

The Newgate prison mill, 1752*

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“Newgate, considered as a Prison, is a Structure of more Cost and Beauty than was necessary, because the Sumptuousness of the Outside but aggravates the Misery of the Wretches within” (William Maitland, *History ... of London*, ii (1756), p.951).

In his later years, the physiologist Stephen Hales (1677-1761) FRS 1717/18, and Foreign Associate of the French Academy of Sciences in 1751 in succession to Sir Hans Sloane, turned his attention to the design of ventilating systems for ships, prisons, &c. He was led into this subject from his experimental work on animal respiration and plant transpiration, which latter he discovered. Some of his extracting ventilating ducts or trunks were worked by little windmills designed by a millwright with scientific interests, Thomas Yeoman (c. 1708-81), FRS 1764. In 1752, Yeoman erected a windmill to work Hales's ventilators on the 20 gun “Sheerness” man of war¹. By June 1754 he had put up another to work those on Maidstone gaol, and by 1758 he had erected other windmills to work the ventilators of Bedford and Aylesbury gaols, and of St. George's Hospital, London².

Manual ventilators were fitted in Newgate when Sir Richard Hoare was lord mayor (i.e. 1745-6), and ventilated five chief wards (rooms) where the women were. A little toy size windmill, probably with copper or brass sails, twirling in the mouth of the extraction trunk, caused a bell to ring continuously, in order to keep the men labouring at the ventilators on their toes (the same system was used at Winchester hospital). The Newgate manual ventilators fell into disuse, and nothing was done till Hales's ventilators, worked by a windmill on the leads, were installed in Newgate prison in 1752, as a delayed response to a major outbreak of gaol fever (typhus) there, which spread to the court of the Old Bailey, in 1750, delayed by the question of whether to rebuild the prison or not. Hales himself, attending the Old Bailey as a witness in May 1750, had experienced the offensive smell there.

William Maitland, in his *History and survey of London*, second ed., ii (1756), p.951, wrote of Newgate that it

is a dismal place within. The Prisoners are sometimes packed so close together, and the Air so corrupted by their Stench and Nastiness, that it occasions a Disease called the *Gaol-Distemper*, of which they die by Dozens, and Cart-loads of them are carried out and thrown into a Pit in the Church-yard of *Christ-Church*, without Ceremony; and so infectious is this Distemper, that several Judges, Jurymen, and

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Lawyers, &c. have taken it of the Prisoners, when they have been brought to the *Old-Baily* to be tried, and died soon after; of which we have had an Instance within these seven Years The City has been so good lately as to introduce a Ventilator on the Top of *Newgate*, to expel the foul Air, and introduce fresh, to preserve the Prisoners Health; and the Prisoners are many of them kept in distant and more airy Prisons, till within a few Days before their Trials. Sweet Herbs also are strewed in the Court and the Passages to it, to prevent Infection; and the Snuffing up Vinegar, it is said, is the most likely Way to preserve the Healths of those that are obliged to attend such Trials.

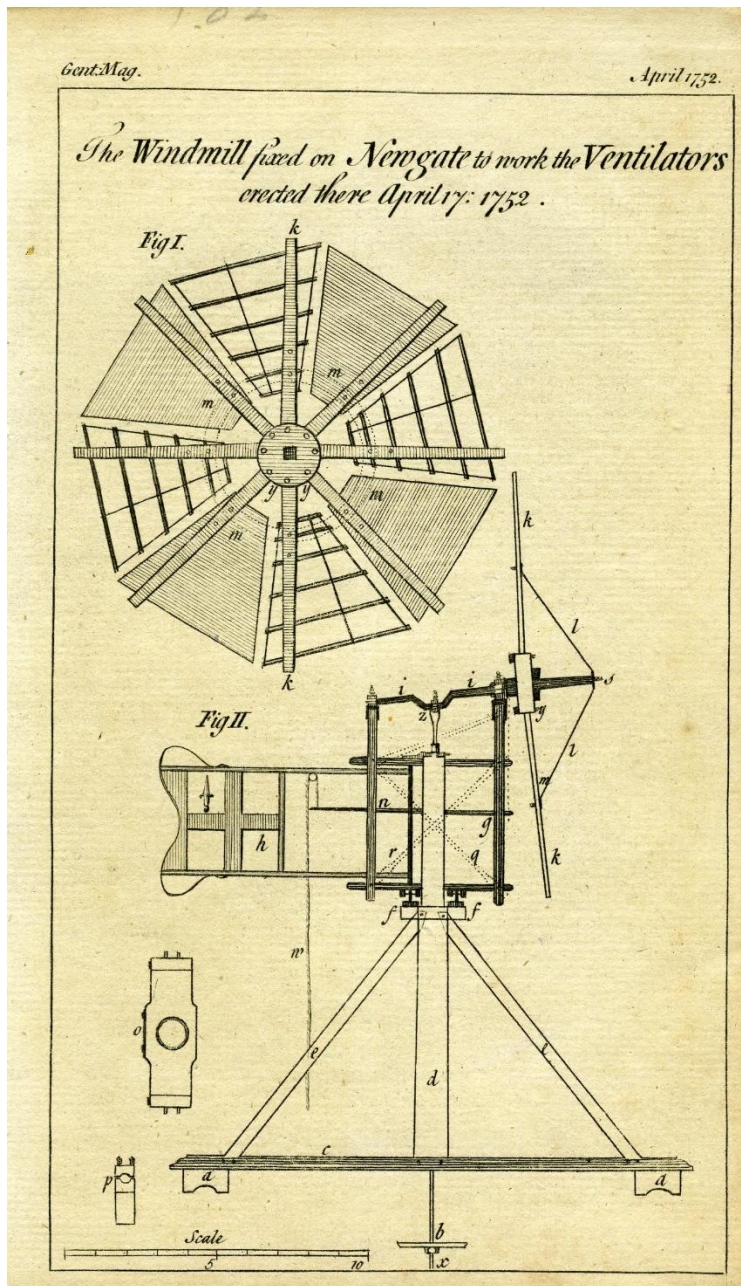


Fig. 1: "The Windmill fixed on Newgate to work the Ventilators erected there April 17: 1752" – engraving from the *Gentleman's Magazine*.

Immediately on their completion, ventilators and mill were well publicised by a description and two copperplates in the *Gentleman's Magazine*, April 1752, pp.179-182 (fig. 1). This was deliberate promotion by Hales of the "humane and laudable" example of the City of London, and he immediately sent copies to interested parties in France, Italy and Germany. One of these was the French botanist, agriculturist and technical writer Henri Louis Duhamel du Monceau (1700-1782), who published the view of the sails in it in his *Traité de la conservation des grains...*, new ed., Paris, 1754, plate 7 fig.3, a careful copy. "M. Hales has sent me the exact description of the machine [mill] which he has had constructed at Newgate gaol", he wrote (pp.212-213), here are the sails, but he (Duhamel) intends to publish the whole in the *Journal Oeconomique*; but it does not appear in this Paris journal. Duhamel describes Hales's ventilators in detail, which he calls the best available (p.252f and plate 12), and has a short account of the Newgate ones, p.211. The mill, wrote Hales in the *Gentleman's magazine*, was "designed and contrived to move with a small degree of wind, and withal to obtain a sufficient power in a small compass." The description and copperplates of ventilators and windmill were republished in Hales's *Treatise on ventilators*, pt. 2, London, 1758, p. 31f and plate 4; the windmill is a careful re-engraving, drawn in reverse (except for the City's arms). The *Universal magazine of knowledge and pleasure*, London, June 1752 issue, plate opp. p.273, redrew the windmill as a spirited perspective view. The text is simply a précis of the *Gentleman's Magazine* account, so there is nothing to say if the changes, such as the stage (see below) spring off the trestle, and the pent roof, are based on what was there, or are imagination.

The ventilator itself comprised a very large box beneath the leads divided into four big compartments, two over two. Each compartment contained a large (wooden) "midriff" or diaphragm laid flat, 9' long by 4½' wide (2743mm by 1372mm), hinged at one short end and moving up and down through 15" (381mm) at the other. A system of one-way valves ensured that on each up stroke of the midriff, air was sucked in below it and expelled above it; on the down stroke, new air was sucked in above, and the air below was expelled. The valves were hinged with (moved on) strips (lists) of tanned sheepskin, and in closing fell on strips (lists) of woollen cloth nailed round the valve holes, to break their fall and make them more airtight. The four midriffs were connected to both ends of a rocking lever, itself connected to the reciprocating rod from the windmill. Two main extraction trunks, 12" (305mm) square internally, led air to the ventilators, a single large exhaust duct vented the air above the leads, air so foul that two workmen who breathed it, instantly vomited so violently that they vomited blood. The branches from the extraction trunks to the rooms had manually controlled shutters or slides, so that the rooms could be ventilated in their turns. And in case all the shutters were closed while the ventilators were working, each pair of compartments had an atmospheric valve which automatically came into play to obviate the risk of bowing of, or damage to the midriffs in this event.

The Newgate windmill was built by the Poplar millwright Cooper or Cowper, and is not mentioned in the *Gentleman's Magazine* account of April 1752. In June 1752, Hales wrote:

As to the Windmill, it is a very good one, and so compleatly well made, with strong Iron Braces, and Brass Friction Wheels, or Castors, for the Frame to turn round on an Iron Plate, so as the more readily and easily to turn and face the Wind; that the Millwright complains, that it will be too hard a Bargain for him, if he is obliged to stand to his Agreement, to maintain and oil the Mill for three Years: He humbly prays therefore, that he may be released from that Part of his Agreement.

Hales supported him in this, saying the millwright (i.e., Cowper) built the mill for 50 guineas, that another millwright who had asked him (Hales) £59 for an inferior mill would no doubt have asked £70 for this one. The mill for the "Sheerness" was made by Yeoman, who had recently told Hales in all seriousness that it had cost him £50 over the agreed price. And, Hales concluded:

It was absolutely necessary to fix a Scaffold round the Mill, in order for a Man to stand upon, to furl or unfurl the Sails; this, the Millwright says, was not included in the Agreement to make the Mill for Fifty Guineas³.

The windmill plate in the *Gentleman's Magazine* comprises scaled elevations which show the mill was tailvane winded and had a windwheel of eight broad paddle blades, 14½' (4.42m) in diameter. These had a weather angle of 35° degrees, preferred by Hales on both theoretical grounds "and by experience with a small windmill placed before the nose of my ventilators", and close to the 30° degree weather that the Earl of Northumberland had told him "has been found by experience ... to do very well in such small mills." These angles compare with the maximum heel weather on normal-sized mill sails with variable weather, of 25-27°; and on sails with constant weather, the angle would not be much over half that. The (wrought) iron sail axle is continued forward as a bowsprit, with eight bracing rods to the blades. There is a stiffening iron ring to the arms of 6' outer diameter. The text says the braces are bolted on at the same point, but as drawn they go further out. The sail arms are wood, mortised into a solid wood hub, the bars &c of the light open frames of the sails or blades could be iron or wood. The sail frames are mostly on the trailing side of the arms. They differ quite a lot from 19th century fan blades, but like a fanwheel or a pumping windwheel, they will have a high starting torque, and so extract some air even in a light breeze.

The brake acts round the windwheel's hub. An iron reciprocating rod connects the 13" throw crank of the iron sail axle with the rocking lever working the two pumping midriffs of the ventilator. The three sail axle bearings, two at the ends, one round the cranked part, were split brass rings which could be tightened as they wore. The rod passes through "the main oaken post, which is bored hollow". The mill head framing (if it is three-dimensional, this is not shown) has crossed iron ties "to keep the frame from wracking", turns round the top more slender part of the hollow post, and is carried by

brass friction wheels, 5½" in diameter by ¾" thick, staggered to run at different radii round an iron plate on a collar round the top of the thicker part where the trestle braces die into it. The tailvane is much too close in, the one thing conspicuously wrong with the design. On the face of it, the windwheel is far too solid to the wind, but the blades being open frames, cloth covered, experience would soon dictate how far to spread the cloth. The tailvane bears the City's arms.

The cross-trees scale at 18½', and rest on blocks at their ends through which they are firmly bolted down to the roof (this is essential as the mill is far too light to be stable on the trestle by its own weight). The quarter-bars are called spurs or braces by Hales, but I think we have a normal post mill trestle stressing with the quarter-bars transmitting the mill's weight.

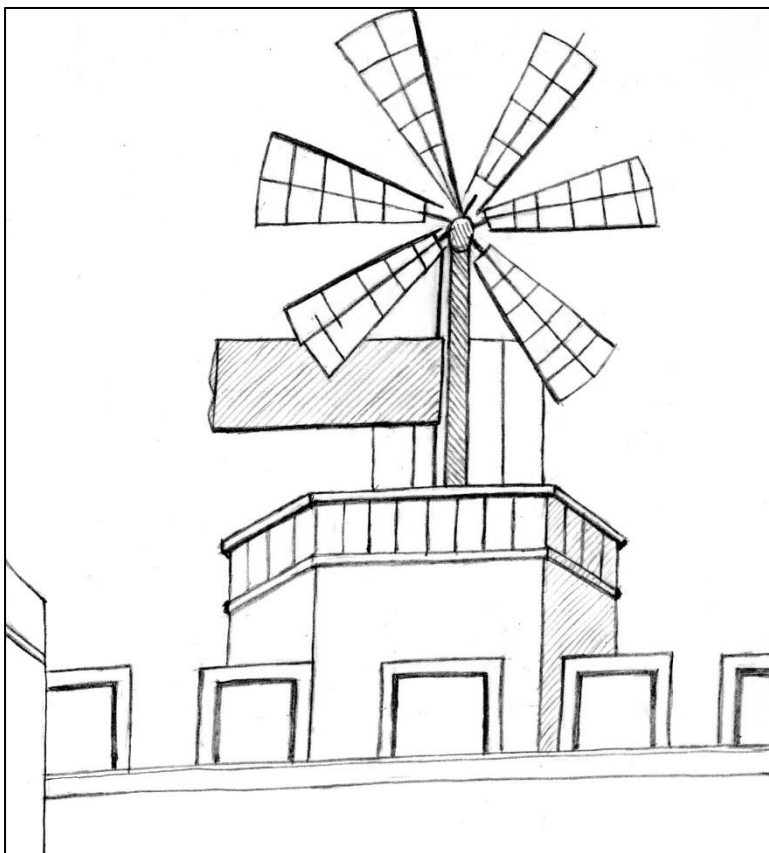


Fig. 2: Newgate jail, ventilating windmill (William Maitland, History & survey of London, 2nd ed., i (1756), frontispiece (detail)).

Two engravings of old Newgate crudely represent the mill as a detail. The first is the frontispiece to William Maitland's *History ... of London*, i (1756) (fig. 2) ; the second is in Walter Harrison's *New ... history ... of London and Westminster* (1775), the plate opp. p.426 (fig. 3). In the latter it has a pent roof and four sails, in the former it has six sails, the sails in both are narrower than in 1752, but I would not read too much into any of this. Both show it placed over an hexagonal or octagonal "base" rising above the ornamental battlements, which must be the reefing stage erected by Cowper, and hiding the trestle. Both hint at the ornamental shape of the tailvane. Maitland's view of

Newgate was the basis of a commemorative medallion issued in 1780 or shortly after, the mill very nicely shown⁴. Though supposedly a straight copy from Hales's *Treatise* of 1758, as re-engraved in Abraham Rees's *Cyclopaedia* of 1819, "Pneumatics" plate 17 (for text, see "Ventilator"), there are quite a few changes in the windmill, notably it has been compressed vertically to fit it on the page.

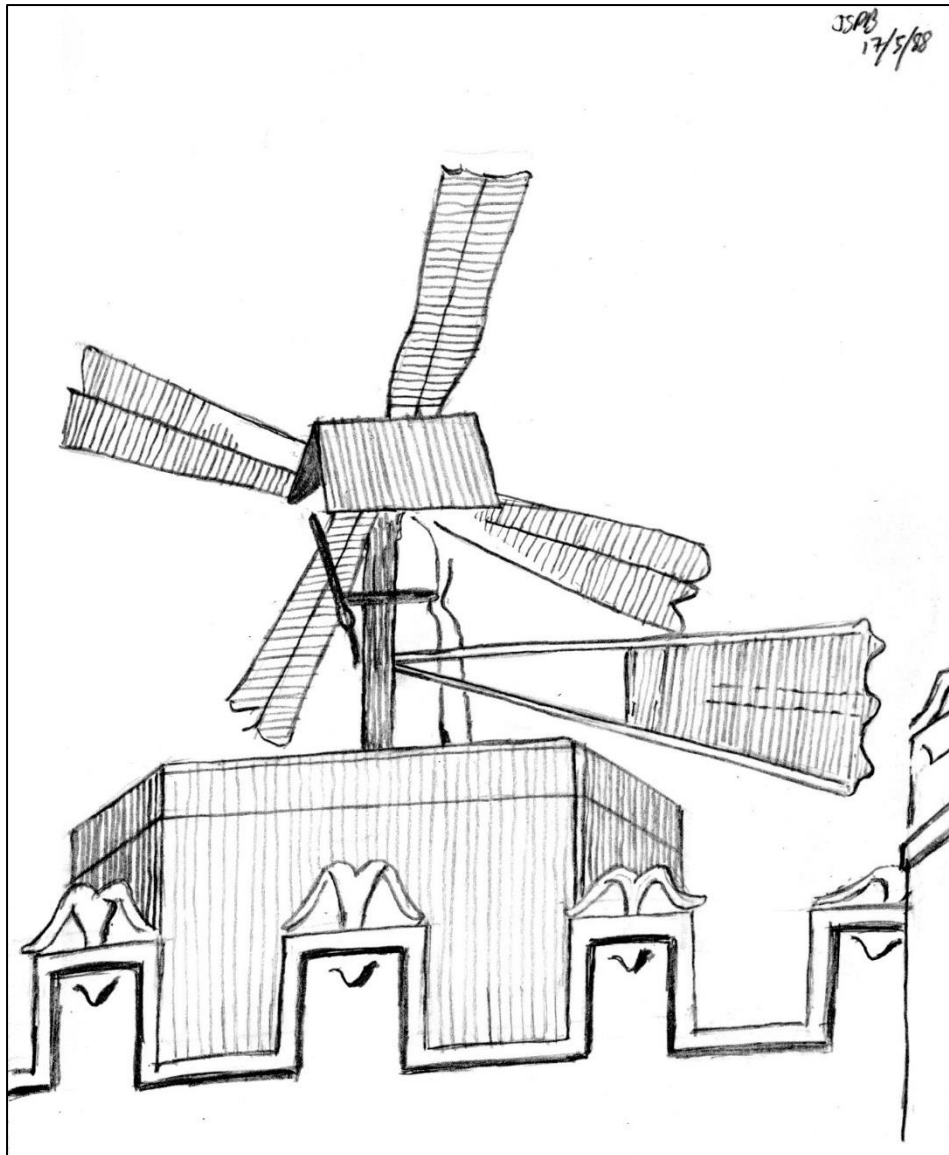


Fig. 3: Windmill ventilator, Newgate (Walter Harrison, *New... history of London* (1775), plate opp. p. 426 (detail)).

I suppose the mill is much like those built by Yeoman. The one he fixed on the "Sheerness" in the same year, about the same time or just before, was a vane winded mill of generally similar construction to judge from Hales's account of it of 1758. Its chief difference was that the eight sails spanned 21' (6.4m). They are bowsprit braced, but are not otherwise described. When fully tested with four sets of ventilators (the same number as in Newgate, but one was largely ineffective) on 11 August 1752, the mill did 20 r.p.m., "all Hatches, Gratings &c. being closed, the Blast of Air into the Ship was so

great through the whole Ship ... [that] the Flame of a Candle, held by the Seams, in almost all Parts, was sensibly blown into them”.

At Newgate, all the branching trunks to the twenty-four wards (rooms) were installed by October 1752, the air being sucked out of the wards in turn. In February 1753, Hales reported a great reduction in the mortality in the jail in the four month period October to January, compared with the same period of the previous six years, but ventilation by itself was a mere palliative to the conditions inside it. On 9 June 1752, Hales and two medical doctors, Knight (doubtless Gowin Knight (1713-72), FRS 1747, first principal librarian of the British Museum, see *DNB*), and Pringle (John Pringle (1707-82), FRS 1745, PRS 1772, Physician-General to the Forces in Flanders 1744, baronet 1766, see *DNB*), went to Newgate and viewed

the Ventilators worked by a Windmill, drawing, like large heavy Lungs, at the Rate of 7000 Tuns of foul Air *per* Hour, out of several Wards at the same Time, which were thereby sensibly sweetened, to the great Comfort of the Prisoners, who informed us with Pleasure, that they thereby enjoyed much the better Health. I think it will be very requisite to have the Mill go as much as it can every Day: And even in Winter to change the Air daily to such a Degree, as it shall be found the Prisoners can bear without Inconvenience. For foul Air long confined, will putrify in Winter, though not so soon as in Summer ...⁵

The air, said Hales, does not have time to stagnate and putrefy, which takes many days, and it is this putrefaction, “which by being the most subtile Dissolvent in Nature” dissolves the blood and humours of our bodies, thereby producing gaol fever. In fact, typhus is caused by a micro-organism whose vector is the tiny body-louse of filthy clothing, but this was not discovered till the early 20th century. Therefore, other causes must explain the reduction in mortality. Perhaps it was the luck of a single short, four month period, or perhaps it was the effect of other changes which were proposed at that time, those of burning brimstone (which repels lice), and of cleaning the wards and scraping their walls. But in any event the wards stank, so the ventilation was welcomed.

The “Tuns” of air are volumes, not weights. A tun of water was the volume of water contained in a tun or cask, whose mass came to be called the ton weight. The weight is therefore, in origin, a derived unit. Doubtless Hales was using the liquid measure, the old beer or ale tun, of exactly $35\frac{1}{4}$ ft³ (0.998m³) capacity, equivalent to a weight of water of c.2196 lb (just below the later metric ton). Duhamel du Monceau in his *Traité de la conservation des grains* (1754), p. 212, it may be noted, takes the capacity of each of Hales’s 7000 Newgate *tonneaux* as forty cubic feet. This would be equivalent to a weight of water of almost 2500 lb. English. Possibly, Hales told him this figure, or he may be using a French *tonneau* (of which there are several) of or about forty cubic Paris feet capacity. Assuming the English ale tun is meant, Hales’s tuns can be imagined as ghostly cubes with sides one metre long, or as ghostly cylinders 3’ 4” in diameter by 4’ long. His

7000 tuns/h is therefore a rate of air extraction of 7000m³/h, 117m³/min, and 2m³/sec (246, 750ft³/h, 4113ft³/min, 69ft³/sec).

Hales was a great scientific quantifier, and was skilled in this class of measurement, so his round-figuring is probably accurate enough. He may have calculated his 7000 tuns/h from the volume of the ventilators, perhaps making an allowance for leakage in them, and for resistance to flow in the ducts. Ignoring these factors, each midriff (9' by 4½', its free end rising and falling through 15") in its box sucks in nearly one boxful of air (nearly, because the box is slightly larger) and expels the same amount for each complete reciprocation of the midriff, above 50ft³ of air (1.4m³). But there are four midriffs, so 200ft³ (5.7m³) are drawn in and expelled/completed stroke. Therefore, to expel 7000m³/h requires 20½ strokes /min, or 20½ r.p.m. of the mill sails, a very likely figure for such a small mill. Doubtless, Hales simply counted the number of strokes. He said the "Sheerness" ventilator conveyed air *into* the ship at the rate of 14,000 tuns/h when the mill did 15 r.p.m., and it could turn faster. The sail span, it will be remembered, was 21'. Earlier, at the county hospital at Winchester, Hales had tested the efficacy of the manual ventilators by filling a ward of length 58' (17.7m) and capacity 278 tuns, with the fumes of burning pitch and seeing how long was taken to clear them. The time nine minutes, which, assuming the air was completely renewed in this time, is 1853m³/h, 31m³/min, 0.5m³/sec (65,330ft³/h, 1090ft³/min, 18ft³/sec). The number of men at the ventilators is not stated, but the useful power output of the Newgate windmill is unlikely to have exceeded about a quarter h.p. or 180 watts, about that of two and a half men working steadily.

The factors to be considered in ventilation are respiration, perspiration and body heat. Then compared with the much later ventilation norm of 350ft³ (10m³)/person/h for prisons and workhouses,⁶ the adequacy of this improvement in Newgate when the wind was blowing steadily (enough for 700 people at the 10m³/h extraction rate), even given the crowding in the four floors of the gaol before the sessions, becomes apparent. Hales's ventilators were made mandatory in the Royal Navy by Admiralty decree in 1756. And by March 1752 they were in use in the vessels of the French East India Co, but, it was claimed, the continuous fatigue to the crew in working them was such that many ships had laid them aside. Nevertheless, Hales's work is thought of sufficient importance for him to be counted one of the fathers of public health.

In June 1752, Hales wrote:

It will be absolutely necessary to have a Man to furl and unfurl the Sails of the Mill, as Occasion shall require; and also to open and shut the sliding Shutters of the several Trunks, daily, that all the foul Wards may be refreshed in their Turns. It is probable that about eight or ten Wards may be aired at a Time.⁷

Although it appears that after some delay this suggestion was carried out, on 15 February 1755, Dr Pringle wrote:

In passing by Newgate, from Time to Time, I am sorry to see the Machine so often standing still, though there seemed to be Wind enough to turn the Sails. I doubt the Effect of that Contrivance is in a great Measure lost, by there being no Person appointed to keep it in Order, to regulate the Sliders, and to turn the Sails to the Wind, when the Wind is too weak to perform that Action itself. But the Truth is, I despair of getting thoroughly the better of the Distemper and Contagion, without building a larger Prison, better aired...⁸

Repairs were made to the ventilators in 1758; their working was interrupted for “many weeks” in 1763; by 1772 neglect had rendered them “totally useless”, but repairs were done in 1774.⁹ In November 1755, it was resolved to erect a new jail, which, after many delays, occurred between 1770 and 1780, when it was promptly burnt out in the Gordon Riots. The old Newgate was cleared away between 1776 and the 1780s. In conclusion, it may be noted that the windmill bears a surprising degree of family resemblance to a very well thought-out self-winding windpump, with a timber hollow post, but largely blacksmith’s work, erected over a well-head in Marseilles, and superbly illustrated in V. (invariably so catalogued but in fact César Nicolas) Le Blanc’s *Recueil des machines, instrumens et outils ...*, ii, Paris, (c. early 1830s). The arms and framework of the six cloth sails are entirely of iron bars and rods, and the sail span is 5.3m (17½’).

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¹ Stephen Theodore Janssen, *A letter to the right honourable the lord-mayor ... and the rest of the ... committee appointed for the rebuilding of the jail of Newgate. From Sir Stephen Theodore Janssen, Bart. Chamberlain of the City of London ...*, London, 1767, appendix VII (Hales to Janssen, Teddington, 10 June 1752, the PS); Stephen Hales, *A treatise on ventilators*, pt 2, London, 1758, pp. 162, 164 (pt. 1 was published in 1743 as *A description of ventilators*, & re-issued in 1758 as *A treatise*, pt. 1).

² Stephen Hales, *A treatise on ventilators*, pt 2, London, 1758, passim.

³ Janssen, op. cit., appendix VIII (account of ventilators and windmill by Hales, (June) 1752).

⁴ *Country Life*, 4 Oct. 1973, p. 1015 fig. 3. Both engravings show the mill central to the gateway. Guidhall print collection, Pr. 446/OLD (2), photographs of 6 MS plans of old Newgate by George Dance sr. (c. 1767), show crossed timbers on the roof scaling at exactly 19’, but they are on one end of the roof, so might be for a flagpole.

⁵ Janssen, op. cit., appendix VII (Hales to Janssen, 10 June 1752).

⁶ Walter S. Hutton, *The works’ manager’s hand-book of modern rules, tables, and data for civil and mechanical engineers*, 8th rev. ed., London, 1917, p.204.

⁷ Janssen, op. cit., appendix VII (Hales to Janssen, 10 June 1752).

⁸ Janssen, op. cit., p.45 (Pringle to Janssen, 15 Feb. 1755).

⁹ R.B. Pugh, “Newgate between two fires,” *Guildhall studies in London history*, iii/4 (April 1979), p.201.