Form 619.

1623493 A.C.2 BIRD J.H

PRINCIPLES OF FLIGHT
AND
METEOROLOGY.

ROYAL AIR FORCE.

1 FLIGHT.
10 COURSE.

Notebook for use in Schools.

91/2250. Wt. 6865. 500M. Bks. 12/41. J. D. & Co. Ltd.

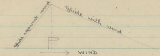
Principles of Flight

Air Speed and Ground Speed. 22nd. Sept 1942.

The lift on an aircraft is obtained by the motion of the aircraft thro' the air. To maintain it in the air, it must have a certain speed relative to the air, called air speed (A/S). The speed relative to the ground (G.S) is not required.

Effect of wind

There is always a "head wind" when flying, even when the wind relative to the earth is from one side the airflow or relative wind over the aircraft is still from ahead due to air-speed. The earth wind and ground-speed are only taken into account in landings, take-off and then we reduce the ground speed by flying into wind. In a climb or glide we may need the actual path relative to the ground so we consider the earth wind - the path against the wind being steeper. Motion relative to the ground seems to be important only when we can see the ground. We may appear to have sufficient speed if flying down wind and the airspeed may be very low. Illusions may be dangerous e.g. when turning with or into wind.



<u>Change in wind speed</u>

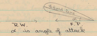
If an aircraft is flying into wind and the wind speed suddenly increases the aircraft tends to go on at the same ground speed as before due to its inertia - so the air speed increases. If the wind speed suddenly decreases the air speed will suddenly decrease and may result in loss of control.

<u>Wind Gradient</u>

This is the change in wind speed with height. Fifty feet to a hundred feet from the ground friction with the earths surface slows up the wind so that the wind at fifty feet may be far less than the wind at 200 ft. This is important in landings and take-offs.

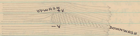
<u>Aerofoils</u>

The object of the wings or aerofoils is to provide sufficient force to support the aircraft. They are designed so as to give a smooth airflow and to meet the airflow at a small angle of attack. The angle of attack is the angle between the chord line (usually a line from leading to trailing edge) and the relative wind which is the reciprocal of the flight path.



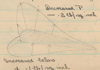
α is angle of attack

<u>Airflow</u>



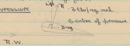
The airflow for a small angle of attack is smooth with an upwash in front and a downwash behind the wings. The wings push the air downwards and in doing so experience an upward reaction from the air. The streamlines are closer above giving increased speed of air and further apart below giving decreased speed.

<u>Distribution of Pressure.</u>



The sum of the energy due to the speed and the static pressure remains a constant for a streamlined airflow. Therefore if the speed is decreased (below the aerofoil) the pressure increases and if the speed is increased above the aerofoils the pressure decreases. The total average difference is about ·3 lbs/ sq. inch giving about 43 lbs/ sq. foot.

Centre of pressure



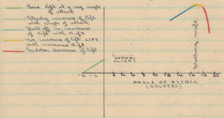
The effects of the pressures distributed round the aerofoil can be combined into a resultant force at right angles to the chord line thro' the centre of pressure.

This resultant force can be resolved at right angles to the relative wind giving lift and parallel to the relative wind giving drag. Lift is used in lifting the aircraft and overcoming the weight. Drag resists forward motion. For an efficient modern wing $\frac{L}{D}$ is greater than 20/1

Lift and drag depend on:-

(a) The shape of the cross section of the wing.
(b) The angle of attack on the wing
(c) The area of the wing
(d) The density of the air
(e) Air speed (as the square)

The effect of increasing the angle of attack

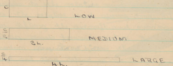



4°


13° (BUBBLING)

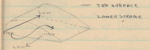

14° (STALL)

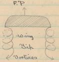
__Density.__ More lift (and drag) from denser air.
__Wing Area.__ Greater wing area great lift and drag.
__Speed.__ Increased speed increases lift and drag. Double the speed gives four times the lift and drag.
__Stalling.__ Increase in angle of attack alters the airflow and also alters the centre of pressure. If centre of pressure moves forward tends to increase the angle of attack and further forward movement of the centre of pressure. This tends to raise nose of the machine and gives instability. If after maximum lift have stall decrease in centre of pressure near leading edge causes nose to fall and decreases the angle of attack, so tends automatically to readjust the balance.
__Aspect Ratio__ is the ratio of span to chord.



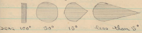
Increase in aspect ratio increases lift and to lesser extent drag. Structurally high aspect ratio is difficult so seek compromise.

__Biplane and Monoplane__
Monoplane more efficient because of interference in a biplane of upper with lower wing causing a loss of lift to both wings. Can be overcome to a certain extent by stagger i.e. one wing being placed in front of the other.
Advantage lies in structural efficiency - lightness.
__Drag.__ reduces speed so must be reduced as much as possible.
__Wing Drag__ - Induced drag.





__Induced__ is a result of a decreased pressure above and increased pressure below wing causing vortices i.e. eddy's at the wing tips. is reduced by taper Is reduced by taper and large aspect ratio but never eliminated
__Form Drag__



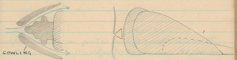
Form Drag is due to the shape of the wing

Form drag can be reduced by streamlining the wing

Skin friction. The layer of air in contact with the wing is at rest and the next layer has a small velocity. Succeeding layers have increasing velocities until the friction of the surface has no effect. The drag of the surface depends upon the thickness of this layer. It is more important for streamlined shapes and high speeds. It can be reduced by using smooth surfaces but it can never be completely illiminated.

Parasite drag. This is due to all parts of the aircraft that give no lift e.g. undercarriage, radiator, fuselage, engines, struts and turrets. The form drag can be reduced by streamlining the shape. The skin friction can be reduced by using smooth surfaces.

Cooling drag. The airflow is used to cool the engine or radiator. This disturbs the airflow and so causes drag. It has been reduced by cowling. The heat of the engine may be used to attract the airflow giving negative drag i.e. the otherwise waste energy from the engine in the form of heat is converted into useful work



DRAG

- WING DRAG
  - INDUCED DRAG (High Aspect Ratio & taper)
  - FORM DRAG (Streamlining)
  - SKIN FRICTION (Smooth surfaces)
- PARASITE DRAG
  - FORM DRAG (Streamlining)
  - SKIN FRICTION (smooth surfaces)
- COOLING DRAG (COWLING)

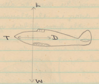
Frontal area and size must be kept down to give less drag and result in cramped quarters for the crew.

Speed By increasing the speed we increase drag.

$$D = KV^2$$

Therefore if we half the speed we quarter the drag so that reducing the drag saves the engine.

Straight and Level Flight



There are four forces acting on the aircraft in straight and level flight.

① Lift. Acting at right angles to the flight path in this case acting vertically.

② Drag. Acting parallel to the flight path in this case horizontally

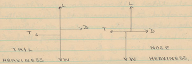
③ Thrust. Parallel and opposite to drag (horizontal)

④ Weight. Acting vertically downwards

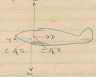
For equilibrium these 4 forces must balance so that L = W and T = D. The pilot unconsciously causes L = W, T = D by manipulations of the throttle and controls. If $\frac{L}{D}$ = 10 and W = 10,000 lbs then L must equal 10,000 lbs D is 1,000 and

T must be 1,000 lbs to maintain straight and level flight

C. of P. and C. of G. These four forces must act in correct places or the aircraft will not be in equilibrium – may result in nose heaviness or tail heaviness



These are settled by the designer so the C. of P. is behind the C. of G. in most land-planes and the L W couple is balanced by the T D couple. When the thrust is cut out the aircraft is nose heavy and so takes up a gliding position



Alterations of Speed. The lift must equal the weight, if the speed is reduced the total lift must be made up by increasing the lift from the angle of attack. This is obtained by increasing the angle. It can only be increased up to stalling angle when the total lift can no longer be maintained. If the speed is increased the angle of attack must be decreased to maintain equilibrium.

Example Speed	120 m.p.h.	Angle of attack	4°
	180 m.p.h	"	2°
	230 m.p.h	"	½°
	80 m.p.h	"	8°
Stalling Speed	60 m.p.h.	Stalling angle	16°

NOTE This only applies to one particular aircraft the speed applicable varies with all types.

When the stalling angle is reached the aircraft tends to get out of control – the pilot cannot measure the angle of attack, so he calls it stalling speed, this stalling speed varies for different conditions of flight. The stall is due to loss of lift because of turbulent airflow and reduced speed. Landing is stalling the aircraft when very near the ground, so a low stalling speed means a low landing speed.

Newton's laws of mechanics 14th. Dec. 1943.

1, Moving air will tend to remain moving, still air to remain still, and to resist any change of direction or speed.

2, Force must be applied to the air to change its state of uniform rest or motion or direction of flow. The more sudden the change or the greater the air mass affected the greater must be the force applied.

3, Application of such force will cause an equal and opposite reaction on the surface producing it.

Eddy resistance

That portion of the resistance caused when air flows past a solid body disturbing the smooth streamline flow.

Advantages of cambered aerofoil

1, Less drag (smooth airflow)

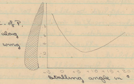
2, Better lift (Venturi effect of bottleneck).

3, Depth gives strength

Centre of Pressure.

That point on an aerofoil through which passes the resultant of all the lift forces acting on the aerofoil.

Centre of pressure moves at varying angles of attack due to the differing pressure distribution. This causes instability but modern design has largely overcome this

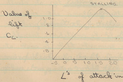


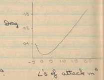
Lift and drag

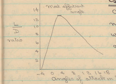
Both depend on (i) aerofoil shape and angle of attack (ii) Air density (iii) Airspeed (iv) Wing area.

Lift $= C_L \frac{1}{2}\rho V^2 S$

Drag $= C_D \frac{1}{2}\rho V^2 S$.





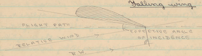


Stalling speed

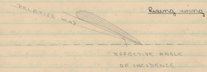
A certain minimum air speed needed to maintain lift below which speed further increase of angle will not maintain lift. However a wing stalls at an angle not a speed hence a high speed stall. A given lift can be obtained by either high speed + small angle or low speed + large angle.

X Autorotation X

Falling wing



Rising wing



Definitions

__Adiabatic.__ The word which is applied in the science of thermodynamics to the changes which may take place in the pressure and density of a substance when no heat is communicated to it or withdrawn from it.

__Aerobatics.__ Evolutions voluntarily performed with an aircraft, other than those required for normal flying.

__Aerofoil.__ A structure analogous to the wing or tail of bird designed to obtain reaction from the air approx. at right angles to the direction of its motion.

__Aeroplane.__ Any mechanically-driven heavier-than-air aircraft with fixed wings.

__Aileron.__ Aerofoils used for causing an aeroplane to roll about her longitudinal axis for the purpose of balancing. These aerofoils are usually hinged near the wing tips in continuation of the wing surfaces. They are rotated in the opposite directions by interconnected control wires attached to the control column.

__Aircraft.__ A generic term for all types of air-supported vehicles.

__Airscrew.__ A generic term which includes all types of screw with helical blades designed to rotate in the air. An airscrew may be either tractor or propeller.

Airscrew slip. The ratio of the difference between the forward speed of an aeroplane and the forward speed which is necessary for the airscrew to give a zero thrust (i.e. no thrust). The airscrew is considered to be rotating at the same number of revs. in each instance.

__Aspect ratio.__ The ratio of span to chord of an aerofoil.

__Bank.__ The angle between the lateral axis of an aeroplane and the horizontal is called the angle of bank and is denoted by the symbol Ø.

__Camber.__ The curvature of a surface of an aerofoil.

__To cant.__ To tilt, to take any inclined position.

__Centre of Gravity.__ That point in a body through which the resultant of the weights of its parts passes, in every position that the body can assume.

__Chord.__ A straight line touching the under surface of an aerofoil at or near the leading and trailing edges. The length of the chord is the projected length of a section of a plane i.e. normally the length of a line joining the leading and trailing edges. In an aerofoil having compound curvature the chord requires special definition.

__Control column.__ The lever (or the pillar supporting a hand-wheel) by which the elevator and aileron controls are operated.

Centripetal forces. P. 1. Ch. 14

Dihedral angle. In geometry - the angle between two planes. The planes of an aeroplane are at a dihedral angle when both port and starboard are inclined upwards or downwards to the transverse axis. If the inclination is upward the dihedral is positive, if the inclination is downward it is negative

Drag. The resistance along the line of flight; the head resistance i.e. the total resistance of the whole aircraft, including wings, fuselage, undercarriage etc.

Drift. To move sideways or crabwise over the ground. It is measured as the angle between the course and the track made good.

Elevator. The horizontal control surface by which the upward or downward inclination of an aeroplane in flight is controlled. The elevator is usually hinged to the trailing edge of the tail plane.

Empennage. Tail unit

Endurance. The maximum time an aircraft can continue flying under given conditions without refuelling.

Fabric. An outer covering of the main plane structure, control surfaces and fuselage. It is generally made of linen and doped to cause it to tauten and so preserve it from the weather.

Fairing. Additions to any structure to reduce its head resistance

Fin. Vertical surface or surfaces forming part of the tail unit by which the yawing of an aeroplane in flight is controlled

Flattening out. The change of the path of flight from the gliding angle to a path parallel to the ground

Flutter. An unstable oscillation due to the interaction of aerodynamic and elastic forces upon the inertia of any structure.

Flying position. The attitude of an aircraft when the lateral and longitudinal axes are parallel to the ground.

Fuselage. The main structure or body of most types of aeroplanes, to which the main planes, tail unit and other surfaces are attached.

Ground speed. The speed of an aeroplane in flight over the ground.

Gap. The distance between one plane and the next immediately above or below it.

Incidence rigging. The angle between the chord of the main plane and the horizontal when the aircraft is in the rigging position.

Indicated Horse power. The power actually developed in the cylinder.

Keel surface. The sum of all those areas on the aircraft which give rise to side pressure when the aircraft slips.
Leading edge. The forward edge of a streamline body or aerofoil
Leeward. Away from the wind
Leeway. The same as "drift"
Lift. A force, perpendicular to the path of flight of an aircraft, which sustains the aircraft in the air.
Performance. The flying characteristics, such as the speed of level flight, rate of climb and ceiling, of an aircraft under specified conditions
Airscrew pitch. The distance through which an airscrew must advance along its own axis during one revolution in order to give no thrust
Pitching. Angular motion about the lateral axis.
Plane of symmetry. A plane dividing an object into two parts each of which is a mirror image of the other.
Power. The time rate of expending energy in doing work
Range. The maximum distance an aircraft can travel under given conditions without refuelling.
Rolling. Angular motion about the longitudinal axis. A complete revolution about that axis is commonly called a roll
Side slipping and skidding. Movement sideways through the air from the course ahead.
Skin friction. The resistance caused by the movement of a fluid (air) over the surface of a body.
Slipstream. The stream of air that is discharged aft by a revolving airscrew.
Span. The overall distance from wing tip to wing tip
Spinning. A diving descent combined with a continued rotation about the direction of motion of the centre of gravity of an aeroplane.
Stability. The quality by virtue of which any disturbance of steady motion tends to decrease.
Stagger. When main supporting surfaces are of equal chord, and when one such main supporting surface of a biplane is in advance of another these planes are said to be staggered
Stalling speed. The airspeed corresponding to the maximum lift coefficient of an aeroplane An aircraft is said to stall when its air speed drops below that necessary to support it in the air.
Streamline body. A body so shaped that it offers a minimum of resistance to motion thro' a fluid
Thrust. The force acting along the axis about

which an airscrew is being rotated
Time lag is the lapse of time between cause and effect.
Torque. The moment of resistance of an airscrew to rotation
Trailing edge. The after edge of a streamline body or aerofoil.
Wash in. An expression used to denote an increasing angle of incidence towards the wing tip
Wash out. An expression used to denote a decreasing angle of incidence towards the wing tip
Wing. The word used in aerodynamics to describe that portion of one of the main supporting surfaces of an aeroplane from the centre line of the a/c. to the wing tip
Yaw. To turn an aeroplane in the air about the normal axis. An aeroplane is said to yaw when the fore and aft axis turns to starboard or port out of the line of flight. The angle of yaw is the angle between the fore and aft axis of the aeroplane and the instantaneous line of flight

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Autorotation (cont.)
Assume aircraft flying stalled hits bump causing one wing to rise, other to fall then falling wing meets relative upward airflow. angle of attack increases wing more stalled - less lift, wing drops even faster. Rising wing meets relative downward airflow - angle of attack decreases, wing now unstalled, more lift wing rises even faster. Result:- a rolling moment in direction of initial movement which continues. Trying to raise the dropping wing by lowering its aileron as in normal flight has adverse effect.
Dihedral (see definition). It gives lateral and directional effect.
Gap and stagger (see definition) normally gap equals chord. Stagger stops interference between the pressure areas, the amount being governed by pilots view and accessibility to cockpit.
The ideal aerofoil. It would have (i) small movement of C. of P. (ii) high maximum value of lift (C_L). (iii) - low landing speed. (iv) low minimum value of drag (C_D) - high top speed. (v) Good L/D ratio - general efficiency and weight carrying (vi) Depth of section - strength. Impossible to combine the above

qualities in one wing. The three main types of aerofoil are high lift, high speed and general purpose. The main changes are in camber and in depth, the large camber gives good lift but more drag therefore less speed, small camber gives less drag therefore more speed but less lift.

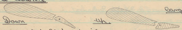
Slots.

Small auxiliary aerofoils fitted by hinges parallel to leading edge. At normal angles they lie flush with the leading edge and have no effect. At large angles they are sucked out as above and retain smooth airflow over wing via venturi effect by gap provided. Usually fitted along wingtips only for added lateral stability and control at low speed. Effects 60 - 100% more lift, stalling angle delayed, stalling and landing speeds lowered, speed range increased, autorotation less likely.

Aileron drag and control at slow speed.

Bank is applied by increasing effective camber of one wing by lowering aileron. A secondary effect is that nose of aircraft tends to swing towards rising wing tip, lowered aileron being more exposed than rising one to airflow and causing more drag. See fig. 33. Chap 1. for various types of aileron used to overcome aileron drag. Consider a gliding turn to left at too slow a speed. Left rudder has little effect (no slipstream - slow airflow). Applying bank probably stalls rising wingtip. Aileron drag swings nose towards rising wingtip. Probable result is spin to right instead of turn to left.

Frise aileron

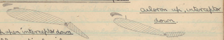


Down Up. Large drag.

Interconnected Slat and aileron

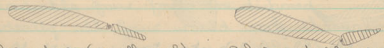
Aileron down (slat open) Aileron up (slat closed).

Automatic Slat and interceptor



Slat open interceptor down Aileron up, interceptor down.

Differential ailerons



Aileron down (small angle) Aileron up (large angle)

Aerodynamic Balance.

It is using the airflow to assist pilot to move controls to save fatigue (see Par 46).

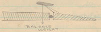
AUXILIARY AEROFOIL TYPE

INSET HINGE BALANCE

HORN BALANCE

Never more than one fifth of total area in front of hinge.

Mass Balance or Static Balance.



It is used to stop control flutter at high speed, due to pressure variation or bending moments. It also overcomes the effect of bumps (see Par 46 II). It is sometimes concealed in front of the inset hinge.

Trimming tabs and Balance tabs (Par. 44)

They enable the pilot to trim ~~away~~ the plane in any aircraft in flight and today are combined with balance tabs.

Airscrews.

Modern high speed aircraft with fixed-pitch air screws have very poor static thrust i.e poor take-off due to large blade angles necessary for the high speed in level flight. Fine pitch or small blade angles are necessary for good static thrust i.e. good take-off. The V.P air screw is now used; it can be set by the pilot to fine pitch for take off and coarsened by him in the air to give the same relative blade angles at the higher speeds.

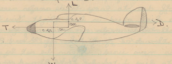
Forces acting on an aircraft in level flight

An aircraft is in equilibrium when flying:-

1, at constant height.
2, at constant speed.
3, in a fixed direction

① occurs when lift equals weight.
② occurs when thrust equals drag
③, which is prevention of rotation, depends on how the four forces are disposed.

Ideally all four would work through one point, but C.P and C.G. move in flight (change of angle of attack or load). This forms a couple between L and W causing the nose to rise or fall. The usual arrangement is as indicated; a deliberate couple is arranged between L and W balanced by another couple T D.



Non lifting tail planes.

A tail plane is fitted to balance the forces under certain conditions. It must be symetrical so as to give no lift when forces are balanced and when nose tends to rise or fall due to movement of C.P. or C.G the airflow striking the tail plane will stop aircraft diving or trying to stall.

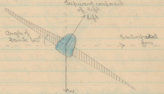
Lifting tail planes

Sometimes a permanent up or down load must be carried by the tail plane in flight e.g certain flying boats (inverted cambered aerofoil with positive rigging incidence)

Adjustable tail plane

Enables pilot to adjust fore and aft balance of aircraft in flight.

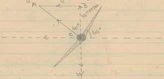
"Forces acting upon an aircraft in a turn"



Aircraft flying S and L is in equilibrium. Therefore when turning it is no longer in equilibrium. When flying S and L it is obeying Newton's 1 st. law and resisting any change of direction. Therefore an acceleration force known as centri~~fugal~~petal force must be applied towards centre of turn to make aircraft turn and this is done by banking. Wing loading increases on turn and stalling speed rises. Therefore open throttle to overcome loading and increase speed to make up for lift lost by banking.

<u>Question</u>

Aircraft is turning at 60° bank. What is the centripetal force and the load factor if the aircraft weighs 10,000 lbs?



Load factor = $\frac{AC}{BC}$ = 2

Centripetal force = AB = $10{,}000 \times \sqrt{3}$

<u>Motions of a turn</u>

Bank and rudder in required direction, ease stick back to make aircraft turn. When desired bank is reached hold off bank (faster outer wing gets more lift and tries to go on banking).

There is a correct degree of bank for every radius of turn, the quicker the turn, the steeper the bank, because the greater is the C.P.F. medium. Overbanking or under banking cause slipping in and skidding out

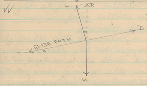
<u>Gliding turns</u>

Increase speed to overcome loading, then proceed as above, little or no need to hold off bank. Outer wing faster but inner wing steeper spiral downwards.

<u>Climbing turns</u>

Proceed as above but must hold off considerable bank (outer wing both faster and larger spiral upwards.

<u>Forces acting on an aircraft when gliding</u>

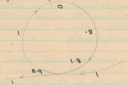


<u>The resultant of lift and drag will always be opposed to weight</u>

modern aircraft have flatter glide paths than older types <u>because better design gives better $\frac{L}{D}$ ratio</u>

Flaps
When lowered, camber is increased therefore lift and drag also. Pull them down for landing, not more than half down for take off (most lift for least drag)
Steeper glide path, lower landing speed, act as air brakes on landing run, enable fast aircraft with flat glides to land on aerodromes with obstruction on boundary which otherwise they could not use
Spinning
A form of autorotation due to applying rudder at the stall. Movement occurs in all three planes around the spinning axis with one wing partially stalled trying to fly around the other stalled wing
Axes and planes of reference
Normal axis is a straight line through C.G. at right angles to the other two axes When straight and level it is vertical, rotation around it is in the yawing plane controlled by rudder. Longitudenal axis (rolling plane) and lateral axis (looping or pitching plane)

Loading during a Loop



Trimming tabs

1. Fixed tab consists of a strip of metal fixed to the trailing edge of the main control surface which can only be adjusted by hand on the ground. It is used to correct slight rigging faults
2. Controllable type. Controllable in flight by the pilot from the cockpit to: a) assist

in manoeuvre b, assist in take-off c, give trim for hands and feet off control when fitted to all control surfaces. d, it obviates the necessity of fitting an adjustable tail plane.

3. Automatic or balance tab is a form of aerodynamic balance and is fitted in such a way that when the main control surface moves the tab moves in the opposite direction

4. Combination of 2 and 3.

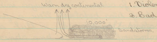
Rudder bias sometimes used instead of or in conjunction with rudder trimming tabs. It is a spring loading of the rudder bar, controllable by the pilot to:- a, overcome effect of slipstream b, Reduce yaw with one engine c, Give trim for straight flight, feet off.

Hail is more dangerous on its upward journey. If the lightning is in the cloud itself it is known as sheet lightning but if it occurs between a cloud and the ground or between two seperate clouds it is called fork lightning

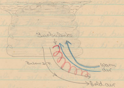
Flying through a cold front

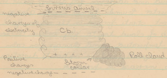
Freezing level in the cold sector is lower ~~in~~ than in the warm sector. Muggy weather, strati formed cloud and advection fog always occur in the warm sector. Cumuli formed clouds always in the cold front, strati formed in the warm front. Heavy bank of cloud, try to fly between the clouds. Decrease of temperature, wind changes from calm breezes to squall wind in opposite direction. Wind veers, increase in pressure.

Desert sandstorm



1. Violent turbulence
2. Bad visibility

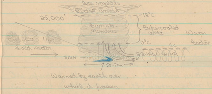


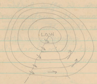


Hazards encountered in a cold front

1. Violent turbulence
2. Ice accretion
3. Hail
4. Lightning and thunder
5. Heavy rain
6. Bad visibility

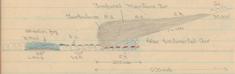
Cold Front



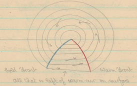


Line squall

A line squall is a series of thunderstorms along a well developed cold front, when there is a lull in the upward currents cold air descends and is pushed forward giving a line squall.

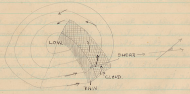


The base of the Sc. is often higher than that of the N.S. This is because the surface over which the Sc. forms is warmer than the cold air over which the N.S. forms. If on entering a warm front and icing is encountered, turn back, climb and use de-icing equipment



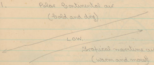
The speed of the depression is the same as the direction and speed of the wind in the warm sector. When the cold front catches up to the warm front the result is an occlusion.

Warm front

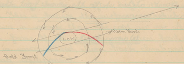


Air masses, depressions and fronts.

1.



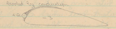
2. N. Hemisphere



The cold air being denser than the warm, the friction caused is greater and thus the cold air movement is slower than the warm. Warm air over-rides the cold air on the warm front and cold air forces its way underneath the warm air thus causing the warm air to rise giving the cold front. The stronger the depression the faster it moves.

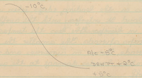
Glazed frost icing.

Forms in falling rain which comes into air below freezing point. As it hits the aircraft it spreads out and is frozen. The larger the drops the worse the accretion

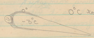


Sublimation

When an aircraft, descending rapidly from a height where temp. is say $-10°c$, comes into air of temp. above F.P. ice will form on the aircraft. This is due to the air in contact with the cold surfaces of the aircraft being cooled below its dew point and F.P. thus causing the water droplets produced to freeze.



Transparent or translucent



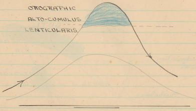
0°C to -4°C

Water droplet hits wing. Part of it freezes. In doing so gives out latent heat which causes the water to spread out over the wing. The water, being warmer than the wing, heat will flow from it to the wing thus reducing the water below freezing point. The ice builds up rapidly and freezes up moving parts. Occurs in low layers of cloud.

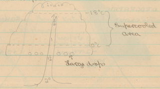
Rime icing

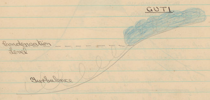
-8°C to -15°C.

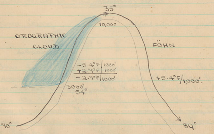
This forms on the leading edges when in the higher layers of cloud. It interferes with the airflow but breaks off in lumps. The less the temperature the less the drops spreads. The smaller the drop the less it spreads. Forms on airscrews and may thus cause vibration besides damage to the airframe when it breaks off

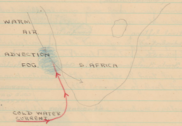


Ice accretion

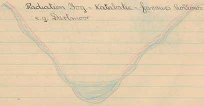


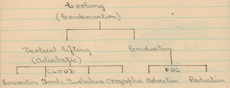


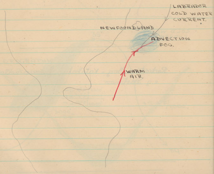




Radiation Fog - Katabatic - favours hollows
e.g. Dartmoor







S. F. T. S.

Heat will always flow from a substance with a higher temp. to a substance with a lower temp

Radiation is the transfer of heat from one body to another without heating the medium thro' which it passes.
Conduction is the transfer of heat by contact
Convection is the transfer of heat bodily

Humidity refers to the moisture content of the atmosphere
Specific Humidity is the actual amount of water vapour measured in gms/per Kgm.
Relative Humidity is the ratio of the actual amount to the total amount required to saturate the air at that temperature expressed as a %.
Dew point is the temp. to which air must be cooled in order to become saturated

Cold Front

The following changes are experienced:-

a, Large Cu. or Cb. Heavy rain.
b, Decrease in temperature
c, Veering wind
d, Followed by fair weather and good visibility

Polar Air Mass.

a, Is unstable if it moves into warmer regions. Produced by the heating from below.
b, It will thus give Cb, thundershowers and a fair amount of rain
c, Good visibility owing to particles being carried up by the vertical currents

Tropical Air Mass

a, Is stable if it moves into colder regions
b, Will give low cloud if it moves into colder regions, and drizzle if its lower layers are cooled below dew point
c, Poor visibility due to particles being kept in lower layers (No convection currents).

Warm Front

With the passage of a warm front the following weather changes are experienced:-

a, Continuous precipitation
b, Increase in temperature
c, Veering wind
d, Fog and low cloud or fair weather later
e, Usually followed by poor visibility

	TROPICAL		POLAR.	
	CONTINENTAL	MARITIME	CONTINENTAL	MARITIME
Temp.	High	High	Low	Low
Humidity	Low	High	Low	High
Pressure	Low	Low	High	High
Weather	Fair	Overcast. Fog Muggy.	Fair	Showers Thunder. B.I.
Cloud	Fair Cu.	St. and Sc.	Fair Cu.	Cu. Cb.
Visibility	Hazy	Poor	Good	Good
	STABLE		UNSTABLE	

Weather Observations

1) Surface observations made at each hour (and also when sudden changes occur) at met. offices and other places such as lighthouses, observer corps posts, etc. in the U.K.
2) Observations called plobs, made by aircraft crews during flight and handed in on landing.
3. Observations made by a number of special met. flights (temperatures, wet and dry-bulb at various pressure levels).
4, Observations of upper winds.
5, Observations from Allied and some neutral countries

Stable Air

It is air that having been forced to rise, will only rise to a limited height and will then stop or tend to return to its original position. Results in fair weather with little or no cloud.

Unstable Air

It is air that having once started to rise will continue rising indefinitely. Produces large masses of cloud with thunderstorms and rain.

Stable

Rising Air		Upper Air Temp
	65	
	66	
	64	
65	68	
40	69	
45	40.	

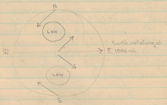
Unstable

Rising Air		Upper Air Temp
55	54	
60	58	
65	62	
40	66	
45	40	

Duties of the Met. Officer

1/ To make met. observations
2/ To supply routine weather forecasts and warnings
3/ To provide weather forecasts for all intended flights
4/ To describe weather, past, present and future, accurately and promptly.

It is not the duty of the met. officer to pronounce upon the suitability of the weather for flying. This is done by the C.D. officer authorising flights after consultation with met. officers.



REAR OF FORM 2330
(Observations by crew of aircraft).

TIME	POSITION	1014 MB. ALT. HT.	TEMP	DOWN VIS.	CLOUD TYPE AND AMOUNT BELOW	ABOVE	HT. OF BASE OR TOP OF CLOUD	WIND	WEATHER
0630	54°N 03°W	8000'	-1°C	MODERATE.	3/10 Cu.	4/10 Ac.	BASE Cu 4000'	280°/20	Cb. to E

Form 2330

This is a route forecast and not a weather report. It is issued as a matter of routine on all operational flights and route forecasts should be obtained for any flight over 100 miles (AMOS). Ample warning should always be given to the met. office if route forecasts are required stating route, time of take-off, and duration of flight. Heights are all A.M.S.L. Observations are made by crew during flight therefore these forms should be returned immediately on landing as they are used for plotting on a synoptic charts called Plobs.

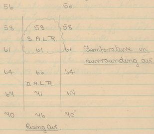
Form 2331 Index to code figures.

__Dry Adiabatic Lapse Rate__ equals 5.4°F per 1,000ft

__Saturated Adiabatic Lapse Rate__ equals 2.7°F per 1,000ft

__Lapse Rate__

The pressure decreases with height in the atmosphere at a constant rate. If air is forced to rise, it enters an area of reduced pressure and expands which uses up energy. This energy is in the form of heat, so that rising air will lose this heat (adiabatic condition) and a drop in temperature will therefore take place



__Types of weather information available at Met. offices__

1. __Route Forecasts__
Available at any time on demand (notice should be given). Issued on Form 2330

2. __Local forecasts__
Issued as a matter of routine, say three times a day, and only apply to a radius of 20 miles around the station. Used as a guide for local flying

3. Gale warnings
4. Squall and thunderstorm warnings. Movement and developement of storms are watched and a warning given of the arrival at a certain place
5. Frost and fog warnings
6. Barometric pressures
7. Warnings of sudden deteriorations or changes in the weather to a/c in flight
8. Time of sunrise and sunset.

Form 2330

STAGE	Outward and Homeward	Target	Base on return
SURFACE WIND			N'ly 10/15 MPH
2,000'	300°/11 M.P.H		
4,000'	240°/15 MPH		
6,000'	250°/30 MPH		
WEATHER	Mainly fair except for isolated showers	Fair	Fair
VISIBILITY	Good except in showers	Hazy	Good
CLOUD	5 - 7/10 Cu. at 4,000' 6 - 8/10 Cb. in showers	4/10 Cu. at 4,000'	7/10 Cu + Sc. at 4,000'
ICING INDEX	High in Cb. above 10,000'		
FREEZING LEVEL	8,000'		
PRESS. AT STATION LEVEL	7		1,011 m.b. little change
PRESSURE AT M.S.L			1,014 m.b. little change

REMARKS. Condensation trails likely about 10,000'
Heavy swell on sea

Types of Met. stations

Type 1. Attached to group or command H.Q. and does all administration. Constructs synoptic charts and issues general forecasts at any time. Acts as receiving centre for collection of reports (e.g. Salisbury)

Type 2.
Situated where information required cannot be met by type 3 or 4 i.e. large bomber stations. Constructs synopic charts and issue independant forecasts. They brief, issue form 2330, and observe (e.g. Bulawayo)

Type 3.
Constructs synoptic charts but receive forecasts and brief and issue form 2330 to aircrew. Situated at bomber stations (e.g Kumalo or Thornhill)

Type 4.
Simply act as a link between some met. office and aircrews. Do not construct charts but observe (e.g. Induna). Found mostly at fighter stations

cloud altostratus Form 2330

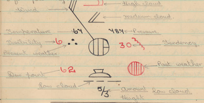
Aviation weather report. 4th Apl 43

An aviation weather report consists of the first three groups of the international code. All observations are visual, and thus it is simply a statement of the actual weather at a certain place at a certain time.

111 $C_L C_M$. WWVhNh. DDFWN.

These observations are made at regular intervals at all reporting stations. They are transmitted by the quickest method to a collecting centre where they are used for making route forcasts and for platting on a synaptic chart.

Pressure and temp. are reduced to a common level before platting.



Effects of air change of density on an A/c.

To summarize in general terms, at low levels (where air is dense), lift is high, air screw slip is less, engines are more powerful and airspeed indicators read correctly. Conversely, at high levels (where air is rarified) lift is lower (hence an aircraft finally reaches its ceiling) engines are less powerful, (hence the introduction of superchargers to compensate) and airspeed indicators read low. Decreased air density at mountain aerodromes greatly increases take-off and landing runs.

Weather Reports

Bulaways – Large cumulus or cumulonimbus cloud and thick altostratus or nimbostratus. Heavy thunderstorms with rain or snow. Vis. between 500 and 1000 metres. Base of low cloud 200 - 300 metres high about 7/10 of sky covered by it. S E wind fresh breeze. There has been showers and sky is overcast.

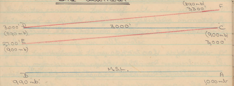
Lusaka, sky is cloudless visibility up to 12½ miles. No cloud below 8,000'. Calm and fine

Salisbury. Fair weather cumulus with ~~m~~ medium

Information put on weather maps

1. Atmospheric pressure reduced to M.S.L.
2. Barometric tendency (change in pressure in the last three hours)
3. Temperature
4. Humidity (usually dew point)
5. Visibility
6. Clouds (type, amount of low cloud, height of base, total amount of cloud)
7. Weather (present and past)
8. Surface wind in direction and force.

The altimeter



N.B. Pressures in brackets have been calculated by means of the 30'/mb rule and are therefore only approximate

N. Hemisphere
Port wind (Starboard drift) altimeter over-reads
Starboard " Port drift " under-reads
S. Hemisphere Vice Versa

30 mph wind on beam altimeter will be in error by 1 ft. for every mile flown

If actual mean temp. of air column is above the low value for the mean temp. then altimeter will under-read.

Visibility

Visibility is the furthest distance at which objects are clearly recognisable in a horizontal direction by a ground observer with the naked eye

If visibility is 1100 - 2200 yds it is called mist or haze
" " " less than 1100 yds . . . " fog
" " " less than 550 yds it may be dust storm

It is measured at night by using a light of specified candle power and viewing it through smoke glasses of different shades. Each of these shades represents a certain visibility at night

Relative humidity is the ratio of the amount of water vapour present in a given volume to the amount which that volume could contain if it were saturated, expressed as a %

Measuring the height of clouds

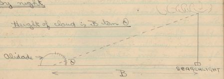
By day.

a) Using a pilot balloon, the time is noted of the time the balloon takes to disappear.
b) By means of an altimeter
c) By judgement from practical experience.
d) By comparison with hills or mountains, the heights of which are known beforehand.

At night a Chinese Lantern may be fixed to a pilot balloon but this method is seldom used. The most common method used for finding height of cloud at night is by having a searchlight placed a definite distance from the met. office. It is pointing vertical and the angle from the met. office and where the searchlight hits the cloud by means of an alidade.

By night

Height of cloud is B tan θ



Cumulus at Sea

It is formed by cold air passing over a warmer sea surface. Well out to sea there is no diurnal variation. Near to land it tends to form in the early morning but as soon as the land gets warmer it is dispersed.

Condensation trails

The condensation of engine exhaust water vapour sometimes causes trails behind aircraft flying in clear air. They may be faint and invisible from any great distance; on the other hand they may be long white streaks betraying aircraft position and lasting and spreading out for twenty minutes or more. Finally they may look more like cirro-cumulus, alto cumulus or cirrus cloud.

Dense trails rarely form under about 28,000' in summer and 22,000' in winter. They always cease on, or shortly after entering the stratosphere. Dense trails may therefore be avoided by stratosphere flying. Otherwise the pilot should seek drier air, usually found just above a cloud layer. If cirrus or any other high cloud is about beware of the trails.

Operational use of clouds.

1, Direct use

i.e. for tactical purposes.

e.g. for cover in attack

for cover for evasion

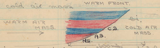
Important points

1, Degree of continuity
2, Height of base
3, Vertical thickness
4, Visibility
5, Bumpiness
6, Icing.

2, Indirect use

Clouds often give good indication of weather to be expected in the near future or in certain directions.

A frequent sequence of clouds is as follows. Cirrus – Cirrostratus – Altostratus – Nimbostratus. It is caused by a warm air mass passing over a cold air mass.



If in NS. the air above is just above F.P. and below it is just below F.P. glazed icing may occur

name	Cirrus (Ci)	Cirrostratus Cs.	Cc Cirrocumulus	Ac Altocumulus	As. Altostratus
Description	Fibrous, delicate, white wisps or tufts against blue sky. Ice crystals	Thin whitish veil, not blurring outline of sun or moon Produce halos, ice crystals	Layer of tiny white flakes or globular masses in line or waves resembling ripples	Layer of fairly small globular masses in lines or waves. Edges sometimes joined	Greyish veil usually covers sky blurs sun or moon. Does not produce halos
Ht of base	20.-30,000'.	20 - 30,000'	20 - 25,000 ft	7 - 20,000 ft	" 7 - 20,000 ft "
Vertical thickness	Thin.	Thin.	Thin	Thin	" Up to 10-15,000 ft.
Visibility	Very good.	Very good	Very good	Good	Thin 100 - 1,000 yds Thick 20 - 100 yds
Bumpiness	smooth.	smooth	smooth	smooth	Fairly smooth
Precipitation	nil.	nil	nil	nil	occasionally light rain
Ice accretion	nil.	nil	nil	Unlikely and harmless	may occur but not likely to be serious
Suitability for single A/c flying	no danger	No danger.	no danger.	No danger	Suitable
Suitability for formation flying	no danger.	no danger.	No danger.	no danger	Usually suitable
Direct operational Value.	NIL. Too high and too thin	NIL Too high and too thin	NIL Too high and too thin	LITTE Lacks continuity. Can be used for quick change of direction only for evasion.	very great. very good cover good for evasion (best cloud of all).
Indirect ops. Value.	Often indicates detoriating weather. Indicate	Indicates detoriating weather liability to	Indicates warm front Condensation Trails	Generally little.	Indicates approach of warm front.
additional notes			Very rare often confused with A.C.	C.c and A.c sometimes produce mackerel sky	

Nimbostratus N.S.	Stratocumulus S.c.	Stratus St.	Cumulus Cu.	Cumulonimbus Cb.	Description Name
Uniform dark grey layer covering whole sky usual with F.S. beneath.	Layer of fairly large globular masses or rolls in lines or waves often joining together	Uniform formless layer resembling fog. Very low base enveloping low hills	Detached heaps with flat base & rounded top often considerable vertical development.	Heavy towering masses with fibrous cauliflower like tops of spreading out like an anvil.	Description
1, -4,000' or lower.	2 - 4,000'.	Less than 1,000'	2 - 3,000' ft.	3,000 ft or lower	Ht of base
10, -15000' or more	500' - 3,000'	500' - 2000'	up to 8,000' or more.	15,000 - 30,000'	Vertical thickness
Bad often less than 10 yds	10-30 yds usually 15-20.	usually less than 20 yds Poor but variable.	Poor often less than 10 yds	Bad often less 10 yds	Visibility
Bad often severe	Fairly smooth	Sometimes gusty	Bad often severe.	Violent	Bumpiness
Rain, sleet, snow often heavy (continuous)	Sometimes fine drizzle	Sometimes drizzle	no precipitation	Rain, hail, snow, sleet. heavy	Precipitation
may be fairly heavy (0 - -7°C) Sometimes glazed frost beneath	may occur but not usually heavy (0°C - -7°C)	only in winter not heavy (0°C - -7°C).	may be heavy and rapid (0°C - -15°C).	may be very heavy and rapid (0°C - -15°C)	Ice accretion
Practical only if adequate height is maintained	Practical	Dangerous.	Practical	Dangerous.	Suitabily for single A/c flying
Totally impracticable	Practical for small A/c but only if no Cu. or Cb is present.	Impracticable	Totally impractical	Totally impractical	Suitability for formation flying.
Good cover but dangerous	Great, good cover and good for evasion.	Can fly above it only. screened from surface. more use over sea	Lacks continuity but good for evasion	Dangerous but good for evasion in necessity	Direct operational Value
Part of warm front cloud sequence	Little	Little	Have certain indirect value associated with their diurnal variation.		Indirect operational Value.
Flying beneath N.s is danger, owing to bad visibility and F.S. enveloping hills	Above Sc layer flying is very smooth. Air may be warmer & dryer. wind may be different in direction & strength	Indistinguishable from fog from above.		Lightning is likely in Cb. Aerials must be wound in and earth. A/c must be bonded (all parts in contact. Compasses? mag. error?)	Additional notes.

on below N.S. May form over hills. Great vertical extent. Visibility is bad. Bumpiness occurs and may be severe. Rain occurs and may be heavy. Snow occurs. It is quite likely there may be ice accretion, may be thick. Flying is bad beneath N.S. Danger of hills. Very dangerous cloud for flying.

Stratus

Continuous layer, covers whole sky, not very thick, very low base, and ragged. Varies in height from 0 - 1,000 ft. Almost same as fog. Flying in it is very risky indeed. Does not produce rain. Icing not common but when it does occur is very light not bumpy.

Stratocumulus

Between 2000 - 4000 ft. A layer of fairly large globlets or ~~line~~ rolls sometimes forming lines or waves. Layer may be from 500 - 3,000 ft thick. Visibility variable, usually 15 - 20 yds. Fair to moderate as a rule. not rain producing. Fairly smooth flying conditions. Above clouds it is very smooth. Icing is common but not likely to become serious. Only dangerous when temp 0° - -4°C. Wind & direction above cloud may be different than below.

Cumulus, cumulo always signify heap cloud.
Nimbus, nimbo .. .. rain producing
Fracto cumulus or fractostratus .. broken.

Flying conditions in clouds.

Danger zone for icing in layer cloud is from 0°C to -4°C.

Cirrus, cirrocumulus, and cirrostratus are ideal for flying but afford no cover from hostile aircraft.

Altocumulus

Icing unlikely. If it does occur it will not be very dangerous as droplets are very small and scattered. Good visibility. No bumpiness. no precipitation

Altostratus.

Generally covers whole sky. ~~Blu~~ greyish. (C.S. does not blur outlines of sun or moon). Variable in thickness. May blur or cut out sun or moon. Visibility is fair, good in thin cloud. Fairly smooth flying. May produce light rain but not usual. Icing may occur but is not serious

Nimbostratus

Uniform dark layer. Low in sky. Rain & snow producing. Ragged misty low cloud may join

Ice accretion or Icing

① Super-cooled water droplet Icing
- occurs in clouds in which temp. is below F.P.
- due to disturbance of super-cooled drops by aircraft. Then freezes on leading edge etc immed. Commonest type but not as dangerous as ②

② Glazed frost Icing
- occurs in air below F.P. into which rain is falling from cloud above in which temps. are above F.P.
- occurs all over aircraft forming transparent sheet. Very dangerous.

CLOUDS.

FAMILY	AV. HEIGHT OF BASE	CLASS.	
High	20,000 - 40,000	Cirrus Cirrostratus Cirrocumulus	C C.S. C.C.
Medium	7,000 - 20,000	Altocumulus Altostratus	Ac A.S.
Low	Ground - 7,000.	Nimbostratus Stratocumulus Stratus	Ns Sc St
Great Vertical	1,500 - 7,000	Cumulus	Cu.
Extent		Cumulonimbus	Cb.

Cirrus and Cirro always signifies high cloud
Alto " " " " medium "
Any other prefix " " base below 7,000'
Stratus & Strato " " layer cloud.

Dispersal Change in wind.

Characteristics
① Forms by day or night
② " " over land or sea
③ May form in strong winds
④ " " " under cloudy skies
⑤ Does not favour hollows
⑥ Not nearly so localised as night cooling fog

RAIN.

Heap form cloud never produces rain unless it is over 10,000 ft.
Layer clouds can produce rain from 7,000 ft but it will be very light.
Drizzle floats down. It is not rain but small droplets. Can come from clouds of 3,000 ft. if upcurrents are very weak.
Precipitation rain, drizzle snow or hail.
Cloud-burst caused by sudden cessation of upwards currents.
There is no maximum size of hailstorm
" " a " " " rain-drops.

Clouds

(1) Heap-Form (2) Layer.

Layer not so thick. Rain not as heavy as from H. F. Weather not so changeable but rain lasts longer.

Heap-Form. Thunder and heavy storms may occur.

Fog

Produced by cooling of air by contact with cold surface.

Night-cooling fog (Radiation)

(1) Formation (a) Clear sky. Cloud will reflect back earths heat and prevent cooling sufficiently (b) Moist atmosphere (c) Light wind (slight turbulence).

(2) Dispersal (a) by heating by sunshine in morning – not always strong enough in winter (b) Rise in wind force.

(3) Characteristics (a) Forms at night only (b) Forms over land only (c) Tends to form in hollows and valleys. (d) Tends to form over moist ground. (e) Patchy or localised.

Movement Fogs (Sea) Advection

Produced by movement of warm moist air over a cold surface.

Conversely if the pressure is rising the altimeter will underread.

Suppose the pilot keeps the altimeter steady at 3,000 ft. If pressure is dropping his altimeter will be steadily overreading more and more and so he will be descending. If pressure is rising he will be ascending. In both cases his altimeter tells him that his height is unaltered.

Sequence of events in formation of cloud

(1) Something occurs to make air rise

(2) Rising air comes under reduce atmospher pres

(3) It therefore expands.

(4) And hence cools.

(5) If it rises far enough it will eventually cool to its dew point temperature and so become saturated (N.B. definition)

(6) Any further rise will cool it below its dew point and some water vapour will have to condense out as minute droplets of liquid water which are cloud.

Warm air passing over cool air gives fog

Cool " " " warm " " convection cloud currents

Altimeter Pressure Errors.

If we know accurately the relationship between pressure and height we can take an aneroid barometer and graduate the dial to read height and pressure. This instrument will then always record drop in pressure as increase of height and rise in pressure as decrease in height.
Height is not the only factor which affects atmospheric pressure. In any particular place pressure may vary from hour to hour. Also pressures at places at the same level may vary across the country (horizontal variation). These horizontal variations are very small compared with those in rising the same distance vertically but nevertheless they are often big enough to affect the altimeter.
Imagine an aircraft flying level at 3,000'. If the atmospheric pressure is dropping the altimeter will register a change since it is really an aneroid barometer. Drop in pressure is usually associated with increase of height and so the altimeter shows a reading of more than 3,000 ft. although the aircraft is still at the same level i.e. it overreads.

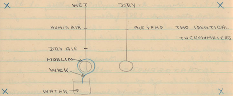
their origin to unequal heating at the equator and the poles

STRATOSPHERE — Temperature remains constant with height

TROPOSPHERE — 4 miles — Temperature normally decreases with height, or an average at the rate of 1·6°c (3°F)/1,000'

Rate of decrease of temp. with height is called LAPSE RATE

Layer in Stratosphere in which temperature increases with height is called INVERSION



Cloud. For cloud to form air must be lifted sufficiently to cool below its "dew point". Cloud consists of visible drops of water plus industrial particles. When air is lifted and unsaturated it cools rapidly (5.4°F per 1000ft) due to the decreasing pressure allowing it to expand.

Clouds may be formed in three ways (1) Mechanical lifting e.g. due to a range of mountains in a path of moving air. (2) Thermal lifting due to unequal heating of the earth's surface causing convection currents (3). Frontal lifting due to the meeting of a warm air mass and a cold air mass. In the first place these air masses are

Formation of cloud and fog.

Humidity At a given temperature a given volume of air can only hold a limited weight of invisible water vapour. When it holds this limited amount it is said to be saturated and at that temp. it can hold no more. The higher the temp. the greater the weight of water vapour necessary to saturate a given volume of air. We define the amount of water vapour present in air as the relative humidity which we may state as

$$\frac{\text{weight of water vapour present at first}}{\text{weight of water vapour required for saturation}}$$

This is usually expressed as a %. e.g. if a cubic foot of air contains 1 gm. of water vapour and is saturated when 0.25 gm of water vapour are added then $R.H = \frac{1}{1.25} = 80\%$.

If an unsaturated mass of air be cooled it must eventually reach a temperature at which it is saturated and visible drops of water condense out. This temperature is known as THE DEW POINT. Both "relative humidity" and "dew point" are measured by an instrument called the wet and dry bulb thermometer

WIND.

Land is warmer than sea in daytime, colder at night
" " " " " summer, " in winter.
Surface wind is measured at 30' above ground:
Upper wind " " above 30'. Height at which it is measured must be specified A.M.S.L.
Surface winds are given direction by 16 points of compass. Upper winds in ° from true north. North is never 000° but 360° as 000° is no wind.
Speed of wind is always indicated in m.p.h. in met. Surface winds can be measured by force but upper winds are always measured in m.p.h.
The Beaufort scale is used for measuring wind force.

GUSTY WIND: One which varies rapidly in speed and direction. The figures given are averages. Eddys are caused by friction on the earths surface such as trees, houses, hills etc. In the upper layers this is called TURBULENCE. With aircraft a gusty wind may cause varying lift which may cause "bumps".

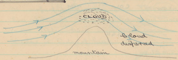
The higher the dew point the moister the atmosphere
" lower " " " " dryer " .

Temperature °F	-60	-40	-20	0	20	40	60	80	100
Gms of water vap.	·02	·1	·5	1	3	4	14	25	43

in saturated air of
1 cubic metre

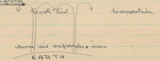
Expansion always results in drop in temperature
Compression " " " rise " .
Air cools at 5·4°F per 1,000 ft.

Mechanical lifting



Mountain mist or fog is the same as cloud.

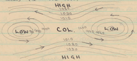
Thermal lifting



The air cools as it rises and when it reaches dew pt. cloud forms.
Cloud forms in morning, maximum at 14·00hs dispersed at night

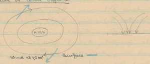
system. weather fine as in anti-cyclone. Difference fine weather rather brief (twelve to 24 hours) due to proximity of low pressures.

Col no isobars, so no wind or light and variable winds. In winter - fog In summer thunderstorms It moves with the low or disappears so weather only lasts 12 - 24 hrs.



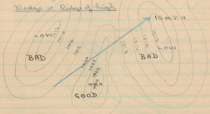
Good weather systems

High pressure or anti-cyclone



Wind at 1,500 ft given by the isobars - clockwise. At surface wind away from the centre still towards low pressure. Have descending air currents in the centre. Often have inversion ascent.

Wedge or Ridge of high

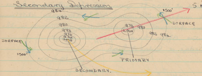


no pointed isobars no front associated with this

A. Deep Depression. Very low pressure in the centre (960 - 970 millibars).
B. Intense Depression Very strong winds (close isobars)
C. Shallow Depression Light winds (isobars far apart)

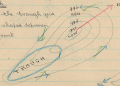
All depressions have much cloud and precipitation the majority travel S.W. to N.E. but can come from any direction and at any speed usually about 20 M.P.H.

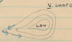
Secondary Depression



A Trough.

The centre and the trough give bad weather. V shaped depression caused by a front





Pressure Distribution

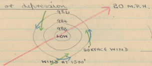
Isobars are lines on a met. map joining places of equal sea level pressure.

Winds blow along the direction of the isobars at 1,500 feet according to Buys Ballots Law. This states that if you stand with your back to the wind in the N. Hemisphere the low pressure system is on your left.

The speed of the wind is proportional to the pressure gradient. The geostrophic scale measuring the distance between the isobars gives the speed of the wind. This scale is really a ruler.

Bad weather systems

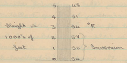
Low or depression



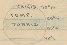
Wind at 1500 ft along the isobars in an anti-clockwise direction. Surface wind due to friction at 30° towards centre of low and strength about ·6 of the wind at 1500 ft.

and have now reached the stratosphere where the temperature remains constant.

Inversion



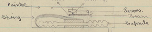
When temperature increases with height. Often occurs on still clear nights when the land cools and so cools the lower layers of air. Cold air does not rise. The earth is considered as being built up of five zones - Torrid, N. and S. Temperate. N. and S. Frigid



Density a decrease in pressure means a decrease in density. A decrease in temperature means an increase in density but only when the pressure is kept constant. Actually the decrease in density due to change of pressure overpowers the increase due to temperature change. Therefore an increase in altitude means decrease in pressure, temperature and density

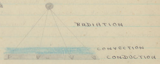
equal one millibar and 20,000 ft. Pressure varies horizontally, places at sea-level having differing pressures at different times

Mercury Barometer



Aneroid Barometer and altimeter

Temperature



① Heat transferred by radiation to the ground
② Ground transfers heat to the air next to it by conduction
③ Warm air rising causes convection currents.

Temperature decreases with height, the normal lapse rate equals 3°F. per 1,000 feet. At about seven miles the lapse rate ceases. This is the end of the troposphere.

Meteorology

It is studied because ① it increases air crew efficiency and safety ② it enables air crew to understand the medium in which they work ③ it enables air crew to discuss weather information with the met. officer ④ It enables air crew to bring back useful weather information.

Atmosphere

This consists of ① gases, oxygen, nitrogen and water vapour. ② liquid - water ③ solids - water, dust, smoke

Pressure

The air exerts a pressure depending upon the column of air above it (compare head of water). This pressure is measured by a mercury barometer or an aneroid barometer. In the mercury barometer the air pressure is balanced against a column of mercury (about thirty inches at sea-level). In the aneroid barometer the pressure is balanced against the elasticity of the lid of a hermetically sealed, partly exhausted box or capsule. Aircraft altimeters are aneroid barometers calibrated in feet instead of millibars. Pressure varies with height thirty feet being equivalent to one millibar. This is an average reading for medium heights, sixty feet