

A COUNT ON HEAT

Until about 1850, heat was regarded as a sensation produced by a weightless fluid. The fluid penetrated all substances, separated their particles by lodging between them and diminished their attraction. It dilated bodies, liquefied solids, and rarefied liquids so much as to make them invisible. The fluid was known as "caloric". When it flowed into one's body, the body was warmed and when caloric flowed out the body was cooled. Quaint and fanciful as it may sound, when you think about it, that is not much different from what we, from our superior C21st intellectual position, call "heat".

Anyone who has studied physics will be generally aware of the work of Rumford in beginning to dismantle the caloric theory, but, will probably not be aware of some of the curious detail. I had visualised a Rumford, Fellow of the Royal Society, somewhat in the mould of Watt or Cavendish. But no. Benjamin Count of Rumford FRS MRIA was in fact an American - Benjamin Thompson born 1753 died 1814. He was granted the title after successfully administering the kingdom of Prince Maxamillian of Bavaria for many years. He was married to the widow of Lavoiser the co-discover of oxygen. Sir James Jeans¹ says he is generally credited with the invention of steam-heating and the shape of the smoke free masonry chimney.

Rumford was aware that a lot of caloric was necessary to turn ice into water. He reasoned then that the totality of the water formed from melting the ice should be noticeably heavier than the ice had been. On conducting such an experiment he found that the weights of the ice and water were the same to a very high level of precision - one part in one million according to Jeans. He concluded that caloric was indeed weightless.

This precision in the comparison of weights would have required a balance of extraordinary sensitivity. By the date of Rumford's ice experiment, the precision beam balance had arrived. Many of the great instrument makers, Troughton, Mégnié, Fortin and Ramsden, designed and built balances based on the pioneering work of none other than John Harrison of marine chronometer fame who had built perhaps the first truly precision balance, for Cavendish, in about 1770-75.

Rumford's perhaps better known experiment arose from his superintending the boring of cannon in the arsenal at Munich. Canon boring mills had existed for some considerable time. Illustrations survive from 1540. They were water or horse powered. By the early C18th they had become the first heavy machinery to work to a reasonable standard of accuracy. They were undoubtedly a spur to the development of the rotary steam engine.

Rumford was "struck by the very considerable degree of heat" of the metallic chips being produced. (Canons were generally bored from the solid at this time.) He did not understand where the heat was coming from. He conducted an experiment to show that the heat was not being generated by the chips themselves.

He then constructed or modified a small horse driven canon boring mill in which a blunt boring tool was run against the end of a hollow cylinder in a tank containing about two gallons of water. After an hour the temperature of the water had increased by 47 degrees to 107 on Farenheit's scale. At two hours and twenty minutes it was at 200 degrees and at two hours and thirty minutes the water actually boiled. The spectators were very impressed.

Rumford was more than a little pleased himself. The supply of caloric from the cylinder to the water appeared to be inexhaustible and Rumford reasoned that caloric could not be a material thing and was more likely to be some sort of motion.

¹ Sir James Jeans, *The Growth of the Physical Sciences*, Cambridge University Press, 1957