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.

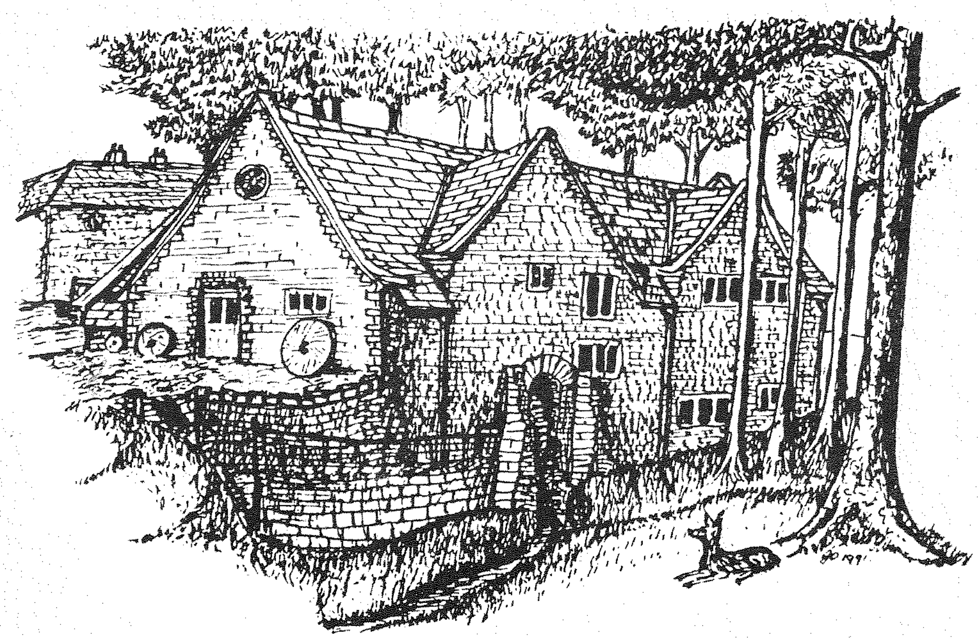
For further particulars, please contact:

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

Wind and Water Mills

The Occasional Journal of the Midland Wind and Water Mills Group

Volume 11



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. Dunham Massey Sawmill, drawn by Jo Roberts.

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ERRATUM - The author of the article 'How Does It Work? The Flyball Governor' on Page 27 is Norman M. Clarke not Norman N. Clarke.

SMELTING MILL, DIMMINGS DALE, STAFFORDSHIRE.

By Barry Job.

The River Churnet rises in the Staffordshire Moorlands and flows in a south-easterly direction until it joins the River Dove near Uttoxeter. On its way to its confluence with the Dove, the Churnet runs in a steep sided and secluded valley between the villages of Oakamoor and Alton. This area lies some 6 miles north of Uttoxeter and some 12 miles east of Stoke-on-Trent. Lying directly to the west and running into the valley of the Churnet at this point is the densely wooded Dimmings Dale. This deep valley is cut in red Triassic sandstones and the stream that flows down the valley is dammed to form a substantial mill pond, the mill being built into the dam wall. The attractive site (SK 060432) is now quiet and isolated, although it was not always so. The old coach road from Cheadle through Alton to Ashbourne ran down the valley and the local names Smelting Mill and Oldfurnace indicate a period of industrial activity.

An entrepreneur called Lawrence Loggin is recorded as having rented sites along the Churnet Valley from the famous Bess of Hardwick. In 1593 he established the furnace at the top of the valley utilising the available water supply, obtaining charcoal locally and transporting iron ore from Consall and Froghall a few miles to the north. Humphrey Beddall, the first iron-founder from Stourbridge, left after a few months and the project does not seem to have been a success, production ceased after a few years. The mill site may have been associated with this early enterprise although in 1741 the mill was described as 'new erected'. In 1760 the large sum of £504, was spent to produce a 'smelting mill, refinery, slag hearth, smith's shop, two houses, and barn and about nine acres of land lying near the same with a pool of water'. Shareholders included the Duke of Devonshire and others involved in the very profitable Ecton Mine in Derbyshire. In spite of this investment the mill had been converted to corn grinding by 1786. Further up the valley a pair of substantial cottages built beneath the Earl's Rock carried the date 1790. The further history of the site has not been recorded but it is difficult to see how, in an area of densely wooded valleys, corn grinding could have been any more profitable than iron production. The date when the mill stopped work has unfortunately not been preserved but the advanced state of dereliction of the machinery and building fabric indicates some considerable time ago.

The mill is well supplied with water. The flow from the large pond is directed into a large headbox. Overflow from the pond and tailwater from the wheel flow some considerable distance in a culvert down to the River Churnet. The pitchback wheel is of particularly fine construction. Set on a slender cruciform axle, the pierced hub plates are 5 feet in diameter, 16 wooden spokes (long

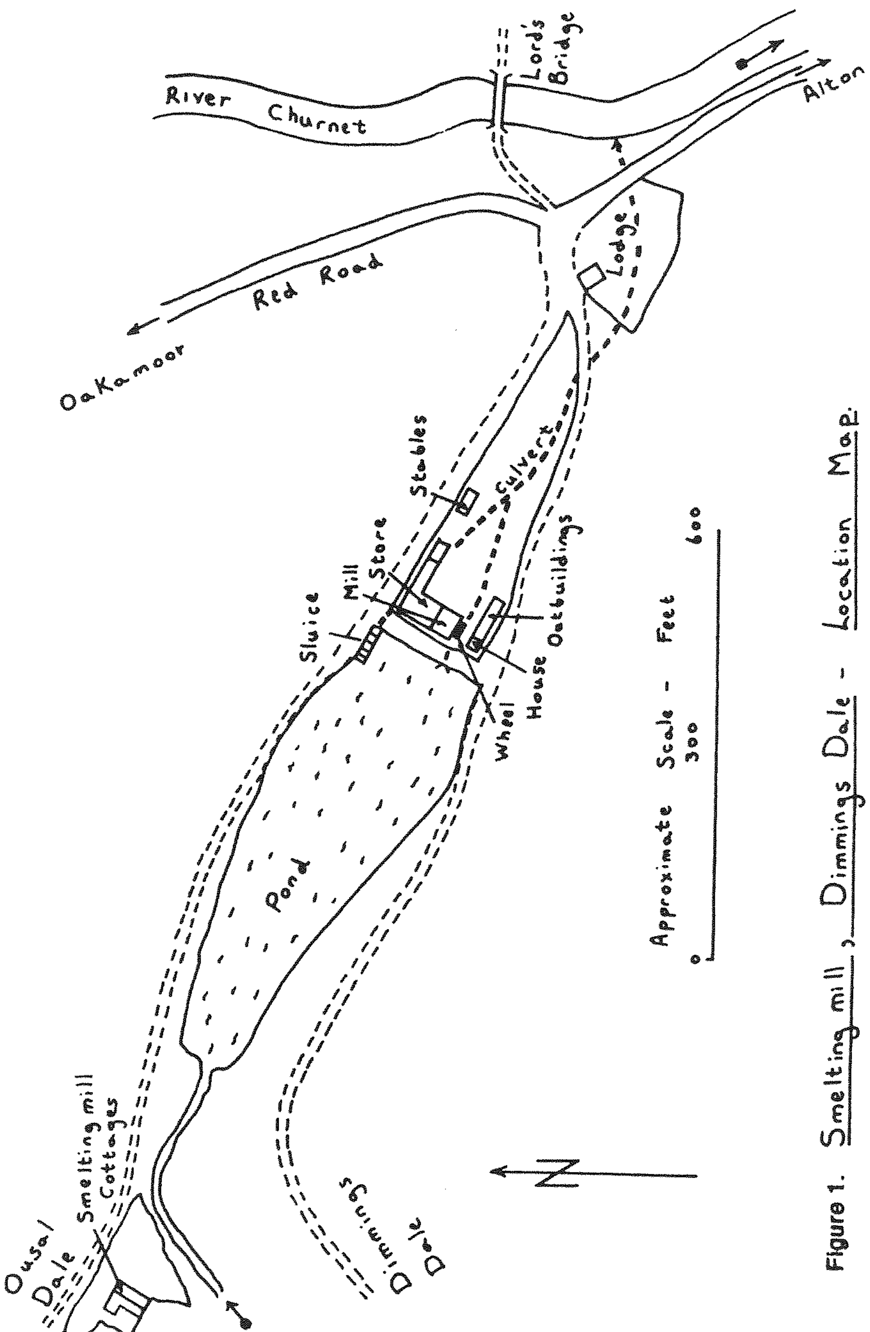

Figure 1. Smelting mill, Dimmings Dale - Location Map.

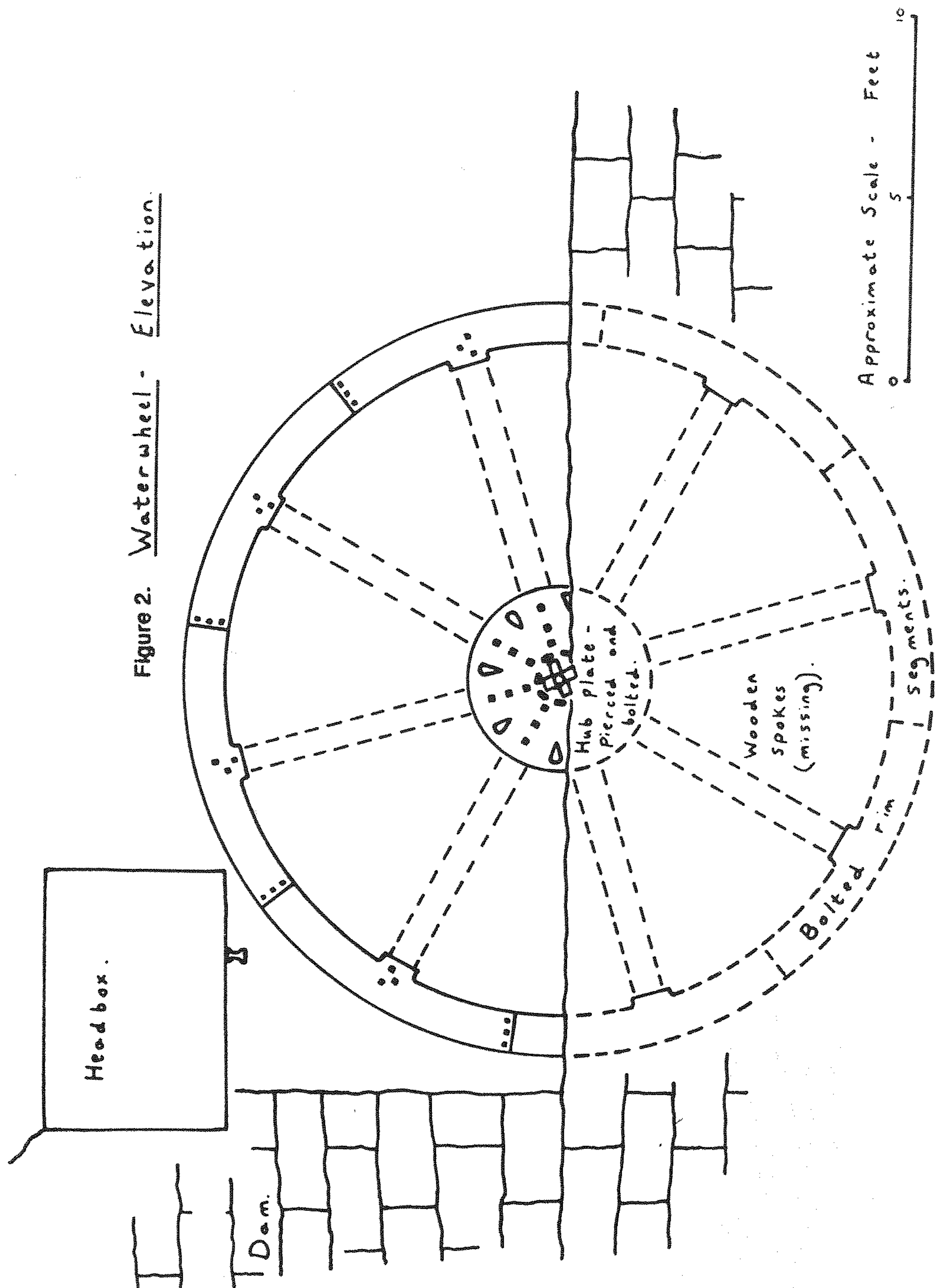

Figure 2. Waterwheel - Elevation.

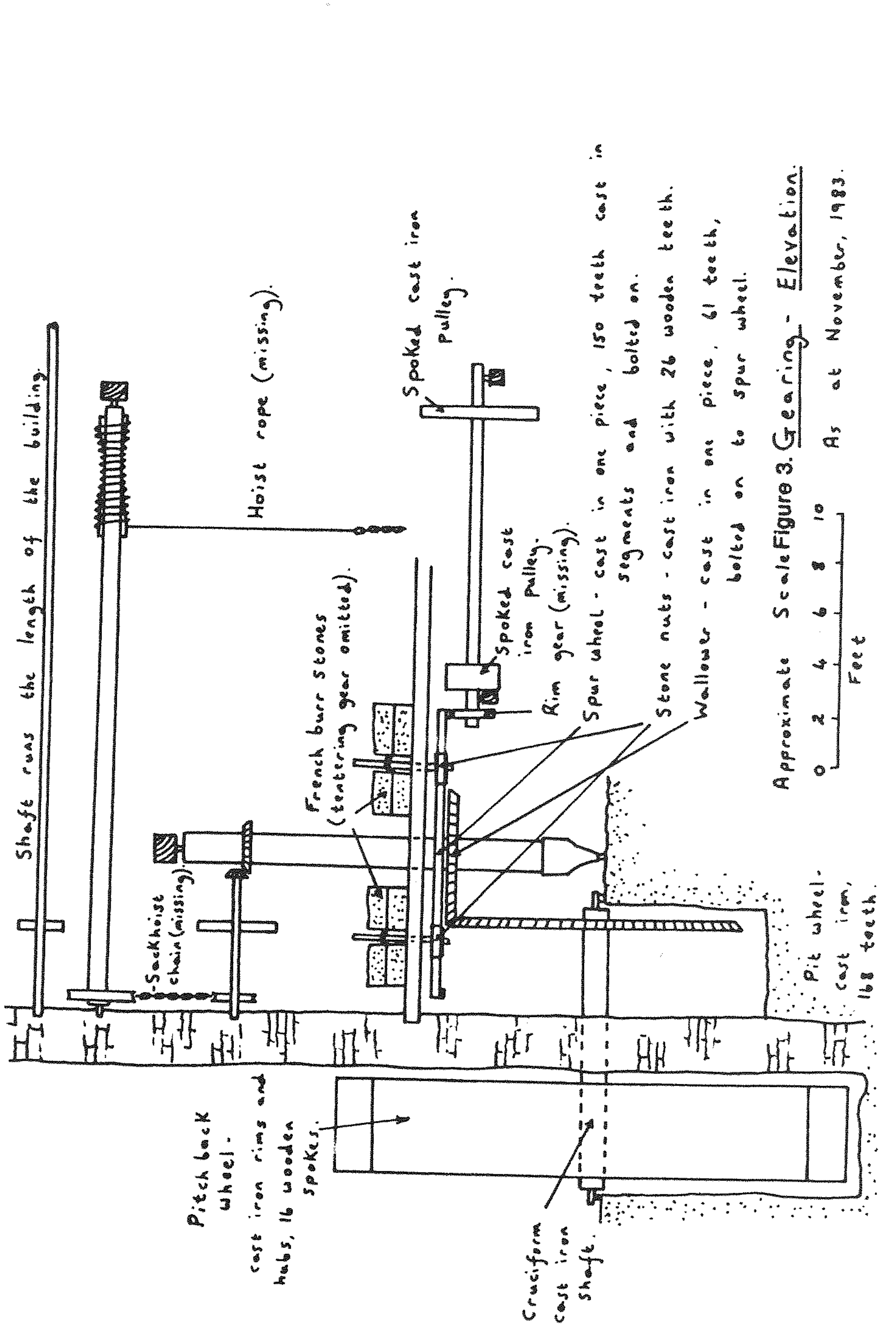

Figure 3. Gearing - Elevation.

As at November, 1983.

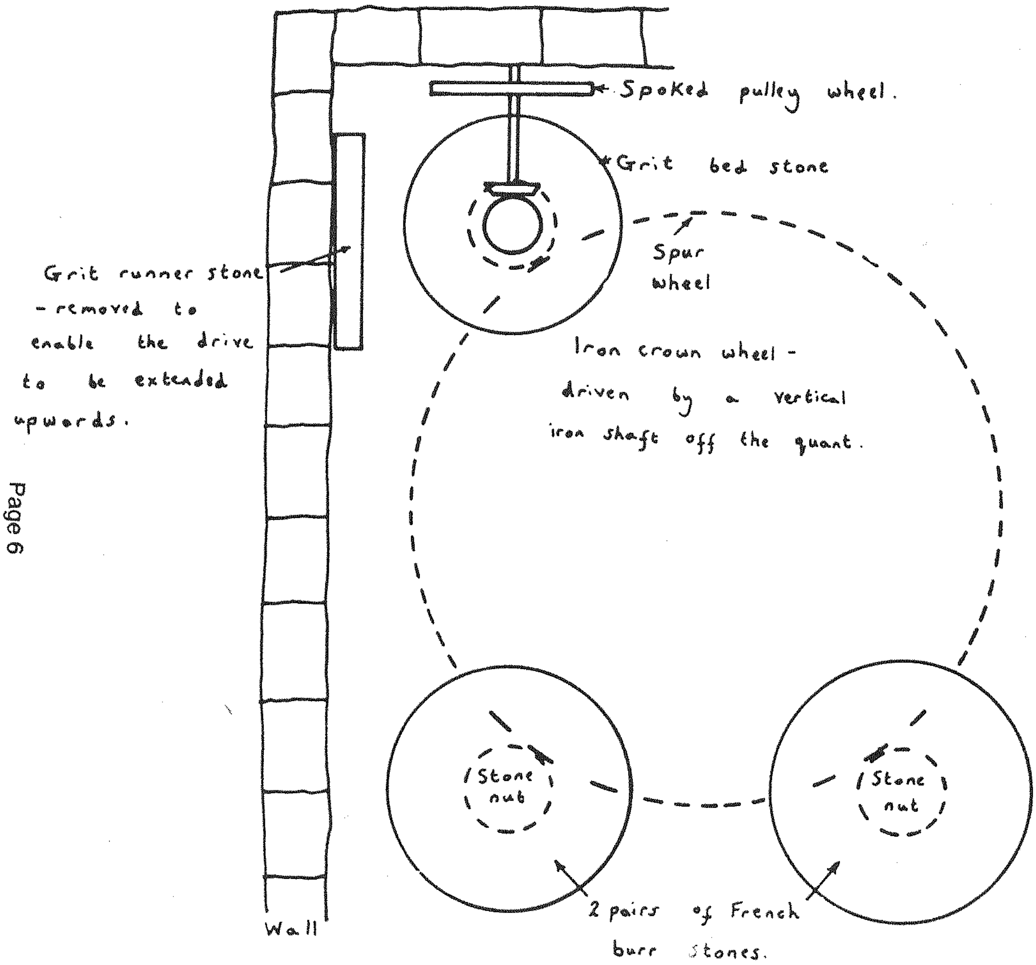

Figure 4.

Stones – Plan

As at November 1983.

Plate 1. Exterior view of Smelting Mill, 1968. *(by courtesy of Staffordshire County Council)*

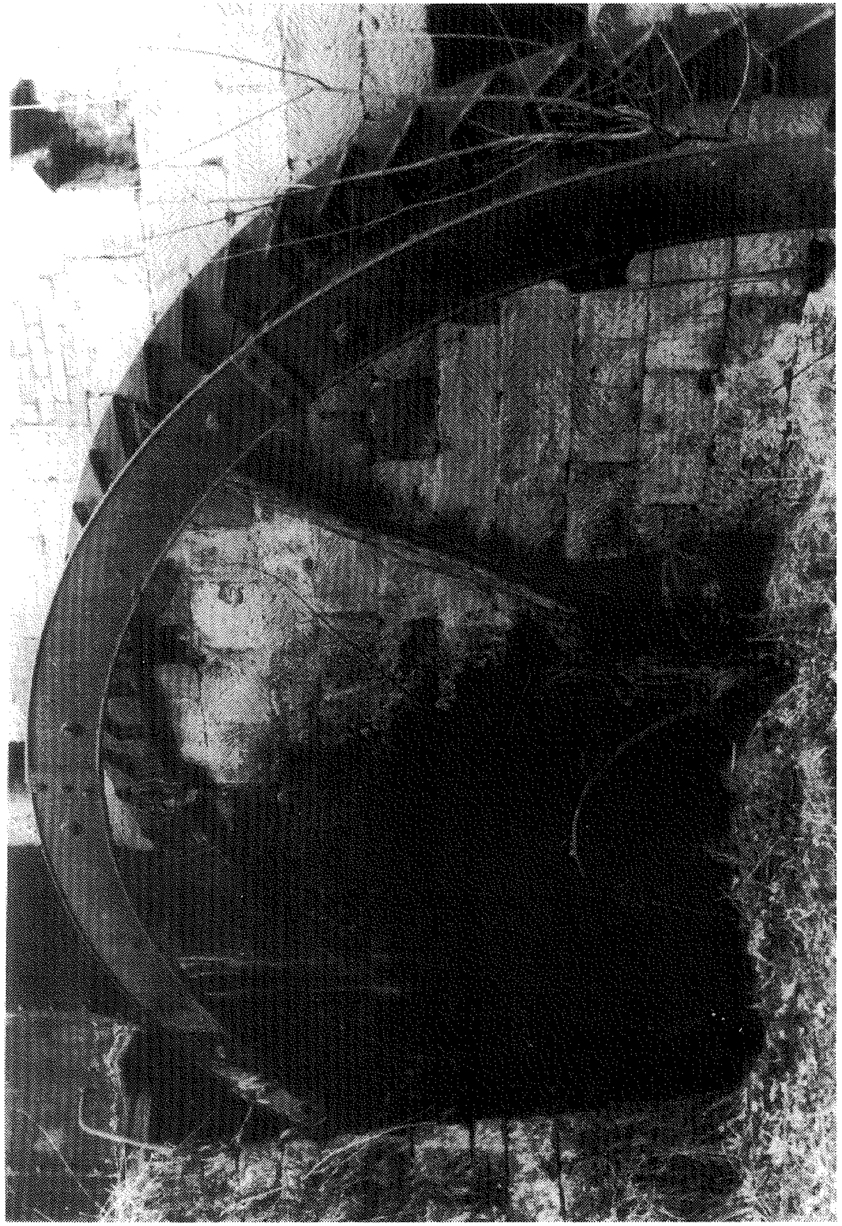

Plate 2. The Waterwheel, Smelting Mill, 1968. *(by courtesy of Staffordshire County Council)*

Plate 3. Vertical shaft and gearing, Smelting Mill, 1983

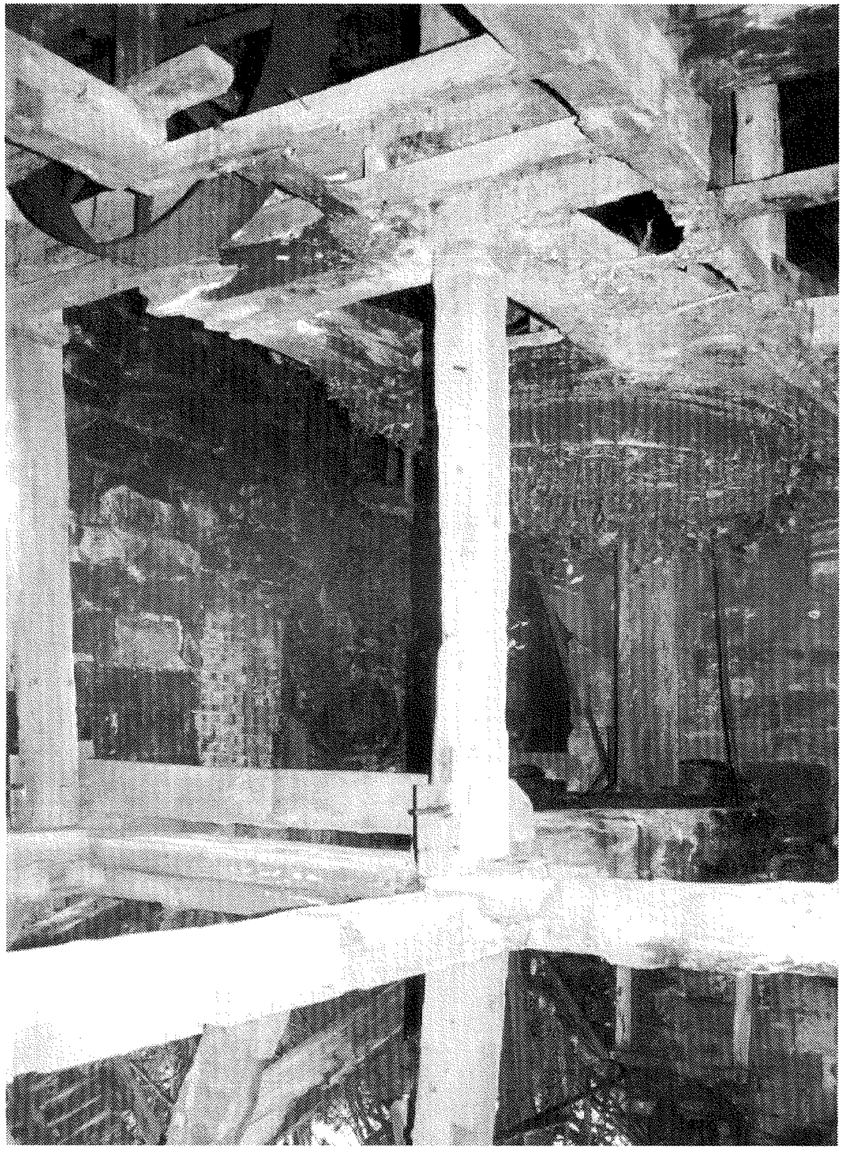

Plate 4. The stones, Smelting Mill, 1983

since rotted away) carried cast iron rims which held 64 wooden buckets. The wheel is some 20 feet in diameter by 3 feet 3 inches wide, the bottom half is buried in the debris of the wheel pit but unfortunately no maker's name is visible. Inside the mill the machinery is conventional with originally three pairs of underdriven stones. Two pairs of French burrs were in place until recently, but the third pair had the grit runner stone removed and replaced by a vertical iron shaft which drove a bevel gear, a cross shaft and an iron spoked timber lined pulley. The sack hoist was of the slack chain type driven by a bevel gear on the top of the slim vertical shaft. This drive shaft also carried a wooden drum which powered a belt to drive a shaft which ran the length of the buildings. An unusual feature was the iron spur wheel. cast segments bearing the teeth were bolted on to drive the stone nuts in the conventional manner but the teeth were carried downwards to drive a rim gear (missing) fixed directly below the spur wheel. This rim gear drove a cross shaft carrying two pulleys, one of large width and possibly driving a belt out of the mill, through a doorway, to drive machinery outside. Alternatively, it may have been possible to drive the mill machinery from a external steam engine in the unlikely event of the mill being short of water.

The complex of buildings was constructed of irregular sized blocks of dressed sandstone with the doorways being formed from carefully shaped pieces of stone, all under tiled roofs. Directly adjoining the two storey mill was a substantial storage building entered through a large doorway with a separate stable block to the east. To the south was a three storey house, its meagre size contrasting with the rest of the buildings. A flight of steps runs from beside the house doorway to the top of the dam. The pronounced wear on the stone treads bears testimony to the countless feet they must have carried. Adjoining the house were various two storey outbuildings of later date.

By 1983 the buildings were in a poor state. The mill roof had partly collapsed, the roof of the outbuildings had long since gone and none of the other buildings were weather tight. Only the iron components of the wheel remained, inside all the flooring had gone and the machinery was deteriorating . The future for the mill looked bleak and attempts to preserve it were unsuccessful. However, things looked a little brighter when it was purchased by a local firm who had a good reputation in sensitive conservation work. The new owner showed an interest in the history of the mill and when work commenced it was obvious that the major machinery was to be retained and conversion concentrated on the storage building. The roof was stripped off, the outbuildings and stables were demolished to provide stone and rebuilding commenced. Similarly work began on the cottages further up the valley, they were virtually demolished and reconstruction was begun. Unfortunately in the intervening years very little progress appears to have been made and, at the time of writing (1989), the mill is still awaiting a further period of activity.

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AN INTRODUCTION TO WINDMILLS IN THE ANJOU REGION OF FRANCE.

By Alan F. Gifford.

The Anjou region of France is situated inland, some 200 kilometers south east of Paris, with the River Loire dividing it into two areas, generally centred around the town of Angers (see Figure 1). The region is better known to many for its fine wine, rather than for its windmills. For the molinologist however it offers much in the way of windmills and almost rivals parts of Holland for the variety of artifacts remaining. My interest in Anjou started a few years ago when on holiday near Nantes. A chance observation on a yellow Michelin showed the presence of numerous windmills symbols a few miles to the east - a feature which obviously required investigation!

A Brief History of the Windmill in Anjou.

In the middle ages the Anjou region contained a large number of windmills, of various types. According to the Association des Amis des Moulins de l'Anjou (A.M.A.), the earliest record is said to date back to 1119 AD when reference has been found to a mill which was called 'Buison', located at a place called Bouchmaine. References become more frequent at the start of the 14th. century, and from the beginning of the 18th to the middle of the 19th century the number of windmills increased significantly in the region. The A.M.A. believe, after much study of old maps, documents and other archives that, over the past 300 years, there were up to 1600 windmills present. As an example they quote that a survey in 1865 showed: 296 in the district of Anjou (around Angers), 44 in Bague (East North East from Angers), 188 in the area of Cholet (South West from Angers), 170 in the area around Saumur (South East of Angers) whilst there were 56 in the district of Segre (to the North). To these could be added 437 water mills and 12 steam powered mills, in total driving perhaps 2000 pairs of mill stones.

The mills were widely distributed in the country areas but were also concentrated in areas of dense population, i.e. in the large towns. The town of Angers (Anjou) had itself many mills and, according to a map by Cassine, dated 1760, there were 46 windmills present. These increased to 68 in 1794 (with a single water mill) but then declined to 53 in 1842. There are however no remains of windmills in the town at the present time. In the adjacent town of Saumur, a map dated 1810 identified 35 windmills and the Rue des Moulins alone, on the cliff tops close to the chateau, had 24 mills in a long line overlooking the River

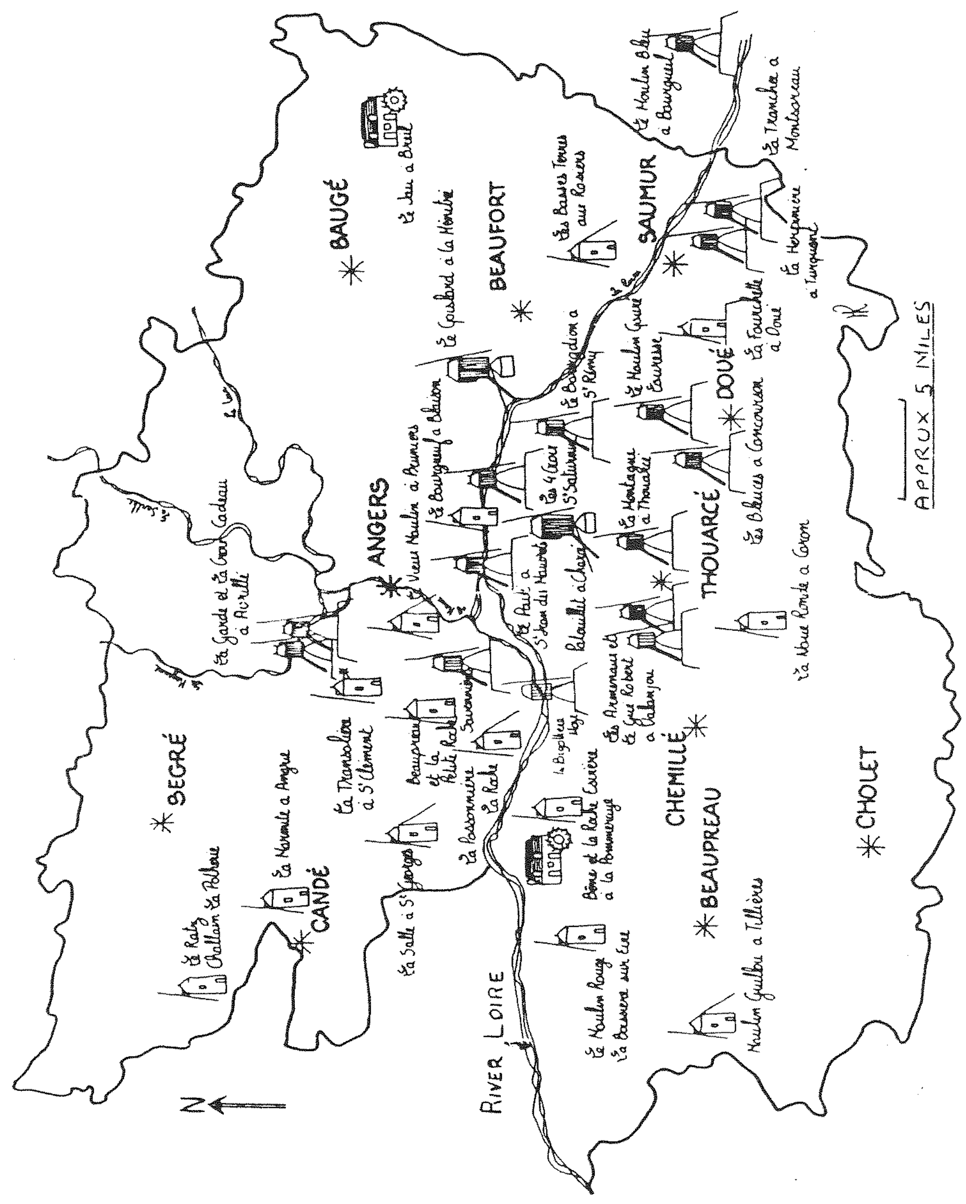

Figure 1. Map of the Anjou Region of France showing mill sites.

Loire. Again unfortunately none of these have survived, although there are a number of excellent sketches and some early photographs available.

Most of the mills, as was the practice in Holland, were given individual names, which in association with the town or village name, help to locate the mills but the absence of grid reference on current Michelin maps and on A.M.A. literature can lead to many car miles being required in order to be able to find them! Details of the locations of some of the mills of the region which are open to the public are given in the Appendix, relating to the nearest towns or villages, the road number and also the direction from the town of Angers, e.g. NNW.

Type of Windmills.

The mills of Anjou region of France can be divided into three main categories (see Figure 2) and one other type which had only limited presence:-

CAVIER. A form of hollow Postmill (for which no direct equivalent is known by the author in this country) with a wooden buck mounted on top of a stone cone.

CHANDELIER. A Post mill, similar in general construction to those in this country,

TOUR. Similar in principle to a UK tower mill.

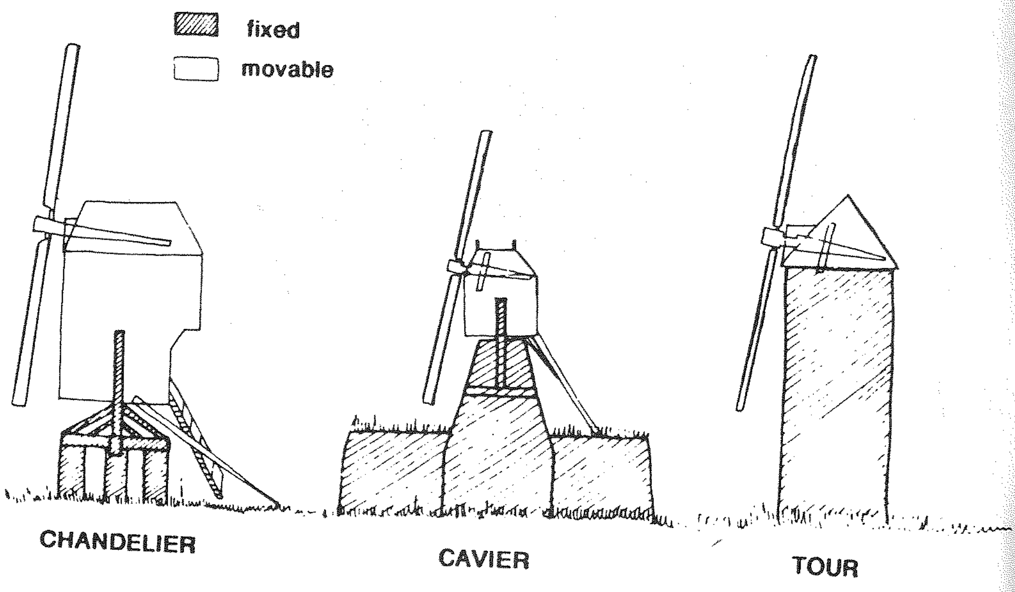

Figure 2. Main types of windmills in Anjou.

PIVOT TOURNANT. A form of Post mill now extinct in the region, in which the buck was supported on a stone tower, but which pivoted on a vertical post, which passed through the centre of the almost solid tower to a bearing at the base.

These types of mill are described in general terms, with comments on some specific mills.

Moulin-Cavier.

The 'Moulin Cavier' is a form of hollow post mill which is made up of three main parts, a large masonry and earth mass, on and inside which, a stone 'cone' is built and the 'hucherolle' or wooden buck which rotates above the cone and which contains the windshaft, brake wheel and wallower. The mill stones themselves are installed within the cone and are driven by an approximately 2ins square iron quant which passes through the hollow wooden post on which the buck is supported. The general form of construction is shown in Figures 3 & 4. The vertical post itself is supported on 'cross trees', steadied by quarter posts, which are built into the masonry of the tower itself and maintained in a vertical plane by the stone work, although it may also be kept in position by packing masonry, at the top of the cone. The hollow post is made of wood, generally fabricated from four seperate pieces and held together by frames and wedges.

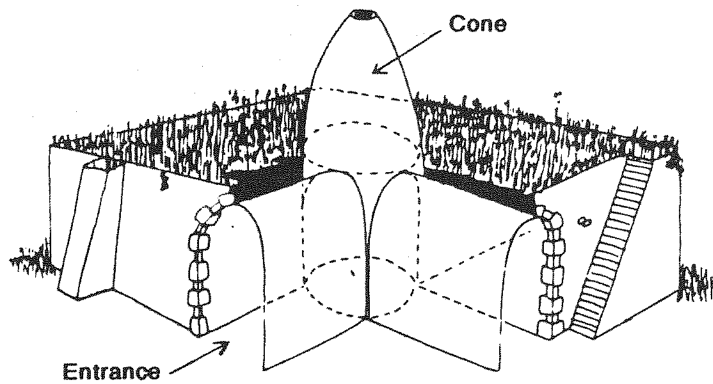

Figure 3. Priciples of construction of the mound of a Cavier mill.

Many of the mills examined had one pair of stones but two pairs were not uncommon. These were accessed through a cave or tunnel which passed through the mound to provide a room at the base of the cone. The mound was up to 48ft square and was typically between 10 and 12ft high. The height of the stone cone above the mound varied considerably, from a low 12ft to a quite significant 30ft. The cone was between 12 and 15ft diameter at the base tapering in a variety of shapes, to about about 3ft diameter at the top of the

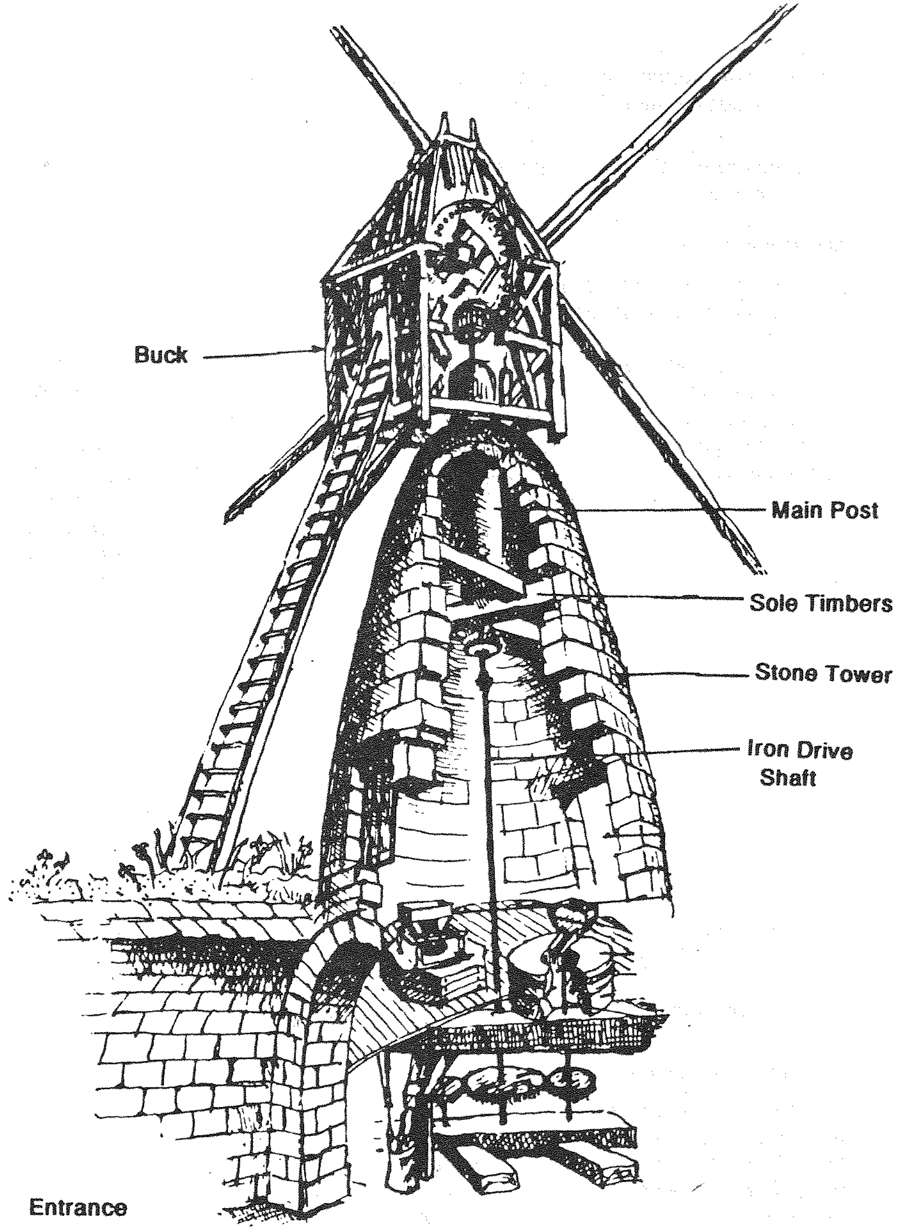

Figure 4. The 'anatomy' of a Cavier type mill.

cone. The cylindrical structure of the cone passed through the mound to ground level and, in some cases, provided access to numerous tunnels or rooms in the mound, which were used as living or store rooms.

The wooden buck was accessed by a large, massive, and often almost vertical, ladder which, in a number of cases acted as the tail pole, and possibly as a counter balance to the sails.

The construction of the the 'hucherole', (or buck) , was similar to that of a post mill. The size varied considerably but was typically about 12ft long, 8ft wide and about 10ft front to back, whilst the height, to the top of the angled roof, was some 12ft. The rear of the buck was often left open and sometimes exhibited quite elaborate carved or shaped wooden framing. The buck typically contained a large section, though generally square, wooden wind shaft, with iron clad bearing surfaces at its tail and neck. All the neck bearings examined were stone. On the wind shaft was mounted a wooden brake wheel, about 7ft diameter; this was encircled with an iron brake band, which could be activated via a lever and rope from ground level. The wallower was either of iron or of wooden lantern pinion construction. A few, probably later mills, had iron windshafts and brake wheels. In a number of cases the mill stone was driven from the brake wheel, through a lantern pinion wheel, the drive being transmitted through the vertical iron shaft or quant referred to earlier, whilst multiple stone mills used a great spur wheel and stone nuts, again driven from the vertical quant.

The wooden stocks were mortised into the windshaft, although in almost every case local iron bands were used to reinforce the area. The sails were either common cloth spread on typical open French hemlaths but many more used the Berton form of sail construction, which could be regulated whilst the mill was in operation.

Various materials were used for the stones, although multi section French Burr stones were very common. The stones, housed in the base of the stone cone, were often mounted on a heavy wooden hurst frame and were up to 6ft diameter and 14ins thick. The vat and furniture did not differ significantly from that used in this country.

The method of tentering observed was through a beam, adjusted by a screw which was turned by a hand wheel. In one case a governor was fitted.

Moulin-Chandeliers, or Post mills.

There are now only two 'complete' moulin chandeliers remaining in the area and these are both in a restored condition. The round houses of some dozen others are all that remain of the 150 sites which have been located in the area, there being 25 in the town of Angers alone at one time.

The basic shape of post mills of the region (see Figure 5) is similar to those in England. Many of the mills were mounted on a stone round house, with steeply angled slate or tiled roof. The height of the round houses varied considerably, with one, (at Pouzez), in excess of 23ft. Two examples of mills with open trestles are noted but both of these are protected with wooden

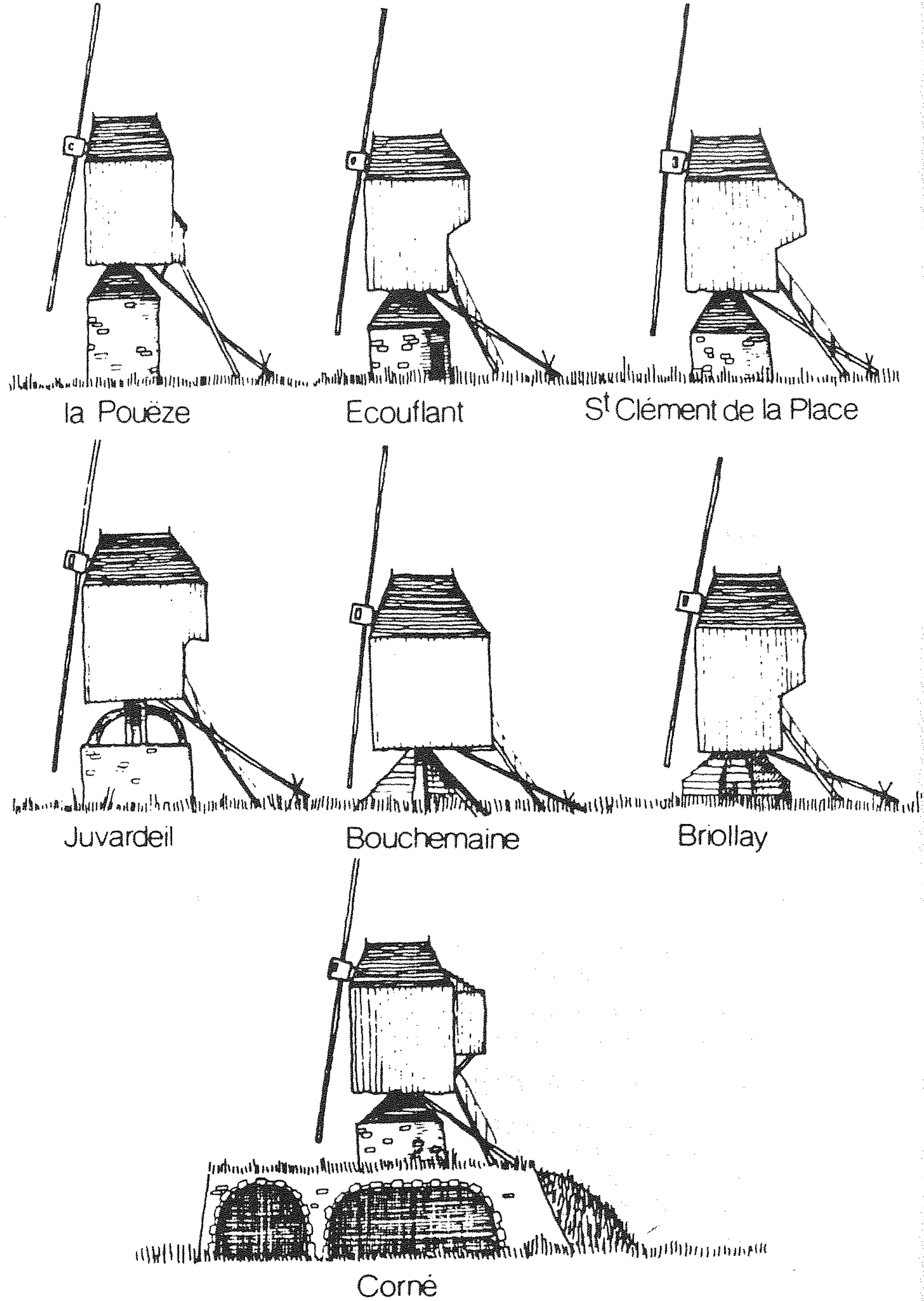

Figure 5. The shape of some post mills in the Anjou Region.

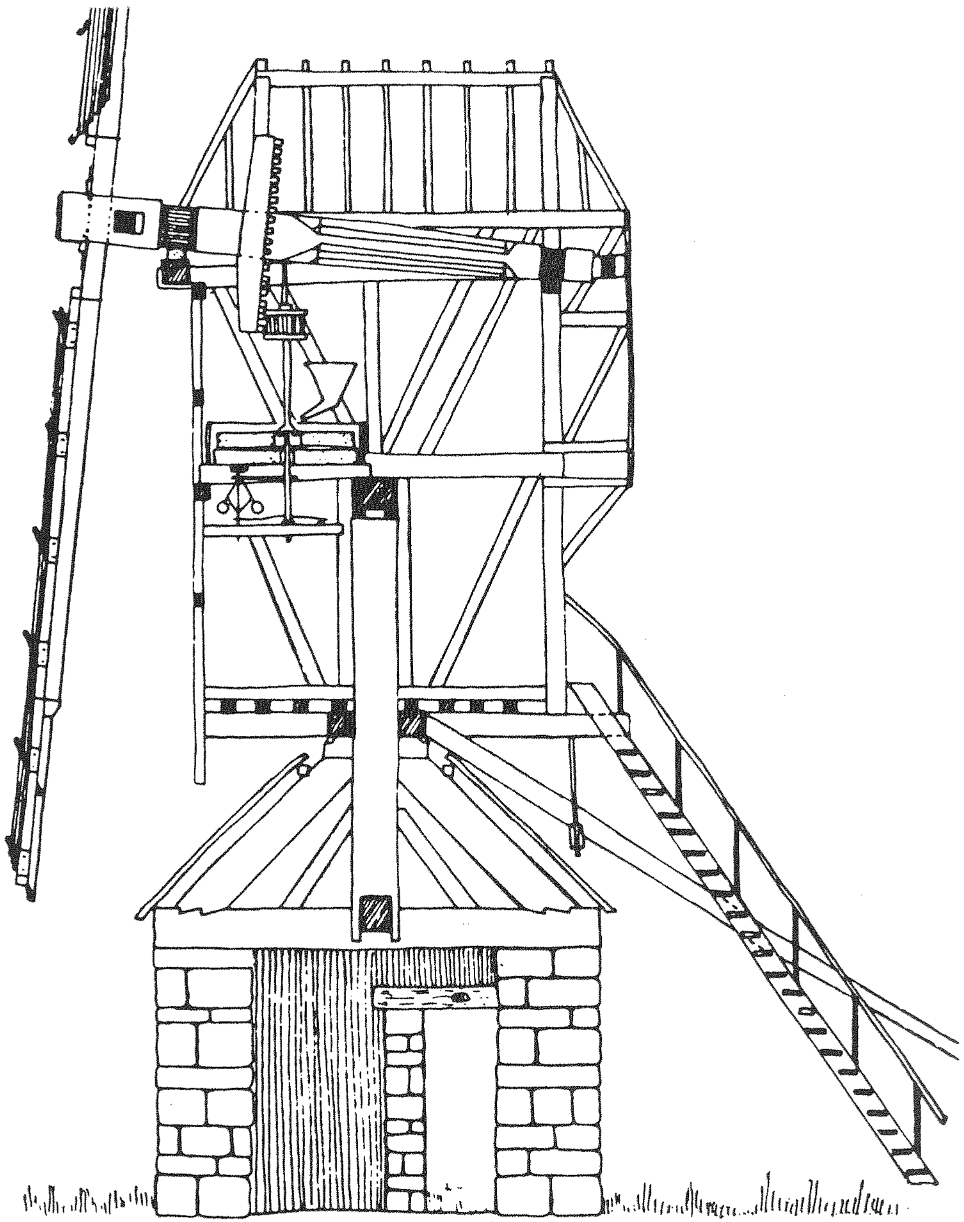

Figure 6. Sectional drawing of a Chandelier type mill (post mill).

cladding. The mill at Juvardeil had exposed quarter bars above the round house whilst that at Corne was built on a mound.

The mills varied considerably in size, often having very tall wooden bucks, some with additional storage space being provided by extension porches at the back. The buck was approached up a steep set of wooden steps. None of the mills are shown to be fitted with any form of fantail or other device to automatically turn the mill into the wind. All of the mills illustrated in 'Les Moulins d'Anjou' have wooden wind shafts and stocks which were generally fitted with the Berton system of sails although one example, at Bouchmaine, had common sails.

No details are given of the internal mechanism or of the number of stones fitted and no access has been gained by the author into the two remaining examples at La Menitre or at Raindron. A sectional drawing of a typical mill however shows a tapered wooden wind shaft driving a lantern pinion gear directly from the brake wheel. These can be regulated by a ball type governor fitted under the stones (see Figure 6).

Moulins à pivot Tournant.

There are now no mills of the type called 'pivot tournant ' remaining in the Anjou region and at best they were rare. They were primarily located in the west of France, extending from the Channel down to the the Vendee region, on the Atlantic coast, where there were reported to be in excess of 600 in 1886.

The pivot tournant represents a form of post mill, the origins of which are unclear but sketches by Jean Baptiste Florentin, which have been dated as 1542, clearly show the form of construction which, at first glance, would probably appear to have been a straight forward post mill with a pitched roof buck, sitting on top of a squat stone tower.

However the small wooden buck, which was turned into the wind by means of the access ladder, had a vertical wooden post inside the tower which was attached to the crown post running from the front to the back of the buck. The vertical post passed through the top of the very solid stone tower and was supported by a wooden collar, built into the structure, which served to keep the post vertical, whilst at the same time permitted the post to rotate. The buck itself ran on small wheels, on top of the tower, on a trackway. The vertical wooden shaft pivoted at the base of the tower on heavy wooden cross beams built in the base of the tower. Thus the buck pivoted on the vertical post, at ground level and was steadied by the stone tower structure.

The form of construction is shown in Figure 7 where it will be seen that the drive to the stones in the buck is conventional. No information is presently available as to the benefits to be gained by this form of construction and the limited storage space available would appear to be a positive disádvantage.

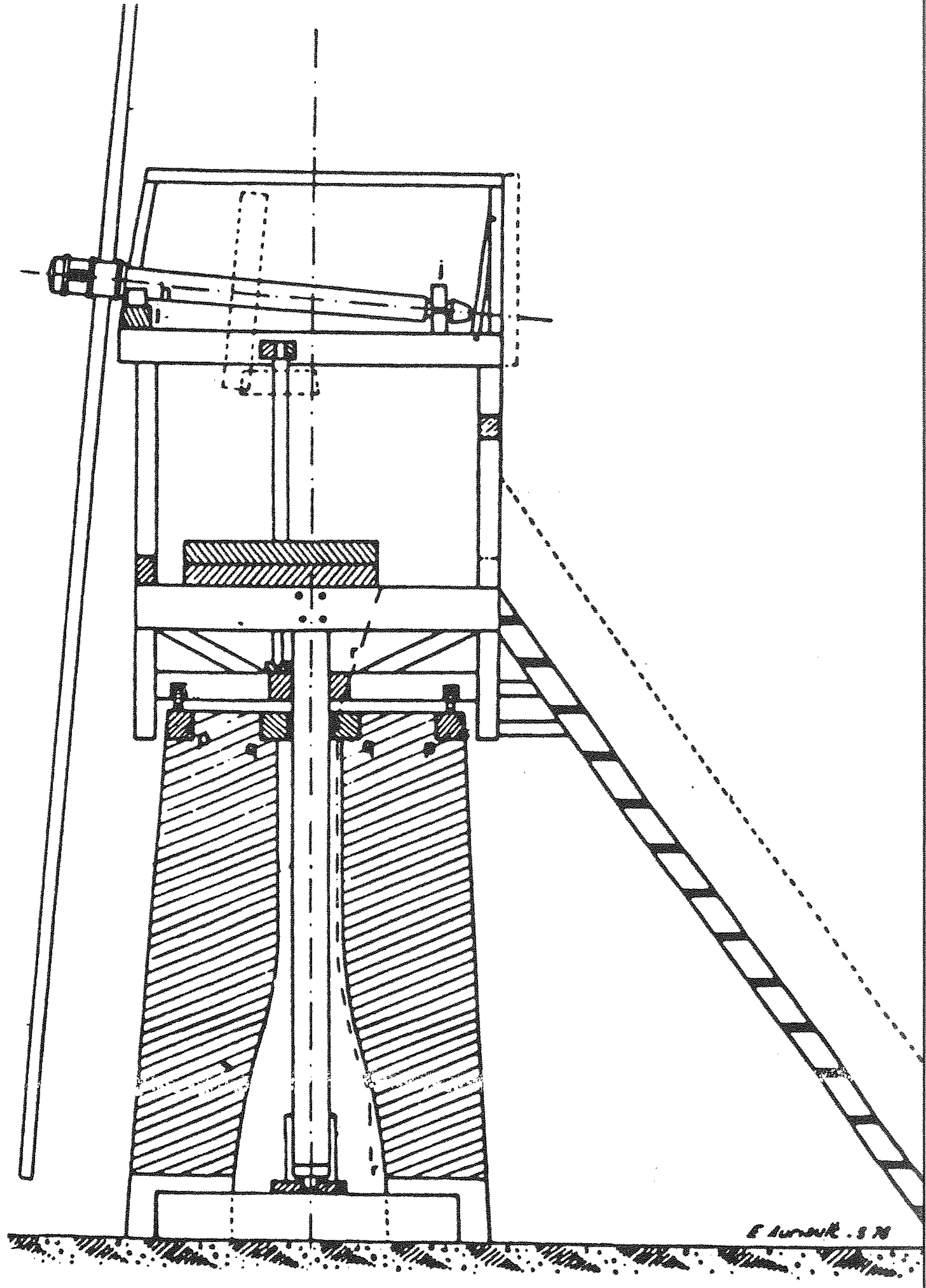

Figure 7. Section of a Pivot Tournant type of mill.

Moulin-Tour, or Tower Mills.

Tower mills were the latest addition to the mills of Anjou and often replaced a cavier or post mill. They are, of course, much more durable than other mills and the region is dotted with up to 200 towers, of which some 20 now have caps and sails, although the sites of up to 500 more are known. A cross section through the tower mill La Roche, at la Possonniere, is shown in Figure 8. This mill has now been restored.

Tower mills were generally built in stone and were typically about 20ft in diameter and with walls, at the base, around 4ft thick. Unlike towers in this country, the French tower mills are often built without batter, and are therefore very noticeable for the virtually vertical walls. The height of the towers vary, but they range from about 13ft to some 40ft, and whilst many have two floors, some with four floors were noted. The wooden framed caps are generally conical and are either tiled or covered with slates. The windshaft normally emerges through a small garret type construction in the cap which is turned into the wind by means of a hand operated tailpole. Examples of an internal rack and winch system, turned by a geared hand wheel, were seen. In one case the miller winded the mill by inserting a large pole between the teeth of the cap rack and a roof beam and just levered! Several mills were fitted with 'moulinet d'orientation', or fan tails, e.g. St Clement de la Place, but no details of the operation is known.

The wind shaft, often of wood but sometimes of iron, were inclined at 8 to 15 degrees to the horizontal and had either wooden or iron brake wheels fitted. Wooden wind shaft were deeply carved for the neck and tail bearings and also to permit the control mechanism for the Berton sails to be fitted.

The vertical shaft was either of wood or iron, as was the gearing, although wooden gear teeth or cogs appeared to dominate. In some case wallowers, of lantern pinion type construction, were used and these drove one, two or three pairs of stones, through great spur wheels and stone nuts, which again were sometimes of the pinion type. Governors ('regulateur a boules') were occassionaly fitted and operated a tentering arm in the conventional manner. All mills were fitted with a sack hoist, which generally worked from a slack belt and was activated from any floor by a rope and lever mechanism.

Some of the mills were fitted with rotary silk flour dressers and sieves and were all of wooden construction. The stocks themselves were all wooden and generally carried Berton sails.

The Berton Sail.

Many of the windmills in the Anjou region of France are fitted with four Berton sails, or demonstrate the remains of such a system. (see Figure 9).

The sails (3) consist of 8, 10 or 12 wooden boards (2), each about 20ft long x 6ins wide x 3/8in thick, which are so arranged that they slide over each other, rather like a pack of cards. Mounted on the stocks, on pivotted inclinded cast iron brackets, are a series of wooden cross arms (1), the length of which is

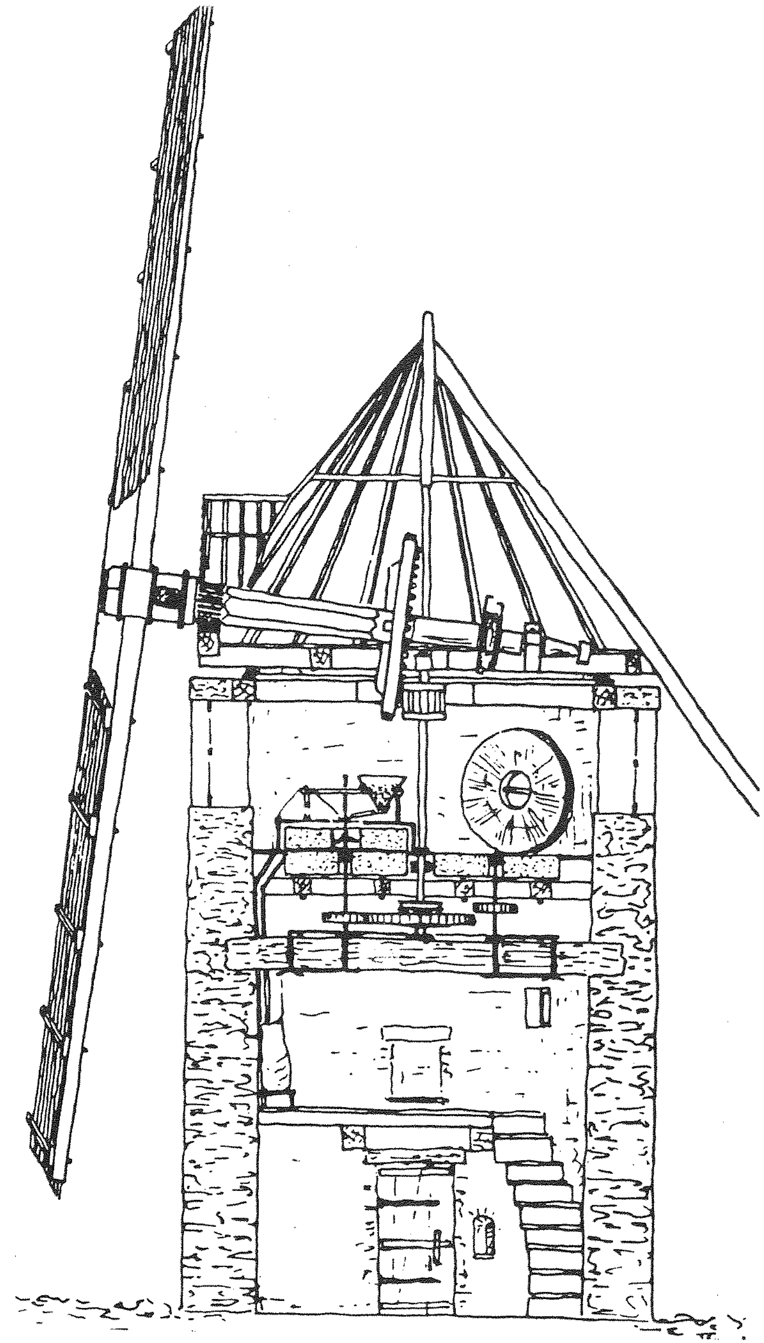

Figure 8. Sectional drawing of the Moulin de la Roche at Possonniere.

approximately the same as the total width of all the boards. The latter are attached to the cross arms by soft iron, often galvanised, metal strips, about 5ins long, 1in wide and 1\16in thick by loose fitting wood screws and are thus able to change the composite shape when the cross arms (1) are rotated, from a rectangle, through a trapezoidal shape until they finally are stacked above each other, as a bundle, not much wider than one board.

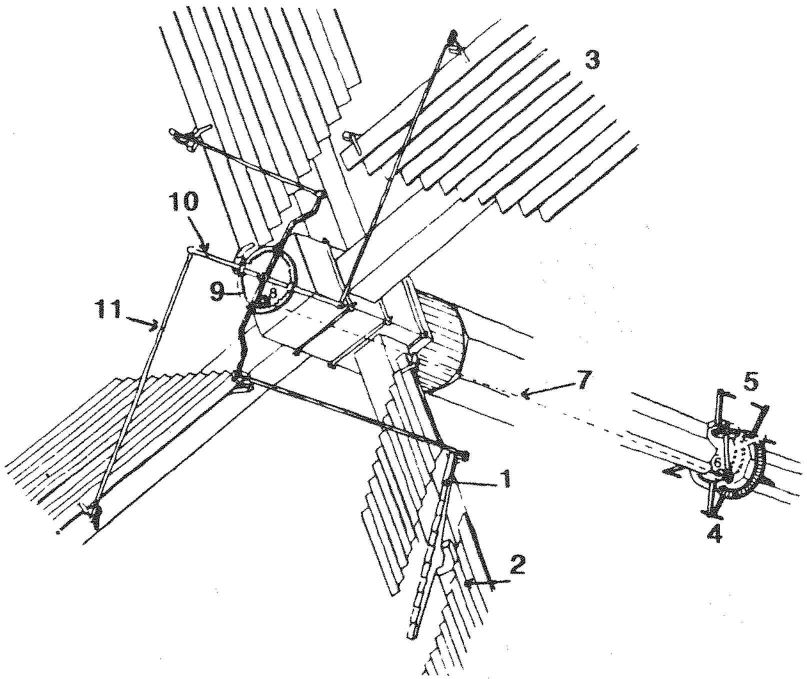

Figure 9. The 'Berton' system of adjusting sails during operation of the mill.

This movement is effected by metal levers (10) attached to an annular gear (9), about 18ins diameter, located at the front of the wind shaft and mounted on a stub axle. This is in turn driven by a small pinion (8), which is rotated by a metal rod (7) which passes through the wind shaft but which is significantly displaced to one side of the shaft.

Close to the tail end of the windshaft are two large iron bevel gears which completely surround the shaft and which both mesh with a smaller, common, iron bevel gear. This is mounted on a metal spindle set at right angles through the shaft, at the other end of which is a worm gear connected to the rod passing along the length of the windshaft. When this is turned the annular gear rotates and actuates the sail opening.

The two large bevel gears both have four substantial metal arms projecting

from them (5), into the free space around the shaft. The arms are cranked at the end to form an 'L' shape. Heavy weighted wooden lever arms, some 4ft long, are pivoted off the mill structure such that, by pulling on a cord from the floors below they can be swung up and hence become engaged with one of the projecting lever arms and thus prevent the gear in question from turning as the wind shaft rotates. As a direct consequence the pinion on the short transverse shaft starts to rotate and, via the worm gear, transmits motion along the rod (7) to the gears at the front end of the windshaft. The annular gear (9) now rotates and, via the levers (10) and (11), causes the sails to move. The direction of movement depends on which of the two bevel gears (4) or (5) is prevented from rotating with the windshaft. Preventing the rear bevel gear(5) from turning, closes the sails after a few turns of the windshaft, whilst stopping the front bevel opens the sails. The arms on the bevels can also be rotated by hand to adjust the sails or to open or close them if the wind shaft itself is not rotating.

The action of opening or closing the sails is quite rapid, being accomplished in about 30 seconds and thus clearly meeting the inventors objective in saving time for the miller. This type of sail adjusting system was not adopted in England.

Summary.

The Anjou region of France contains a number of very interesting windmills of the types described in this paper which are either working or are capable of operation and which are open to the public. There are however many other mills in the region, some of which are easily accessible and for which permission to enter can usually be obtained. In addition some water mills can be found.

Acknowledgements.

Thanks are due particularly to Mme. Caille of the Association des Amis des Moulins de l'Anjou for her help and assistance, especially in obtaining permission to use the information and illustrations from 'Les Moulins d'Anjou' which are included in this article.

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Useful Address.

Association des Amis des Moulins de l'Anjou,
17, rue de la Madeleine,
49000 Angers,
FRANCE.

APPENDIX.

Some Mills Open to the Public.

TYPE	COMMUNE	MILL NAME	LOCATION	NAME/PHONE
Tower	Angrie	Moulin Neuf	WSW, near Cande on D770	M.Gauguet 41 92 04 28
Tower	Challain-la Potherie	La Ratz	NW, 2km SW of Challain	M.Hoinard 41 94 14 83
Post	Charce	La Patouillet	SSE, on D323 near St.Ellier	M.Lesein 41 66 34 61
Cavier	Louresse-Rochemenier	Moulin Goure	SE, CD69 near Doue	M.Baron 41 59 21 67
Cavier	St.Saturnin	Les 4 Croix	SE, D751 near Angers	M.Horeau 41 91 93 03
Cavier	Turquant	La Herpiniere	SSE, To E of Samur near river	41 70 47 83
Tower	St.George sur Loire	Moulin de Rat	SW, off the D961	Sign Posts

NOTES.

See Michelin Maps 63 and 64 (1/200,000).

Location directions (e.g. SW) are relative to Angers.

HOW DOES IT WORK?

THE FLYBALL GOVERNOR.

by Norman N. Clarke.

One of the common pieces of mechanical engineering encountered in mills is the flyball governor, reputedly invented by Thomas Mead in 1787. It was certainly in use when James Watt applied it to steam engines in the later part of the 18th century. The flyball governor is a complicated piece of mechanical engineering. So much so that its operation has been incorrectly described in a recent mill booklet for Llynon Mill on Anglesey. The general arrangement of the governor at Llynon is shown in Figure 2. and this has been produced in diagrammatic form in Figure 1. to emphasise the nature of the levers involved in the mechanism.

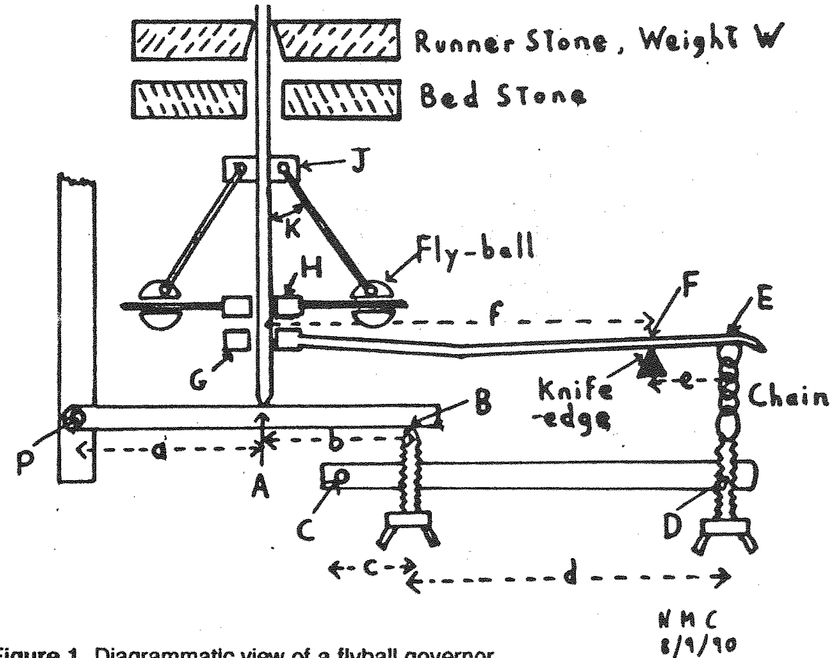


Figure 1. Diagrammatic view of a flyball governor.

P-B, C-D and E-G are all levers, which together with the chain D-E form a balance, supporting the weight of the driven stone on the short arm of the balance (P-A) by a proportion of the weight of the fly-balls acting at the end of the long arm of the balance at point G. The weight of the stone at point A is carried by the pivot P and the pivot B. Since the point A is midway along P-B, the weight W of the stone is carried equally at P and B and so B must carry W/2. In a similar way, the lever C-D carries the weight W/2 at B, but now the pivot point is closer to C, so the weight at D is now quite small. The ratio of the weights D and C are in the ratio of c:d+c. Since c:d is likely to be say, 1:4, then the weight at D is now 1/5 of W/2, i.e. about W/10.

The weight of the stone is therefore balanced by the upward pull of about W/10 by the chain at point D. The upward pull of the chain is provided from point E by the lever E-G which pivots about point F. The collar G is free to ride up and down the stone spindle, but is held down by the collar H which is in turn weighed down by a fraction of the weight of the fly-balls; most of the weight of the balls is carried at J.

The lever E-G works in the same way as C-D so that the weights at G and E are in the ratio e:f. Since e:f is likely to be about 1:10 then the weight at G need only be about 1/10 of that at E (W/10) so we get about W/100 at G! Figure 2. shows an overall ratio of 36:1 i.e. we need W/36 at G; this ratio seems a little on the low side - many mills use anything up to perhaps 200:1, depending on the weight of the stones. The miller can adjust the gap between the stones by turning the screw adjusters at pivots B and D.

The chain D-E plays an important role in this balance, as it provides a variable length link between D and E, and is only stiff in one direction (when it is being pulled!). The proportion of the weight of the fly-balls which acts on the collar H (and hence balances the weight of the stone) depends on the angle K between the spindle and the ball tie-rods. For small angles of K only about 1/4 of the ball weight is applied to H; at large angles about 3/4 is applied to H. The miller can then make crude adjustments to the balance with the chain - shortening the chain raises G and H and increases the angle K, hence increasing the proportion of the ball weight on the balance. Finer adjustments can be made by moving the knife-edge at F along the arm G-E.

A quick calculation shows that two iron balls 5 inches diameter weigh about 17 kg (37 lbs) - allow 20 kg with the collar H. The variation in the height of H (and the angle K), by the chain D-E allows between a quarter and three quarters of this weight (say 5-15 kg) to act on H, the rest is carried at J. With our calculated ratio of 100:1 this means that these two balls can balance a stone between 500kg and 1500kg in weight (i.e. between 0.5 and 1.5 tonnes!). Notice the curious but common feature that part of the weight which is balanced by the balls is part of the weight of the balls themselves, since the pivot J is locked to the stone spindle!

When the stone begins to turn, the iron balls are flung outwards by what is usually (and wrongly!) called centrifugal force - try whirling a conker around on a string and see the effect! Because the balls are pivoted about the collar J (which is locked to the spindle), they rise in the arc of a circle, and the bar and collar H which is free to move on the spindle rides up, allowing the collar G also to rise. As G rises, the lever G-E pivots about point F, and E descends. Hence D

descends, B descends and so does A, lowering the stone to decrease the gap as the stone speeds up. With a smaller gap, the flour is finer, and therefore takes more work out of the mill; the speed then tends to decrease and the gap gets larger. Once properly adjusted, this mechanical 'feedback' system is inherently stable and will maintain the desired gap to mill the flour perfectly - the accuracy is only limited by the 'sloppiness' in the mechanical components like pivots and bearings. The chain plays an important role here; if the driven stone is forced upwards (say by a pebble), it is free to do so and the chain goes slack. The rigidity of the chain when stretched defines the minimum gap between the stones. In addition the chain partially isolates the fly-ball governor mechanism from any vibrations of the stone which would otherwise be magnified 100 times at the collar G if a rigid rod connected D and E! Such a 'rigid' feedback mechanism would result in oscillations, and damage to the whole system, since part of the weight of the balls being moved up and down by G is the weight of the balls themselves!

The work done by the mill appears partly as heat in the flour - feel the fresh milled flour next time you visit a working mill, it is warm to the touch. The low speed of traditional stone grinding means that the rise in temperature of the flour is small compared with modern roller mills, where the rollers are water-cooled to prevent the flour bursting into flames! The comparitively gentle treatment of stone-grinding yields the finer flavour and keeping qualities of traditional flour.

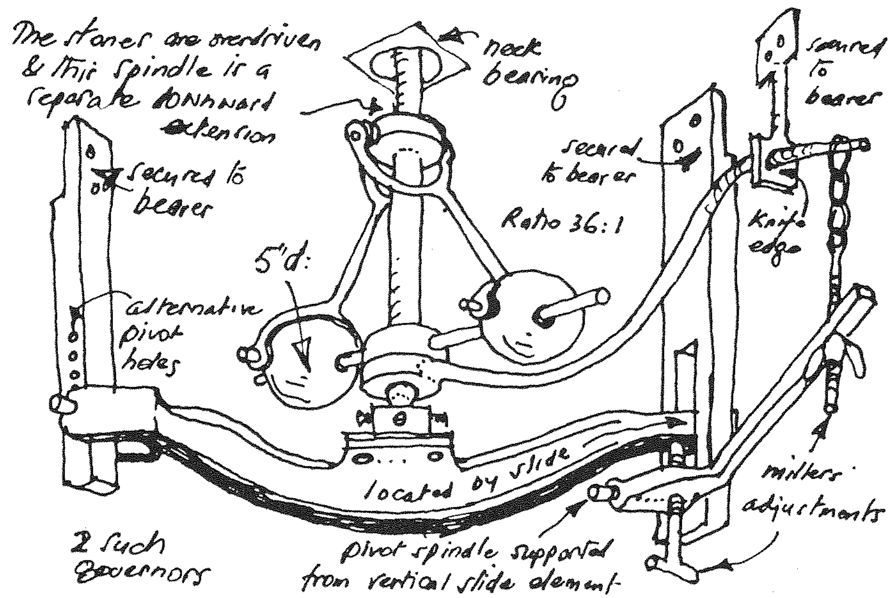


Figure 2. The flyball governor at Llynon Mill. *(drawn by Wilf Foreman)*

DUNHAM MASSEY SAWMILL.

By Dr.Cyril Boucher.

The Dunham Massey House and estate lie in Cheshire some 10 miles south-west of Manchester (SJ 735873), about 2 miles from Altrincham, just off the A556, the main Manchester to Chester road. The estate is now owned by the National Trust, and in the grounds of the estate there is a sawmill that has been restored by Boucher & Sons, Chartered Engineers & Millwrights

The Mill.

The earliest illustration of the mill is the panoramic view by Knyff, engraved by Kip, which hangs in the house at Dunham. Dated 1697, it shows the park, the mansion as it then appeared, and the mill. The whole complex was in the Elizabethan style and the mill, apart from some doors and windows added in the nineteenth century, is shown externally as it is today. During the early eighteenth century the mansion was rebuilt in its present form, but the mill remains to conjure up the style of the former Hall.

All the Elizabethan buildings were completed in 1616 by Sir George Booth (1566 - 1652) the first baronet and a direct ancestor of the tenth Earl of Stamford, and this surviving section of that complex shows all the charm of the period. With its stone flagged roof, mullioned windows, stone dressings, warm red brickwork and multi-gables the mill is a delightful example of industrial architecture. The brickwork is in English Bond, that is alternate courses of headers and stretchers. The general texture of the bricks used seems to show that they came from a clamp rather than a kiln, for clamp burning always produces a wide range of colours and many bats which could not be wasted.

Inside, the half-timbered partition which goes right up to the roof was once filled with wattle and daub as the holes and grooves for the wattlework still testify. Some of the woodwork is older than the present building and must have been re-used from an earlier one, for the purlins in the north gable appear to be a pair of crucks. The methods of timber conversion in use at that time are well illustrated here in several places. In the carpenter's shop are two handsome curved beams supporting the floor above. They are identical twins for each is a half of the same tree sawn in two lengthwise. The irregular sawmarks changing direction at intervals as the top or bottom sawyers moved relative to each other, show that they were cut by hand on a saw pit. These marks facing each other are reflected images. The other two faces and the bottom edges were produced by the adze.

Cornmilling.

The structure was built as a corn mill, but later in the nineteenth century it was refitted as a saw mill. There is only one certain visual piece of evidence that

it was originally a corn mill. Bolted to the purlin or roof beam over the circular saw bench near the window is a large iron ring. This has no present purpose but was used to attach lifting tackle for the purpose of turning over the heavy millstones for recutting. There is a similar ring for this purpose in the Nether Alderley corn mill (SJ 843762). It is also nearly certain that the millstone dated 1684 standing outside, and brought from the inner courtyard of the Hall, was once part of the equipment. The room over the carpenter's shop was almost certainly a garner or granary, from the fact that it is or was plastered all over, even on the boarding which has been hacked for the purpose. This used to be standard practice for grain stores.

The waterwheel has been in three different places. Old drawings show it occupying its present place, but some time in between it has been in two other positions, as shown by the bricked up axle holes and the corresponding circular cuts made by the wheel in the wheelpit, one set easy to see, but the other more difficult to detect.

Sawmilling and the estate workshop.

The business of cornmilling was closed down when Bollington Mill (SJ 730870) was built nearby on the banks of the River Bollin, around 1860. At this time the Dunham Massey mill was refitted as a sawmill and estate workshop. The machinery was all new and specially designed, most of it being housebuilt. This term means that the various items formed part of and were attached to the structure and could have no separate existence, unlike modern machines which are self-contained and can be moved from one building to another.

As well as the big frame saw for cutting up trees and the power fed circular saw for resawing, there is a crane for handling the timber. There was formerly another one of which the winch portion remains, while rope relay pulley and socket for the crane post can be seen outside the double doors. Inside the sawmill there were two machines that have been removed. One was probably the heavy wood-boring machine which has been brought back to the mill. It can only be guessed that the other was perhaps a morticing machine of the old reciprocating type. There was a large lathe downstairs with a 10ft bed and a travelling tool rest, large enough to have turned the ornamental columns in the stables, but unless these were added later they are much too old to have come from this workshop. The bandsaw is of a type that was being produced around 1870. All this machinery is driven by belts from line shafting, and this in turn takes its motive power from an overshot waterwheel of 15ft 4ins diameter producing about ten horsepower.

The exact date when the machinery fell into disuse is not known, but an old man who died in the 1970s started work on the estate at the age of seventeen in 1895 and testified that it had never worked in his time. The reasons for discontinuing work are not recorded, but are not hard to guess. Sawing up trees all day long and every day by water power uses a lot of water, and in long hot summers the lake, which has only a small supply would be emptied.

The Restoration of the Machinery.

When the estate passed into the care of The National Trust, following the death of the tenth Earl of Stamford in 1976, Boucher & Sons were asked to inspect and report on the machinery and waterpower of the mill.

The waterwheel was marked by an odd segment and the rest lay as a heap of rubbish in the wheelpit. The beams of the frame saw had rotted away down below, while above floor level the crosshead, feed mechanism and timber carriage had all disappeared. The circular saw bench was largely intact, but not of course in working order, while of the large lathe only the bed remained.

The work commenced by clearing out a large amount of mud and rubbish from the wheelpit and then building the present overshot waterwheel to the original dimensions. After this a coffer dam was constructed in the lake and within this the entrance to the culvert that forms the headrace was opened up and a new penstock fitted and built into the brickwork. A gate valve (in effect a big tap) and a launder which together control the supply of water to the wheel were provided and then at last the waterwheel began to revolve, a sight which had not been seen for over eighty years. Famous musicians have written water music, but imitation is the sincerest form of flattery, and the syncopated sound of water roaring, hissing, splashing, gurgling, bubbling, chattering and singing in the buckets as the wheel goes round is an original composition of water music that delights all who listen to it.

Following this the frame saw was rebuilt and all the missing parts supplied or specially manufactured. The necessary belts were fitted to the transmission and at last it became possible to have a trial saw, to carry out the necessary adjustments. These big frame saws were usually given a name, and this one is called 'The Dunham Ripper'. The energetic leaping of the saw, the measured snoring as the big teeth rip through the wood, the clicking of the ratchet as it moves the carriage on, and the background of the water music as an accompaniment have indeed brought the old mill back to life, while the shriek of the circular saw, the slap of the belts, the whir of the pulley wheels, the scent of newly worked timber and the sight of all this motion inside the old Elizabethan building is an attraction that is quite different from the stately mansion but as fascinating in its own way.

The Wheel and Lineshafting.

At Dunham the motive power is an overshot waterwheel of 15ft 4ins diameter and 3ft width. The arms and shrouds are of oak, the buckets of elm and the soleboards of Scots pine. The oak is used for the parts named because it is a hard timber able to withstand wear and tear, and resistant to decay; the elm because it is obtainable in large sizes, and being open grained can be heavily creosoted for long life; while the Scots pine, also easily impregnated for long life, can be readily obtained ready tongued and grooved and is then jointed in pitch to give a watertight construction.

This watewheel produces about 10 h.p. and drives, through gearing, a wooden flywheel, which in its turn is belted up to and drives the lineshaft on the floor above.

The drive from the lineshaft is taken via fast and loose pulleys to a secondary shaft below floor level, and from this to the main driving axle, adjacent to the waterwheel. This driving axle has a crank with a 26ins throw and a pitman, or connecting rod, which pushes up and down the big frame saw overhead. To balance the weight of the frame there is a heavy balance weight on an arm mounted on the axle, and to give smooth motion there is a large flywheel. Up above, the frame mounted saw, 6ft long with a stroke of 26ins, cuts trees up to 3ft diameter. These rest on a carriage which is moved forward by a rack and pinion motivated by a small secondary crank on the driving axle which operates, through bar motion, a ratchet on a gear wheel, and so drives the rack and pinion. Up above in the loft is a quick motion forward and reverse action which can be operated when the saw is not working.

Originally, long trees passed out through an opening in the wall (now bricked up but clearly visible), but the new carriage has been constructed within the limits of the building and will take tree sections up to 10 ft. long. All the motion as described - together with the slides and guides -is directly attached to the masonry or to the beams and framework of the building and could not have a separate existence.

The timber carriage and its geared drive, the top crosshead and the saw are among the new parts manufactured.

The Frame Saw.

Frame saws are the oldest type of wood sawing machinery and are imitative of pitsawing. Indeed the connecting rod which gives the motion to the frame is sometimes called a pitman because it supplies the function of the bottom sawyer down in the sawpit.

What is believed to be the first installation of this type dates from 1592 when a frame saw powered by a windmill was set up in Holland, but within a few years there were water-powered examples in England, still in the reign of Elizabeth I. They continued in use, but in improved forms, until well into this century. A steam-powered frame saw is remembered by the author, in use in 1930, but it is believed that Dunham Massey has the only one now working, although at least one is preserved in working order in a museum in Wales, another has been restored in Norfolk, and one is operated by electricity in Newtown, Powys, where the waterwheel is expecteed to be restored.

The Circular Saw.

Circular saws are a later development dating, it is thought, from around 1800 and they are at their best for resawing (as used at Dunham Massey) and not for primary conversion.

Key to Figure 1.

1. Main lineshaft.
2. Tensioner for stretching saw.
3. Upper crosshead.
4. Slidebars.
5. Ripsaw.
6. Crossed driving belt with fast and loose pulleys.
7. Lineshaft under floor.
8. Driving belt to saw motion.
9. Bar linkage to feed gear.
10. Lower crosshead.
11. Gate valve.
12. Pitman or connecting rod.
13. Pipe 12ins diameter conveying water from milldam outside.
14. Small crank giving motion to bar linkage.
15. Balance weight.
16. Flywheel to give even motion.
17. Crank with 13ins throw.
18. Overshot waterwheel 15ft 4ins diameter and 3ft wide, with oak arms and shrouds, elm buckets, and woodland pine soleboards.
19. Main driving wheel with belt connected to main lineshaft on floor above.
20. Two gear wheels, one fixed to the driving wheel slides in and out of gear along the shaft shown.
21. Gear lever for putting the drive in or out of gear with the waterwheel.

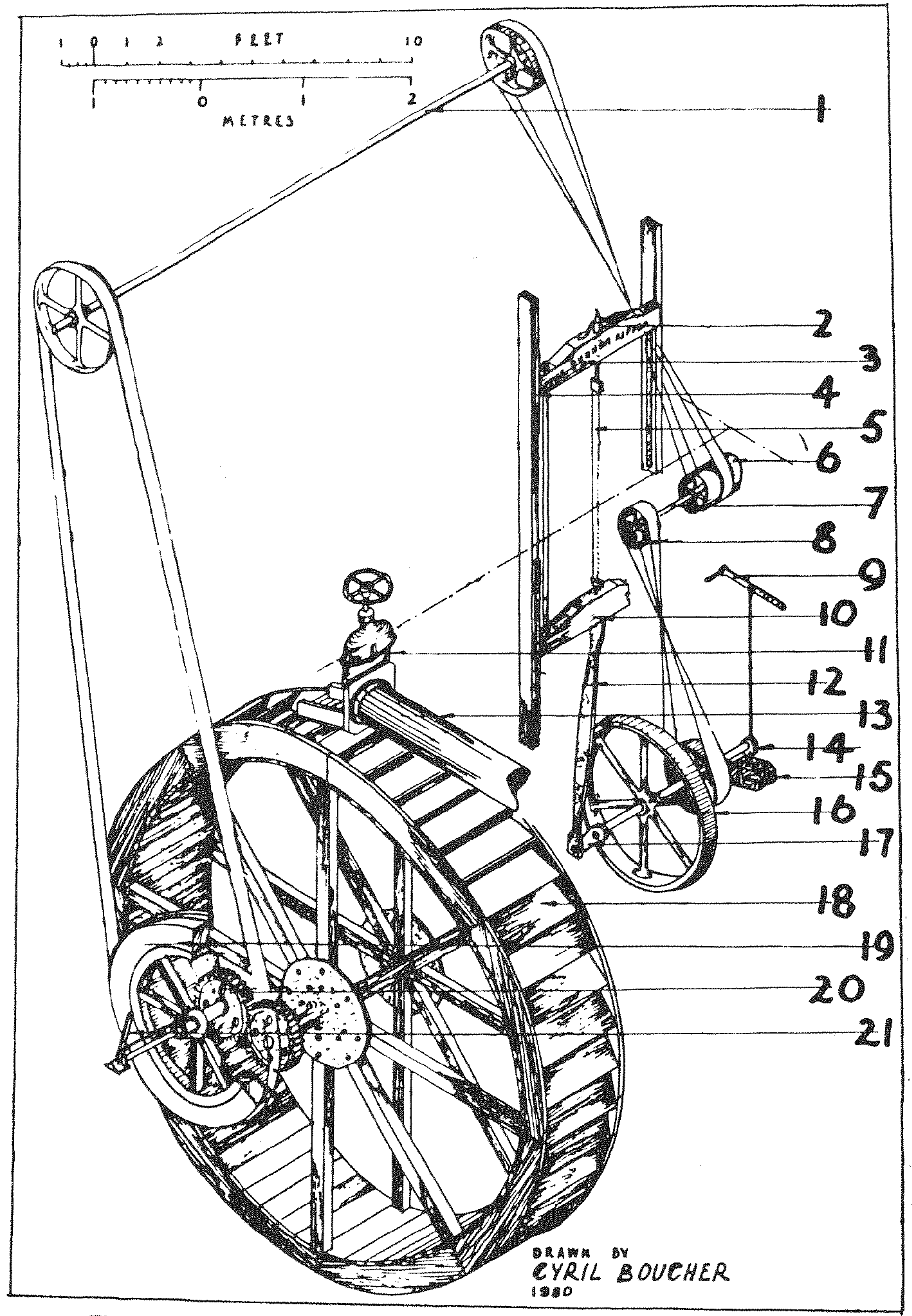


Figure 1. The Waterwheel and Framesaw, Dunham Massey.

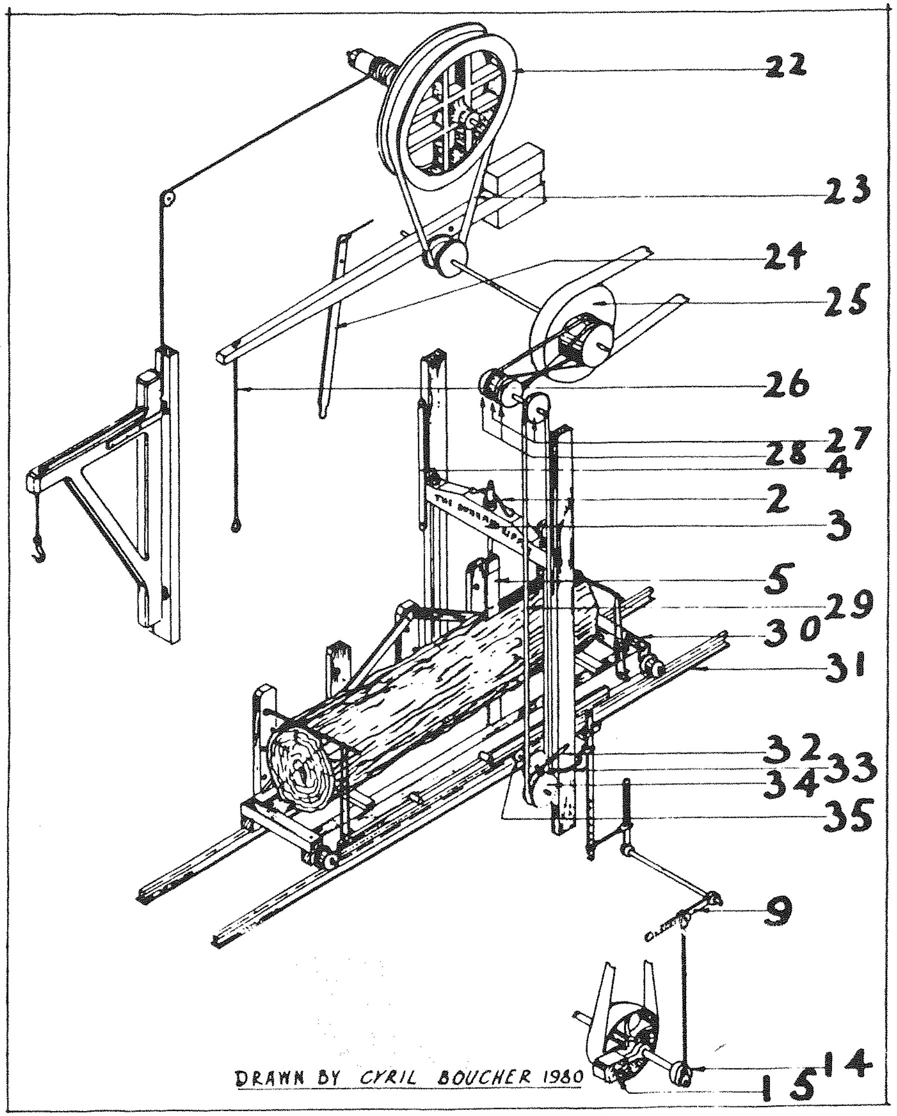


Figure 2. The feed gear, rapid traverse gear, and the crane gear.

Key to Figure 2.

22. Pulley wheel mounted on winding drum with rope relayed to crane.
23. Slack belt drive.
24. Brake lever.
25. Belt and pulley taking drive from main lineshaft.
26. Lever and cord for tightening slack belt drive.
27. Two pulleys fixed on the axle.
28. Two pulleys loose on the axle, the one carrying a straight and the other a crossed belt.
29. Belt from rapid traverse motion above, down to rack and pinion drive below.
30. Travelling timber carriage with section of tree up to 10ft long and 3ft wide.
31. Rails on which the timber carriage runs.
32. Idle pawl to stop the carriage slipping back.
33. Driving pawl actuated by bar linkage (9) driven by small crank (14).
34. Ratchet wheel with which the pawls engage.
35. Rack and pinion geared to (34).

This example, driven from the lineshaft via a fast and loose pulley, has a powered rope feed. A geared winch, out of sight under the bench, winds up, with five possible variations of speed, a long rope, which goes to the head of the bench, passes over a pulley and comes back to the saw, where, by means of a dog it bites into and pulls along the slab of timber to be resawn. When the saw is put in motion, winding commences and the timber is drawn through thr saw at the pre-determined speed.

The Boring Machine.

This heavy duty machine is used for boring holes in wood up to 1.5in in diameter. A typical use would be for making fence posts where three 1in holes would be bored in line and then trimmed out by a carpenter by hand to form a mortice to receive a 3ins by 1in fencing rail. It would of course be used for any large mortices, or for single holes. It is of a type made last century. It comes from the Stamford Estate Yard, and, at a guess, could have been taken from its present position in the mill.

The Band Saw.

This band saw is one of a type made around 1870. A band saw made at any time this century has only two wheels, but previously they had three, partly so that the middle wheel, raised and at the rear, behind the sawing action, could have a handle inserted for manual working where no machine power was available. The hole for the handle to be fixed in should be noted on this one, but after the turn of the century it was not considered likely that this contingency would ever arise or be worth catering for.

The Hand Morticing Machine.

This machine is of a type that was once common, and examples are still occassionally found in use in small workshops. This one was made over 100 years ago. The engraved brass plate records the day of the month as well as the year of manufacture.

The Crane.

The wooden crane is activated by a slack belt drive up in the loft. The rope from the winding barrel is relayed over three pulleys out to the jib of the crane. Action is set in motion by pulling the cord provided, and there is a brake which holds the load in position. The crane was provided to lift slabs from the frame saw carriage across to the circular saw, for resawing into smaller scantlings; but by means of the relay pulley attached to the circular saw bench, the crane rope could also be passed out through the doorway to drag in timber from outside.

Up in the loft there is the mechanism for a second crane. At first sight this could pass for the works of an old tower clock and it was originally powered by shaft drive. The rope was relayed by pulleys outside the building to a crane mounted on the wall adjoining the double doors. The top bracket for the crane

post and the pulleys still remain together with the machinery as described.

The Lathe.

This is capable of turning items up to 10ft long and was originally fitted with a traversing tool rest operated by a rack and pinion, as the remaining rack testifies.

When restoration commenced everything had disappeared except for the bed. The headstock, tailstock, adjustable tool rest, and cone pulleys are all new. The traversing tool rest may be the subject for future restoration.

Editor's Note.

SOME IRISH WATERMILLS.

By Niall Roberts.

Introduction.

During the summer of 1988, my wife and I went for three weeks to Ireland in order to see some of its many watermills. In preparation for this expedition I wrote, at the suggestion of the London office of the Irish Tourist Board, to eight folk, heritage, and agricultural museums spread across six of the twenty-six counties of the Republic. Only two replied, but one of these was an invaluable source of information. Dr. Austin O'Sullivan, Secretary and Curator of the Irish Agricultural Museum in Wexford not only sent two most helpful letters listing many mills and drawing attention to particular features, but also spent over an hour with us when we later reached Wexford, telling us in more detail about what and who to try and see. We are most grateful to him for all his help, and also to Dr. Gavin Bowie of Southampton, and Dr. Fred Hamond of Belfast for their advice about some particular mills.

As often happens when one undertakes a series of mill visits, some of the people one meets draw attention to yet other mills worth seeing, and altogether during our three weeks we saw the interiors of twelve watermills with vertical wheels which still have their machinery, and three mills with horizontal wheels that either had their machinery or were being reconstructed as working replica mills. Two of the 'vertical' mills were still working commercially and two were preserved or restored museum mills that were sometimes run for demonstration purposes. The other eight 'vertical' mills had survived with much or most of their original machinery.

Besides seeing the interiors of those fifteen mills, we stopped to look at the exteriors of nine empty but often impressive shells, and two ruined sites. One of these ruins was the result of a deliberate demolition carried out recently in order to avoid accidents to youngsters who broke into derelict buildings. That was at Ennis (Co. Clare). The other was the traditional site of 'the busy mill' referred to in Oliver Goldsmith's poem 'The Deserted Village'. This was at Lissoy (Co. West Meath) about 10km north-west of Athlone. We also met two practising millers, five retired millers, and three non-milling owners of mills.

The maps show the sequence of our bases for this mills tour, together with the geographical distribution of the twelve 'vertical' mills with machinery that we visited: seven of the twelve were in Co. Wexford in the south-east. This article records the main features of each of these 'vertical' mills. In the following sections, the twelve mills are grouped not geographically, but according to their general condition (working, preserved, or survived).

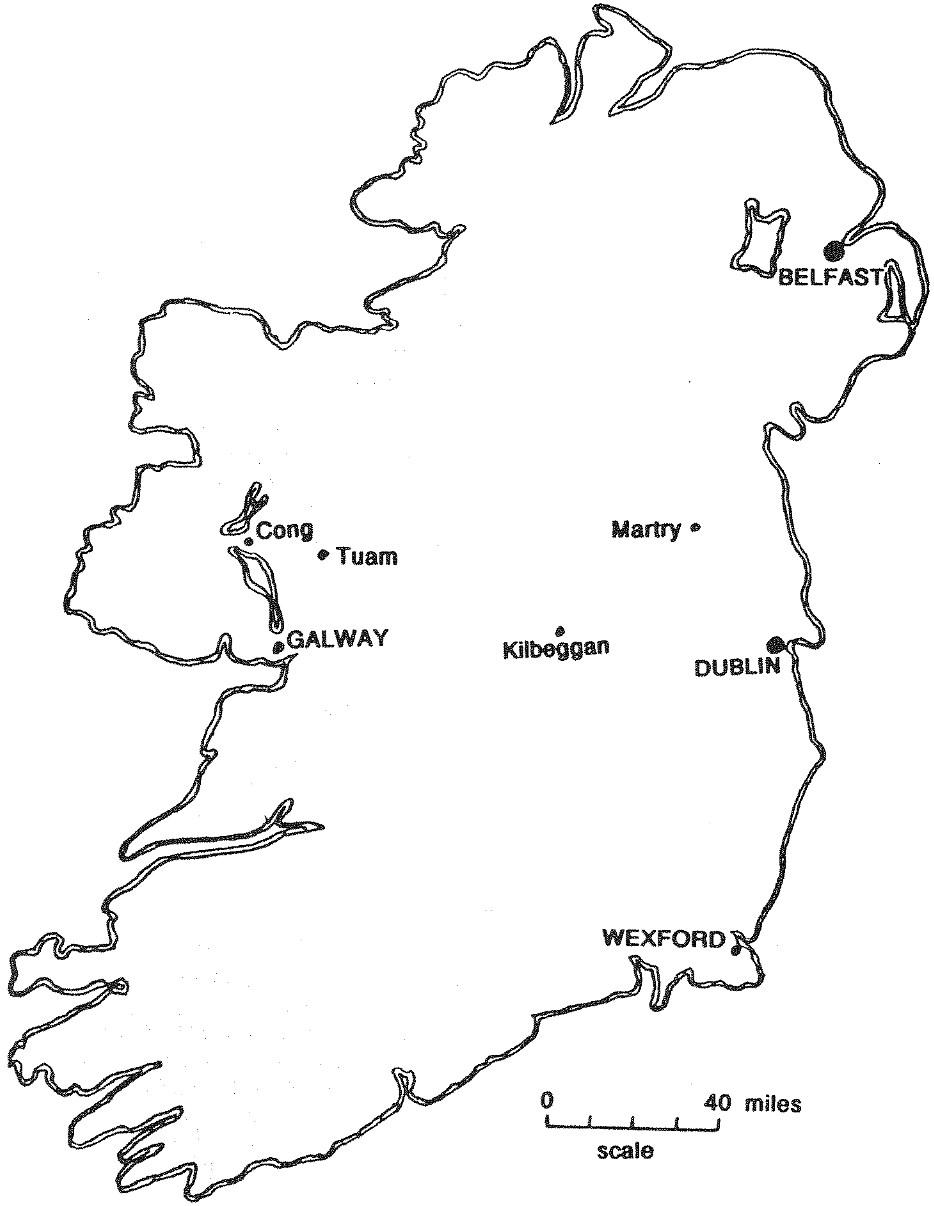


Figure 1. Map of Ireland showing the mill sites, (for Co.Wexford see Figure 2)

THE WORKING MILLS.

Martry Mill.

This is situated roughly midway between Navan and Kells in Co. Meath, on the N3 running north-west from Dublin. It was the first complete and working mill we saw and in one respect it was the most extraordinary of all the watermills we visited. It was not on our original list of mills to see and we would not have known about its existence had we not stopped in a nearby town (Slane) where we had just noticed a large old mill building by the river as we crossed the bridge over the Boyne. My wife called in the local newspaper shop to ask if there was perhaps a booklet on the town's history that might say something about this mill. We were not only sold a local history but were told where the author lived, across the road. With some hesitation we walked up the drive to the impressive house of Dr. C.E.F. Trench, local historian. He was most welcoming to these two strangers and told us about two working mills. One was a restored flaxmill and the other was Martry corn mill. Our host very kindly tried to make appointments by telephone with the respective owners, and succeeded in arranging for us to see the corn mill. When we arrived at Martry, Mr. James Tallon, the owner-miller kindly showed us round.

The mill is part of a group of neat stone buildings with slate roofs. About ten years ago the Rivers Authority undertook an extensive (and doubtless expensive) scheme of 'improved' river management, and among the effects of this scheme was the lowering of water levels in the area by 5 -10 metres or so, and this working mill was left literally high and dry. After much correspondence and threats (if not the actuality) of litigation, a most unorthodox arrangement was agreed upon for restoring a water supply to the wheel if not the mill: the wheel was moved from its position immediately outside the mill and was re-erected on a new site about 2 metres below its original level and about 5 metres away from its original position. The new iron wheelshaft carries a sprocket wheel and this is connected by a large 'bicycle chain' to a second sprocket wheel vertically above it, on the outer end of an extension to the pitwheel shaft. The new waterwheel is undershot and has wooden starts and floats mounted on an iron wheel.

Internally this mill has a spur-gear drive to four pairs of underdrift stones. Two of these stone pairs run with a fixed gap for oat processing. In one such pair, the gap is set by four vertical mounting bolts on the stone spindle footstep bearing. In the other pair, a long sleeve on the stone spindle appears to turn on a thread cut in the spindle itself and supports the mace. Of the two variable gap stone pairs, one has 'classical' tentering through an iron subtree and a long suspension-iron that is adjusted by means of a nut resting on a stout conical iron block mounted in the stone floor. The other pair is tentered by an ingenious and very compact device. In this the screw, on which the ring jack is operated by means of a hand-wheel, itself can rotate, and in doing so acts directly into the bottom of the footstep bearing beneath the stone spindle. At Martry, this tentering action is achieved by using a 'captive' ring spanner and a fixed nut on the tentering screw. In this mill all four stone nuts have ring jacks, and 'jack

screw tentering' is a logical development of the ring jack. I had never seen this device before but we found such devices on six other of the twelve mills with machinery that we visited. One of the variable gap stone pairs was said by the owner to consist of two monolithic burrs.

Sadly, despite the resourcefulness of whoever designed the new drive arrangement for the re-positioned waterwheel at this mill, the new sluice had jammed, and the one set of stones that works is powered by electricity. (There is other machinery in the mill but it is the stone drive and adjustment arrangements that were of particular interested.) There is an elevator rather than a hoist. Mr. Tallon told us there was a manual hoist until the 1970's.

Redmond's Mill, Foulkesmill.

This mill still works commercially and we were kindly shown around by the miller Mr. John Murphy. Foulkesmill is situated on the Corock River in Co. Wexford and is roughly midway between Wexford and Waterford. The mill is rather a austere looking, five floored building, with rendered walls and slated roof. The wide external iron wheel is breastshot and has an externally toothed gear ring driving a countershaft to the pitwheel. Internally, there is a spur wheel underdriving four sets of stones as well as a 'fast shaft' to power auxilliary machinery and the sack hoist. All the stone spindles are fitted with 'jack screw tentering' as described for Martry Mill, but at Foulkesmill the handwheel for the ring jack is complemented by a permanent two-arm crank handle for tentering.

The hoist has a lift-beam, slack-belt drive through bevel gearing on a short layshaft, and is fitted with a weighted wooden 'lock-lever' to hold the drive engaged, and a lock-release control rope (in addition to the usual 'drive' rope). The waterwheel sluice is controlled by a three-spoked iron handwheel resembling a small marine helm. When I asked how the stones were separated for dressing, Mr. Murphy produced a stout, roughly circular post, about two metres long and as wide as the eye of a runner. He said he inserted this into the runner's eye and this levered the runner off the bedstone. This seems to me to be a risky method that could damage the edges of the stones, but perhaps sacking was first inserted in the gap to protect them.

THE MUSEUM MILLS.

Tuam Mill Museum.

This mill is situated in the town of the same name about 30 km north-east of Galway City in Co. Galway. The survival of this small mill and its subsequent restoration as a museum is due to the remarkable efforts of a group of boys at the local Christian Brothers' school. With the guidance and support of members of the school staff, they successfully resisted a proposal to demolish the mill, clear the site, and construct yet another car park. Their well thought out proposals provided for the creation of a small public park beside the mill and included recommendations for alternative car park sites. The overall project won first prize in a conservation competition for young people, sponsored by Irish

Shell and BP Ltd in 1970.

This mill was originally built in the seventeenth century and was modernised in 1922, and again in 1944 when the two upper storeys were added. Probably on one of these occasions, an alternative electric motor drive through belting and bevel gear to a nut engaging with the great spur wheel was added, together with the fixed-gap third stone set. I understand that the alternative drive was installed because this mill, as at Martry, was deprived of its water supply as a result of regrading of the local river as part of an 'improved' water management scheme by the River Authority. The mill ceased work in 1964. Fortunately it has been possible to arrange a limited supply of water to the reconstructed headrace as part of the restoration programme.

The mill is housed in a four-storey, pitched-roofed, white painted building which has an external, 4 metre diameter and about 1 metre wide, iron undershot wheel with wooden spokes, starts and floats. Internally there are three sets of stones, one of which as already mentioned, operated with a fixed gap. The other two sets are fitted with 'jack screw tentering'. Whilst at Martry the tenter control was operated by means of a ring spanner and fixed nuts, and at Foulkesmill by a two-handled crank, at Tuam the tenter screw has a transverse hole for a removable tommy-bar.

There are three separate bucket elevators, and one of these has been left with its side-boarding off at its lower end. This makes a very informative exhibit. There is also a rather roughly reconstructed slack-belt driven sack hoist in the top storey, but more striking is a huge modern rotary vertical drying kiln that takes up the full height of the building. There are also some cleaning and winnowing machines. One room in the building is devoted to an audio-visual display about the restoration of the mill. There are also a series of roughly scale working models of horizontal and vertical wheel watermills and of a windmill.

Lockes Distillery Industrial Museum, Kilbeggan.

This museum in Kilbeggan in Co. West Meath is situated on the N6 about 90 km west of Dublin and about 30 km east of Athlone. As the name indicates, this is a preserved and partly restored distillery site, but a conspicuous feature as one approaches it from the east is the large external waterwheel. This low breastshot wheel, about 3 metres in diameter and 4.5 metres wide, complemented by a Cross compound steam engine, drove three sets of millstones, mixing vats and pumps. The waterwheel was fitted with an externally-toothed gear ring whose diameter was only about half that of the waterwheel. This ring drove a pinion on a short countershaft leading to the pitwheel, which in turn drove a large pinion on one end of the main layshaft that drove the three sets of in-line stones through bevel gears.

The main layshaft could be disengaged from the pitwheel by sliding the end pinion out of gear, and the steam engine could then be connected to the opposite end of the main drive shaft by engaging a dog clutch. Two of the bevel stone-nuts were positioned on one side of their respective layshaft driving bevel gears, and the third bevel stone-nut was positioned on the opposite side of its

driving bevel gear. This means that the first two runner stones would have rotated in one direction and the third runner would have turned in the opposite direction. Such an arrangement was designed to reduce the horizontal thrust along the layshaft that would occur if all the stone nuts were on the same side of their respective bevel gears.

The iron hurst frame was very impressive, with shaped circular trays and levelling screws for the bedstones, elegantly shaped bridge beams to support the layshaft bearings beneath each stone set (as well as at each end of the hurst) and fixed bridge-trees to support the footstep bearings of the stone spindles. The whole design was very compact with the layshaft passing immediately beneath the line of the three footstep bearings so that there was no space for tentering screws acting into these bearings. Instead, there were three stout horizontal screwed rods within each bridge-tree evidently driving a wedge beneath each bearing, and controlled through bevel gears by vertical shafts that each had a handwheel beside each bridge-tree, with another handwheel beside each stone on the floor above.

This mill was one of the few mills seen that had a stone crane (and calipers). The distillery was established in the mid - 18th century and ceased work in 1953.

THE SURVIVING MILLS IN WEXFORD.

Garrylough Mill.

This is near Screen, about 4 km north of Wexford town. We were very kindly shown round by Mr.Finton O'Beirne, son of the last miller. The mill was built in 1851 and worked commercially until the death of Mr. John O'Beirne in 1964. In 1975 the mill was leased to the National Trust for Ireland (An Taisce) for ten years, and in return during that time the Trust carried out a large amount of repair and restoration work (a significant part of which was financed by the O'Beirne family). The large millrace was cleared out in 1977 by an international 'work-in' lasting for two weeks, when fifteen students from six European countries took part. This was organised by Dr. Austin O'Sullivan of the Irish Agricultural Museum in Wexford.

The mill was the tallest of a small group of stone buildings and had four floors. Outside was the large iron breastshot waterwheel of about 6 metres diameter and about 2 metres wide, with wooden spokes and an internally-toothed cog-ring attached to the rim. This drove a large pinion of about 2 metres diameter on the outer end of the pitwheel shaft. The cemented flume had a wooden trap in the bottom, to provide a by-pass, rather than a sluice at the end and a second channel for the by-pass. There was a sump in the flume bottom between the trap-flap and the wheel, to catch stones or other heavy objects before they damaged the buckets of the waterwheel.

Internally there were five positions in the hursting for drives from the great spur wheel but only four of these were used, three for stone sets and one for a 'fast shaft' auxilliary drive to the hoist and also to an elevator, sieves and winnowing machines. All three stone sets were fitted with 'jack screw tentering' using a two-arm control crank handle (as at Foulkesmill) and a handwheel for the ring jack. The sack hoist was driven by a bevel gear lay-shaft off the top of the auxilliary shaft through an unusually wide slack-belt controlled by a jockey pulley. A stone counter-weight held this pulley off the belt.

This mill had an iron stone crane and calipers similar to those at Kilbeggan (Co. West Meath), and a three-spoked 'helm' to control the head-water similar to that at Foulkesmill (Co. Wexford). There was also a tiled kiln. Since our visit, Dr. O'Sullivan has told us that this mill has been sold and that the new owner, a Mr. Ferguson, hopes to put the mill back into use.

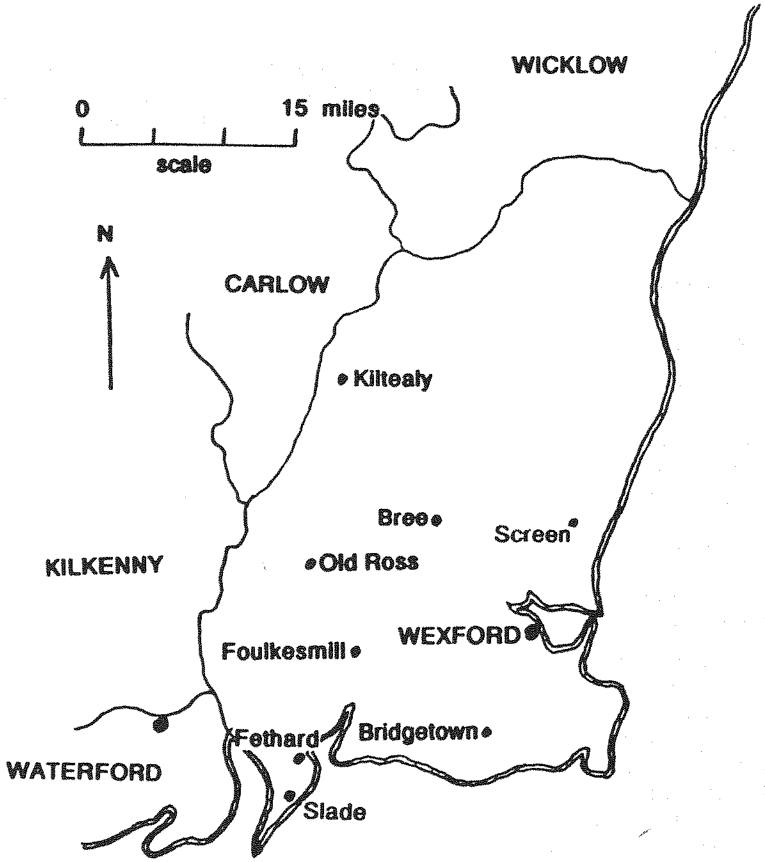


Figure 2. Map of Wexford showing the mill sites visited.

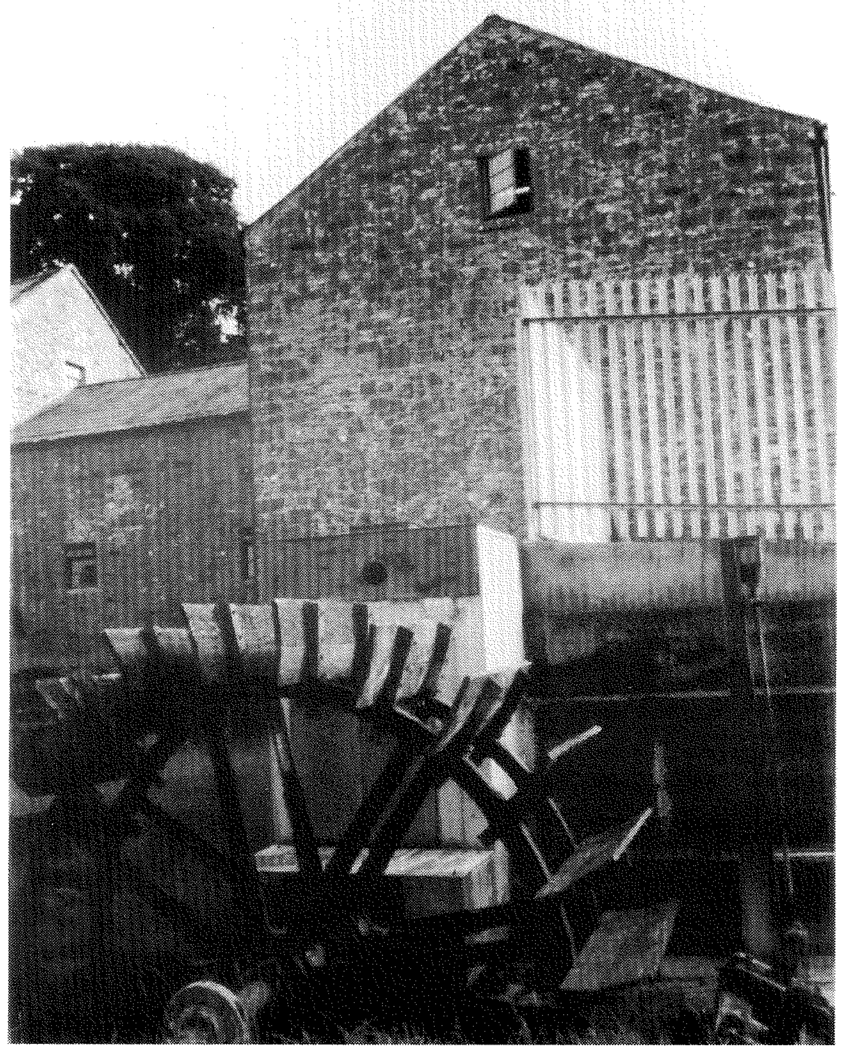
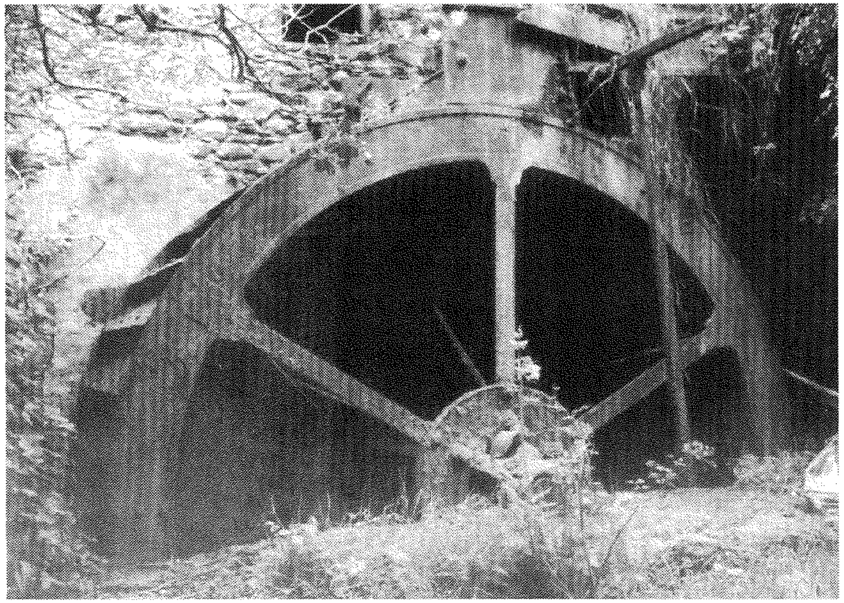
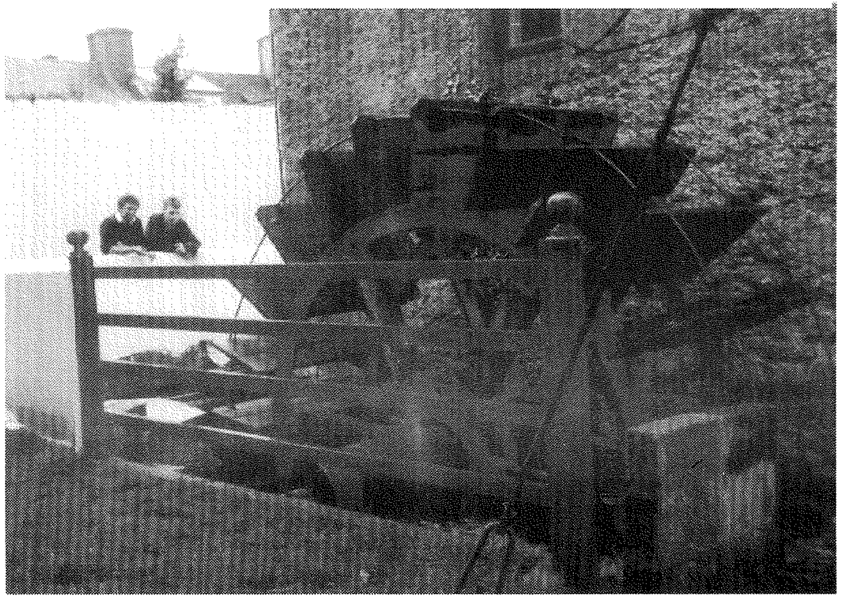


Plate 5. Martry Mill and Waterwheel.



Plates 6. Pitchback waterwheel at Bree mill.



Plates 7. The waterwheel at Tuam

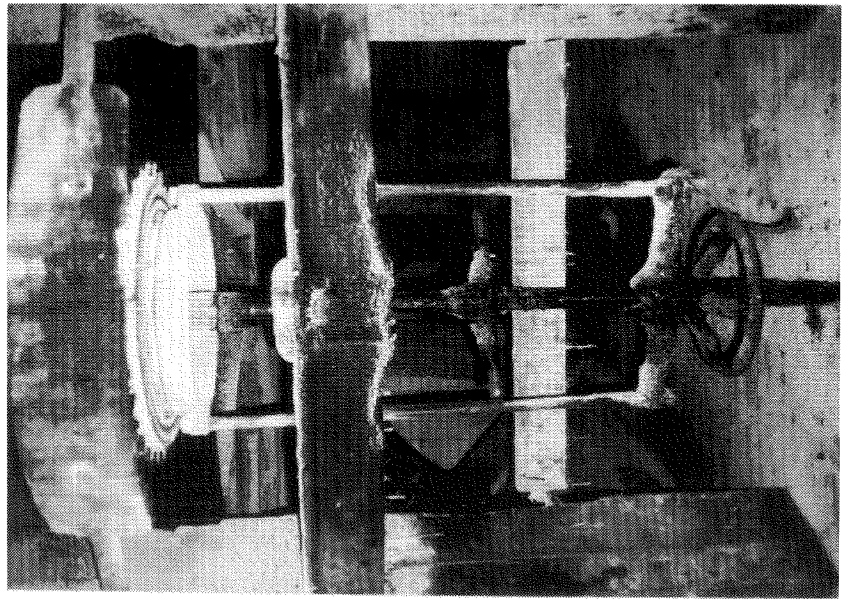


Plate 8. Jackscrew tentering at Foulkesmill.

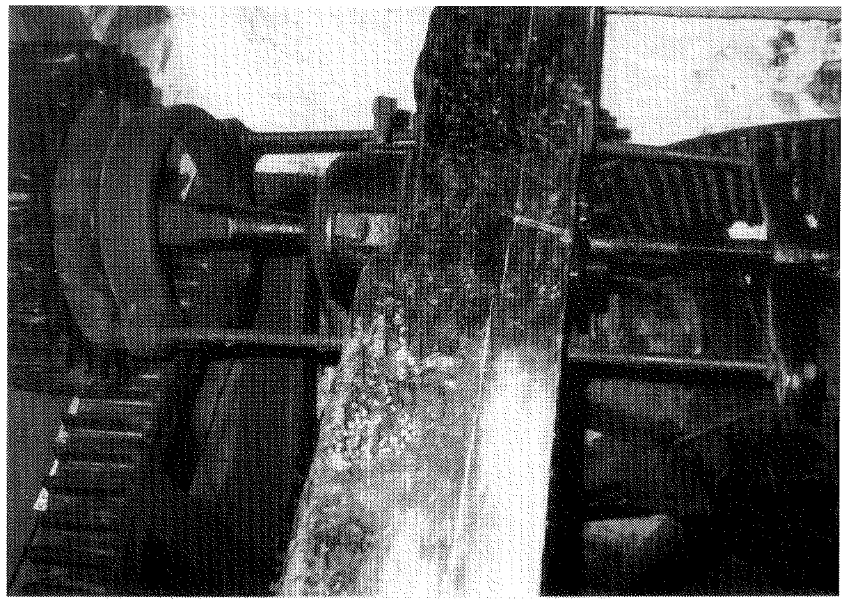
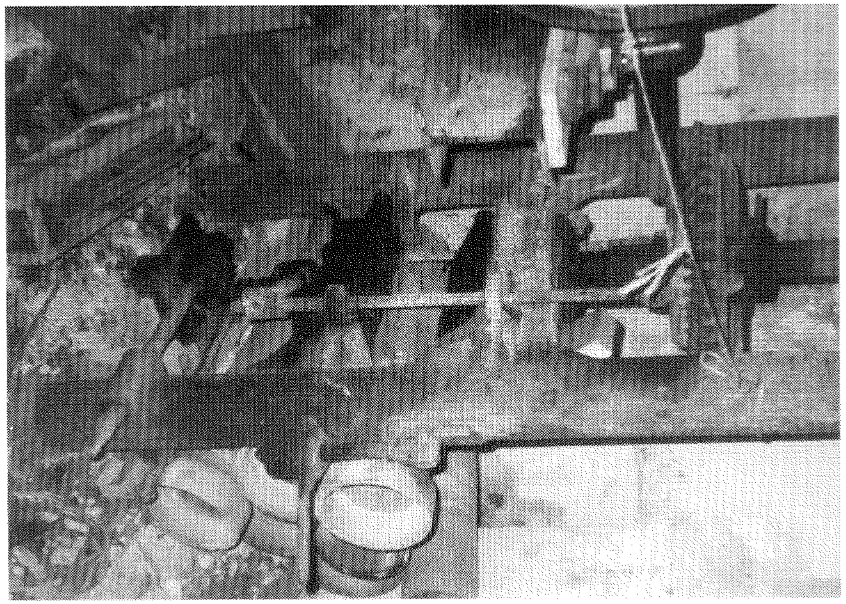
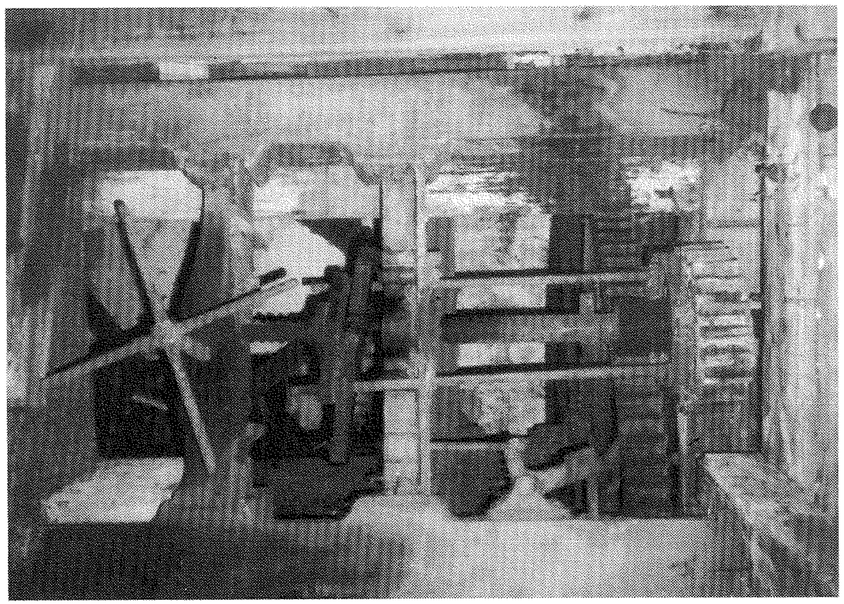


Plate 9. Jackscrew tentering at Tuam, note the hole for the tommy bar





Plates 10 & 11. Layshaft Hursting at Marshall's Mill.

Browne's Mill, Old Ross.

This mill is near the village of Old Ross which is about 25 km west of Wexford town. We were courteously welcomed by Mrs. Revell, daughter of the last miller (Mr. Browne) and allowed to 'crawl' over the disused mill as we wished, sometimes accompanied by four young family members and their friends. The three-storey mill is on the site of a 13th century mill but had been extended since then. It had, as in several of the mills we visited, three sets of stones and an auxilliary vertical shaft, driven through spur-gear by an iron overshot wheel.

In this mill the great spur-wheel and the stone nuts were made of wood with wooden teeth. Disengagement of the nuts was probably by removal of slip cogs. Tentering was by means of handwheels on screws acting directly into the footstep bearing of each stone spindle. The sack hoist barrel was driven directly by a 'crash gear' bevel drive from an extension of the main upright shaft. The beam carrying the upper bearing of this extension could be slid horizontally so as to bring the two bevel gears into mesh. A weight on the end of a rope passing over a pulley held the bevels apart, but when the 'drive' control cord for the hoist was pulled, a notched beam fell into position to hold the clutch closed. When the 'release' control cord was pulled, this notched beam was lifted, and the counterbalance weight pulled the bevel clutch open. There was what looked like a fail-safe release crank with an iron ring for the hoist chain to pass through, but the release linkage was not complete. This mill had two drying kilns side by side, one of which had a tiled floor, whereas the other's floor was made up of perforated iron plates.

Cloney's Mill, Fethard on Sea.

This Fethard, in Co. Wexford, is not actually called '...on sea' on the Irish OS map but it is marked thus on some maps in order to avoid confusion with the 'inland' Fethard that is only 65 km to its north-west, in Co. Tipperary. The mill at Fethard on sea, called Cloney's Mill, which is situated behind Dungulph Castle (a private residence), about 30 km. south-west of Wexford town, is not the only 'Cloney's Mill' in Co. Wexford! It had an external all iron breastshot wheel of about 5 metres diameter and 1 metre wide which drove two pairs of stones from the great spur wheel. A third pair was set in-line and was belt-driven from a 'fast shaft'. The two spur-wheel driven stones were tentered by 'ring jack screws' with vice handles and handwheels for the jacks. The belt-driven stones were tentered by a two-handled screw acting directly in the footstep bearing.

The sack hoist was driven by a crash-clutch bevel gear and, not surprisingly, at least one of the bevels had broken teeth.

Bridgetown.

This very closed, small two-storeyed mill is situated beside an extensive storage and silo area of a Co-operative firm of grain merchants, and when we were there, most of the area was covered by piles of freshly harvested grain, with lorries still arriving from local farms. Bridgetown is about 15 km south-west of Wexford town. The Co-op office kindly opened up the mill for us and although little machinery seemed to be left, what was there was most unusual. The external breastshot waterwheel of about 5 metre diameter (of which sadly only the iron shaft, hub, and rim supported by two or three surviving wooden spokes, now remain) drove a huge 'home made' iron belt pulley, and this in turn drove a short counter-shaft above it, connected by bevel gears to a vertical shaft that carried a second belt pulley. From this, a belt drove the one remaining pair of stones. The gap between this pair could be set by means of a large bolt projecting downwards from the footstep bearing on the fixed bridge tree. A second pulley on the stone spindle once drove a shaker screen.

On the upper floor was a slack belt sack hoist powered from a bevel-driven layshaft from the top of the upright shaft which was controlled by a lifting beam with a locking bar and two control cords. Lying on one of the floors was an iron stone crane. There was also a derelict drying kiln.

This was yet another mill where we were able to meet and hear from the last miller, Mr. James Furlong, something of the mill's working days. He told us that the belt pulley, pitwheel, and belt drive to the remaining pair of stones were put in when the inner bearing of the waterwheel and the footstep bearing of the original upright shaft had dropped. The mill had formerly had two pair of spur wheel driven stones.

Bree.

This mill is about 15 km north-west of Wexford town. The external all-iron pitch-back wheel drove two pairs of stones through spur gears. Tentering was by 'jack screw', and in this mill one of the two-arm crank handles had become disengaged from the screw and had fallen to rest on the ring jack's supporting double crank immediately above the handwheel that drove the jack. Evidently the key had come out and the keyway higher up in the tenter-screw was clearly visible. The sack hoist was controlled by a crash-clutch bevel drive, with (in this case) a spring operated locking device and two control cords.

Here again we were welcomed by the last miller and owner, Mr. Bill Hassy. He told us how once the packing for the stone spindle neck-bearing in one of the bedstones had caught fire, but how this had been found before any serious damage occured because the stone spindle and damsel were running hot.

Kiltealy.

This complete corn mill is surrounded by a modern electrically powered sawmill and timber yard. It is situated about midway between Wexford town and Carlow to the north-west. The proprietor, Mr. Murphy, was not particularly welcoming because we had not only arrived without notice but also when he was busy dealing with trade representatives. Despite this he did conduct me to where I could see the mill machinery and the waterwheel. There were three pairs of stones driven from a spur wheel, and a slack-belt sack hoist controlled by a lifting beam. The wheel had one extraordinary feature: an iron or zinc tray

shaped as a large horizontal 'U' had been added to the launder in order to change the direction of the water feed to the wheel (and hence of the three spur gear driven stones). This most peculiar arrangement raises a number of questions but none of them can be convincingly answered. Had the wheel been removed and remounted facing the opposite direction to avoid tail water problems (even though this would have meant either redressing all the stones or adding intermediate gearing to preserve the original direction of stone drive)? Had the wheel been remounted to avoid having to redress two or three pairs of newly aquired stones? Had the power to the mill been increased by changing the water feed from breastshot to 'overshot'? Had millwork from another site been meticulously re-erected on the only available site at its new location even though a simple overshot water feed could not be provided? Whatever the explanation it is dificult to understand why a simple backshot water feed had not been arranged. In the particular circumstances of this visit, it was not possible to ask searching questions, or take photographs, so the answers to these questions remain unknown.

TWO OTHER SURVIVING MILLS.

Marshall's Mill.

This large mill complex was situated a few kilometres from Kilbeggan (see above) in Co. West Meath. There were two distinct groups of buildings on this site, and Mr. John Marshall (son of the last miller and previous owner) kindly showed us round. The mill is now largely derelict but once had two waterwheels, later replaced by turbines in the 1920's. There were two separate iron hurst frames each with two complete stone drives from iron great spur wheels on iron upright shafts. One hurst still had the bedstones in place. Tentering was by 'sub-tree', rod, bell crank, and screwed handwheel, and stone disengagement was by rack-and-pinion driven ring jack.

One of the hursts had two fixed bridge beams one below the other. Although the lower beam now housed the rack-and-pinion drive for the ring jack, this latter bridge beam incorporated locating lugs for the bearing of a horizontal shaft and had evidently been designed for use with a layshaft drive to its stones. These iron hurst vertical stanchions and bridge beams must have either have been adapted from another mill layout on this site or elsewhere, or perhaps they were part of a standard 'mill kit' provided by the manufacturer.

The other piece of iron hursting was of a different design but had the same basic characteristics of two bridge beams and integral tentering, though in this case the upper bridge tree was itself pivoted at one end and its other end was supported on a spanner-adjusted vertical screw. Lugs with holes for the ring-jack rods were also incorporated in the bridge tree and in the lower bridge beam. The rack-and-pinion jack drive was positioned below the lower beam which was thus clear for seating a layshaft bearing between lugs on its upper surface.

There was a modern electrical hoist in which a friction pulley, on the drive shaft parallel to the windlass, was brought into contact with a corresponding pulley on the windlass shaft when the control cord was pulled. There was also a stone crane fabricated from two arcs of sheet metal rivetted or bolted together.

Cong.

This attractive small town is just in Co. Mayo, near the boundary with Co. Galway, where it passes between Loughs Mask and Corrib. The four storey stone mill is at the end of an umpromising track that passes beside and beyond the local Esso garage. On the front of the building is a finely carved stone bearing the inscription 'Built by Thos Sheeed [sic] Esq. AD 1839' within an oval frame. At one end of the mill were the remains of a wooden breast or undershot wheel on a wooden shaft. The mill was locked but through the bars across an open window the pitwheel and spur gear drive to the three sets of stones could be seen. All three were fitted with 'jack screw tentering', in this case with a hole through for a tommy bar as at Tuam.

I would have very much liked to see the interior of the rest of this mill but there was no sign of anyone to ask. My wife had said that she saw smoke coming from a tiny cottage accross the yard from the mill, but I had dismissed this as impossible in view of the derelict appearance of the cottage. The smoke must, I suggested, have come from a bonfire over the tall hedge. I was due for a surprise... as I changed my film in the shade of the cottage doorway, the front door slowly opened and a bewildered face appeared. It was the miller himself. He told us that the mill had not worked since the wheel had - he said - been maliciously destroyed in about 1968. Unfortunately we forgot to ask his name, so astonished were all three of us to meet in this extraordinary way. The miller kindly opened the mill and I clambered around on the upper floors.

On one of these floors was a huge bolter, 9 metres long. The longest I had previously seen in these islands was one of 24 feet (about 7.25 metres) at Sapiston Watermill in Essex. Between two floors was a pair of wire machines mounted one above the other but inclined in opposite directions, one at an angle of about 30 degrees above, and the other at an angle of about 30 degrees below the horizontal. Each was bevel-driven by one of two inward facing bevels on a vertical shaft, so that the two wire machines rotated in opposite directions. (I would not think that the direction of rotation was of any significance for the functioning of these two oppositely-inclined machines.)

A Millstone Quarry.

Whilst in the south of Co. Wexford, in the Hook Peninsula, we set out to find the millstone quarry to which our attention had been drawn by Austin O'Sullivan, and following his advice we sought out and found Mr. Billy Colfer in a tiny stone-vaulted shop at Slade Harbour. He gave us more detailed directions that took us through a farmyard towards the cliff below where the quarry was to be found... but alas our path was effectively blocked by a disconcertingly large pool of slurry. We were however fascinated to hear from Mr. Colfer how, during the beach-side quarry's working days, the cut and prepared stones were moved out by lashing them beneath boats at low tide. When the tide had risen enough to lift

the stones off the bottom, the boats were rowed or sailed round to Slade Harbour where the boats were apparently secured above low carts so that at low tide the stones could be untied and hauled to larger carts (or maybe sometimes to larger boats) for onward transport to their destination.

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