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John Smeaton
The Father of English
Civil Engineering
B.F. Duckham

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By courtesy of the National Portrait Gallery

JOHN SMEATON, 1724-1792, *portrait by George Romney, after Rhodes*

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THE FATHER OF ENGLISH CIVIL ENGINEERING

Born near Leeds, a builder of bridges, canals and an inventor of mechanical equipment, Smeaton was an eminent forerunner of his profession

By B. F. DUCKHAM

"CIVIL-ENGINEERS ARE A self-created set of men, whose profession owes its origin, not to power of influence; but to the best of all protection, the encouragement of a great and powerful nation;—a nation become so, from the industry and steadiness of its manufacturing workmen . . ." Such was the claim of the Society of Civil Engineers in the year 1812 when the industrial revolution was already transforming much of English society and calling into existence public works on a scale never before imagined. Yet only a century earlier the term "civil engineer" was virtually unknown in England, and enterprising traders or landowners who promoted river improvement or bridge-building had often to rely on the services of some scarcely literate millwright. Of the many talented engineers who helped to raise their profession from these humble origins during the eighteenth century, none had a more powerful influence than John Smeaton.

Smeaton was born on or about June 8th, 1724,[1] at Austhorpe near Leeds in a small country house which his grandfather had built in 1698. His father, William Smeaton, was a successful provincial attorney who had every expectation that his son would himself follow that occupation. If we are to believe the evidence of Smeaton's lifelong friend, John Holmes, however, these hopes must have early suffered

[1] There is some doubt. He was baptised on June 24th, 1724, at Whitkirk Church, near Leeds.

History Today, March 1965, 200 - 206.

some diminution. Before he was six years of age the boy had given his elders every indication that his genius had a mechanical rather than a legal bent: " One day," notes Holmes, " he was seen (to the distress of his family) on the top of his father's barn fixing up something like a windmill." On another occasion, he fashioned a pump—which actually raised water—from a few pieces of spare piping discarded by workmen erecting a real pump in a neighbouring village.

Soon afterwards, Smeaton was sent to the Free Grammar School in Leeds, then a small market town pleasantly situated on the banks of the Aire. Tradition has it that geometry and arithmetic made most appeal to him, but records of his schooling are almost completely lacking. At the age of sixteen he started work in his father's office, but was bored by the legal documents he was given to copy. In 1742 Holmes spent a month at Austhorpe Lodge with the Smeatons and found the aspirations of the young clerk far removed from the law. He was astonished at his friend's manual skills and records that as a hobby " . . . he forged his iron and steel and melted his metal; he had tools of every sort for working in wood, ivory, and metals."

William Smeaton persisted only a little longer with his plans for his son. Although John was sent to London to attend the courts in Westminster, his father showed good sense in shortly afterwards allowing him to be apprenticed to an instrument maker. By the time he was twenty-six, he had set himself up in the trade and read his first paper about improvements in the mariner's compass to the Royal Society. In 1753 he was elected a Fellow and quickly attracted the attention of the new President, George Parker, 2nd Earl of Macclesfield, who had been instrumental in procuring the change of style in the previous year.

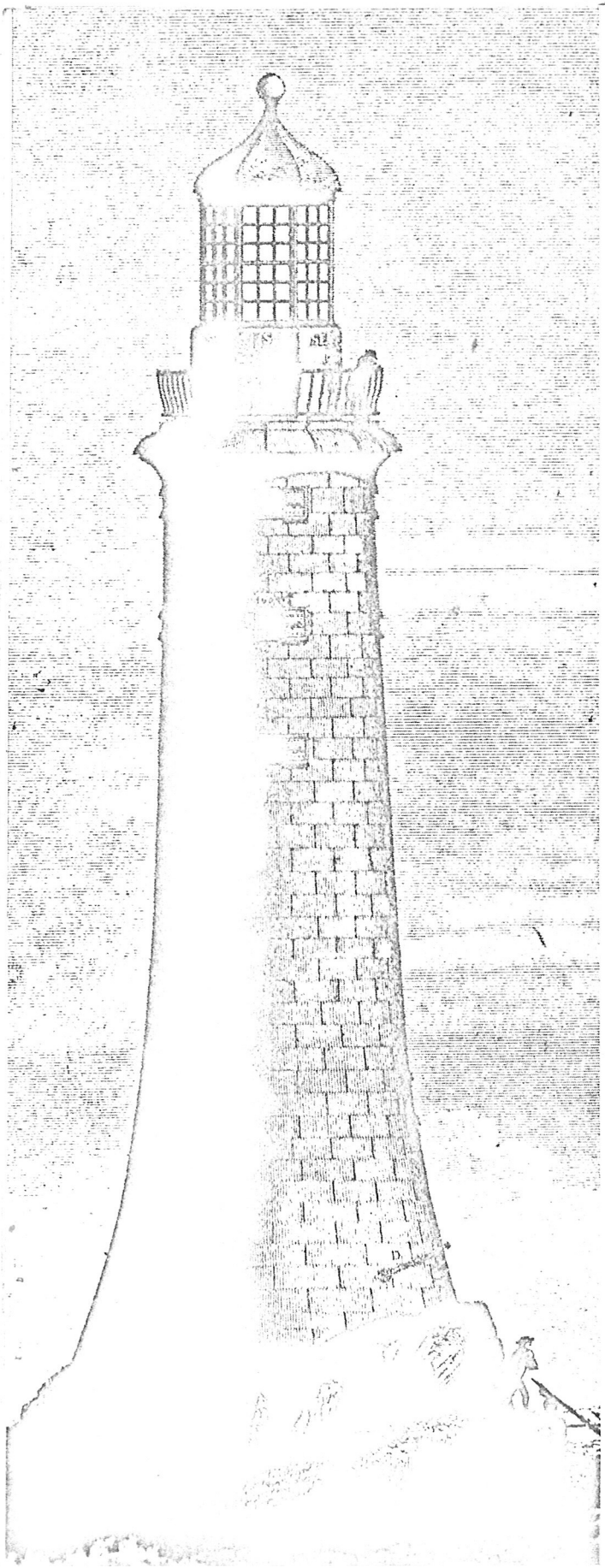
It was 1755, however, which was to be John Smeaton's year of destiny and was to determine the lines his subsequent career would take. In the summer, he visited the Low Countries to study canal and harbour engineering; in the winter, the second Eddystone Lighthouse was destroyed by fire. Both events were to have far-reaching consequences for him.

The journey he undertook through the Low Countries in 1755 provided him with first-hand experience of the methods used by Dutch hydraulic engineers, an invaluable asset for someone embarking on the profession of civil engineer. England already stood on the very verge of the canal age, and Smeaton may well have owed his earliest commissions as a transport engineer to this visit. The diary he kept of his tour shows an intelligent appreciation of the problems of canal and harbour works, and demonstrates forcibly that he already possessed a formidable theoretical knowledge of the subject.

Smeaton was much impressed by such structures as a famous lock at Bazinge, which he described as " one of the prettyest pieces of Hydraulick Architecture that I have seen in my whole Tour," but he was often critical of Flemish wind and water mills. He thought the post-windmills he saw were " built in a very awkward fashion," and commented that the performance of a celebrated mill he was taken to see at Rotterdam " seemed a little clumsy especially the Water Wheel, and in the manner of its taking the water." It may be noted that Smeaton was to become one of the leading authorities of his century on wind-and-water-power and be awarded the Royal Society's Copley Medal for his experiments.

Though chiefly devoted to scientific phenomena, the diary contains several entries that reveal Smeaton as a shrewd and interested observer of life. A staunch Protestant, he was yet capable of attending High Mass at the Jesuits' Church in Bruges, visiting a convent of English ladies, and seeking permission to look in on the worship of a Jewish Synagogue. He seems to have found the last most to his liking. Picture galleries were dutifully visited, though three paintings by Van Dyck left him unmoved and " . . . not remarkably struck with them, for want of being sufficiently initiated in the mysterys of Conoisureship." His visit to the great organ at Haarlem probably gave him most pleasure; yet even here we see the engineer rather than the art lover: " It has 68 stops and 12 pair of Bellows the largest pipe being 32 feet long and 16 Inches Diamr.; being made of Tin, or more properly white Iron."

Five months after Smeaton's return to England, John Rudyerd's lighthouse on the



Eddystone Rock, fourteen miles south-south-west of Plymouth, was burnt down. The principal leaseholder and the prime-mover among the shareholders of the undertaking was John Weston, a man Smeaton later described as " remarkable for his strict integrity." Determined that a new light should be erected within the minimum possible time, Weston wrote to Lord Macclesfield asking his advice on the choice of a suitable architect. The Earl immediately put forward the name of the young man whose ingenuity and close attention to detail had already commended themselves to him.

John Smeaton, it seems, did not at first recognize his good fortune, being under the impression that the lighthouse had merely been damaged. " I concluded therefore," he wrote later, " that the object was to repair or restore the upper works: and therefore I received the call without joy, or indeed much emotion of any kind." By April of the following year he was in no doubt that the commission was worthy of his mettle, and he had considerable trouble before he could even land upon the rock to make a survey. On the 6th of that month he wrote to Weston:

> " . . . Friday last was the first day there was a probability of landing on the rock. We accordingly set out (being near upon the greatest spring tide) the wind easterly, and we came within a stone's cast round the rock, but could not attempt to land, as the sea broke high upon the landing place. . . . It is a most turbulent place indeed, and, had I never seen it, I never should have had an adequate idea of the rock or its situation."

The story of the construction of the third Eddystone Lighthouse has been told many times, not least effectively by Smeaton himself. Here it will be sufficient to note that the novel approach to the problems set and the massive achievement of the completed structure both fired the imagination of Smeaton's contemporaries and established his reputation. Smeaton insisted in building in stone and not in timber as his predecessors Winstanley and Rudyerd had done. Moreover, the huge blocks of masonry were dove-tailed together for maximum stability, while the whole tower was firmly rooted in the rock itself. When the lighthouse had to be replaced late in the nineteenth century, it was because part of the rock had become dis-

View of the Eddystone Lighthouse, 1759; from Smeaton's own account of its construction

lodged, and not through any shortcoming in the design. For those unable to see the original, Smeaton's own model of the lighthouse proved a considerable attraction. " Such were the numbers," he wrote, " . . . that for some years after flocked daily to see the model; that to avoid having the whole of my time consumed in satisfying their curiosity, I found myself under the necessity of deputing Mrs. Smeaton to show and explain the model."

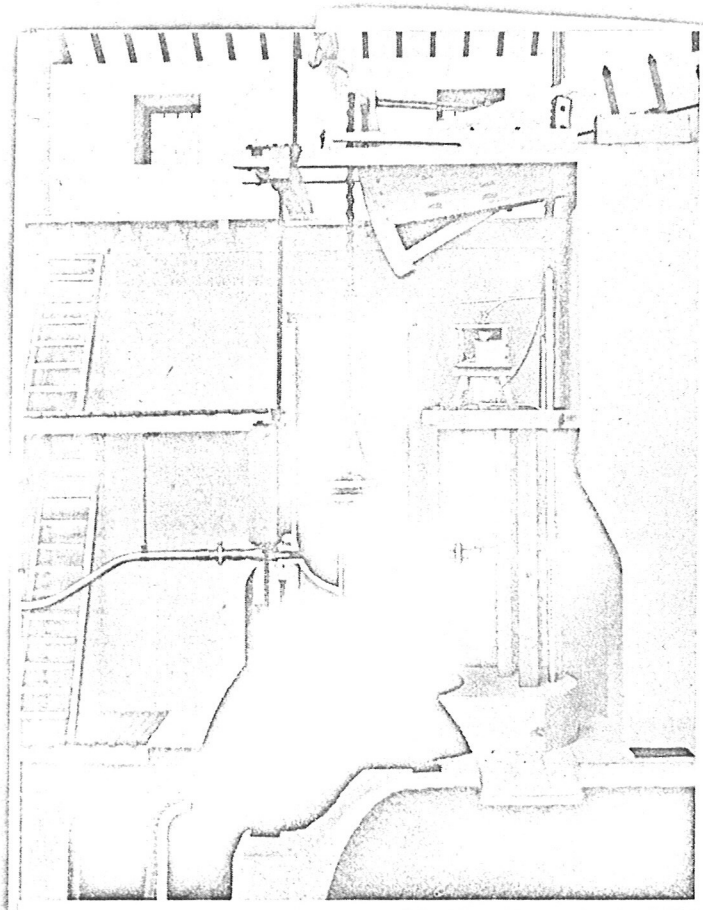
From this time onwards John Smeaton was always in demand for engineering work of one kind or another, though it took several years after the light at Eddystone had been kindled—on October 16th, 1759—before he could live entirely from his fees. Between 1764 and 1777 he acted as one of the receivers of the Derwentwater Estates in order to supplement his income; but there is evidence that by 1770 he usually had enough commissions to keep him fully occupied. The variety of Smeaton's work was considerable, and though it was not yet the age of the specialized engineer—even James Watt had to do his stint of general surveying—the field covered by the Yorkshireman was wider than that of any of his contemporaries. Not only was he in the forefront of the canal builders of his day, but he was also a noted bridge-designer, harbour-improver, and adviser on land drainage. Over and above these achievements, he was a mechanical engineer of more than average ability, though he was a child of his age in the emphasis he gave to wind and water as the prime motive powers. Smeaton's name, it is true, will always be associated with the development of steam power, but it can hardly be coupled with that of Watt who saw its potentialities more clearly.

Nevertheless, Smeaton's improvements to Newcomen's atmospheric engine were important for their day and formed a vital link in the provision of power for the early industrial revolution. It was Watt who provided the engine with a separate condenser and later perfected his rotative motion; Smeaton's role was more humble. His modifications to the valves of the Newcomen engine and use of a larger cylinder—up to seventy-two inches in diameter—soon gave greater power and did a little to reduce the huge quantities of coal that the engine devoured. Smeaton had first become interested in the " fire. engine "—as the atmospheric steam pump was popularly known—when as a child he had watched one working at a colliery near Austhorpe. He was familiar with its many failings and it is to his credit that he raised its efficiency to the highest level of which the machine was capable. Colliery managers were full of gratitude for its improved performance and, since for them coal was cheap, could afford to ignore the greater fuel economy of the Boulton and Watt engine. Many mines persisted with their old beam engines until well into the nineteenth century, and a colliery near Wakefield kept one in use until 1918. Since the terms of Watt's patent were restrictive of other inventors and manufacturers, Smeaton's improvements continued to have significance until anyone was free to build engines with separate condensers.

As regards the development of a steam engine that could provide reliable circular motion, Smeaton was never a challenger for the mantle that was to fall on Watt's shoulders. His mind—always shy of pure theory—seems scarcely to have entertained the possibility, and he preferred where appropriate to harness the power of wind and water. No man ever built more ingenious water mills than did Smeaton; and before the appearance of Watt's " sun and planet " motion they were in constant demand. It was he who provided the waterwheels that generated the blast and turned the boring machinery at Roebuck's great Carron Ironworks in Scotland.

In November 1781, the Commissioners of His Majesty's Victualling Office enquired whether it might not be possible to drive a corn mill directly by means of a steam engine and crank. Smeaton remained stubbornly loyal to natural forms of power. " I apprehend," he told the Commissioners, " that no motion communicated from the reciprocating beam of a fire engine can ever act perfectly equal and steady in producing a circular motion, like the regular efflux of water in turning a mill-wheel." This opinion is perhaps the more surprising since Watt had in the October of that year patented five methods of producing such motion and was by March 1783 able to market a commercially successful rotative engine.

It is as a canal engineer that Smeaton has



By courtesy of the Science Museum, London, S.W.7

A sectional model of Smeaton's atmospheric mine pumping plant, 1772

left more enduring evidence of his ability. He had, however, the misfortune to be the adviser on several projects that never materialized in his lifetime through lack of financial backing. Unlike his great rival, James Brindley, Smeaton never had a Duke of Bridgewater or a Josiah Wedgwood as his employer. But for this, his name would almost certainly be more celebrated than it is. If he lacked the originality and daring of Brindley, he had at least none of his rival's dogmatism.

His first considerable success in the world of canal building was the construction between 1758 and 1765 of the Calder and Hebble Navigation through difficult terrain from Wakefield to Sowerby Bridge, near Halifax. Although technically counted as "river improvement," the scheme did necessitate the digging of many long cuts in a valley subject to sudden and disastrous flooding. During these years he was also called upon to advise the proprietors of the famous Aire and Calder Navigation and, in addition, was consulted about the Witham and Fossdyke in Lincolnshire and the Nith at Dumfries.

The best known canal of Smeaton is the Forth-Clyde canal, though this too was dogged by financial difficulties and was completed by Whitworth after the work had been suspended for some twenty years. The idea of linking the two great Scottish estuaries was by no means new when Smeaton was requested to advise the undertakers in 1764. Powerful backers were behind the plan, including the Carron Iron Company and Lord Dundas; but many differences of opinion as to the course and nature of the proposed canal existed.

Smeaton surveyed two routes for the canal during which time he was troubled not only by the conflicting wishes of his employers, but also by the Scottish weather. He complained bitterly about the latter, with its "violent squalls of wind and rain that occured [sic] the whole time of the survey [and] made it exceedingly difficult and troublesome to manage any instrument for this purpose." The Carron passage, or short route, was the one that Smeaton himself favoured. It ran from Carron Shore, a little above the River Carron's confluence with the Forth by way of Tophill (near Falkirk), Bonnie Bridge and Kirkintilloch, to enter the Clyde at both Dalmuir and Glasgow. The other possible and more northerly route was considerably longer, running from the Forth above Stirling to Loch Lomand, thence by the Leven which enters the Clyde at Dumbarton.

Careful consideration was given to the problems posed by a canal which would have to climb and descend some 158 feet across countryside where concealed rock alternated with extensive tracts of bog. The report Smeaton submitted to the promotion committee in December 1764 was a model for any engineer. It was exhaustive in its treatment, yet clear and firm in its recommendations. For an outlay of some £79,000 he estimated that a canal could be provided for vessels drawing four feet and measuring seventeen and a half feet in beam. The scheme met with the approval of Lord Dundas; but the committee

procrastinated, and eventually distressed Smeaton by calling for the advice of numerous other engineers, including that of James Brindley. Several promoters favoured the construction of a much narrower canal and hoped Brindley would be the designer.

Smeaton, who could seldom suffer fools gladly, was furious. His anger was not improved when the committee sent him the reports of the several engineers for his comments. Never a man to curry favour or to adopt a servile attitude before his superiors, he threatened to wash his hands of the whole matter unless the interference ceased. In October 1768 he told the committee to make up their minds in no uncertain terms:

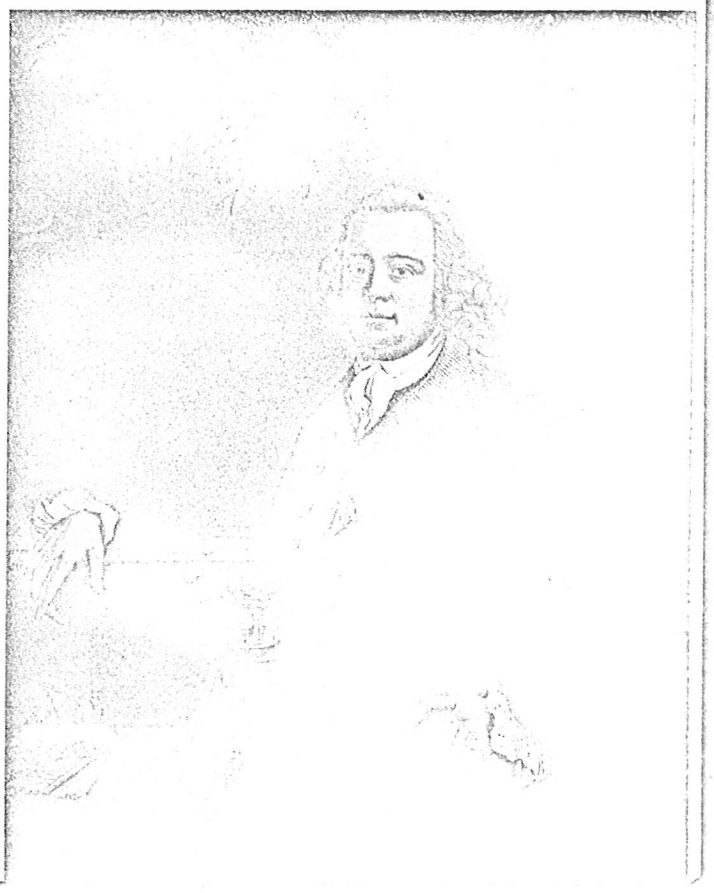
> " . . . if engineers are to be constantly brought down to inspect and see how the pot boils, I think neither I nor any other man can go on with it, to the advantage of the proprietors, under such circumstances, any more than I could sit down at the cross of Edinburgh, and write this answer to my brethren, while every one at pleasure had an opportunity of overlooking and asking me why I began this paragraph in this manner, or treated that subject thus. . . . All the favour I desire of the proprietors is, that if I am thought capable of the undertaking, I may go on with it coolly and quietly, and whenever that to them shall appear doubtful, that I may have my dismission."

Nor was Smeaton disturbed merely by this obvious insult to his professional competence; he was piqued when he considered some of the changes Brindley had seen fit to make in the original suggestions. It is difficult not to feel some sympathy with Smeaton, since he had at least studied the problems thoroughly, while his rival had drawn up his own ideas on the basis of only a brief survey. Brindley's cardinal error—over which Smeaton quickly poured scorn—was to bring his preconceptions about a Midland narrow canal with him to Scotland. " As no difficulty is too great for Mr. Brindley," commented Smeaton, " I should be glad to see how he would stow a fire engine cylinder cast at Carron, of 6½ feet diameter, in one of his seven feet boats, so as to prevent its breaking the back of the boat, or oversetting."

Brindley also proposed digging the canal from the summit and working simultaneously in both directions, as it was " his constant practice to do so." " Pray Mr. Brindley, is there no way to do a thing right, but the way you do? " was Smeaton's rejoinder. He prophesied that the former millwright would not " . . . finish the canal in four years, as he asserted, nor as I think in twice four . . . " and pointed out that it was bad practice to begin with new workmen on the most difficult part of a project.

In the end Smeaton won the day, for when operations actually commenced they were substantially to his plan and not to that of James Brindley. Though some fur had been made to fly, the two engineers continued to have a healthy respect for each other, but it is clear that their relationship never bordered on affection.

In the sphere of bridge building Smeaton was responsible for several truly noble structures in stone that were in no way inferior to those that the great Thomas Telford later erected in the same material. Smeaton's larger bridges were all built in Scotland, notable examples being at Perth, Banff and Coldstream. His only considerable bridge in England, that across the Tyne at Hexham, collapsed during a severe flood in 1782 and has the distinction of being the only work of the engineer that can be



Smeaton's great rival, the engineer, JAMES BRINDLEY, 1716-1772; *engraving by H. Cook*

By courtesy of the National Portrait Gallery

classed as a failure. To Smeaton the credit is due, however, for the creation of a bridge at once more intangible but lasting: that which joins the civil engineer to the public he serves.

John Smeaton was the first Englishman to style himself *civil engineer* in the French fashion. In all probability he originally had the simple intention of distinguishing himself from military engineers; but through his achievement and public life the term soon came to be a guarantee of professional integrity. From the very beginning, Smeaton was anxious to foster a code of ethics for engineers, both by practice and precept. He held, and often stated, that " the abilities of the individual are a debt due to the common stock of human happiness "; and he always refused remuneration in excess of what he took to be a just payment. It was an iron rule with him that any commission about which he entertained serious doubts must on no account be accepted. At a time when there was no regular form of training for civil engineers, it was moreover fortunate that the father of the profession should take an active interest in the welfare of his younger colleagues. Of his " pupils " perhaps William Jessop achieved most fame.

It would have been fitting had Smeaton been the founder of the modern Institution of Civil Engineers; in fact, it is Telford who may fairly claim this distinction. Smeaton with a handful of his followers did nevertheless in 1771 agree " that the civil engineers of this kingdom do form themselves into a Society . . . which shall meet once a fortnight on Saturday evens at 7 o'clock." Later, it was named the Smeatonian Society of Civil Engineers in his honour. It was an informal gathering, meeting in London during Parliament's sessions, where members could smoke their pipes and talk over their plans and experiences. Smeaton was always recognized as the most distinguished member; and his own high standards must necessarily have communicated themselves to his companions. It is not too much to claim that it was this society which first made civil engineers aware of the dignity of their calling and of its social responsibilities.

By 1785 the health of the great engineer had begun to decline, and he accepted fewer commissions. In his last years Smeaton spent more time in his house at Austhorpe where he had added a tower containing his study and workshops. He immersed himself in scientific and antiquarian pursuits; his younger daughter, Mary (Dixon) tells us that he frequently devoted long hours to the study of astronomy, and he clearly derived much solace from it. His wife, Ann Jenkinson, had died in 1784, but his two surviving daughters had married locally and continued to be a support to their father. Smeaton's family life had always been singularly happy; and it was not unknown for father and daughters to co-operate over the production of engineering drawings.

The end came on October 28th, 1792. In the previous month Smeaton had been walking in his garden when he suffered a stroke which deprived him of the use of his right hand. He had always dreaded the possibility of outliving his faculties; and he wrote to Holmes a week after the seizure: " I conclude myself nine-tenths dead, and the greatest favour the Almighty can do me (as I think) will be to complete the other part." In the event he met death with composure and even joked with his daughters about his " slowness " to the very last.

In both character and physique Smeaton seems to have possessed many of the attributes popularly held to typify a Yorkshireman. In his prime he was, we are told by his colleagues, " of a middle stature, but broad and strong made, and possessed of an excellent constitution. He had great simplicity and plainness in his manners." Mary Dixon recorded that her father talked little of his work and less of his achievements, and never allowed " the multiplicity of business, and pressure of cares . . . to deaden his affections, or injure his temper." Outside his home, however, it is evident that Smeaton was used to speaking his mind with " a certain warmth of expression " when the occasion demanded. But beneath the brusque manner was a man who cared passionately for his fellow creatures and always had time for those likely to benefit from his help. Perhaps a remark of James Watt would serve as an epitaph: " his examples and precepts have made us all engineers."