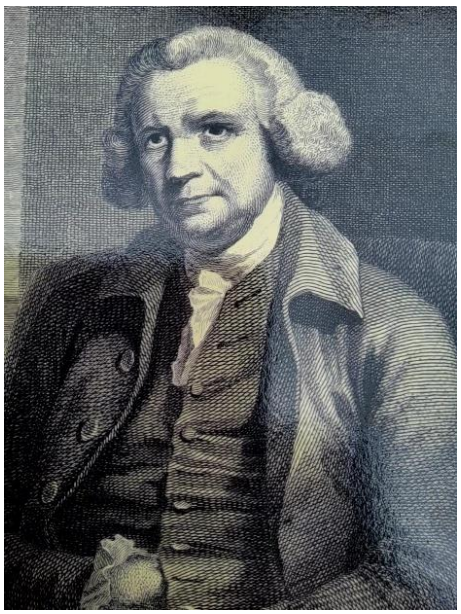
The River Wandle millwork of John Smeaton and John Rennie

John Smeaton (1724-92) was the earliest of the great British civil engineers. Although best known for the Eddystone Lighthouse, and work on canals, bridges, harbours, fen drainage and early steam engines, he also worked on waterwheels and watermill machinery. His work on the efficiency of waterwheels and his pioneering use of cast iron, in addition to wood, marked a step change in mill technology.

John Rennie (1761-1821) was eminent in the fields of civil, hydraulic and mechanical engineering. Two of Rennie's notable achievements were the Bell Rock lighthouse and the design of the first Waterloo Bridge and the London Bridge which replaced the medieval bridge. He was responsible for advances in the use of cast iron mill machinery, and in utilising Boulton and Watt steam engines to drive machinery.



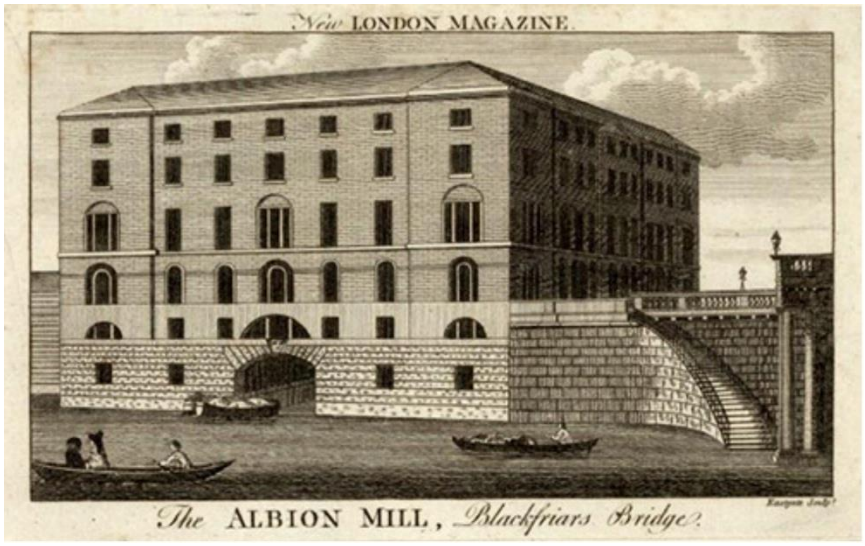
John Smeaton

John Rennie

Both engineers came from fairly privileged backgrounds, were mechanically minded from childhood, and combined theoretical and practical skills. Smeaton abandoned the law to train himself as a scientific instrument maker. He conducted scientific experiments and wrote papers for the Royal Society, of which he was made a fellow. His contacts there led to his first engineering commissions. Rennie learned about mills and millwrighting from a miller on his father's estate. He went on to study at Edinburgh University, attending the classes of Professor Robison who recommended him to Boulton and Watt, who were looking for someone to act as their London agent and to erect the machinery at their planned Albion Mills factory in London.

Rennie established his reputation through his design and construction (1874-88) of all the mill machinery at the Albion flour Mills, adjacent to the south-eastern corner of Blackfriars Bridge. This was the first major factory in London. Smeaton visited it and was impressed. It was ground-breaking for its size - twenty pairs of millstones - and for being steam powered, using two Boulton and Watt engines, each generating 50 horsepower.

Albion Mills rendered its competitors obsolete until it burned down in 1791 after only 3 years in operation. The cause of the fire was never established, although the factory was unpopular with its competitors. William Blake might have had it in might when he wrote a few years later of “dark satanic mills”. Rennie took a lease on the site to use as his mechanical engineering workshop. Rennie’s later involvement in millwork on the Wandle seems to have been lighter touch, usually limited to paying a visit and offering advice in a report. As his reputation grew he became more preoccupied with large civil engineering projects.



Smeaton’s and Rennie’s working method upon receiving a millwork commission was to visit the site to take measurements, then produce reports and/or designs, and subsequently to act as consulting engineers making occasional visits until the project was completed by local engineers, masons and millwrights. Once Smeaton was satisfied he would note the project as a “mill executed”. Smeaton’s home was near Leeds, and he spent a number of weeks in London each year. If visit dates could not be agreed, it is possible that mills and waterwheels built to his designs were not noted in his “mills executed” list. Rennie’s workshop could supply bespoke or “off the shelf” mill machinery, which might have been erected on site by Rennie’s employees and local labour.

There were skilled master and journeyman millwrights working at the Wandle mills before and after Smeaton and Rennie arrived. Those millwrights worked largely in wood. They probably relied mainly on blacksmiths for metalwork. They were highly protective of their craft, regulating their numbers and their pay by means of restrictive indentured apprenticeships, a closed shop policy and strikes or threats of strikes. The millwrights’ restrictive practices survived the ineffective Combination Act 1799, but they were swept away and replaced by mechanical engineering trades by the 1820s with the growth and development under the influence of Smeaton and Rennie of steam power, iron machinery and a larger industrial scale of production for a rapidly growing population. Although Rennie is known to have lobbied for legislation against the restrictive practices, both he and Smeaton as consulting engineers used the services of millwrights and indeed Rennie employed them at his workshop.

Smeaton's millwork

Smeaton demonstrated experimentally in 1759 that overshot waterwheels were the most efficient, and that the weight of water filling a bucket was more powerful than its impact on a paddle. His insight that efficiency could be measured by comparing the power of the water with the useful work produced by the wheel, and the ingenuity of his experiments to measure these quantities, were set out in a paper, *An Experimental Enquiry concerning the Natural Powers of Water and Wind to turn Mills, and other Machines, depending on a circular Motion*, that won him the Royal Society's Copley medal.

Smeaton was also responsible for advances in the design of waterwheels, their housing and their buckets or paddles, realising that the power of any water escaping down the sides or back of the wheel would be lost, and any water pooling under the wheel would slow it down.

Throughout his career Smeaton improved the efficiency of mills by substituting breast-wheels for undershot. This would have been achieved by raising the crown of the fall by means of millponds, leats (millstreams) and sluices, or by lowering the wheel and the mill floor.

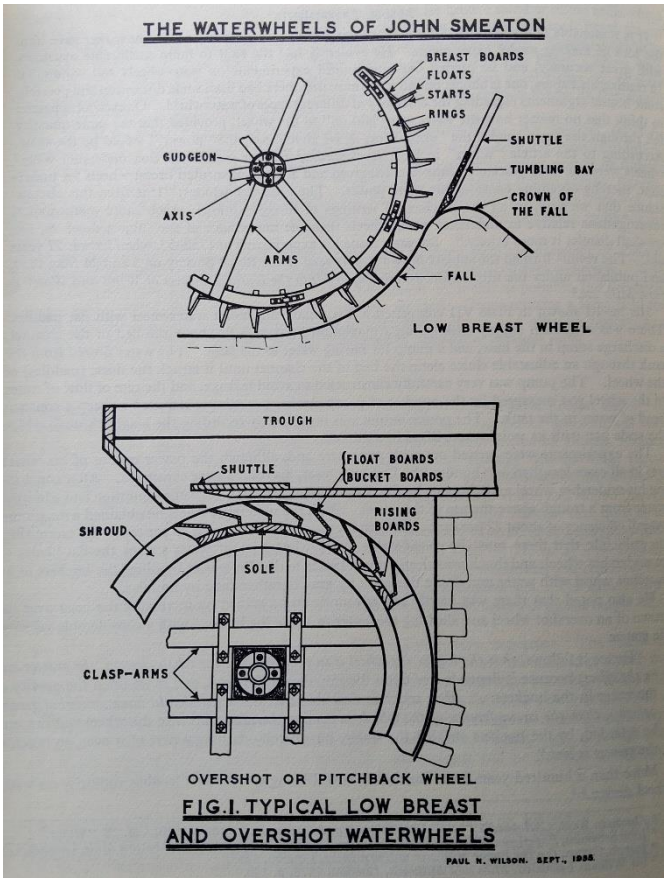
Smeaton designed strong connections between wooden wheel rims and the central axles which transferred the wheel's power to the mill machinery. The transfer of power was achieved by the waterwheel turning the axle, and the same axle turning a cogged pit wheel which drove other gears and shafts connected to millstones, hoists etc.

Smeaton introduced cast iron axles on which to mount waterwheels and to transfer their power to he mill machinery. He also introduced other cast iron waterwheel parts, making wheels both more compact and heavier, enabling a smoother motion.

Smeaton was consulted about the design of all kinds of other mill machinery as well as that found in flour mills, such as blast furnace blowing engines, forge hammers, roller mills, edge tool grinders and boring machines.

Smeaton designed and built steam engines, improving on Newcomen's original model; but he accepted that Watt's condensing engine superseded the most efficient possible Newcomen engine. He used steam engines on some of his projects to pump water back to the top of overshot wheels in order to maintain a regular flow at times of water shortage. Direct use of steam power to produce rotational motion should have been more efficient, but early steam engines were reciprocating beam engines, designed for pumping; and when the motion was converted to rotation by means of crankshafts they could not produce as regular a rotation as waterwheels and indeed were susceptible to stopping abruptly.

The influential engineer William Jessop (1745-1814) was apprenticed at the age of 14 to Smeaton. In 1799 Jessop advised against the construction of a canal alongside the Wandle and as a result the Surrey Iron Railway was built and was in operation between 1803 and 1846. Jessop was better known as chief engineer for the West India Docks and the Grand Junction Canal.



Smeaton's Wandle millwork

Smeaton took part in the design or remodelling of several Wandle mills. His earliest Wandle commission in 1768-69 was by George Shepley and Hugh Mears of "Wandsworth Mill", now known as the **Upper Mills** on Garratt Lane.[1] He designed two low breast waterwheels, 14ft in diameter and 5ft and 7ft wide, with a head of 4ft 8in, to drive these corn mills. The previous waterwheels had been undershot. The mill pond for the upper mills was quite long on 19th century maps, and it is possible that the pond was lengthened to increase the head of water at the waterwheels. This mill figures in Smeaton's list of "mills executed".[2]

Insurance records indicate that the property description changed in 1782 from two separate corn mills to two "water corn mills in one building".[3] This was probably the building shown straddling the river on later maps, and known later as the Eastern Mill or Mill A. If it was rebuilt around 1782, rather than merely given a different description, it is likely that Shepley and his millwrights consulted

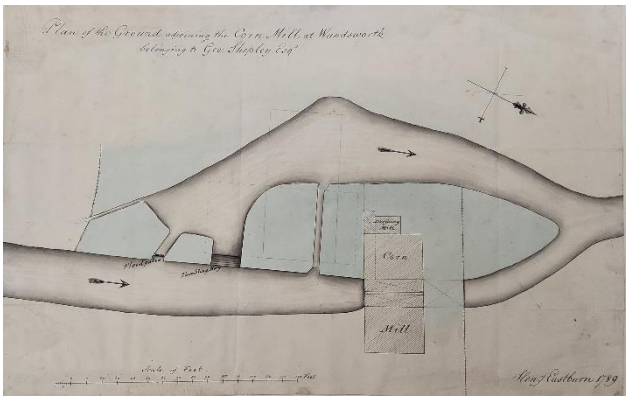
[1] This article uses the mill nomenclature adopted by Peter McGow in his notes on the River Wandle mills, on the Wandle Industrial Museum's website at http://www.wandle.org/mills/millsindex.html

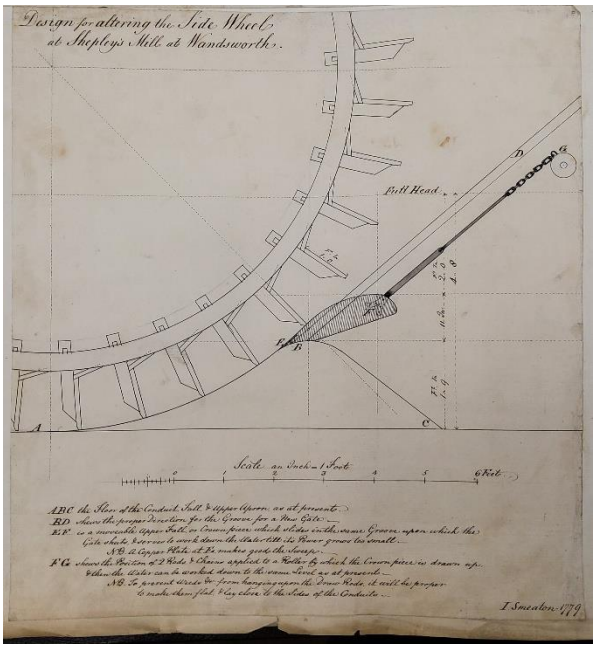
[2] *The Waterwheels of John Smeaton*, PN Wilson, Transactions of the Newcomen Society, Vol 30 1955-57; *John Smeaton FRS*, Ed AW Skempton. These constitute the main Smeaton sources for this article. Both works contain lists of Smeaton's millwork, extracted from Smeaton's own reports. Transcripts of Smeaton's six volumes of reports have been published.

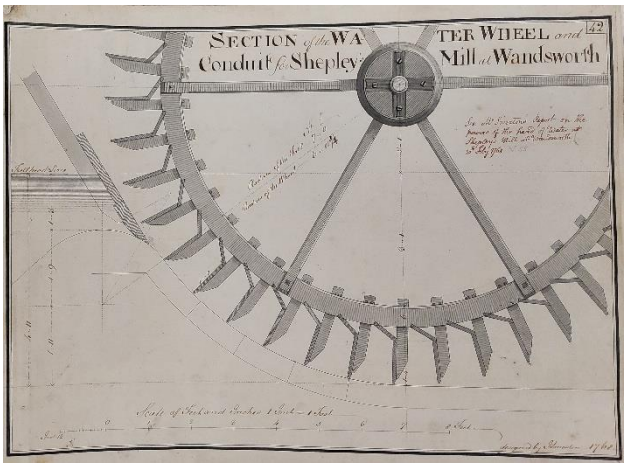
[3] Peter McGow's notes. Most of the references in this article to mill produce, proprietors, millers and insurance records come from this source.

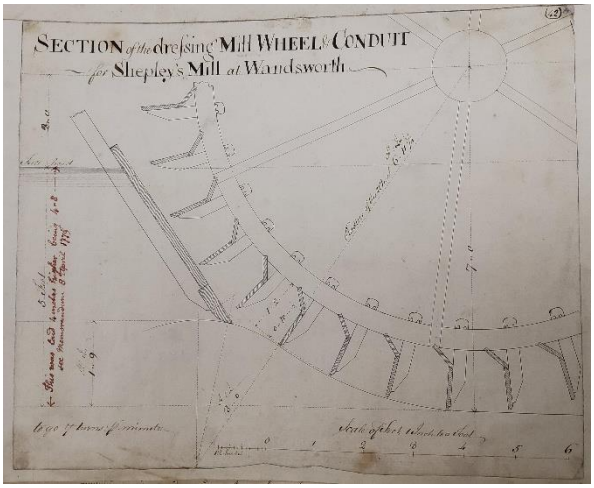
Smeaton on the rebuilding and repositioning of the waterwheels to maximise their efficiency, as Smeaton is known to have corresponded with Shepley family members about their mills between 1768 and 1789.

In 1789 George Shepley commissioned Smeaton to design a new oil mill on the Upper Mills site. He proposed a 16ft by 7ft low breast wheel, with a cast iron axis and some cast iron gearing. This was not on his list of mills executed, but we know that a new mill building straddling a bypass channel a little to the south-west of the main mill was insured as an oil mill in 1791. This later became known as Mill B. It was converted to corn milling in the 1820s.









George Shepley engaged Smeaton again in 1778, to design a new waterwheel for "Carshalton Mill" according to Smeaton's papers, but known now as **Hackbridge Mills, Carshalton**. Their location was just below the confluence of the Croydon and Carshalton streams of the Wandle. Smeaton produced drawings for an 18ft by 3ft 6in low breast waterwheel to operate machinery for an oil mill on a head of 7ft 3in. This was not in his list of mills executed. However, an oil mill was insured in 1779. There was also a leather mill on the site and the oil mill supplied linseed oil for the leather-making process. According to a writer in 1789, the mills burned down in 1783 and had since been rebuilt. Smeaton does not appear to have been consulted on the rebuilding.

In 1779 James Henckell of **Adkins Mill, Wandsworth**, at that time an iron mill, engaged Smeaton to advise on improvements to the operation of the mill. Smeaton proposed a method of repositioning the 17ft 6 waterwheel to become a low breastshot rather than an undershot wheel, by elevating the "crown of the fall" and thereby the head of water. He also designed machinery for the works. The project does not appear in Smeaton's "mills executed" list. Smeaton might also have advised on water management, as neighbouring mills had complained about the mill's management of the flow of the Wandle. Smeaton described the mill as an "iron hoop mill", implying that it used a kind of rolling mill to manufacture barrel hoops, or hoops to connect lengths of hollowed-out wooden water pipe. Later, the mill was said to have produced ordnance, including cannons used at the Battle of Trafalgar. Perhaps Smeaton facilitated the expansion of the mill's output – cannon manufacture would have required a boring machine, and Smeaton is known to have designed those.

John Hilbert acquired the **Upper Mill, Carshalton**, in October 1779. The indenture of sale referred to "three water corn mills under one roof". Hilbert commissioned Smeaton in 1780 to design new waterwheels. Smeaton proposed two options: two low-breast wheels measuring 18ft in diameter by 6ft wide, or two overshot wheels measuring 7ft 4 in diameter and 7ft 6 wide, to operate on a head of about 8ft. Hilbert opted for the overshot waterwheels. Smeaton also designed a cast iron water wheel axle, generally octagonal in section with two circular sections, 7 inches in diameter, for the wheel bearings. At one end a 2ft 6in square box formed the centre for the clasp arms of the pit wheel.[4] Hilbert and Smeaton met in September 1783, together with the millwright James Cooper, to discuss details of the construction of the mill. This mill figures in Smeaton's list of "mills executed", and its insurance value doubled from £1000 to £2000.

The Upper Mill was sold in 1887 and the building was demolished and replaced by water-powered electricity generators which were in use up to around 1924. It is unlikely that Smeaton's wheel lasted until 1924, but his waterwheel pits and central spillway survive in Grove Park, and are the last remaining parts of Smeaton's Wandle mills.

[4] Description and diagram in *John Smeaton FRS*.

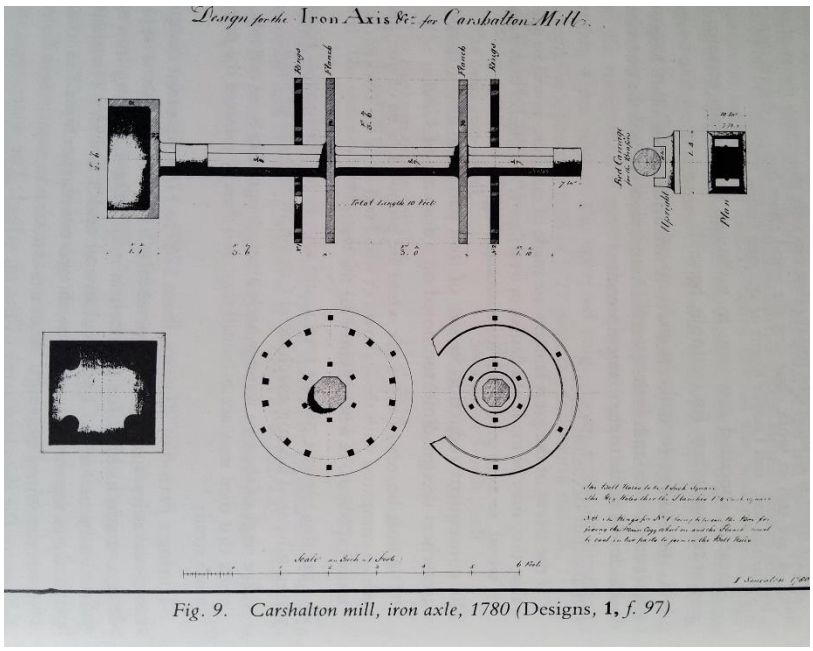
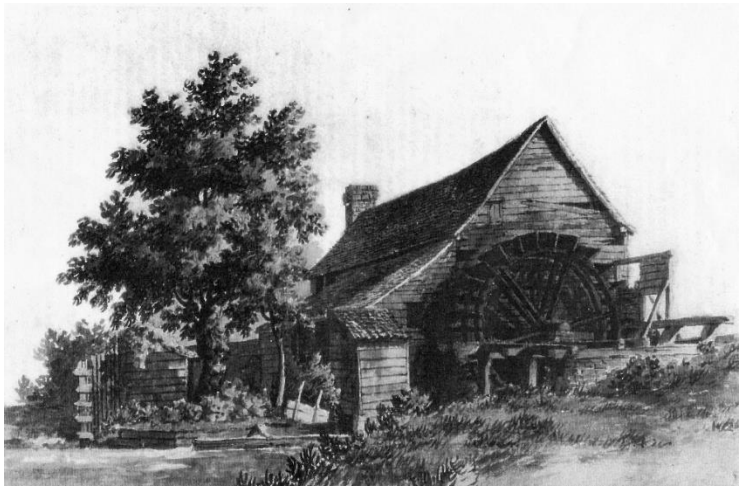


*Fig. 9. Carshalton mill, iron axle, 1780 (*Designs, **1,** *f. 97)*

Hilbert thought highly enough of Smeaton to commission a portrait of him in 1783 by Mather Brown. The present whereabouts of the portrait are unknown. Hilbert commissioned Smeaton again, after he had bought the lease on **Waddon Mill, Croydon**, in September 1788. Smeaton produced a design for a new overshot waterwheel 8ft 2 in diameter and 6ft 2 wide for this corn mill. It is not known for sure whether the wheel was made and installed. It does not appear in Smeaton's list of "mills executed". However, there was an increase in the insurance value of the mill from £800 in 1783 to £1800 in 1791, indicating that substantial work had been undertaken. An auction notice in 1819 indicated that the mill had three overshot waterwheels: it is not clear whether one of these was of Smeaton's design, or whether his wheel had been replaced by then by three new wheels..

Smeaton designed a new low breast waterwheel measuring 15ft by 7ft for William Curteis of the **Paper Mill, Carshalton**, in 1789. Again there is no proof that the wheel was made and installed, but the mill, still under the control of the Curteis family, was rebuilt the following year. It is reasonable to speculate that the new design was incorporated in the reconstruction.



Carshalton Paper Mill

Rennie's millwork

All the machinery at Albion Mills was made of iron, with the exception of some hardwood cogs which were used to reduce noise when engaging with iron cogs. In addition to his use of steam power to drive millstones, Rennie introduced other new applications of steam power there, including the operation of grain cleaning and bolting machinery, sack hoists, and cranes to lift grain and coal from barges on the wharf outside the mill.

Rennie's workshop developed and produced wrought and cast iron gears, shafts and machinery for mills. The teeth of cogwheels, both iron and wooden, were formed more accurately than previously by chipping and filing to the form of epicycloids. A growing population in the late 18th and early 19th centuries required a more industrialised production capacity. Steam power and iron mill machinery could meet that demand.

Rennie's workshop made machinery for all types of mills: e.g. corn, oil, sugar, flax, paper, sawmills, and rolling mills.

Rennie promoted the installation of Boulton and Watt steam engines in mills, and was expert in erecting the engines and connecting them to the machinery of his design that they drove.

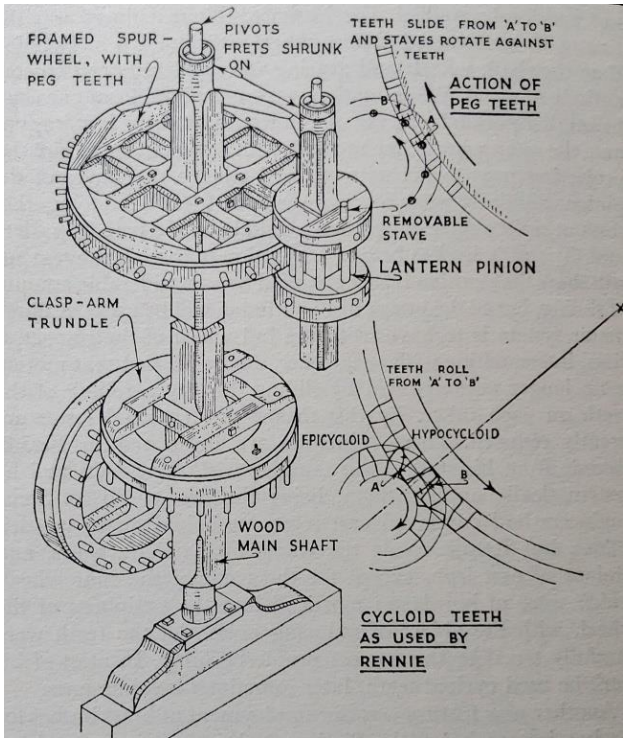
He pioneered the use of centrifugal governors to equate the load of the machinery to the not altogether uniform motion of early rotative steam engines.

He popularised the use of brass bushes for bearings connecting rotating shafts to their housing. There is less friction in the movement of brass on iron than iron on iron.

Rennie also worked and innovated in water millwork. He invented the "depressing sluice", which was lowered rather than raised, to admit water over the top in a thin stream and obtain maximum fall. He also improved the design of the buckets in overshot waterwheels so that the air could escape more easily as the buckets filled.

Others made further improvements, including Poncelet in the 1820s who improved the shape of waterwheel paddles (or buckets) and the sluices (or shuttles) that controlled the flow of water to the wheel. Poncelet was known particularly for improving the efficiency of undershot wheels.

Another later innovation was to attach the pit wheel to the perimeter (or "shroud") of the waterwheel rather than the axle, so that no rotational force acted on the axle. However, this was not possible at mills where the waterwheel was outside the mill building and the axle went through the wall to drive the machinery.



Examples of wooden gearing, and illustration of an improvement made by Rennie

Rennie's Wandle millwork

Rennie's biographer, CTG Boucher, listed the following Wandle mills in which Rennie had some involvement:

- 1797: "Wandsworth Mill, Report."
- 1797: "Perry's Mill at Merton. Report. Perry was proprietor of The Morning Chronicle. He subsequently wrote Rennie's obituary notice."
- 1798: "Beddington Mills on the River Wandle. Examination and report."
- 1803: "Report on Palmer's Mills, Wandsworth."

Boucher did not go into detail on Rennie's work at these mills. His list was extracted from the "Rennie Reports".[5] This article provides more detail from the Rennie Reports and other sources.

The only evidence in the Rennie Reports relating to the **Wandsworth Upper Mills** (to which Boucher alludes as "Wandsworth Mill: Report") is a letter from Rennie to George Shepley in 1797 assessing his loss arising from Gardiner's tumbling bay being 3.8 inches lower than Shepley's. Henry Gardiner was a calico printer who used the meadow adjacent to the Upper Mills as a bleaching ground irrigated by Wandle water. Rennie estimated Shepley's loss of water to be equivalent to a loss of 2.6 bushels of wheat per hour. He added that this figure was uncertain because Henckell's iron mill upstream drew water unevenly, causing variations in Shepley's head of water.

[5] Sources of information in this article about Rennie's millwork are the Rennie Reports, held in the archives of the Institution of Civil Engineers. They comprise 13 manuscript volumes by Rennie and a further 14 handwritten volumes by his son Sir John Rennie. Unlike Smeaton's reports they have not been transcribed and published. A biography of Rennie by CTG Boucher (1963) contains a summarised list of Rennie's works extracted from the Reports: this is reproduced and interpreted in the present article.

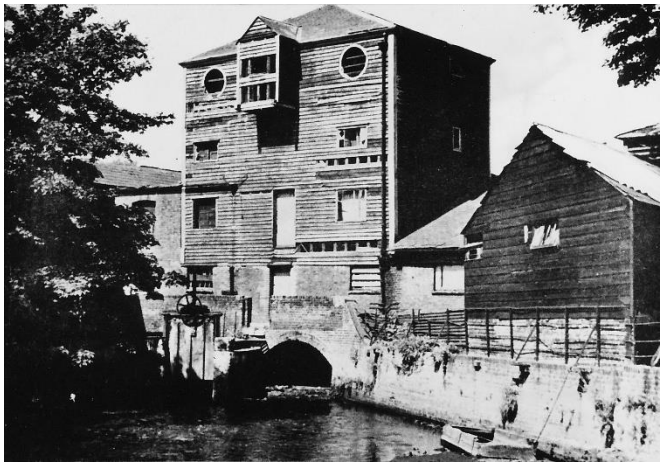
According to Edward Brayley, Rennie rebuilt the Wandsworth Upper Mills shortly after completing the Albion Mills.[6] In that case Smeaton and Rennie might have collaborated, but there is no evidence of this in the Rennie Reports. Nor did Brayley give a source. Brayley went on to say that after the destruction of the Albion Mills, the Wandsworth mills "became the most considerable of the mills in London." Writing in the 1840s, Brayley stated that the Upper and Middle Mills, under Messrs Watney and Wells, worked 31 pairs of stones, which at an average of 1,000 quarters per pair, would produce 60,000 sacks of wheat per year, to the value of £150,000. Milling operations were performed partly by steam and partly by water power; the business employed 26 work horses and 10 or 12 nags; and not more than 50 men were required to prepare and distribute flour to 50,000 persons.

An article published in 1911 claimed that Rennie rebuilt the corn mill (Mill A) on the Upper Mills site in 1818.[7] However, the article gave no source and there is no record of this work in the Rennie Reports. The new proprietor Daniel Watney might well have had the mill rebuilt in 1818, but probably not by Rennie.

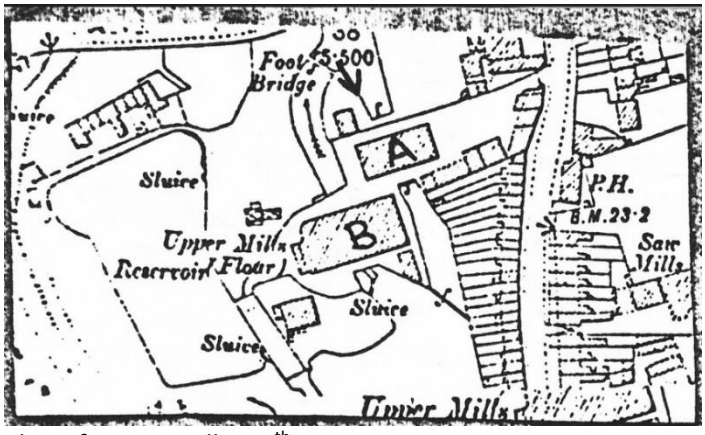
Mill A was an impressive stone-built building, but it was destroyed by fire in 1926. The brick and weather-boarded Mill B, which might originally have been Smeaton's oil mill, continued in operation but flour production ceased before the war. The building was put to various other uses before being demolished in 1962.

Upper Mill A, 1885

[6] *History of Surrey*, Edward Brayley, 1850: vol 5, Appendix, page 26.
[7] *The Mealemen of Wandsworth* by "AEG", Wandsworth Borough News and Battersea Borough News, 1911; reprinted at the time in a compilation by Cecil T Davis, Wandsworth Borough Librarian and local historian. Available to view at Wandsworth Heritage Service, Battersea Library.



Upper Mill B, 1950



Plan of Upper Mills, 19th century

Perry's Mill at Merton, also known as **Merton Mill** or **Connolly's Mill**, carries the plaque reproduced below, claiming that Rennie erected the building shortly before 1800 as a corn mill. The timing is a matter of record, because land tax and poor rate assessments both increased abruptly between 1797 and 1799.[8] The claim that Rennie built the mill is questionable, however. The name "Connolly" relates to the building's last industrial use as part of an extensive leather works. The interior of the old mill building has been remodelled as apartments. It straddles the main channel of the River Wandle (actually an artificial channel created in the 1690s) on the corner of Wandle Bank and Byegrove Road, Colliers Wood. The waterwheel was housed inside the building where the water flows underneath it.

[8] *Mitcham Histories 9: Colliers Wood or Merton Singlegate*, EN Montague; page 87.

Connolly's Mill building, 2021

The Rennie Reports state that Rennie examined the mill's water supply and made a report to the proprietor James Perry in 1797. He advised that an outflow in Perry's millhead which supplied a neighbouring calico bleaching grounds with water was injurious to Perry's business. It seems that the outflow had been blocked with weeds and mud but had recently been cleared and that the flow through Perry's waterwheel was reduced. If two other outflows were also to be cleaned, a sixth of the mill's water supply would be taken and the value of Perry's property would fall by twenty-five per cent. Rennie advised that the abstraction of so much water would probably mean that the outflows were being used for purposes beyond their original purpose, and that a court would probably regard that as unlawful.

The proprietor of the building, James Perry, was proprietor of the Morning Chronicle and a friend of Lord Nelson. Rennie's son noted in the Rennie Reports that Rennie and Perry became good friends (they were both Scottish) after Rennie surveyed the mill's water supply, and that Rennie subsequently examined the mill several times, giving his opinion respecting several improvements which were more or less adopted.

The claim that Rennie erected the mill might have arisen from advertisements of an auction of Perry's estate, including the mill in 1822, after Perry's death. The notices advertised "a water corn-mill, erected by Mr Rennie, at an expense exceeding £20,000", and "...considered equal to any in the kingdom."[9] It failed to sell and the Perry family trustees were obliged to let it out for many years before a leaseholder eventually acquired the freehold. Perhaps potential purchasers in 1822 suspected that the claims made about the mill were exaggerated. Rennie had died in 1821, so was unable to challenge the claim that he had erected the mill.

Rennie's report on the "**Beddington Mills**" proposed the alternatives of a single mill with a fall of 16ft 6 inches, or two mills with lower falls. He gave estimates of the costs and wheat milling capacity of the options. He advised that if one mill be erected it ought to be placed to the north-east of the "Wilderness"; if two mills one ought to be placed on the Oliver Acre field and the other on the Dog Kennel meadow. One large reservoir or pen could be made for both mills, although they could be independent of each other. Rennie's son adds that it was not stated whether this advice was followed or not.

McGow's notes do not say whether any of the mills in the Beddington area were remodelled at the time in accordance with either option. The locations quoted by Rennie do not identify definitively the mill in question. There was a Dog Kennel Meadow near Waddon Mill, Croydon, but that mill appears to have been remodelled in accordance with Smeaton's advice less than ten years previously (see above). There was an area of shrubbery which could have been the "Wilderness" near Beddington Mill, but that was a snuff mill at the time and Rennie had advised on flour milling capacity. There is a Wilderness Island at the confluence in Carshalton of the two branches of the Wandle, but that appears to be a relatively recent name, and the nearest mill to that location was the Hackbridge Mills, which were oil and leather mills and had in any case been rebuilt some time between 1783 and 1789 (see above). There were corn mills at Beddington Corner, Carshalton and Mitcham, but no indication in McGow's notes that Rennie advised on remodelling them.

Palmer's Mills, Wandsworth, did not belong to Palmer. Rennie's son and Boucher identified the mill as Palmer's Mill because one of the documents relating to it was a letter from Rennie to Serjeant Palmer. The title "serjeant" denoted that Palmer was a "serjeant-at-law", a senior barrister. Rennie's letter was his assessment of the apportionment of liability between the Shepley family, the proprietors, and William Holding, the miller, for repairs to the **Middle Mills, Wandsworth**. Rennie was acting as an expert witness in a Chancery suit which appears to have been referred to arbitration with Palmer as arbiter. So the mills in question here were those we know as the middle mills.

Rennie's first report dated 5 March 1804 was to George Shepley. He itemised the work needed to put the watermill into a proper state of repair as follows, using his terminology:

- New bedstone on western side of the mill
- New pair of stones for grinding barley
- Gears on western wheel to be trimmed and repaired, as they now go very uneasily
- New brasses to be put under both shafts of waterwheels
- The curbs to be repaired, those covering the millstones being in bad repair

[9] McGow cited a notice in the Times, 11 July 1822. EN Montague in *Mitcham Histories 9: Colliers Wood or Merton Singlegate* cited a poster or flyer giving sale particulars in Surrey History Centre (G85/2/1/147). George Robins, the auctioneer, might have made exaggerated claims about the mill in an attempt to maximise the proceeds of sale for Perry's family. If so, the plaque is incorrect.

- Another wire machine should be erected, one being inadequate to the business
- The two flour mills to be repaired
- Waterwheels want a considerable number of elbow boards.

He added that "We advise that Mr Holding should have an allowance to keep the mill in repair, otherwise the cost of repairs would exceed any allowance, and the proprietors should retain power of occasional inspection and direct repairs to be done when necessary."

The day before Rennie made this report, the miller William Holding had issued proceedings in the Court of Chancery claiming that George, Richard and Michael Shepley had failed in their undertaking in the 28 Sept 1801 lease agreement to "preserve and keep in repair the mill wheels and machinery and other items not hereby agreed to be repaired by Holding; and to make good any loss incurred by Holding for failure to carry out repairs."[10] In return Holding would pay rent to the Shepleys of 12 shillings per load for the grinding of 50 loads per week of wheat, equating to £1,500 per annum; he would not do or suffer to be done any wilful or negligent damage to the mills; and he would take out insurance of at least £1,500.

Holding claimed that the windmill and wheels "became and were" so much out of repair three months after he took occupation as to prevent him from grinding; he immediately gave the Shepleys notice of this but they neglected to do the repairs. The windmill had been useless since January 1802. (At that time the mill comprised two waterwheels and a windmill. The windmill was an octagonal smock mill which had been added alongside the water mills around 1750.) Holding claimed that he had worked the mills in a workmanlike way and had not done any wilful or negligent damage. He had found that the mills would never have ground 50 loads per week, and were not worth more than a rent of £200 per annum including some tenements worth £40. That was the rent that had been charged to the former tenants, yet Holding was now required to pay an enormous rent of £1,500 per annum without the tenements. The Shepleys had taken undue advantage of Holding. A reasonable rent should be substituted and the 1801 agreement cancelled. The Shepleys had brought actions against Holding in the Court of King's Bench for arrears of rent. The remedy sought was a writ of injunction to prevent the Shepleys from proceeding at law in their actions and to take no fresh actions, and to perform and abide by any order by the judge.

The Shepleys' answer to the bill of complaint, dated 17 May 1804, affirmed that to the best of their knowledge the mills were in good repair when Holding moved in, and Holding had inspected them before signing the agreement. They had never neglected repairs when given notice of them. Holding had been negligent and repairs were frequently wanting due to the bad manner in which the mills were worked. Gudgeons were frequently not oiled as they should have been, and Holding had ground barley on the wheat stones, causing damage and requiring frequent dressing. He had negligently allowed the windmill to rotate too quickly in a strong wind, breaking the main shaft. A scarcity of water in 1803 might have prevented the mill from grinding the required quantity of grain, but the price "frequently rose accordingly" so Holding should have incurred no loss. He might have ground 50 loads a week or more if he had been so disposed, or at least the mill would have enabled him to do so if it had been properly managed. He could have derived considerable profit after paying the £1,500 per annum. The agreement was fair and bona fide and voluntarily entered into and ought not be cancelled. A schedule presented tables of figures purporting to show that in 1799 and 1800 the watermills ground on average more than 50 loads per week.

[10] The National Archives C13/40/18, Holding v Shepley, 1804.

The documents at The National Archives do not include a judgement. There is reason to believe that the judge persuaded the parties to agree to arbitration by Palmer, with expert input from Rennie.

The next document in the Rennie Reports was a report dated 20 July 1804 by Leakin, Edwards, and Williams of their survey of the mills undertaken on 13 July. Moher says that a John Edwards, millwright and pumpmaker, was engaged by Rennie in 1804 to do some millwork in Wandsworth.[11] This report provides the crucial clue that the dispute had been referred to arbitration. The report noted that the watermill had not the power to work more than four pairs of stones and machinery, and the windmill not more than two pairs of stones. The eastern waterwheel was in very bad repair. The wheel and headstone wanted new gearing. There was a 14 ft by 6ft 4 in waterwheel on the windmill side. The windmill was entirely useless and the Shepleys had failed to repair it. The Shepleys had claimed to have carried out the repairs recommended by Rennie in March, but had not done so. The loss to Holding could be assessed by comparing the theoretical quantity that could be ground with the quantity produced by Holding. The arbitration would rely on Rennie's estimate of the cost.

The final document in the sequence was Rennie's report dated 25 July 1804 to Palmer. Rennie itemised the repair work done and not done further to his recommendations in March:

- New bedstone completed but not put to work.
- New pair of stones made and put in place, but not worked as the miller said the bridge tree [a beam in the timber framework supporting the millstones, used to adjust the gap between the stones] was too weak – "this seems a frivolous excuse".
- The gears of the wheel next the windmill have been trimmed.
- One brass only has been done.
- The curbs have had a little repair done.
- No additional wire machine.
- The two flour mills are in the same state as in March, and work indifferently.
- Waterwheels are in very bad repair indeed. One has broken floats. The other has sunk, and the upright shaft is too weak and vibrates a great deal.

Rennie added that the machinery was very old and badly constructed, and kept very short of grease. The state of repair of the tumbling bay was such that much water was wasted.

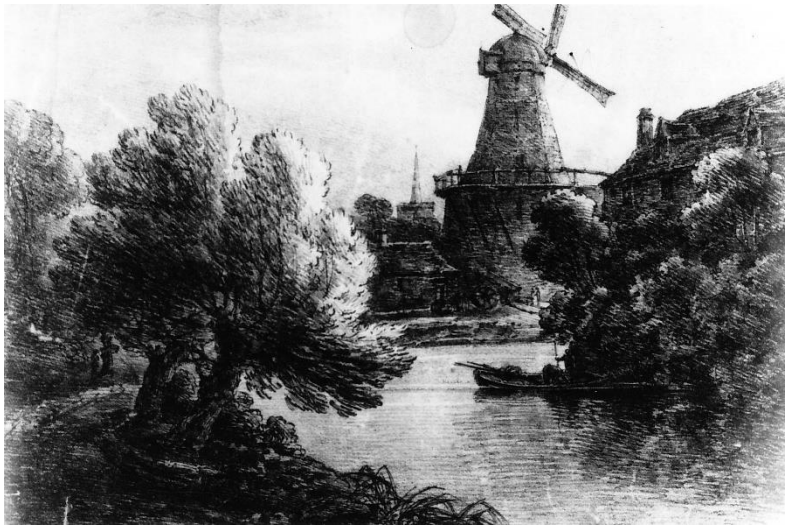
On capacity, Rennie's view was that a complete and modern mill and windmill on the site should manufacture 90-95 loads per week. The present mills, if kept in good order, the wheels and gudgeons well greased, the stones perfectly dressed, and water prevented from escaping from bad tumbling bays and sluices, should be capable of manufacturing 50 loads per week. But in their present state of repair and without the windmill at all there must be a considerable diminution in output. The windmill had been out of action for more than two years, but could have been repaired in 2-3 months and making at least 300 loads per annum.

Rennie concluded: "Had the bad state of the watermill arisen entirely from want of the necessary repairs I should certainly have recommended a considerable diminution of the rent, but as I think Mr Holding has neglected her, the repairs have become more frequent than would otherwise have been necessary. But although I think blame attaches to both [Holding and the Shepleys], yet I think the mill should have been kept in a better state of repair than she seems to have been. What may have been lost on this account must depend on the evidence, for having only seen her twice I dare not

[11] *The London Millwrights*, Dr James G Moher, published by The Mills Archive; page 25.

venture to calculate beyond what I have stated above." The evidence to which Rennie referred might have been that actual output when the defective mill was worked assiduously.

The Rennie Reports do not reveal the outcome of the arbitration. Holding was still named as the tenant in Holden's 1808 Directory, but not in the 1809-11 edition. An ink drawing of 1811 shows the windmill with sails, and a painting of circa 1825 shows the windmill to have been without sails; the windmill was probably demolished not long afterwards.[12]



Middle Mill, 1811, and the River Wandle

Finally, a piece of work not mentioned in Boucher was the procurement in 1811 of a steam engine for **Tritton's Brewery, Wandsworth**. Rennie acted as agent for Boulton and Watt and would have visited the brewery, specified the engine, corresponded with Boulton and Watt's works in Birmingham, and supervised the engine's installation and connection to machinery. It is possible that the engine was used to pump water. The engine was described as a 6 horsepower bell crank engine, with a 16 inch cylinder and a 2 foot stroke.[13] George Tritton (1761-1831) inherited the Ram Brewery in 1786. He was a shareholder in the Surrey Iron Railway and High Sheriff of Surrey in 1811. The brewery was sold to Young and Bainbridge, later Young & Co, in 1831. They procured a Woolf Compound A frame beam engine in 1835, which presumably replaced the Boulton and Watt engine.

Conclusion

Smeaton and Rennie came to prominence as a result of a combination of their own qualities and self-confidence as practical and theoretical engineers, and being in the right place at the right time to influence and take advantage of the industrial revolution. Both excelled in both civil and mechanical engineering. Neither had a traditional mason's or millwright's background and training, but trained themselves to realise their vision. They were prepared to take responsibility for projects of unprecedented size and complexity. They raised the status of engineering, and Smeaton was present at the formation of civil engineering as a profession as a founder member of the Society of Civil Engineers in 1771. They were active at a time when the power of steam was being harnessed and when there was a demand for their services, in millwork of all kinds, the construction of bridges, canals, lighthouses, waterworks, docks and harbours, and the drainage of fens. They paved the way

[12] *The Windmills of Surrey and Inner London*, KG Faries and MJ Mason, 1966; pp 213-214.
[13] Birmingham City Archives, Boulton and Watt collection, MS 3147/5/783.

for later engineers and industrialists who worked on roads, railways, factories and other manifestations of the industrial revolution.

Smeaton seems to have had the greater direct influence of the two engineers on millwork on the River Wandle, mainly through his designs for the prominent millowners Shepley, Hilbert and Curteis. The extent of his personal involvement in the construction of buildings and the erection of machinery on site is not clear. Local masons and millwrights would have been quite competent within their limits. He had an indirect influence over time, as mills had to be competitive to survive, and would have been obliged to replace and upgrade outdated waterwheels, machinery and buildings from time to time.

Rennie's direct engagement with Wandle mills seems, on close inspection of his projects, to consist mainly of visits, surveys and reports for various limited purposes. Only one, at Beddington, might have been a commission for a new or replacement mill. He had bigger fish to fry and probably did not spend much time at Wandle mill sites, but he too must have had an indirect influence on the mills reforming from a cottage industry with wooden machinery to a more industrialised system with steam engines and metal machinery.

The history of the industrial revolution is beyond the scope of this article, but Smeaton and Rennie shaped a revolution in the development of industry on the River Wandle.

Image credits

Smeaton portrait, engraving by W Holl after portrait by Mather Brown. Numerous printed and online sources.

Rennie portrait by Raeburn. Numerous printed and online sources.

Albion Mills: old magazine illustration.

The waterwheels of John Smeaton: Paul N Wilson, *The Waterwheels of John Smeaton*, The Newcomen Society Transactions 30, 1955-57; page 28.

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Middle Mill: Wandle Industrial Museum.