# A history of *the rain gauge*

**When you look at a rain gauge, do you really appreciate the thought that has gone into it? I was surprised to discover quite how much work went into its development, and think it important that this early work is not forgotten.**

Originally invented in the Orient the rain gauge was reinvented much later in Western Europe. There is also evidence to suggest that a form of rain gauge was used to monitor rainfall for irrigation purposes in several parts of India as early as the 4th century BC. Research indicates that around AD100 rain gauges were being used in Palestine to measure rainfall, again for agricultural purposes.

In 1910, Dr Y Wada, Director of the Korean Meteorological Observatory, published an article about 15th century Korean rain gauges.

> *'In the 24th year (1442) of the reign of King Sejo, the King caused a bronze instrument to be constructed, in order to measure the rain. This is a vase (30 cm) in depth and (14 cm) in diameter, standing on a pillar. The instrument has been installed at the Observatory, and each time that rain falls, the officials of the Observatory measure the height with a scale, and make it known to the King. These instruments were distributed in the provinces and cantons, and the results of the observations were sent to the court.'*

This refers to probably the earliest meteorological network of any kind. It is astonishing to consider that the form and dimensions of the instrument used are very similar to those of the modern standard Met. Office gauge: 30 cm high, 12.7 cm in diameter.

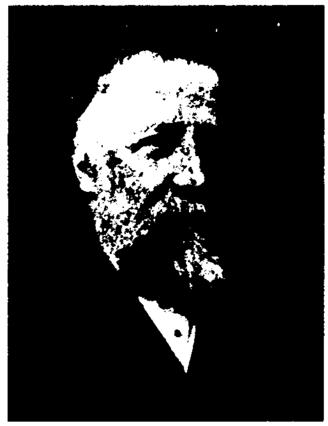
## First rain gauges in England

One of the earliest gauges recorded can be attributed to Christopher Wren, the architectural genius. In 1661 he showed the Royal Society his "Experiment of filling a vessel with water, which emptyed it self, fil'd at a certain hight (sic)." He went on to use this 'tipping bucket' mechanism in a rain gauge that "...at the year's end discovers how much rain has fallen on such a space of land...". It is remarkable that a variant of this tipping bucket mechanism is still used in today's automated rain gauges.

In 1663, Wren produced a recording gauge that worked by bringing a succession of containers under a collecting funnel, one every hour. He abandoned this idea when he realised that the collected rain would largely evaporate before it might be measured. However, the basic idea persisted and is found, in slightly refined form, in a book of machines by Jacob Leupold in 1726. This was driven by a discontinuous motion provided by a one-toothed gear, as shown opposite.

Development continued throughout Europe, but the rain gauges were of such disparate size, shape and mechanism, that comparisons between readings over large areas were difficult to make.

## 19th century work on standardisation begins



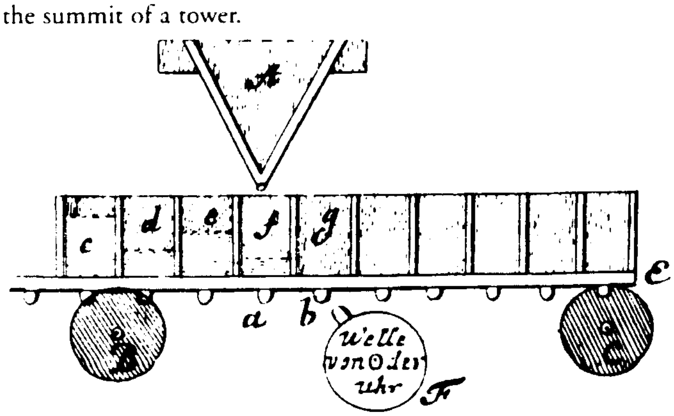
Mr G J Symons

In England, Mr GJ Symons was one of the first to address the problem of standardisation of gauges for use in a network. When he issued his *English Rainfall 1860*, he had to organise a body of observers and determine which instruments and methods were to be used. In 1863, at Calne in Wiltshire, a set of gauges was established, designed to test the effect of aperture size and height above ground level on the amount of rainfall catch.

In 1865, a Mr R Chrimes set up an elaborate set of gauges on the flat roof covering of the Boston reservoir at Rotherham, Yorkshire. As well as examining the effects of elevation, these gauges examined the effect of wind direction and the angle of the mouth of the gauge.

Then, in 1866, the Reverend TE Crallan began observing rainfall catch with gauges of uniform aperture but composed of different materials. After a year, he handed these over to the Reverend CH Griffith, an enthusiastic observer of Strathfield Turgiss Rectory near Reading. Eventually, Mr Symons' early experimental gauges and the gauges at Calne were sent to join the collection of gauges already under Reverend Griffith's care. Experimentation at Strathfield Turgiss carried on until 1870, when it was decided to test in a rougher climate, on the Yorkshire upland, facing the sea, by the Reverend FW Stow.

Further experimentation continued, including an important series of experiments carried out by Mr George Dines in 1877, who used gauges of different sizes and in different positions on the summit of a tower.



In 1881 the results were summarised. Anomalies in the readings at different heights, were shown so it was decided to conduct further tests at a uniform height of five feet above the ground. This was completed in 1890.

## Conclusions from early experiments

### *Material of gauge*

The material of the funnel was found to be important. It should be smooth on its surface and durable in all weather conditions. Consequently, 'ebonite' (a mixture of rubber and synthetic materials) was recommended. However, as this was an expensive material, ebonite funnels never went beyond the experimental stage.

The next best material was copper. This was cheaper and as durable, and, once a thin skin of oxide formed over the surface, it would not change its shape. Its durability also made it a good material for the outer case of the gauge.

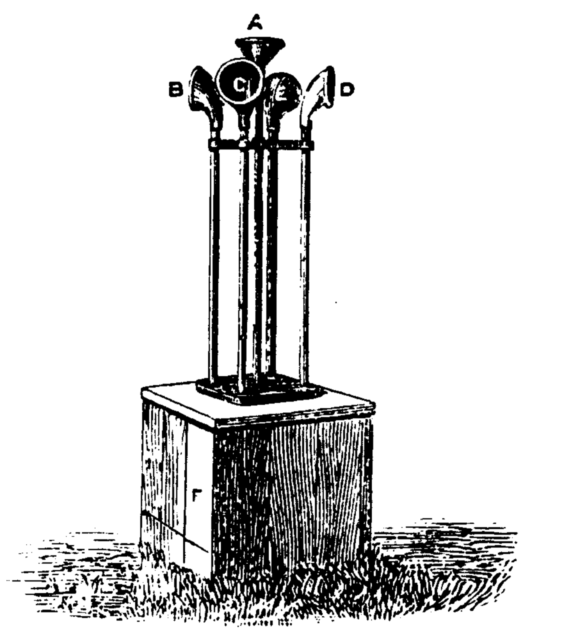
### *Size of aperture*

Different aperture sizes were carefully explored, and experiments were conducted using gauges of one, two, four, five, six, eight, 12 and 24 inches in diameter, with the rim one foot above ground level. The results revealed a fairly close agreement between the catches of gauges from 4 inches to 24 inches, with the smaller gauges collecting a few per cent less rain. After consideration it was decided the best gauge size to use was the one that gave greatest practical utility and this proved to be the five-inch gauge.

### *Exposure and elevation*

The work at Calne in particular showed that, as the elevation of a gauge increased, the amount of rain caught was reduced. When results from a particular day's averages were considered instead of long-period averages, discrepancies would appear that were sometimes so large that it was clear some variable influence was at work. This influence proved to be wind.

Experiments proved that roof gauge readings were extremely variable, depending almost entirely on the wind. It was the first experiments at Rotherham by Mr Chrimes between 1865 and 1872 that really showed the influence of the force and direction of wind on rainfall catch. Consequently, Mr Symons arranged for further experiments to be carried out, including one using the five-funnelled gauge.




*Gauge to estimate the angle and bearing of rainfall. Vertically falling rain would be caught only in A; if the rain fell at an angle of 45 degrees from the west, the vertical gauge facing west and A would catch equal amounts, the others none; and so on.*

The results proved conclusively that the quantity of rain caught in horizontal-mouthed gauges diminished with height. This was because of the angle at which the rain fell, and this depended on the velocity of the wind. However, the story did not end there. More experiments were carried out showing the effect of the locality on the catch. Investigations into where the gauge was positioned in relation to the sweep of the wind were also carried out.

In 1878, Mr Symons summed up the conclusions of all the experiments in his publication, *British Rainfall.*

- The greater part of the decrease (in catch with regard to increasing height) is due to wind.
- The stronger the wind, the greater the horizontality of the path of the rain, and the more horizontal the rain, the greater the decrease in catch with elevation.
- Although the actual total falling at (say) 25 foot above the ground may be slightly less than that at one foot, the greater part of the decrease...is due to the eddies produced by the rain gauge funnels and by the buildings on which they are placed.
- The less the diameter of the elevated gauge, the less it will indicate; the larger the gauge, or the more it is protected from the direct impact of the wind, the more it will indicate.

## Basis of modern-day standardisation

All the experiments were beginning to form the basis of standardisation.

- A five-inch copper gauge was most practical.
- A standard height of rim of one foot above the ground was decided to negate the effects of raised gauges on the rainfall catch — a gauge set lower than this would be prone to increased rainfall readings because of 'splash in'.
- Any abrupt change in the slope of the surface near the gauge should be avoided.
- Sheltering influences, such as trees and buildings, should also be avoided.

Mr Symons urged the importance of uniform conditions on observers, and the numbers of gauges set to his standards increased rapidly and continued to do so for many years. A network of standardised gauges, with readings that could be readily compared, was created.

These standards still apply, and it is part of the responsibility of The Met. Office to visit rain gauge sites and check that these same standards are being adhered to. Only then can the observations provided, which are archived and available to the general public, be used in a meaningful way.