Lapse Rate for the day is less than the Dry Adiabatic Lapse Rate, then the atmosphere is said to be stable i.e. Rising air is not going to be continually rising and when a rising mass of air attains the same temperature of the surrounding air, the mass of air tends to be thrown back.
b) Atmospheric Unstability
When the normal Lapse Rate for the day is very steep, such as is obtained during a very hot day and greater than the Dry Adiabatic Lapse Rate, then the atmosphere is said to be Unstable, and air will continue to rise and Thunderstorms are likely to appear.

	Atmospheric Stability			Atmospheric Unstability
4000 ft.		48°	48°	
3000 ft.		51°	56°	
2000 ft.	54.6°	54°	64°	74.6°
1000 ft.	60.0°	57°	72°	80.0°
0 ft.	65.4°	60°	80°	85.4°

4. <u>Barometers and Altimeters.</u>

a) <u>The Mercury Barometer</u> - is used to measure pressure.
The air pressure balances a column of Mercury and the height of it is measured in Millibars and is corrected for.

a) Temperature - Standard ~~Pressure~~ Absolute Temp. - -285°C
b) Height above 'drome or Mean Sea Level
c) Latitude - Standard is 45°
d) Instrumental Error.

b) <u>The Aneroid Barometer.</u> - is less accurate than the Mercury Barometer but it is more compact and is self-recording.
It consists of a metal box which expands and contracts with changes of pressure and may operate a pen giving a constant record of the pressure on a revolving chart.
It is adapted for use as an Altimeter.

c) <u>The Altimeter</u>
An Altimeter is an Aneroid Barometer which measures change of pressure and interprets it as change of height. Therefore we must assume some relationship between pressure and height.
<u>The Mark XIII Altimeter</u> assumes a constant temperature of 50°F and a Surface Pressure of 1013.2 millibars.
<u>The Mark XIV (Kolsman)</u> assumes that the surface pressure is 1013.2 millibars and that the Surface temperature is 15°C decreasing 1.98°C every 1,000 feet up to 36,000.

An Altimeter therefore reads height above a fixed pressure and will only read height above a fixed level if the pressure at that level remains unaltered. If the pressure changes at the same level the Altimeter will indicate a change of height.
On the Mark XIV Altimeter, the Millibar subscale always gives the pressure at which the instrument would read 0 ft. This subscale can only be altered by hand.
If the air temperature does not agree with the standard conditions there will be a slight error in the indicated height. In warm air the Altimeter will underead.
Flying in <u>Warmer</u> Air than standard <u>Alt. underreads</u>.
" " <u>Colder</u> Air " " <u>Alt. overreads</u>

5. <u>Wind</u>.

On a weather map Isobars are formed joining places of the same Sea Level Pressure at a given time. They are drawn for every 2 millibars The Wind at 2,000 feet blows parallel to these Isobars with Low Pressure on the left. (See BUY BALLOTS LAW) in the Northern Hemisphere.
The wind speed is proportional to the closeness of the Isobars.
In the British Isles, if the Isobars are 60 miles apart, the wind is about 30 mph. If they are a hundred miles apart the wind speed is about 18 m.p.h.
The closer the Isobars, the stronger the wind

<u>Surface Wind is</u> generally estimated using the <u>Beaufort Scale</u>. This divides Winds into 12 ranges. Eg.
Force 0. - Winds of less than 1 m.p.h.
Force 3. - Winds of from 8 to 12 m.p.h.
Force 6. - Winds of from 25 to 31 m.p.h.
Force 12. - Winds more than 75 m.p.h.

With each Wind Speed a description of the behaviour of common objects is given such as:-
Twigs, Paper, Leaves, Sea Surface etc.
The direction is estimated by Smoke, Flags, Wind Socks, etc.
On a weather map wind is shown by an arrow with feathers to indicate the Beaufort Force.
<u>Surface Winds</u> may be measured with a <u>Cup Anemometer</u> incorporating an electric buzzer to count the revolutions. It does <u>not</u> record the direction but only the speed.
<u>The Anemograph</u> is a Pressure tube which gives a constant ~~rec~~ record of the Wind speed on a rotating chart. A second pen gives the direction of the wind on another revolving chart.

N.B. When flying at about 2,000 ft, Starboard Drift means that the Altimeter will over read i.e. Flying from High to Low Pressure. If the wind is on the Port side, the M.S.L. pressure will decrease along the Track. If the wind is 30 mph. on the Port Beam, the Altimeter will overread 1 foot per mile.

Upper Winds are measured by Pilot Balloons and Theodolite.
The balloon filled with Hydrogen rises at the rate of 500 feet per minute and its bearing and Elevation are measured each minute.
The Radio Balloon carries a transmitting set and its position is fixed at regular intervals by 3 ground stations. This method can be used to get wind at 60,000 feet.
The Nephoscope. This method is used to find wind speed by watching the clouds. The height of the cloud is found by approximating times: 5 miles High and Alto Cumulus - 3 miles. It is a usefull method but not accurate. This method can only be used when either or both of the above two clouds are in the sky.
The prongs of the Nephoscope are moved into the cloud direction - that gives Wind direction. The cloud is then timed between the prongs and that gives wind speed. This method can only be used between heights of 16,000 - 26,000 feet.

BUY BALLOTS LAW. When standing with your back to the wind in the Northern Hemisphere, the Low Pressure is on your left. In the Southern Hemisphere the facts are reversed.

Gustiness
This is the variation in wind speed at the Earth's surface produced by obstacles on the ground and surface friction.
In gusty winds, low level flying is often dangerous over buildings, hangars, etc. and great care should be taken.

Changes of Wind Direction
When wind alters its direction Clockwise it is said to VEER.
When wind alters its direction Anti-clockwise it is said to BACK.

Diurnal Variation of Winds
Diurnal means, what happens throughout 24 hours.
A. By Day. Surface Air Turbulence is marked due to the Earth becoming heated and the air above becomes warm, - expands and rises causing a mixing up of air.
The 1500 foot wind BACKS and lulls as gives up some of its force to the lower winds, which increase in speed and also tend to VEER
The surface winds usually attain their highest speed about the early afternoon.

P.T.O.

B. At Night.

The turbulence dies down and surface winds BACK and lull. The 1,500 foot wind freshen and VEER.

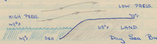
The upper affected limit varies with; Place, Season and Wind Stregnth.

Local Winds

1. Land and Sea Breezes.

Day time. The land becomes hotter than the sea, so the air above the land is heated and rises, while cooler air from over the sea comes in to takes its place. It can be felt inland to about 10 to 15 miles and in the British Isles the speed is usually 10 to 15 m.p.h.

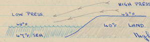
It is a normal feature of a quiet summers day. At 500ft. it is weak and it fades out alltogether at 1000ft. Nearer the Equator it is stronger Usually takes place from 1400 to 1800 hrs.



Day Sea Breeze.

Night-time

The land cools more rapidly than the sea so the air over the sea rises and cooler and heavier air comes to take its place from the land, causing a night land breeze which persists quietly until the morning unless upset by stronger disturbances. Its greatest effect is usually from 0100 - 0600 hrs.

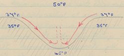


Night Land Breeze

2. Katabatic Winds

Night time.

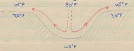
When air over high ground is colder than the air in the valley or on plains below, it tends to flow down the slope under gravity. This causes Katabatic Wind. The maximum effect is from 0100 to 0300 hrs. The slope determines the wind direction. All hills and mountains provide milds Katabatic Winds in fine quiet weather, more marked in Winter time when Snow is on the hills. It has a great effect in causing radiation fog.



3. **Anabatic Winds**

Day time

The sun heats the hillside and the air gets warm and rises and the air is hotter than the air at the same level over the valley.
Therefore the cold air sinks in the valley and tends to creep up the sides of the valley to take the place of the rising air. The effects are not so marked because the heavy air has to work against gravity. Therefore Anabatic Winds are not as strong as Katabatic Winds. They take place from 15-1900 hrs.



6. **Clouds**

a) **Humidity**

The amount of Water Vapour that a volume of air can contain. Humidity is expressed in one or the other of the following ways:-

1) **Relative Humidity** - when the air is saturated it is shown by the fraction.

= Weight of Water Vapour first present / Weight of Water Vapour when dew forms at the same temperature. It is expressed as relative humidity in %-age

Saturated air has a humidity of 100%
Dry air " " " 0%

NB. The years average is about 70%

Dew Point

Is the temperature at which the Water Vapour present in the air is sufficient to saturate it. When the temperature of the air falls bellow Dew Point, then water particals form - gives Dew. It is possible for the Dew Point to be less than the freezing point, therefore when the the temperature falls bellow Freezing Point then Ice particals form giving Frost.

b) The Wet and Dry Thermometer

The dew point is found by using the Wet and Dry Thermometer.

This consists of 2 thermometers. The Dry one is a normal thermometer and the Wet one has a muslin bag round the bulb. Attached to the muslin bag is a wick the end of which is in a small bowl of water. This keeps the muslin bag wet, - the water evaporates and therefore the air cools. This is shown on the Wet Thermometer. The difference in readings between the Wet and Dry thermometers can be applied to tables from which the Dew Point can be determined.

c) Formation of cloud - Stages.

1. A condition of rising air
2. Expands owing to reduction in pressure and cools
3. Less Water Vapour to saturate it
4. Cooling below Dew Point gives condensation into visible water drops.
5. Water drops are supported by up currents.

1. Convection Cloud. Cumulus or Cumulonimbus.
The heat of the Sun will heat the ground by day and the air in contact with the ground becomes warm and rises, if this is cooled to below its D. Point then cloud will form. Since the warm rising air is replaced by cooler air. Convection is momentarily stopped and so this cloud seldom covers the whole sky. Its base is usually between 1500 to 5,000 ft. and it shows marked vertical development with tops upto 30,000 feet in favourable conditions. These clouds disperse inland at night when surface heating ceases. Over the sea they are formed by air movement and will tend to remain at night owing to the none variation of sea temperature.
2. Turbulence Cloud. - Strato-cumulus.
Eddies, which are set up near the surface by obsticals and by friction, produce irregular up and down currents. If these are sufficiently vigourous and the air damp enough a layer of cloud is formed. Usually these clouds have quite a low base, generally between 1000- 3000 feet thick.

3. Ascent of Warm Air over Cold. (Warm Fronted)
When a large mass of cold air meets a large mass of warm air then the warm air rises over the cold. As the warm air rises so it cools and condensation takes place and cloud is formed. Cloud formed in this way is usually of very wide extent both horizontally and vertically. A large sheet of cloud is formed extending from a very low level up to a height of about 5 miles.

4. Orographic cloud - Cumulus.
This cloud is formed by air rising over high ground such as hills etc. The air does not follow the hill down but sweeps down gradually, therefore the cloud sinks and breaks up and disperses on the leeward side of the hill or high ground.

Heaped Clouds are lumpy in appearance and show marked vertical development. They are usually associated with showers since they are detached, and very large ones with Thunderstorms.
Flying conditions are exceedingly bumpy.
Layer Clouds are usually formed by Turbulence or at a Warm Front. They lie in nearly uniform sheets covering a wide area and give continuous drizzle or rain.

Cloud Classification

HIGH.	MEDIUM.	LOW.	Clouds of Gt Vertical Extent.
20,000-40,000ft	7,000-20,000ft	Surface-7,000ft	1,500,-7000 feet.
Cirrus	Alto Stratus	Stratus	Cumulus.
Cirro stratus	Alto Cumulus	Strato cumulus	Cumulo nimbus.
Cirro cumulus		Nimbo stratus	

(d) TYPES of CLOUD.

Name.	Formation	Appearance	Weather	Flying Conditions and Ops Value.
Cirrus. (Ci)	Ascent of Warm Air over Cold.	Fibrous wisps of cloud ice crystals which bang together and increase.	Approach of Warm Front, indicated about 500 miles away when Ci increases. Fine or Thundery weather.	Too high & thin to affect normal conditions, danger of condensation trails when flying at Ci height.
Cirro-stratus (C.s)	Ascent of Warm Air over Cold.	Thin whitish veil often covering whole sky giving halo round sun & moon.	Approach of Warm Front indicated.	Cloud too thin to afford cover and too thin for normal use.
Cirro cumulus. (C.c.)	Turbulance at high levels.	Layer or patch of very small globular masses in waves or ripples. (called Mackeral)	Fine	Nil.
Alto stratus. (As)	Ascent of Warm Air over cold.	Grey veil covering the whole sky. Sun & Moon vis. but not through thick.	Near apprch of Warm Front & precipitation. occasional slight drizzle.	Slight or mod. bumpyness. ditto icing between 0°& -7°c. Vis upto 1,000 yds in thin, & 100 yds in thick Gt. ops importance. Affords cont. cover over wide area. 10-15,000 ft. thick
Alto cumulus. (A.c.)	Turbulance at Medium levels.	Layer or patches of rather flattened masses, in lines waves or bands.	Normaly fine. banded type often indic's apprch of Front.	Slight bumpyness. icing unlikely No complt. cover afforded for A/C but useful for evasion and alteration of courses.

P.T.O

CLOUD (Cont).

Name.	Formation	Types of Appearance	Weather	Flying Conditions and Ops Value.
Stratus (St)	Turbulance or Orographic	Uniform layer resembling fog when at very low levels.	Occasional drizzle.	Slight bumpyness, Icing particualy in Winter 0°to-7°c. Too shallow & low to be of gt importance except as cover from ground observation. Dangerous, often covers high ground.
Strato cumulus. (Sc)	Turb. at low levels or spreading of Convection Cloud.	Extensive layer of globular masses in rolls, lines or waves often covers whole sky	Normally dry, if any prec'tn is drizzle.	Mod. bumpyness in & below cloud - smooth above. Icing 0°to-7°c. but rate of accretion not usually rapid. Vis 15-20 yds Often increase of temp above cloud. Affords cont. cover & usually thin - 500-3000 ft thick
Nimbo stratus. (N.s.)	Ascent of warm air over cold.	Dense layer nearly uniform & of gt vert. thickness. More than 10,000 ft - patches of turbulant cloud below.	Continuous heavy rain, snow, sleet or drizzle.	Slight or mod bumpyness in cloud. Severe in Turb. Cloud below. Slight or Mod. icing - 0°to-7°c. Severe below cloud of temp below freezing pt. Vis less than 20 yds Complete cover for A/C but use limited by flying conditions and low cloud base.
Cumulus. (Cu.)	Convection	Thick cloud of Vert devel'mt. flat dark bases - white cauliflo'r tops. 20-30 thous. ft. thick	Scattered showers 'pending on cloud depth & stre'gth of up currents.	Very bumpy in & below clouds. Heavy & rapid iceaccretion. - 0°to-15°c Vis less than 20yds. No cont. cover usefull only for evasion.

P.T.O.

Types of Cloud (Cont)

Name	Formation	Appearance	Weather	Flying Conditions & Ops Value.
Cumulo nimbus (C.b.)	Heavy convection & strong up currents.	Heavy masses of cloud. Gt. Vert development. Summit tower, upper part having a fibreous texture & spreading out - Anvil ~~sp~~ shaped - Thunder	Heavy showers & thunderstorms with hail & squally winds.	Severe bumpyness in & below clouds. " icing between 0° & -15°C Vis less than 10 yds, danger from lightning No cont. cover. Only usefull as a last resort & then only for evasion on account of severe flying conditions.

Condensation Trails

At high levels, water vapours from the exhaust may condense giving a trail of cloud which spreads out and resembles Cirrus or Cirro cumulus. Dense trails rarely form below 28,000 ft. in Summer and 22,000 feet. in Winter.

Cloud Amount. - is noted and reported by the number of tenths of sky covered by each cloud type.

Measurement and Estimation of Cloud Height and Thickness.

By Day 1) Measurement. (a) Pilot Balloons.
(b) Special Met. Flights.
2) **Estimation** (a) Comparison with known heights.
(b) Visual Estimation.

By Night. 1) Measurement. (a) Cloud Searchlight.
(b) Met. Flight through cloud, to find thickness.

7. Visibility in Cloud.

By visibility we mean the horizontal distance that can be seen on the ground with the naked. By day it is measured by means of land marks whose distance from the MET office is known. The furthest object which can be clearly seen is the measure of visibility. Visibility may also be regarded as the Obscurity of the Atmosphere, and at night, to measure this, fixed lights of known power and distance are used and viewed through a smoked glass of graduated shading. This is called the Visability Meter.

The Atmosphere may be Obscured in 3 ways.
1) Fog. made of Water Drops. - Vis. less than 1100 yds.
2) Mist, made " " " . - Vis. between 1100 to 2200 yds
3) Haze, made up of small particals of dust etc.
Vis. as. Mist

Haze is more or less confined to Industrial Areas. The lee side of Aerodromes ~~fel~~ feel the effect from pollution of the Atmosphere by chimneys.

Fog - being composed of Water Drops is produced by condensation at Surface Levels without any vertical movement of air.

There are 2 main types of Fog.
1) Radiation or Night Cooling Land Fog.
This forms under the following conditions.
a) Clear Skies. - Necessary so that Earth may radiate its heat rapidly and so become cooled appreciably. If sky is cloudy the heat lost by the ground is re-radiated from the cloud layer and so no extensive cooling of the ground takes place.
b) Light Winds. - less than 8 mph. Allow a shallow layer of cool air to form near the Surface of the Earth. The slight air movement is sufficient to produce mixing through this shallow layer and throughout this layer cooling takes place.
In a strong wind the turbulance effect takes place through too deep a ~~stat~~ layer and so cloud is more likely to form.
(c) High Relative Humidity.
(d) Cooling below the Dew Point - Time factor.

P.T.O.

Radiation Fog forms chiefly over low lying country and marshland and is common in valleys owing to the drainage of cold air down the hillside at night.
Such Fogs are most frequently found in the Autumn and Winter when the night radiation period and longest and usually forms in the early hours of the morning. Normally the fog clears later in the morning owing to heating by Sunshine, but in Wintertime when the heat of the Sun is insufficient, the fog tends to persist until an increase in wind produces more turbulance and mixes the fog with warmer air above it causing it to evaporate.

2) Advection or Sea Fog.
This fog is formed when warm air moves over a cold surface. Such conditions usually being fulfilled at sea, though in very cold weather a sudden influx of warm air over frost bound ground may produce a fog.
Since the fog does not depend upon Radiation for its formation, it may form under cloudy skies and in strong winds i.e. in the movement of the air.
When by contact the air at the surface is cooled to below its Dew Point - fog will form.
Such fog may drift many miles inland and is most common in late spring and early summer, when the sea is coldest.
Owing to the nonvariation of the sea temperature this fog may form at any time of the Day or Night.

Fog Thickness.
The depth of Radiation fog increases with time. After 1 night, it is seldom more than 100 feet thick, but after several nights it may be in the order of 1,000 feet thick.
Sea fogs are of Variable depths.
Fogs in Industrial Areas are always more dense since they are polluted with smoke and dust which cannot be carried away.

8. Precipitation - that which falls from cloud

The 4 main types of precipitation.
1) Rain.
2) Snow
3) Sleet.
4) Hail.

1) Rain. - The water drops in a cloud which are supported by up currents gradually grow in size by further condensation and collision until they are too heavy to be supported by the up currents whence they fall to the ground as rain. The size of the drops depends upon the strength of the up currents and the depth of the cloud. That is why the rain falls from heaped clouds is normally heavier than from layer.

2.) Snow. - When condensation takes place at a temperature below freezing point, ice crystals are formed. These grow in size by further condensation until they are too large to be supported and then provided that the temperature of the air from the cloud base to the ground is below freezing point everywhere, snow will fall.

3) Sleet.
Occurs when snow falls through a temperature a few degrees (0 to +3°) above Freezing Point and consists of a mixture of Snow flakes (partly melted) and Rain.

4) Hail. - consists of hard pellets of ice produced by rain drops being caught by swift up currents of air and carried up above Freezing Level long enough for them to freeze. In their subsequent movement above the Freezing level in the cloud they grow by collision with super cooled water drops which freeze immediately on impact, ultimately the hail stone falls to the ground, either because it is too heavy to be supported by the up current or because the up currents cease.
Hail can be formed only in cumulo-nimbous clouds.

9. ## Ice. accretion

Ice forms on an aircraft when it encounters water drops at a temperature below freezing point. A constant watch must be kept on the aircraft thermometer particularly when entering cloud, remembering that these thermometers do not record the True Temperature ~~at~~ unless a level flight for at least 2 minutes has been made.
Ice forms a danger owing to both increased weight and to change in Wing Section Shape

Types of Icing

a) Glazed Frost Icing.
The most important and serious type of icing. It forms all over an aircraft which is flying through air at a temperature below freezing point through which rain is falling. The rain must fall from a region where the temperature is above Freezing Point and this rain takes a long time to freeze as it falls, but on striking a solid object it will freeze immediatly. The type of icing usually occures below Nimbo stratus at a Warm Front.

b) Icing in Cloud. is another serious type of icing and one which is more frequent and occures when an aircraft flies through a cloud of super cooled water drops.
These conditions are found in all water clouds between temperatures of 0° to -15°c.
These drops do not freeze into ice unless they are disturbed, but the aircraft producing that disturbance causes them to solidify on impact with it forming a transparent coating of ice.

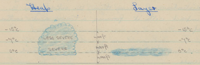
Clouds in which Ice. accretion is encountered.

1) Severe.
   a) Cumulo nimbus } 0° to -10° C.
   b) Cumulus }
   c) Nimbo stratus. -0° to -7°C
2) Moderate.
   a) Alto stratus } 0° to -7°C
   b) Stratocumulus (Not rapid) }
3) Slight
   a) Stratus.

The severity of icing depends upon the size and number of super cooled water drops which in

P.T.O.

turn depend upon the strength of the up-currents. The size of the Water Drops decrease as the height increases and is gradually replaced by ice crystals.
In ~~small~~ clouds, the most severe icing occurs between 0° and -7°c, and to a lesser degree down to -15°c.



Thunderstorms - are the result of Cumulo nimbus clouds which generate large electric charges and are ultimately able to break down the resistance of the air beneath the cloud. The spark which takes place is what we know as Lightning and Thunder is the noise produced by it. For flying conditions and weather see Cu nimbus cloud. Compass and Radio are affected by the electrical discharge but danger from Lightning is rarely serious unless A/c has no trailing wires.

10. **The RAF Meteorological Service**
The observations and information for preparing forecasts are distributed by the Central Office to 4 main types of stations.
They are:-

Type 1) At headquarters of Bomber Command and Fighter Command and the Group Headquarters of these Commands. Their staffs are able to provide forecasts at once and at all times. They supply the forecasts and administer the type 2, 3 or 4 offices at Aerodromes of the Group and the 'dromes of other Groups such as Training Command which have not a Type I office at Group.

Type 2. Found at 'dromes such as operational stations of Coastal Command which require staff able to provide forecasts at any time. Their requirements cannot be fulfilled by a Type 3.

Type 3 There are attached to 'dromes of Bomber Commands, O.T.U. of Coastal Com'nd, H.Q.S's, A.F.U's and Ferry Pilot Pools. They obtain forecasts from their parent Group office (Type 1), but their staffs are qualified to brief crews and P.T.O.

explain forecasts.

Type II. Found at Operational Control Rooms of Fighter Command where the staffs obtain all information from the Type I office. Offices at stations which have night fighter squadrons have forecasters on duty all night.

A Weather Report. - describes the weather at a given place at a given time.
A Weather Forecast outlines what weather conditions may be expected during flight. When a flight is to be made, a route forecast must be obtained on a Form 2330 and in requesting such a form, the following information should be given. ie Either place or area + duration of flight, or Route and duration of flight.

Information in Standard Forecasts (Form 2330)

1) Date, Route or Area, Period and time of origin.
2) Brief account of the latest weather situation
3) The Weather.
4) Cloud (Type and Amount given in 10ths)
   If high ground is likely to be in cloud then this is stated explicitly.
5) Freezing Level given to nearest 500ft Above S.L. estimated icing conditions in cloud is given as as Icing Index, - High, Moderate or Low. If Glazed Frost is expected it is specially mentioned
6) Visibility - given as a distance.
7) Surface Winds in Compass Points / M.P.H.
8) Upper Winds " Degrees / M.P.H.
9) Barometric Pressures at Drome Level (QFE) of destination airfield and likely diversion airfields and at MSL (QFF) for places en Route.
10) The Sun + Moon Rising and Setting times and phase of moon.

NOTE On operational flights, place names are omitted and Item 2. is secret.

The Form 2330 is completed by the members of the Aircraft's crew and returned to the MET. office after the flight.
Observations on Route are made and the points to note are, Times, Positions, Altimeter Readings, Cloud Type, Amount, height of Base and Top if possible, Temp. and Visibility

P.T.O.

Besides Route Forecasts, the following are issued as required.-

1. Gale Warnings. - issued when surface wind in the open is expected to exceed 40 mph. The max force of gusts is usually given.
2. Squalls or Thunderstorms - if either approach the stations a warning is issued at once.
3. Frost Warning. - issued when the air temp is likely to fall below 30° F. In winter when a frost is a daily feature of the weather, a warning is only issued only when the frost is likely to become more severe. The minimum temp. is allways given.
4. Snow Warnings - issued so that preparations may be made to keep runways clear.
5. Local Forecasts - issued 3 or 4 times a day to cover a period of about 8 hrs and a radius of 20 miles.

Basis of Forecasting

An air mass is a large volume of air who's characteristics of temperature and humidity are constant throughout the mass. As the air mass moves, it will bring with it the characteristics of its latitude or region of origin. As it drifts to other latitudes, from what we know of temperature, pressure, and humidity, these will give rise to weather changes.

A Factors affecting the Weather.

1) Air mass.
2) Pressure distribution and Fronts.
3) Climates and Seasons, Shape, Size and position of Land and Sea.

B. Polar Air Weather.

Air, cool and dry, warmed at the surface causes convection cloud. Showers, perhaps Thunder, Gusty Surface Winds, Good Vis, Bumpy flying by day but Smoother at night, and icing in cloud.

Tropical Air Weather

Air warm and moist, cooled at the Surface.- Little or no convection, Layers of cloud formed, usually Stratus, Drizzle, Poor Vis, and Fog, Slight or moderate bumpyness, Slight icing.

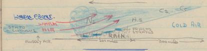
11. **FRONTS.**

A Front is a zone of transition between two different air masses, and on a weather map are drawn as a line.

A. Weather Change with a WARM Front.

If, after a spell of cold weather with good visibility, the clouds become gradually thick and low with a period of continuous rain and drizzle, The wind VEERS and the temperature rises and the weather is warm, muggy, drizzly and overcast with poor visibility, then a WARM FRONT has gone through.

WARM FRONT.



B. Weather Change with a COLD Front.

If, after a spell of warm, musty, drizzly overcast weather, the clouds become very thick with very heavy rain, the wind VEERS and the temperature falls, followed by a clearance and then bright intervals and showers with good visibility, then a COLD FRONT has gone through. (See diagram at foot of page).

12. A. Beaufort Weather Notation.

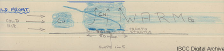
Not to be confused with the Beaufort wind Scale.

Originated as a universal method for noting down weather observations in a concise form. Letters were first used but these have been gradually replaced by a figured code, though the letters are still used to a slight extent.

B. Information on a Weather Map.

1) Pressure reduced to M.S.L.
2) Pressure change in last 3 hours.
3) Temperature.
4) Dew Point.
5) Visibility.
6) Wind Force and Direction.
7) Cloud, - Type and Height of Base.
8) The Weather.

COLD FRONT.



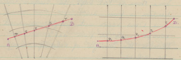
D. R. Navigation

INDEX

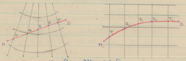
1. How to plot a Gt. Circle Brg on a Mercators Chart using a Gnomonic Chart.

a) Join the 2 places concerned on the Gnomonic Chart
b) Note the Latitudes where the track cuts various meridians. (As in diagram P.Q.R.S.T.)
c) Transfer these positions by Lat. and Long. to a Mercators Chart (P_1, Q_1, R_1, S_1, T_1.)
d) Jointhese positions freehand.

The resultant curved lines represents a Gt Circle on a Mercators Chart.



Southern Hemisphere



Northern Hemisphere.

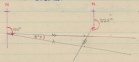
2. Drift and Wind Lane Method of Wind Finding.

Depends on the fact that the Wind VEERS with height by 10° for 1,500 feet.

Example. Co, 100°T; TAS 170K; Height 1500 ft.

Method.

1) Measure Drift, (Say 8°P)
2) Measure the General direction of the Wind Lanes by means of Bearing or Astro Compass (Say 035°T or 215°T)
3) Since there is Port Drift, the Surface Wind direction is from 215°T.
4) Since Wind VEERS with height, wind at 1,500 ft will be from 225°T.
5) Therefore the Triangle of Velocities may be solved.



Disadvantages

1) Cannot be used at night, though Wind Lanes can be seen by shining the headlight of the A/c on them. This is impracticable during wartime.
2) Can only be used at heights of 1,500 ft or less
3) Can only be used over sea.
4) There must be sufficient Surface Wind to form Wind Lanes
5) Cannot be used for flying UP or DOWN-wind, i.e. You must be making a Drift.

Advantages

1) No alteration of course necessary.
2) Quick and accurate.
3) Fix unnecessary.
4) "Up to minute" Wind Velocity.
5) Easily provides a check on Ground Speed.

---

3. The Square Search

1) Purpose. To Locate objective
2) Data Required.
   a) Wind Velocity.   c) T.A.S.
   b) DR. Posn. of Objective.   d) Visibility.

P.T.O.

3. Sequence of Operations

a) Fly A/C up or down Wind to make good a Track equal to 2V (Twice Visibility)

b) Lay off Track at 90° equal to 2 V

c) " " " " 90° " " 4 V

d) " " " " 90° " " 4 V

e) " " " " 90° " " 6 V

etc.

4. The possibility of Error

1 only. - Underestimate V rather than overestimate it.

5. Practical Application.

a) Work out all courses and ETA's for all Tracks in Search before arriving at the D.R. position

b) Failing to located objective, steer the following courses (See tables)

c) Check W/V at turning points by Double Drift

d) Plot courses and air distances from the air position from which commence search. NB Plot AirPlot from last fix.

TRACK	DIST.	G/S	Co. T	TIME	AIR DIST.
167	12	165	164	4½	14
257	12	213	243	3½	13
347	24	275	347	5¼	19
077	24	213	091	6¾	25

etc.

DATA

W/V = 167/55K

TAS = 220K

Vis = 6 N.m.

14. Position Lines

a) Methods of Obtaining Position Lines

1) By observing 2 known objects in transit.

2) By bearing Compass.

3) By bearing plate or Astro Compass (Rel. Brgs.)

4) By Loop. (Rel. Brg.)

5) W/T. D/F.

6) Astronomical Observations

7) By determining Range of a known object.

b) Uses of a Single Position Line

1. To check G/S.

Eg. Track 090°, Fix A. 1000hrs

Posn. Lines at 1020 hrs. from

LTH. B.

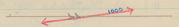
If on Track, then will have flown distance A to X in 20 mins.

NB. To check G/S, posn Lines should not cut the Track at an acute angle.

2. To confirm the Track

Track 090°, Obtain Posn line

ie. Not far off Track.



NB Must make a small angle with the Track.

P.T.O.

3. <u>To give the Req'd Track to a Certain Position</u>

a) By Visual Bearing.
b) By W.T. D/F. Bearing.
c) By Loop Bearing.

If a bearing can be taken of B then the bearing can be the Track to B.

---

5 i) <u>Drift.</u>

a) <u>The Importance of Drift</u>
1) Determines the T.M.G.
2) It acts as a check on W/V
3) Provides a means of determining W/V.

b) <u>Methods of Obtaining Drift.</u>
1) C.S.B.S.
2) Drift Recorder.
3) Rear Turret. Guns trained on some object that the A/c has recently passed over.
4) Back Bearing.
5) By determining T.M.G.

ii) a) <u>Methods of Obtaining T.M.G.</u>
1) By 2 fixes
2) By measuring Drift and applying to Co. T.
3) By reversing a Back Bearing.
4) By W.T. D/F Bearings (In certain cases, i.e. having passed over the station and not altered Co.)
5) By QDM's and QDR's.
6) By Loop Bearings (having flown over station).
7) By 3 or more position lines from one or more engines.

b) <u>Measuring Ground Speed.</u>
1) C.S.B.S.
2) By Drift Recorder
3) By 2 fixes
4) By position lines cutting the Track almost at right angles.

---

6. <u>Mean Equivalent W/V (For Climbing)</u>

The method used when using 2, 3 or 4 winds, but the height interval between the given Met W/V's must be equal and the Rate of Climb must be steady

1. Met Wind at 6,000 ft = 190/36 mph
2. " " " 10,000 ft = 202/40 mph

a) Plot the first wind.
b) " " 2nd " on tail of first.

AC = Wind No 1
AB = " No 2.
BC = Mean W/V for 2 hts = <u>198/67 mph</u>
= <u>198/67 mph</u>

<u>For decending, same procedure holds good.</u>

Wind Finding - Relative Advantages and Disadvantages

Method	Advantages	Disadvantages
1. Multiple Drift.	a) Up to the Minute Wind (Bombing) b) Does Not require fix c) Provides its own check on accuracy. d) Obtained over Sea and Land e) Little time lost, 60°-120° turns used. f) Need not be plotted.	a) Alteration of course necessary. b) Not allways possible to obtain Drifts (Cloud). c) Certain amount of time lost d) Local Wind which may not have any bearing of future conduct.
2. Air Plot.	a) Gives mean wind which may be very advantageous for return flight b) Give PILOT freedom of action c) No alteration of course necessary d) Accurate providing G/pains and fixes may be accuratly obtained. e) Promotes interest in checking Course TAS and time.	a) Plotting and Courses must be accurate b) Reliable fixes must be obtained otherwise W/V's found become merely check winds. c) The mean W/V may have no bearing on the actual W/V at a particullar time (NO use for Bombing).
3. Track and G/S.	a) No loss of time - no alteration of Co necess. b) Simple, c) No plotting Req'd.	a) ~~Can be found~~ Ground pains are nessecary. b) Accurate time necessary, c) Does not allow PILOT freedom of action. d) Course and TAS Must be kept steady.
4. Drift & Wind Lane.	a) W/V found over Sea without fix. b) Alteration of Co. unnesecary c) No loss of time. d) Only 1 accurate drift required. e) No timing necessary. f) Need not require plotting. PTO	a) Can be found over sea only b) Good Visibily required. c) Depends upon the assumption that wind VEERS 10° with 1500 ft in height. d) Little practical value in excess of 1,500 ft. PTO

Drift and Wind Lane Method of Finding Wind (cont)
Advantages (continued)
g) G/S obtained in same operation.
h) Up to the minute wind.

Disadvantages (continued)
e) Sea must not be too rough or too calm otherwise Wind Lanes cannot be observed.
f) Cannot be used when flying up or down wind.
g) Cannot be used at night.
h) Local Wind - may not have any bearing on future conduct.

---

8. Form 441
The purpose of Log Keeping
1) To prevent mistakes being made in the air. Dangerous to commit to memory in the air, Log gives a written record.
2) To enable another member of the crew to take over should the Navigator become a casualty.
3) To enable the flight to be constructed, so that navigator can justify any action taken.
4) Gives a record of actual weather experienced, also information useful to Intelligence.
5) Gives a record of engine and airframe times.
6) Gives a record of W/T Signals sent and messages recieved.
7) Can be used in court of law as evidence.

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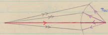
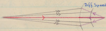
9. The Effects of Changes of W/V on Drift and G/S

Effect on.

1. Head Winds — Drift — G/S
a) Change in Direction — Large — Little



Drift — G/S
b) Change in Speed — Little — Large.



P.T.O.

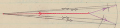
2. TAIL WINDS

a) Change in Direction

Effect on:-

Drift	G/S.
Mod. Large	Little.

b) Change in Speed.



Drift	G/S.
Little	Large.

3. BEAM WINDS

a) Change in Direction

Effect on:-

Drift	G/S.
V. Small.	Large.

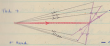
b) Change in Speed.

Drift	G/S.
Large	Small.

4. QUATER WINDS

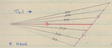
a) Change in direction

Effect on:-



	Drift	G/S.
-A,	Mod. Large	Mod. Large
-D,	Small	Mod. Large

b) Change in Speed



	Drift	G/S
-A,	Mod. Large	Mod Large
-B,	Large	Mod. Large

10. Methods of Fixing Positions Lines. Summary in order of accuracy.

1) Visual Fix

a) A Visual Ground Position

b) By 2 or more Visual position lines.

2) Astro Fix

a) First class Astro Sights accurate plus or minus 10 miles irrespective of distance from any means of navigational aid. Improvements

P.T.O.

in Sextants will reduce error considerably in the future.

3. D/F Fixes in order of accuracy:-

a) First class D/F Brg and crossing coast line
b) 2 or more first class D/F Brgs.
c) 2 or more second class D/F Brgs.
d) 2 or more third class D/F Brgs.
e) Loop Brgs. - cannot be assessed.

Note: 1st class D/F Bearing is accurate to +or- 2°
2nd " " " " to +or- 5°
3rd " " from 5° upwards

2° error will give an error of about 2 miles at a distance of about 60 miles. The accuracy of the fix will therefore depend upon:-

a) Distance from the Station
b) Angles at which Pos Lines cross each other. - the more ~~acute~~ acute, the greater the possibility of error.

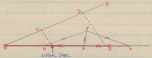
II. The Critical Point - between 2 fixed Bases.

DEFINITION. - is the point from which it is equally quick to fly to either base.

DATA REQD. 1) Reduced Air Speed. 4) W/V
2) TAS. 5) Distance.
3) Track.

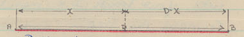
2 Methods of Finding the Critical Point.

1) Graphic



a) Draw Track A-B
b) Choose any point along AB, ie. X and Lay off W/V, XY.
c) Draw arcs (Radius = RAS) from Y cutting Track at H + O
d) Therefore HX = G/S Back & XO = G/S Out.
e) Lay off a line from A at any angle AY
f) Mark off G/S Back along AY = C. and then from C mark off G/S Out along AY = D.
g) Join D and B.
h) Join C to Track, parallel to DB and where it cuts the Track is the Critical Point.

2) Out and Home Formula



Time = $\frac{\text{Dist}}{\text{Speed}}$.

H = G/S Home $\quad \therefore \frac{D-x}{O} = \frac{x}{H}, \therefore DH - xH = xO.$

O = G/S Out. $\quad \therefore DH = xO + xH$

$\therefore DH = x(O+H)$

$\therefore x = \frac{D \times H}{O+10}$ = Distance formula.

12. Refined Method of Plotting Position Lines
Introducing the CURVE of EQUAL BEARING.

Applicable only when the C.A is ½° or more

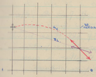
1) True D/F Brgs
a) ~~On a Topographical Map~~
On a Mercators Chart

Method of Layin off Position Line

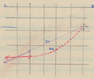
1) Calculate DR position of A/C or, if hopelessly lost assume a position.
2) Calculate CA
3) Apply CA to Gt Circle Brg (Given by the station) to obtain a Rhumb Line Bearing.
4) Lay off RL Brg from Station.
Since Wireless Waves follow the Gt Circle Track, it would be more accurate to assume that the Position Line is part of the Great Circle Track about your D.R. position.
5) Therefore from position where Rhumb Line Bearing cuts your ~~track~~ D.R. meridian draw a line TOWARDS the Station and AWAY from the Equator inclined to the Rhumb Line by the CA you have previously calculated.

a) Mercators Chart (cont.)

1. Northern Hemisphere



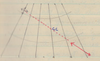
2. Southern Hemisphere



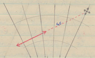
⟷ Refined Pos'n Line.

b) On a Topographical Map.
Method of Laying off Position Line.
1) Lay bearing off direct from the W.T. Station as a straight line.

1. Northern Hemisphere



2. Southern Hemisphere.

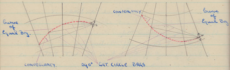


P.T.O

2 Loop Bearings

a) On a Topographical Map

A bearing say 090° laid off from the A/C can be laid off to the station from every meridian. (see diagram). If all these points where each bearing crosses the respective meridian where joined together a curve concave to the Pole would be produced.



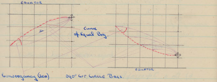
Southern Hem. Northern Hem.

The Curve of Equal Bearing - is a line joining all places which have the same Great Circle Bearing of a given position at any instant. It constitutes a more accurate position line obtained from D/F Loop Bearings.

b) On a Mercator Chart.

A Great Circle Bearing of 090° is laid of from the A/C to to station from every meridian. If all the points where the Grt Circle Brgs cut the respective meridians were joined, the result would be a curve concave to the Poles. (See diagrams).

Southern Hemisphere. Northern Hemisphere.



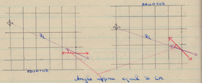
Method of Plotting the Tangent of the Curve of Equal Brg.

1) Work out Loop Brg in the normal way and Plot the Rhumb Line Bearing from the Station
2) Where the Rhumb Line Brg cuts the D.R. Meridian draw a line inclined at and angle of CA to the R.L. TOWARDS the D/F Station and TOWARDS the Equator. P.T.O.

This will represent a Tangent to the Curve of Equal Bearing and is a more accurate position line to use from Loop Bearings. (See Diagrams)

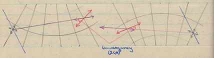
a) On a Mercators Chart.

Northern Hemisphere Southern Hemisphere



b) On a Topographical Map

Northern Hemisphere Southern Hemisphere



Plotting the Curve of Equal Bearing on a Topographical Map

This is carried out the same way as on a Mercators Chart except that your DR Meridian must be transfered to pass through the D/F Stn. This is necessary because the Loop Brg was taken relative to your D/R meridian.

NB. The True Great Circle Bearing is plotted, not the Rhumb Line Bearing.

Amendment.

3rd Method of finding Critical Point.

ie By Computer.

Place Ground Speed Home over sum of Ground Speeds Out and Home and against Total Distance on inner scale, read off critical distance on outer scale.

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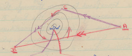
13 Reasons for Deviation from most direct route.

1) To make sure of visual fixes.
2) To avoid well defended areas.
3) To avoid unfavourable weather (See diagram)
4) To avoid difficult country ie. Jungle, Desert, and long stretches of Sea.
5) Practical Reasons - to give surprise.

P.T.O.

b) To be in accordance with SD 158 (Prohibited Areas).

(3) To avoid unfavourable weather.



Cold Front. Warm Front.

a) To fly along direct Track from A to B results in contrary winds, Heavy Rain and perhaps Icing from Warm Front, and Heavy rain perhaps icing with possible Thunderstorms in Cold Front.

b) To fly along Indirect Route from A & C to B you avoid the Fronts and will have favourable winds.

11a. Flying at Various Heights. Advantages and Disadvantages.

1. Track Crawling.

a) ADVANTAGES.

i) If visibility permits, frequent Pin Pointing and checking of Drift a destination will be eventually be reached and/or a specified area searched.

b) DISADVANTAGES.

i) In bad visibility, no check can be kept on G/S or W/V.

ii) If pilot alters course without fixing the position of the A/C:-

1) A new D.R posn may not be found nor

2) A course to make good a Required Track.

2. Low Flying.

a) ADVANTAGES. (500 feet or less)

i) View restricted

ii) Pilot unable to maintain steady Co. or A/Speed.

iii) Hence difficult to obtain DRIFT.

iv) Astro observations impossible

v) D/F Ranges severely restricted (Bradling and cannot be ruled out)

vi) Close up fixing only possible

b) DISADVANTAGES.

i) Safety

ii) Surprise

3. Medium Altitude Flying. (500 to 10,000 ft).

a) ADVANTAGES.

i) Ground often visible - enables visual fixing.

ii) Drifts easily obtained.

iii) W/V's checked with accuracy.

iv) Good forecast of winds.
v) Able to make use of cloud cover if necessary.
vi) Cold usually not too severe.
vii) No Oxygen necessary.

b) DISADVANTAGES
i) Astro observations may be restricted - cloud.
ii) Range of D/F less than at great heights.
iii) Enemy opposition likely to be greatest.

2. High flying (above 10,000 feet)
a) ADVANTAGES
i) Astro observation conditions good.
ii) D/F facilities good with good range.
b) DISADVANTAGES
i) Use of Oxygen necessary.
ii) Cold can be very severe.
iii) Drifts difficult to obtain, even if ground is visible.
iv) Visual fixing difficult.
v) W/V's difficult to forecast and often very strong.
vi) Accurate wind finding difficult.