Pilot's WEATHER

– a commonsense approach to meteorology

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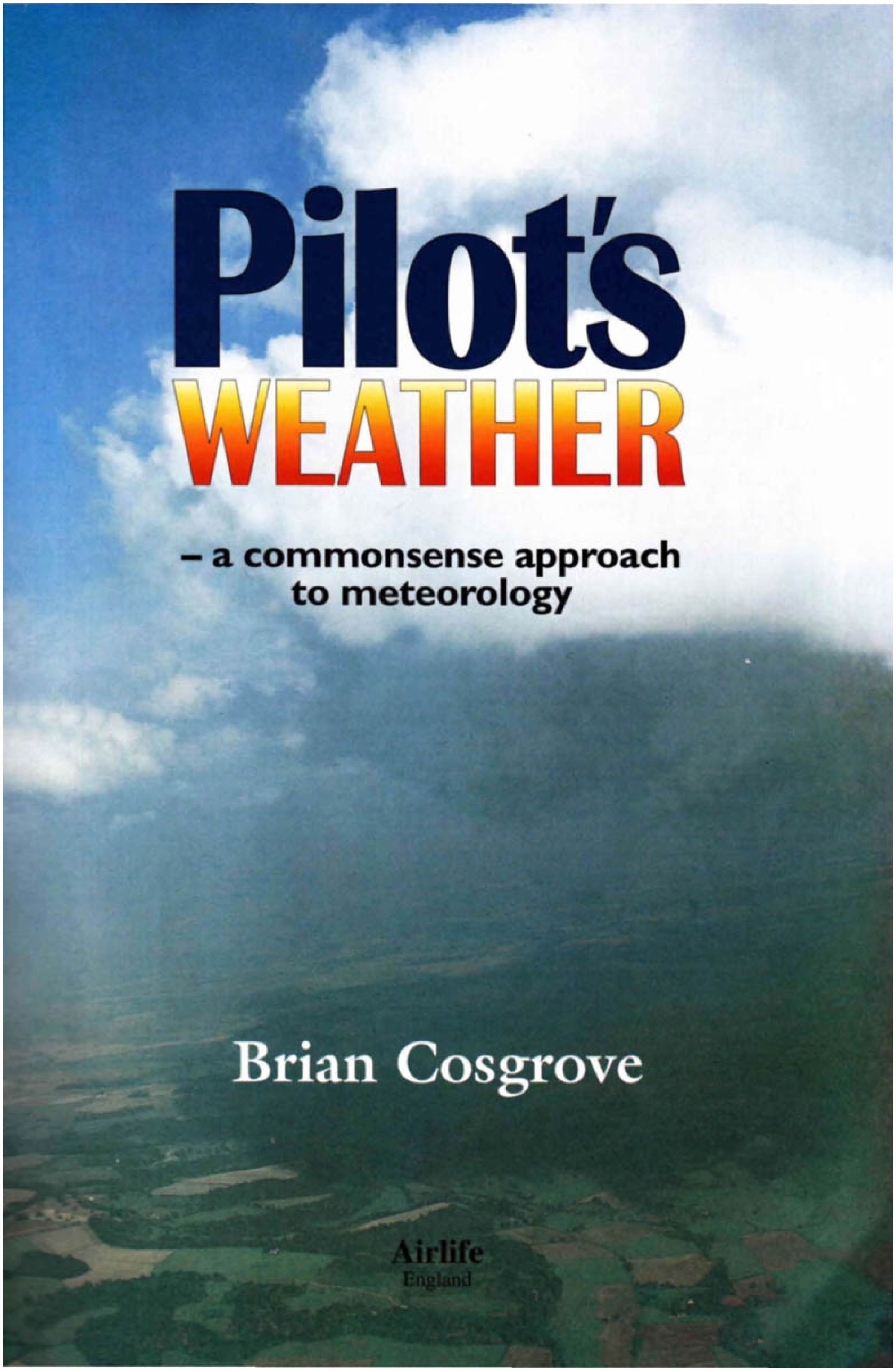
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– a commonsense approach
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Dedication

To John Bannister, Julian Doswell and Peter Coles – a truly patient trio.

Contents

Introduction

Pilot's Weather aims to provide the meteorological 'know-how' needed by you as a student pilot – and just maybe some existing pilots! It will be relevant whether your aircraft is a light aeroplane, sailplane, hang/para glider, ultralight, microlight, powered parachute or whatever.

Simplicity is the intention as far as possible; achieved through adopting a logical progression of the events to be absorbed and using numerous pictures of the clouds and weather patterns you will come across.

Past experience has shown that even at basic level there are a few whose curiosity likes to go that little bit deeper at the outset. Where such occasions arise, the text will be found in italics placed in a pink tinted box and can be ignored if your only wish is to learn the basics.

Should the day come when you want to extend your pilot status up to commercial or airline standard, or you wish to become a highly skilled sailplane pilot achieving a Gold C with diamonds, there are plenty of other books available to take you that stage further. In the meantime *Pilot's Weather* will ensure you at least have a basic rock upon which to build the advanced knowledge that any future aspirations may demand.

Meteorological terminology and units of measurement are steadily becoming uniform internationally, but currently in the USA there are differences. For students resident or visiting the United States to learn to fly, every effort has been made to identify the major differences in terminology and procedures. Also, since the 1st January 1996 changes have been taking place – particularly in the reporting of weather – to become more in line with the international approach. To cover this transient period, terms will be duplicated in this book where necessary.

Apart from the basic principles of meteorology, the book highlights the weather problems with which you can be faced during your flying life – it is *not* simply confined to your passing an examination.

You may become very competent in other aspects of flight, *BUT* – can any of them be more crucial than a sound familiarity with the environment through which you are prepared to fly yourself and your passengers? When putting your knowledge of met into practice always err on the safe side and use the information available to you in the form of current reports and forecasts by phone, fax, radio or computer.

It is better to be on the ground wishing
you were in the air than in the air
wishing you were on the ground!

Brian Cosgrove

CHAPTER ONE

THE ATMOSPHERE

Quite simply the atmosphere is the air surrounding our planet Earth – mercifully kept in place by the force of gravity.

It is primarily composed of 78% nitrogen, 1% of other gases and, fortunately, 21% oxygen for which we should be truly grateful. Apart from life as we know it being unable to survive without oxygen, combustion would not be possible for engines to function.

As the force of gravity is greater nearest to its source, so the atmosphere is more concentrated near our planet's surface.

There are four basic factors that affect the weather and flight.

They are:

DENSITY	– the weight of a given volume of air.
PRESSURE	– the weight of a given column of air in the atmosphere.
TEMPERATURE	– the warmth of the atmosphere.
HUMIDITY	– the moisture content of the atmosphere.

For occasions when uniformity or a working standard is required, the **International Civil Aviation Organisation (ICAO)** has agreed on an **International Standard Atmosphere (ISA)**. This lays down standards for density, pressure and temperature based on a defined sea level — more on this later.

You must remember that these standards are but a ‘yardstick’ and they are purely theoretical. Rarely would the conditions in the atmosphere ever coincide with the standards all at the same time.

How these ISA standards play a part in aviation will be made clear as we progress.

CHAPTER TWO

DENSITY

Air has weight, and **density** is simply the weight of the number of molecules of air present in a given **‘parcel’** or volume of air at a given time. (The word parcel is frequently used in meteorology as no one has yet thought of a better alternative!)

Density is greatest at the surface; it decreases with height as the air thins out **until** in outer space it is no longer relevant.

Apart from a decrease with height, density is also affected by warmth. When a parcel of air of a given volume is heated it becomes thinner as the molecules spread out and their number becomes less than in the original parcel.

Conversely, when a volume of air is cooled it becomes denser.

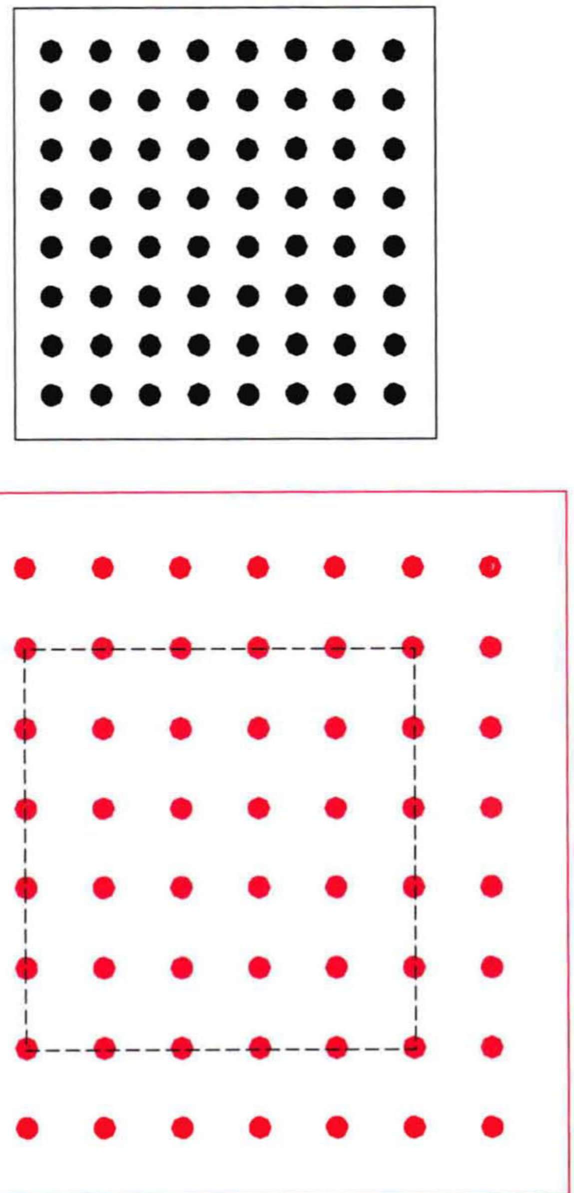
Density also decreases as the moisture content in the air increases, but the effect is relatively minimal.

The ISA standard density at sea level (excepting the Dead Sea!) is 1.225 kilograms per cubic metre (or 1225 grams) or 0.764 lb per cubic foot, where density is defined as 100%. In other words, this would be the defined average weight of all the air molecules in a volume of one cubic metre of air at sea level.

Unlike the other basic factors we shall cover, it cannot be readily measured by instrumentation – its value at a given time requires calculation.

Density plays an important part in an aircraft’s performance; in fact an aircraft’s design limitations are based on the ISA standards. However, as already mentioned, reality rarely matches laid down standards; they are but yardsticks.

The effect of density below the established 100% at 1.225 kg per cubic metre has a definite bearing on an aircraft's stated 'book' performance. This area we shall discuss after you have digested the aspects of pressure, temperature and humidity.



Warmed air expands – notice how the number of molecules in the original volume has decreased

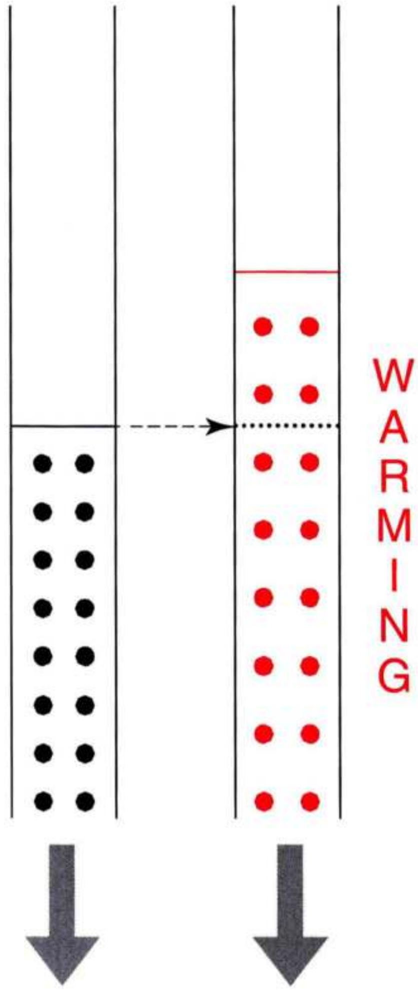
CHAPTER THREE

PRESSURE

WHAT IT IS

Pressure is the weight of a given ***column*** of air in the atmosphere measured at the earth's surface. It decreases with height until becoming nil when air ceases to exist. You may think that the reference to pressure being weight means it is the same as density — this is not so.

Imagine warming a given parcel of air in a tube. This air would expand and spread itself farther up the tube so that the *column* in the tube would become greater in length. But take the volume of the *original parcel* of air in the longer column and you will find it is lighter (less dense) than it was before the warming took place. The same amount of air remains in the column overall so the pressure at the bottom stays the same.



The surface pressure need not decrease with a decrease in density

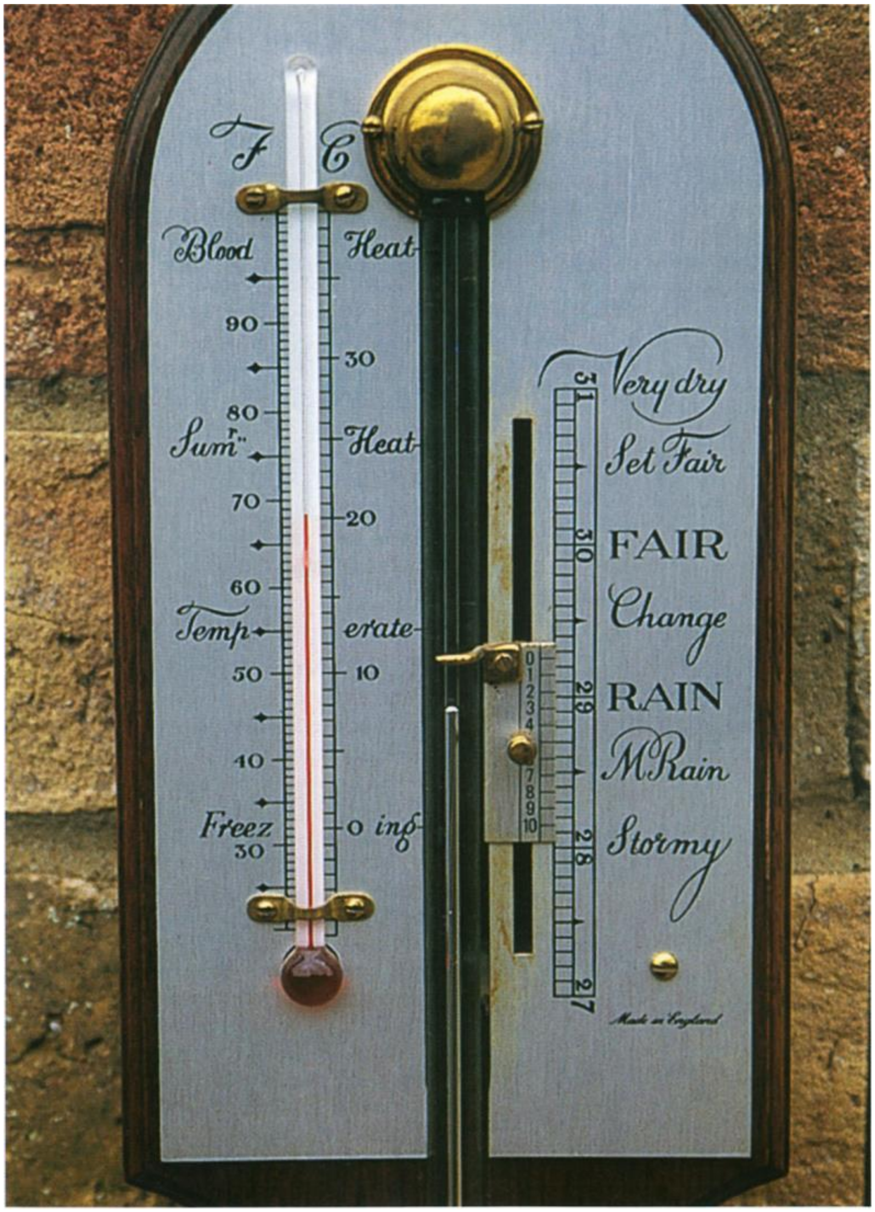
MEASURING PRESSURE

The unit by which atmospheric pressure is measured in the UK has for many years been the **millibar (mb)**. The ICAO has now agreed to a change of unit to that of the **hectoPascal (hPa)**. The change is rather academic in that 1 mb equals 1 hPa so it is a case of “a rose by any other name”!

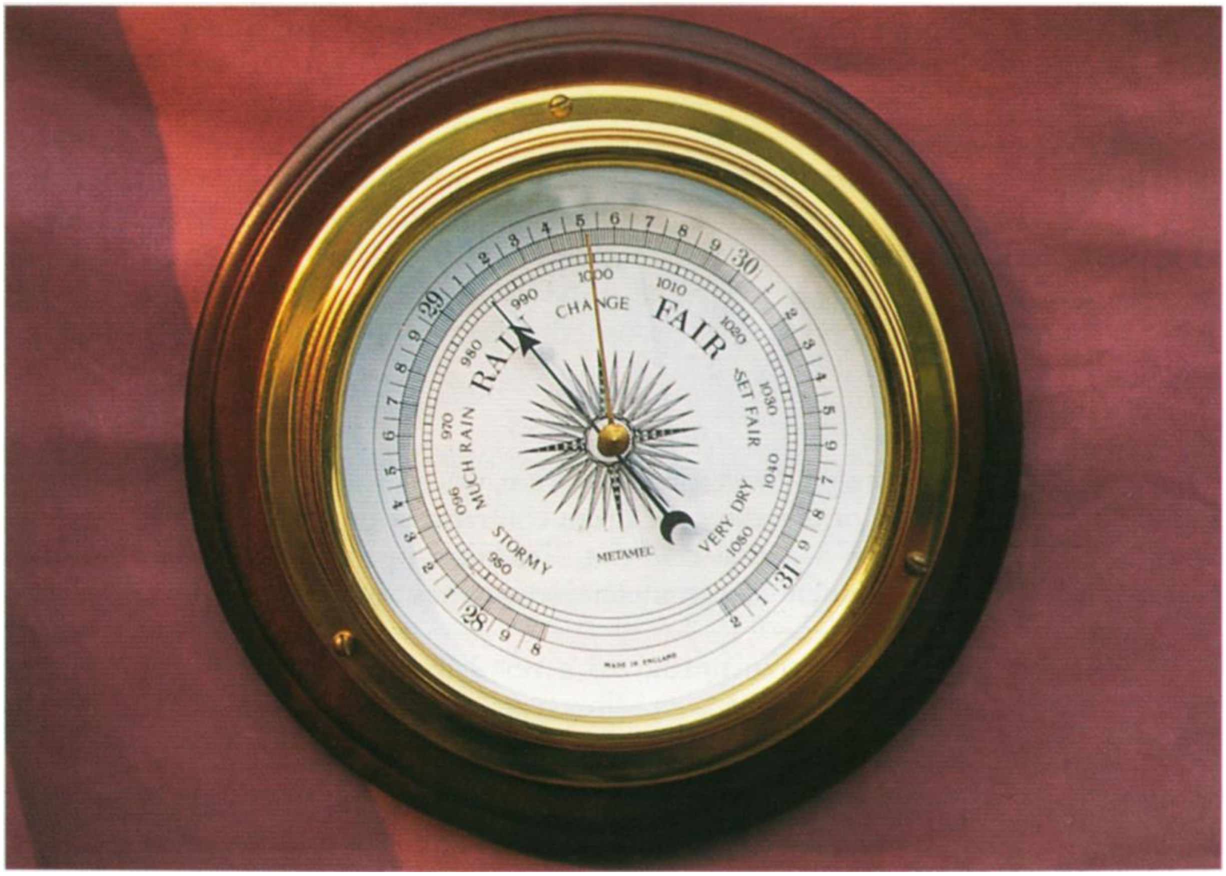
However, the millibar will continue to be used in the UK for operational purposes for the foreseeable future; the hectoPascal will be confined only to those occasions when reference is being made to ICAO International Standard Atmosphere as a definition in itself.

In the light of this present situation we will naturally refer to millibars (mbs) in this book with possibly the occasional insertion of hPa as a reminder for the future.

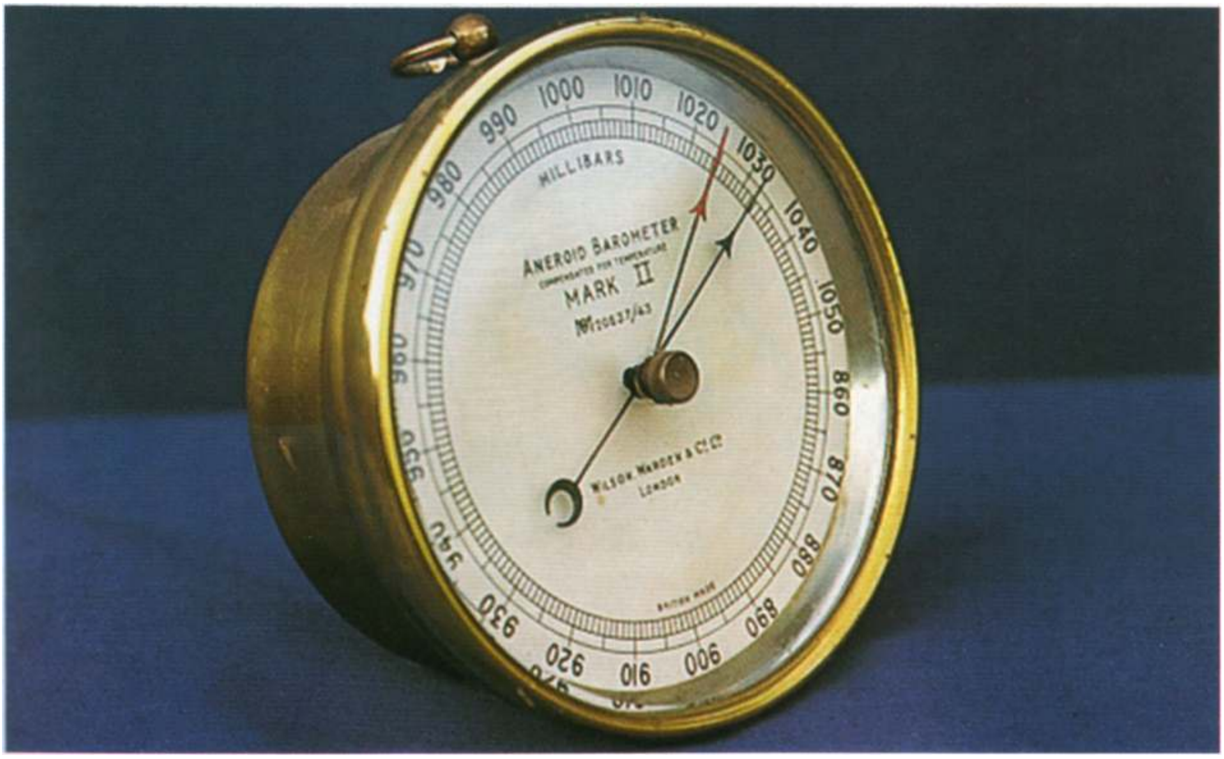
In the United States of America, measurement of pressure is currently in **inches (in.Hg)** – based on the length of a column of mercury in circumstances about to be described.



The mercury barometer consists of a long thin tube extending upwards from a reservoir of mercury. A tiny hole in the reservoir allows air pressure to enter and exert its influence on the mercury. The above is an example from where the inch is the unit of measurement



Readily recognisable with its clock face and scale marked with a range of choices from 'Set Fair' to 'Stormy', or simply a plain dial showing measurement only. A perfectly reasonable instrument can be purchased for a very modest outlay. There is usually an adjustable hand which can be set over a reading at a given time so that future changes are readily observed.



Below is a basic marine barometer usually seen on ships also with an adjustment hand.

The instrument used to measure pressure is the **barometer**, of which there are two main types.

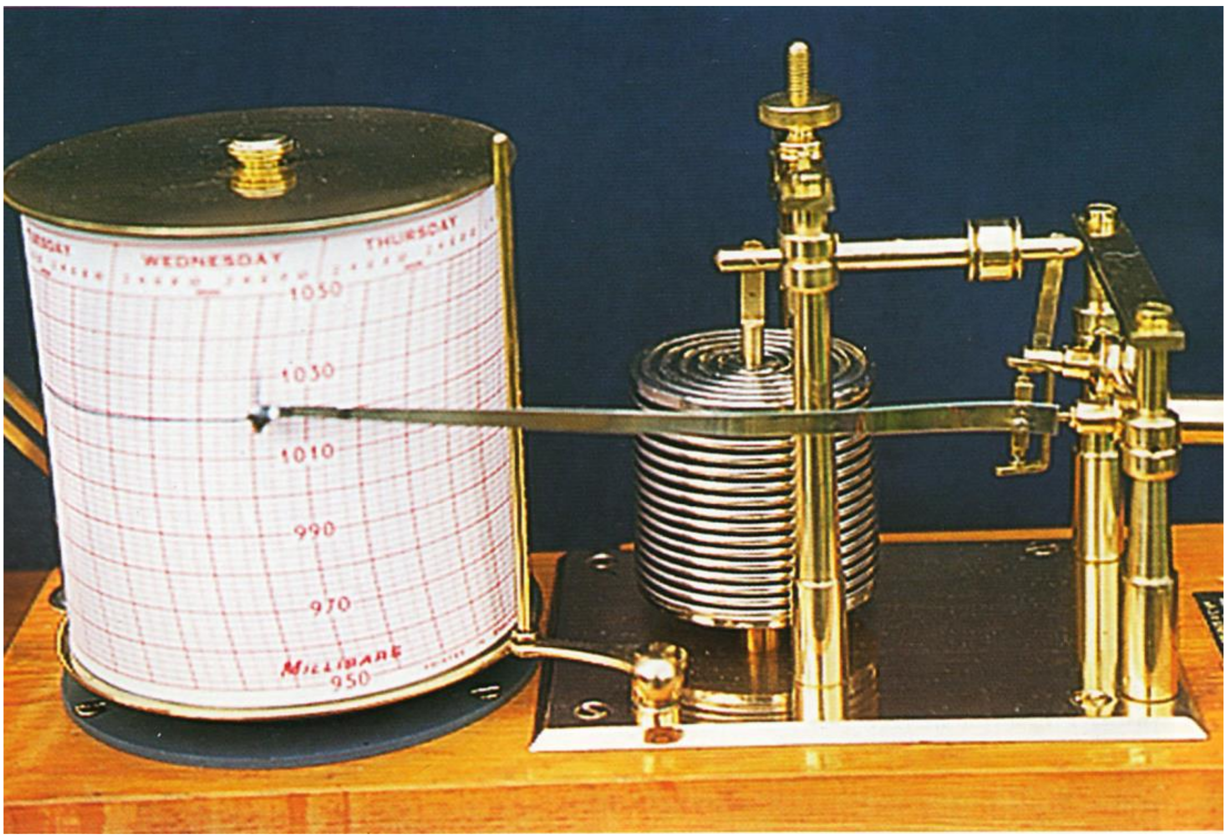
Mercury barometer

This consists of a transparent (usually glass) tube in which a column of mercury extends up from a reservoir at the base of the tube. A tiny inlet hole allows air pressure to enter the reservoir, and the column rises or falls according to the increase or decrease in outside air pressure. The tube is graduated with a scale that is sometimes fitted with a vernier to permit the maximum accuracy in reading off either millibars or inches.

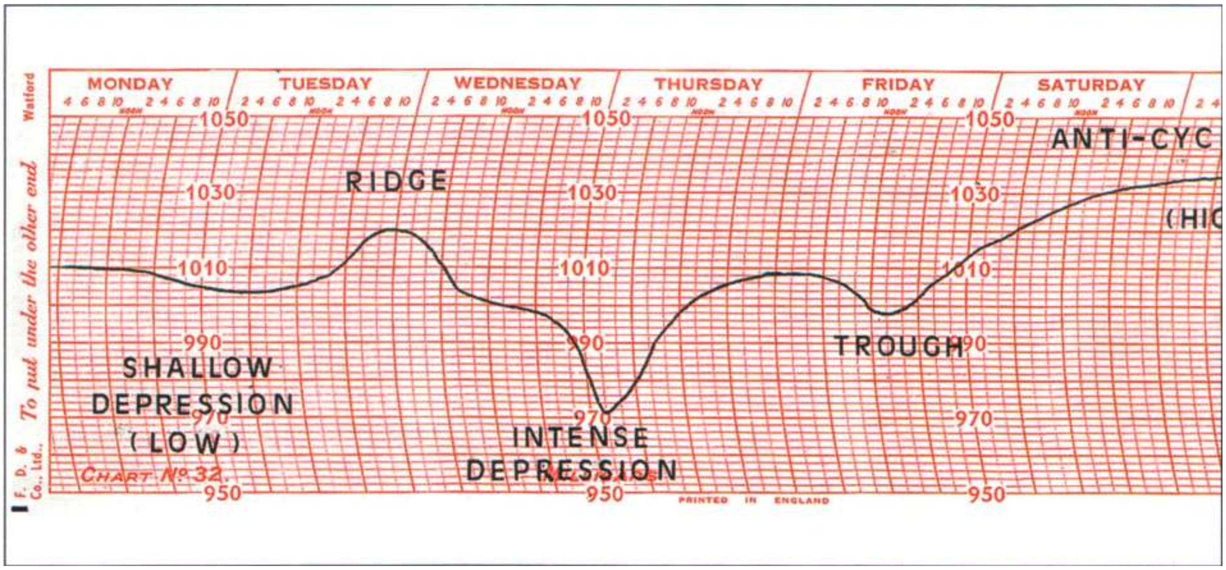
Aneroid barometer

This type consists of a sealed concertina-like drum wherein a fixed pressure exists. As outside pressure increases or decreases the drum contracts or expands, and its movement is transmitted to a dial or a digital read-out. Tradition in the UK still sees the inch measurement on many household barometers, sometimes accompanied by millibars on later models.

The reading can also be transmitted to a revolving drum where a continuous picture of pressure changes can be seen. This type of aneroid barometer is known as a **barograph**.



Here you can see the sealed, concertina-like drum and the linkage associated with an aneroid barometer. In this case the linkage transmits a continuous reading to a chart



The barograph can be very valuable for amateur weather forecasting

Conversion from millibars to inches and vice-versa is as follows:

1 millibar	=	0.02953 in.Hg
and 1 in.Hg	=	33.8653 mb

For example	1000 mb	÷ 33.8653 =	29.53 in.Hg
	or 29.53 in.Hg	÷ 0.02953 =	1000 mb.

Those who enjoy calculations should find that 27 ft per 0,02953 in.Hg equates to 30 ft being the equivalent of 0.032811 in.Hg – hence the 0.3 in.Hg per 30 ft referred to above makes it all the more simple.

At around 20,000 ft in the more rarefied air the change becomes approximately 50 ft per unit of 1 millibar or 0.02953 in.Hg, and increases to approximately 75 ft per unit around 30,000 ft due to the markedly reduced density at that height.

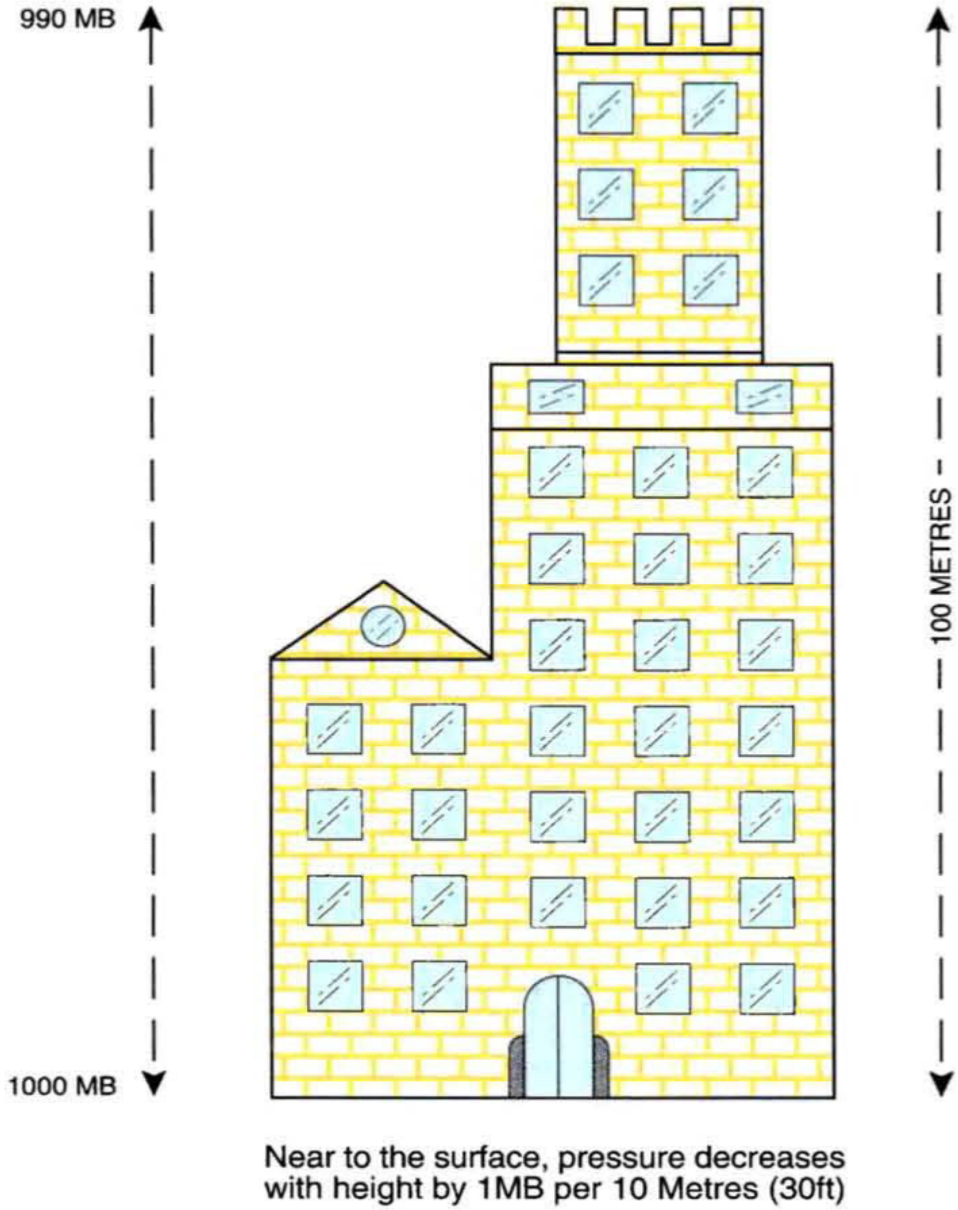
PRESSURE CHANGES WITH HEIGHT

The ISA standard for a change in height is 27 ft per hectoPascal (mb) – the equivalent of 0.02953 in.Hg. However, the generally accepted change is the round figure of **30 ft per millibar** which equates to **0.03 in.Hg** and this combination we will use when required.

UNIFORMITY IN MEASUREMENT

Taking the accepted decrease in pressure with height at 30 feet per millibar (0.03 in.Hg), given a surface pressure of 1000 mb (29.53 in.Hg), a reading taken at the top of a 300 ft (100 metres) building would be 990 mb (29.23 in.Hg) for the same location.

You will realise that if pressure readings were taken at stations located at varying heights it would be impossible to obtain a meaningful pressure pattern at any given time.

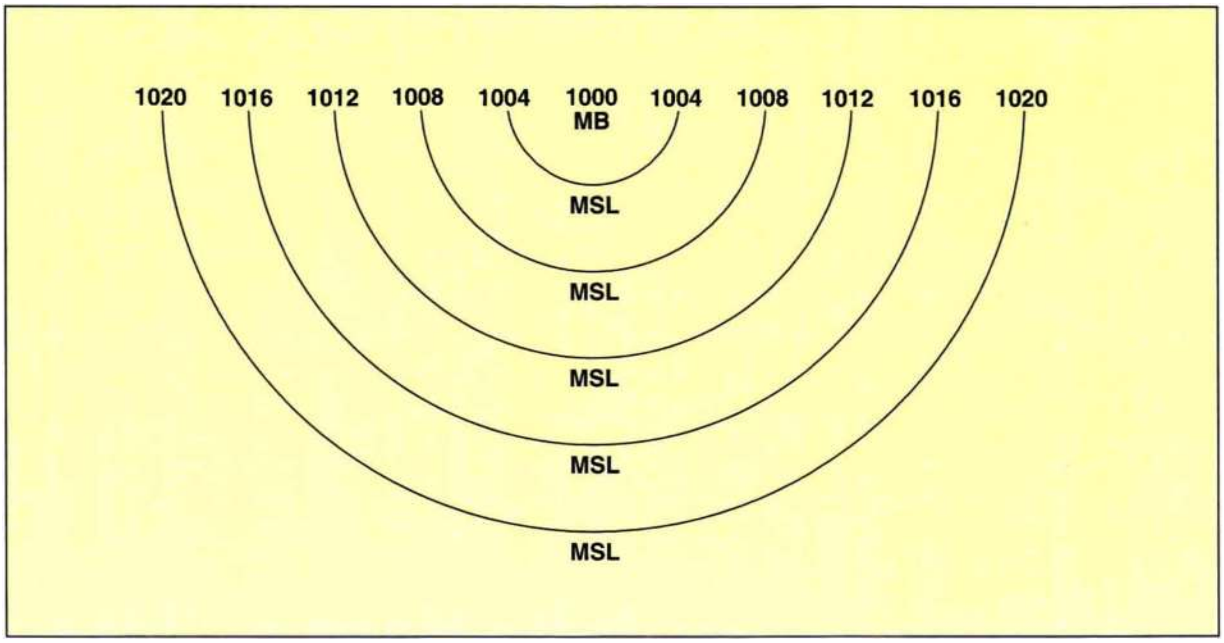


The difference between top and bottom would be 10 mb

Uniformity is obtained by all pressure readings being converted to sea level, with even tidal movement being taken into account, thus ending up with the term **Mean Sea Level (MSL).**

The ISA MSL standard is **1013.25 mb** (hPa) or **29.92 in.Hg**.

Pressure readings, together with other weather data, are noted every day at regular intervals throughout the world and transmitted to main centres. Here the pressures are reproduced on charts with lines joining places of equal MSL pressure. These lines are known as **isobars** and appear similar to contours on a map.



Isobars joining places of equal MSL pressure

PRESSURE SYSTEMS

Isobars produce a pattern which depicts various pressure systems.

- **HIGH** – A centre of high pressure known as an **anticyclone**.
- **RIDGE** – A wedge or tongue of high pressure extending out from the centre of an anticyclone.
- **LOW** – A centre of low pressure known as a **depression**.
- **TROUGH** – A wedge or tongue of low pressure extending out from the centre of a depression.
- **COL** – The neutral area between two highs and two lows.