Trouble at mill

Brian Roberts delves once more in the CIBSE heritage files and discovers the importance of the 19th Century mill industry in the development of air conditioning and fire protection engineering.

Reference was often made during the late 18th and early 19th centuries to dark satanic mills, and there is little doubt that the working, social and environmental conditions were often quite appalling. In 1802, *The Health and Morals of Apprentices Act* provided that cotton mills where poor-law apprentices were employed should be properly ventilated at all times (probably the first piece of factory legislation).

However, it took almost 100 years from the *Morals Act*, until the introduction of the first *Cotton Cloth Factories Act*, for a given rate of ventilation (5 litre/s per person) to be specified, being at that time the only class of buildings in the UK for which a definite standard of ventilation was laid down.

The most significant of the early mills is generally considered to be Lumbe's silk mill at Derby (1717). The mill was a five-storey building and all the machinery was driven by a single water wheel of 5·5 m diameter. Other Derbyshire mills followed, but it was Lancashire that was to become the centre of the cotton industry, with ancillary mills and warehouses in Scotland. Other famous mills included John Marshall's Temple Mill in Leeds (1838), built to the design of an Egyptian temple where "in order to maintain the humidity necessary for flax-spinning, the roof was originally covered with turf".

Bernan, in his *History and Art of Warming and Ventilation* (1845), quotes the first use of steam heating in a factory as being for Mr Neil Snodgrass's cotton factory on the banks of the Spey in 1799, although Tredgold in *Principles of Warming and Ventilation* (1824) states it was a woollen mill in Glasgow.

Boulton and Watt used steam heating in a Manchester cotton mill, where the boiler was placed in the basement and the steam was taken through hollow cast-iron columns which served both as heating surface and structural members. The necessary humidity was obtained by watering the floor.

During the next few years, steam heating was installed in a number of cotton mills. One of these was a very large building of six storeys, with a total volume of some 83000 m^3. Buchanan, in *Essays on the Economy of Fuel* (1810), said that in order to heat a cotton mill to 20 or 25°C, it required 1 m^3 of boiler for each 2000 m^3 of space; (a boiler of 0·7 m^3 has an output of 1 hp). Furthermore, with steam at 20 kPa, 1 m^2 of pipe surface would heat 57 m^3 of space.

Early boiler designs were governed by their use as steam generators, and by the methods then available for construction, ie casting or rivetting. Designs were simple. The only heating surface was that which could be licked by the flames and hot gases.

The Cornish boiler with its internal flue marked the first advance towards increased heating surface, but the growth of the Lancashire cotton industry led to demands for larger engines of greater power. This led to modifications to the Cornish design, which were carried out by Sir William Fairbairn in 1885. He made his boiler longer and larger in diameter, and introduced two furnace tubes: this became the Lancashire boiler.

Fire engineering

The frequency of fires in the wooden-framed textile mills of England led to W Strutt's experiments, in the late 1700's, into the use of cast-iron as a structural material. In USA, from 1852 onwards, crude sprinkler systems were developed to protect the roofs of textile mills. These early systems were simple, perforated pipes, with holes of 2·5 mm diameter typically, located some 220 mm apart on opposite sides of the pipes, which were mounted just below the ceiling.

However, these early systems were not without their problems. The holes in the pipes became blocked with dirt or sediment very easily. The system could not be tested without causing water damage, and perhaps its worst fault might have been that it was not selective in operation. Thus even a small fire produced unacceptable heavy damage due to the action of the water sprays.

The first true automatic sprinkler head was that invented by Harrison, a major in the First Engineer Volunteers in London, in 1864. Henry Parmelee patented and put into practice a similar system at Newhaven in Connecticut in 1874, but the most successful of this period was that invented by Frederick Grinnell in 1881.

The mill-owners of New England were the first to co-operate in mutual protection. By 1884 the sprinklers of ten manufacturers were on the approved list for use by Factory Mutual Members. Around this time the first sprinkler installation rules were written and this led to the establishment of the National Fire Protection Association in the USA. Meanwhile, in England, John Wormald of the Mutual Fire Insurance Corporation of Manchester formulated his first set of rules for sprinkler installations in 1885.

These rules were adopted by the Fire Offices' Committee (FOC) in London in 1888, and the first FOC Rules published in 1892.

Throughout the 19th century very little attention was paid to atmospheric humidity, except in connection with the new textile manufactories. It is no accident that that centres of the cotton and wool industries in Britain were originally located where the local climate was particularly favourable.

The effect of humidity conditions on people was considered by Tredgold in 1824 when he wrote, "Continual absorption of moisture from the body produces headache, the eyes feel wearied and painful, and the whole frame is disordered; if you saturate the air, these sensations do not occur, or at least, in a less degree; but whether it is an advantage to live in an atmosphere constantly saturated with moisture, or it is not, I will not pretend to determine".

Early this century, a Home Office Committee reported that injury to health might be caused by continuous exposure to the hot, humid conditions prevalent in cotton sheds; and the *Factories Act* of 1911 banned the use of humidification when the wet-bulb temperature was 24°C or above.

It was not until 1927 that A Bradford Hill showed that there was no statistical evidence to suggest that either the temperature, or the humidity in weaving sheds influenced the sickness rate (this was not necessarily true a hundred years before, and is certainly not the case in other industries, such as steelworks). In Britain, an Act of 1989 had limited the $C0^2$ content in the air of textile factories to 0·09%; but the subsequent Act of 1911 permitted the higher level of 0·12%.

However, it was the need for controlling humidity in textile mills that led to most of the early attempts to regulate internal space conditions by artificial methods. Atomising nozzles were invented by Garland in the USA in 1878-79, and used to humidify the air of a cotton mill.

In an address to the New England Cotton Manufacturers' Association in 1889, Eugene Foss stated, "We take it as an accepted fact that a high and constant humidity in the spinning of yarns and in weaving is necessary", but complained that with the Garland apparatus the moisture was not distributed uniformly, so that the space relative humidity varied with the location of the atomiser.

The American, G B Wilson, in his book *Air conditioning of textile mills* (1908) wrote, "It is readily acknowledged that previous to the adoption of artificial methods (of humidifying), one of the main reasons that America was never able to successfully compete with European countries in the production of the finer qualities of yarns and fabrics was largely owing to the fact that the atmospheric conditions prevalent on this side of the

Atlantic were not as favourable to manufacture as were those abroad".

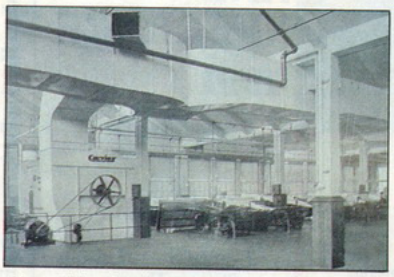
Later on, evaporation of water from pans placed over heating pipes, or from heated pans was used. The Hall and Kay system, used in Britain, worked on the open trough principle. Fresh air was introduced at the end of the trough, and passed out through small air diffusers directly onto the water of the trough. A steam pipe could be used to heat the water to increase evaporation. Hall and Kay went on to introduce a type of washer in which the air was made to pass through a series of filter bags sprinkled with water.

Another device from this time, also developed mainly for use in textile mills, was the spinning-disc humidifier. The British Vortex pattern, or Ventilo-Head unit used feed water under pressure both to drive a water turbine and to humidify the air; the atomised spray being discharged from slots in the periphery of the rotating wheel.

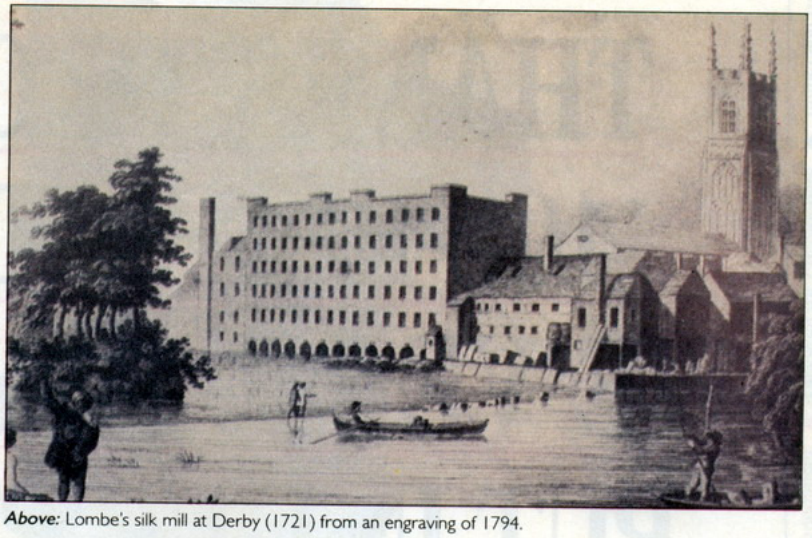
The pioneer of textile air conditioning was, however, Stuart W Cramer (1868-1950). He took out some 60 patents for a variety of devices including a spray-type central station apparatus, a humidifying indicator/controller, and atomising nozzles for humidification.

Cramer has been credited with designing or equipping nearly one-third of the textile mills in the southern states of the USA, but will be best remembered for introducing the term air conditioning at a convention of the American Cotton Manufacturers' Association in 1906. He explained how control of the moisture in the air necessarily meant control of the moisture content of the product, though it was Willis Carrier, often called the father of air conditioning, who made it a practical reality.

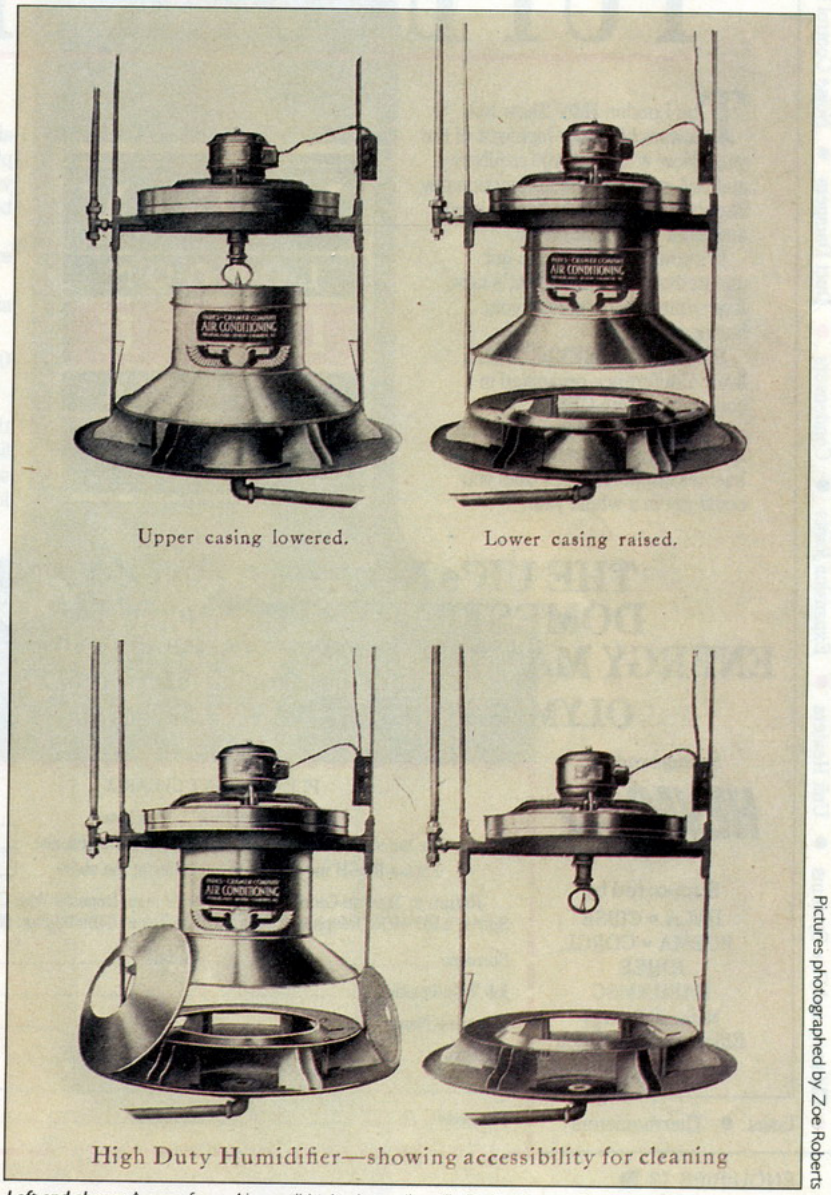
Brian Roberts FCIBSE MASHRAE MIP RP MASPE is Technical Director of Colt H H Airpower and Chairman of the CIBSE Heritage Group.



Above: "The Carrier system of humidifying as applied to textile mills", *Bulletin No.103 (1916).*



Above: Lombe's silk mill at Derby (1721) from an engraving of 1794.



Left and above: A page from *Air conditioning in textile mills*, Parks-Cramer Co, USA (1924).

Pictures photographed by Zoe Roberts