



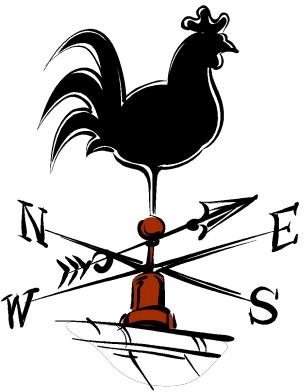
# UNIT-3

# WEATHER AND CLIMATE

# PARAMETERS MEASURING

# DEVICES

## (S6&S7)



# **Weather Instruments**

## **Essential Questions:**

**What are weather instruments and how are they used?**

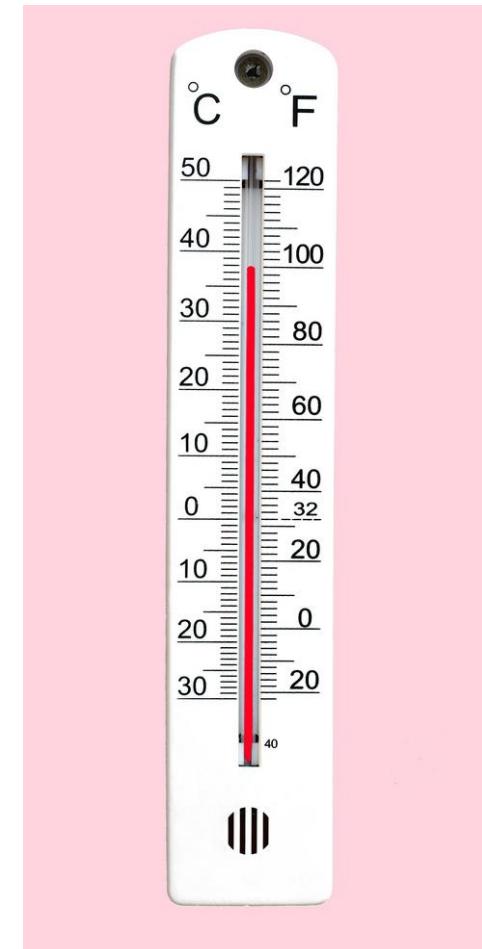
# Weather Instruments

Meteorologist use different tools to measure weather. Here are some of the instruments they use:

- Thermometer
- Barometer
- Anemometer
- Hygrometer
- Rain gauge
- Wind Vane
- Weather balloon
- Satellite

# Thermometer

A thermometer measures heat and cold. Meteorologists use it to measure air temperature. Liquids expand (get bigger) when heated and contract (get smaller) when cooled. That means their volume (occupied space) changes with their temperature.



# Thermometer

The liquid inside older thermometers is mercury. It was used because of its resistance to heat and cold. Unlike water, mercury freezes at minus 39 degrees Celsius (-39°C) and boils at three hundred fifty seven degrees Celsius (357°C).

# Thermometer

## Units of Measure

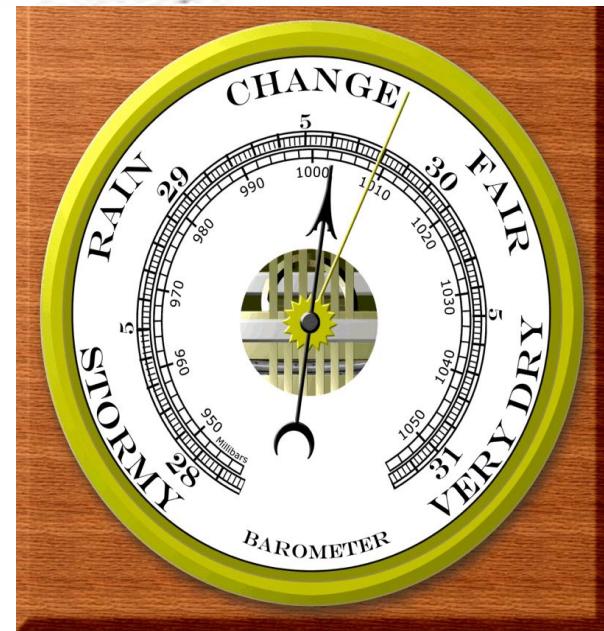
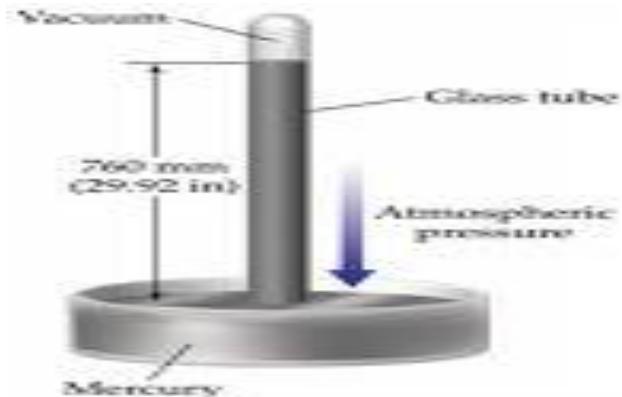
The two (2) measurement units used with a thermometer are degrees ***Fahrenheit*** and degrees ***Celsius***.

The Fahrenheit scale sets the freezing point of water at 32 degrees ( $32^{\circ}\text{F}$ ) and the boiling point at 212 degrees ( $212^{\circ}\text{F}$ ).

The Celsius scale sets the freezing point of water at 0 degrees ( $0^{\circ}\text{C}$ ) and the boiling point at 100 degrees ( $100^{\circ}\text{C}$ ).

# Barometer

A barometer measures **air pressure** or **barometric pressure**. The barometer dial is marked in two scales. The **outer scale** shows the **units of inches of mercury**. The **inner scale** shows **air pressure in millibars**.



# Air Pressure

Air pressure is a function of the quantity of air and the amount of space in which the air is contained. Air pressure is also the function of temperature.

# Air Pressure and Weather

Changing air pressure indicates changing weather.

***Rising*** air pressure usually means that cooler, drier air is coming, so there will be ***fair weather***.

***Falling*** air pressure usually means that warmer, moister air is coming, so there will be ***wet weather***.

# Anemometer

An anemometer  
measures the **speed**  
**or strength of wind.**

The most common  
types of anemometer  
have a mechanism that  
rotates as it catches the  
wind.



# Wind Speed and Weather

Wind speed is related directly to wind strength. Wind strength is commonly reported on the ***Beaufort scale***. The Beaufort scale rates the strength of wind on a scale of 0 – 12.

A Beaufort number of 0 indicates total calm.

A Beaufort number of 12 indicates hurricane strength winds (exceeding 74 mph).

# Hygrometer

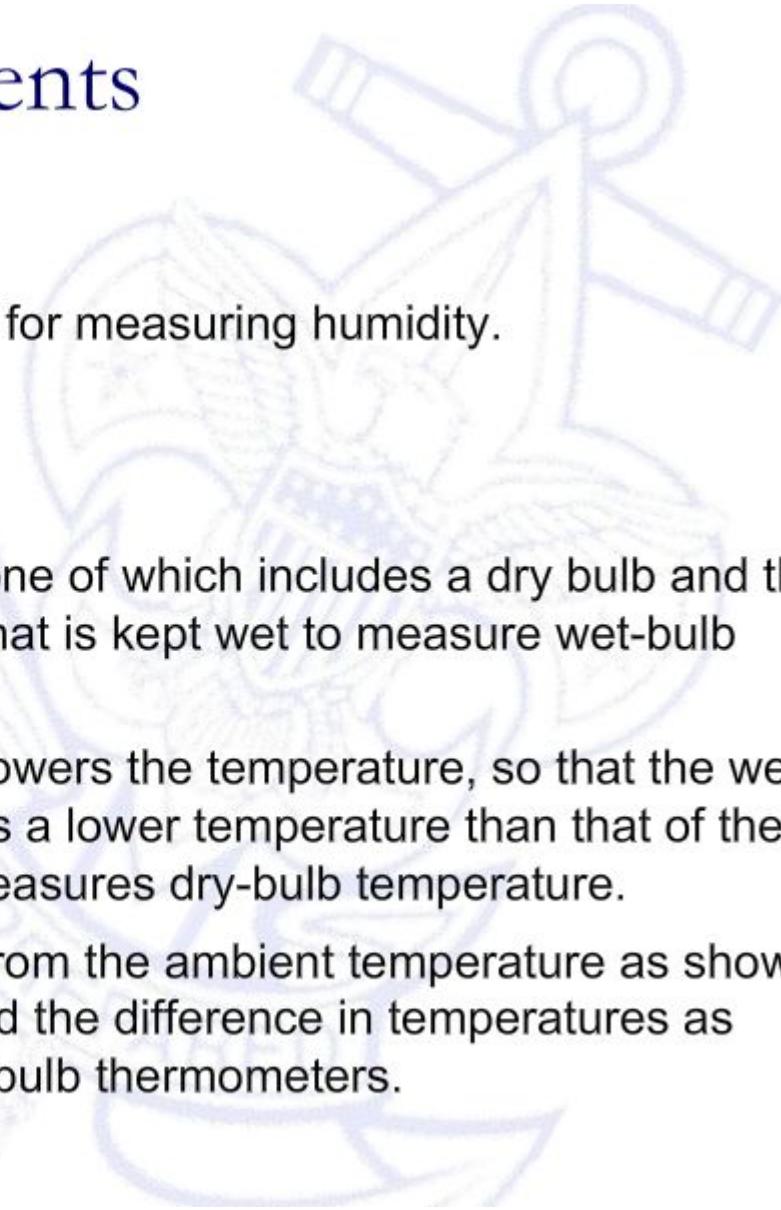
A hygrometer measures **relative humidity**. Humidity is the **amount of water vapor in the air**.

A reading of **100 percent relative humidity** means that the **air is totally saturated with water vapor** and cannot hold any more, creating the **possibility of rain**.





# Weather Instruments



- Hygrometers are instruments used for measuring humidity.
- Psychrometer
  - A simple form of a hygrometer
  - consists of two thermometers, one of which includes a dry bulb and the other of which includes a bulb that is kept wet to measure wet-bulb temperature.
  - Evaporation from the wet bulb lowers the temperature, so that the wet-bulb thermometer usually shows a lower temperature than that of the dry-bulb thermometer, which measures dry-bulb temperature.
  - Relative humidity is computed from the ambient temperature as shown by the dry-bulb thermometer and the difference in temperatures as shown by the wet-bulb and dry-bulb thermometers.

# People and Humidity

The process of **sweating** is the human body's attempt to keep cool and maintain its current temperature. If the air is at 100-percent relative humidity, sweat will not **evaporate** into the air. As a result, we feel much hotter than the actual temperature when the relative humidity is high. If the relative humidity is low, we can feel much cooler than the actual temperature because our sweat evaporates easily, cooling us off.

# Rain Gauge

- A **rain gauge** is an instrument used to gather and **measure** the **amount of liquid precipitation** over a set period of time.
- Most standard rain gauges have a wide funnel leading into a cylinder that is marked in inches or centimeters.
- They are calibrated (set up) so that **one-tenth of an inch of rain measures one inch** when it collects inside. In other words, each inch in the funnel counts as one-tenth of an inch of rain.



# Types of Rain gauges

Rain gauges can be broadly classified into two categories as

i) Recording / Automatic type rain gauge

Weighing bucket,

Tipping bucket,

Floating type

ii) Non- recording / Non- automatic type rain gauge :

Symon's Raingauge

## **Non- recording / Non- automatic type rain gauge : Symon's Raingauge**

- The non-recording gauge extensively used by **Meteorological Department of Government of India is the Symons' gauge .**
- The rain gauge is set up in a concrete block **60 cm x 60 cm x 60 cm.**
- A cylindrical graduated measuring glass is furnished with each instrument, which reads to 0.2 mm. **The rainfall should be estimated to the nearest 0.1 mm.**
- A receiving bottle of rain gauge has a capacity of about **75 to 100 mm of rainfall**, the rain should be measured 3 or 4 times in a day, in case of heavy rainfall. The rainfall is measured every day at **08.30 hours IST.**

- Usually, rainfall measurements are made at 08.30 hr IST and sometimes at 17.30 hr IST also.
- Thus the non-recording or the Symon's rain gauge gives only the total depth of rainfall for the previous 24 hours (*i.e.*, daily rainfall) and does not give the intensity and duration of rainfall during different time intervals of the day.

## The following important points to be kept in mind, while selecting the site for a rain gauge station.

1. The site where a rain-gauge is set up should be an open place.
2. The distance between the rain-gauge and the nearest object should be atleast twice the height of the object. In no case should it be nearer to the obstruction than 30 metres.
3. The rain-gauge should never be situated on the side or top of a hill if a suitable site on a level ground can be found.
4. In the hills, where it is difficult to find level space, the site for the gauge should be chosen where it is best shielded from high winds, and where the wind does not cause eddies.
5. A fence, if erected to protect the gauge from cattle etc. should be so located that distance of the fence is not less than twice its height.

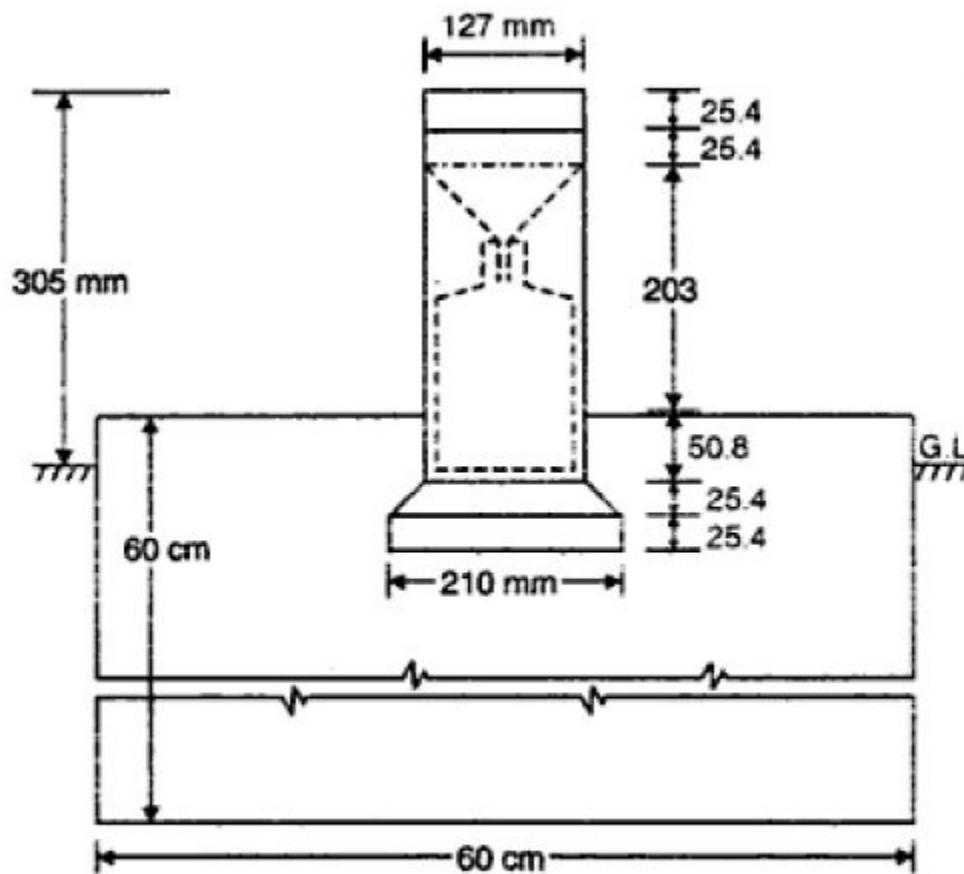


FIG. SYMON'S RAIN-GAUGE (ADOPTED BY METEOROLOGICAL DEPT. OF GOVT. OF INDIA)

# **Recording / Automatic type rain gauge**

- 1. Weighing bucket,**
- 2. Tipping bucket,**
- 3. Floating type**

# Weighing bucket type rain gauge

- Self recording rain gauges are used to determine rates of rainfall over short period of time.
- The most common type of Self recording rain gauge is weighing bucket type. It consists of receiver bucket supported by spring or any other weighing mechanism.
- The movement of the bucket due its increasing weight is transmitted to a pen which traces the record on a clock driven chart.
- The rotation of the drum sets the time scale while the vertical motion of the pen records the cumulative precipitation

- This type of gauge normally has no provision for emptying itself.
- The bucket is been emptied and the pen has been set to zero, whenever the rainfall chart is changed.

### Merits.

- The main usefulness of this type of gauge is that, it can record snow, hail, mixture of rain and snow.
- All forms of precipitation are weighed and recorded automatically.

### Demerits.

- Effect of temperature and friction on weighing mechanism.
- Shrinkage and expansion of chart paper caused by changes in humidity may distort the time and scale of rainfall.

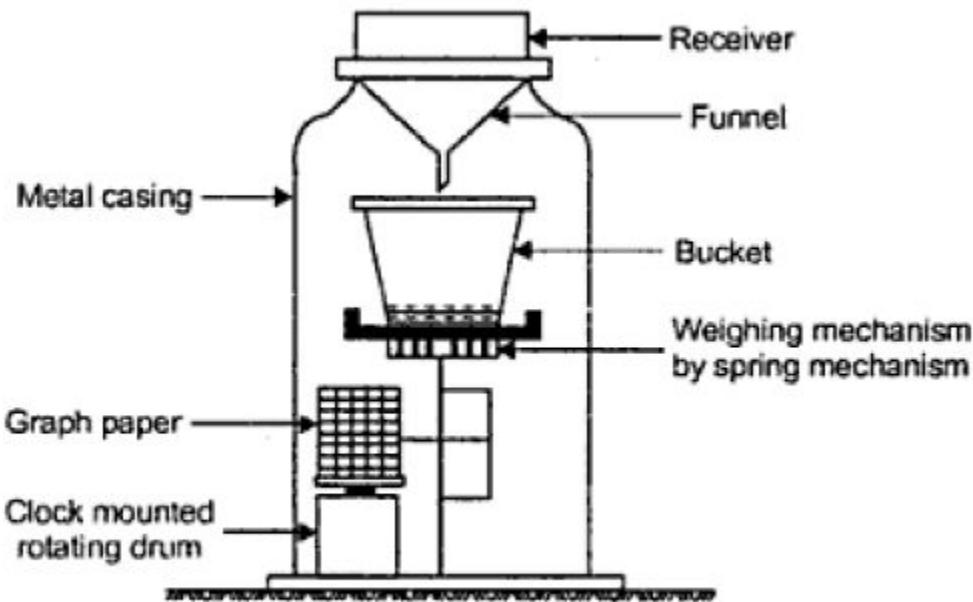
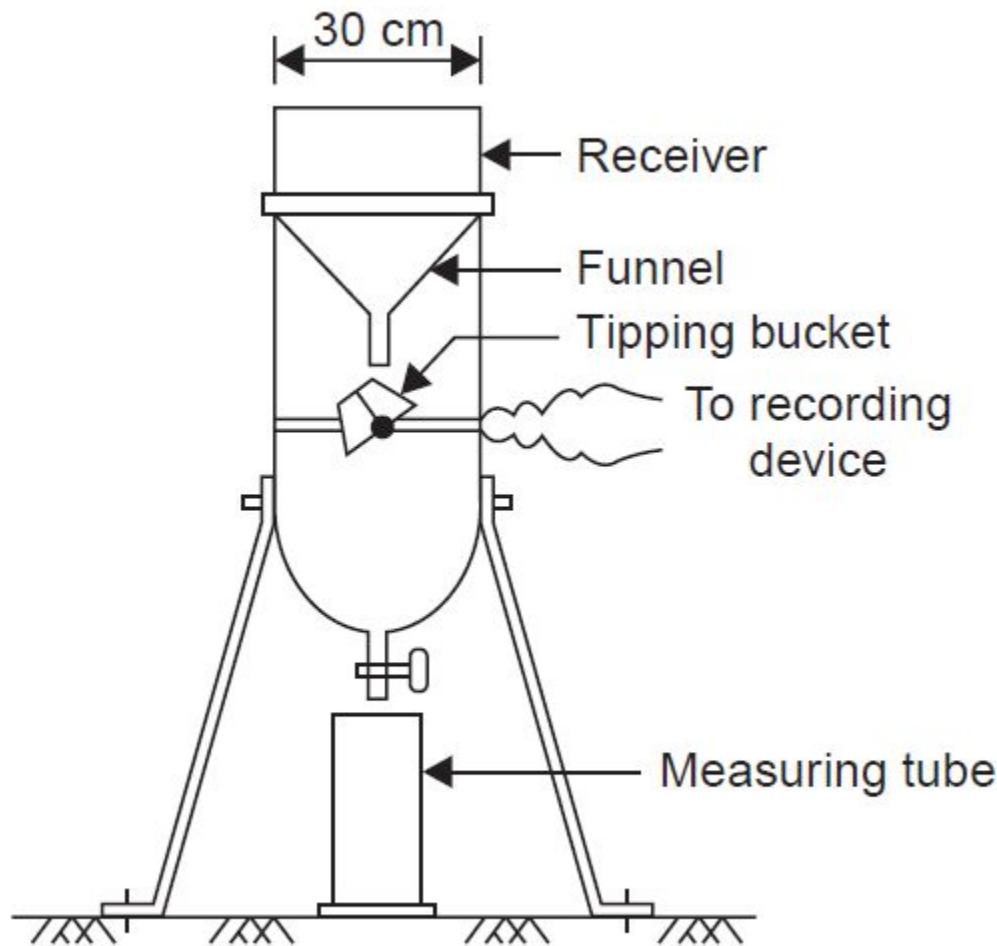


FIG. WEIGHING BUCKET TYPE RAIN-GAUGE.

# Tipping bucket type [Tilting bucket]

- A Steven's tipping bucket type rain gauge consists of **300 mm diameter**, sharp edge receiver. At the end of the receiver is provided with a funnel.
- Just below the funnel a pair of tipping buckets is pivoted such that when one of the bucket receives a rainfall of 0.25 mm it tips and empties into a tank below, while the other bucket takes its position and the process is repeated.
- The tipping of the bucket actuates an electric circuit which causes a pen to move on a chart wrapped round a drum which revolves by a clock mechanism. **This type cannot record snow.**



**Fig.** Tipping bucket gauge

- The water from the tipped bucket is collected in a **storage can**.
- The water collected in the storage can is measured at regular intervals to provide the total rainfall and also serve as a check.
- It may be noted that the record from the **tipping bucket gives data on the intensity of rainfall.**
- Further, the instrument is ideally suited for digitalising of the output signal.

## Merits

- It is the only recording rain gauge, which can be used in **remote places** by installing the recorder at a convenient and easily accessible location.

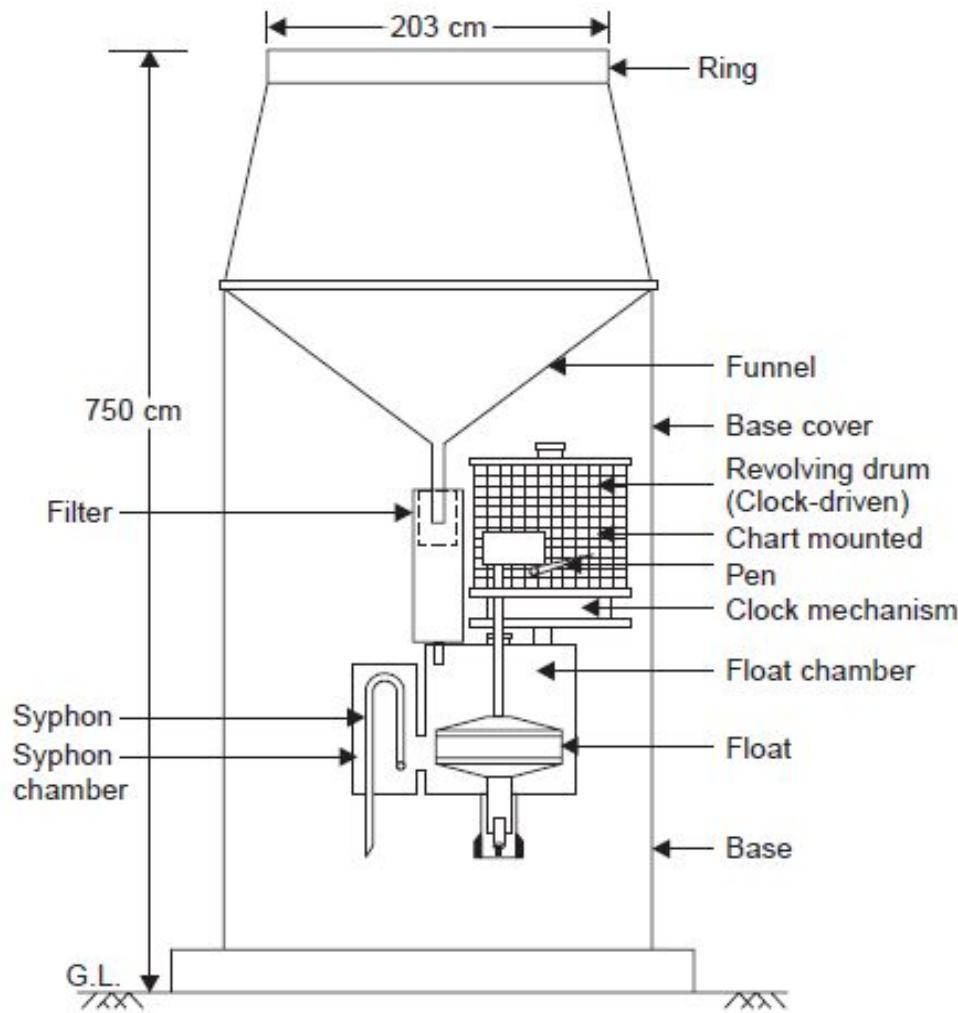
## Demerits

- The instrument is not satisfactory for use in **light drizzle** of very light rain.
- The time of **beginning and end of rainfall** cannot be determined accurately.
- This type of gauge is not suitable for measuring **snow** without heating the collector.

# Floating type rain gauge [Natural siphon type]

- This type of rain gauge is also known as **siphon type rain gauge**, as it uses the **siphon mechanism** to empty the rainwater collected in the float chamber.
- This is adopted by **I.M.D**
- The working of float type or siphon type raingauge is **similar to the weighing bucket type rain gauge**.
- In this type, as the rain is collected in a float chamber, the float moves up which makes a pen to move on a chart wrapped round a clock driven drum
- When the float chamber fills up, the water siphons out automatically through a siphon tube kept in an interconnected siphon chamber.

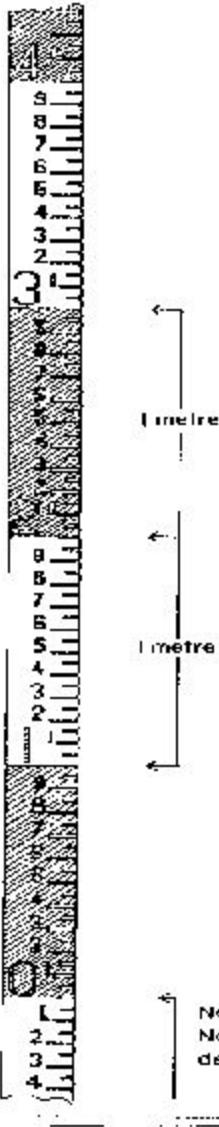
- **The clockwork revolves the drum once in 24 hours.**
- The clock mechanism needs rewinding once in a week when the chart wrapped round the drum is also replaced.
- The vertical lines in the pen-trace correspond to the sudden emptying of the float chamber by siphon action **which resets the pen to zero level.**
- It is obvious that the natural siphon-type recording rain gauge gives a plot of the **mass curve of rainfall.**



**Fig.**      Float type rain gauge

# Tide Pole (or Tide Staff) Gauges

# TIDE GAUGES



12345  
67890

## SPECIMEN FIGURES

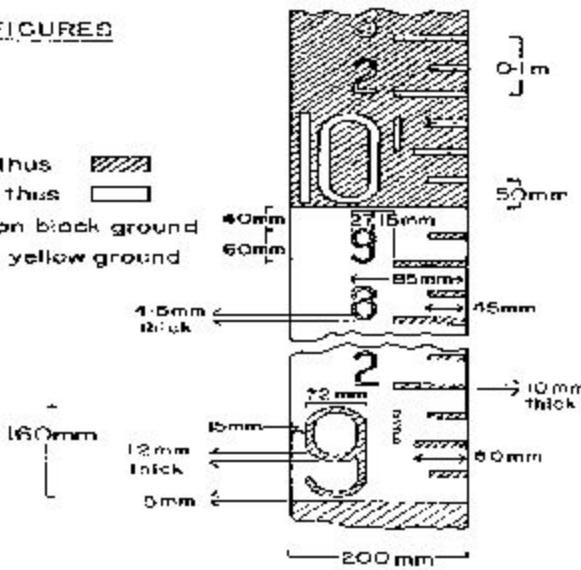
### COLOUR KEY

Black shown shaded thus 

Traffic yellow shown thus

Even numbers yellow on black group

Родина-Матір захищає нас



**Negative readings.  
Note reversal of  
decimetre figures**

MARKING OF  
VISUAL TIDE SCALE

**Committee on  
Tide Gauges**  
January 1970



# Tide pole gauges

- The simplest possible system, and lowest cost
- Very educational
- Important common sense ‘reality check’ alongside modern black box digital tide gauge systems

Of course, tide poles have not for many years been a primary source of sea level data. However, it is always worth having a simple tide pole at every gauge site as a check.

Although they are simple, there is a need for datum control, just as there is for more expensive and complicated gauges

# Float Gauges

# Classical Float Gauge

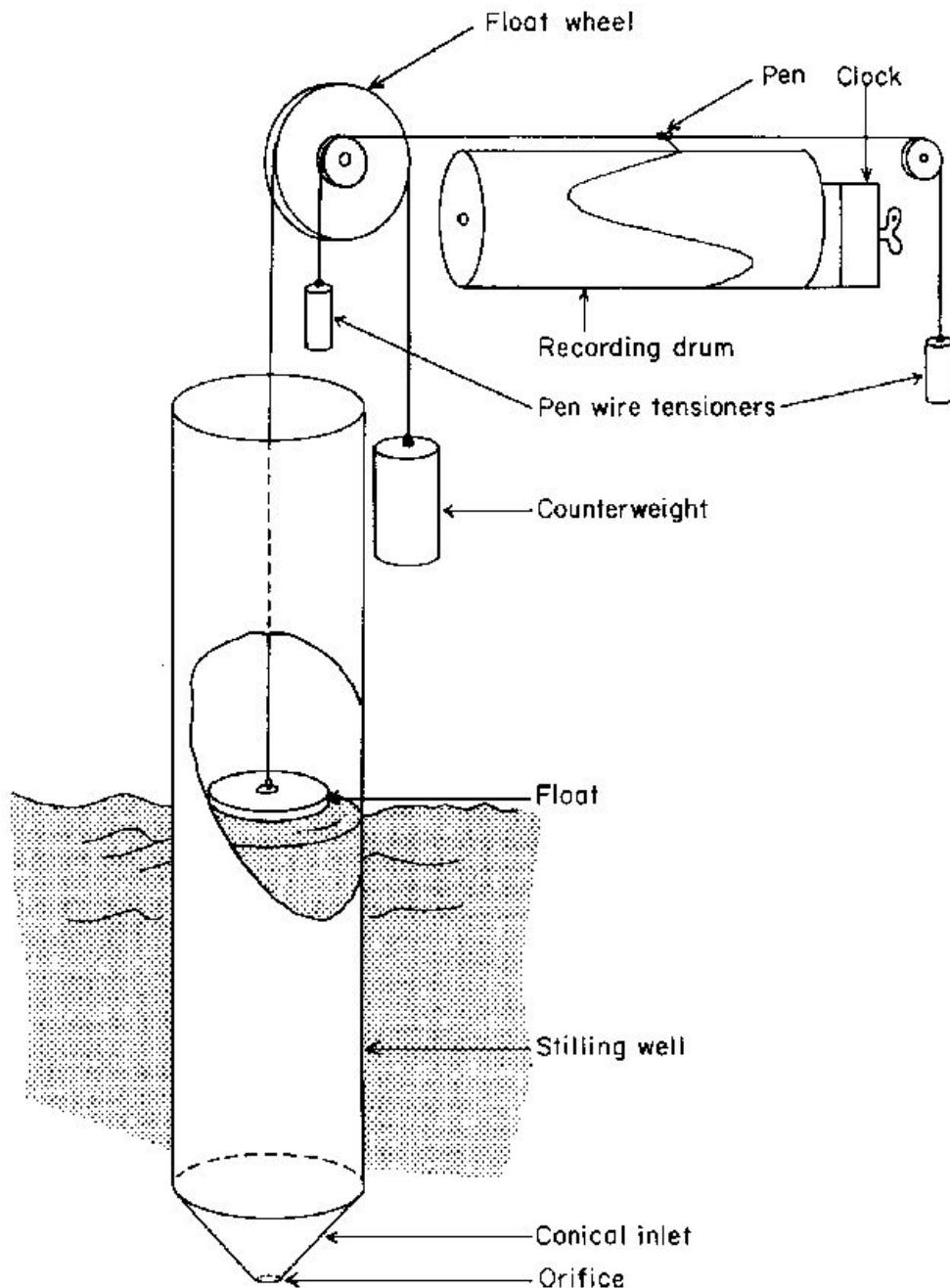


Figure 3.1



Lea chart recorder for  
a float gauge (photo  
taken in 1983)

# Importance of Float Gauges

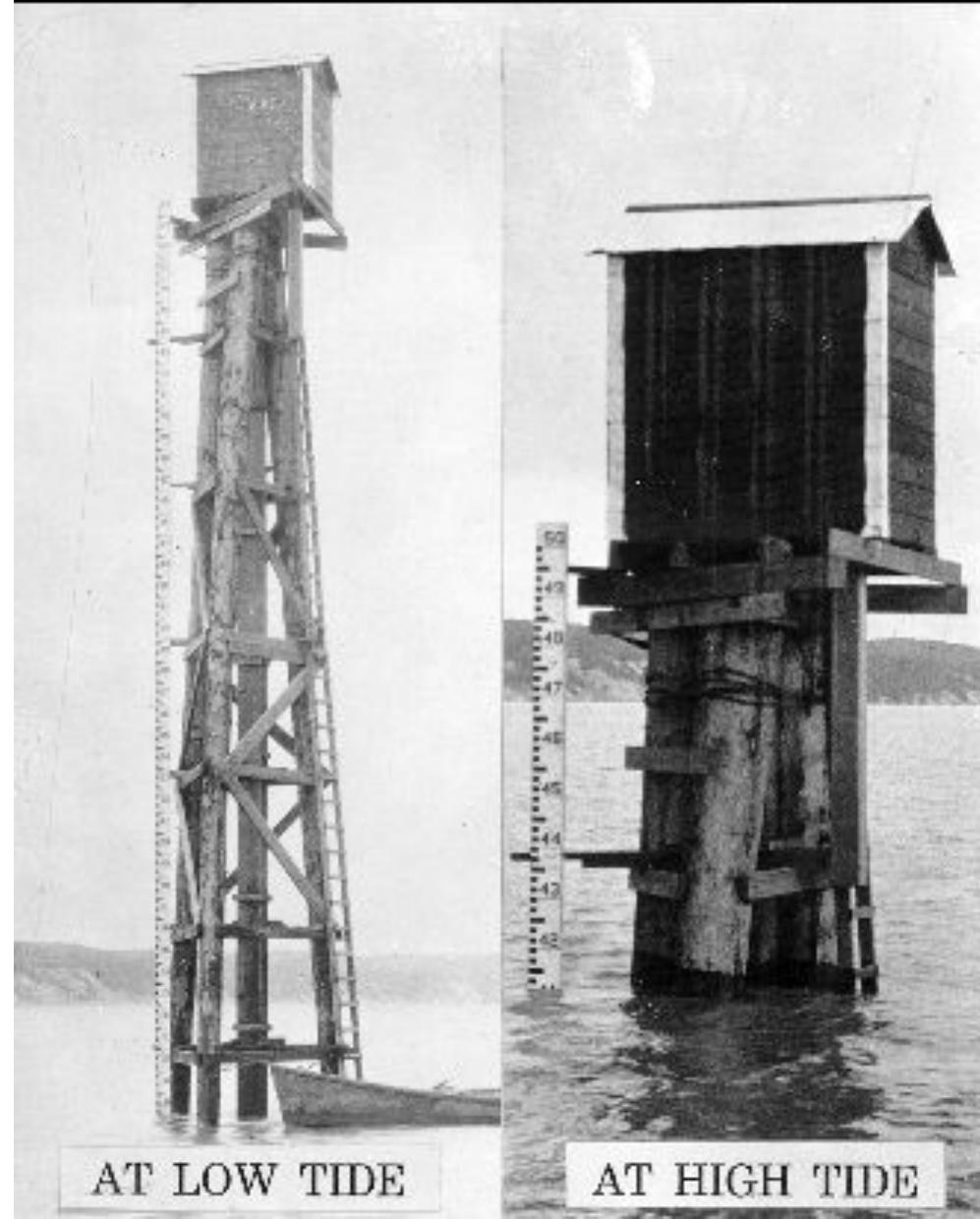
- They still form a large part of the global network
- No need for paper charts now. They can be made digital with the use of shaft encoders
- Even if they are now being replaced with acoustic, pressure and radar systems, they were the source of most of the historical record



## UK Float Gauge at Holyhead

Float gauges are still important components of GLOSS and can be made into digital gauges with the use of encoders

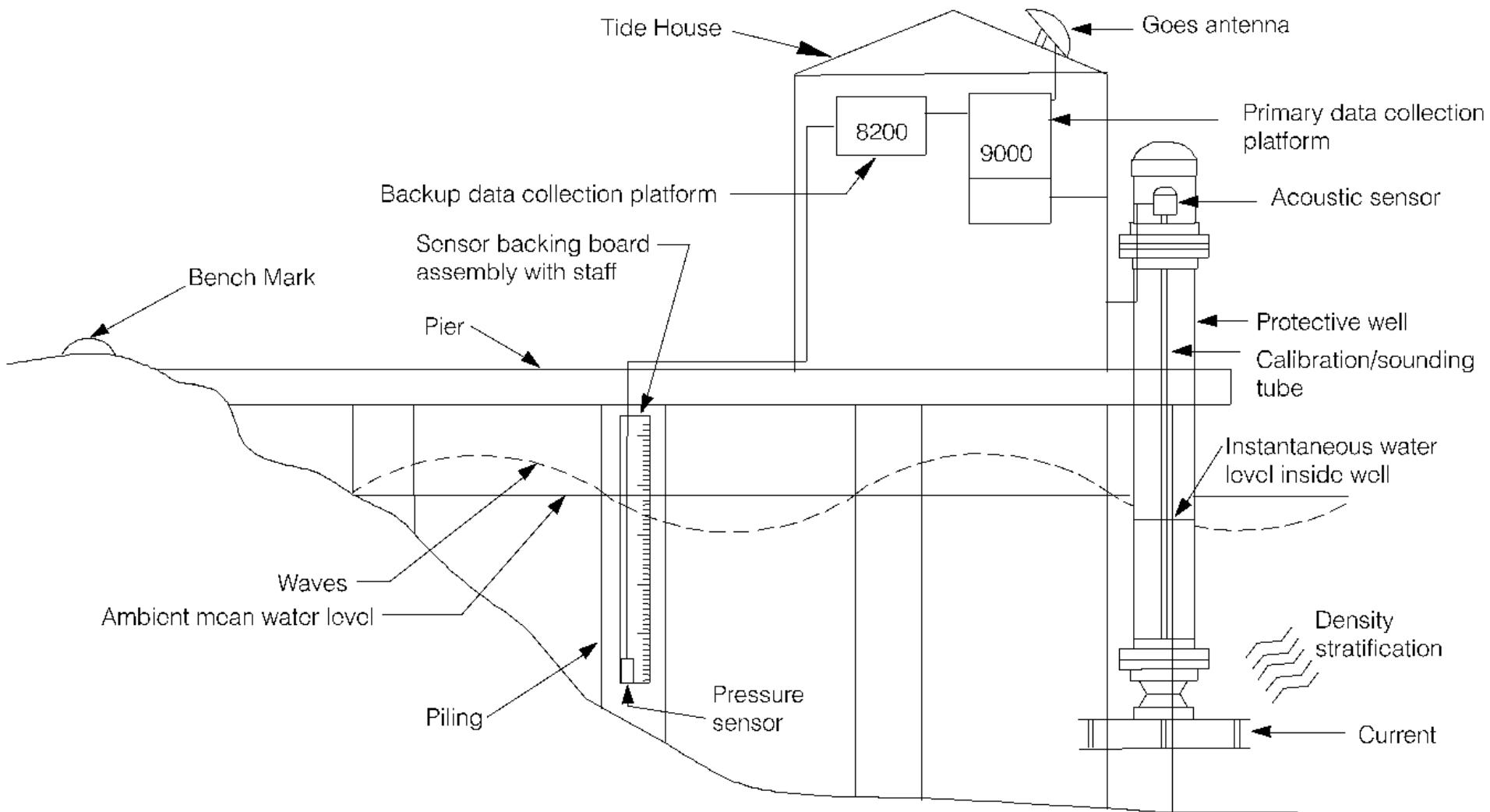
Classical stilling well  
float gauge from the  
US east coast high  
tidal range area



# Acoustic Gauges

# Acoustic gauges

- Acoustic systems in tube with Aquatrak transducer (NGWLMS or SEAFRAME) with various data loggers. These are now something of a GLOSS standard in many areas
- Acoustic systems in open air or inside the stilling wells of float gauges. Cheap but several groups have not been successful in operating them to good standards



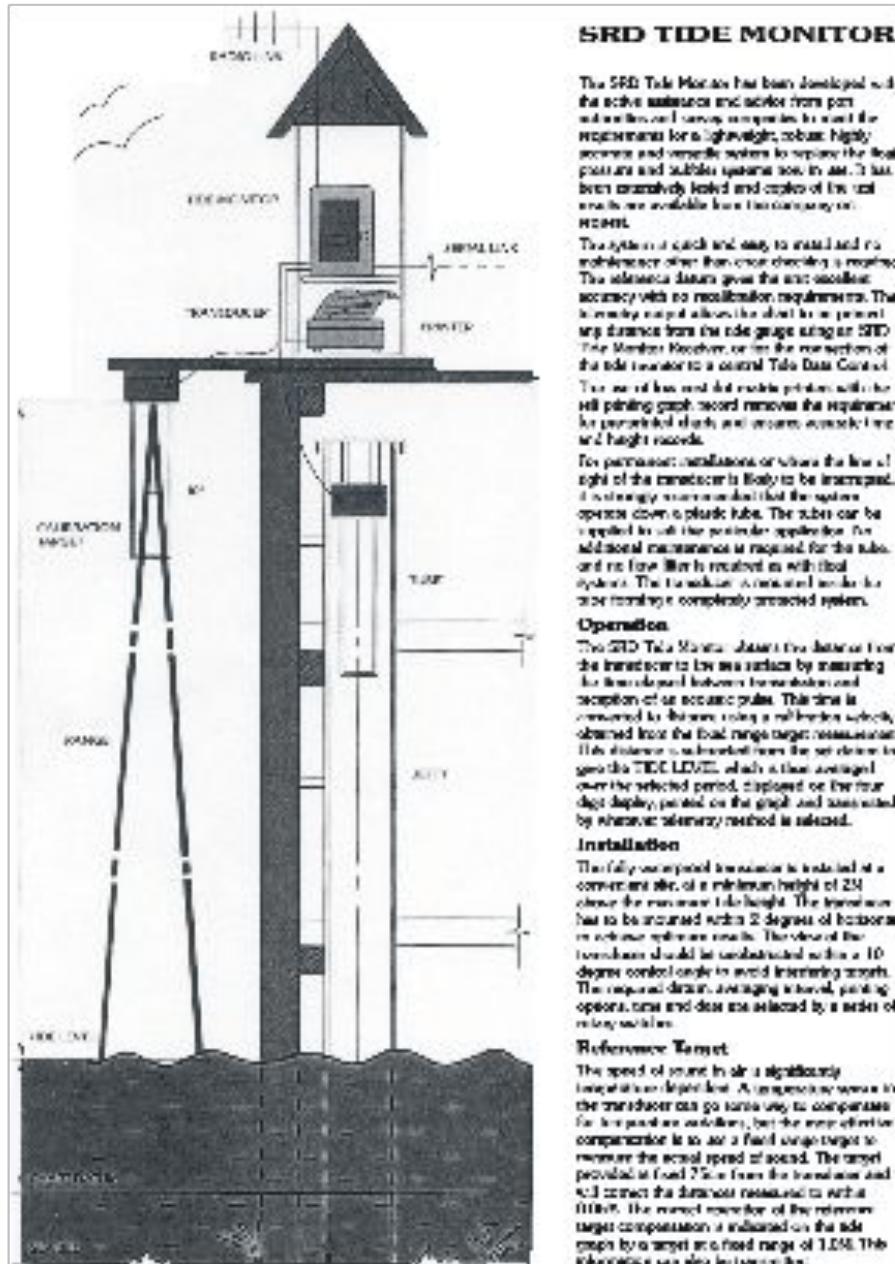
**Schematic of the NGWLMS/SEAFRAME system**

## Acoustic SEAFRAME Gauge in Australia



SRD Tide Monitor  
in a well or in open  
air – Spain and South  
Africa have used these  
not very successfully.

Similar systems are  
manufactured by other  
companies e.g. MORS



# Pressure Gauges

# Pressure gauges

- Bubbler gauges
- Transducer in the sea gauges
- ‘B’ (or ‘triple’) pressure systems

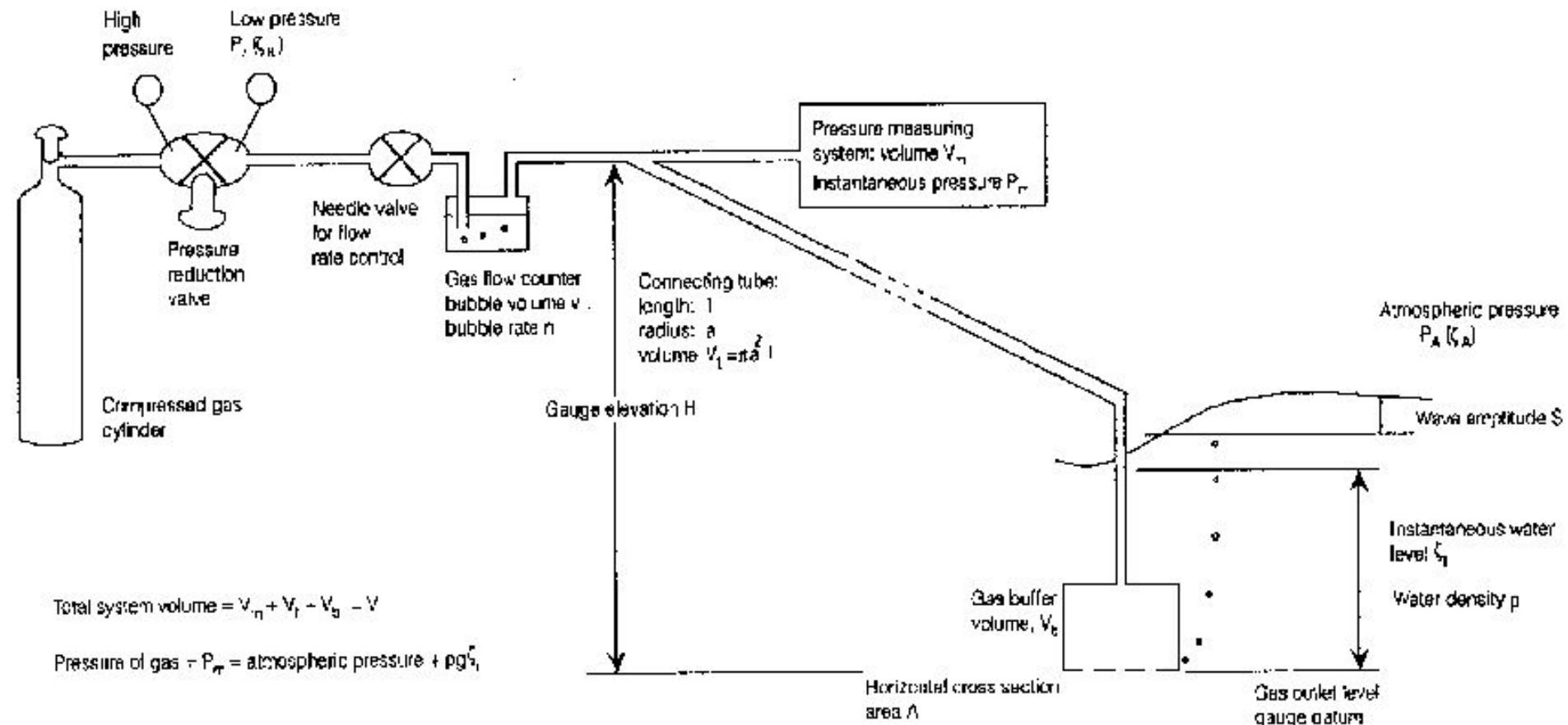


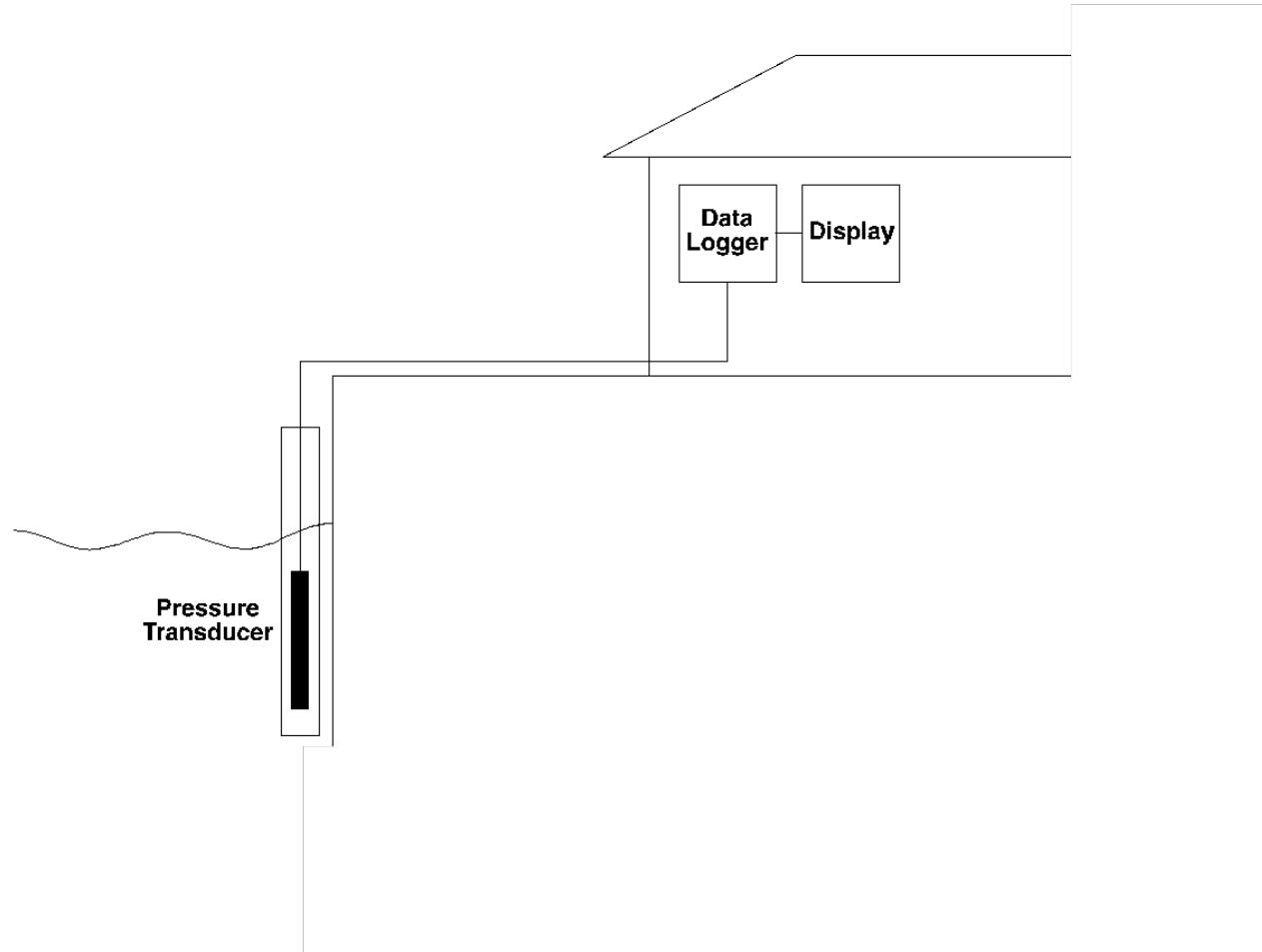
Figure 2.2

Schematic diagram of the pneumatic tide gauge and its principal system parameters

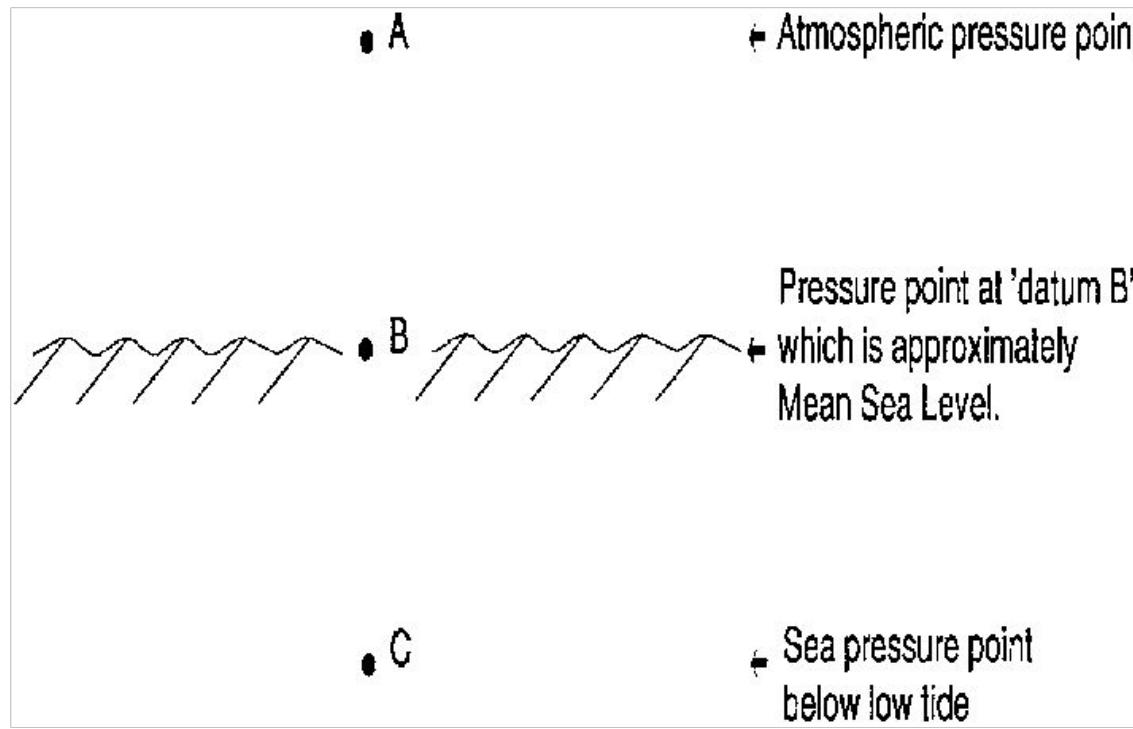
# *Tide Gauge Pressure Point*

*Nozzle*

*Housing*



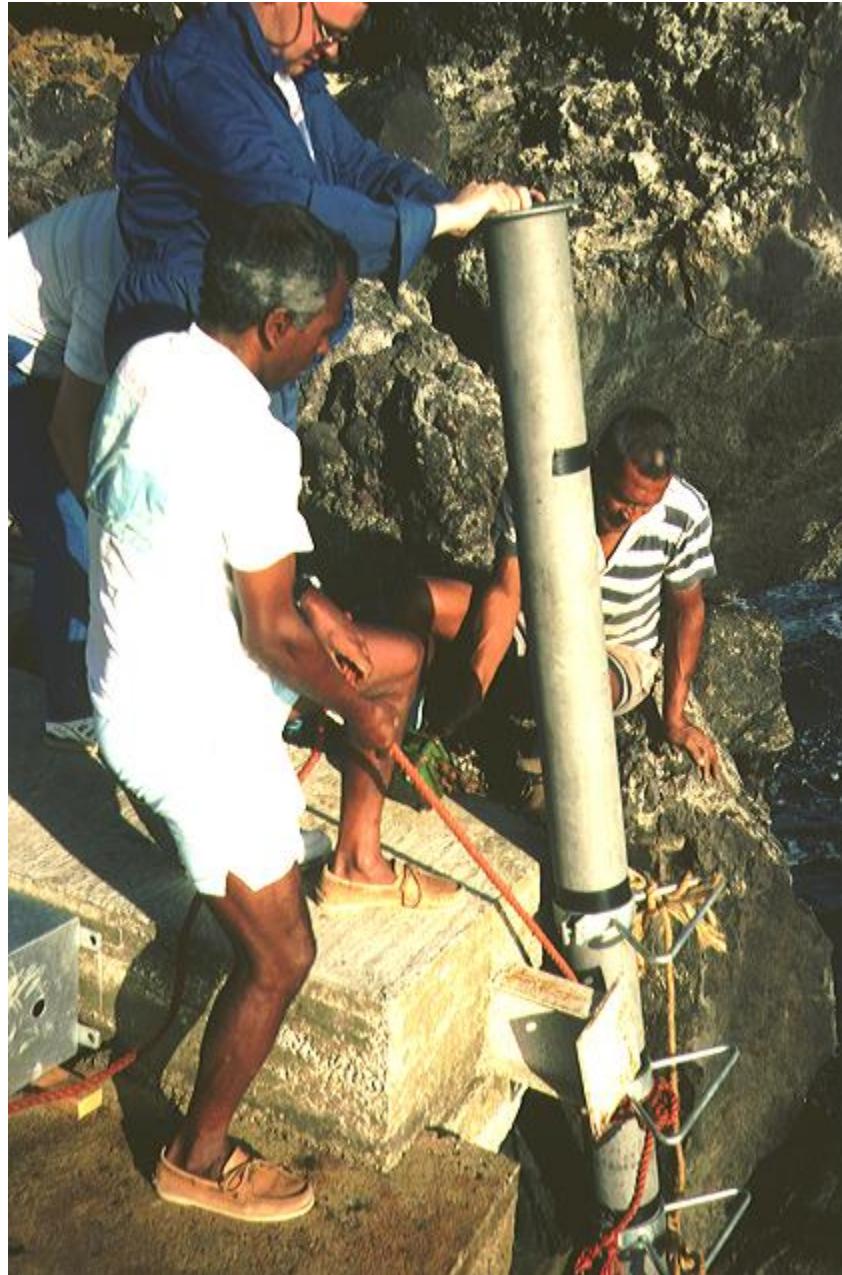
**Schematic of the transducer in the sea pressure system  
Most Appropriate for Tsunami Monitoring**



Schematic illustration of a Triple (or 'B') pressure gauge setup containing three pressure transducers

-This can provide ongoing datum control to the 'C' data but can be very expensive

Installation of a  
'B' gauge –  
See IOC Manual  
4 for more  
details



# Radar Gauges

# Merits of Radar Gauges

- Relatively cheap
- Easily installed (no need for divers or stilling wells etc.)
- Digital so can be ‘real time’
- New technology, but experience so far generally favourable
- Several manufacturers
- But that means not all can be rigorously tested



Liverpool - UK



South Africa





29 7:52 AM

MFIA

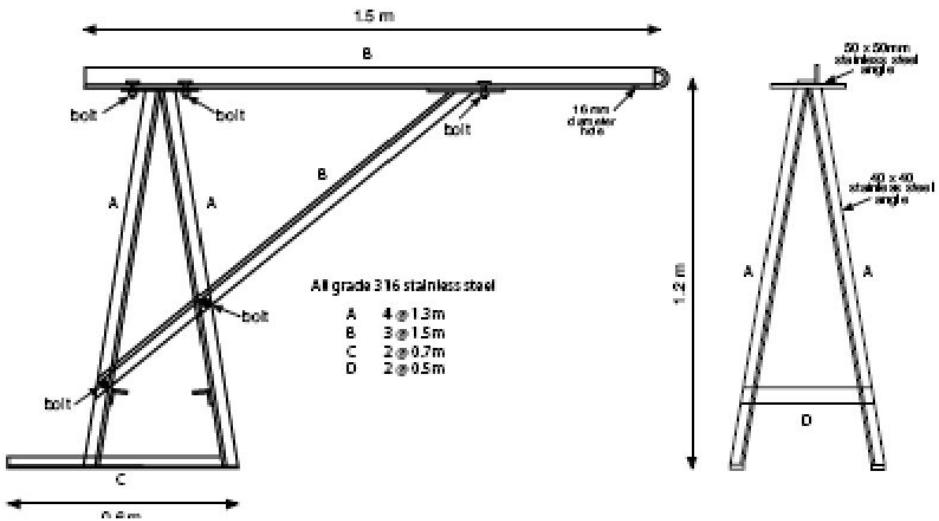


2006 3 8

Kirinda – Sri Lanka

# Infrastructure needed

- An arm for the radar gauge
- Mountings for the pressure sensors (one below low tide and one at approximately MSL)
- A simple stilling well for calibration checks
- Also power etc.
- Note that technical details will be discussed by Peter Foden and Ruth Farre later in the week

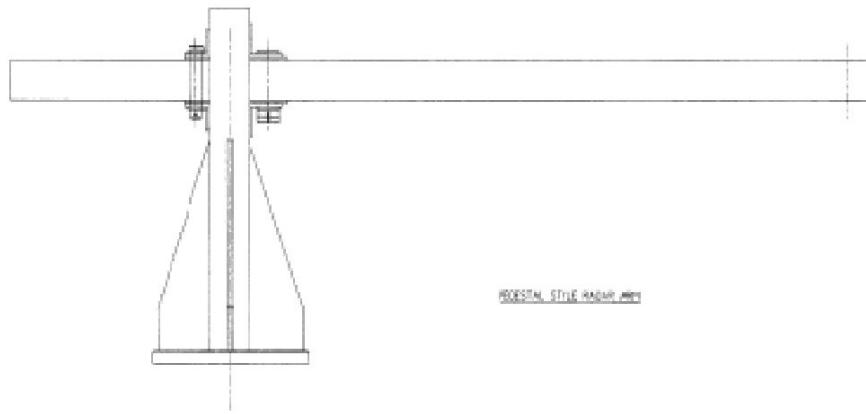
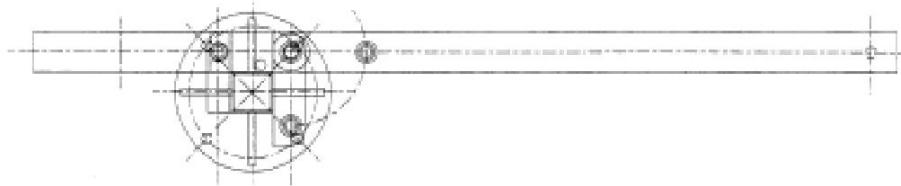


As used at  
Pemba



◀ Assembled davit



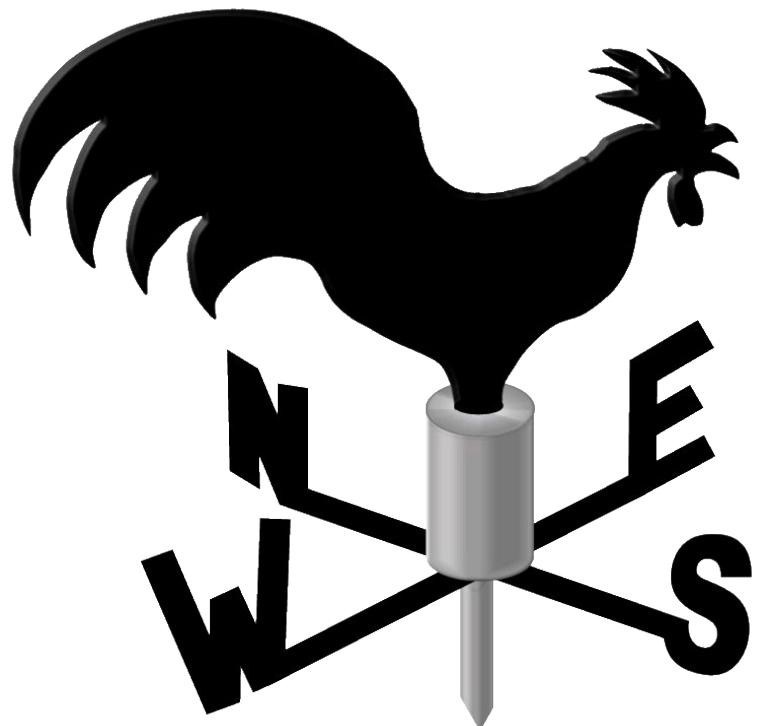


As used at Liverpool

# Other Instruments

# Wind Vane

A wind vane indicates in what direction the wind is traveling.



# Weather Balloon

- A Weather balloon is a mobile weather station sent up to measure atmospheric pressures, temperature, wind speeds and humidity.



# Satellite

- Weather satellites are used for viewing large weather systems on Earth such as hurricanes and other cloud formations.

