

Wind and Water Mills

Number 14

THE MIDLAND WIND AND WATER MILLS GROUP

This Journal is published by the Midland Wind and Water Mills Group, which is concerned with the study of the history and technology of mills and, in principle, with their preservation and restoration. Its area is the region loosely defined as the Midlands, especially the central counties of Staffordshire, Shropshire, Worcestershire, and Warwickshire.

The group holds monthly meetings, with talks and discussions, during the winter, and arranges mill tours and open days during the spring and summer. Members periodically receive a Newsletter and the Journal.

For further particulars, please contact:

**Mrs. M. Tucker,
26, Twatling Road,
Barnt Green,
Birmingham, B45 8HT**



The Midland Wind and Water Mills Group

Wind and Water Mills is the journal of the Midland Wind and Water Mills Group and is therefore naturally concerned with the mills of the Midlands, but it is not intended to be narrowly parochial. Interesting and important articles relating to mill matters in other parts of Britain and the world will be included whenever available. In general, articles by members will have priority for publication, but submissions by non-members will be willingly included.

Cover illustration. Coreley Mill on the Corn Brook, Shropshire. (See page 12)

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Watermills on the Ledwyche Brook and Corn Brook in South Shropshire.

By Tim Booth

This article bridges the gap between the surveys published in 'Some Watermills of South-West Shropshire' by Gordon Tucker and 'Watermills on the River Rea in South Shropshire' by the author.

Ledwyche Brook.

Ledwyche Brook rises on Weston Hill, an outlier of Brown Clee, near the village of Stoke St. Milborough. As it flows south-westwards it is joined by many streams from both Brown Clee and Titterstone Clee, such that by the time it reaches Henley, little over four miles from its source, the brook has become a river of some size and power. Within a mile of the River Teme east of Ludlow, just when union seems inevitable, the Ledwyche Brook turns away to the south-east and meanders around the foot of Titterstone Clee until finally joining the Teme at Burford near Tenbury Wells.

Starting from the source, the first mill site stands on one of the many feeder streams, Bockleton Brook, which rises on Brown Clee above Bockleton Court, north-east of Stoke St. Milborough. A long leat still carries some water to the site of the pond serving Stoke Mill and more was derived from the moat of Stoke Court, but the mill pond itself has been drained.

1. Stoke Mill. SO 568820

There was a mill at Stoke St. Milborough in 1344-5, belonging to Wenlock Priory.[1] In the Court Rolls for that year it is recorded that:-

'William son of Simon is amerced 6d. because he did not grind at the mill of the Lord of Stoke. William de Deukshull is amerced 2s. for the same. Philip Fanton did not grind at the lord's mill and calls to warranty his deed that he is not obliged to grind at the lord's mill and a day is fixed for him to produce the deed at the next court. And the order is given to all tenants who owe suit at the mill of Stoke that they do suit at the said mill under penalty of 40d. for neglect to do so, and the same penalty is enjoined on the miller there that he grind the corn of the tenants there.'

An entry in the Roll for 1411-2 shows that this ruling was enforced.

'William Boulton did not grind at the lord's mill as was

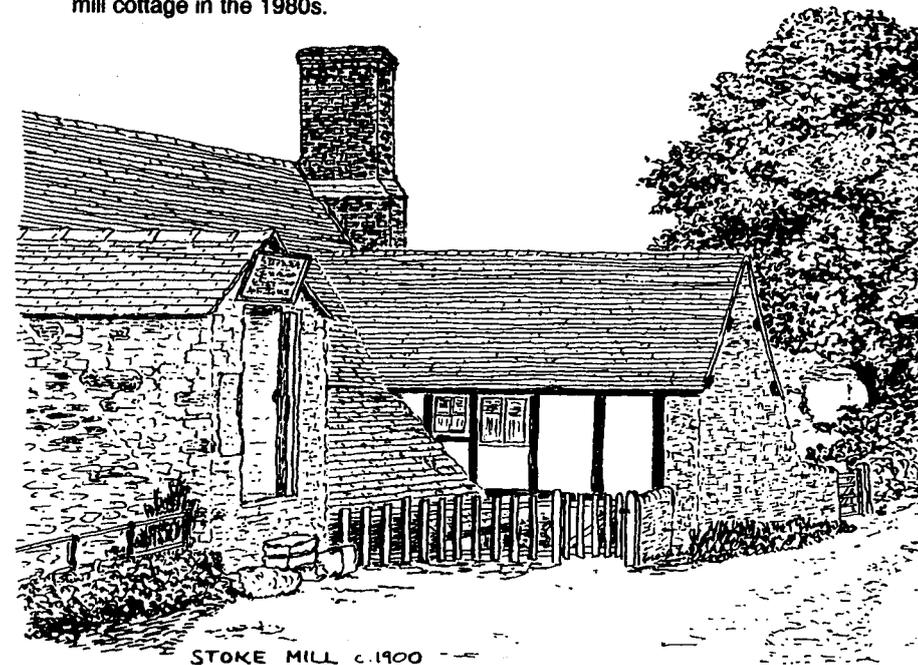
enjoined on all tenants therefore he incurs the penalty of 40d. under this decree.'

When the Priory was closed in 1540, its estates were sold and the manor of Stoke became the property of Thomas Cranmer, archbishop of Canterbury, in 1542. The mill remained part of the manor until this century.[2]

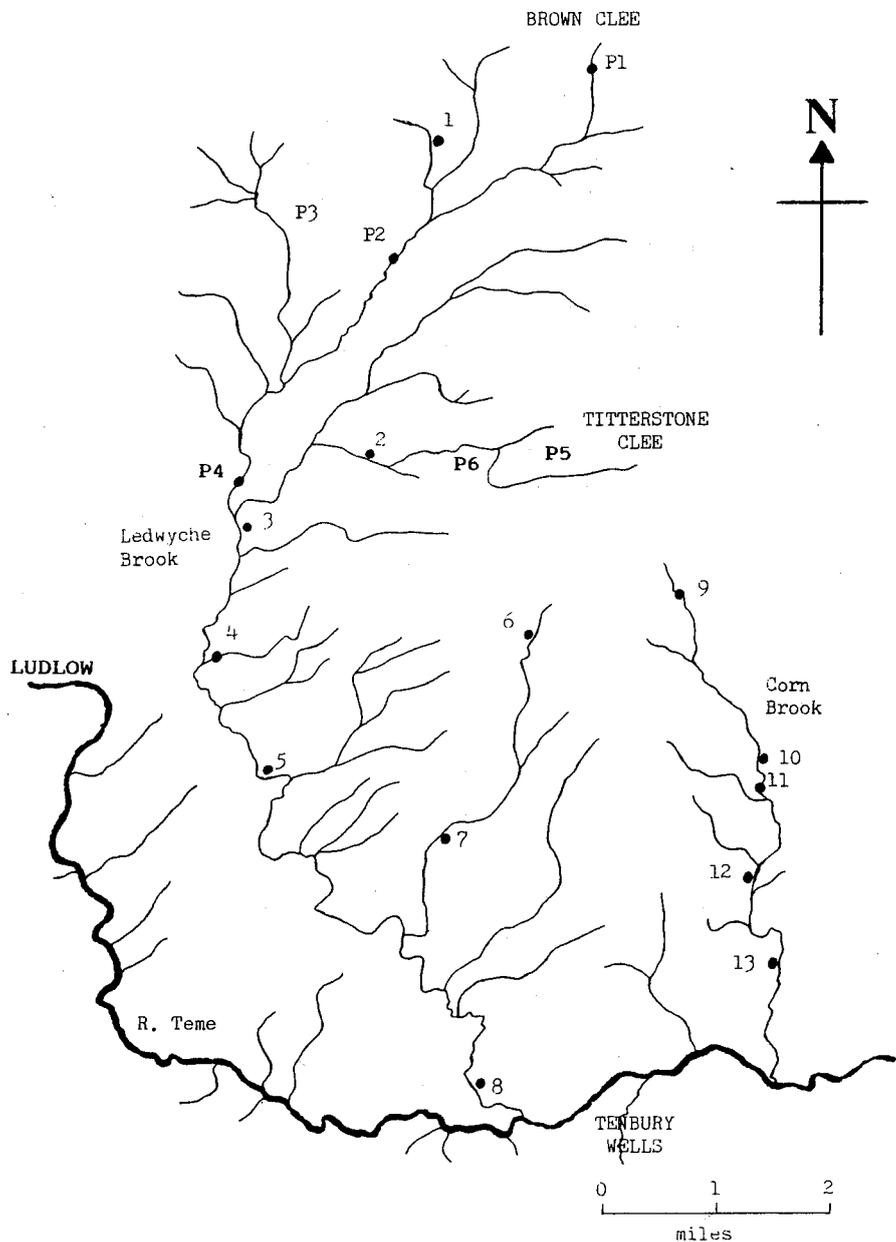
Royal Exchange Fire Insurance Policy No.122508 of 18th July 1791 states:-

'Francis Harding of Stoke Mill in the County of Salop, Miller. On furniture in his dwelling house situated at Stoke Mill, £50. On utensils and trade in a corn mill, brick, stone and thatched, near £150.'

In the nineteenth century, the mill was operated by John Bright in 1861, Edward Poyner from 1870 and various members of the Marston family from the early 1880s. The last miller was William Meredith who came to the mill in c.1913 and worked it until after the Second World War. The mill stood empty and derelict for many years until converted into additional living accommodation for the mill cottage in the 1980s.



The mill and its adjoining cottage are built into the dam of the former mill pond which carries the road into Stoke St. Milborough. The mill buildings are a mixture of stone and brick with some half-timber work in a rearward extension of the cottage. The pitch of the front half of the roof has been reduced at some



Map of the mill sites on the Ledwyche Brook and Corn Brook.

Mill Sites

1. Stoke Mill.
2. Bitterley Mill.
3. Henley Mill.
4. Farm wheel at Lower Ledwyche.
5. Caynham Mill.
6. Knowbury Ironworks.
7. Rockhill Mill.
8. Burford Mill.
9. Cornbrook Furnace.
10. Coreley Mill.
11. Tilsop Furnace.
12. Watmore Mill.
13. Boraston Mill.

Possible Mill Sites

- P1. Mill Farm, Blackford.
- P2. Mill at More.
- P3. Mill at Hopton Cangeford.
- P4. Mill at Middleton.
- P5. Water powered stone crusher on Benson's Brook.
- P6. Bitterley Court.

time by raising the front wall, giving extra storage space on the bin floor. Grain could be unloaded direct from carts on the road into the grain bins via a door over the waterwheel chamber. All the machinery has been removed from the mill but the waterwheel was recorded by E.H.Judd in 1953 as being overshot, 18ft. diameter by 4ft.6in. wide with fifty-six buckets and mounted on a wooden shaft. It was made by R. and W. Miles of Leominster in 1871.[3] The last vestiges of machinery, a short length of shafting and a small wire machine, were donated to Mr. and Mrs.A.George at Daniel's Mill near Bridgnorth in 1989.

P1 - P6 Possible Mills.

In 1344-5, Thomas le Beys was amerced 6d. because 'he did not full his cloth at the lord's fulling mill.' at Stoke St. Milborough.[4] However there is no indication now where a fulling mill might have stood. Another possible mill site within the parish is at Mill Farm, Blackford(P1) SO 593830. Today, the stream adjacent to this farm is a mere trickle but it is remembered as carrying far more water some years ago. There is the outline of a pond and a suggestion of a leat leading to the rear of the buildings so there could once have been a waterwheel here, though the position high on Brown Clee seems more appropriate for a windmill. Evidence of a mill of some sort is in the form of five millstones, all about 3ft. diameter, which now form steps in the garden of the farm cottage. The two best preserved are clearly dressed runner stones of what appears to be a local sandstone. Both have the stone cut to take two different designs of cross-arm rhynd. Medieval records do refer to a mill near Moor Farm(P2), serving the abandoned village of More.[5] It may well have been sited near to the ford at SO 563803.

Hopton Brook, the amalgamation of several small streams rising above the village of Hopton Cangeford, joins Ledwyche Brook at Crow Leasons Farm. Near the village is a building known as Mill Barn(P3) and a field called Mill Meadow[6] but no evidence of a mill for at least the last two hundred years. Ledwyche Brook continues southward through Middleton in the parish of Bitterley. There was a mill at Middleton in 1086, valued at 2s. The only evidence of a possible mill site(P4) today is a substantial weir across the brook at SO 541772. There is no sign of a leat or remains of a mill but pipes from the weir lead to a small building housing a set of hydraulic rams. South of Middleton, Ledwyche Brook is joined by Dogditch Brook, the combination of streams rising on Titterstone Clee. One of these is Benson's Brook which was dammed to provide the head of water to power a turbine driving a stone crusher(P5). This was erected in the 1860s to grade material needed to build the Titterstone Clee railway incline which connected the Ludlow and Clee Hill Railway with expanding roadstone quarries on the top of the hill.[7] All trace of the crusher has long since disappeared and its exact site is no longer obvious. At the foot of the incline, above Bitterley Court, an artificial channel carries most of Benson's Brook across the hillside to Bitterley Brook. A leat from this channel filled a pond behind the Court. The six inch Ordnance Survey map of the 1880s shows a building next to the pond with a nearby sluice(P6). Although there is now no evidence of a mill, a farm wheel here seems a distinct possibility. Bitterley Brook

then flows on through the village and once filled a sizeable pond feeding Bitterley Mill.

2. Bitterley Mill. SO 559773

In medieval times, a mill at Bitterley was a property of Haughmond Abbey. According to the London Gazette, December 21st, 1816:-

'By order of the Court for the Relief of Insolvent Debtors, the petition of William Perry, late of the parish of Bitterley, in the county of Salop, miller and Oatmeal Dealer, but now a prisoner for debt confined in His Majesty's Gaol of the Borough of Ludlow, said County, will be heard 6 Jan. next.'

Later nineteenth century millers were George Morris in 1861, Thomas Freeman 1863 - 1875, Mrs. Marston 1880 and Samuel Powell in the 1890s.

The small mill building still stands, built of brick in 1872, adjoining an 'estate style' brick cottage. No machinery remains in the mill which is used as a store.

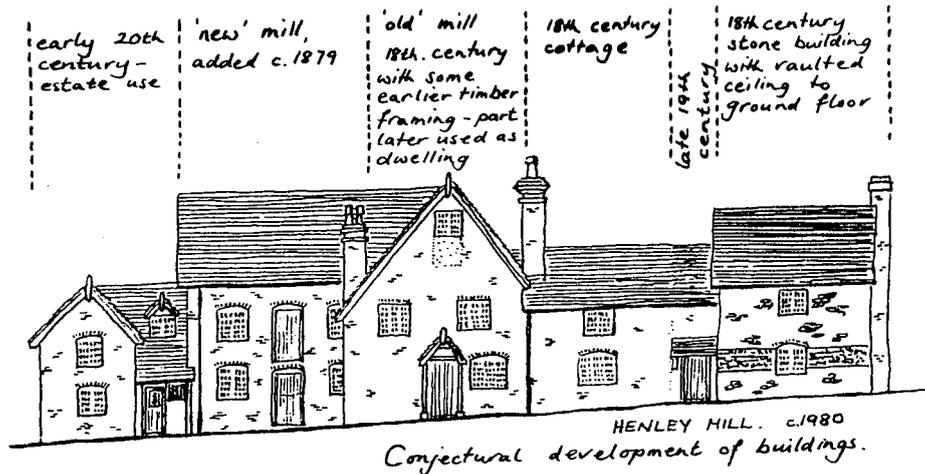
3. Henley Mill. SO 541764

This mill stands just below the confluence of Ledwyche Brook and Dogditch Brook and was served by a leat from both streams. The original leat came from the latter and ran into a small pond immediately behind the mill.[8]. However, when the mill's capacity was increased in the second half of the nineteenth century, a second leat was brought from Ledwyche Brook, crossing Dogditch Brook on an aqueduct, and filling a pond in front of Henley Farm. This leat was at a lower level than the original and the water from the pond was carried in a culvert beneath the earlier mill pond. The original leat remained in use, losing much height in its last few yards to join the new system. By these means, one large diameter overshot waterwheel was replaced by two somewhat smaller ones.

It is thought that the mill occupies an ancient site, indeed there was a mill at Henley in 1086 valued at 4s. However, most of the existing buildings date from the eighteenth and nineteenth centuries. The mill itself is the central section of the varied range of buildings at the site. It is of two distinct ages, a late eighteenth century brick building, with a little half-timbering which may be earlier, of two full storeys plus a half bin floor and a considerable two storey extension which was added in the second half of the nineteenth century.

There are other additions which have either provided accomodation or been used for various purposes by Henley Estate. The population of the Titterstone Clee area increased rapidly from the mid-nineteenth century to serve the needs of the massive roadstone quarries which scar its summit and this probably accounts for the decision to double the size of the mill. The mill continued to operate until after the Second World War, the last recorded tenants being William and Arthur Martin. After closure it was used as a store until sold for conversion into housing units in 1986. Despite a vigorous campaign by Alan

Stoyal of the S.P.A.B. the application to convert was approved and consequently one of South Shropshire's finest watermills will never work again. Much of the mill machinery has been retained in the conversion but landscaping to the rear of the buildings has ensured that the wheels cannot now be turned by water power.



The upstream overshot waterwheel was made by R.R.Miles of Leominster in 1879. It measures 14ft. diameter by 3ft.7in. wide and is mounted on an 8in. diameter circular iron wheelshaft. The 8ft.8in. diameter iron pitwheel drove an iron wallower on a massive wooden upright shaft. This shaft may be a remnant of the original eighteenth century machinery in this part of the mill. The upright shaft carries a wooden compass-arm great spur wheel which drove two pairs of 4ft. diameter French millstones through iron stone nuts. The downstream wheel, also overshot, was made by Bellows and Sons, Iron and Brass Founder of Leominster in 1900. It is a copy of the upstream wheel and may represent a major repair or renewal of a similar wheel. In the course of recent house conversion work, the downstream wheel has lost its pentrough and pipe. The wheel is mounted on a square iron wheelshaft and drives an 8ft. iron pitwheel. The wallower, 7ft.6in. spurwheel and upright shaft are all iron. Again, there are two pairs of French stones driven by iron stone nuts. All ancillary machinery had been removed before conversion though two sack hoists, one driven by each waterwheel, remain in place.

4. Farm Wheel at Lower Ledwyche. SO 536745

South of Henley Hall, at Lower Ledwyche, Ledwyche Brook is joined by a small stream which fills a long narrow pool across the road from an impressive range of farm buildings, now converted into several residences. In the centre of

the complex of barns was a farm mill erected c.1860, driven by a waterwheel which remains in position. The all-iron high breast wheel, by Chaplin Hodges of Ludlow, is totally below ground level. It measures about 18ft. diameter by 3ft.6in. wide. The surviving gearing consists of a spur gear mounted on the waterwheel driving a pinion on a short horizontal shaft which carries two pulleys. No shafting survives above ground level and there is no indication of the farm machinery which the wheel must have driven. The waterwheel is thought to have remained in use until c.1960.

5. Caynham Mill. SO 544729

Immediately downstream from Lower Ledwyche, the Ledwyche Brook turns away from the Teme and cuts through a ridge of limestone at Poughnhill. Beyond the ridge is the fine weir which provided the head of water for Caynham Mill. The leat is heavily overgrown in some places and infilled in others, but enough remains for its course to be followed. In one place, river and leat are so close that the leat had to be piped to prevent water loss. On the final approach to the mill, the leat is clear and open to within fifty yards of the buildings. The mill and house form a continuous range, but the mill itself suffered major rebuilding in the course of house conversion in 1989 and has lost much of its original character. Both mill and house retain a proportion of timber framing, perhaps dating from the late seventeenth century. The site is likely to be an ancient one as there was a mill at Caynham in 1086. All the mill machinery, including the waterwheel, was removed many years ago.

6. Knowbury Ironworks. SO 581748

These ironworks were built alongside Colly Brook, one of the many tributaries of the Ledwyche Brook. The 1794 list of furnaces from the Boulton & Watt papers, mentions a coke-fired blast furnace, blown by engine, at Clee Hill which had been built in 1783.[9] Clee Hill village is less than a mile from this site so it could have been erected here, though another furnace existed at Cornbrook, also nearby. Clee Hill furnace produced three hundred and three tons of pig iron in 1806. Later known as Clee Hill Iron Works, it was described in a sale notice of 1851 as including a forge, a rolling mill and a slitting mill together with its coke-fired blast furnace.[10] An illustration of the works shows a waterwheel on one of the buildings but gives no indication of the machinery it worked (see page 10). The site of these works was later developed as a brickworks and no trace of the earlier buildings remain.

7. Rockhill Mill. SO 571720

Below Whitton village, Colly Brook becomes Stoke Brook which was diverted into a short leat to drive Rockhill Mill. This mill worked until c.1949 but has subsequently been stripped of all its machinery and is now used as a farm store. Much of the gearing was sold for installation in Lutley Mill, Halesowen. Only the wooden waterwheel shaft, complete with gudgeons, lies in a nearby field. The three-storey, red brick building remains in fair condition.



Knowbury Ironworks.

8. Burford Mill. SO 575684

Less than half a mile from its junction with the Teme, Ledwyche Brook was diverted one last time to provide power for Burford Mill.

There were two mills at Burford in 1086, rendering twelve packloads of corn, and there were still two waterwheels driving two sets of machinery when the last building on this site was finally demolished in the 1980s. It had remained in use as a corn mill until the 1930s, being worked by members of the Wheeler family from c.1860. The three-storey brick building became increasingly derelict and dangerous in recent years, however it was possible to salvage much of the machinery before demolition took place.

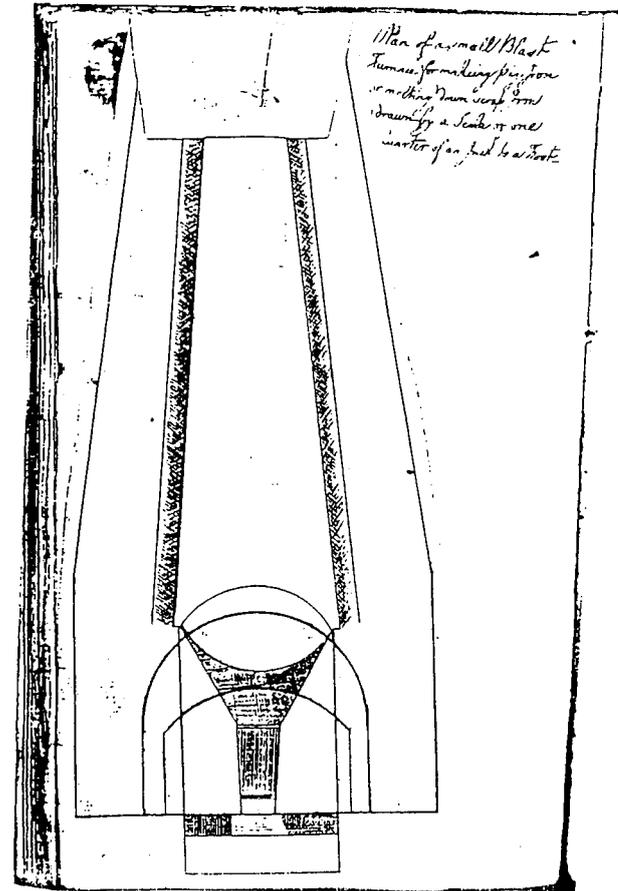
The waterwheel at the northern end of the buildings was an external, iron overshot wheel, measuring 10ft.6in. diameter by 5ft.6in. wide. The hubs and arms were made in 1854, presumably fitted to shrouds of an earlier wheel. It was mounted on a circular iron shaft which carried a 6ft. diameter iron pitwheel. The wooden upright shaft was octagonal on the ground floor but circular on the stone floor. The 3ft.3in. wallower, 7ft. great spur wheel and 4ft.8in. crown wheel were of iron, though the last two had cogs of wood. Two pairs of French burr stones by Kay and Hilton of Liverpool, dated 1855, were driven by 16in. iron stone nuts. Auxiliary drives from the crown wheel drove two Blackmore dressers, a winnower, an Eureka Separator and a sack hoist.

The waterwheel at the southern end was internally sited. It was installed in 1853 by George Turton of Kidderminster being an all-iron high breast wheel, 12ft. diameter by 4ft.4in. wide with 30 buckets (This wheel is now working as an overshot wheel at Offleybrook Mill, near Eccleshall in Staffordshire.) It was fed

from an iron penstock bearing the maker's name and the date of manufacture. The 11in. circular iron wheelshaft carried a 10ft. diameter iron pitwheel which drove a 2ft.6in. diameter iron wallower on a wooden upright shaft. On the stone floor were two pairs of stones driven by 18in. iron stone nuts. No ancillary machinery was sited at this end of the building. The dangerous state of the mill made exploration above ground level extremely hazardous.

The Corn Brook.

Corn Brook rises high on Titterstone Clew and flows southwards to join the Teme near Monk's Bridge one and a half miles east of Tenbury Wells. Near its source, the flow is augmented by a sough which drained many of the coal mines on the summit of the hill. The first waterwheel was sited only half a mile below the source at the hamlet of Old Furnace.



Drawing of a blast furnace on a page of Thomas Botfield's notebook.

9. Cornbrook Furnace. SO 604753

Thomas Botfield supplied charcoal-smelted iron from Cornbrook Furnace to the Stour Partnership forges between 1785 and 1788.[11] One of Botfield's notebooks has survived and includes drawings of a small blast furnace 'for making pig iron or melting down scrap iron' (see previous page). Although these drawings are undated, other material suggests a date of 1784-5. There are also references to a 42ft. diameter waterwheel and it is thought that this was used to provide the air blast. Certainly the site at Cornbrook would give sufficient fall for such a wheel. It would appear that from 1788 the furnace was adapted to produce coke-smelted iron. It was certainly still in operation in 1806, when an output of 292 tons was recorded, but had ceased by the 1820s.

The site lies in what is now called 'Fairy Glen', a conservation area, where there is plenty of furnace slag and some evidence of stone walling but no definite remains of a furnace. The possible line of a leat can be traced to near a cottage on the side of the valley.

Long after the furnace had disappeared the site found an alternative use. Close to the stream below the cottage is a roofless corrugated iron shed which once housed a generator driven by a small waterwheel. Only the shaft and hubs of the wheel remain, but it would have been about 6ft. diameter. Inside the shed are the driving pulleys but the generator itself has gone. A slate board holding some of the control gear lies near the stream. Before the advent of mains electricity, many of the inhabitants of Clee Hill brought their accumulators here to be recharged.

10. Coreley Mill. SO 614730

A leat commencing just below the ford at Cadbury filled the long, narrow pond behind Coreley Mill. The London Gazette of September 23rd, 1815 noted:

'John Oseland, Coreley, Salop, miller, bankrupt. To surrender at Craven Arms, Stokesay, Salop.'

The mill was advertised for sale in the Worcester Journal of January 28th, 1819, when it was owned by John Jones. However, it would appear that the mill remained unsold as it was advertised as follows in the London Gazette of August 3rd, 1824:-

'To be sold by Auction on the 24 August, 1824, at the Swan Inn, Tenbury, by order of a Commission of Bankrupt against John Jones, late of Coreley, in the County of Salop, Lime Burner, Dealer and Chapman. Lot 1. Dwelling house, late in the occupation of the said John Jones jnr. Lot 2. A brick tenement, together with a mill house, three water corn mills and a dressing mill, under one roof, with all necessary out buildings, etc. situated in the said parish of Coreley, and were late in the occupation of the said John Jones. The premises have been put in substantial

repair, and the machinery and waterwheel are new. John Jones jnr. will show the premises.'

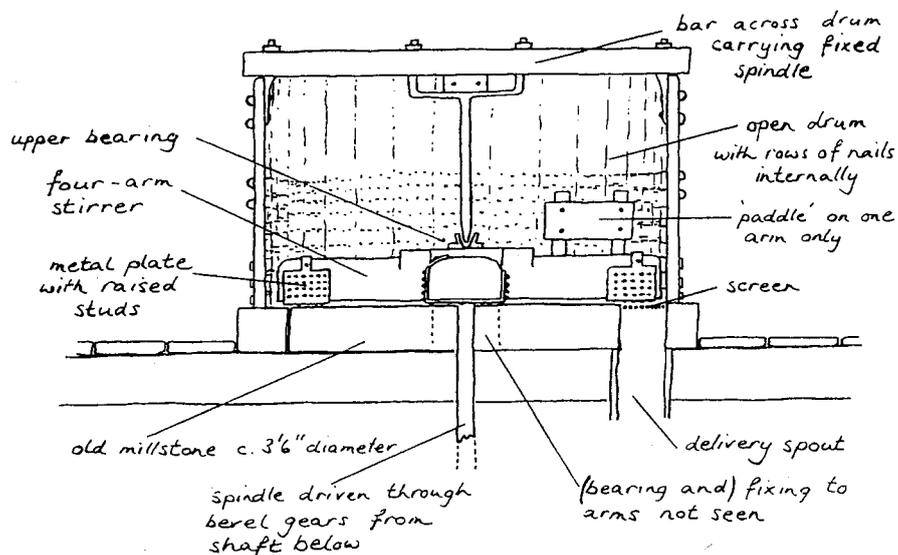
Israel Breakwell was the miller by 1880, followed by Philip Key in 1885, E. Corfield in 1895 and William Amphlett on 1905. Thomas Brown was noted in 1922, followed by John Thomas Brown from 1929 until the early 1940s when the mill ceased work.

The mill building is of brick with a tiled roof and is two storeys high with an attic floor. A small two storey extension adjoins the west gable wall. Unfortunately, the building has suffered severe structural damage which has reduced it to a virtual ruin. Some years ago, decaying battens allowed the tiles to slip and consequently there has been much water damage to the internal timbers, both floors having collapsed. The east gable wall, which is built into the pond dam has bowed in considerably and the west gable leans outwards. The owners have recently attempted to arrest the process of decay by covering half the roof in galvanised sheet.



The waterwheel collapsed into the wheelpit during the Second World War when an attempt was made to remove it for scrap. The remains show that it was overshot, about 18ft. diameter, and all iron except for wooden arms. It was mounted on a wooden wheelshaft which remains in position. The condition of the buildings makes close internal inspection of machinery extremely dangerous.

However, it is clear that an iron pitwheel drove an iron wallower on a wooden upright shaft. The two pairs of stones driven by iron stone nuts and a wood-cogged iron great spur wheel, are complete with tuns and hoppers. Also on the remains of the stone floor are a grain cleaner and a dressing machine. On the machinery floor, an iron pinion, which meshes with the pitwheel, drove a wooden, horizontal shaft. This shaft is carried through the mill wall into the adjoining outbuilding which contains a complete clover mill. Surviving examples are rare in this region, the only other one known being at Arrow Mill, Arrow Green, in Herefordshire (SO 437587). However, the buildings which are said to have housed them remain at several local mills.[12] An account of the different types of machine, their history and use can be found in Melin 6.[13] This example consists of an open drum, 4ft. diameter and 2ft.6in. deep, with rows of nails protruding internally through the lower half of its sides. The base of the drum consists of a 3ft.6in. diameter millstone. There is a four-arm stirrer at the bottom of the drum driven through bevel gears from the wooden, horizontal shaft below. Presumably, the dried clover was fed into the drum where the action of the stirrer and the nails teased the seeds from the heads. The seeds passed through a sieve in the bottom of the drum and a small fan, also driven from the horizontal shaft, blowing across the delivery spout separated them from any accompanying light material. The seeds were retained for replanting while the rest of the crop was used as cattle feed.



Clover mill at Coreley Mill

11. Tilsop Furnace, SO 615725

On the chancel floor of Coreley Church is a slab which reads:

'Here lieth the Body of Elinor, the wife of Edward Hussey of Tilsop Furnace, Gent. 3rd Daughter of Edward Cresset of the Coates in the (C)ounty Esqr. who departed this life the 29 day of April A.D. 1684 Aged 31 yrs.'

The furnace is thought to have been active from c.1660 as it is first mentioned in a rent roll of 1662.[14] It was certainly working in the late 1660s as the Shelsey Forge account of the Foley Partnership for 1669 showed a debt to Lady Blount of £305 for '50 tons of sow iron delivered at the Lowe from Tilsop at £6-2s-0d.' in 1668, and £167-0s-10³/₄d for iron delivered in 1669.[15] It is thought that the furnace was blown out in c.1705, and although no trace of the structure has been found, large quantities of slag line the stream at the reference given.

12. Watmore Mill. SO 614713

A notice in the Worcester Journal, October 15th, 1812, stated that 'the water corn mills called Watmore Mills' were to be sold by auction. The property was offered again in the Worcester Journal, September 3rd, 1818:

'To be sold by auction. All that well accustomed Water Corn Mill called Watmore Mill. The mill is in full business as a Batch and Flour Mill with overshot wheel working two pairs of stones and a dressing machine, situated in the parish of Burford and in the occupation of the tenant Mr.Incell.'

By 1856, James Mytton was the miller, followed by Edmund Davis who was first noted in 1875. By 1900 the mill was occupied by John Price.

The leat has disappeared but the mill building, devoid of all machinery, still stands. It is a small two storey structure, timber framed and infilled with brick, perhaps dating from the late seventeenth century.

13. Boraston Mill. SO 618702

A notice in the Worcester Journal of July 21st, 1808 records:

'To be sold by auction. The well accustomed Water Corn Mill called Borraston Mill in the parish of Burford in the county of Salop. The mill has two water wheels, one of which is for a clover engine, two pairs of stones, the one pair of French and the other pair Welsh and French, both for grinding corn, now in the occupation of Mr.John Perks whose term expires next Lady Day, at the rent of £70 per annum.'

By 1828 William Gill was the miller, followed by E. and J.Mytton along with

Watmore Mill in 1856, William Tombs was noted in 1861, followed by Richard Wood in 1863 and Thomas Morris in 1870. Edmund Davies was at the mill in 1880, John Price in 1891 and finally Robert William Parry in 1895. Such frequent changes of miller suggest that this was not a profitable concern and it is perhaps no surprise that it fell out of use and was demolished so long ago. The mill house remains and there are still traces of the watercourses but not of the mill.

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Newspaper references were taken from the Shropshire Watermills file of H.E.S.Simmons which is housed in the Science Museum Library, South Kensington, London. Lists of millers were extracted from 19th and 20th century trade directories.

The History of Bosley Works, Cheshire.

by Tony Bonson.

The parish of Bosley lies in the south east of Cheshire, roughly halfway between Macclesfield and Leek, and about three miles east of Congleton. The parish is bisected by the Macclesfield to Leek turnpike road, now the A523. The western part of the parish lies on the beginning of the Cheshire plain and is essentially pastoral in character, whereas the east of the parish lies in the first foothills of the Peak District. The River Dane, flowing westwards, emerges from these foothills at the south of the parish, forming the boundary with Staffordshire. The river's progress due west is halted by a substantial outcrop, known as Bosley Cloud, which forces the river to flow in a more northerly direction. It is along this north flowing stretch of the river that a group of industrial buildings, unremarkable in themselves, known as Bosley Works, are situated (SJ 914647). However their history stretches back to the middle of the 18th century, to the earliest days of the Industrial Revolution, and they have been in continuous use, for a variety of purposes, up to the present day.

Very unusually, because of this continuous occupation from the middle of the eighteenth century, the story of Bosley Works and how it has adapted to changing technology and markets gives considerable insight into the overall economic and industrial history of the country. Its success, through approximately 250 years, is an object lesson for the survival of a manufacturing community in a continuously changing economic environment.

1766 - 1801. Copper and Brass.

In the 1740s & 50s Charles Roe had prospered by being involved in the early blossoming of the silk industry in Macclesfield. However, in 1758, he acquired the lease to land in Macclesfield in order to build a smelting works to exploit the copper ores mined at nearby Alderley Edge, using the local coal available in Macclesfield.[1] As the copper business grew, he divested himself of his silk interests in 1762, thereby raising capital to acquire the leases to two 'greenfield' sites suitable for building waterpowered factories. One of these sites was at Buglawton.[2] near Congleton, and the other was at Bosley.[3]

The land and water rights at Bosley were leased from the Earl of Harrington, the local landowner, for 99 years from the 25th September 1766 at an annual rent of £25.[4] It was suggested about 100 years later that James Brindley was responsible for the arrangements for harnessing the great water power of this original establishment.[5] Certainly the scope and size of the works would suggest a millwright of Brindley's stature being involved, and his millwrighting business was locally based in Leek, but unfortunately there is no direct evidence

to support this claim. In fact there are factors that mitigate against James Brindley's involvement. Firstly, by 1766 Brindley was absolutely overwhelmed by canal engineering work. Secondly, Charles Roe was a leading promoter of a scheme for a canal from Macclesfield to the River Weaver, in opposition to the Duke of Bridgewater. On the 18th April 1766 both James Brindley and Charles Roe gave evidence to the House of Lords, Brindley in support of the Duke of Bridgewater against the scheme supported by Charles Roe. Such was Brindley's reputation that the Duke of Bridgewater won the day.[6] Thirdly, earlier in 1765, James Brindley had married and moved to Turnhurst in the Potteries so weakening his local links with Leek. The identity of the engineer/millwright at Bosley therefore remains unknown.

The Macclesfield Copper Company, as Charles Roe's enterprise became, went from strength to strength, having mining interests in Anglesey, Cornwall, the Lake District, and Ireland, and other large smelting works in Liverpool and Neath Abbey.[7] Although production continued at Bosley after Roe's death in 1781,[8] the fortunes of the Company declined steadily until in 1801 the three sites at Macclesfield, Buglawton, and Bosley were advertised for sale.

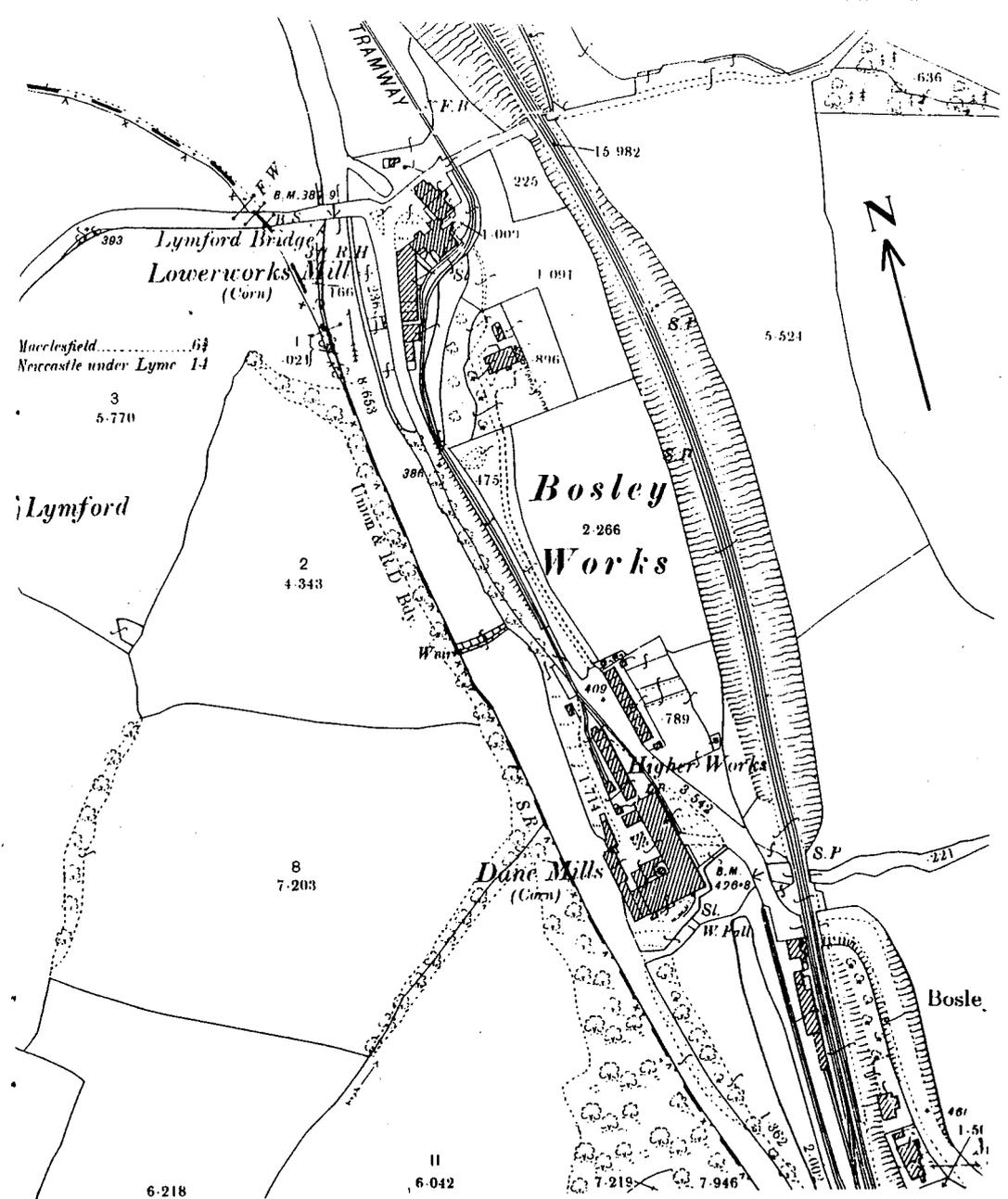
It is from this sale notice that it is possible to determine the scale of the operation at Bosley. There were two distinct areas of operation; the Higher Works had five waterwheels, with a 25ft 3in head, developing 40 H.P., which powered one rolling and four battery mills for brass working. Also there was a blacksmith's, wheelwright's, carpenter's, and cooper's shops, together with a handsome brick dwelling house with stables, a good garden and sixteen acres, plus eight cottages. About 100 yards downstream, the Lower Works, having one waterwheel, with a 14ft 9in head, developing 20 H.P., were used for rolling and hammering copper. Also at the Lower Works there was a warehouse and two other dwelling houses with gardens.[9]

So as the 19th century started, the copper and brass working came to an end at Bosley, due no doubt to the cost of shipping the the raw materials of ore and coal such long distances to this remote part of Cheshire after the local sources had earlier become exhausted. However there was substantial water power available awaiting harnessing to a new use.

1801 - 1864. Textiles.

In 1806 the Macclesfield Copper Company again advertised the property for sale in much the same terms as in 1801 but with a significant addition.[10] The Higher Works had been occupied by Messrs. Berresford for cotton spinning sometime since 1801, although the Lower Works were unoccupied. At this time the Berresford's lease had seven years to run so they had probably occupied the mill in 1801 or not long after. This was the start of a fifty year association between the Berresford family and Bosley Works.

In the late 1820s the Lower Works were advertised to let as a silk factory by Warrington & Hambleton, who probably acquired the lease to the complete site from the Macclesfield Copper Company as an investment for sub-letting.[11]



O.S. Map of Bosley Works showing the Higher & Lower Works, with the tramway which runs northwards towards the Macclesfield Canal.

This silk factory was being worked earlier in the 1820s by Francis Johnson but he had ceased to operate by 1827.[12] At that time the Lower Works had about 300 dozen spindles plus swifts and doubling machines, with considerable room for expansion. The mill itself was a three storey building, 24 yds long by 8 yds wide, and was heated by steam. Also there was a warehouse, wash house, and seven cottages offered with the mill.[13] Warrington & Hambleton seem to have been unsuccessful in letting the Lower Works as it was still advertised to let in 1830.[14]

Meanwhile, at the Higher Works, the Berresford family had taken on a sleeping partner and continued their cotton spinning business as tenants of Warrington & Hambleton. Certainly in 1828 they were known as Warren & Birrisforth (*sic*), cotton spinners.[15] Shortly before 1830 part of the Lower Works became a corn mill, although it is not clear whether this was a new building or an adaptation of the existing buildings.[16] About this time the other part of the Lower works, previously used for silk throwing, was occupied by the Berresfords who continued to operate it for silk throwing.[17]

In 1833 and 1834 both the Higher and Lower Works were advertised to let, even though the Berresfords still had another ten years outstanding on their current lease. At this time one of the waterwheels was described as a 'powerful iron waterwheel of a superior construction which has a supply of water from the River Dane and is equal to 22 H.P.' It is interesting to note that one of the contacts for further particulars concerning the premises was Messrs. Fairbairn & Lillie, Engineers, Great Ancoats Street, Manchester. This suggests that the wheel may have been recently installed by them and may have been a suspension wheel with rim gearing, a type for which they were particularly noted.[18]

The lease was acquired in 1834 by Thomas & Archibald Templeton, who also held the leases of Woodhouse Mill, Buglawton and Forge Mill, Congleton, but by 1840 they were bankrupt, and the Lower Works was advertised for sale including the corn mill.[19] The outcome of this sale is not known, but the Berresfords continued with their cotton and silk enterprises. In 1841 there was a total of 40 workers employed in cotton spinning and 12 in silk throwing. Out of these 52 people, only 13 were female, and the youngest worker was aged thirteen.[20]

By 1850 the Berresfords had given up the struggle with the silk business, concentrating entirely on cotton spinning. The Lower Works were now occupied by Thomas Pimlett, a wood turner, as well as continuing to be used for corn milling.[21]

At the mid-point of the century the whole cotton spinning enterprise had all the signs of being extremely successful. In 1851 there were 62 workers employed at the cotton factory, of these, 36 were female (a higher proportion than in 1841) and the youngest employee was 12 years of age (lower than in 1841). There were seven separate Berresford families at Bosley, all involved in the cotton works. Many of the offspring of these families worked in the factory

and even the wives who had to look after large families of young children are described as 'cotton reeler at home'. The factory also provided support and employment for the members of eleven other families as well as the Berresford clan. The patriarch of this community was Joseph Berresford, born in 1782, and described as a 'master cotton spinner'; his eldest surviving son, John, was the shopkeeper; and his three other sons and a grandson, William, Thomas, Isaac, and James, were all warehousemen in the factory. (The seventh Berresford family was that of Hannah, the widow of Joseph's eldest son James.).[22]

However, in 1853, at the age of 70 and after about 50 years of spinning cotton at Bosley, Joseph Berresford decided to retire and liquidate his assets. Consequently, all the equipment used in the business was offered for sale, thus giving a complete inventory of a small 19th century cotton factory:-

'All that valuable machinery for the preparation and spinning of cotton. A double beater blowing machine (nearly new) for 40 inch cards with fan and dust pipes, by Kaye of Bury; fifteen single carding engines 40 inch on the wire, with rollers, cleaners, lick-in, and plungers by Hibbert & Platt and others; grinding machine with extra rollers for do.; two drawing frames, four heads each, and two deliveries to each head with plungers; presser slubbing frame 48 spindles and 8 inch lift by Higgins & Sons nearly new; do. do. 60 spindles and 6 inch lift by Higgins; four do. pressure bobbins do., 72 spindles and 6 inch lift by do.; new pressure roving frame 7 inch lift and 120 spindles by Kaye; soft bobbin roving frame 6 inch lift and 72 spindles by Higgins; soft bobbin do. 6 inch lift and 120 spindles by do. The following hand mules all by Gore of Manchester: pair of hand mules 648 spindles; three pair do. 720 spindles in each pair; three pair most excellent do. 864 spindles in each pair; and three pair hand mules nearly new 1004 spindles in each pair. The following throstles by Walker & Co. and others are chiefly in first rate working order and are 2 inch lift and 17 spindles, viz four throstles 144 spindles ea; one throstle 168 spindles; two throstles 120 spindles ea; eight throstles 136 spindles ea; one throstle 128 spindles; six throstle 108 spindles ea; one throstle 132 spindles; and two do. 120 spindles ea; thirty cop reels and seven bobbin reels; two wrap reels, all the roving, slubbing, throstle and other bobbins, spools, skewers, etc.; all the drawing and card cans, straps, skips, etc.; mill clocks, lamps, etc.; capital strong scale beams, scales and weights; sets of new cards; tallow, oil, colours and all the stores.

The contents of the carpenter's, mechanic's, and smith's shops embracing chest of joiner's tools, grindstones and

frames, new woodwork benches and vices, stocks, taps and dies; 6 inch single speed lathe with driving apparatus, 8 inch do. with do.; wheel cutting engine; 26 inch bellows and frame, anvil, swage block, smithy and mechanic's tools; capital narrow wheel pack cart, pair of extra wheels and axle for do.; gig; all the warehouse and counting house fixtures counters, desks, shelving, etc.; together with the valuable mill gearing, wrought and cast shafting, wheels, pulleys, pedestals, couplings, hangers, and brass steps; also all the steam piping from 2 inch to 5 inch diameter etc.; and a vast assemblage of other valuable items and effects.[23]

After 1853 most of the Berresford families moved away from Bosley and the Higher Works were converted into corn mills. Only John Berresford, the eldest son of Joseph the master cotton spinner, remained operating the Lower Works as a silk throwster until the middle of the 1860s.[24] This enterprise was not very successful in view of the slump in the silk trade caused by the 1860 Free Trade Act. Even though there were fourteen people employed in silk working in 1861 they were made up of John's immediate family or the young offspring of families involved in the corn milling business.[25] In fact business was so bad that in 1860 John Berresford had to supplement his income by working in the corn mills some of the time.[26] At this time when the whole of the English silk trade was decimated, silk throwing came to an end at Bosley in 1864.

1830 - 1930. Corn Milling.

About 1830 part of the Lower Works was converted to corn milling and was being offered for rental in 1832 for £125 per annum.[27] At that time the mill had a drying kiln, stable, and a dwelling house with garden. In the mill there was 'one pair of french stones, one pair meal, one pair shulling, one pair batch with room for two pair others, turned by two powerful wheels.' In 1841 the miller here was Samuel Malkin who ran it as a family business, eventually employing his son William in 1851.[28]

As stated previously, after 1853 the Higher Works was converted to commercial corn milling, being taken over by Robert Brindley, trading as Francis Brindley & Co.[29] They had been corn millers previously at the steam mills in Marple, Cheshire, and also at the steam mills in Macclesfield, until 1852/3.[30] Certainly by 1861, Francis Brindley & Co. were employing six millers in their corn merchant's business, rising to eight millers and eight miller's labourers by 1871.[31]

About the same time that Robert Brindley took over the Higher Works, Francis Rathbone Thompstone arrived at the corn mill at the Lower Works employing two men and two boys.[32] The Thompstones were a well known family of Cheshire corn millers, members of the family operating both Gawsworth and Prestbury mills around this time.[33]

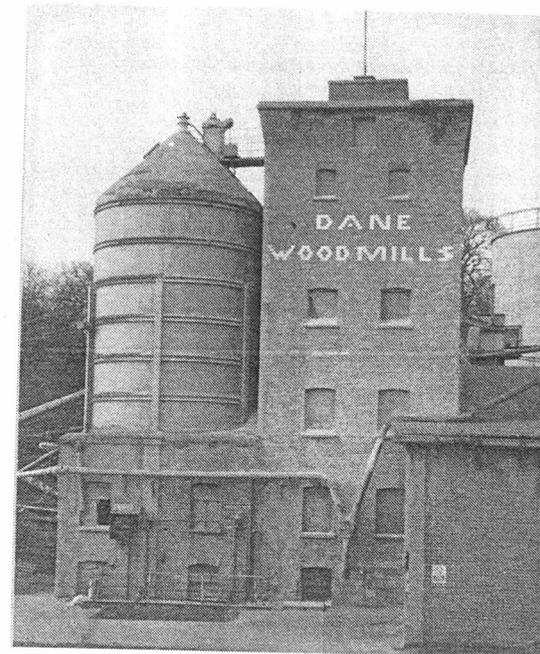


Plate 1. The oldest part of the Higher Works at Bosley, formerly Dane Corn Mills, showing the inlet to the turbines at the bottom left.

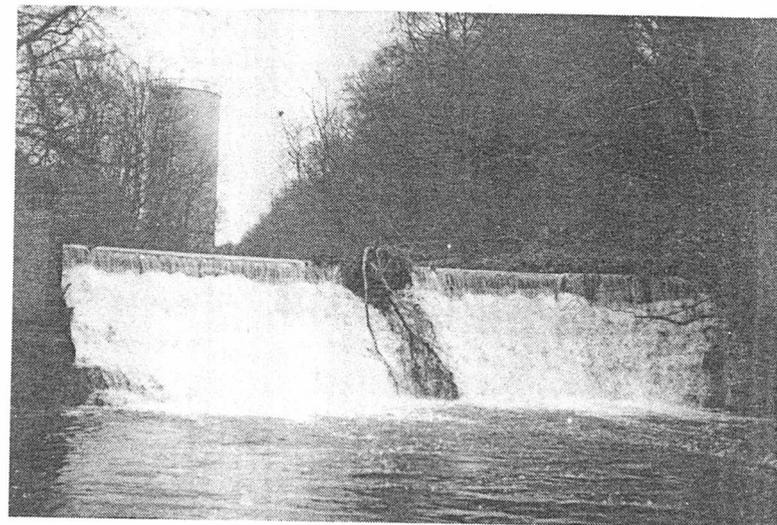


Plate 2. The weir on the River Dane at Bosley, which provides the head of water for the Lower Works.



Plate 3. The surviving workers' cottages at the Higher Works, Bosley.

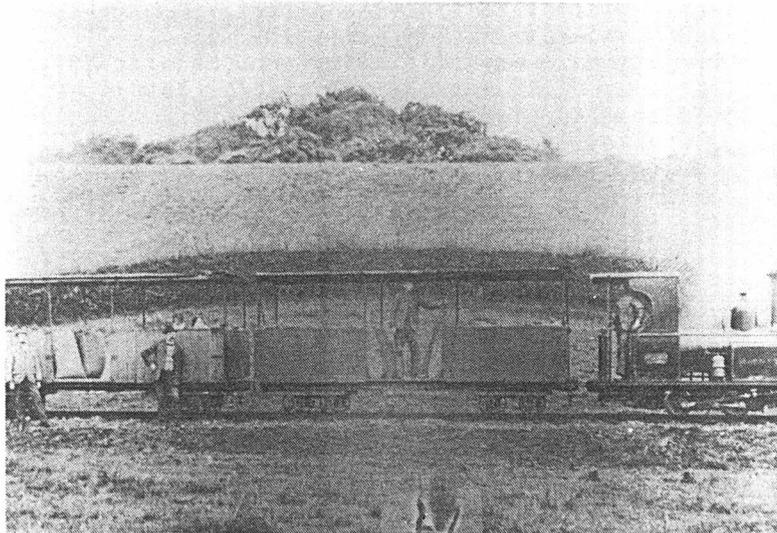


Plate 4. The narrow gauge train used to connect Bosley Works to the Macclesfield Canal during the late 19th and early 20th centuries.

These two corn merchants existed side by side at Bosley for about twenty years until about 1873 when Francis Rathbone Thompstone took over the lease for the whole of the works at Bosley, operating the whole complex for commercial corn milling.[34] In 1881 he employed seven millers, ten miller's labourers, three flour carters, and one flour sack mender.[35]

Both Francis Rathbone Thompstone and his son Frank, who inherited the business in 1902,[36] made many improvements to the mills during their tenure. They were very independent minded and generally undertook any engineering improvements themselves. At one stage, towards the end of the 19th century, they had a dispute with the North Staffordshire Railway, whose tracks ran past the Bosley Works, over the terms of their freight charges. To circumvent the North Staffordshire Railway's monopoly position, the Thompstones built a 2ft 8ins narrow gauge railway running from the mills to a wharf on the Macclesfield Canal about 1/2 mile away.[37] They then used the canal for the transportation of the corn and flour, with a small steam engine hauling the materials over the narrow gauge railway.

In order to remain competitive, the Higher Works was converted to roller milling, probably around the turn of the century, and to provide power more efficiently, water turbines were used to replace the water wheels. In 1888, Gunther's of Oldham were quoting to install a 130 H.P. Girard type turbine for the Higher Works.[38]

In 1894 the Thompstones purchased a 'Titan' sprinkler system, from George Mills & Co. at the Globe Iron Works, Radcliffe near Manchester, to guard against fire. This was installed using a 50 H.P. Girard type water turbine, from Gunthers, that automatically provided the water pressure for the sprinkler system. The system provided two automatic fire alarms. There was a brass hammer attached to the turbine shaft so that when the turbine operated to maintain water pressure (i.e. when there was a fire and the sprinklers showered water onto it thus reducing water pressure) the hammer would repeatedly hit a steel gong. Also when the turbine operated it opened a valve to a steam whistle.[39]

Later, in 1901, the Thompstones were in correspondence with Gilbert Gilkes & Co. Ltd. of Kendal about replacing the water wheel at the Lower Works with a double-vortex turbine of 25 H.P. In 1924 the water feed to this turbine was improved to give 35 H.P.[40] The size and details of the waterwheels replaced is, unfortunately, not recorded, but part of a wheel scrape on the side of the old mill at the Lower Works shows that a wheel of 10 feet diameter, probably overshot, once worked there.

The whole of the Harrington Estate (the original landowner) was advertised for sale in 1920 and the Thompstone family purchased the Bosley Works site, including the cottages and the superior dwelling house known as Harrington House. The sale brochure gives a good description of the works at this time:-

'The highly important and well-known Dane Corn Mills, Bosley, with an attractive residence and land, a house and nineteen cottages with gardens and allotments....The

works adjoin Bosley Station on the North Staffordshire Railway. The Macclesfield Canal bounds the north side of the property, and there is a short Steam tramway connecting the wharf with the Mills...The River Dane provides an ample head of water from the Derbyshire Hills. Gas Engines, steam Drying Apparatus and Electric Light are installed, and the Mills are equipped with modern Corn-milling Machinery.[41]

The Higher Works are described as a substantial five-storeyed structure of brick with a slated roof, having a west wing, water tower, and north wing. In the west wing, the ground and first floor housed the roller mills, the second floor was the purifying room, the third was the centrifugal floor, and the fourth was the scalper floor. In the north wing, the ground and first floors were the screen and sack room, the second floor was the wheat warehouse, the third was the packing floor, and the fifth floor was the flour warehouse. The first three floors of the water tower was the turbine house, with the third and fourth floors being part of the packing room. At the top of the water tower was a 10,000 gallon water tank, supplying the sprinkler system.

The Lower Works consisted of the Old Mill, a four-storeyed, brick built structure, with slated roof, comprising a grinding floor, delivery floor, warehouse and small office. There was also another three-storied mill built of sandstone with slated roof adjacent to the Old Mill.

The whole of this property was purchased by Frank Thompstone from the Harrington Estate at this time. Thus the Thompstones became the owners of Bosley Works after about seventy years as tenants, a situation that exists to this day.

1930 - Present Day. Wood Flour Milling.

The next generation of Thompstones, four brothers, decided to convert the mills from corn milling to wood flour milling, trading as Bosley Wood Treatment Ltd. This conversion was complete by 1930.[42] the process being very similar to corn milling but using woodshavings and sawdust as its raw material, producing a variety of grades of inert wood flour. This is used as a filler by many industries, initially for linoleum and bakerlite production, and now for cosmetics, paints, adhesives, polishes, synthetic rubbers, and all manner of plastics.[43]

This change of business was very successful, and as the business expanded there was a need for more and more power. In 1933, a 268 H.P. turbine from Gilkes was installed in the Higher Works to provide power for grinding. Later, in 1936, a 110 H.P. turbine from the same supplier was installed in the Lower Works to generate electricity.[44]

In 1939 the grinding of mica was added to the range of operations. Mica is a mineral material that is inert in the presence of most acids and alkalis. The ground mica is used as a dielectric in the electrical industry, and for the manufacture of fireproof plasterboard, insulators, welding rod coating, etc. As

the business expanded, the grinding of other inert vegetable materials was added to the repertoire of products; coconut shells in 1945, olive stones in 1970, guar and vegetable gums in 1979, and almond shells in 1986.

These products have a wide application. Olive stone flour provides an extender in glues, a filler in plastics, and is suitable for mixing with resins. Coconut shell flour has similar properties and can also be used as a carrier of pesticides. Guar gum is used in the well-drilling industry to thicken the drilling mud, and in the food industry as a thickener, binder, or stabiliser in pet food meat, sauces, salad dressings, pie fillings, and ice cream. Almond shell flour provides a filling medium where the final product has to take on dyes and stains, such as plastic mouldings where a wood grain effect is required.[45]

The last turbine to be installed was in 1967 when the company purchased a second-hand 32.5 H.P. Gilkes turbine from the Miningaff Saw Mills, Newton Stewart, Wigtown in Scotland, installing it in the Higher Works.[46] However the business was growing at such a pace that the water supply was incapable of delivering the level of power now being required. Also the River Authority started demanding payment for the use of the water as a power source.[47] These factors caused the demise of the use of water power and the switch over entirely to electric power from the National Grid System. Consequently the use of water power at Bosley came to an end after just over two hundred years of continuous operation.

Reflections.

The industrial revolution in Great Britain started in the 18th century with new methods of producing the raw materials needed by all industries, namely metals. Bosley Works was part of this revolution being one of the early sites where copper and brass were produced in quantities not seen previously. This availability of metals made it possible for inventors to contemplate and produce the machines required for the next stage of the industrial revolution, producing the basic threads of the textile industry and thereby creating the factory system. These machines, especially those used in the cotton industry, would not have been possible without the brass used to make the all important rollers, in machines such as Arkwright's water frame for spinning cotton, and without the brass wire used in the complementary carding machines used to prepare the cotton for spinning. The importance of the cotton industry in the industrial revolution is mirrored in the change of use at Bosley Works from brass making to cotton spinning.

Later in the 19th century industry was freed from the constriction of water powered sites, often located in out of the way parts of the country such as Bosley, by the ubiquitous use of the steam engine as a prime mover. This enabled industry to be located in towns and cities where the population grew enormously. This population had to be fed, which led to a rise in commercial flour milling, not just for local consumption, but to feed these cities. This need is reflected in the conversion to large scale flour milling at Bosley Works under Francis Brindley & Co and later Francis R. Thompstone. The milling industry

itself was revolutionised around the beginning of the 20th century by the introduction of roller milling, especially at the country's ports where the flour was imported. Again the works at Bosley were able to adapt by abandoning flour milling and becoming a supplier of filler to the infant plastics industry, which has increased greatly in size and diversity since the first applications of Bakerlite. Even to-day, Bosley Works is in the forefront of new industries, supplying the necessary raw materials to industry, as it has always done since its founding in 1766, with supplies to such industries as oil production and even the storage of food surpluses for the European Community. Its roll call of service spanning such diverse industries as brass working, cotton spinning, flour milling, and plastic filling has in fact been based on Bosley Works only natural advantage, its 25 foot head of water and its operator's hard work and entrepreneurial talents.

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STONE GRINDING AT WASHFORD MILLS, BUGLAWTON, CHESHIRE.

By Chris Bradley

Washford Mills are situated on the River Dane at Buglawton in Cheshire, now a suburb of Congleton but a proudly independent borough until the 1930s. They are thus just outside the Midlands by a couple of miles, but are relevant to them because they supplied the industry of the Staffordshire Potteries. The mills are also of interest because they illustrate the transition from open pan grinding to the ball mill (or grinding cylinder), and also from waterpower to electricity (which did not reach Congleton until 1931 and Buglawton a year or two later). The author studied these mills in 1979 and 1980, by courtesy of the owner Mr.J.M.Goodwin; there have been few significant changes since then.

There are in fact four buildings known collectively as Washford Mills, all backing onto the south bank of the River Dane and reached from Mill Street in Buglawton (SJ 865636). The naming of these mills is confusing, since current practice does not correspond to the names on the early Ordnance Survey maps. Three of the mills, shown in Figure 1, are discussed in this article and are called Washford Mill, the Middle Mill, and Lower Washford Mill following the names used by the owner; but the first of them is sometimes referred to as 'Upper Washford Mill' or 'Top Mill'. Higher Washford Mill, a short way further upstream on Havannah Street, still stands but was never concerned with stone grinding. Washford Mill consisted, until recently, of a centre section and two wings, but the downstream wing was burnt out and demolished in 1988. The wings were not used for stone grinding. The centre section, which is the main subject of this article, is said to have started life as a corn mill and was later converted to stone grinding, though it may have been used in some other way and then reverted to stone grinding around 1900 or a little later. When referring to Washford Mill it is this centre section of the mill that is meant. Lower Washford Mill and the Middle Mill are also of interest, in particular because they are still in use, but they will be mentioned only briefly.

The Mill Building.

The central section of Washford Mill is about 30 feet wide and 45 feet long, with three storeys above street level and a basement below. The lower part of the building is of stone and the upper part of dark brick. At the river end the building extends about 12 feet over the river, with the former wheel house below, and beyond this is a channel with a second, external, waterwheel still in place. Beyond this channel a stone weir extends across the river, giving a head of about 6 feet. The stone grinding equipment occupies the basement and

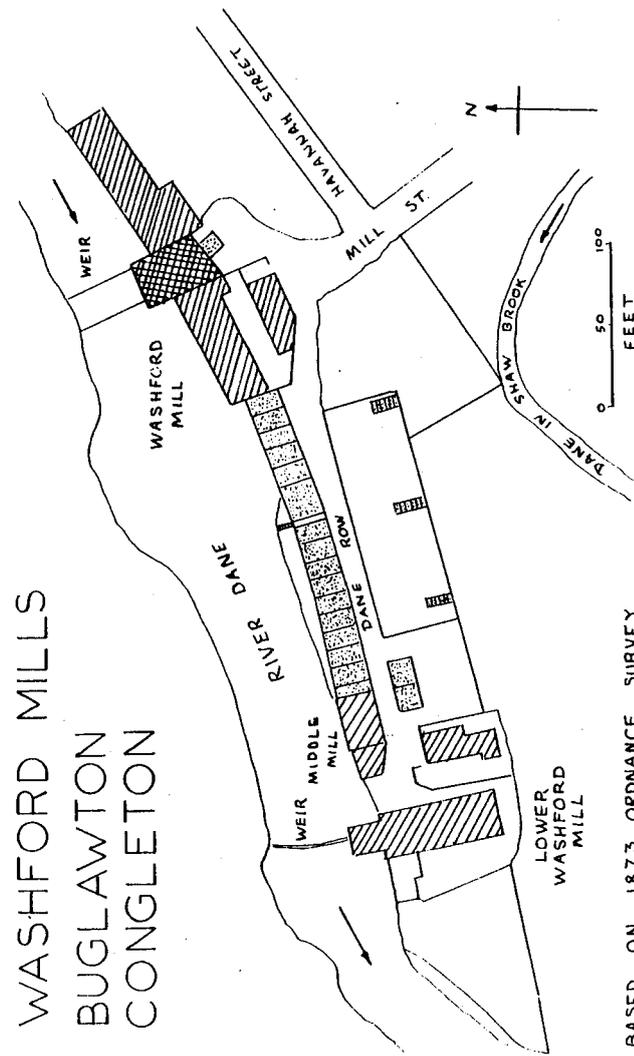


Figure 1. Plan showing the Position of Washford Mills on the River Dane at Buglawton.

ground floor; there is a large opening in the ground floor to give ready access to the basement. Figures 2 and 3 are simplified plans of the basement and ground floor. The upper floors are derelict, with most of the floorboards missing and no means of access, although a staircase remains between the first and second floors. The adjacent wings have been used for textile manufacture, including fustian cutting, at various times, and it is likely that the upper floors of this central section were used in the same way and communicated with one or both of the wings. Blocked doorways in the upstairs walls can be seen, although repairs to the walls make it difficult to see whether power from the waterwheels in the centre section was ever transmitted to the wings. There is now no machinery or equipment on these floors apart from a water tank.

The Grinding Process.

Before discussing the machinery it is necessary to describe the process of grinding stone for the pottery industry. Some kinds of stone (such as Cornish Stone) can be ground in their natural state, but others such as flint must first be fired in a kiln for a few hours to break down their structure. In the older, open pan, process the material is then put into the grinding pan, covered with water, and then ground between the stone floor of the pan and a set of heavy runner stones which are pushed round the circular pan by arms driven by the waterwheel. The water keeps stone dust out of the air.

After a few hours, normally overnight, most of the material will have been reduced to particles of the right size, though some larger particles remain. The 'slop' of ground materials and water is then washed through a channel into a holding tank or 'ark' and then pumped into a circular tank known, because of its appearance, as a 'washtub' which can be stirred by a paddle. More water is added, and the washtub is well stirred, then left to stand for a few minutes. The oversize particles settle out, while the rest remain suspended in the slop and are run out through a plug in the side of the washtub into a settling ark in the basement.

The slop is left in the settling ark for several days, during which the particles gradually settle to leave clear water above and a concentrated suspension below, with quite a sharp boundary between the two. The water is run off to waste by removing a series of plugs, one at a time, from a vertical set of holes in the side of the tank. Finally the thickened slop is pumped from the settling tank into a mobile tank, either for sale in this state to local customers or for transport to the lower mill where it is dried out.

In the more modern process, the open grinding pan is replaced by a 'ball mill' which is a closed steel cylinder with a lining of stone blocks. The material to be ground is loaded into it, together with water and a quantity of flint pebbles which more than half fill the drum. The drum is then rotated about its horizontal axis for some hours to grind the material. This process produces more uniformly ground particles so the washtub stage is not necessary, but because of the way this mill is laid out the washtub and settling ark are used in the same way as for pan-ground material.

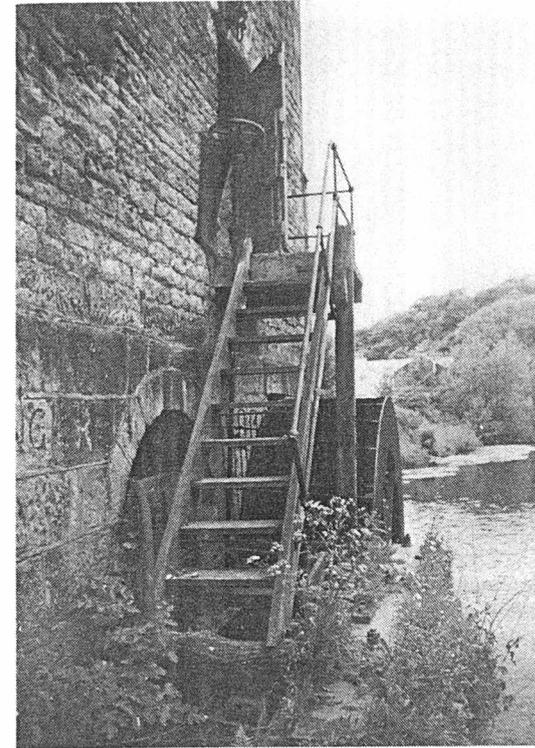


Plate 5. the waterwheel, access stairs and sluice control, Washford Mill.

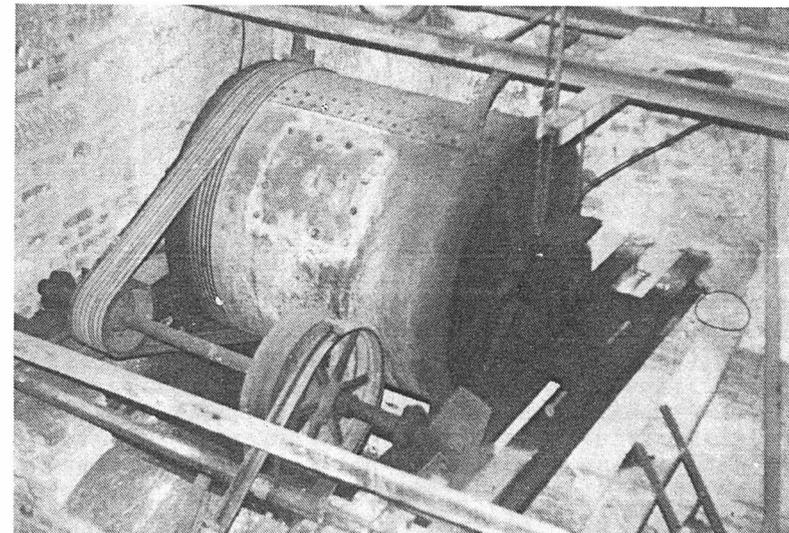


Plate 6. The ball mill for grinding flint, Washford Mill.

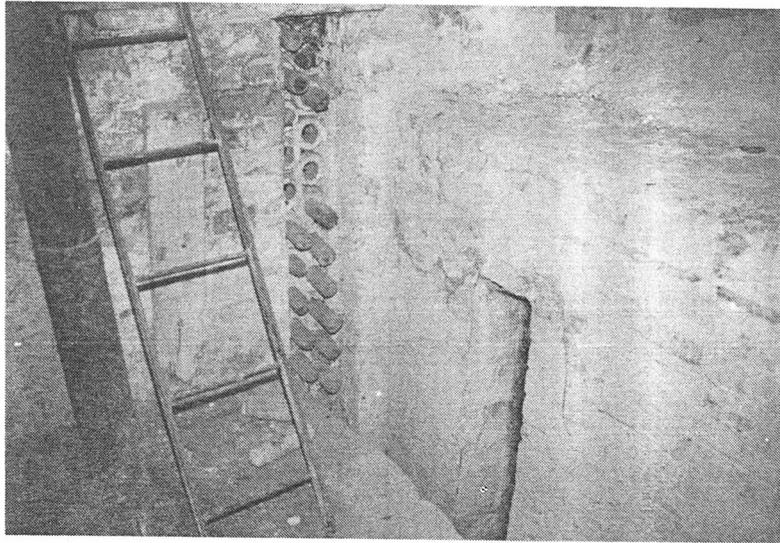


Plate 7. A plug plank used to drain off liquid at various heights, Washford Mill.

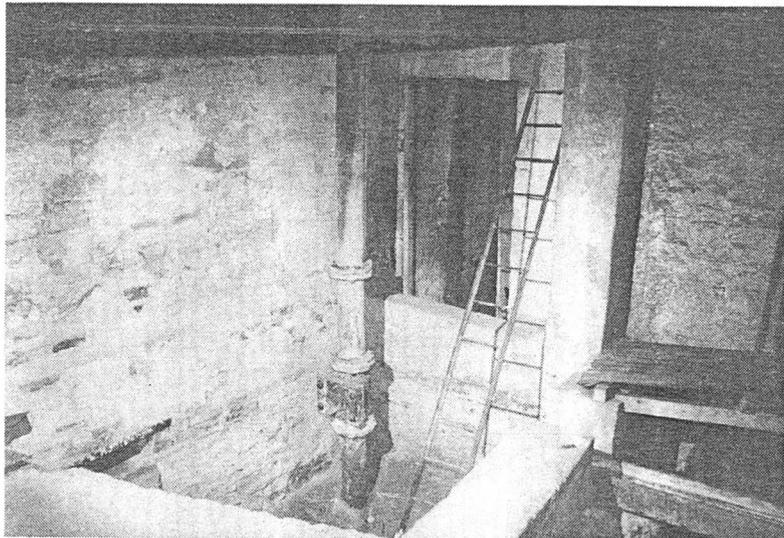


Plate 8. The holding tank and pump, Washford Mill.

An Overview of the Machinery.

The machinery in this mill consists of a single open grinding pan driven by the external waterwheel; and a single ball mill or grinding cylinder (with room for a second one to be added) which can be driven either by an electric motor or by a Gilkes' water turbine. The turbine is located in the wheelhouse under the river end of the mill, replacing an earlier waterwheel. Auxiliary machinery consists of a 'washtub', or holding tank with stirrer, and two pumps, all driven by a second electric motor. There is, as one would expect, some evidence that these were originally driven by waterpower, probably from the same shaft that drives the grinding pan since this extends upwards beyond the pan. When Rex Wailes prepared his paper for the Newcomen Society in 1967 he stated that this auxiliary equipment was driven by water, but it seems that he was mistaken.[1]

The mill is laid out to make maximum use of gravity to move material from one stage of the process to another, but at one point a pump has to be used between stages, and a second pump is used to pump the final product out of the mill.

In addition to this powered machinery there are various masonry-built tanks or 'arks', a small crane, overhead hoist rails for transporting materials between the mill door and the grinding machinery, and a hopper truck on a short length of track; all these except the crane are fairly recent. Just outside the mill door there was a kiln, but this was demolished in the late 1940s. There are now no drying arks at the mill, although there were some outside the building at one time; the wet material is taken in a small portable tank to the lower mill, 100 yards away, to be dried out.

Most of the present equipment of the mill appears to date from a reorganisation in the mid 1930s. The grinding pan and waterwheel may date from a re-conversion of the mill to grinding around 1900; the earlier waterwheel, now removed, may have driven other grinding pans at that time.

The Waterwheel and Gearing.

The waterwheel is of all-iron construction, approximately 14 feet in diameter and 4 feet wide with 30 buckets, and is low breast shot with a head of about 6 feet. There is no maker's name or date, though Rex Wailes suggested that it may have been made by Booth's of Congleton. It is located at the end of the weir with only a short headrace and control sluice. There is thus no storage pond, but the flow of the River Dane is considerable and would be adequate at all times. The weir of Lower Washford Mill is only about 100 yards downstream, but it is low and does not cause the river to back up to this wheel.

The waterwheel is placed near the downstream end of the mill wall, presumably so that its shaft was clear of the second (probably earlier) waterwheel mounted in the wheel chamber beneath the end of the mill. The wheel shaft is of iron, and round. Its outer bearing is on the wall separating the wheel pit from the weir, and a wooden staircase leads up from here to a door in the ground floor of the mill. Just outside this door is a handwheel controlling the

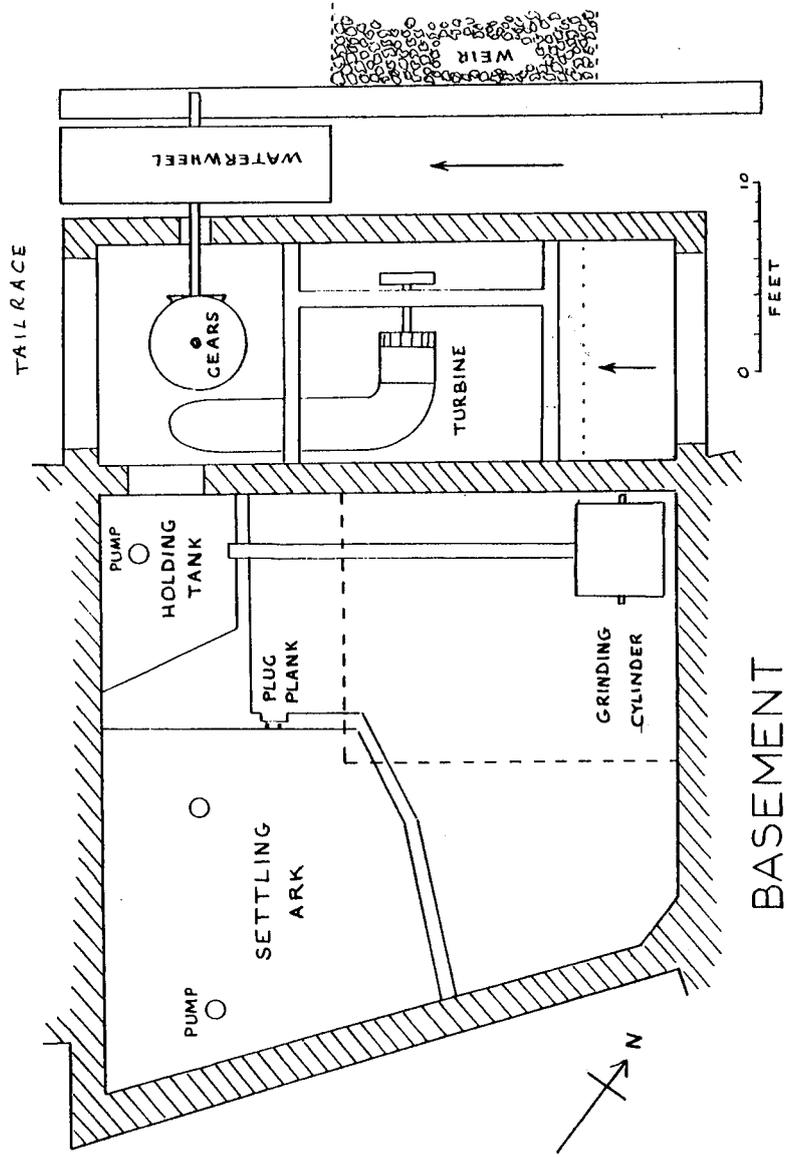


Figure 2. Plan of the Basement at Washford Mills.

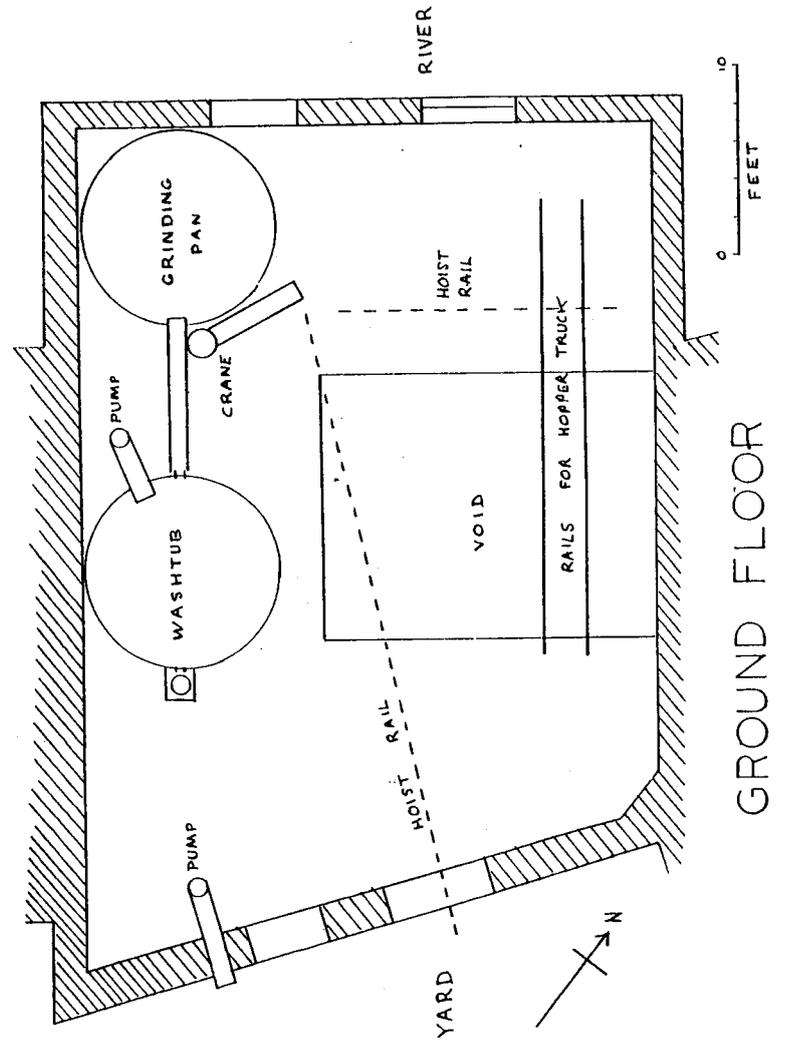


Figure 3. Plan of the Ground Floor at Washford Mills.

sluice which admits water to the wheel. The wheel shaft passes through an opening in the wall of the old wheelhouse, and the inner bearing is carried on an iron frame which also carries the footstep bearing of the grinding pan shaft. The two shafts are linked by iron bevel gears which give a slight speed reduction. The gear on the vertical shaft is keyed and is located by nuts on threaded rods dropping from a collar further up the shaft to allow for adjustment. The other gear is also keyed and is held in place by a collar; this can be moved so that the gears can be put out of mesh, though not while the machinery is running. A door from the mill basement gives access to these gears and bearings.

The grinding pan shaft passes up through the mill floor and the grinding pan, and is located above the pan by a bearing carried on iron brackets attached to the wall. There is an extension to the shaft supported by another bearing. This is now redundant, and is probably a remnant of the former drive from this shaft to the pumps and washtub; perhaps also to equipment on the upper floors, since there is a collar at the top of the shaft and an opening in line with it in the floorboards above. A disused section of lineshafting, whose axis intersects that of the pan shaft, still remains and this carries a crank which probably drove a pump, though it does not match up with the existing pumps.

The Grinding Pan.

The grinding pan is on the ground floor of the mill. It consists of a ring of steel plates about 10 feet in diameter and 3 feet deep, and a small central sleeve around the pan shaft. The floor of the pan is paved with chert blocks. There are four radial sweep arms, slightly curved, attached to the pan shaft through a device which allows the set of arms to slip on the pan shaft if the arms meet sudden resistance, and thus avoid damage. This device consists of a smooth drum keyed to the shaft, around which fits a drive collar in sections which are held together by bolts. These bolts are tightened to the point where the grip of the collar on the drum is enough to transmit the normal force, but not so much as to prevent slipping if the machinery jams. Lugs on the collar drive pins projecting from the sweep arms.

Each sweep arm has three vertical wooden boards, or 'drop arms', bolted to it, and these boards drive a large runner stone around the pan. The boards have iron tips where they make contact with the stone, to reduce wear. The curve of the arm guides the runner stones in a circular path, but an iron ring, or 'slug iron', is attached to a projection downwards from the tip of each sweep arm to ensure that the stones do not touch the side of the pan. The runner stones are large lumps of chert, weighing several hundredweight apiece, and are of irregular shape as they came from the quarry. The floor of the pan is made of chert blocks, roughly squared to 8 or 10 inches across, bedded in a stiff clay to hold them and make the bottom of the pan waterproof. Initially the runner stones are a poor fit with the pan floor, so before the pan is used for grinding it is run for some days so that the stones and the floor grind each other to a rough fit; the pan contains water, to keep stone dust out of the air, and a 'false charge' of some material such as pottery wasters which fills up the gaps between the chert

blocks. In this pan the floor has been re-laid and a false charge shovelled into the pan but not yet ground in. A pan floor will last for many years of continuous use, figures such as 5 to 30 years have been heard; the runner stones may need replacing more often. Chert is used partly because of its hardness, and partly because its chemical similarity to flint means the particles of chert which inevitably get ground off the runner stones and floor (even though these are much harder than the material being ground) do not spoil the ground product.

A cock in the side of the grinding pan, at the level of its floor, allows slop (ground material and water) to be run into a wooden channel beneath the floor which leads it into a holding tank in the basement.

The Water Turbine and Power Transmission.

A large wheelhouse forms part of the structure of the mill, below the river end of the ground floor and separated from the basement only by a wall. At one time this wheelhouse held a waterwheel which must have been considerably larger than the external one. This was replaced by a water turbine after a child had been killed by the wheel, though this was not necessarily the reason for the change.

The turbine was installed in 1936 by which time electricity was available but not cheap. It is by Gilkes of Kendal, and Mr. Goodwin says it develops 10 H.P. from the 6 foot head of water. It is designed to run submerged, so two transverse concrete walls were built across the old wheelpit to divide it into headrace, a turbine pit, and a tailrace into which the turbine draught tube projects below water level. A sluice gate, controlled by a handwheel and worm gear just above it, admits water into the turbine pit, which is normally flooded to weir level well above the turbine. Water flows straight into the turbine from this pit. The turbine speed was controlled by inlet vanes linked by rods and cranks to a handwheel on a pillar in the ground floor of the mill above the turbine, until one of the links broke and immobilised the control mechanism. The turbine itself is now almost covered by silt, but can be seen to be of the inward flow type mounted with its axis horizontal and at right angles to the river bank (i.e. parallel with the waterwheel shaft). The draught tube runs horizontally towards the mill wall, then bends through 90 degrees to pass through the concrete wall into the tailrace, where it is hidden by silt.

The turbine pit is partly covered by a timber floor, now rotten. There is access to this floor by an iron ladder passing through a trapdoor into the ground floor of the mill, though at present it is easier to descend to the waterwheel bearing and climb through the wheel.

The turbine shaft passes through a wall into a narrow pit between the turbine and the outer wall of the wheel house, where it carries a pulley. This is linked by a belt to a similar pulley on a countershaft which runs above the turbine and through the wall into the mill basement. A hand pump drains this pit; but since in practice the turbine pulley is often under water, the top pulley rim is perforated to allow water trapped between the belt and pulley to escape. The

Figure 4. DRIVE TO GRINDING CYLINDER

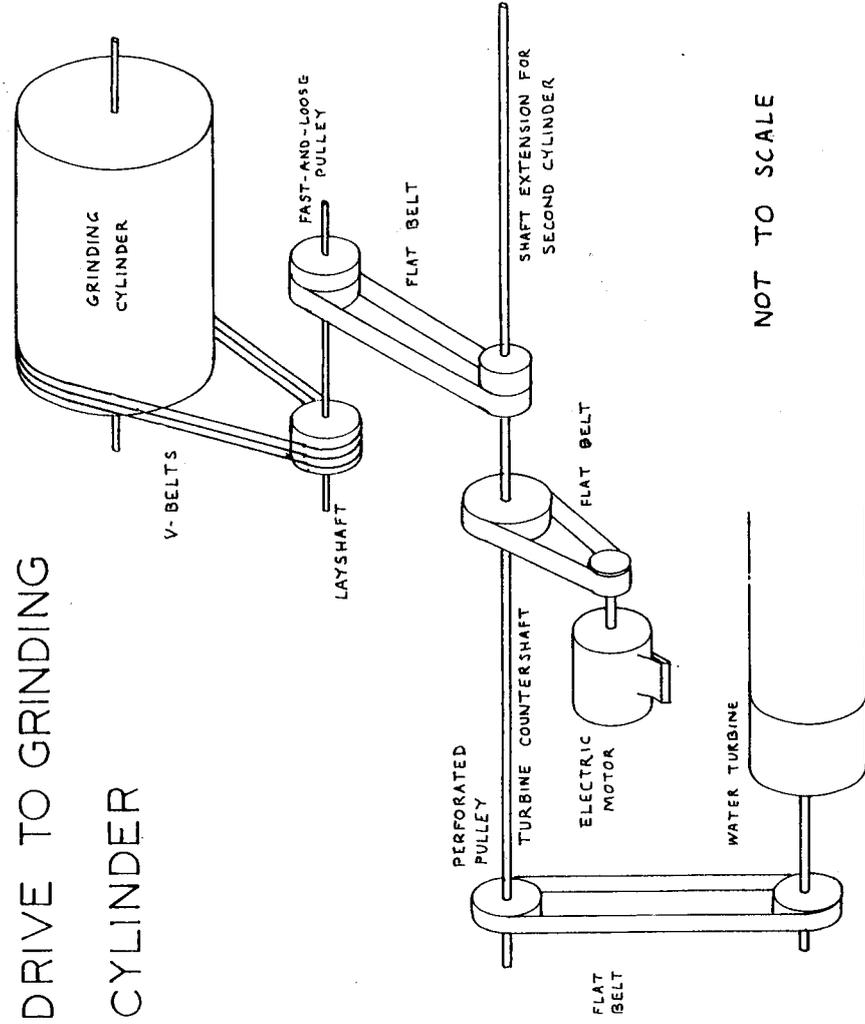
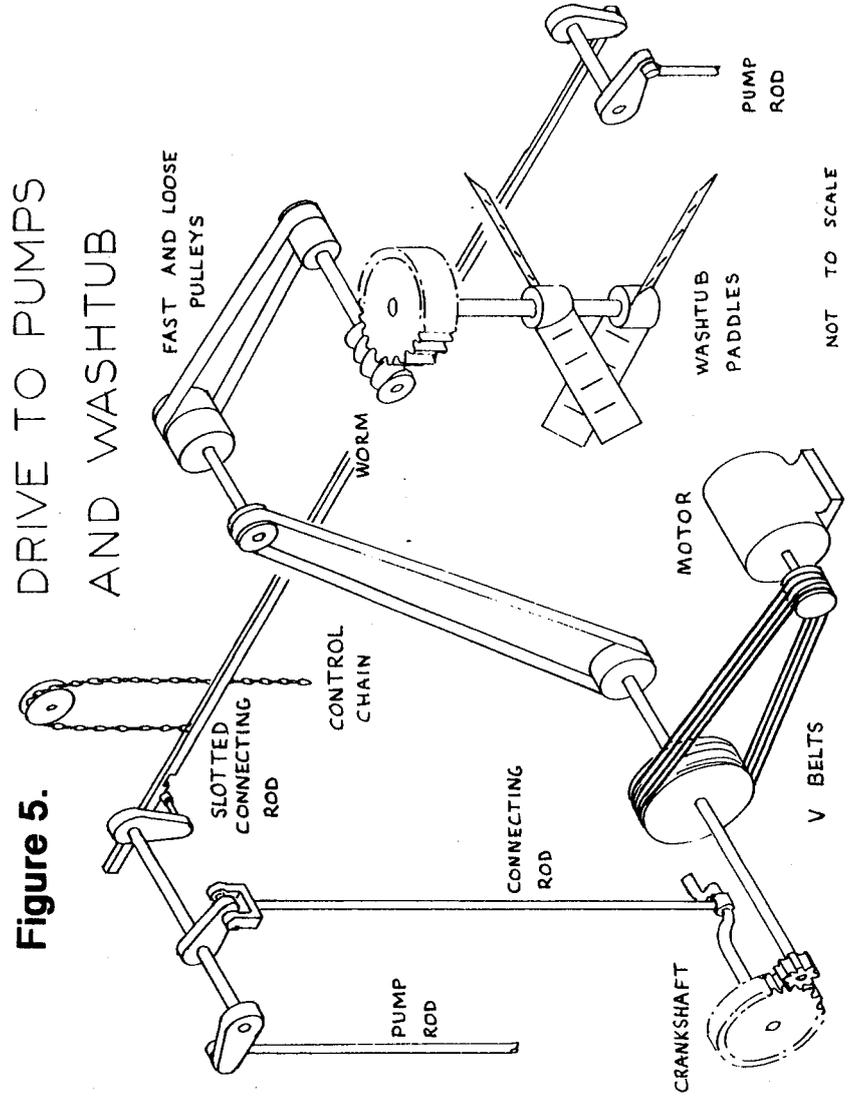


Figure 5. DRIVE TO PUMPS AND WASHTUB



belt and pulleys replace a chain drive which failed because water washed the lubricant away.

The countershaft already mentioned continues into the basement of the mill, where it carries an 18 inch pulley (see Figure 4). This is linked by a flat belt to a 24 inch pulley on a layshaft, and this carries also a 6 inch multiple grooved pulley. Five V-belts run from this pulley to grooves on the outer circumference of the grinding cylinder (ball mill), thus giving considerable speed reduction. The turbine countershaft is long enough to allow a second grinding cylinder with its own layshaft to be installed alongside the first, but this has not been done. A 10 H.P. electric motor is also connected to the turbine countershaft by a flat belt and pulleys (7 inch and 24 inch, giving a further speed reduction), so that the grinding cylinder can be driven either by this motor or by the turbine. There are no clutches, so at any time either the motor belt or the turbine belt would be removed from the countershaft. The flat pulley on the layshaft has a conventional fast-and-loose arrangement so that the drum can be disconnected. This would have allowed the drums to be controlled separately if a second had been installed, and also allows the electric motor to start without load.

The Grinding Cylinder (Ball Mill).

The grinding cylinder is in the basement of the mill. It is fairly small, about 4.5 feet in diameter and the same in length, which gives it a similar throughput to that of the grinding pan. The circumference is of steel plate with riveted joints; the ends have radial ribs and are apparently castings. A stub axle at each end runs in a simple bearing. The grooves for the belts are towards one end of the drum. About half-way along the drum is a manhole about 2 feet square which is removed to give access when the stone lining of the drum needs renewal (every year or two). Opposite this is a 3 inch diameter hole with a cover which is removed to load and unload the drum. For loading this is brought to the top of the drum, and material loaded through a funnel from a small hopper truck which runs on rails above the cylinder at ground floor level. For unloading the cover is replaced by a tube; the section inside the drum has perforations small enough to prevent the flint pebbles escaping, and the other end has a cock to control the flow of the slop. A wooden trough below the cylinder conveys the slop to the same holding tank that is used with the open grinding pan.

The Washtub.

This is on the ground floor of the mill. It is a tank 9 feet in diameter and 4 feet high, built of steel plates and supported 3 feet above the floor on steel joists so that partly ground material can be run back into the grinding pan by gravity. A vertical shaft carries slotted radial arms to stir the contents. Hanging from the lower arm, though hidden by solidified material at present, is a scraper to ensure that particles which sink to the bottom are also stirred. The drive to the shaft will be described later. There are three outlet bosses, about 4 inches in diameter, in a vertical line on one side of the washtub. These are closed by wooden plugs. They discharge into a hopper head and thence by a pipe into the settling tank in

the basement; a cone hung below the bottom of the pipe prevents the flow stirring up material which has already settled. At the other side of the washtub, close to the bottom, is a similar boss through which partly-ground material can be rinsed back into the grinding pan by means of a wooden trough. Above the washtub is a tap fed by a pipe from the water tank on the first floor. The washtub has no nameplate; Rex Wailes[1] says that it was made by the Manor Engineering Co.

Holding and Settling Arks.

In the basement are two arks, brick built and cement rendered; these are the holding and settling tanks referred to above. The holding tank is about 10 feet by 8 feet, and the settling ark about 20 feet by 15 feet, although both are of irregular shape. Both are about 5 feet deep. The holding ark is filled via wooden troughs from the grinding pan and grinding cylinder, and emptied by a pump which lifts the slop into the washtub. The settling ark is filled by a pipe from the washtub outlets, and holds the product of about two weeks grinding. On one side it has a 'plug plank', an iron plate with a vertical row of plugs stopped by wooden plugs. These are removed one by one to allow water to run to waste from above the slop as the ground material settles through it. A second pump raises the thickened slop and discharges it through a trough just outside the mill door. There is evidence (in the form of a redundant plug plank) that another settling ark extended below the downstream wing of the mill at one time. Mr. Goodwin says that the holding tank also used to extend beneath the wing.

The Pumps and Motor Drive.

Two mechanically driven pumps lift slop from the basement to ground floor level. They are apparently bucket-type pumps, although the working parts are not visible. The delivery pipes are continuous with the pump bodies, and there is a wooden trough round the top of each delivery pipe feeding the slop into a wooden channel. There is a rectangular cover near the bottom of each pump which presumably gives access to the inlet valve. Each pump is operated by a pump rod which extends above the top of the delivery pipe and connects to a crank on an oscillating layshaft. These layshafts are driven by a 10 H.P. electric motor through an elaborate system of belts, cranks and rods which is more easily explained by a diagram (see Figure 5) than in words. The pump which lifts slop from the holding tank to the washtub can be disconnected by lifting a slotted link rod clear of its crank, but the pump which delivers slop from the settling tank to the outside of the mill can be disconnected only by removing a pin from the drive crank. Both pumps are of about 6 inches bore and 12 inches stroke.

The same motor drives the washtub stirrer, through belts and a worm drive, with a fast-and-loose pulley arrangement so that the washtub drive can be disconnected. The motor is on the ground floor, guarded by what looks like a length of garden fencing.

A small electrically driven pump is mounted on the wall of the wheelhouse

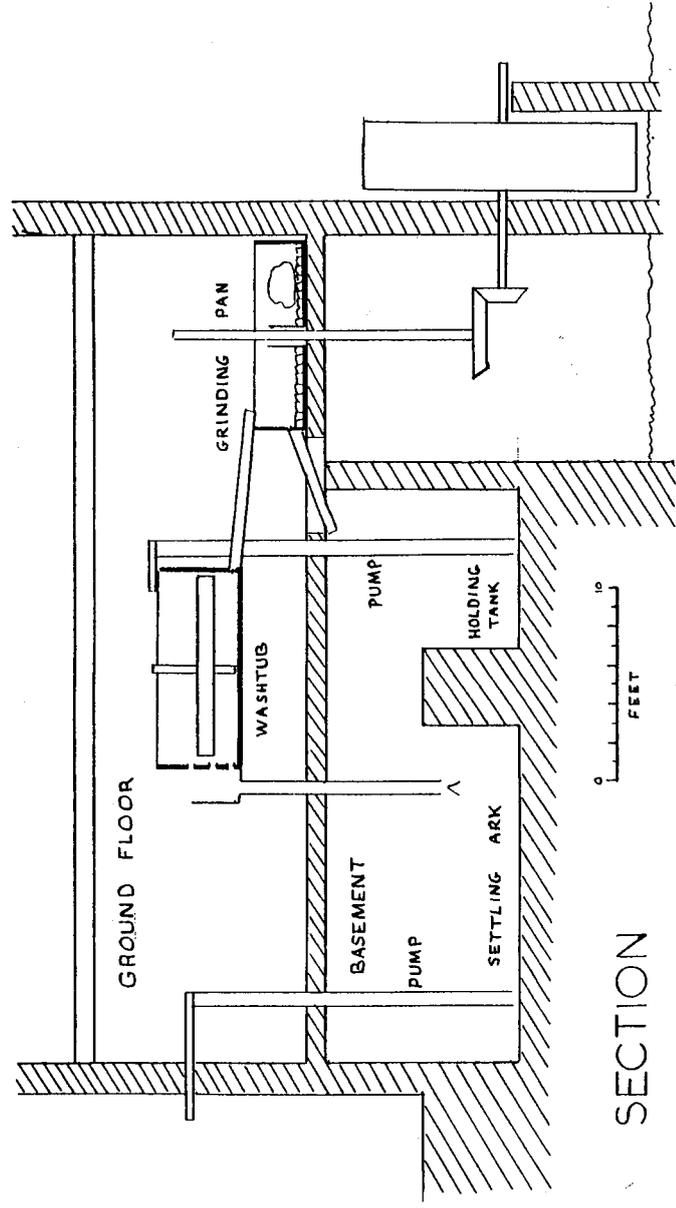


Figure 6. Section through Washford Mills showing the Ground Floor and Basement.

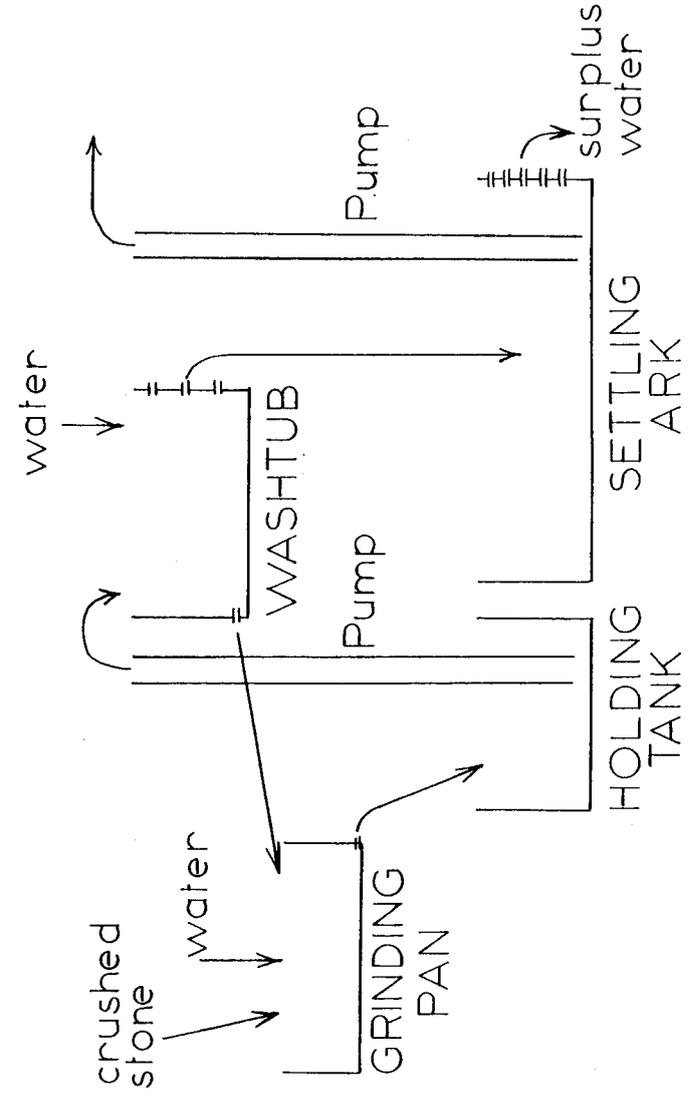


Figure 7. A Schematic Diagram showing the various Processes, and the Flow of Materials during Stone Grinding at Washford Mill.

above the turbine pit. It pumps river water into the tank on the first floor of the mill. From here there are pipes with taps above the washtub, grinding pan and grinding cylinder - the latter has a flexible hose to reach the cylinder filling point.

It is worth noticing how the various levels of the mill have been used to minimise the amount of pumping that is necessary. This can best be seen by comparing the cross section of the mill (see Figure 6), with the process flow diagram (see Figure 7).

Dry Material Handling Equipment.

There is a small hand-operated crane near the grinding pan, used to lift runner stones when necessary and probably also to lift containers of stone into the pan for grinding. This is of wood and steel construction. It is rated at 10 cwt. There are two overhead rails each carrying a chain-block hoist. One (rated at 30 cwt) runs from the mill door to a position within reach of the crane, near the grinding pan; it used to extend outside the mill door to the top of the kiln. The other (rated at 10 cwt) runs from here to a point near the opposite wall of the mill. This end of the second hoist rail is over a short length of rail track, which spans the opening in the ground floor and runs directly over the grinding cylinder. On this track is a small hopper truck used for loading the grinding pan with material to be processed, and also with flint pebbles. These were stored in the mill near the end of the rail track.

A cylindrical tank, about 3 feet in diameter and 4.5 feet long, is lying in the mill. This was at one time mounted on a cart, and used to transport slop from this mill to the drying arks at Lower Washford Mill.

Lower Washford and the Middle Mill.

These are of some interest, not least because they are still in use. Lower Washford Mill was at one time a water-powered silk mill, with a low weir giving a fall of only a couple of feet (so as not to back up to the Washford Mill wheels) and a very wide waterwheel in a wheelhouse attached to the end of the mill. The wheelhouse has a datestone which appears to read 1848. In the 1920s the mill was equipped for stone grinding with several ball mills. The waterwheel, and a gas engine which supplemented it, were removed about 1940 but the mill is still in use, driven by electricity. One of the ball mills is reputed to be the first one installed in this country, although not on this site.

Besides the ball mills there are two jaw crushers, various settling tanks, and a pair of drying arks - large very shallow tanks with a floor of quarry tiles supported on a metal frame with a furnace beneath. In these arks the slop from settling tanks (from both this mill and Washford Mill) is dried out and then shovelled into sacks for delivery. All this equipment is still in use. In the Middle Mill are more grinding cylinders and drying arks, used occasionally for dark coloured materials so that these do not contaminate material in the main mills.

The access road from Mill Street to Lower Washford Mill was formerly called Dane Row, and as well as the Middle Mill there were several cottages between it

and the river; their gardens and privies were on the other side of Dane Row. These cottages were demolished in the slum clearances of the 1930s, although a slightly larger one remains on the other side of Dane Row and is used for storage.

The machinery in Washford Mill has not been used since 1968, all production being now at Lower Washford Mill. At the time of the miners' strike in the 1970s, when industry was forbidden to use electricity for two days a week, Mr. Goodwin started to prepare the machinery for use; the main task was to clear silt from the waterwheel and turbine. However the strike ended before this was completed. Washford Mill and its machinery are intact (in spite of a recent fire next door); the structure is in reasonable condition. The building is classified as Grade II, which should give it some protection, and the present owner has no plans to alter it.

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4. Robert Copeland, *A Short History of Pottery Raw Materials and the Cheddleton Flint Mill*, Cheddleton Flint Mill Industrial Heritage Trust, 1972.
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Pierre-Théophile Berton and his Windmill Sails

By Christian Cussonneau

Translated by Gordon Tucker & Alan Gifford

In April 1987 the President of the Association des Amis des Moulins de L'Anjou was informed of the discovery of the grave of Pierre-Théophile Berton in the Eastern Cemetery at Angers. This funerary monument is made up of a flat gravestone, at the head of which was erected a headstone in hard limestone which had been broken into several pieces. The headstone carries a decoration in bas-relief representing a tower mill. The stocks of the sails were in bronze and remain in place. In the detritus around the grave two bronze sails were discovered; they showed displaced boards forming a trapezium, and were originally fixed on the aforementioned stocks. The foot of the headstone carries the following inscription:-

'Pierre-Théophile Berton - Inventor - 1827-1894'

This name, associated with the representation of the windmill with board type sails, immediately recalls the BERTON sail system; however even if the date of the introduction of this technique is known, not much has been known about its inventor, his activities, and the places where he operated. This grave has therefore formed the starting point of the researches that have resulted in this article.

The Berton Family.

There were two men called Pierre-Théophile Berton, the father and the son. The grave described above is, in fact, that of the son.

The Berton family came originally from the north of France, from Barbonne in the Marne. The grandfather, Pierre Nicolas Berton, was a farmer there. His son, Pierre-Théophile, born 7th August 1803, first of all practised the craft of wheelwright in Barbonne, where he lived up to 1840. In May 1840 he was in Douai in the Department de Nord and in the following months he moved to set up in Paris, at the Rue Saint Nicolas d'Antin, then in La Chapelle Saint Denis. In 1826 he had married Victoire-Pelagie Mugard: two children were born of this marriage, Octave-Théophile and Pierre-Théophile, the latter born on 5th March 1827, at Barbonne. Pierre-Théophile's education and training are not known but, at the time of his marriage to Marie Anne Ruffine Honorine L'Homme, he was described as a 'mécanicien' or mechanic like his father. He resided at the time at La Chapelle Saint Denis, whilst his father lived at Angers, Rue Château-

Gontier, where he appears to have become established towards 1850. Between 1855 and 1860, the son joined his father; they then lived in the Rue Bouillon (actually Rue Bardout) in the suburb of Saint Michel. There they rented a workshop from a Monsieur Boutreux which formed the angle between the Rue de Bouillon and the Impasse du Cheval Blanc, and which has now been demolished. Pierre-Theophile, the father, died on 9th September 1861, aged 66, in the Rue de Bouillon. His son appears to have kept the workshop and the house at least until 1888. He died on 27th April 1894 at 217 Rue de Paris. His will showed that he left no inheritance and that a Certificate of Poverty was drawn up on 18th April 1895. The cessation of activities and the liquidation of the Berton enterprise can therefore be fixed at between 1888 and 1894.

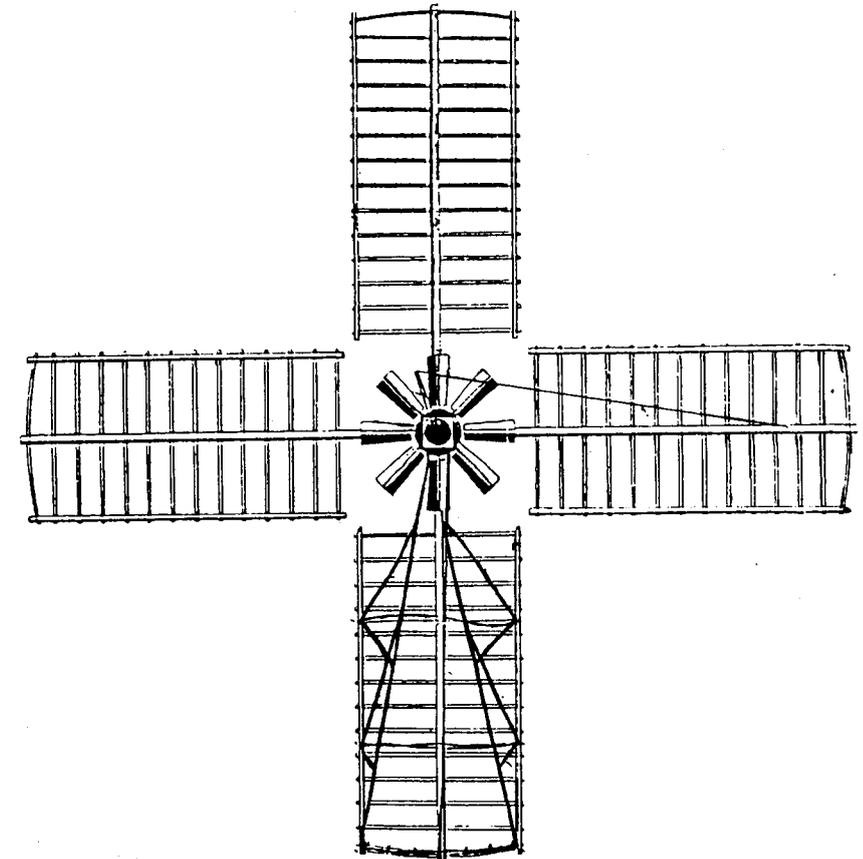


Figure 1. Berton's first patent in 1839 using a number of small sails.

Technical Innovation - From canvas to the board sail.

Practising his craft as a wheelwright in Barbonne, P-T Berton the elder was certainly led to visit and to repair windmills which were quite common in the region. Observation of the millers furling and unfurling their cloth sails several times a day, at the whim of the gusts of wind, suggested to him the idea of improving the traditional cloth system for sails. In all the technical works of the Bertons, father and son, one keeps finding two constant concerns: first of all to succeed in controlling the surface area of the sails, as a function of the strength of the wind, and secondly to make this operation automatic. The objective was obviously to make the work of the miller easier, to save him time, to make the operation of the machinery more regular and thus to maximise effectiveness.

P-T. Berton, the father, filed his first patent at Chalons, in the Prefecture of the Marne, on 2nd January, 1839; it had the title 'Suitable means of extending the Sails of all kind of Wind Machines.' It operated by means of four or eight separate, small sails which drove a windlass; these were fixed at the front extremity of the windshaft of the mill; and by means of cords and springs they opened or closed shutters (on the stocks) relative to the strength of the wind. When the wind was slight the springs extended the shutters to their maximum; when it was strong the windlass, connected by the cords or chains, started to turn driven by the small sails, counteracting the effect of the springs and thus reducing the surface area of the sails. If the wind became violent the shutters were completely closed and so avoided the risk of racing the mill (see Figure 1).

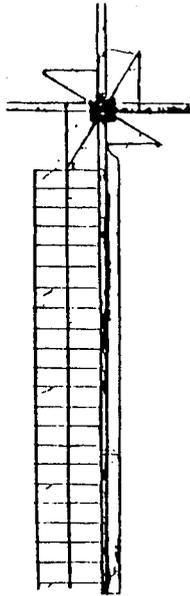


Figure 2. Improvements of 1840.

During succeeding years, P-T Berton perfected his mechanism and filed five addenda to his patent. The general principle remained the same but various improvements foreshadowed what was to become the board sail. Thus, in certificate No.11,546, at the beginning of 1840, there appeared for the first time the principle of the deformable wooden support for the sail. This deformation, which reduced the surface area of the sail, was produced by a system of metal rods which replaced the less reliable transmission by cord or chains which featured in the first patent (see Figure 2). The addendum No 12,690, of September 1841, was an essential step in the evolution of the Berton system; the sails were made of eight boards, parallel to the drive rods, mounted on pivots, which together formed a rectangle when they were completely extended. From the operation of toothed racks, mounted at the front extremity of the wind shaft, controlled by a rod passing through the centre of the wind shaft and two toothed wheels situated at the end of the windshaft, the pivoted boards folded up on

one another. Thus the sail changed from a rectangular shape, through a trapezoidal shape, until the surface was reduced down to the width and length of the next board (see Figure 3). In the description which accompanied the patent, P-T Berton indicated for the first time that the sails could be either in wood, in metal, or in canvas.

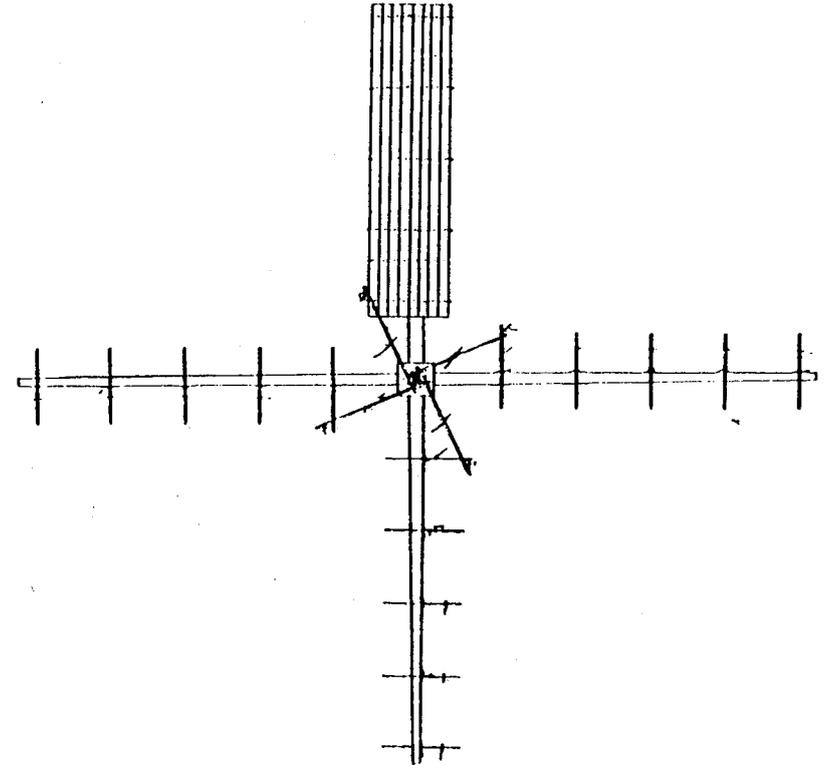


Figure 3. The patent of 1841, using eight longitudinal sail boards.

Although the principle of the sail with moving boards parallel to the stocks had been established since 1841, Berton continued to seek improvements to his earlier patents. Thus in 1846, he considered canvas sails again and perfected the mechanism for manual opening and also the system for unrolling the canvas; although it became more complex it appeared to be more reliable and functional. Cords or chains were replaced by pivoting squares on which the canvases were fixed, moved by iron bars disposed along the stocks. These bars were themselves controlled by four toothed racks sliding at the end of the windshaft (see Figure 4). At the end of his description Berton added:-

'With the mechanism for which I request a patent, one has the facility of extending or retracting instantly, to any convenient extent, the canvasses of the sails of windmills without stopping the rotation, being inside the mill and close to ones work; those are the advantages of this mechanism. One can do much more work and it is much easier to prevent accidents than in the old system where one has to go to the sails one after the other, thus occupying 15 minutes - whilst with this mechanism all is accomplished in less than one minute. I designate these sails by the name BERTON.'

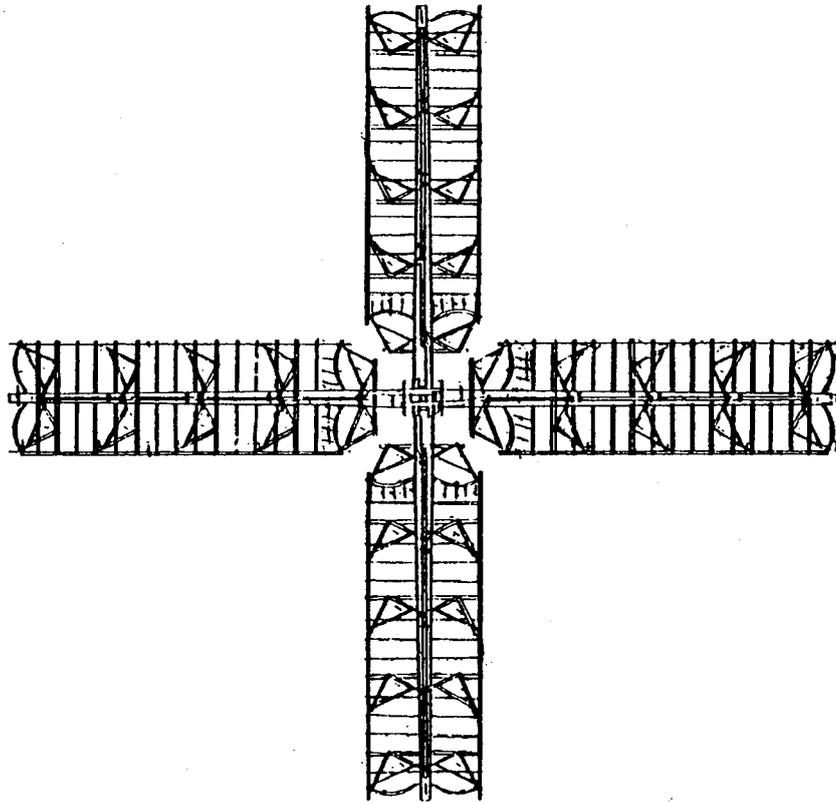


Figure 4. Improvements of 1846 to the original patent using canvas sails.

In 1849 P-T Berton thought up a new system of board sails; the boards were perpendicular to the stocks. When this sail closed up its width was equal to that of one of the boards (see Figure 5). He stated 'moreover the rack rods are controlled by the same mechanism that I have known in my patent application of 18 August 1846; a mechanism that I use daily in my sails (with longitudinal boards) which have been known and used for seven years...' According to the evidence, the mills in the region of Paris were functioning with Berton sails from about 1842.

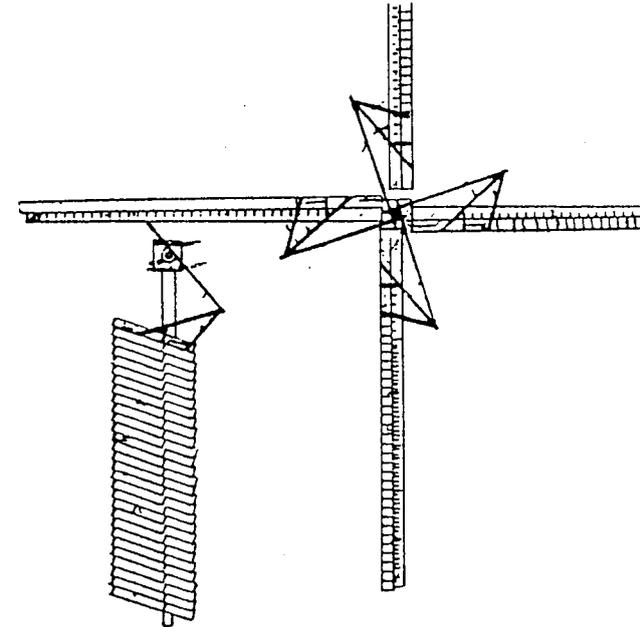


Figure 5. The 1849 system using sail boards perpendicular to the stocks.

It was, however, only in 1855, after the filing of multiple patents and additions, that Berton sails assumed the form we now know. The rack rods were firmly abandoned in favour of transmission by a pinion engaging with the inside of a toothed annular crown gear (at the end of the windshaft), to which was fitted the metal bars which controlled the pivoting of the transverse bars to which the boards were attached. At last the differential 'four arms' regulating the manual opening of the sails had arrived (see Figure 6).

In 1865, P-T Berton the son, filed a last patent having as its objective the braking of the mill and the automatic control of the sails as a function of the strength of the wind. Thus, the son, 25 years later followed up on the initial investigations of his father, without any greater success it would seem, because no mill is presently known to us which retains this automatic mechanism.

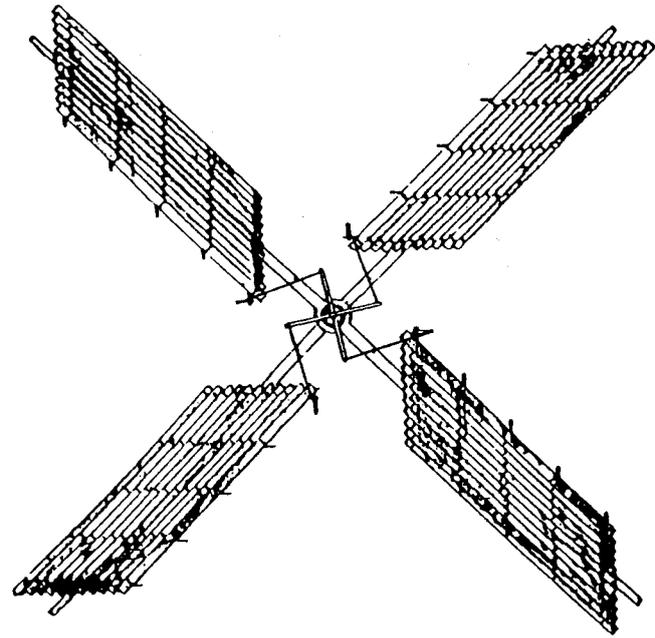


Figure 6. The final version of the folding board sail of 1855.

The Berton Enterprise in Anjou.

The first move of P-T Berton the father, desiring to commercialise his inventions, was to set himself up in the Department du Nord at Douai, in 1840-1. This region, rich in windmills was not, however, hospitable to him, since his sails, with the rectangular canvases of his first patents, were hardly able to give a better performance than the highly perfected ones of the Flemish type of mill. So he speedily moved to Paris! The capital of France presented him with two interests: the caps of the Parisian mills, and those of La Beauce, formed a potential application for his board sails, which was first put into practice in 1841-2. Secondly the spread of the value of his invention would be helped by his recognition and approval by the scientific élite of Paris. Thus in May 1846, P-T. Berton made contact with the Society for Encouraging National Industry, (La Société d'encouragement pour l'Industrie Nationale, or S.E.I.N.) from whom he sought guidance and advice on the soundness and utility of his work. As a result the S.E.I.N. published, in 1849, a description of the board sail opened by toothed rack rods.

The Berton enterprise, whose workshop was situated at La Chapelle-Saint Denis, appeared to operate satisfactorily until about 1850. However during a period of about nine years a significant number of Parisian and Beauceron mills had been equipped with the Berton sail and the necessity arose to find a new market. Thus P-T. Berton decided to move to the west of France. The departments of Maine-et-Loire, Loire Atlantique, Vendée and Charente were indeed amongst the best provided with windmills and became a suitable target. The choice of the town of Angers to be the base for his activities was certainly not just fortuitous; the river network serving the Loire Atlantique and then the Vendée, the River Loire, and to the north of the town of Angers by the Rivers Sarthe, Mayenne, and the Loir, was such that they could facilitate the transport of the relatively heavy board sails!

After a brief stay in the Rue Château-Gontier, the business was set up in the Rue de Bouillon. The contents of the workshop is known to us as a result of a detailed inventory which was made on the death of P-T. Berton, the father, in 1861. Apart from the material of the forge and the carpenter's shop there were:-

- 517 sheets of deal, the length of which varies from 7 to 8 metres, some rough, others bleached, 'destined to make the sails of mills'.
- some planks.
- a mill stone.
- 'a model of a windmill, incomplete as a result of having been opened up'.
- a windmill with eight sails, complete, for pumping water.
- several hundred kilogrammes of various pieces of iron.
- two oak boxes, 7 metres long approximately, apparently intended for the transport of completed sails.

In short the workshop contained all the material required for the fitting of windmill sails. The suppliers to Bertons were numerous and were set out in the inventory:-

- Richou, iron merchant, Angers
- Baron, ironmonger, Angers
- Talond, paintmaker, Angers
- Dusoubli, iron merchant, Paris
- Rouaud, timber merchant, Angers
- Harpin, ironmonger, Paris
- Berendorff, mechanic, Angers

A colleague and closest friend of the Bertons appears to have been Charles Miot, a smith in the Rue Sainte Jean, in Angers; he appeared several times as witness to the registrations of births and deaths in the Berton family.

The inventory mentioned above is also valuable in another way; it gives in effect a list of about a hundred debtors of the business, almost all of them were

millers! It concerns the proprietors or the operators who had had Berton sails installed in their mills. Fifty two of the sums due are for less than 100 francs and correspond, perhaps, to repairs carried out on the mills already converted. Forty one other sums range from between 200 and 700 francs; the commonest being for 670 francs (occurring 13 times). This could correspond to the standard purchase price for the Berton sail. The list also permits us to locate the customers of the business, because the place of residence of the debtors is exact. The most important group was situated in Maine-et-Loire, around Angers, mostly to the east of the town, along the River Loire. But others resided in Mayenne, towards Laval, and Château-Gontier in Loire Atlantique, towards Ancenis, or even in Vendée, at La Roche-sur-Yon and at Sable-D'Olonne. Finally others were situated further away: Epannes, near Niort, St.Pierres-Echaubrognes near Maudleion, and Patay, near Orleans.

Although very incomplete and only partially showing the clients of the Bertons, this sample attests to the success of the board sail in the west of France at the beginning of the 1860s. On the death of P-T Berton, the father, the total of his estate reached 27,000 francs, which placed the family in the 'petit bourgeoisie'.

The cessation of the activities of P-T Berton, the son, at the end of the 1880s is attributable to two complementary causes:-

Firstly - the number of mills available to be equipped diminished because so many had been so fitted between 1850 and 1870.

Secondly - the role of the windmill declined from 1860 to 1870 with the establishment of the great industrial flour mills.

For example, one single turbine drove ten pairs of stones in 1872, at the mill of Châteauneuf-sur-Sarthe. The multiplication of such establishments in the last quarter of the 19th century dealt a definitive blow to the traditional mill and brought about the ruin of the Berton business.

Final Monument to the Berton Family.

The Berton grave has been made the object of an entry in the Supplementary Inventory to the List of Classified Personal Objects, by a prefectural decree of 10th July 1987. Apart from the originality which the monument shows, the town and the people of Angers must, we believe, conserve and restore this tomb in memory of the family which had made Anjou their adopted homeland and, because of the technical importance of the invention which marked the end of the history of the French windmill.

Translators' Note.

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