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# WINDPOWERED GRAIN MILLING, FLOUR PRODUCTION AND BREAD CONSUMPTION IN HAMPSHIRE IN THE EIGHTEENTH AND NINETEENTH CENTURIES

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## ABSTRACT

*The development of the milling industry in England in the eighteenth and first half of the nineteenth century was based on natural energy resources, and although waterpower was generally preferred during the period, the windmill was developed as a viable alternative where water resources were either lacking or inadequate. Furthermore, windpower had decided advantages over steampower until the second half of the nineteenth century. Although windpower was applied to a wide range of industrial uses, and to the drainage of fenland, its principal use remained the traditional one of grain milling. Hampshire was no exception. In the county, windpower was used for hardly any other purpose during this period.*

*Hampshire's windmills are also placed in the wider context of social and economic history, particularly population growth and the general changes in diet and consumer preference which prompted developments in the structure and organisation of the milling industry. Aspects of this which are considered include the switch in consumer preference to bread made from sifted wheat flour in southern England after the mid-seventeenth century, advances in the technology of milling with millstones and sieving flour, and the forms of occupational integration, particularly millers' links with farming and the baking trade. Finally, brief consideration is given to the reasons for the decline of this system of milling in the late nineteenth century.*

## INTRODUCTION

The history of the windpowered grain mill in Western Europe before the eighteenth century is given elsewhere. Key dates were the introduction of the 'post' mill in the late twelfth century, and the 'tower' mill design in the thirteenth century (Darby 1956, 113–21, 144–45; Reynolds 1974, 150–56; Gregory 1985, 24–26; Bowie 1992, 1–3). There was a new phase of design innovations in the eighteenth century, and a new type of tower mill was introduced in England in the 1750s. The term 'smock' mill was used when the tower was made of wood instead of brick or stone. Dutch millwrights had developed the design during the early part of the eighteenth century, and were building such mills in significant numbers by the 1740s (Stockhuyzen 1962, 33; Titley 1938, 29, 31). These new windmills were built taller than the old ones (over fifty feet high rather than about thirty feet) so that they might be more powerful. Wind has less force at ground level, due to the effects of surface turbulence and small obstacles, and taller mills generated more power.

The new tower/smock mills were specifically designed to work two pairs of millstones simultaneously in a steady force four to five wind on the Beaufort scale. Here winds averaging sixteen to twenty-five mph generated sixteen to twenty-three brake horsepower (bhp). Allowing for friction and transmission losses in the gearing, each pair of millstones required about eight bhp for grinding wheat, and about half that amount for crushing barley and oats for animal feed. With a strong steady wind, they were capable of processing eight to twelve tons of flour per week compared with an output of about two tons per week from earlier mills which had only a single pair of millstones (HC 21 May 1792, 1; HT 8 May 1820, 3; Vancouver 1810, 109–10) (Figs 1 & 2).

Tower and smock mills could be made bigger and stronger, were more flexible in terms of internal space for the location of ancillary machinery, and had more storage capacity for grain above the millstones, than post mills. Nevertheless, ordinary post mills could be built for about half the cost of tower or smock mills, their design continued to evolve, and they continued to be built in some areas (Farries 1982, 115–20; Gregory 1991, 161–62, 210).

The new design of tower/smock mill generally replaced existing traditional post mills as they

## HAMPSHIRE.

TO be LET, and entered on immediately,--A large SMOCK WIND-MILL, ſituated at DENMEAD, in the pariſh of HAMBLEDON, in the county of Southampton, about 11 miles from Portſmouth, 5 from Havant, 8 from Peterſfield, and 8 from Fareham and Biſhop's Waltham, which works two pair of Stones and two Bolting-mills, and is capable of clearing ten Loads of Wheat a week; together with a Dwelling-houſe, Garden, Stable, and convenient Out-buildings, a well-planted Orchard, and about four Acres of very rich Land to the ſame adjoining and belonging.

For further particulars apply to Mr. Brown, attorney at law, Hambledon; of whom may be had any ſum of money from 200l. to 600l. upon good Land Security at 4 per cent.

Figs 1 and 2. The potential output of the new generation of windmills was much greater than earlier mills, and sale advertisements in Hampshire newspapers express this. Fig 1 refers to Glidden smock mill, Denmead in 1792 (HC 21 May 1792, 1), and Fig 2 to Bursledon tower mill in 1820 (HT 8 May 1820, 3). The 'load' referred to weighed about 22 hundredweight.

became worn out, or suffered extensive storm damage, and was the preferred design for windmills built on new sites. Nearly all of the windpowered grain mills in Hampshire during this period were of the new type, and over thirty were built between 1780 and 1825; five or six were smock mills and the rest were tower mills. Hardly any post mills were built in Hampshire at this time; indeed, it is probable that only three or four of those already existing or built in the late eighteenth century were still at work in the 1830s (Moore 1990).

Another major reason for the increase in potential output was the introduction of two-stage gearing systems during the first half of the eighteenth century. The main two-stage system was known as 'great spurwheel' gearing. Here a large horizontal spurwheel, which was fixed to the vertical millshaft, connected with pinions, or the 'stone nuts' of the millstones. This doubled the speed of rotation of the runner stones compared with one-stage gearing, and also was convenient in that up to five pairs of millstones could be disposed around the great spurwheel compared with the single pair of millstones worked by one-stage gearing. Both 'underdrive' (where the great spurwheel was located beneath the millstone) and 'overdrive' (where the great spurwheel was above the millstones) versions were being used in Dutch windmills in the first half of the eighteenth century (Linperch 1727, figs 15, 24; Natrus 1736, Figs V–VI; Titley 1938, 29, 31). Great spurwheel gearing was adopted generally for new wind and waterpowered grain mills constructed in England during the second half of the eighteenth century (Ferguson 1770, 69).

Underdrive great spurwheel gearing was often to be found in new tower and smock mills in areas of England where watermills predominated. It is not known which gear design

WINDMILL FOR SALE,

*AT BURSLEDON, HANTS.*

FOR SALE by PRIVATE CONTRACT, —All that good-accustomed WINDMILL, almost new, capable of grinding and dressing seven or eight loads of Wheat per week; together with the DWELLING-HOUSE, Stable, Cow-pens, Piggeries, and other Out-buildings, with an excellent Garden, well stock with Fruit Trees, and rich Paddock adjoining; the whole containing about two acres of Land, more or less; distance from Southampton, five miles, seven from Fareham, and twelve from Gosport.—The Premises are delightfully situated on an eminence, commanding extensive and picturesque Views of the surrounding Country; and is well worth the attention of Capitalists. It is held by Copy of Court Roll, under the Bishop of Winchester, nearly equal in value to Freehold.

For further particulars, enquire of Mr. Langtrey, on the Premises; and of Mr. Mecey, Auctioneer, Southampton; letters post-paid.

Fig. 2

was used in most of Hampshire's new generation of windmills, as such detailed information about mill interiors does not generally exist. Bursledon tower mill has underdrive gearing that is contained within a wooden 'hurst' frame that is reminiscent of watermill practice, and Chalton tower mill, near Clanfield, appears to have had underdrive gearing for two pairs of millstones. However it is probable that at least one or two of Hampshire's tower and smock mills had overdrive gearing.

## GRAIN MILLING WITH NATURAL POWER RESOURCES IN HAMPSHIRE

Until the late nineteenth century, grain milling in Hampshire was mainly dependent upon the natural power resources of river and stream, tidal ponds and the wind. Watermills were generally built in preference to windmills because they were less expensive to build and maintain, and water was easier to control and a more reliable source of power.

Although there was little potential for establishing new waterpower sites in Hampshire in the late seventeenth century, many existing watermills were capable of redevelopment. The chalk streams and rivers within, and issuing from, the Hampshire Downs were famous for maintaining an even and reliable flow irrespective of drought, but there were problems caused by competition with other water resource users in these river valleys. Watermeadows were the most important of these, and the management of both interests were so different that at best the two groups of users could only be reconciled for most of the time. Essentially, millers were concerned with storing water whilst the aim of watermeadow users was the careful distribution of irrigation water over large areas. There was sporadic conflict, exacerbated by the fact that some millers also tenanted watermeadows. Occasionally there was legal action (Bowie 1987b, 157–58). In the Itchen valley the situation was worsened with the completion of the Navigation between Winchester and South Stoneham in the late seventeenth century. Maintenance was sporadic, its banks breached with monotonous regularity, and it added considerably to the risk of flooding in the valley (HRO 18M54; Course 1983, 10). It would be unwise to exaggerate the effects of the above, but it should be recognized that working life was not as 'easy' as might be imagined for millers dependent on these chalk rivers and their tributaries.

Tide mills were the preferred second option to conventional waterpower, but the opportunities to construct them were restricted to a narrow coastal and estuarine zone. It should also be remembered that tide mills were less convenient to work than ordinary water mills because they were subject to the lunar cycle; though reliable at pre-determined times, they provided different work phases each twenty-four hours, and at neap tides quite short work periods. They were also subject to damage from high tides and floods. Many tide mills had two sets of waterwheels in order to maximise production when power was available. Examples of this include Eling Mill, near Totton, and Ashlett Creek Mill, near Fawley, both of which had two sets of waterwheels, each driving two pairs of millstones (SJ 24 Feb 1752, 4).

Windpowered grain mills were built where waterpower sites had already been used up, or were incapable of further development, and also in areas where water resources were limited or lacking. Water resources were inadequate in south-east Hampshire, and there was a significant concentration of windmills in that part of the county. The ratios of water to tide pond to windpower in Hampshire during the period reflects the above; in about 1850 there were approximately 180 conventional watermills and fifteen tide mills capable of work, and twenty-five windmills. There was only one steampowered grain mill at work in the county at that time (Freeman 1976b, 47; Ellis 1978, 42–43; Moore 1990).

*Structure and organisation of the milling industry*

The development of natural power resources for grain milling was stimulated by an increase in consumer demand for wheat flour. This in turn was generated by an upsurge in population after about 1750 (Wrigley & Schofield 1981, 528–9). English domestic wheat output is said to have expanded by 70 per cent in the eighteenth century compared with an aggregate increase in all grains of about 50 per cent (Holderness 1975, 70–71; Turner 1982, 504). Hampshire agriculture reflected both this increase, and the shift in emphasis to wheat production in arable farming. By 1801 significant acreages of wheat were grown


Fig. 3 The population of England, 1601–1841, based on Wrigley & Schofield 1981 (528–9)

in parts of the county where little had been grown before (Pelham 1953, 142–43).

Millers in England responded to this increase in demand by developing an additional, more sophisticated, management system. Traditionally, grain milling in most areas was a service controlled by the lord of the manor, and was in no sense an industry. Villagers brought their own grain to the mill to be ground, and the miller took about ten per cent of it as payment for the service provided. This was known as 'toll milling'. The new system meant that, as well as toll milling, many millers also came to act as 'middlemen', buying the grain in bulk and storing it until required, and making a significant profit by selling the ground products. This was known as 'merchant milling' (Jones 1969, 306–11; Tann 1980, 45).

Such merchant millers needed an increased storage capacity for both grain and milled products. However, although milling units were built larger than their predecessors, they were generally only developed up to the point that they were sufficient for the needs of a small local market. Each mill normally served a village and its surrounding farms, or a small urban area, and produced flour from locally-grown wheat, or at least from wheat grown not very far away (Freeman 1976a, 19). The major factor which determined this organisation was the high cost of transporting grain and flour long distances by horse and cart, a situation which remained unchanged until the spread of a national railway network in the 1850s and 1860s (Freeman 1976a, 57–58, 75–77).

The output of each mill was generally adequate, and production sufficiently diversified, to meet the many needs of a small surrounding area (Perren 1990, 422). In terms of effort, if not value, many of these mills were as much concerned with processing animal feed as with flour for human consumption. Hampshire windmills reflected this dual function. In the late 1820s Dummer tower mill had a pair of French burr millstones for grinding wheat and a pair of 'peak' stones for grist milling (RM 11 Aug 1823, 3). Moreover, there was no strict demarcation between rural and urban grain milling. Urban areas also required horse feed, feed for fowl, 'domestic' pigs, and other livestock. Bursledon tower mill probably fits into this category as in the 1840s it contained two pairs of 'burr' stones and a wire machine, and also a pair of 'peak' stones for grist milling, and a small 'bean mill' for rolling horse feed. In 1808 Quay tower mill, Fareham, was described as 'well situated for Corn [merchant milling] and Grist Work' (HT 19 Sept 1808, 1).

Another factor with regard to productivity was that two-stage gearing doubled the output from the same number of millstones. An example of a transitional stage in this development was the replacement of an existing mill with a new one at Shawford, south of Winchester on the River Itchen. The new mill was built between 1686 and 1691, and had three waterwheels, each of which worked a single pair of millstones through one-stage gearing. Although it had more pairs of stones than its predecessor, and thus a greater total output, output per pair of millstones with such one-stage gearing was more or less the same. However the next mill on the site, built in the late eighteenth century, had one large waterwheel which linked with three pairs of millstones through great spurwheel gearing, and thus had a much greater potential output (HRO 46M72). Frogmore Mill, East Meon, was perhaps typical of the new generation of waterpowered grain mills; in 1812 it was described as 'capable of working two pair of stones', with an output which was equivalent to four pairs of millstones with one-stage gearing (HT 10 Aug 1812, 1; Ellis 1978, 19–20).

### *Time and labour saving innovations*

A major factor which determined the continued viability of windpower for grain milling in the nineteenth century was the introduction of 'tentering' governing. Towards the end of 1787, a Thomas Mead, 'carpenter', of Sandwich, Kent, was granted a patent for a 'Regulator on a New Principle for Wind and other Mills . . . and for Regulation all Kind of Machinery where the First Power is Unequal' (pat. no. 1628). The system was based on the action of a regulator, or 'governor', which consisted of two weights revolving around a vertical spindle as pendulums (Watts 1985, 336; Dickinson and Jenkins 1927, 222). Mead described and illustrated the use of the governor both for furling and unfurling sail cloths, and for raising or lowering 'runner' millstones in response to changes in wind speed. The first idea was not

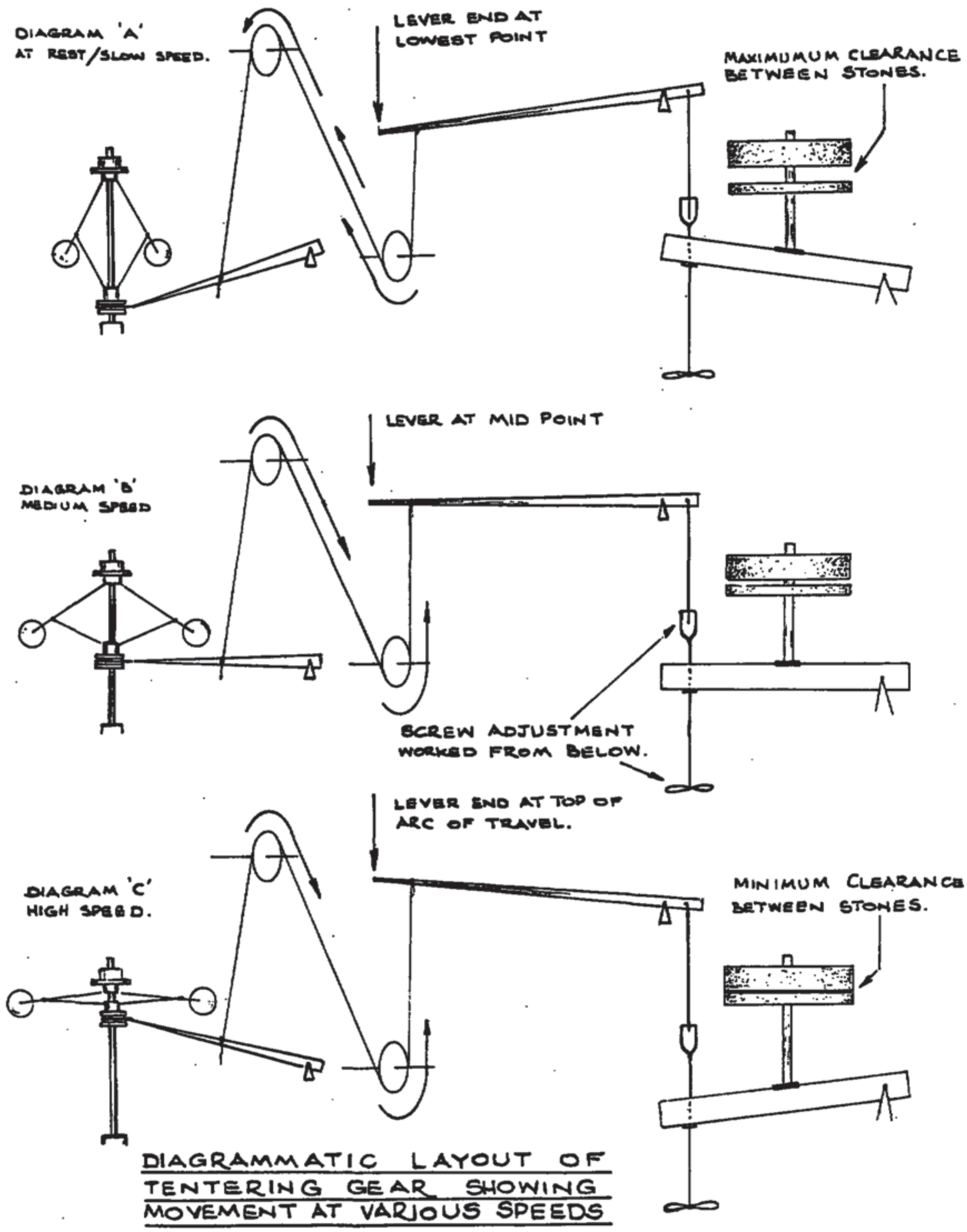


Fig 4. The normal 'tentering' governor works through levers, but at Bursledon, and also Bembridge tower mill, Isle of Wight, a pulley system replaced two of the usual three lever arms. (George Rowe)

applied at this period because, when attempted, it actually increased rather than decreased fluctuations in wind speed. Instead, it was the latter which was applied generally in windpowered grain mills (Freese 1971, 51–53).

Tentering governing was important for two principal reasons. First, it allowed the miller to maintain the production of a consistent quality of flour, equal to that provided by the constant rotation of water and steam power, even in fluctuating wind conditions. The crucial factor here was that practical milling was possible with the runner stones revolving at a wide speed range (60–125 rpm), and control of speed of rotation was less important than a rapid response to fluctuations in wind strength. Before governors were introduced, millers had to be constantly adjusting the stone tentering gear by hand when the wind gusted and lulled in an effort to maintain the production of a reasonably consistent texture of flour. Otherwise the flour would be too fine and 'dusty' when the sails turned slowly, and too coarse when the sails turned quickly. This meant that millers tried to avoid using certain winds, such as northerlies, which blew strongly at one moment and died away at the next (Watts 1985, 335, 342). However, governors regulated the tentering automatically, and so broadened the range of winds which the miller could practically use. The governors themselves were usually belt-driven, either from the main (upright) millshaft, or from the stone spindles. Sometimes they were mounted on the stone spindle itself. One such set of governors could control up to four pairs of stones, or each pair of stones might have its own governor. Most governors acted through an arrangement of three levers. However, at both Bursledon tower mill, and Bembridge tower mill on the Isle of Wight, string and pulley arrangements were used instead of the levers (Major 1970, 23–24) (Fig 4). The reduction of movement was many times to one, the maximum travel on the stone spindle being quite small – about one-sixteenth of an inch. When the wind gusted, the governor weights moved outward, bringing the runner stones closer to the bedstones. When the wind lulled, the weights dropped and moved the runner stone away from the bedstone.

Secondly, governor tentering was also labour saving. At the beginning of each milling session the miller adjusted the tentering gear by hand in order to establish the texture of flour he required for a batch of grain. Thereafter he was mainly concerned with replenishing the grain bins, checking the grain feed and bagging-off the flour. He could even leave the mill to run itself for short periods.

Labour and time-saving innovations were of particular importance for windmillers because they had a variable capacity to meet a fairly constant and regular demand for flour. Sometimes they had too much work to do. One of the first improvements was concerned with the traditional and cumbersome 'tailpole', which was used to turn the body or cap of a windmill in order to keep the sails facing into the wind. The tailpole functioned as a simple direct lever, and required up to three men to push it. The 'endless-chain' gear was introduced in the 1750s; it required less effort than was necessary with a tailpole, because it used gearing rather than simple leverage to turn the cap into wind, and the miller could work it on his own (RS 5v, 6 [1752]; Short 1971, 45–51). The next development was the 'fantail' mechanism, which used its own power to turn the cap into wind and keep it there, and was automatic. Although patented in 1745, the fantail was not generally applied until after the 1780s, and was more expensive to install and maintain than the endless-chain gear (Fig 5). Although fantails came into general use in the tower and smock mills of Hampshire, a few mills such as Bursledon and Owslebury were fitted with endless-chain gear (Buckland 1987, 18–20, 26–29; Farey 1812, plates XIV, XV; Gregory 1991, 80).

There were also two phases of innovations in sail design which helped to save time and labour. The first of these made setting and reefing sailcloths quicker and easier. The 'common' sail was a seventeenth-century Dutch development, and was a simplification of the traditional double-sided design where the sailcloths were woven in and out of the sailbars. Nevertheless, the cloths were still set or reefed one sail at a time, with each sail stopped in turn at the vertical position. The sail clothes were tied-off at various positions according to the strength of the wind and the power requirement for the work that needed to be done. 'Full cloths' were needed in a light wind, but the sails could be partially reefed in a strong wind, particularly if only one pair of millstones was

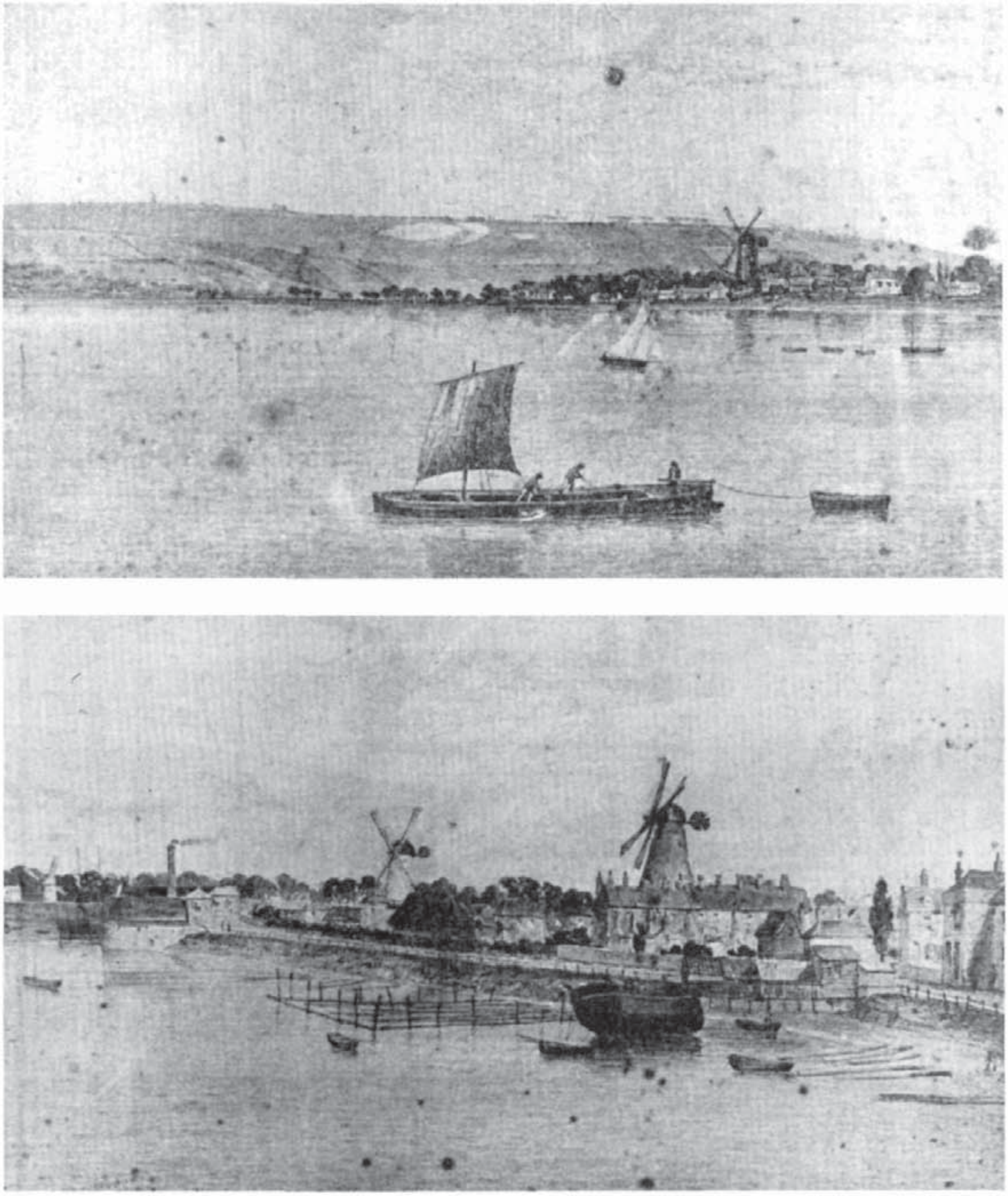

Fig 5. Views of the Old Flathouse area of Portsmouth in about 1830. HT 13 March 1931) Today the foreground is occupied by the Continental Ferry Terminal. Three of the windmills have horizontal fantail supports. Generally these were replaced by vertical ones when the frames became rotten. (Hampshire County Library)

being used. Partial reefing was essential in a wind which was rising towards a strong gale (force six to seven), otherwise the windmill's brake mechanism might not be capable of stopping the sails turning.

The second phase of innovations in sail design used small hinged shutters, like those of Venetian blinds, instead of sailcloths. The Scottish millwright, Andrew Meickle, introduced the idea of 'spring sails' in 1772. Each sail still had to be stopped vertically in order to set or release the tensioning springs, but setting and reefing were much quicker. Also, the tension could be adjusted for the prevailing wind strength, so saving the time necessary for setting or partially reefing sailcloths when wind strength varied significantly during a milling session (RS 6v [1772]). However, Meickle's mechanism was complicated, and spring sails did not come into general use until the early nineteenth century when the design was simplified (Fig 6).

In 1807 William Cubitt introduced the 'patent' sail, which combined the shutters of the spring sail with the remote control of the 'roller reefing' sail invented by Capt Stephen Hooper in 1789. Hooper's control, or 'striking gear chain' was suspended from the back of the cap, and was operated from either the reefing stage of a tall mill, or from the ground if the mill was small. This innovation meant that the mill could be started quickly at the beginning of a milling session and shut down rapidly at the end of it. Also, different weights could be attached to the striking gear chain according to the prevailing wind strength. The weight here replaced the separate springs of spring sails, and acted on all sails simultaneously so that adjustments for changes in wind strength could be made without stopping the mill machinery. The patent sail became the standard design for windmills in eastern England after 1821, when the design became free from patent right royalties (Wailes 1948, 18–20; Gregory 1991, 89; Freese 1971, 58–60; Brunnarius 1979, 14–17). It was applied to about half of Hampshire's windmills (Figs 7 and 8).

However, the common sail continued in use because it was cheaper and easier to make and maintain than the patent sail, and also provided more power at lower wind speeds because it was lighter in weight. Although Bursledon tower mill could have been fitted with patent or spring sails when it was built in 1813–14, common sails were used instead, probably for reasons of familiarity and economy. The fact that fantails and advanced sail designs may or may not have been applied probably indicates that, although the miller may have been overworked at times, in some cases the extra cost of a particular innovation was not necessarily off-set by overall time and labour savings (Fig 9). This also applies to John Smeaton's efforts to optimise windmill power output when he introduced the idea of five-sail windmills in the 1770s (RS 7v, 8, 9 [1774]). In the nineteenth century, five, six, or eight sails were sometimes used. These multi-sail arrangements provided more power than the conventional four sails, but were more expensive to install and maintain. However, the normal number was sufficient for most mills, and, as far as is known, all of Hampshire's windmills had four sails.

*Aspects of windmill management*

As an alternative to being overworked, at times there was either no wind or insufficient wind to mill, and during such periods the miller was effectively underemployed. In this case other occupations, or various forms of 'occupational linkage', were important. A relevant direct link here was that of miller/baker, which not only provided an additional occupation but also ensured that the bakery was supplied with fresh flour when required. In the mid-1770s Dwarf tower mill, Portsmouth was owned and operated by James Judson, who was also a local baker (GL, RE 1776). In the early 1780s, William Galley was a 'miller and baker' at Galley Down windmill, Bishops Waltham (HC 27 May 1782, 3). In the late eighteenth century Lumps tower mill, Southsea Common, was owned by John Snook of Queen Street, Portsmouth, 'Miller and Baker'; the 'bakehouse' was adjacent to his dwelling in Queen Street (GL, SF 1791). In 1801, Speltham tower mill, Hambledon, was described as 'A strong brick built windmill, with a dwelling house and a large baker's oven adjoining the Mill, lately put in good repair' (HT 14 Sept 1801, 2). At the same period, Newton tower mill, Portsmouth, was 'Well adapted for carrying on an extensive baking business, having three ovens and other desirable conveniences' (HT 14 Sept 1801, 4). In 1828 Norn Hill tower mill, near Basingstoke, was offered for

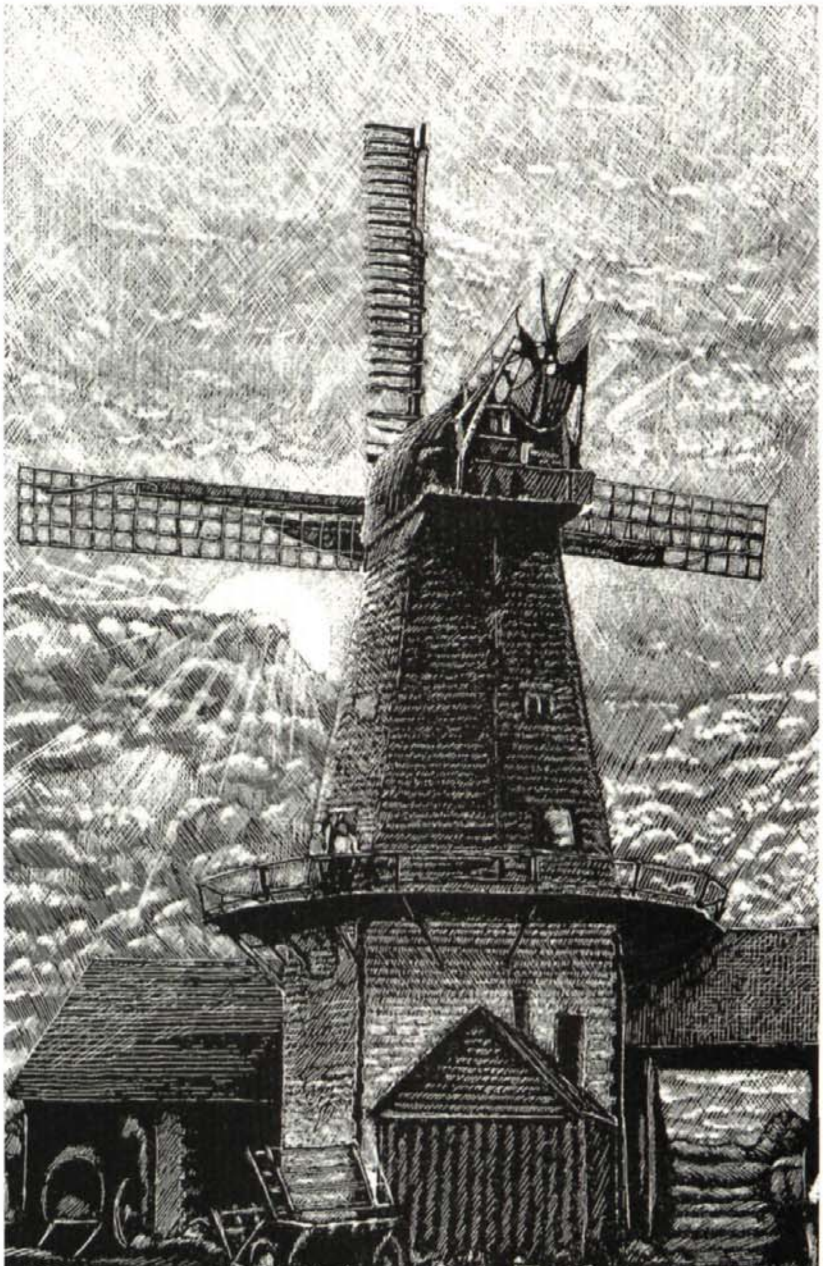

Fig 6. Weston smock mill, near Petersfield, Hampshire, was built about 1808, disused by the late nineteenth century, and the wooden tower pulled down in 1911. It had a pair of common and a pair of spring sails, which was a practical and sensible combination of sail types. (Martin Jones)

Fig 7. The New Dock Mill, Portsmouth, was built in 1816–17, was derelict between 1834 and 1868, and was then rebuilt. It worked until the 1890s, and was demolished in 1923. (Hampshire County Library)

sale together with a 'bake-house [and] Shop' (RM 13 Oct 1828, 3).

Another factor was that milling could be an intermittent 'seasonal' activity, responsive mainly to the quality and quantity of the latest harvest, and the varying needs for animal feeds throughout the year. In this sense milling might be a part-time occupation in rural areas (Perren 1990, 423). A typical linkage in this case was that of farmer/miller. Dr R Perren makes this point about the farmers in England and Wales in the 1851 census who returned milling as a subsidiary occupation; these farmers 'represented a surplus capacity that could be brought into production whenever seasonal demand rose'. In Hampshire, Stoke post mill, St Mary Bourne, was owned by Charles Holdway, 'Yeoman', in the period 1791–1809, together with two farms (GL, RE 1809). At Owslebury tower mill in the 1830s Henry Young was tenant of 204 acres surrounding the windmill, and an Elizabeth Young, who was probably his wife and certainly a close relative, its tenant (HRO 21M65, Owslebury) (Fig 9). Another example was Dummer tower mill, which was the subject of a fourteen year lease starting in 1830. The property consisted of 43 acres of arable land and meadow, a farmhouse, outbuildings, and the windmill. Though small, the farm was subject to the conventional landlord's cropping restrictions at this period, indicating that the farming activity was taken as seriously as the milling; the tenant was 'not to take two successive wheat crops on the same ground, nor to grow more than fifteen acres of wheat a year, and that after a summer fallow or a green crop of clover, peas or beans' (HRO 55M67/T52). The 'farms', or small-holdings, attached to mills could be quite small, but clearly contributed to overall viability. In the 1840s at Longdown tower mill, Hythe, the tenant also rented a ten acre plot surrounding the windmill, three and a half acres of which were arable (HRO 21M65, Hythe).

However, other forms of occupational integration were less simply motivated than that of farmer/miller and miller/baker. One of these was the desire to control a local market. In the late 1780s William Mundy, who worked Kimpton post mill near Andover, was not only a farmer but a 'baker [and] shopkeeper' as well, so that, potentially, he had control over an entire production process, from cultivating the wheat to selling the bread (GL, SF 1787).

The miller or mill-owner might have other business interests as well, with the additional motive of trying to spread the risk of personal loss or failure. Indeed it was not until the end of our period that joint stock companies and 'limited liability' began to be adopted at this level of commercial activity (Mantoux 1927, 255–56). Other related forms of occupational linkage were relevant here. These included those connected with processing other grains such as miller/maltster and miller/brewer, and 'carting', an occupation linked with transporting grain and milled products. A good example of a combined

Fig 8. Barn Green tower mill, Denmead, Hampshire, was built in 1819 and was disused by the early years of the present century. It was demolished in 1922. It had 'double shuttered' patent sails, and an upright fantail.

milling and malting establishment was Quay tower mill, Fareham. Here in 1791–92 James Godwin had, in addition to the windmill, a 'malthouse and storehouse adjoining' (GL, RE 1791; SF 1792).

*The 'white' wheaten loaf*

Before about 1650, different grains were regularly cultivated together as mixed crops, or cultivated as separate crops and mixed together before milling. These mixes might include dried pulses. Such flour was made into bread, pies, and puddings, and was sifted with a horsehair sieve where appropriate to remove some or most of the 'bran', or fibrous skin of the grain (Collins 1975, 98–99; Ashley 1928, 170–71). However, from the mid-seventeenth century, bread was increasingly made from wheat alone in south-central and south-east England, where, by 1750, the traditional practice of growing 'maslin' (a mixed crop of wheat and rye) for bread making had largely died out (Ashley 1928, 7, 15–19; Mingay 1956, 336). However, wheat did not grow so well in much of Wales and northern England where other grains continued to be eaten, mainly in the form of gruels (like porridge) and puddings, pancakes and unleavened breads (Collins 1975, 104).

There was also a shift to bread made from 'sifted' white flour, where most of the bran was removed by sieving, a process known as 'dressing' or 'bolting'. Traditionally this had been expensive, and the prerogative of the rich and wealthy 'from the time of Moses' (Humphries 1911, 26). However, during the late

Fig 8a. Barn Green c 1920.

seventeenth and the first half of the eighteenth centuries, bread made from white flour became an important food item in the family budgets of all social groups in many parts of south-central and south-east England, including Hampshire. It supplemented, and then gradually replaced, porridge, puddings and mixed grain breads as major items of diet (Collins 1975, 98–99). After 1750 such bread became *the* major food in the area, particularly for the labouring classes of town and country who constituted over eighty percent of the population (Burnett 1979, 75–77). By the end of the eighteenth century these low income groups regarded this white bread as a necessity and not a luxury. Consumption at this period probably ran at eight to nine pounds of bread per head per week, and over sixty per cent of the family food budgets of rural labourers was being spent on flour and flour products (Davies 1795, 164–69; Fussell 1927, 269–70). Bread retained this pre-eminence for most of the nineteenth century. However, in the late nineteenth century consumption per head appears to have decreased to about six and a half pounds per week (Lawes and Gilbert 1880, 328; Wood 1911, 5–7). This was due to a general rise in real incomes, and to the substitution of some of the bread with meat in family diets (Bowie 1987a, 15; Afton 1993, 220–21).

The change to wheat and sifted flour meant that millers became involved with 'cleaning' wheat grain before it was milled, and also with 'dividing the [whole] meal into various commercial products' afterwards (Humphries 1911, 26). This represented another important aspect of the development of merchant milling, and new and complex machinery was installed in mills in addition to the millstones. From the late eighteenth century, 'gig' and rotary 'screens' were available to clean wheat, ridding it of non-wheat grain, husks and weed seeds. However, there was limited need for such screens in most mills in southern England until the end of the nineteenth century because domestic grain was generally used, and farmers produced a fairly 'clean' sample of grain (Perren 1990, 431; Afton 1987, 244–46; Fussell 1952, 158–63).

On the other hand, the mechanisation of the process of dressing/bolting wheat wholemeal was very important during this period. Bran formed about thirty per cent of the wholemeal, and sieving with the traditional hand sieve was tedious, and also time consuming for large quantities of flour. The process began to be mechanised in bakeries in the sixteenth century, though the machines continued to be hand-operated. Power operated mechanical sieves were introduced in the late seventeenth century. This involved a shift in the location of the bolting operation from bakeries to mills, because the latter provided the power to drive the sieves. Bakers continued to use sieves, but millers gradually took over this function. The transition from bakery to mill accelerated after about 1750 (Jones 1969, 309–11, 325–28; HCR 1774, 18). When bakers and housewives had done their own

Fig 9. Owslebury tower mill, Hampshire, was built in about 1800, disused in the early years of the present century, and subsequently demolished. It had endless-chain cap turning gear and common sails. (Martin Jones)

sieving by hand, the bran, or 'offal' as it was called, was generally given to their own horses and livestock. Now the miller supplied dressed flour, and supplemented his income by selling the offal, if he wished.

Amongst the earliest types of mechanical sieve was the 'cloth bolter'. The sieve mesh was made of woollen yarn, and the cloth was fixed to an inclined cylindrical wooden framework known as a 'reel'. Such bolting machines were used in series to make two grades of flour. The finest flour was used to make cakes and pastries, and what was known as a wheaten bread, for the rich and wealthy. The product of the second sieve, a coarser 'seconds' flour, was used to make household bread, which most of the rest of the population ate (HCR 1774, 4, 7, 9).

The 'wire machine', patented in 1765 by John Milne, wireworker, of Manchester, was a distinct improvement on the cloth bolter, and came into general use when Milne's patent rights expired in the 1780s. It was called a wire machine because the sieve-meshes were made of woven iron wire. The mesh was fixed to the inside of a reel, which was inclined like the cloth bolter. The reel also had a power-driven iron shaft with radial arms bearing brushes which ran the full length of the cylinder. Wholemeal was fed in at the upper end, and the rotating arms brushed the meal through the wire mesh. Different gauges of wire mesh were fixed to the cylinder, which allowed fractional sieving and grading. As many as five different meshes were used. The upper two fine meshes were the most important as they provided two grades of creamy-coloured flour (HCR 1774, 6, 13–14). A coarser sieve mesh gave small quantities of 'thirds' flour which was generally used for making biscuits. However, millers made a significant extra profit if even a small proportion of thirds flour could be added to the seconds. Wire machines generally had a hinged board between the hoppers of the second and the third flours which the miller adjusted to 'take-off' as much whitish flour as possible before it became too brown because of the bran content (HCR 1774, 18; Wilson 1847, 319). There were even coarser sieve meshes at the lower end of the wire machine, and these separated the bran to make various types of animal feed. The fine bran was used for pigs and poultry, and the coarse bran mixed with barley or oats to make 'bran mashes' for horses and cattle (Wilson 1847, 318–19).

It is probable that most, if not all, of Hampshire's windmills were fitted with cloth bolters or wire machines. Examples include Stoke post mill, St Mary Bourne, with its 'wire machines and dressing mills', the first windmill at Bursledon with 'wire machines and dressing mills therein', Dummer tower mill with a 'flour machine . . . and a Bolting Mill', and Stoke tower mill, Hayling Island, which had a 'fantail . . . two pairs of stones, flour machine, bolter, and running gear complete' (GL, RE 1809; GL, RE 1805; RM 11 Aug 1828, 3; SA 22 May 1855, 3).

### *The limited impact of steampower*

Steampower did not have the impact on the grain milling industry that might have been expected. Where waterpower resources were deficient or absent, millers generally preferred windpower to steampower until the second half of the nineteenth century. However, it appeared initially to contemporaries that steampower would rapidly come to dominate the milling industry. Reliable rotative stationary steam engines were introduced in the 1780s, and the power for such 'steam' mills was generally supplied by the Watt type of 'beam' engine working at steam pressures below about twelve pounds per square inch (psi). The main features of this technology were that it was reliable and fairly safe (the low working pressure reduced the risk of boiler explosions), but also inefficient. This meant that fuel costs were high and that steam engine technology was only appropriate where regular and continuous production was a major consideration, and anticipated profit margins were generous. Such conditions prevailed in the textile industries of northern England, and in large-scale town and city brewing, where this type of steam engine technology was successfully applied (Dickinson 1938, 79–83, Fig 14; Briggs 1982, 56–57, 60–61; Hills 1989, 113–15).

This helps to explain why most of the steampowered grain mills built in Hampshire before 1850 were not viable economically, and did not last more than a few years. Most of these were about the same size as contemporary water and windmills, and served the same local markets. A good example of such a steam mill in Hampshire was Potter's Chapel Mill, Southampton, built 1781–82; this had three pairs of millstones and six bolting machines, and was linked with an adjacent bakery. However it cost more to build and maintain than the equivalent water or windmill, required operatives in addition to the miller to tend the power unit (steam engine and boiler), and needed coal to generate its power compared with the free energy of water and wind resources. The higher comparative running costs were the crucial factor. Potter's Mill closed in 1784 (Pelham 1963, 24–31; Tann 1980, 50–53).

The 'horizontal' types of stationary steam engine introduced in the 1850s–60s were more appropriate than earlier steam engines for the milling industry because of their greatly improved efficiency (Dickinson 1938, 141–45). This was due to higher boiler pressures (about fifty psi), and improved valve gears which made better use of the expansive properties of steam in the cylinder (Briggs 1982, 162–64). Incidentally, both of these developments were feed-back technology from steam railway locomotive practice (Hills 1989, 132–34, 178–86). The new stationary steam engines were cheaper to install and run than their predecessors, and, for the first time, the spread of the railway network brought coal at an acceptable cost to many parts of rural southern England.

However, the unit costs of steampowered grain milling remained comparatively high, and few new steam mills were built in Hampshire at this period. A modern steampowered mill in the 1850s was described as having five pairs of millstones, and required a stationary steam engine of about twenty-five bhp to drive it. If it worked one hundred and ten hours a week, about eleven tons of coal were needed, and output was about thirty-two tons of flour (Morton 1855, 433). This output was little more than that of the larger of the new generation of watermills which had been built from the late eighteenth century. A few such mills had been built in Hampshire where local market conditions justified bigger enterprises than usual. Examples include Botley Mill, south Hampshire, where a new mill building was built in the late 1780s which contained two waterwheels, each of which drove two pairs of stones (Freeman 1976a, 45). Bishopstoke Mill on the River Itchen was a similar new development which, in the early nineteenth century, had 'four pair of stones' driven by two waterwheels. The potential output of both mills was twenty to thirty tons of flour per week (HT 14 Sept 1801, 2; HRO 18M54, 4). Hence the 'free' power derived from existing and well-tried natural energy technologies remained a dominant factor until the 1880s (Freeman 1976b, 54).

*The decline of windmills in Hampshire*

The system of milling which has been described depended on relatively high returns for milling domestic wheat, a crop which was in itself highly priced in the absence of any serious foreign competition. Change was provoked by poor grain harvests in the early 1870s, and the onset of a prolonged depression in English agriculture. Instead of the scarcity of the domestic product causing prices to rise as they had done in the past, wheat prices collapsed as huge quantities of grain flooded in from North America (Crawford 1895, 78, 83–84, 97–99; Afton 1993, 209–12; Perren 1990, 423; Burnett 1979, 133–34).

The 'roller milling' process, which involved the gradual reduction of the wheat grain into flour through a succession of pairs of metal cylinders, was a new technology introduced into Britain in the 1880s. The reasons for the rapid spread of the new technology are complex, and require further research, but two factors are particularly relevant for natural power resources. Firstly, roller milling machinery needed a constant speed of drive to work properly, and the intermittent and variable power of the wind was unsuitable for this. Consequently none of Hampshire's windmills were fitted with the new machinery. Secondly, although waterpower provided the constant speed of rotation required by the new roller milling machinery, plants generally needed more power than most sites could provide. Here the new generation of stationary steam engines were efficient enough, and capable of being made large enough, to power the new technology.

In Hampshire, after about 1890, a few existing

Fig 10. Peel Common tower mill, Fareham, circa 1900. It is clearly disused, with the fantail blades removed. The artist was Martin Snape, 1852–1930. (HCCMS 974.212.29)

Fig 11. Bursledon tower mill in the late 1870s. The mill is clearly in regular use as the cloth sails are tied round the leading boards of the sails, and these would have been taken down if the mill was closed or not being worked for an extended period. One of George Gosling's threshing drums, and also a straw elevator, can be seen to the left of the mill. (HCCMS 0 1976.27)

watermill sites installed steam-driven roller mills, and some new 'purpose-built' steam mills were erected (Freeman 1976b, 47, 54). The economies of scale were such that the new milling units were generally much larger than their predecessors (Perren 1990, 429, 432; Wood 1911, 8–9). Most watermills did not adopt the new technology on site and, like the windmills, lost their lucrative flour milling trade; they either went out of use, or shifted their emphasis to 'provender' milling, crushing grain for animal feed. The number of watermills in the county decreased from about 190 in 1880 to 115 in 1900. Similarly the number of windmills at work declined from about eighteen in 1880 to two in 1900; all were out of use by 1910 (Freeman 1976b, 47). Most of these windmills probably finally went out of use because major repairs were required which were no longer worthwhile (Figs 10 and 11). Bursledon tower mill is a well-documented example of the decline of Hampshire's windmills (Fig 11). George Gosling bought the mill in the early 1870s as a base for a new threshing enterprise. In 1878 he described himself as both 'miller [and] threshing machine . . . propr.', but by the early 1880s milling had ceased. Meanwhile George Gosling, his son, and grandson continued as threshing contractors based on the site until the general introduction of combine harvesters in the late 1950s (White 1878, 182; Bowie 1991, 2–3).

## CONCLUSION

The milling industry in Hampshire was based on natural energy resources until the second half of the nineteenth century, and was organised in small production units with a strong rural bias. Watermills were preferred to windmills because their power source was generally more reliable, and also they were cheaper to build and maintain, but the use of windpower remained a viable alternative where water resources were either lacking or inadequate. Rotative stationary steam engines were introduced in the 1780s, but steampower did not become important in Hampshire milling until the late nineteenth century when flour milling technology changed radically, and there was a shift in emphasis to milling imported wheat.

The problems caused by the variable and intermittent nature of windpower were moderated by improved windmill design, and technological innovations, in the eighteenth century and the early years of the nineteenth century. The new generation of windmills was able to make better use of what wind was available than their predecessors and were capable of producing a quality and quantity of flour comparable with that of contemporary watermills. Furthermore, labour input was low as the new windmills could be operated by the miller alone for most of the time. Occupational linkage, and other forms of business integration, encouraged the efficient use of labour resources, and also provided the possibility of broadly-based business enterprises. The two main forms of vertical integration (farmer/miller and miller/baker) offered both a degree of market stability and the probability of enhanced profit.

The viability of windpowered grain milling in the eighteenth and nineteenth centuries is difficult to put into words because it is really about describing a state of mind. Milling was closely tied up with farming, and a major determinant in the success or failure of the latter was the weather. The vagaries of the wind was just another aspect of this which was accepted without much thought because little or nothing could be done about it. This ethos also encompassed a sort of fatalism as the damage and devastation caused by storms, tempests and 'big winds' was generally assumed to be determined by the inscrutable mind of a displeased and vengeful deity. It should also be remembered that another major industry, the merchant marine, was totally dependent upon windpower until the late 1820s, and largely dependent on it until efficient sea-going steamships were developed in the 1860s (Hills 1989, 146–47; Science Mus. Cat. 1949, 15). For modern society, the fact that the wind has little respect for organised working hours is considered to be a major problem, but until the second half of the nineteenth century the limitations of wind energy were an accepted part of life. Ultimately, survival/success depended upon whether the miller was able to stop whatever else he was doing at short notice, and was prepared to work at any time of the day or night, if necessary for many hours at a stretch, in order to maintain an adequate overall output. This should perhaps be regarded as a small price to pay for a pollution-free, renewable energy resource.

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*Abbreviations*

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|---|---|
| BCL | Birmingham Central Library |
| GL | Guildhall Library, London |
| HC | Hampshire Chronicle |
| HCR | House of Commons Report |
| HRO | Hampshire Record Office, Winchester |
| HT | Hampshire Telegraph |
| ICE | Institution of Civil Engineers, London |
| NLS | National Library of Scotland, Edinburgh |
| RE | Royal Exchange Fire Insurance |
| RM | Reading Mercury |
| RS | Royal Society Library, London |
| SA | Sussex Advertiser |
| SF | Sun Fire Insurance |
| SJ | Salisbury Journal |

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