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 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.

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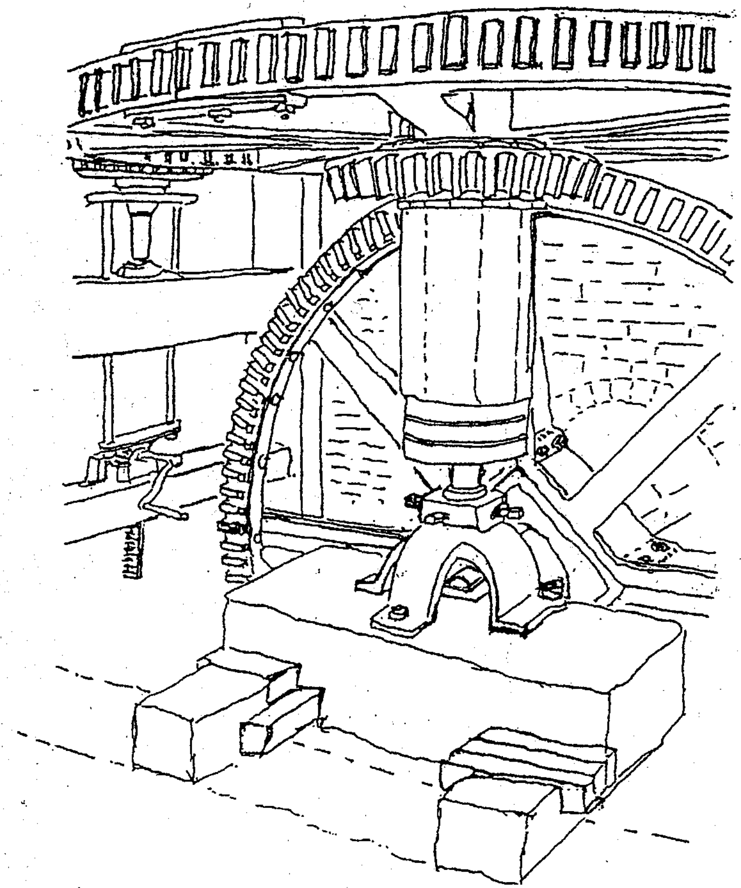
Wind and Water Mills

Number 16



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. The pit wheel and associated gearing, Chesterton Watermill, Warwickshire. (See page 28).
Drawn By Tim Booth.

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THE DAKEYNE MILL AND ITS ROMPING LION

By Phil Wigfull

Introduction

My grandfather was born in 1860 in Toad Hole, a small village in the Parish of Darley some two miles north of Matlock in Derbyshire. Apart from fairly extensive modern residential development at the western end, the village remains much as it was in Victorian times, stretching along the B5057 Chesterfield road from the A6 eastwards until it peters out round the acute hairpin bends of the notorious Sydnope Hill.

Not apparent to the casual visitor concentrating on the ascent up the hill in what is now known as Two Dales, are the two valleys on either side, Hall Dale to the north, and Ladygrove to the south.

Ladygrove, about 1.5 miles long, is a narrow steep-sided valley through which runs Sydnope Brook. Joined by Hall Dale Brook in the village, it flows into the River Derwent a mile to the west.

Throughout much of the last century, the local population were heavily reliant on the only employers of significant size, the Dakeynes, who not only owned the village and much of the surrounding land, but who also owned and managed the local flax mill - Ladygrove Mill (SK 288630).

The Romping Lion

As a small child in the early nineteen-forties I was frequently taken on walks by my grandfather and, as often as not, Ladygrove was on our route. Grandfather had been born in a cottage not a hundred yards from the mill and I was destined to become almost as familiar with the area as he was.

As we walked past the mill, he never failed to point out the ruins of the building that had housed the 'Romping Lion', a machine that emitted a deep regular growling noise which the village children had obviously held in some awe. Indeed he needed little persuasion to imitate the noise to make clear why it had earned its name. Conceivably he, but certainly not I, had any idea what this mysterious machine was. However it did generate power - where the line shaft crossed the lane to drive what Grandfather called 'the old mill' was always pointed out.

Further up Ladygrove were three dams, in ascending order, the Regulator, the Fancy, and the Potter. The path climbed up the flank of the valley to a point halfway up the hillside, far above the Fancy. Here we took an abrupt right turn onto another path still climbing the hillside but in the reverse direction.

At the junction of the paths were other water courses - long narrow ponds through which water only trickled. The new route continued the climb eventually taking us out of the valley to the top of the 'Holt Field' where we looked across and down to the mill perhaps a hundred feet below.

Jumping over the wall, I played in 'Moss Castle' - a semi-circular embankment built into the hillside and commanding a glorious view of the territory I was defending. But I had to keep well away from the centre - that was boggy!

It was only some thirty years later that, on reading Frank Nixon's then recently published 'Industrial Archaeology of Derbyshire', I realised that the Romping Lion was the unique Dakeyne water engine.

The Dakeynes and their Mill

The Dakeyne family had been landowners in Derbyshire since at least the 16th century. John Dakeyne, at the time only 19 years old, left the family home in Bonsall to settle in Darley. He married a local girl, Frances Watson. John died in 1777 and was succeeded by his eldest son, Daniel who had been born in 1733.

In 1789 Daniel went into the textile business, acquiring a 'newly erected' cotton mill at the bottom end of Ladygrove, together with 5 acres of land and some new houses. The mill was equipped with 612 spindles but had space for 1200.

Daniel and his wife Isabella had nine children but it was their younger sons, Edward and James who were destined to achieve prominence in later years.

Whilst Daniel had continued to run the cotton mill, his principal business was the manufacture of flax. Edward and James were clearly engineers of some competence for in 1794 they had invented the 'Equalinium', a machine for the processing of flax prior to spinning. This was patented in the name of their father because, it is said, they were still minors. In fact, in 1794 they were respectively 24 and 22, but it is quite possible that, when the application was filed, James at least may well not have attained his majority. By the early part of the 19th century, the Equalinium was in widespread use in the flax industry throughout the country.

But any royalties derived from its use were to late to save the business. By 1802 D.Dakeyne & Sons were bankrupt!

In fact, not only was the business bankrupt but so were the senior members of the family, Daniel, his second son Thomas, and the latter's two younger brothers Daniel Jnr and Joseph. Only the eldest son John, who was a solicitor and presumably not directly involved in the business, and the youngest members of the family, Peter, Edward, and James escaped. (By this time, the eighth and ninth children had died.)

In June 1802 the Derby Mercury advertised the auction of the whole of the Dakeyne estate, on behalf of the Assignees, in the next month. That included the principal family residences, Knab House and Holt House, and of course the mill. In fact there were now two mills, the original cotton mill 'Sydnope Old Mill', still equiped with cotton machinery, and on an adjacent site a 'newly erected flax mill on five floors' and measuring 40 yards long by 10 yards wide. With a capacity of 2000 spindles, this mill was powered by two water wheels of 30 feet diameter, and a steam engine of 'upwards of 28 H.P.' was in course of erection. The latter could be completed at, it was suggested, a cost of less than £150. The wheels were supplied from two large dams, whilst the cotton mill could take its water either from the main dams or two small dams originally built for that mill.

30 acres of surrounding land which contained the dams were included, as was, rather ominously, the 'Children's Lodge'. On a nearby site, this, the prospective purchaser was assured, could accomodate upwards of 100 children.

The existence of the flax mill as early as this appears to contradict its oft quoted attribution to Edward and James who, it is said, built the mill in 1826. When, in 1924, the Dakeyne estate was finally broken up and sold, the largest principal building on the site was a 'large three storey mill'. Of obviously later construction than the other buildings, this must be the 1826 mill built by the brothers. Their father's original flax mill had five floors, but whether this meant a five storey building is not clear - it could have been two buildings, one of three and one of two stories respectively. Apart from the cotton mill, there is a two storey building on the site that clearly predates the 1826 mill. Whether this is two floors of Daniel's original mill is considered more fully later, but it cannot be ruled out entirely. What is certain is that Edward and James demolished their father's mill, but whether in whole or in part cannot be established.

The Dakeyne Estate was again offered for sale by auction in 1804, this time on behalf of the Commissioners in Bankruptcy. Presumably there was some difficulty in selling the now moribund business, and the rather grand houses. But by 1839, James owned the mill and the majority of the estate including Holt House, where he lived with Edward and Peter. The largest and grandest of the family houses, Holt House was originally occupied by, and almost certainly built by, their elder brother Daniel Jnr. What had happened in the intervening years is not known, but the probability must be that James acquired the properties directly from the Commissioners, conceivably at a very low price.

The bankruptcy of the older members of the family does explain why Edward and James had control of the business, and not their elder brothers as might have been expected. Thomas went to Gradbach, in the Staffordshire Moorlands, where he built a new flax mill. Joseph went to Manchester, and Daniel Jnr died in 1806. His father survived him, dying in 1819 at the age of 86.

The Disc Engine

In 1830 Edward and James patented their 'Hydraulic Engine for communicating motion to machinery' - the disc engine. Writing in 1969, Frank Nixon says that 'The most striking characteristic of this ingenious machine is

perhaps the difficulty which is experienced by those trying to describe it: the patentees, and Stephen Glover, succeeded only in producing descriptions of monumental incomprehensibility.' When one realises that the disc produced rotary motion but did not itself revolve, one begins to appreciate why! Figure 1 shows a drawing that accompanied the patent, but fails to demonstrate the working principle.

The engine was big. The outside diameter of the casing that contained the disc was 10 feet and it alone weighed an incredible 7 tons. The base of the engine was mounted on a foundation at ground level with the axis of the casing in the vertical position. The output shaft was also vertical, above and in line with the casing axis. With a head of 96 feet the engine developed 35 horsepower.

Within the casing, the disc was mounted concentrically on a large sphere or globe, the diameter of which was over half the diameter of the casing, perhaps as great as 6 feet. Figure 2 is a diagramatic view of the core of the engine.

The casing itself was in two halves. Geometrically, each half was a shallow cone with an outer rim. The cones were mounted concentrically one above the other, the bottom one nose up, the upper one inverted. However the top of each cone was cut away, (in reality, of course, these never existed) so that the sphere could sit on the lower cone. When the upper cone was lowered into position, the then completed casing retained the sphere between two halves. The top of the sphere protruded above the upper cone or casing, and similarly, the bottom of the sphere protruded below the lower cone. This, and the conical surfaces of the casing can be seen in Figure 3.

There was sufficient clearance between the sphere and the cones to allow it to move or at least tilt until the disc came into contact with the conical surfaces. The maximum angle of tilt from the vertical that this arrangement allowed was about 15 degrees.

The outer rim of the casing was designed so that the outer edge of the disc was always in close contact with its inner surface irrespective of the angle of tilt. If the disc, when viewed from the side, were to be tilted from, say, left to right, the edge of the disc would describe an arc with a radius equal to that of the disc. The profile of the casing rim's inner surface followed that same radius. Again, this is illustrated in Figure 3. (Geometrically, the inner surface was a section of a larger sphere with a diameter equal to that of the disc. The width of the section was equal to the distance the edge of the disc travelled in moving from one extreme angle of tilt to the opposite angle.)

Because the top of the sphere protruded above the casing, it was possible to mount a shaft on to it in the upwards position and at right angles to the disc. Obviously, as the disc tilted so did the shaft. The end of the shaft was connected to a crank arm from a vertical shaft - the output shaft - mounted in bearings directly above the engine centre line. See Figure 2.

Once the crank was connected, the disc was no longer free to tilt to any position. It was always held at the maximum tilt angle with its upper surface in contact on a radial line with the upper conical surface of the casing, and the

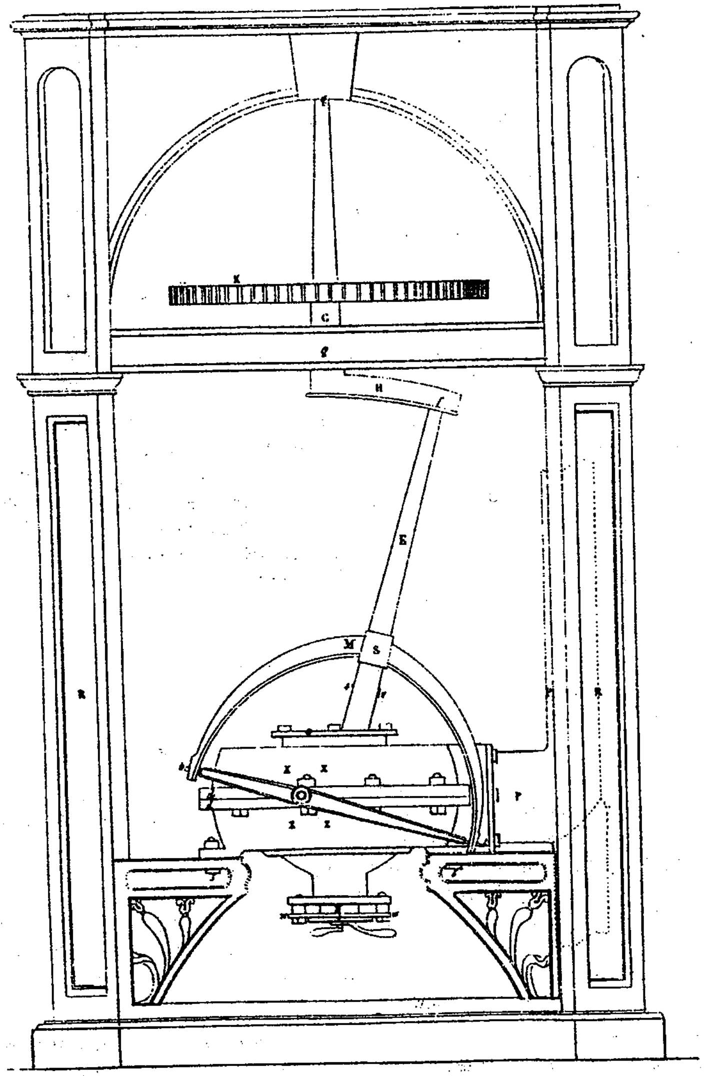


Figure 1. Part of the original specification drawing of the Dakeyne Engine.
(Courtesy of H.M. Patent Office)

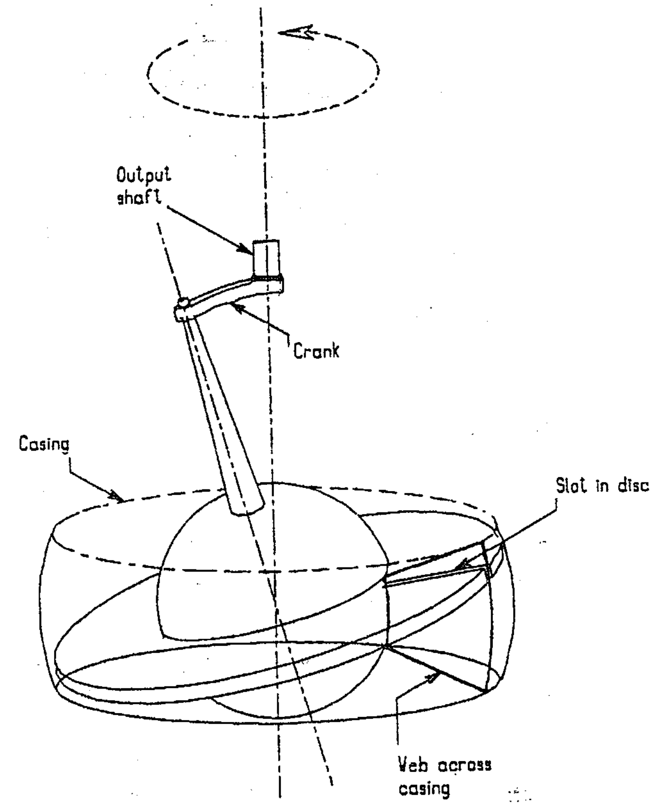


Fig 2 THE DAKEYNE DISC ENGINE - DIAGRAMMATIC VIEW

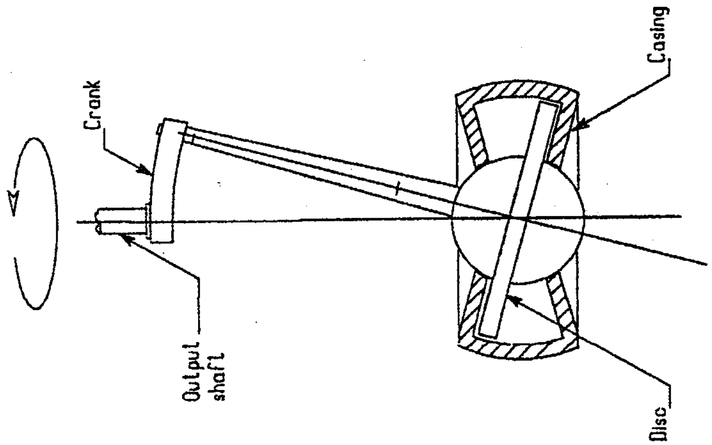


Fig 3 SIDE VIEW

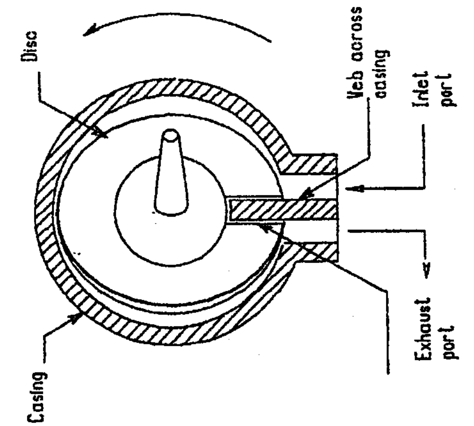


Fig 4 PLAN VIEW

DAKEYNE ENGINE SHOWING CASING SECTIONED - DIAGRAMMATIC

P A Vigfall 27 November 1996

underside similarly in contact with the lower casing, the two lines of contact being 180 degrees apart. The disc will, of course, always be tilted downward immediately below the crank.

If the crank were to be rotated, the line of contact between the disc and the lower and upper casing would also rotate. In other words, viewed from above, the position of maximum tilt is always in line with the crank. To achieve this 'rotation' it is not necessary for the disc to rotate - it simply needs the freedom to tilt progressively around the casing. It is, hopefully, possible with a little imagination to illustrate this apparent contradiction.

Assuming the engine itself were to be removed, a person could stand directly below the output shaft and crank. Assuming also that the latter were of suitable (much smaller) dimensions and that the crank had a handle like, say, a winch, it would be possible to reach up, grasp the handle and rotate the shaft. If, in so doing, the upper arm were kept still with all the motion deriving from the elbow, the lower arm and wrist together with the socket joint of the elbow simulate the action of the engine shaft and sphere respectively. Only the disc is missing from the human model!

In practice, the disc was prevented from rotating anyway by a vertical radial web in the casing sealed to the upper and lower conical surfaces and the outer rim. A matching radial slot in the disc allowed the disc to fit around the web when it was assembled. This arrangement is shown in Figure 4. In addition to preventing the disc rotating, it also permitted the admission and discharge of water under pressure.

On either side of the web in the casing, there was a port. One acted as the water inlet, the other as the exhaust. There were no valves. When the engine was stationary with, say, the disc tilted upwards at the inlet port, the edge of the disc would be touching the lower edge of the casing rim at a point diagonally opposite to the port. There would also be line contact between the disc and the conical surface of the lower casing from the point where the disc touched the lower rim to the centre. (Similarly, the upper side of the disc would be in contact with the upper casing above the port.) Therefore a chamber was formed between the underside of the disc and the lower half of the casing, bounded at one end by the web next to the port and at the other by the line of contact between the disc and the casing. (To be precise there is a third boundary - the contact between the disc circumference and the casing rim.)

Admitting water under pressure into the port would expand the chamber forcing the disc to precess - to tilt progressively around the casing. As it did so, the edge of the disc would descend across the port, reducing the supply to the lower side of the disc, but simultaneously admitting an increasing volume of water to the upper side.

When the disc has precessed through 180 degrees from the start point, the port would be fully open to the upper side of the engine. Because the inlet and exhaust ports are side by side and thus work in tandem, at this stage in the cycle the exhaust is also fully open to the upper side of the disc. Therefore the initial charge of water is still in the engine trapped beneath the disc on the opposite side. Cut off from both inlet and exhaust, (and probably at ambient pressure due to leakage through the engine, a factor which must have significantly reduced the efficiency) it would have no effect on the engine output at this phase in the cycle. As the disc continued to precess beyond the 180 degree point, both ports would progressively open to the underside of the disc allowing the initial charge to exhaust, and a second to enter.

It was probably the discharge of the water through the exhaust port to the culvert below that made the lion roar twice with each revolution of the crank!

The Water Supplies

When in perhaps 1970, I first read the late Frank Nixon's 'Industrial Archaeology of Derbyshire', I was intrigued by his comment that 'The quiet and beautiful dams filling this valley, the uppermost 96 feet above the mill, would repay study of the means employed for their control.' I decided that one day I might just do that.

Nixon went on to state that to cope with the head of water, the Dakeyne brothers had patented a disc engine in 1830. Another book, published over a decade later, again referred to the series of dams up the steep valley and the need for the disc engine to handle the 96 feet head. It was perhaps a reasonable assumption on my part that it was the three dams in the valley, the Regulator, the Fancy, and the Potter, that were being referred to.

When I started to give the subject some more thought on my retirement two years ago, I realised that to actually use the 96 feet head from the highest dam, the Potter, would have meant a piped supply approaching one third of a mile in length. Not impossible, but unlikely. Moreover what were the lower dams for?

It was at this stage that I began to wonder whether the embankment high on the southern flank of the valley, Moss Castle, had been built by the Dakeynes to supply water to their engine.

It seemed to fit. It was directly above the mill, although on the opposite side of the valley. But more significantly, the site of the engine house pointed out by my grandfather lay immediately below it, and that was on the south side of the brook. But how could my theory be tested?

In the event it proved ridiculously easy, solved by a few hours spent at the County Records Office in Matlock. The first clue was the 1/2500 Ordnance Survey map of 1880 (see extract in Figure 5) - Moss Castle was filled with water! Moreover, there was a channel of water running along the hillside which appeared to be connected to Moss Castle. This in turn seemed to be linked to two ponds to the south side of the Regulator and the Fancy but well up the hillside.

The 'Schedule of Tithes for the Township of Darley and the Lordship of Little Rowsley' and the accompanying map published in March 1839 gave me the definitive proof I was looking for. Not only were Moss Castle and the other water

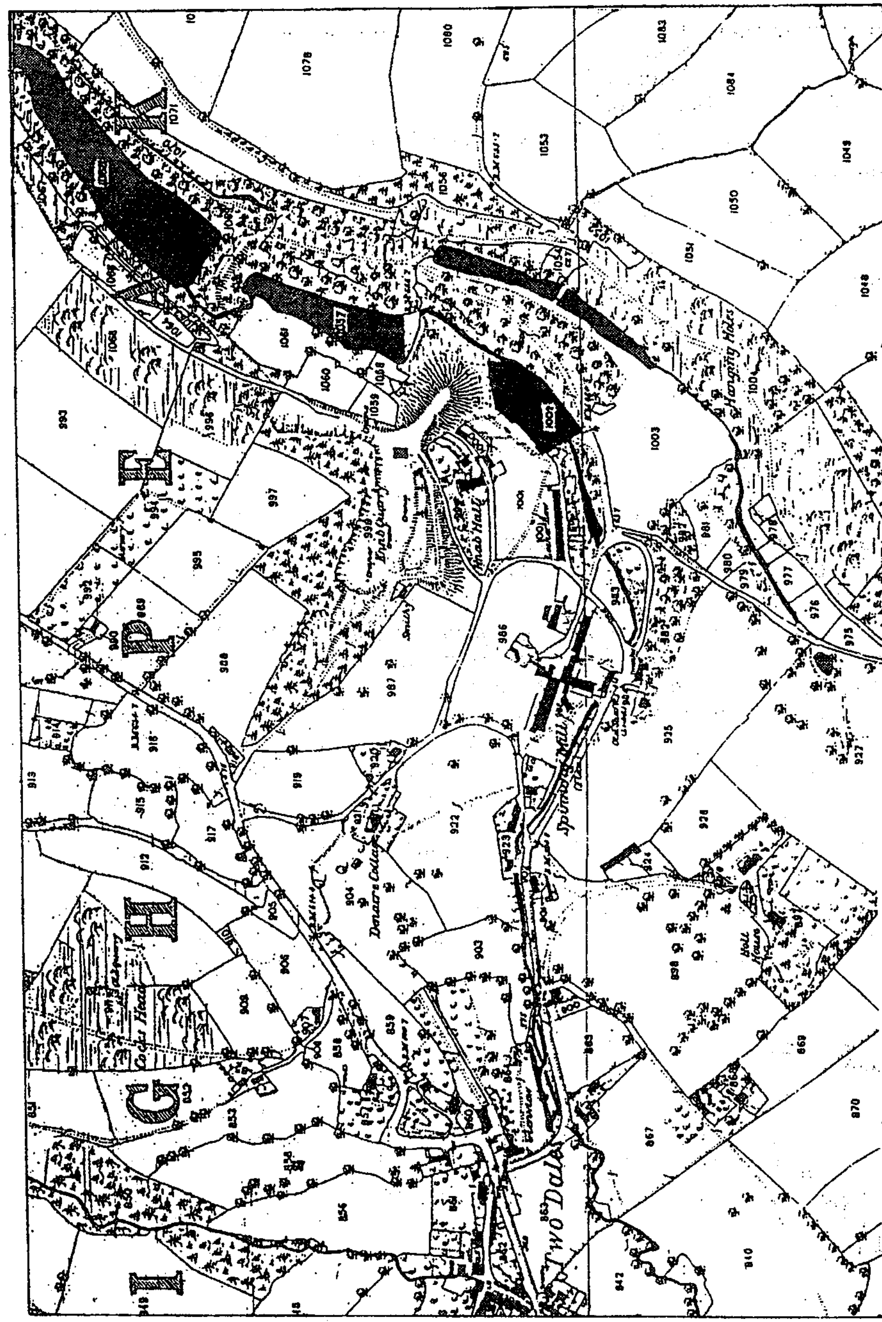


Figure 5. Part of the 1880 edition of the 1/2500 Ordnance Survey map showing the position of the Dakeynes' flax mill to the west of the village of Two Dales. Note the position of Moss Castle at the bottom centre being shown filled with water, as is the leat leading to it. (Courtesy of Ordnance Survey)

courses on the hillside coloured in blue on the beautifully drawn map, but they were clearly connected. Figure 6 is a computer enhanced reproduction of the relevant section of the Tithe map.

In the schedule, Moss Castle was designated as an 'Engine Head' and the string of water courses were 'Goits' - the old Derbyshire term for an artificial water channel or aqueduct. In a field down the valley and opposite the mill there was a small building. The field was called the 'Engine Close' and if any further confirmation were needed, there was a distinct line between Moss Castle and the building! Furthermore a second line from what was clearly the Engine House indicated the position of what could only be the line shaft.

Close examination of the map suggested that the goit joined Sydnope Brook some distance above the site of the Potter. But herein lay another surprise - the Potter did not appear on the map at all. So the uppermost of the dams that exist today could have no connection with the disc engine, directly or indirectly.

A Rational Solution?

The unanswered question is, of course, why had the Dakeynes chosen to build the disc engine when an apparently simpler solution would, *prima facie*, have been to build another dam and more water wheels? It is doubtful if we will ever have a certain answer, but at least a hypothesis can be advanced.

The original cotton mill would probably have a simple form of water power. The two original dams built for the cotton mill that were referred to in the 1802 and 1804 sale particulars could not have had sufficient head to supply the wheels of the new Dakeyne flax mill. The known location of one, The Moiety, 150 yards upstream of the mill suggests it may have been used as a reservoir, perhaps necessary in view of the relatively low flow of the Sydnope Brook. Although not specifically referred to in the Schedule of Tithes, the accompanying map shows what must be a small dam adjacent to the end of the cotton mill. Presumably the Moiety fed water into the latter when the mill, probably powered by an undershot wheel, was in operation.

When Daniel and his partners contemplated building their much larger flax mill, they would certainly have recognised that they could not meet the power requirements unless they were able to harness the potential of the steeply rising valley; only by using a relatively massive head could they compensate for the low flow.

Building a dam wall to give any significant head adjacent to the mill would have required massive earthworks - the valley has widened out considerably at this point. But 200 yards upstream, construction of a 100 feet wide wall was sufficient to form a relatively large dam, the Regulator. Water from a sluice at the top of the dam wall must have flowed via an aqueduct or a pipeline to the two 30 feet wheels. Today the head of water available at the mill is some 60 feet, so, assuming the wheels were side by side rather than one above the other, building the dam wall to that height may not have been necessary initially.

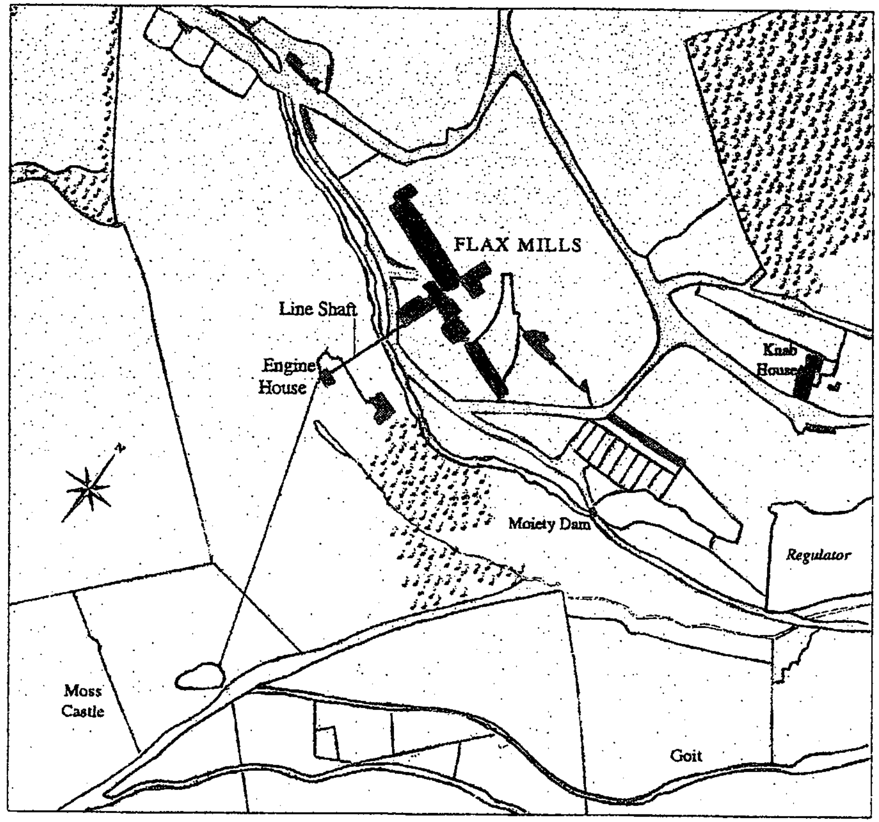


Figure 6. A reproduction of the 1839 Tithe Map of Darley and Little Rowsley The location of Moss Castle is the circular area at the bottom left which was entitled 'Engine head' in the corresponding Apportionments. The interconnection between Moss Castle and the Engine House and what can only be the line shaft entering the mill are clearly marked.

Clearly, the permissible variation in the Regulator's water level must have been relatively small if it was not to drop below the level of the supply duct or pipe, or be wasted over the spilway. That problem is compounded by the small size of the dam - just under one acre. Whilst they could have built a much higher dam wall, well above the sluice height, the Dakeynes chose to build a second dam, the Fancy, some 40 yards beyond the top end of the Regulator.

No data is available on the precise height of these two dams. Although accurate figures could only be established by survey, what figures do exist suggest the level of the Fancy is about 75 feet above the mill.

Building the second dam was almost certainly the optimum solution. Less material would be required - using estimated figures from a consultant's report written in 1971 suggests the average depth of the Fancy to be less than 9 feet.

The capacity of the new dam was subsequently estimated to be 2.4 million gallons compared with the 2.9 million of the Regulator - but since relatively little of the latter could be used, this represented a significant increase in availability.

Despite these relatively major works, the power generated by the two waterwheels did not meet the potential demand, and by 1802 the 28 H.P. steam engine was being installed.

The most comprehensive account of the Dakeyne mill ever written is contained in Stephen Glover's 'The History of the County of Derbyshire' written in 1833 when the younger brothers, Edward and James, were in control. He refers to the four dams, quoting the level of the highest to be 75 feet, but stating that these powered three overshot wheels, '...the water descending from one to the other'. Of the steam engine there is no mention.

So, at some time between 1804 and 1833, and most probably when they built their new mill in 1826, the brothers had replaced the original two wheels driving the flax mill with the three working one above the other.

It may have been necessary to raise the level of the Regulator, but whether this was done or not, the overall result must have been an appreciable increase in the power available. Presumably the steam engine never went into service. Indeed the manufacturer would almost certainly have been a creditor of D.Dakeyne & Sons, and may well have reclaimed the engine in lieu of a financial settlement.

Glover goes on to state that an 'additional' 96 feet head of water from Sydnope Brook was now being used to power the recently installed disc engine which was to drive 'a large flax manufactory now erecting'. He also records that the engine was also used occasionally to drive the 'established works' instead of the waterwheels.

But what was this 'new manufactory'? Probably this was the conversion of the cotton mill to flax production. There is no reference to the spinning of cotton in Ladygrove by Glover nor is there in any other subsequent written source. Furthermore the lineshaft transmitting the power of the disc engine entered the old mill - although it was clearly linked to the shafting in the main building as well.

Whether that theory is correct or not, the additional machines meant that the Dakeynes had been faced with the problem of extracting yet more power from the Sydnope Brook.

They knew perfectly well that the flow from the Regulator would not support another wheel or wheels in addition to the existing three. Just as they did before, they saw that only one solution was open to them -they had to find a way of creating a yet higher head. Raising the levels of the two dams even further may have allowed an additional wheel to be installed above the three already there. But this would have been an expensive solution, adding to what was already an apparently complex drive system, and most importantly, may well not have delivered the power thay were looking for. Clearly resourceful and competent engineers, they found a more radical solution. By taking water from a point upstream of the dams they could achieve a significantly higher head and do so without any modification of the existing supply and source of power.

Harnessing the flow of water was, of course, another problem entirely. After all, a pipeline from a dam on the contour line of the point at which they had chosen to extract the new supply would result in a static head approaching 50 p.s.i. Certainly engines capable of handling that sort of pressure were available and indeed were in use to pump water from the Alport lead mines a few miles to the north-west. But these 'hydraulic engines', located some 150 feet or more down a mine shaft, were reciprocating machines simply lifting a pump piston. (both the pumped water and the water used to drive the engine discharged into a 'sough' - an underground aqueduct falling to a river or stream usually several miles away.) No one had sought to, or indeed needed to, adapt these engines to provide a rotary drive.

Given their evident mechanical ingenuity, it seems impossible that they would have failed to consider using a crank on a reciprocating engine. After all, they must have been familiar with the steam engine that had been largely installed at the mill previously. But a primary concern would have been to ensure the constant speed essential to the spinning process. That could not be achieved with a reciprocating engine, which, although an established design, was also relatively complex with many moving parts.

Water turbines were being developed at the time the Dakeynes were wrestling with their problem, but that was in France and moreover they were only capable of working with relatively low heads. In fact, as late as the middle of the 19th century, turbines were not really in use in England. So they had no option. If they wanted to extract more power from the Sydnope Brook they had to design their own engine.

When completed, the goit or water course was over 1000 yards in length and two sections were in fact ponds, each about 300 feet long, and 50 to 60 feet wide. Although the flow from the brook would have been appreciably augmented by springs high up on the hillside, the ponds suggest a recognition that however the water was used, the power generated at the mill depends ultimately on the total flow in the brook. Every opportunity to store water had to be taken.

The 96 feet head quoted by Glover (and also by Nixon and others writing subsequently - although conceivably they thought they were referring to the Potter where coincidently the head above the mill is also around 96 feet) could only be verified by survey. Spot heights on the Ordnance Survey maps adjacent to the mill and Moss Castle show a difference of 150 feet. Although the water level in the 'Engine Head' would be lower than the adjacent benchmark, it does not seem to account for a difference of that magnitude.

And the Potter? To date, all that is known about its history is that it was built sometime between 1839 and 1880. Conceivably, it proved difficult to ensure a sufficient water supply both to the disc engine and to the wheels simultaneously. Despite the reserves in the goits, when in use the disc engine must have taken the bulk of the brook's flow. Conceivably the Fancy did not hold enough to keep the wheels in operation in periods of low rainfall when the only opportunity of topping it up might have been overnight. And that assumes that the mill only worked in the daytime.

Bigger and deeper, the Potter's 14 million gallon capacity increased the total available storage by a factor of five, and may well have mitigated the impact of seasonal rainfall.

The building of the Potter was the last chapter in terms of the major engineering works in the heyday of the development of Ladygrove Mill for flax production.

Other Dakeyne Engines

Glover, no doubt encouraged by Edward and James, foresaw a wide spectrum of applications for the revolutionary design, not only in industry but even in domestic use for 'culinary purpose'. It could be powered by steam instead of water, and, with a suitable source of power, it could act as a pump raising water up hills 'in a continuous stream'. They were to be sadly disappointed.

The author recorded that a Mr.John Dakeyne was 'directing the installation of a pipe organ in his house' which was to be 'put into action by the said patent machine'. John, the solicitor, and the oldest brother of Edward and James, lived at Knab House, on the hillside above the mill.

However, a second large machine was intended for installation at a lead mine in Lathkill Dale some 6 miles from Two Dales. With a head of 66 feet, it was expected to develop 130 H.P., and was to de-water the mine. A newspaper article written in 1831 refers to the manufacture of the casting. Glover recorded that the inventors were then erecting the machine prior to its installation. Another report in January 1833 states that the engine was then actually at work in the mine. Although an unusually wide shaft large enough for the engine still exists there is no confirmatory evidence that the engine was ever installed.

But, in fact, Glover's high hopes were in part realised. The Dakeyne engine inspired several other patentees who sought, in the main, to resolve the

difficulties of sealing the working space that is inherent in the design. The majority of engines built were steam powered, and were in vogue until at least the middle of the 18th century. An account written in the eighteen-fifties records that a large number to an earlier design were still in service, as well as there being twenty machines built to the author's design. Amongst the advantages quoted were its lightness, its compact design and (surprisingly) low fuel consumption compared with conventional engines. In the eighteen-forties, trials were carried out in a naval pinnace and subsequently in the 300 feet long H.M.S. Minx. Around the same time, six canal tugboats were powered by disc engines.

Perhaps in their later years the Dakeyne brothers derived some satisfaction from their having originated the concept. With the wisdom of hindsight the limitations of the design are obvious, but that should not detract from the achievment of these two self-taught engineers working largely in isolation in a remote Derbyshire valley.

The Last 150 Years

The 1851 census shows that James, (the head of the family despite being the youngest) at the age of 77, and Edward, then 79, were still running the business. They still lived at Holt House with their elder brother Peter, who by then 82 years old had actually retired! He died the next year. Edward was to live another 11 years dying in 1860 at the age of 90. Two years later James, the last of that generation, was to follow him.

None of the three brothers had ever married, and on James' death, the estate passed to their late brother's, Daniel Jnr's, children. Three of the siblings, Ann, Charles, and Baldwin, had continued to live together in the village. When they came into their inheritance, they moved back to what originally had been their father's house. The brothers, by then in their late fifties, managed the mill.

By the time of the 1881 census, only Charles remained. He had been joined at Holt House by a widowed sister, Catherine. Whilst Charles (at the age of 79!) still quoted his occupation as a flax spinner and employer, a note added in the margin of the census records that the mill was out of use. Charles was to die that year.

Although those Dakeynes who survived beyond early adulthood lived to remarkable ages, marriage eluded many of them. Neither Ann, Charles nor Baldwin had married and they were the last of those who bore the family name to live in Two Dales. When their widowed sister, Catherine, died in 1887, a young clergyman, the Reverend James Dearden Dakeyne Cannon, moved into Holt House as head of what was left of the Dakeyne family in Two Dales. He had married, and adopted the surname of the principal beneficiary of the estate, another Catherine. That second Catherine had earlier lived for at least some time at Holt House with her aunt, Ann, and two uncles Charles and Baldwin. Born in Manchester, she was the daughter of their brother Arthur.

The reign of the Reverend Cannon was to be a short one. He died in 1899 at the age of 36. On 18th June 1924, the whole of the estate, then owned by their son, Edwin Cannon, was sold.

And what of the mill in these last years of the Dakeyne dynasty? Clearly by the time of Charles's death in 1881, the flax business was at an end. A letter written in 1933 in reply to an American enquirer states that in the late eighties it was leased to a Mr.Hope. In 1891 the mill was being used as a twine manufactory. Subsequently, various spasmodic attempts were made to utilise the mill including leather manufacture, for fur stripping, and for the repair of machinery. During World War I it was used as a training centre by the Leeds Rifles.

When the estate was broken up in 1924, the mill and lower end of Ladygrove, including the dams, were bought by two brothers, Sidney and Ernest Johnson. They were flour millers, and today, over 70 years later Sidney's family still own and run S.& E.Johnson Limited, although the products are now animal feedstuffs and petfoods.

But what happened to the Romping Lion? The 1933 letter confidentally records that it was then running 'as powerfully and silently as ever'. That seems very unlikely. By then the mill was powered by electricity - but with one exception. Johnsons were still using a Gilbert Gilkes 60 H.P. turbine installed in 1894. Supplied by pipes running at dam level from the Regulator to a tower where the water dropped via a vertical pipe to the turbine below, it must have replaced the water wheels and very probably the disc engine. At best, the Dakeyne design must have been very inefficient, and over half a century of use must have taken its toll - if indeed it survived that long!

The organ and its disc engine did not. It was torn out of Knab House and burnt about 1880. During digging of the garden over the years all that has been found is a couple of cast gear wheels.

The turbine was used by Johnsons to drive a steam flaking plant installed in 1932. Despite a catastrophic failure in 1963, the turbine was rebuilt and continued to run until about 1979. It and its water supply are still there and will hopefully provide the basis for another chapter in the powering of Ladygrove Mill.

The Legacy of the Dakeynes

On a visit to Ladygrove this year, I found the only evident change in the last 40 years to be the disappearance of Losker Row - a row of cottages just below the Regulator built to house the mill workers - and that the sides of the valley have become significantly steeper! But it was possible to look at it with a greater appreciation of what to look for.

Of course the dams are still there, although in recent years the depth of the Potter has been reduced by deepening the spillway by perhaps 15 feet as a safety measure.

The wider parts of the goits are still filled with shallow water, supplied from

the many springs along the hillside. The narrower channels run alongside the main path as it penetrates further into the valley. Only one section, perhaps 100 yards long, has disappeared without trace.

Beyond the Potter, at exactly where indicated on the map, was the point at which the Dakeynes had chosen to divert the water from the brook. But instead of the minor earthworks to split the flow that I had anticipated, there is a 30 feet high embankment across a narrow ravine in the valley bottom. Built to increase the head rather than conserve water, the dam may have been backfilled upstream when constructed, but in any case it was now possible to walk across the dam behind the wall. A stone aqueduct, perhaps 2 feet square, tunnels through the top of the embankment. It leads directly into the goit.

Back at the other end of the valley, Moss Castle is still boggy. Mindful of past warnings, I kept well away from the centre. Talking to the owner of the adjacent cottage, I discovered that very recently a large flat stone on top of the embankment had been moved to reveal a stone shaft, about 2 feet square and 6 feet deep. This connected with a second shaft of similar construction pointing down the gradient in the direction of the mill. Whilst an underground aqueduct lined with masonry cannot be ruled out, the pressure at the bottom of the hill would suggest an iron pipe would have been much more probable. No doubt some excavation down the route would reveal the facts.

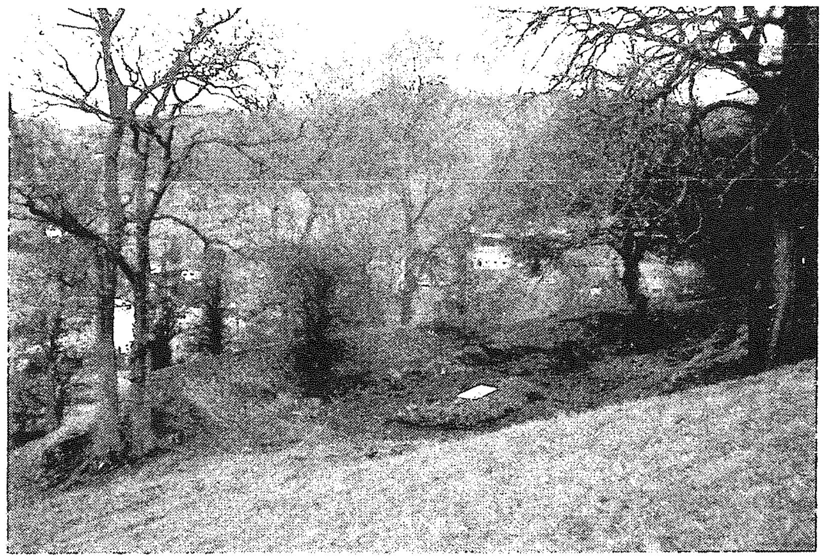


Plate 1. A view of Moss Castle, with the mill visible through the trees at the left.

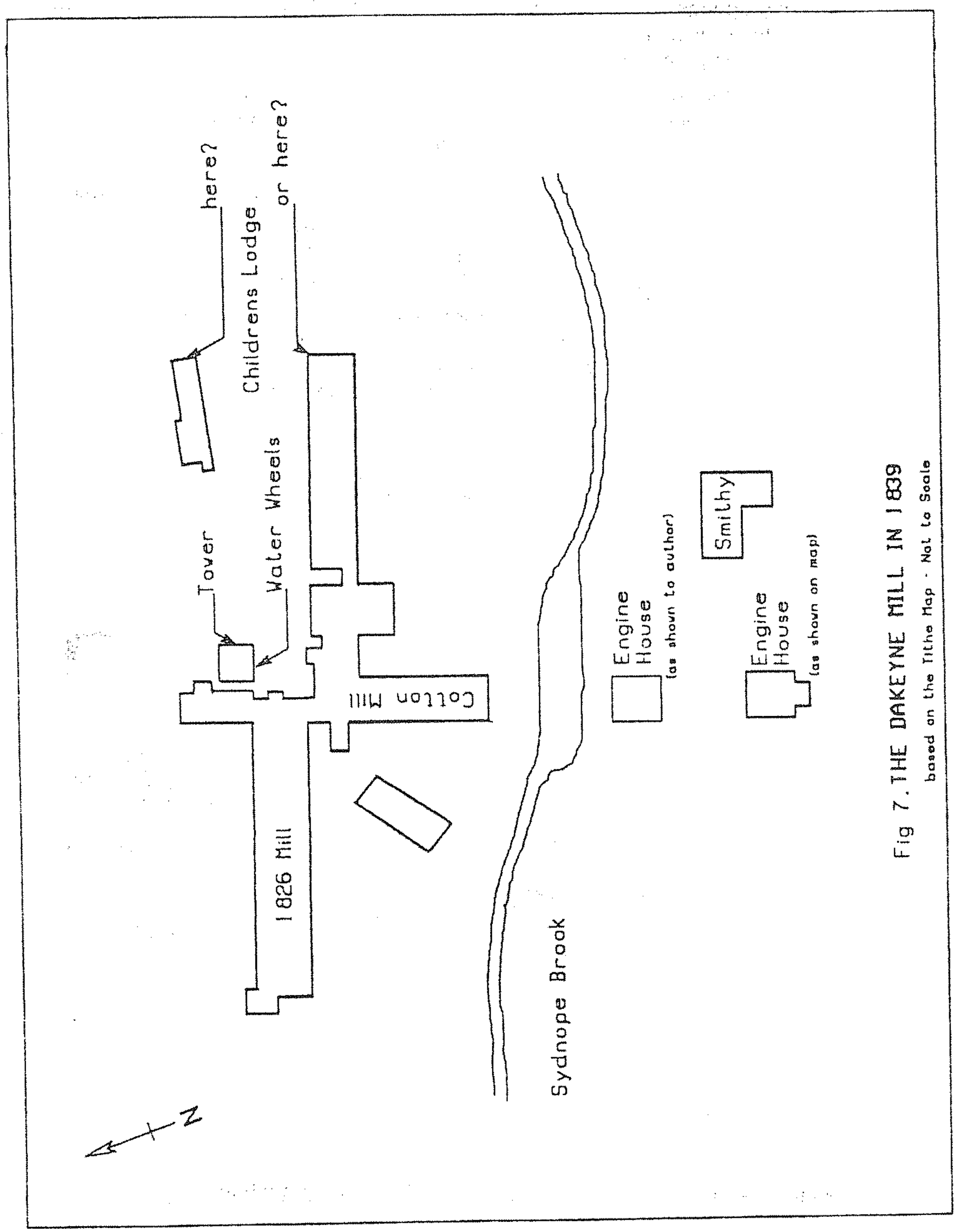


Fig 7. THE DAKEYNE MILL IN 1839
based on the Tithe Map - Not to Scale

Down at the factory (see Figure 7), the old cotton mill, the south wing of the complex, has been extended and new bays added on either side. Nevertheless the shell remains and the dimensions conform to those quoted in the sale advert of 1802.

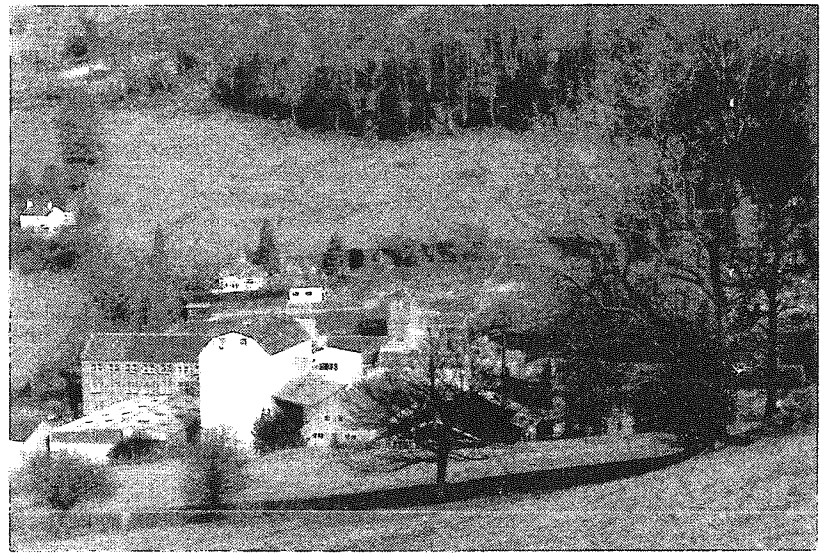


Plate 2. The Mill at Two Dales as seen from the hillside near Moss Castle. The bell tower is in the centre with the 1826 mill to the left, & the east wing to the right.

Originally two storey, the lower floor down at brook level, well below the level of the mill yard, has long been filled in. Adjacent to the end of the mill there is weir possibly 6 feet high. This suggests the theory that the wheel was undershot is correct.

Across the lane, what I believe is the site of the Engine House remains - not some 40 feet up the hillside as shown on the early maps, but closer to, and level with, the cotton mill. Perhaps my grandfather was wrong. After all, it seems unlikely that both maps, drawn 40 years apart, could be so much in error. But is it likely the Dakeynes would have sacrificed that additional head and introduced the need for a much longer lineshaft angled down the slope of the hillside? Neverthe less it might explain the 96 feet head quoted by Glover - significantly less than the potential head.

Although it no longer dominates the site, the west wing, the 1826 mill, is little altered externally, although the windows and part of the roof have been replaced.

The bell tower, still the highest building, and perhaps the most instantly recognisable feature of the mill, remains. But the primary purpose of the tower was not to summon employees to work, but to support the end of the aqueduct carrying water from the Regulator before it cascaded over the three wheels. The height of the tower has been increased at least once and the bell tower then added. The construction of the lower part suggests it pre-dates the 1826 mill. In 1895 it was modified to incorporate the pipework and pentank for the new turbine in the basement below. The whole installation is still *in situ.*

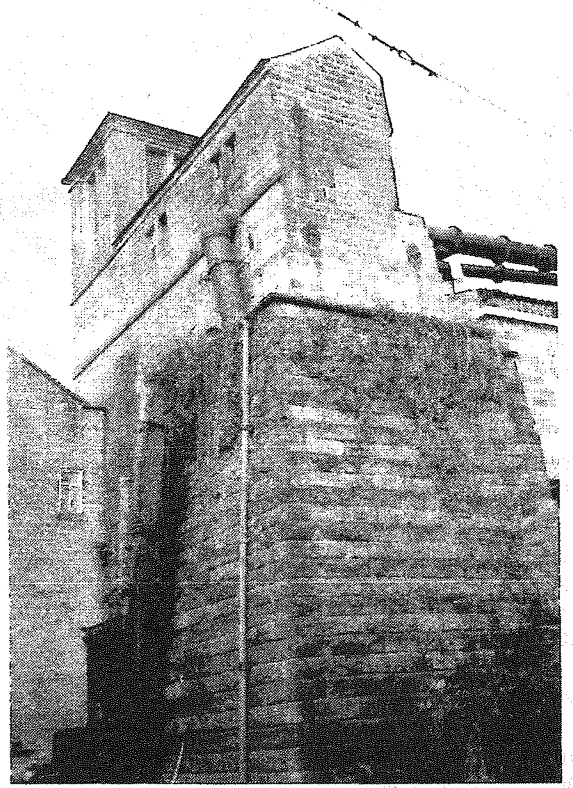


Plate 3. The Tower, showing the horizontal pipes from the Regulator. The vertical pipes fed the turbine.

It is the east wing of the mill that is perhaps the most intriguing. A long narrow building with limited headroom, it has three floors at the western end but, because of the gradient of the yard, the bottom floor only extends a third of the length of the building. Clearly one of the oldest buildings on the site, it has been little altered over the centuries except for the replacement of the roof. Was it part of Daniel's original flax mill or was it the Children's Lodge.

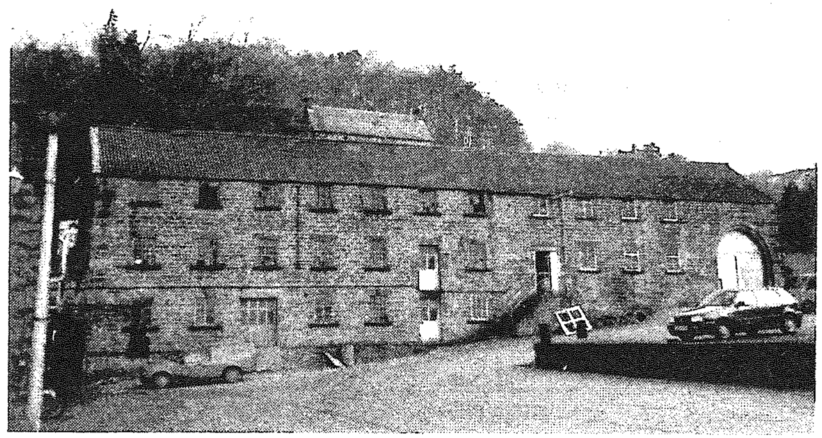


Plate 4. The East Wing, Children's Lodge or Warehouse?

Its length at 120 feet conforms to that quoted for the mill in 1802 sale particulars. But it is only 24 feet wide not the quoted 30 feet. An error of such magnitude is unlikely. It is built into a bank and although there is a roadway at first floor level, there is only one window and one door. It faces onto a mill yard surrounded on two sides by a massive stone wall over 8 feet high - and the cotton mill would have originally formed the fourth wall of a compound. Why was such security necessary when it was not required for the buildings where the manufacturing was carried out?

If a mill, how was it powered? - there is no evidence of a lineshaft having entered the building. And if a warehouse, would it not have been built with more headroom?

The 1802 sale advert refers to '...the land contiguous with the said mill and lodge through which the Water is conducted from the said Dams...'. And where this building is sited that is indeed the land through which the water runs.

Whilst it is tempting to conclude that this building is a relic of an unfortunate period in our industrial history, the evidence is not conclusive. On both the 1839 Tithe map and the 1880 Ordnance Survey map there is another building, up the hillside at the back. Admittedly this is much smaller than the east wing, and unless it were multi-storey, it seems unlikely that it could accomodate 100 children even in the cramped conditions that were the norm.

Furthermore, the Schedule of Tithes refers to a number of ancillary buildings including a Heckling shop, a Warehouse and a Foundry. As none are identified on the map, the east wing may have been any of these. There is no reference to a children's home. But by then the employment of children may have ceased.

Were the Dakeynes able to return they could tell us. In that unlikely event even they surely would be amazed that so much of their long forgotten enterprise remains after nearly two centuries.

Acknowledgements

The author gratefully acknowledges the help and advice given by local historian Ernest Paulson, David Westmorland, Chairman and Joint Managing Director of S.& E.Johnson Limited, and by the staff of the Derbyshire Records Office and the Local Studies Library in Matlock. He is also grateful for the consent of the County & Diocesan Archivist for permission to reproduce the Tithe map and to Malcolm Swanston of Arcadia Editions Ltd. for the excellent re-creation of that key document.

References

Nixon, F., *Industrial Archaeology of Derbyshire*, David & Charles, 1969.

Cooper, B., *Transformation of a Valley*, 1983.

Glover, S., *History and Gazetteer of Derbyshire*, **Vol.2**, 1833.

Rieuwarts, J.H., *Lathkill Dale; Its Mines and Miners*, 1973.

Smith, E.C., *A History of Rotary Engines & Pumps*, The Engineer, 26th May 1939.

Schedule of Tithes, Township of Darley & Lordship of Little Rowsley, 5th March 1839, Derbyshire Records Office.

Dakeyne, E. & J., Hydraulic Engine for Communicating Motion to Machinery Etc. Patent No 5882, 1830.

Census of 1841, 1851, 1861, 1871, & 1881.

Letters from the Barmaster's Library & Whitworth Institute to David Dakin, February 1933, Derbyshire Records Office.

Matlock Field Club, *The History of Ladygrove Dams*, Newsletter **No 21**, 1st December 1980, Derbyshire Records Office.

Bagshaw & Sons, W.S., The Dakeyne Estate, Sale Particulars, 18th June 1924, S. & E.Johnson Ltd.

Husband, H.C., *Report in Accordance with the Reservoirs (Safety Provisions) Act, 1930, Potter Dam*, June 1971, S.& E.Johnson Ltd.

THE CONTROVERSIAL WINDMILL OF MUCH WENLOCK, SHROPSHIRE

By Jean Lawley

Much Wenlock is a small market town in central Shropshire (SJ 623000) 11 miles south-east of Shrewsbury and 8 miles south-west of the new town of Telford. Although only about 4 miles distant from Ironbridge and Coalbrookdale, Much Wenlock is still a rural town which has kept much of its medieval character. About a half mile north of the town, just to the east of the B4378 road (at SJ 625009) stand the remains of a tower. It is about 25 feet high, four-storeys high, with a slight batter, built of limestone slabs and blocks, and castellated at the top, as can be seen in Plate 1.

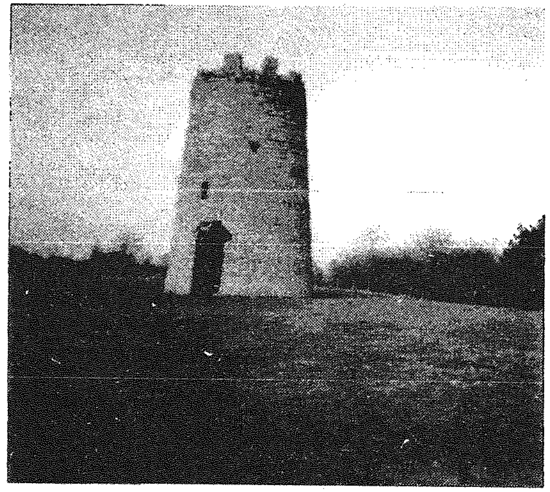


Plate 1. The remains of Much Wenlock windmill.

Suggestions were made some years ago that this empty tower overlooking Much Wenlock may have been a 17th century guard tower (an article in the local newspaper of August 1970 makes specific reference to this speculation). More recently, a visiting lecturer insisted that it was a folly built to resemble a windmill. Both entirely wrong! The structure atop the hill is, in fact, the surviving tower of what was once a working windmill.

The precise date of construction is not known but it was in existence before 1713 (Victoria County History, X, 'Shropshire Forthcoming', states '...might be identified with the malt mill mentioned, 1622-47'). It was shown on a map of Much Wenlock of that date and listed in the 1714 Survey of the Manor prepared for Sir John Wynn of Watstay when buying the estate from Viscount Gage. The Survey shows that the miller was Richard Counley (actually Coundley), who held two water grist mills, a windmill, and a dwelling house, etc. His father's will signed in 1685, bequeathed 'all the right, title and interest I have in the mill I now hold of my landlord Esquire Bertie and the same to have and to hold the said mill unto my son, Richard, for and during the remainder of years'. Sir John died in 1719, the estate passing to his cousin, Sir Watkin Williams of Wynnstay.

Further proof is on the part of Roque's map, dated 1752, indicating the edifice by a symbol clearly depicting a windmill (see Figure 1). A windmill symbol is also shown on the first edition of the Ordnance Survey issued in 1833 (see Figure 2).

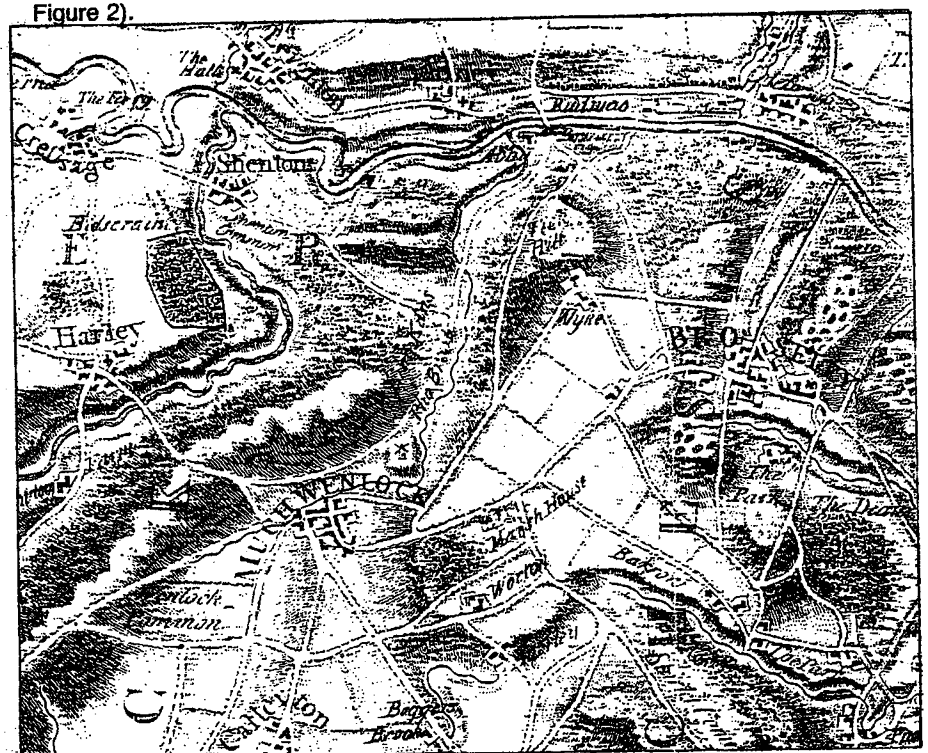


Figure 1. Rocque's map of 1752 showing the tower windmill at Much Wenlock.

1850 saw William Jeffreys operating the mill. On a rental sheet for that year opposite an entry 'Windmill', a note has been added 'not in working order' - no reason being given. However, in another document, dated 1858, listing payments is the following:- 'Paid Wm.Jeffreys compensation for loss of windmill, struck by lightning, as awarded by Captain Burlinson, being 8 years at £5' - and a total of £40 is shown.

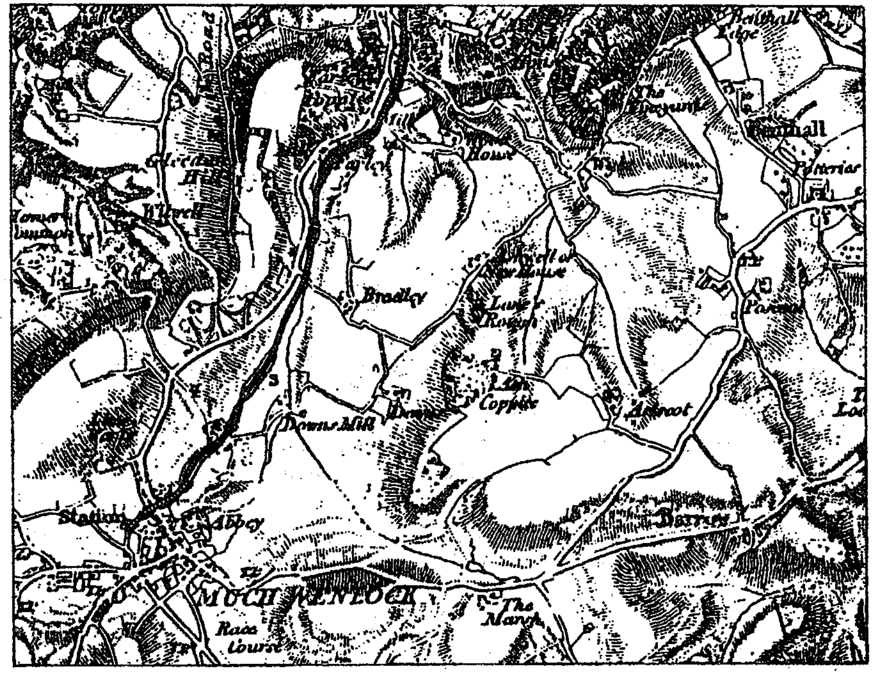


Figure 2. The 1st ed. O.S. map of 1833 with windmill symbol at Much Wenlock.

The windmill was not restored to working order. Down the years it is probable that the inner workings were gradually removed. Notes exist stating that machinery was taken out and left in the Bull Ring in the centre of Much Wenlock; beams were removed and used in other buildings.

One distinquished resident of Much Wenlock during the mid-19th century was Dr. William Penny Brookes who founded the Olympian Society and organised Olympian Games for the whole of England at Much Wenlock, long before the first International Olympiad of 1896. In the 1859 Wenlock Olympian Games Programme the tower was referred to as 'The Old Windmill'. A note in the programme states 'James Milnes Gaskell, Esq., M.P. for the Borough has kindly given permission for the fitting up of the windmill, from the summit of which an excellent view may be obtained of the games and surrounding countryside'.

The mill is now a Grade II Listed Building. No-one has shown an interest in restoration until in 1994 the Much Wenlock Civic Society expressed concern, carrying out a survey of the building, revealing that the outer walls were sound. During a meeting of the Civic Society and the Town Council a project for renovating the old windmill was discussed; ownership might be complicated, but an observation platform could be made overlooking the town.

Acknowledgement

The author would like to thank Mr.Glyn MacDonald, the archivist to Wenlock Town Council, for allowing access to the various documents mentioned.

CHESTERTON WATERMILL
PART 1 - INTRODUCTION

By Barry Job

This unusual mill is to be found at National Grid Reference SP 348590 some 5 miles to the south-east of Warwick (see Figure 1). Although now fairly close to the M40, it is still in a secluded setting over the hill from the Roman Fosse Way. Chesterton itself is a depopulated village and the manor house, the ancestral home of the Peyto family, was demolished in 1802. So Chesterton today is found as a few scattered farms, a cluster of what were originally cottages for farm workers and rural craftsmen, and a very attractive church, founded in the 11th century and containing excellent tomb monuments dedicated to the Peyto family.

As will be shown later the watermill is an extremely fine building which has possibly been converted to a mill from a previous use, so that it does not look like a mill. So why is it so little known? The reason is that it is overshadowed by the famous windmill which stands on Windmill Hill above it(see Figure 2). Both mills have been worked in conjunction with one another and their histories are interlinked.

The watermill was visited by the Midland Wind & Water Mills Group in June 1994. This prompted the suggestion that the Group could carry out a survey similar to that done at the nearby Harbury Windmill a few years previously. So a party consisting of Dave Baddeley, Tim Booth, Norman Clarke, Tony Green, Barry Job, and Derrick Rodgers met at the mill in April, 1995. The survey itself was carried out using conventional taping techniques, although for the more inaccessible distances and vertical heights a Pentax electronic distance measurement instrument was used. This will give values to the nearest millimetre, however, this is the view as seen by the observer. The only problem is when perspective comes into play, for example, on Figure 7 the brick chimney in the foreground appears higher than the stone chimney in the background, whereas their true relationship is shown in Figure 11.

Around the mill yard are various outbuildings, these would have included cartsheds, stables, pigsties, and a small bakery. The Tach Brook originally filled the pool, a sluice gate being used to divert the water as necessary, but this led to flooding and was done away with. The supply is now by field drains and springs, the latter, being slightly salty, accounts for some of the unusual plants to be found there. Whilst the mill building itself is no longer used, the adjacent pool forms the basis of a popular trout fishery. There is no doubt that this activity has helped to preserve the mill and keep it secure against vandalism and the weather. It must be emphasised that the mill is privately owned and is not normally open to the public, and it is sincerely hoped that this will be respected. Finally the survey could not have been carried out without the encouragement of Mr.Brian Merriman, the owner, and the active help of Mr.David Mann, the site manager, to whom we extend our grateful thanks.

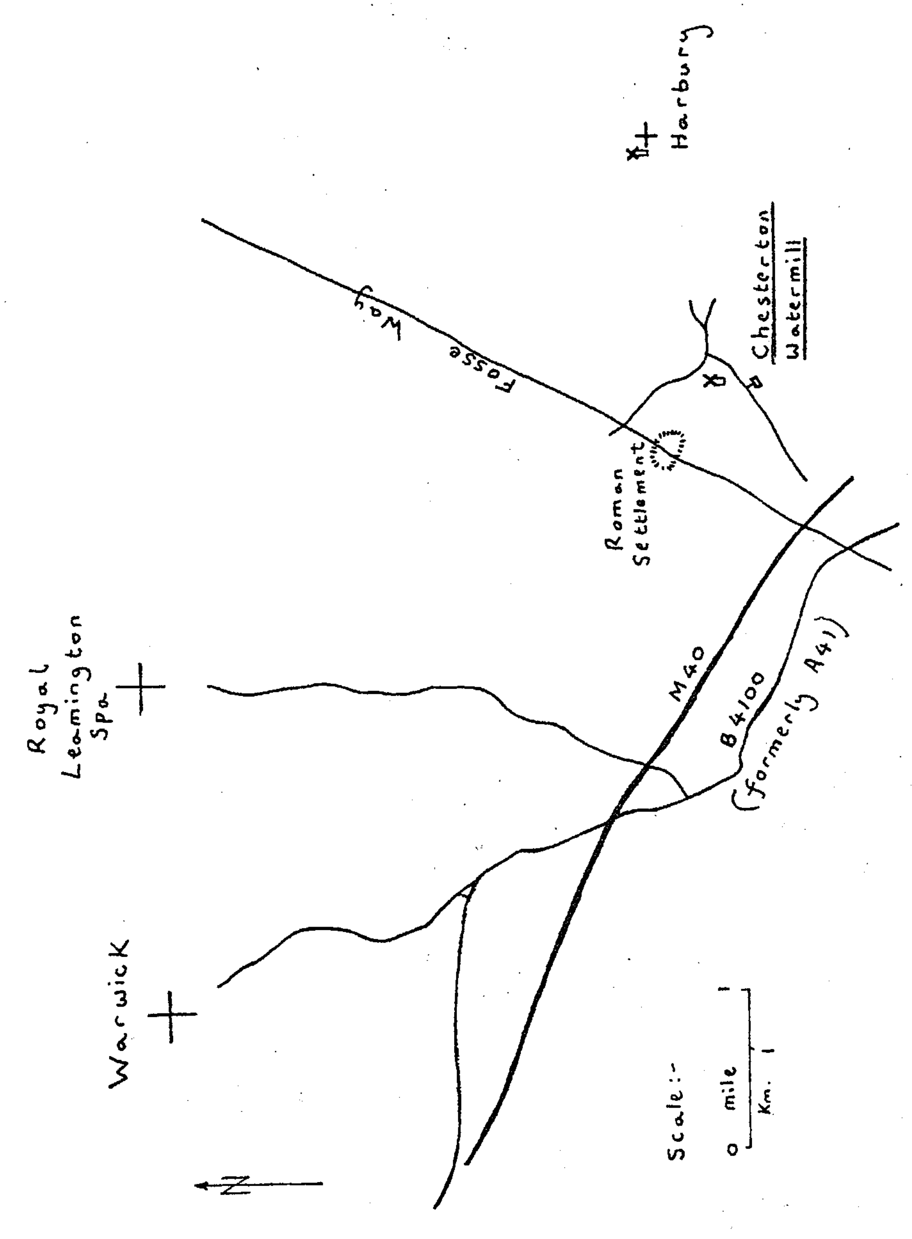


Figure 1. Map showing the location of Chesterton with respect to the towns of Warwick and Leamington Spa.

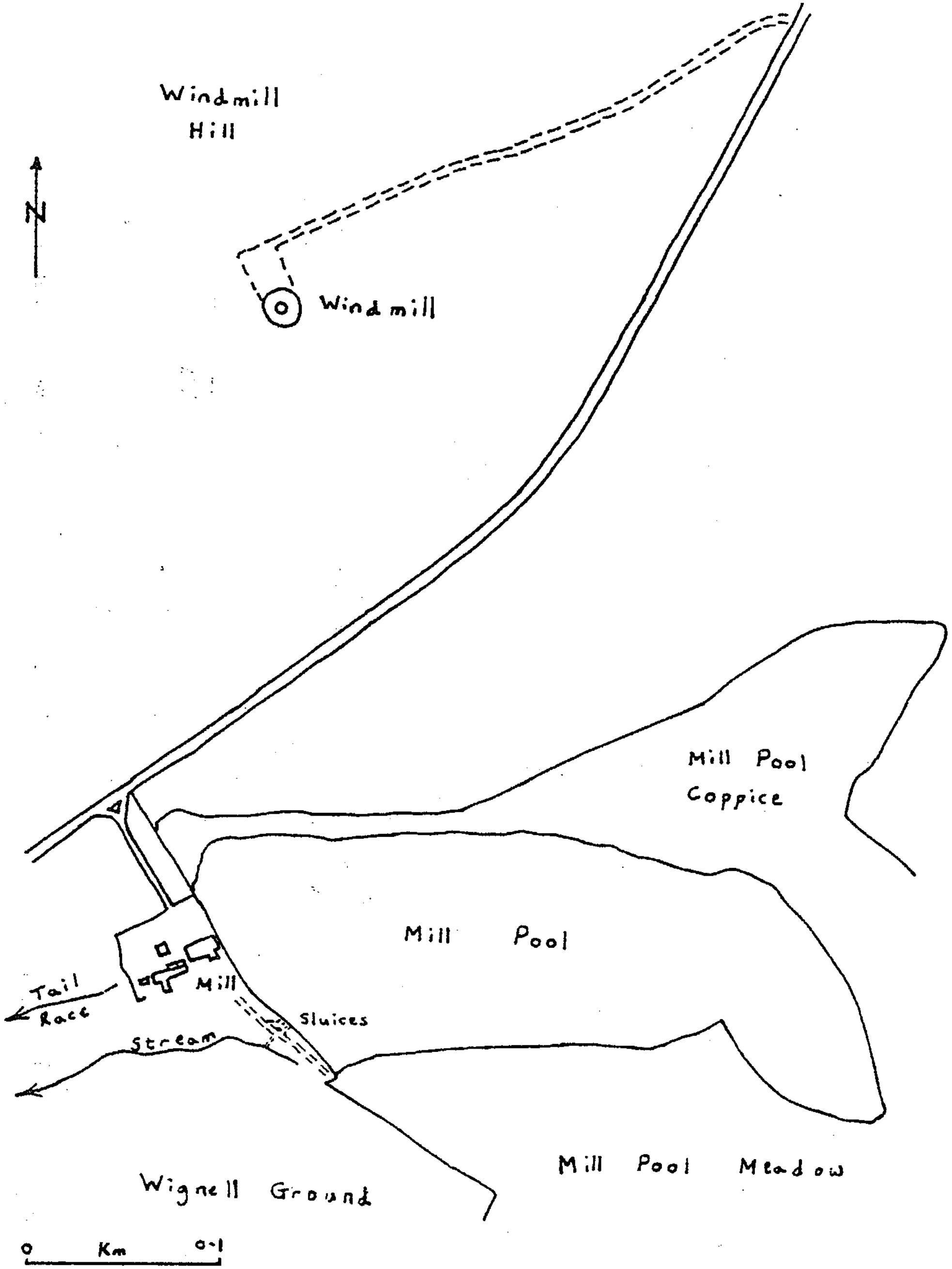


Figure 2. Map showing the relative position of the watermill and the windmill at Chesterton.

Plate 1. A member of the team with surveying equipment.

PART 2 - THE HISTORY OF THE MILL

By Norman M.Clarke & Barry Job

The mill would almost certainly have been built by Sir Edward Peyto who had a penchant for unusual buildings, as witnessed by the windmill and the now demolished summerhouse, built to look like a small Scottish castle. The mill machinery has been built within the basic structure and, as Figure 6 suggests, an inserted floor cuts across the tops of the front and side doors, and across the tops of the lower windows. Thus there are different possibilities. For example, it may have been built as a watermill (although intended not to look like one), with the 17th century machinery fitting comfortably within the original structure, changes to the gearing, in say the early 19th century, required the insertion of the extra floor. Alternatively, another scenario is that the building was built to serve another purpose, being converted to a watermill at a later date. The quality of the construction of the watermill indicates some status within the local community and it may have been built as an imposing lodge for the estate, or as a shooting lodge. It has been suggested by Noden(1) that it was originally a Court House, and, as was the fashion in the 17th century, with a Statue of Justice with her scales residing in the niche over the front door. The Court House is a definite possibility in so much as there is a suggestion of small cells at the back of the building, and, with living accomodation above, it may well have been used for general estate duties such as collecting rents (although the site does seem an unlikely choice).

Unfortunately it has not been possible to ascertain the year when the building was constructed. The Shakespeare Birthplace Trust, Stratford-upon-Avon, holds the Willoughby de Broke Collection. This consists of the Warwickshire papers of the combined families of Verney, of Compton Verney, and Peyto of Chesterton. This large collection includes medieval deeds and court rolls, and marriage settlements, estate accounts and personal papers from the 17th century. For example, it records payments for building the 'new' manor house in 1662. It may well be that these documents hold the answers to many of the questions regarding the mill, but they are very difficult to read and must await more persistent research.

Large dressed stones at the rear of the mill would suggest that it incorporates an earlier structure (there is also brickwork, although this may represent repairwork, especially the need to gain access to the wheel). There was certainly a mill and pool here in 1554(2), so one scenario is a watermill, being replaced by a Court House, which is later converted back to a mill. The problem here is that the erection of the Court House is most likely to have followed the building of the windmill in 1632, the windmill being deemed to make the old watermill redundant. This would be supported by there being a lot of construction work on the estate at that time and the style suggesting a mid

Figure 3. Graffiti initials and date. Taken from rubbings from the stone work, thought to be the work of children. Original kindly supplied by Mrs.D.Noden.

Figure 4. Graffiti initials and dates.

1600s date. Yet graffiti dates from within the mill (see Figures 3 and 4) arguably include 1622, 1628, and 1648. Assuming that these are not re-used materials this would put the construction date before 1620. This is supported by letters patent granted to Sir Edward Peyto dated February 1625(3) which refer to a watermill, in 1638 a Richard Cockbolt is paid for 'drawing lime to ye watermill'(4), in March 1638 Batchelour was paid 6d 'for carrying the spindle of the watermill to Southam'(5), in December of the same year John Mostly was paid 2/6d for work 'out and about the watermill'(6), and a conveyance of November 1647 refers to the pool and watermill(7). These give the watermill (presumably the later conversion) a fairly continuous history, the transport of the 'spindle' to Southam being particularly interesting. This undoubtedly refers to the waterwheel shaft, and if it was to be repaired because of rotting, as opposed to damage, then this would again support a pre-1620 conversion date. In any event the 'Court House' must have had a very short life (and thus supports the suggestion that the building has always been a watermill). Interestingly, a recovery of Chesterton lands dated May, 1647(8) refers to 3 mills. This probably refers to the watermill, the tower windmill on Windmill Hill (but called Clay Hill on the older maps), plus an older windmill which presumably stood in the large field called Mill Hill on the 1823 Estate map which lies to the south of the village. This mill does not appear to be mentioned again and had presumably gone out of use with the completion of the tower mill. Certainly another recovery of March 1689(9) refers to one watermill and one windmill.

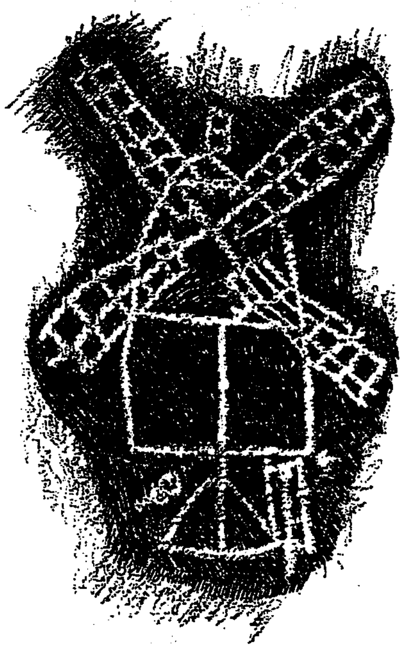


Figure 5. Graffiti found inside the mill on an upstairs window facing the tower mill. From an original kindly supplied by D.T.N.Booth.

The gable at the rear of the tower windmill carries the date 1632 and the initials EP. It has been suggested that the windmill was designed by Inigo Jones, apparently for no better reason than it is in his style, and also that it was originally used as an observatory(10). Baxter suggests that the machinery 'was not completed for several years', citing work he dates as 1637(11). The actual documents include:-

5th March.	Payd in part for sayle cloths	£6-0s-0d
15th October.	Payd to Packthridd to mend sayle cloths	4d
4th December.	Payd to Thomas Band for 20 feet of stone used at the windmill	3s-4d

These are dated 1637, even allowing for the 'New Year' to be in march at that time, this is clearly an error, the date should read the following year, 1638.

However, the Estate Accounts for the period 28th May to 29th September, 1633, also show work at the windmill. For example(12):-

John Richardson and sonns for digging at Quarry for ye windmill	£1-0s-0d
1 day & $^1/_2$ day at the windmill for cutting the upper stone of the windmill	6d
Thomas Priest for seeling (roofing?) the windmill	3s-0d
Westly and his sonn 16 working about the windmill	16s-0d
8 dayes work at ye windmill	8s-0d
M Saunders for 97 yards of cloth for the wyndmill	£3-12s-9d

Thus the building was never used as an observatory and was operational as a mill by late 1633, with sail cloths being in disrepair some 5 years later.

Certainly in later years, and undoubtably throughout their history the windmill and watermill have been worked in conjunction with one another. This was not uncommon. It would make economic sense, where the mill pool had a poor water supply, to work the windmill whilst the wind was blowing and the pool was filling up, ready for the next period of calm. Thus the Estate Accounts often do not differentiate between the two mills, indeed, there would not be any reason for them to do so. For example, a series of accounts for 1637(13) commence:-

October 8th.	Received of Thomas Chapman the miller	16s-9d
October 15th.	Received of Thomas Chapman the miller	11s-0d
	Received of the miller for the use of the horse	
	3 strikes of millcorn and half a strike of wheat.	

Interspersed with these regular entries are:-

December 17th.	Payd for sharpening 6 dozen mill picks	1s-0d
	Payd for 4 wedges for ye watermill	1s-0d

And for the following year:-

5th March.	Paid to Chapman the miller for his half years wages due 25th March next(14)	£2-0s-0d

And different accounts(15) for 1638 include pages of:-

'Receipts for corn sold at the mill'

A typical entry being:-

24th February. Goodwife Smoake 1 strike of millcorn 2s-0d

The mill appears in Hearth Tax returns of 1662-74(16), where a watermill with two hearths is mentioned, its history then becomes obscure for nearly 100 years. By 1758 James Beck was the miller, followed by John Beck in 1781(17). Recorded in the 1841 Census(18) was another James Beck, born in 1771, and thought to have taken over the mill in 1814, with his wife Hannah. Their eldest son, born at Chesterton in 1811, was also called James, and he married a girl, also called Hannah, from Harbury. With their children and two young lads as labourers there was a total of nine people living at the mill. By the 1851 Census(19) both the elder James and his wife Hannah were gone, the mill being run by James the son and Hannah, who had taken over in about 1847. They had a total of seven children, with their eldest son also being called James, and a daughter being named Hannah. By the Census of 1861(20) both James and Hannah were still there, but by 1871(21) they were no longer at the mill. The miller's job was taken over by their son, but this time it was William, born in 1837, and his wife Mary Ann, who came from Manchester, the first time someone from outside the area is recorded.

In 1881(22) Samuel Thomas Haynes, born in 1822 at Braunston in Northamtonshire, is the miller. He had come from Fillongley, near Coventry, but had married a girl from Napton, surprisingly she was also called Hannah, and their son Samuel was born in 1857. Although the mills were still owned by Lord Willoughby de Broke, the tenant occupier of the farm and mills, from at least 1860, had been Charles Griffin, followed from 1880 by his son John. The tenancy of the farm and mills was sold by John Thomas Griffin to Samuel Thomas Haynes and William Turnall Haynes, of Leire Mills, Lutterworth, in 1862 for the sum of £125 for the fixtures and trade etc.(23)

The sale documents record all of the equipment about the windmill and watermill, the latter includes a new French burr stone, one Peak runner stone, a total of 25 mill bills and 3 handles, and various rat traps. Part of the same document, but dated 1900, is a separate valuation which, interestingly, includes an 'Oil engine and machinery' valued at £70. Surprisingly, a William and Charles Haynes are recorded as millers at the watermill in 1884, 1888, and 1890(24), (as well as at Harbury windmill), although Samuel was actually working the watermill.

He was the last miller to live in the mill cottage and died there in 1900(25). His son William then ran the mill. He died in 1916 whilst A.H.Summers, the millwright, was replacing the wooden waterwheel shaft with an iron one and putting in a new gate to the pentrough. The business continued to trade under his executors for a number of years, being last recorded by Simmons in 1924(26). However, William's son Herbert claims to have worked the mill for a further 10 years, with a Mrs.Lee being the occupier of the cottage(27).

By the 1960s the pool was overgrown with weeds and the owner sent for experts to try to clear it(28). They assured him that the spray they used would

not harm the fish, so they went ahead. Certainly the fish survived the spray, but the rotting vegetation made the water foul and the fish died anyway. It was to be many years before it began to recover. Certainly whilst Frank Rishworth, of Emscote Mill, Warwick, and Rock Mills, Leamington Spa, owned the mill, the pool was renowned for the enormous golden carp.

Then the pool silted up, but the mill had been bought by Mr.Thwaites in 1979. He owned a local company building dumper trucks, so he had the dam breached and used the products from his factory to clear away a considerable volume of sediment and restore the pool back to its original depth. Thus the present era of the trout farm began.

References

1. Noden, Dorothy A., *The History of Chesterton and Kington, Warwickshire.* First Edition 1978, page 38.

2. *The Victoria County History of the County of Warwick,* Oxford University Press, 1949, page 42 and Chan.Inq.p.m. (Ser.2), CIV, 114.

3. Shakespeare Birthplace Trust (S.B.T.), Statford-upon-Avon, DR98/1062, letters patent.

4. S.B.T., DR98/1708, Estate Accounts, mainly detailing wood sales.

5. S.B.T., DR98/1710, Estate Accounts, (although why it should have been taken all the way to Southam is unclear).

6. S.B.T., DR98/1711, Estate Accounts.

7. S.B.T., DR98/1093, Indenture.

8. S.B.T., DR98/1097, Recovery of lands at Chesterton.

9. S.B.T., DR98/1428, Recovery of lands at Chesterton.

10. For Example, The Victoria County History of Warwick, *op cit.*; or
Titley, A. & Haines,H.D., *A Warwickshire Windmill,* Transactions of the Newcomen Society, **Vol XXVIII**, 1951/2, page 233; or
Colvin, H.M., *History: Chesterton, Warwickshire,* Architectural Review, August 1955, page 115.

11. Baxter,E.G., *Chesterton Windmill,* Warwickshire History, Autumn 1971, **Vol 1, part VI.**

12. S.B.T., DR98/1708, Estate Acounts.

13. S.B.T., DR98/1710, Estate Accounts, (a 'strike' being a bushel).

14. A surprisingly low wage considering the revenue being generated.

15. S.B.T., DR98/1711, Estate Accounts.

17. Booth,D.T.N., *Warwickshire Watermills,* Midland Wind and Water Mills Group, 1978, page 45.

18. *Ibid.*

18. County Record Office (C.R.O.), Warwick, Census Returns 1841, MI 333/5, page 2, Chesterton.

19. C.R.O., Census Returns 1851, MI 201/207, page 1, Chesterton, and Tithe Apportionment, May 1849, 569/62.

20. C.R.O., Census Returns 1861, MI 267/27, page 3, Chesterton.

21. C.R.O., Census Returns 1871, MI 336/5, page 5, Chesterton.

22. C.R.O., Census Returns 1881, MI 370/18, page 1, Chesterton.

23. C.R.O., Maps and Surveys index Z 483 (SM)-1900.

24. Science Museum Library, South Kensington, notes of Herbert E.S.Simmons.

25. *Ibid.*

26. *Ibid.*

27. *Ibid.*

28. Noden, Dorothy A., *op cit.*, page 38.

PART 3 - THE SURVEY OF THE EXTERIOR

By Barry Job

Commencing with the basic mill or 'Court House' structure, it was originally of 2 storeys plus attic (although another floor has been inserted, see Figure 6). Built of local Jurassic limestone ashlar with a moulded cornice and a tile roof, the north-west front (see Figure 7) is symmetrical about a central doorway with a moulded round-arched niche above. The oak double door (see Figure 8) is very narrow, with 8 panels (which at first glance appear to be symmetrical above and below, but in fact are not), set in a very finely moulded architrave. This is encased in a pedimented Tuscan doorway of baseless half columns to either side surmounted by a pedestal and ball finial. The limestone is fairly soft material and, although resisting weathering remarkably well considering its age, it is sadly deteriorating in places, especially in the lintel above the doorway. To either side are ground floor and first floor moulded stone cross windows (see Figure 9), in moulded architraves with a frieze and cornice above and a moulded sill below. Originally fitted with leaded glass these have sadly been vandalised.

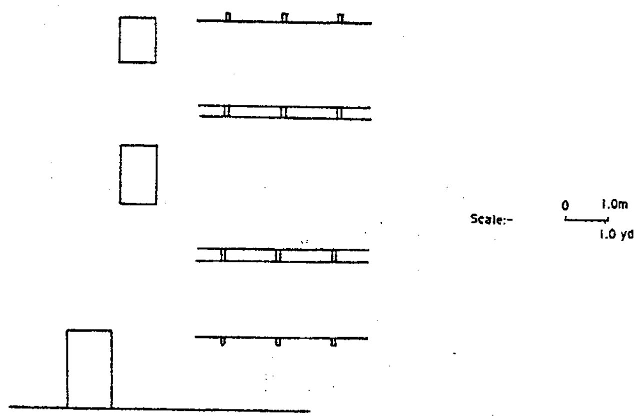


Figure 6. Side elevation (south-west) showing the relationship between the various floor levels within the mill and the external features.

The detail around the windows and door is impressive (and is too fine to be adequately shown on the Figures), emphasising the quality and status of the building. It has been constructed immediately adjacent to the dam for the pool (see Figure 2), the dam was undoubtedly there first as there was originally a high level doorway from it into the building. The dam has had to be supported by

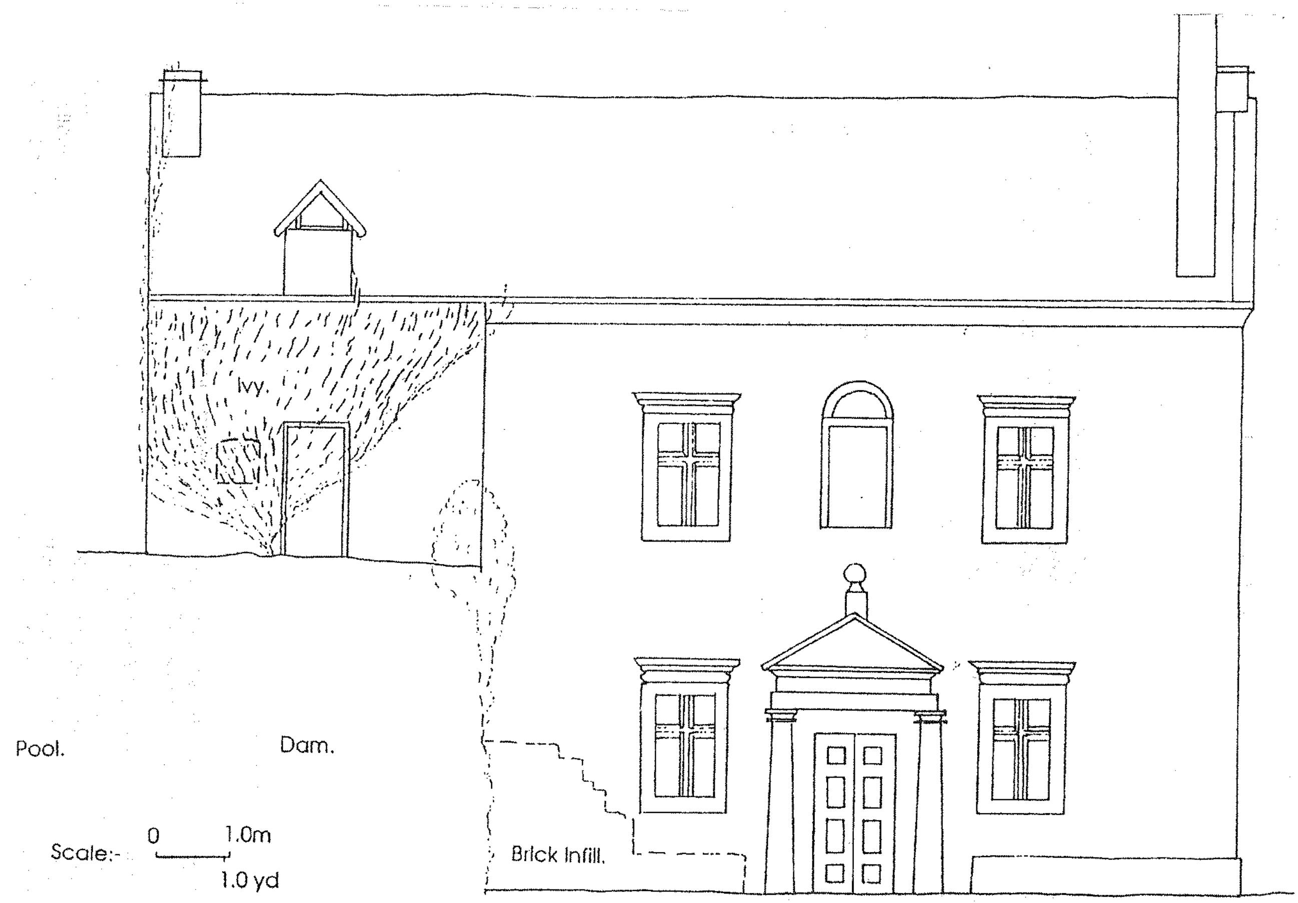


Figure 7. Front elevation (North-west).

Plate 2. View of the front of the mill showing the main entrance.

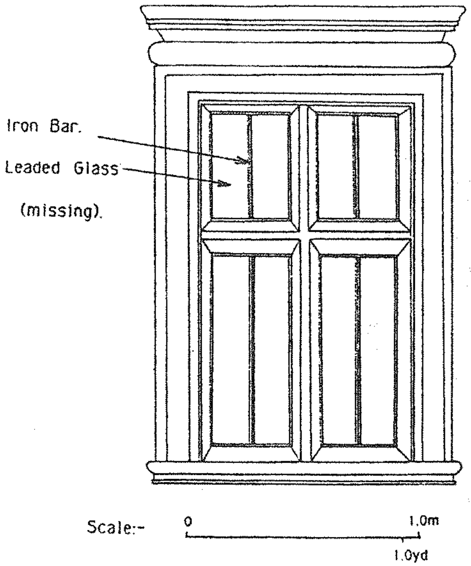


Figure 8. Window detail.

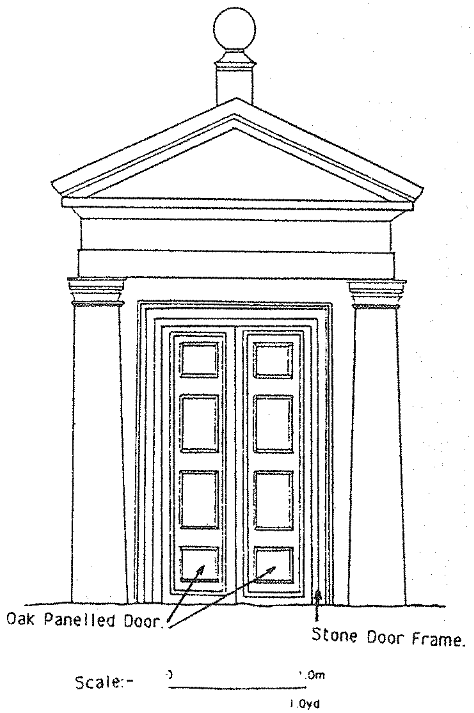


Figure 9. Doorway detail.

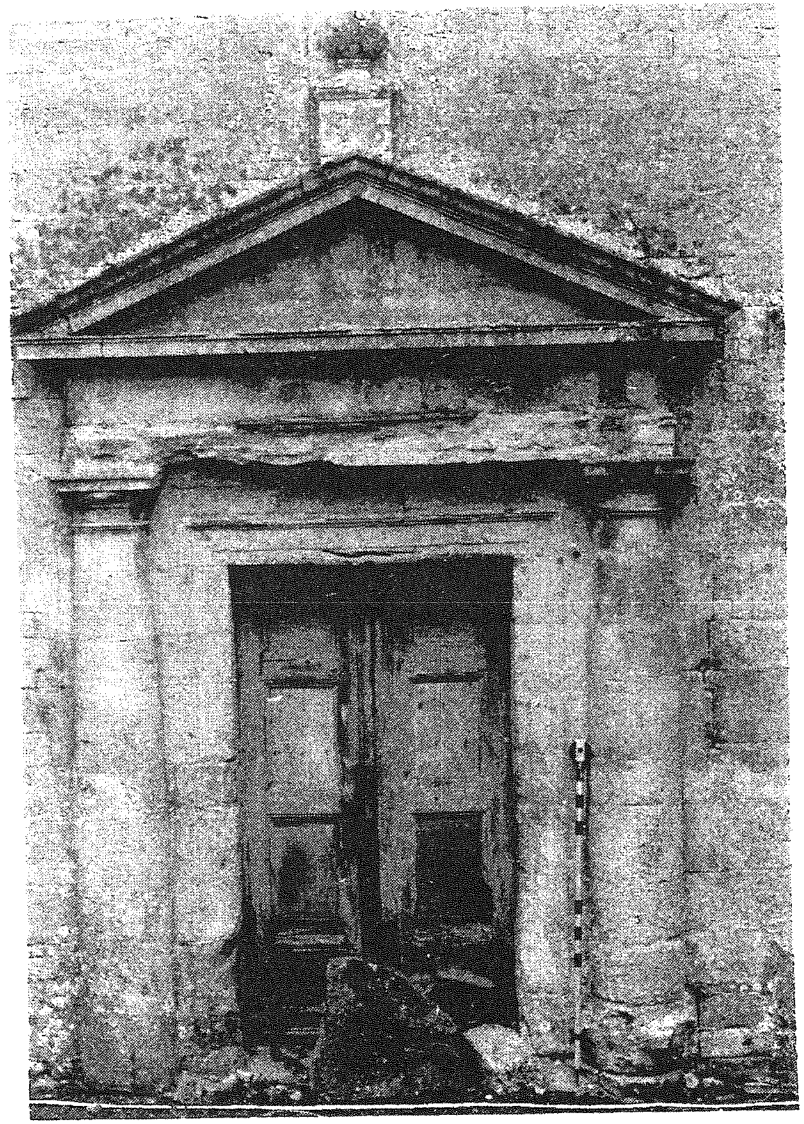


Plate 3. The main doorway into the mill.

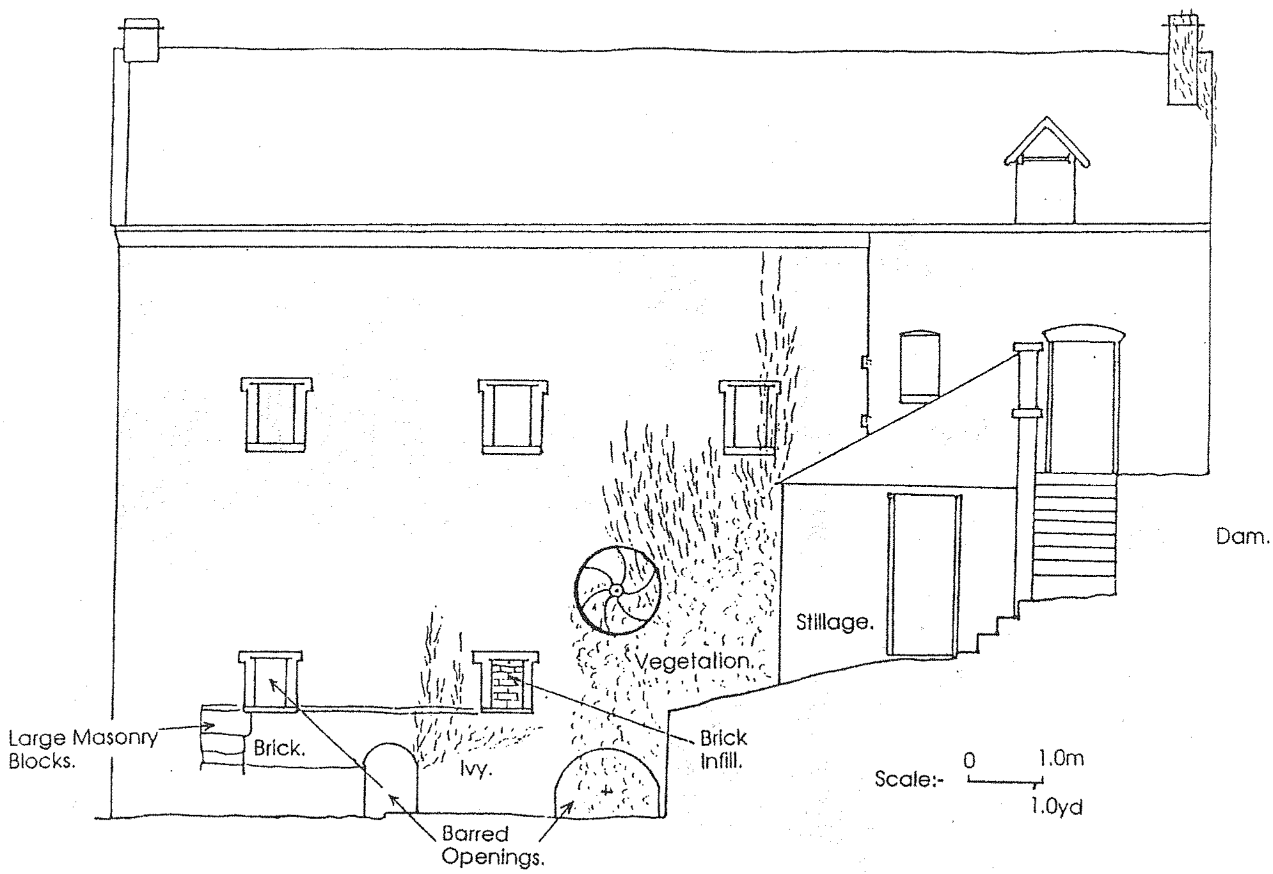


Figure 10. Rear elevation (South-east).

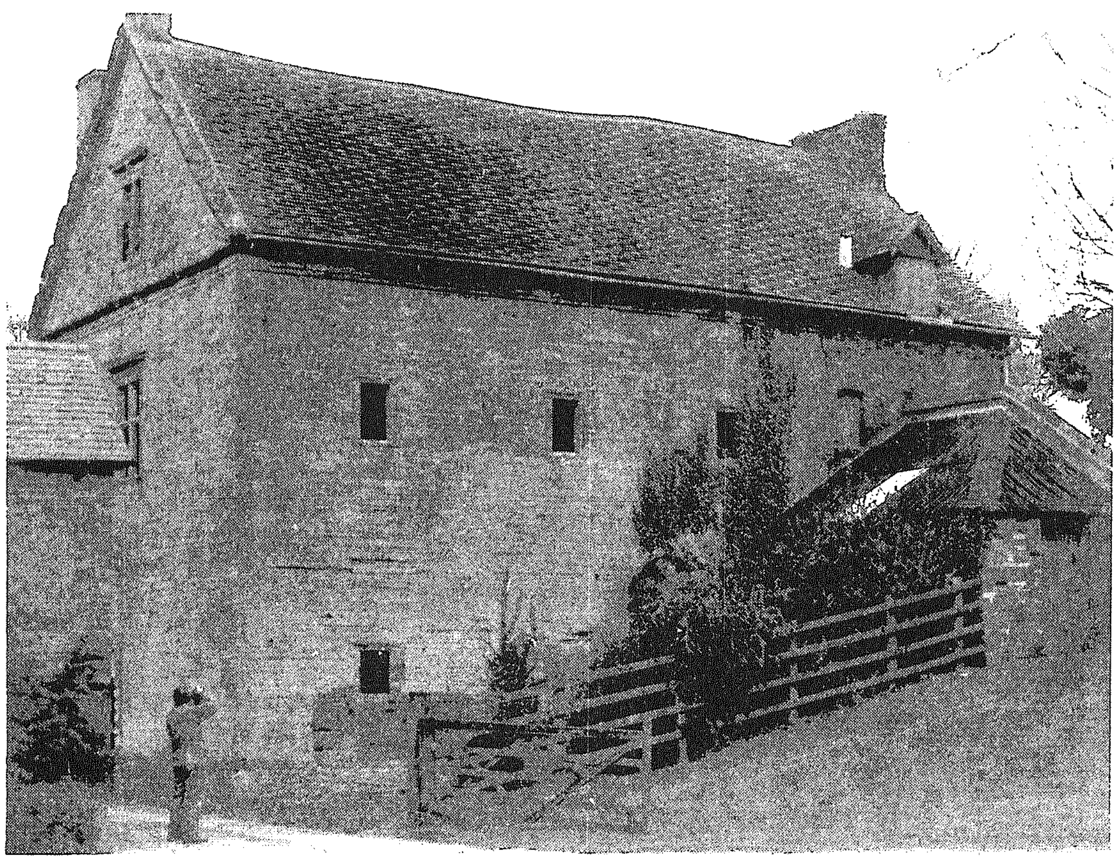
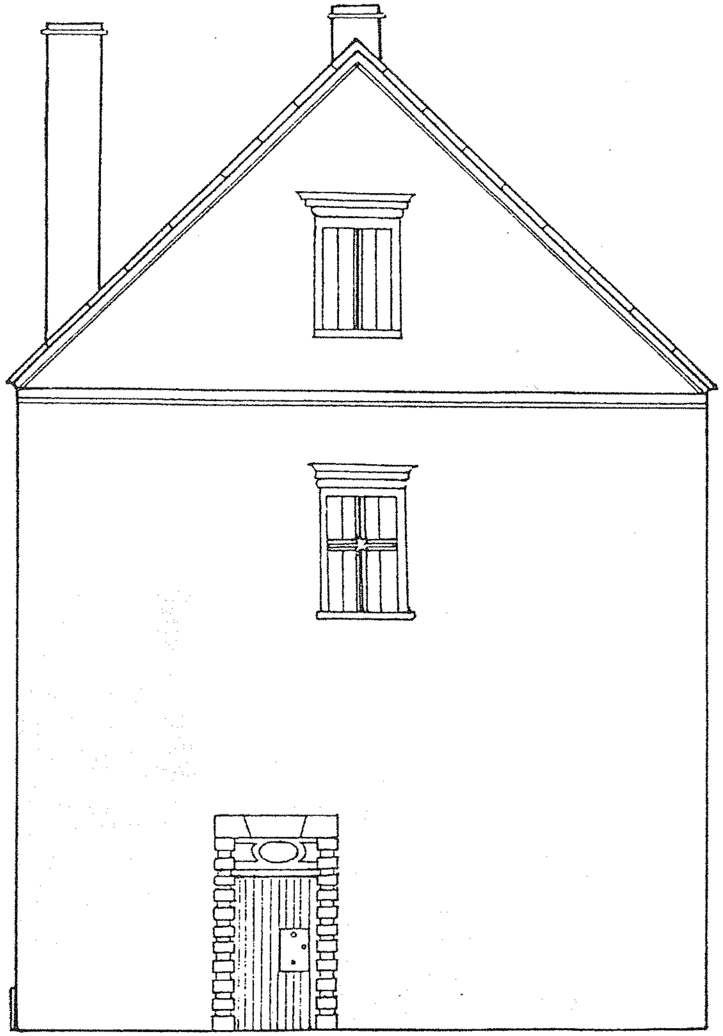


Plate 4. View of the rear of the mill showing the pulley used for the auxiliary drive.



Scale:- 0 1.0m 1.0yd

Figure 11. Side elevation (south-west).

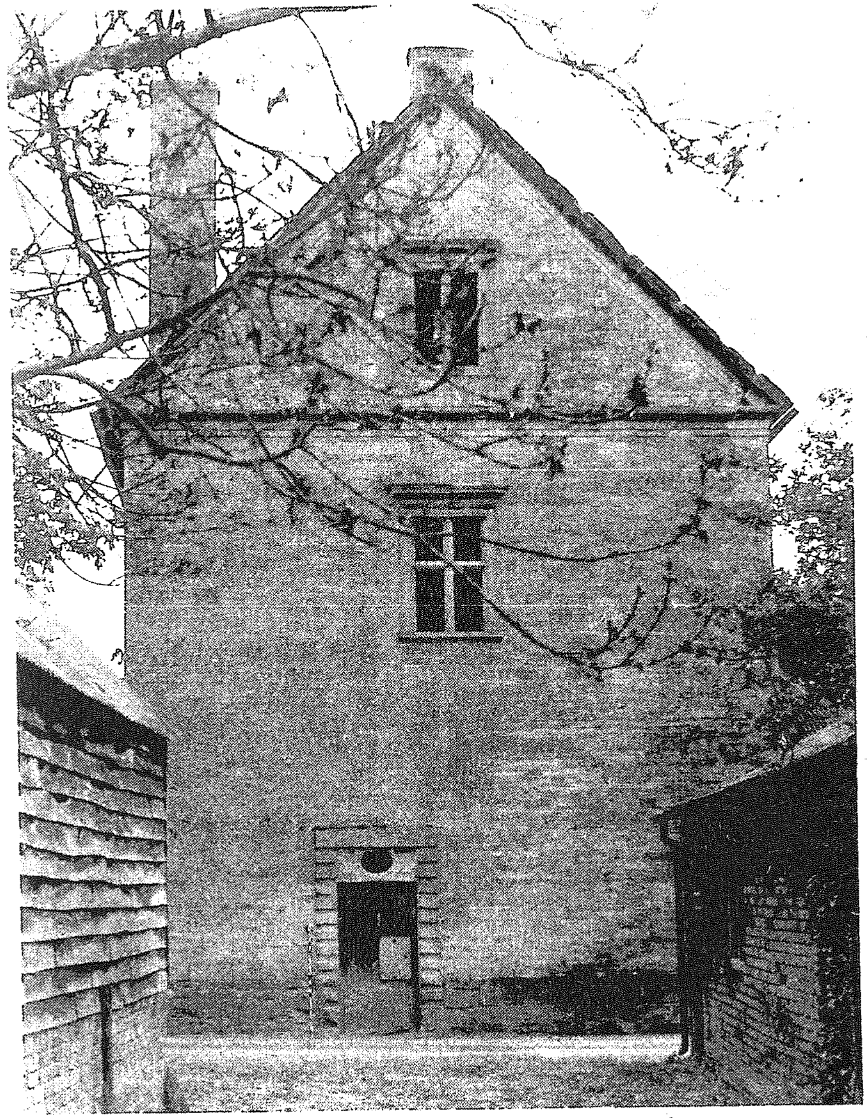


Plate 5. Side view of the mill showing the side doorway.

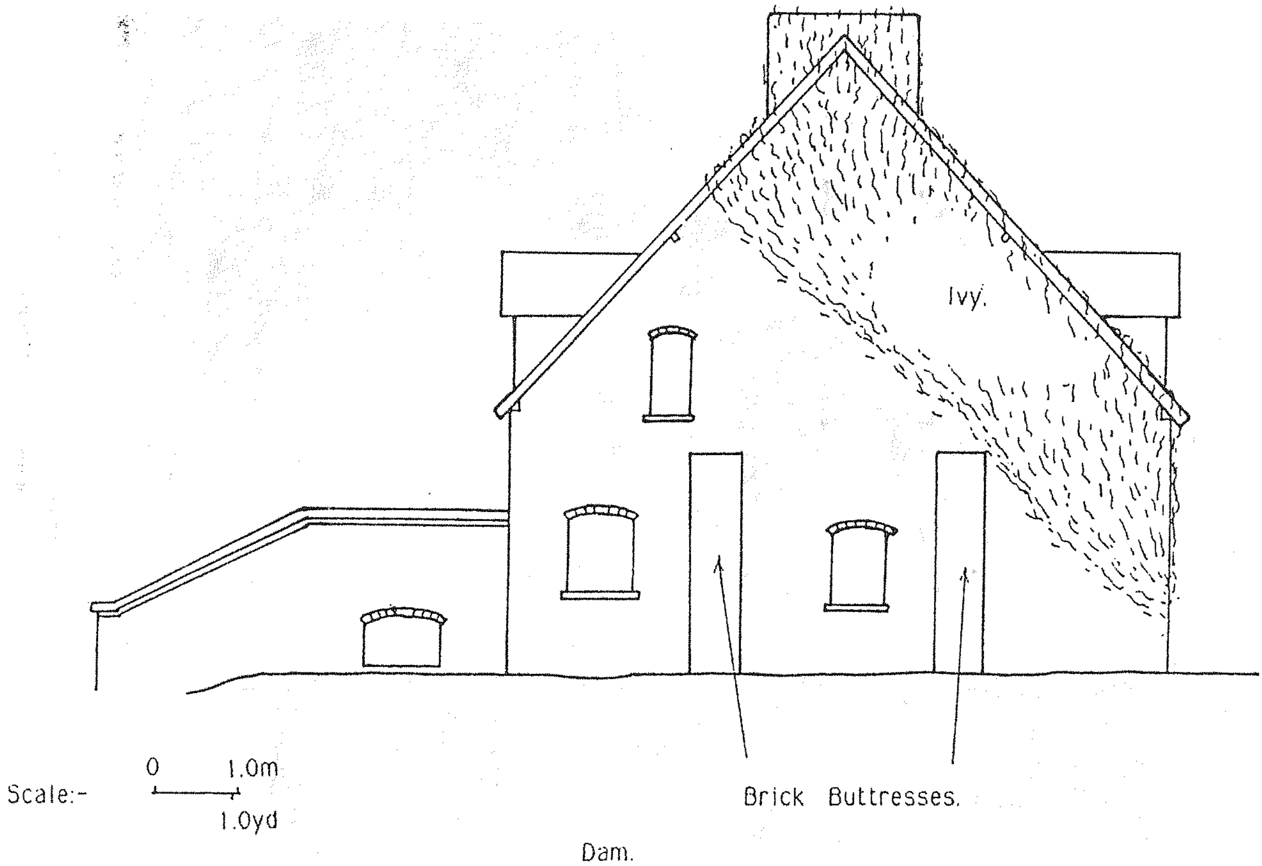


Figure 12. Side elevation (North-east).

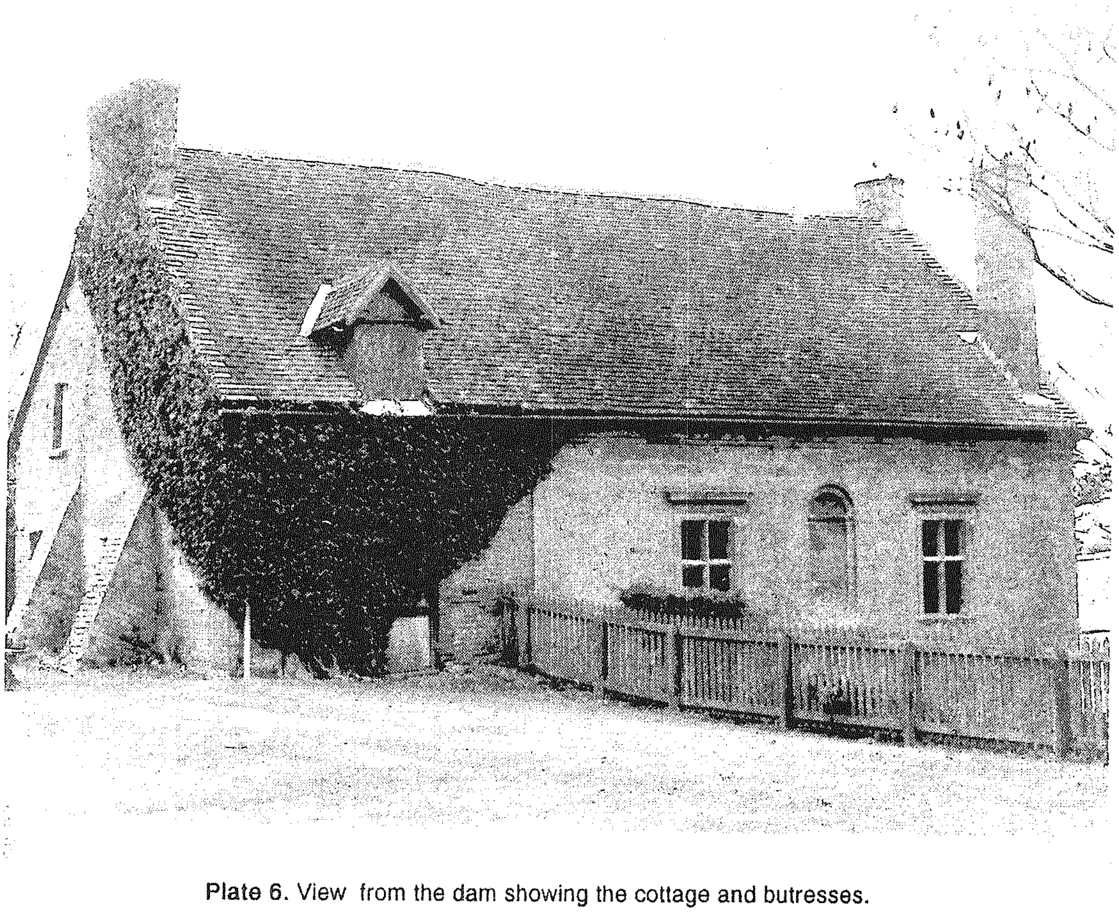


Plate 6. View from the dam showing the cottage and butresses.

brick buttresses immediately in front of the mill, and some repair work has been carried out to the mill in the corner adjacent to the dam. This has been done in brick.

Moving to the rear elevation (see Figure 10) a much simpler design is seen, again basicly symmetrical with smaller windows in moulded eared architraves. One lower window is barred, another infilled. Also at ground level are two barred segmented arches leading to the waterwheel pit. To the left can be seen the incorporated large masonry blocks suggesting the corner of an earlier building. Also in this area is a quantity of brickwork indicating repair work to the structure. Slightly above is a 6 spoked pulley wheel which would have transferred a belt drive into the mill, typically from a portable steam engine, but in this instance undoubtebly from the oil engine referred to in Part 2.

The side (south-west) elevation (see Figure 11) has symmetrical windows similar to the front, at first floor and attic levels, with a central stone internal chimney stack; and a later internal brick stack to the left. Offset to the left is a wide vertical plank door with a moulded lintel, containing an oval window, and set in an intermittently rusticated surround.

Moving to the later cottage addition, we see that no attempt has been made to match the style of the original building. It is of Flemish bond brickwork and only at the rear has any effort been made to physically bond it into the existing structure, yet the tiled roof is successfully carried over. Because it has been built at a higher level on top of the dam it only consists of a single storey plus attic.

The front (see Figure 7) presents a doorway with an ivy covered window immediately alongside to the left and a dormer window above. The side elevation (see Figure 12) has two shallow brick arched windows at the lower level, with a smaller arched window above, and a large internal brick chimney stack. The cottage must have suffered substantial movement as this side carries 2 large brick butresses. At the rear (see Figure 10) is another doorway, with steps leading down, a window to the left, and a dormer window, matching the front, above. A later addition is a brick built stillage, with side windows and single doorway, built partly across the mill.

Thus we have a very fine limestone building, probably built just before 1620, with an impressive front aspect, an interesting doorway on the side, and a simple rear elevation. Either built as a mill, or converted to a mill very soon after, its status was diminished, and as living accomodation was undoubtedly cramped within the mill, and storage space became a problem, we have a simple brick cottage tacked on the side, the only place it could be added, above the dam. This may have been in the early 19th century, possibly when an extra floor was inserted. the location has restricted its size and resulted in subsidence problems, however, being at a higher level and ivy covered at least its visual impact is reduced. The whole structure is a mixture of styles, producing a building every bit as interesting as the windmill nearby.

PART 4 - THE SURVEY OF THE MACHINERY

By Tim Booth

The waterwheel is overshot, measuring about 17ft 6ins diameter by 34ins wide. Access for an accurate survey is very difficult now as all openings to the wheelpit have fixed grilles. The measurements given here are those taken in 1971 during the author's survey of Warwickshire Watermills. The wheel has two sets of wooden arms, 6ins x 3½ins , bolted into the sockets of the cast iron naves. The arms are also bolted to the wooden shrouds which are 11ins deep and 2¾ins thick. The joints in the shrouds are reinforced with iron plates. The forty-eight buckets and the sole boards are made of iron. Part of the wheel has now collapsed and is generally in very poor condition.

The circular, cast iron wheelshaft, installed in 1916, measures 12ins in diameter and has four cast ribs. It clearly replaces a wooden shaft of somewhat larger proportions. The eyes of the hubs are hexagonal, no doubt reflecting the section of the wooden shaft, and the gaps between these and the later shaft are made up with hexagonal iron collars, keyed to this shaft, and wooden wedges. The pentrough is currently inaccessible though it appears to be all of iron, the gate having been renewed in 1916.

On the inside end of the wheelshaft is a cast iron mortised bevel pitwheel which measures 9ft in diameter. The pitwheel is constructed in four sections which are bolted together and has a total of one hundred and twelve cogs. The eye of the pitwheel is 17¼ins square, suggesting that the wooden wheelshaft was square at this point. However the space between the eye of the pitwheel and the later shaft is filled by a substantial casting and wooden wedges. The inner bearing of the wheelshaft is set in a massive wooden block which also supports the tripodal casting carrying the footstep bearing of the upright shaft. Above the three iron bands at its foot, this shaft is octagonal on the machinery floor, each face measuring 5½ins. The cast iron wallower is mounted 30ins above the foot of the shaft. This bevel gear, cast in one piece, measures 29ins in diameter and has thirty one teeth. Immediately above the wallower is the cast iron mortised great spur wheel which is 8ft in diameter. It has eight arms and was cast in two parts which are bolted together at hub and rim. There are one hundred and thirty four wooden cogs. The great spur wheel drove two cast iron stone nuts, both 19ins diameter with twenty five teeth. Both stone nuts could be disengaged by jack rings lifted by rack and pinion gear below. Tentering was effected by means of screws mounted on the ends of the bridge trees.

On the inserted stone floor are two pairs of millstones minus all their furniture. The upstream pair are millstone grit 4ft 4ins in diameter with a 8ins eye. The runner stone is mounted on a gimbal rynd which has two pins resting in recesses in the mace. A square boss carried the damsel which is missing.

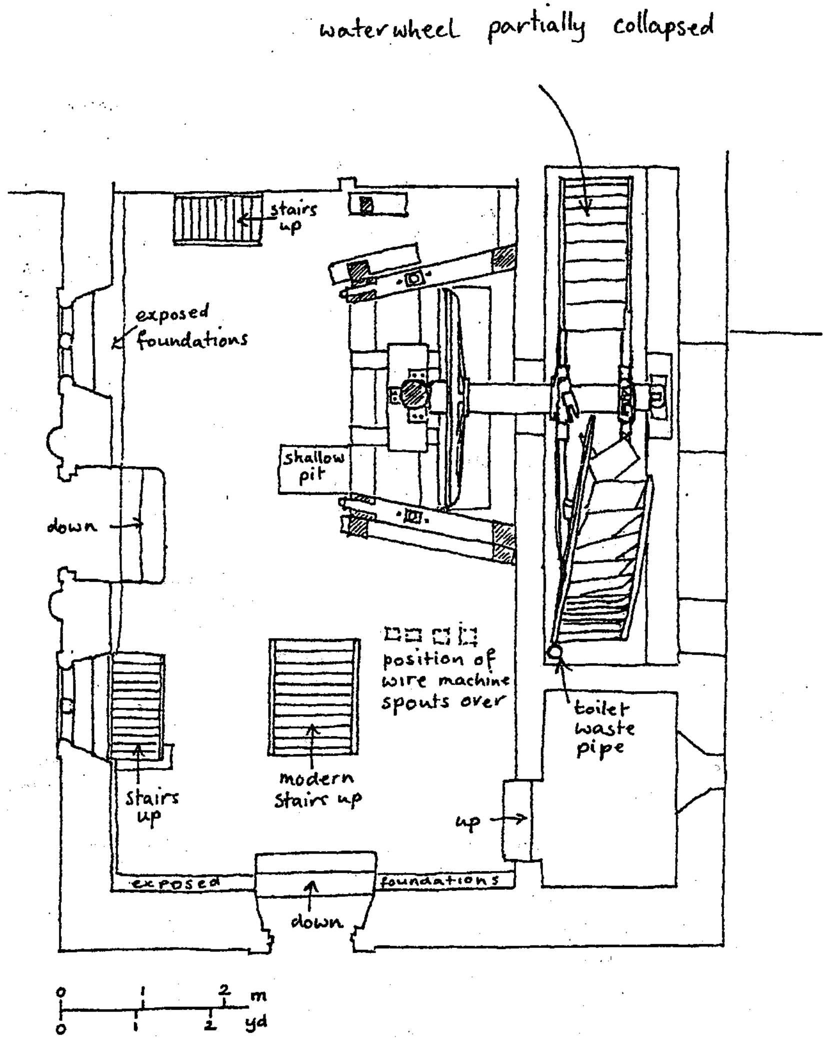


Figure 13. Level 1: The machinery floor.

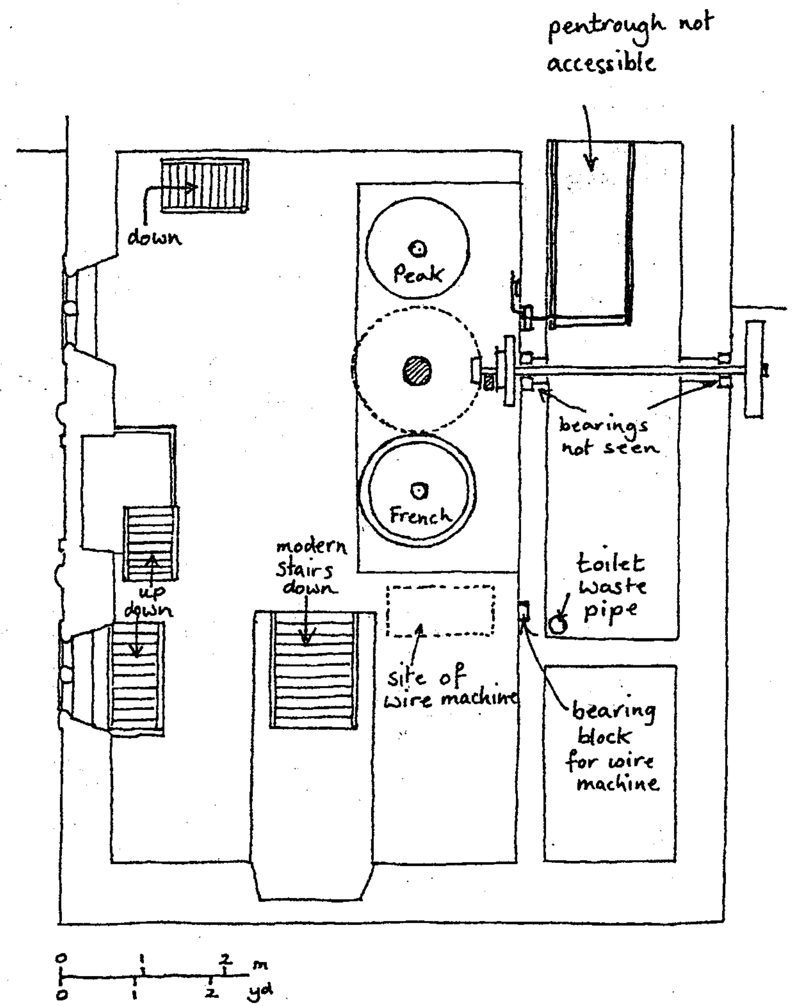


Figure 14. Level 2: The stone floor.

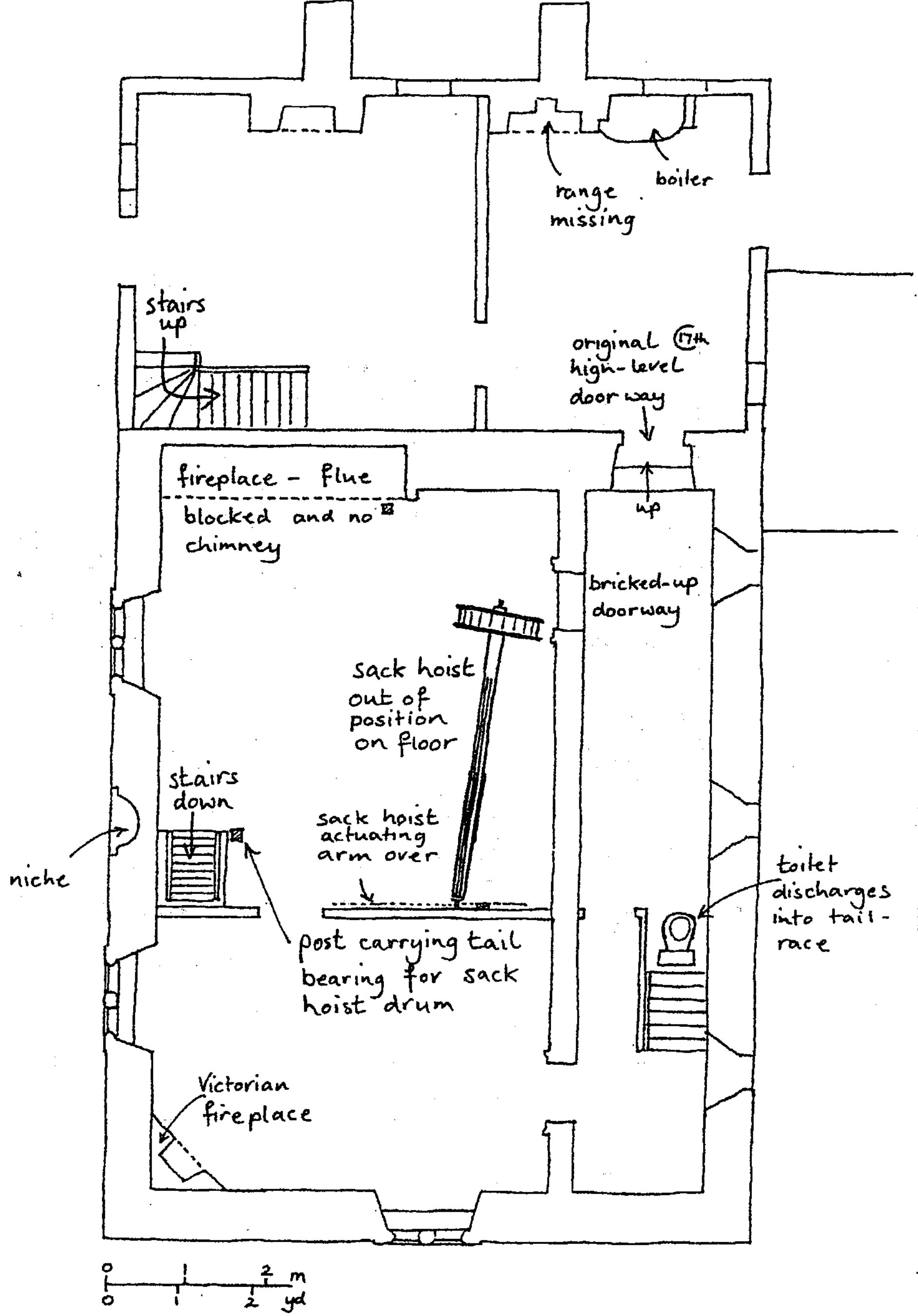


Figure 15. Level 3 with the position of the sack hoist.

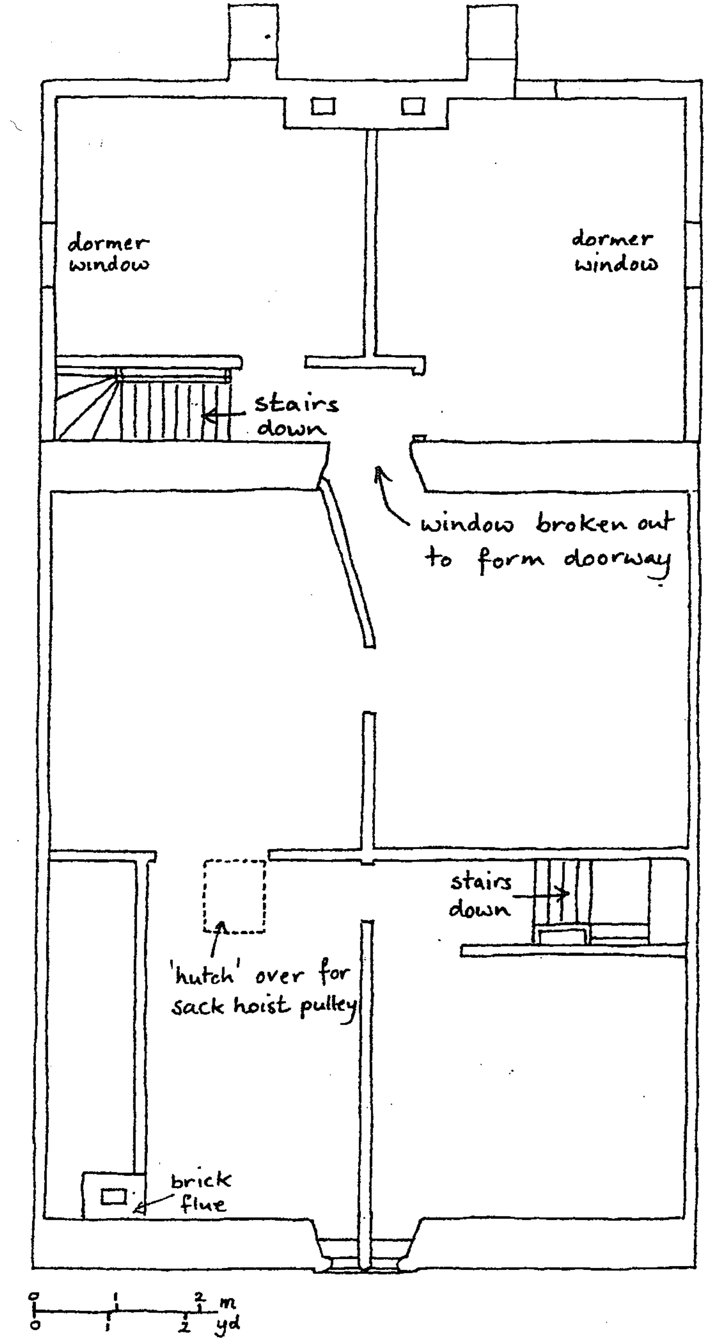


Figure 16. Level 4.

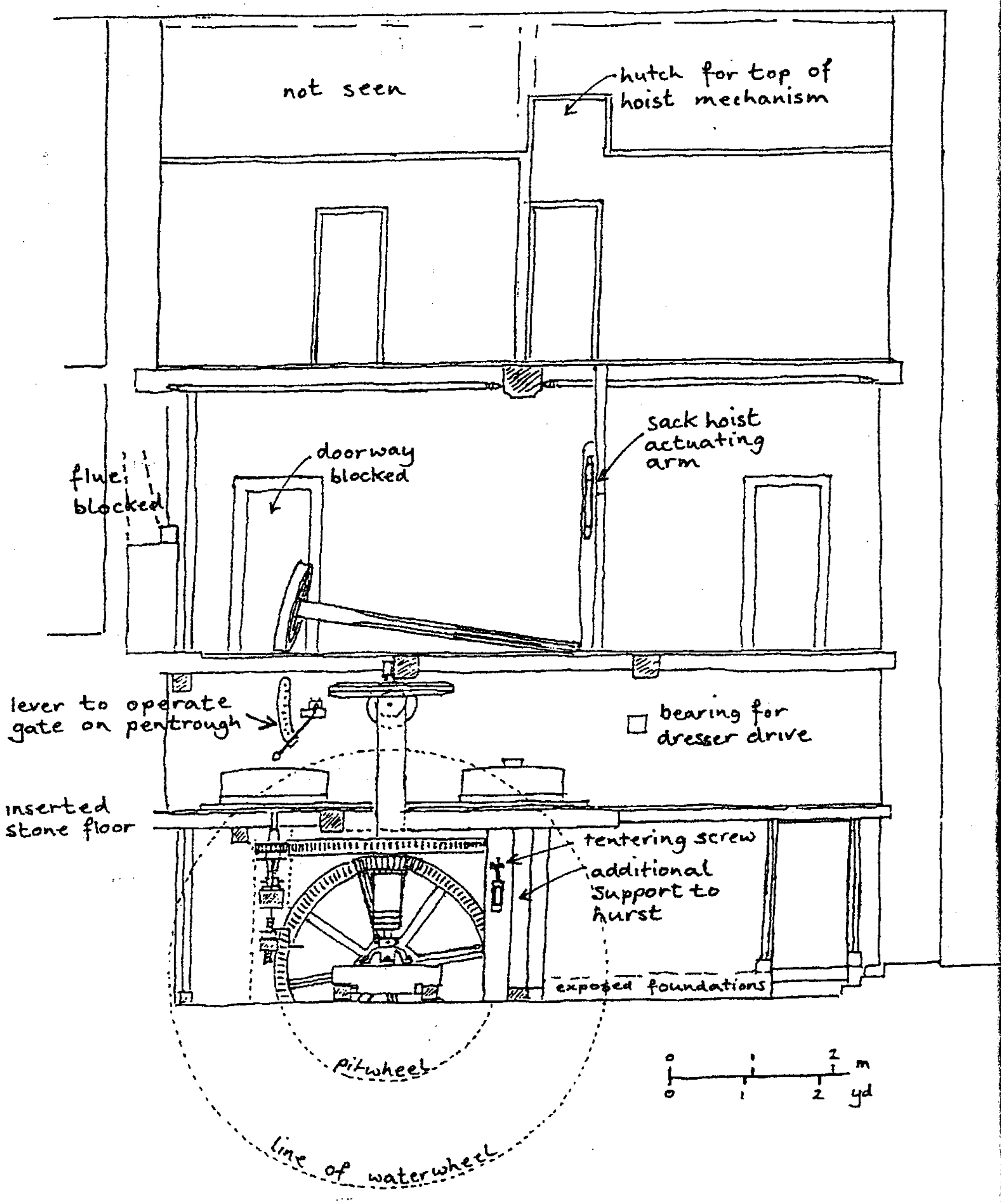


Figure 17. Section through the mill.

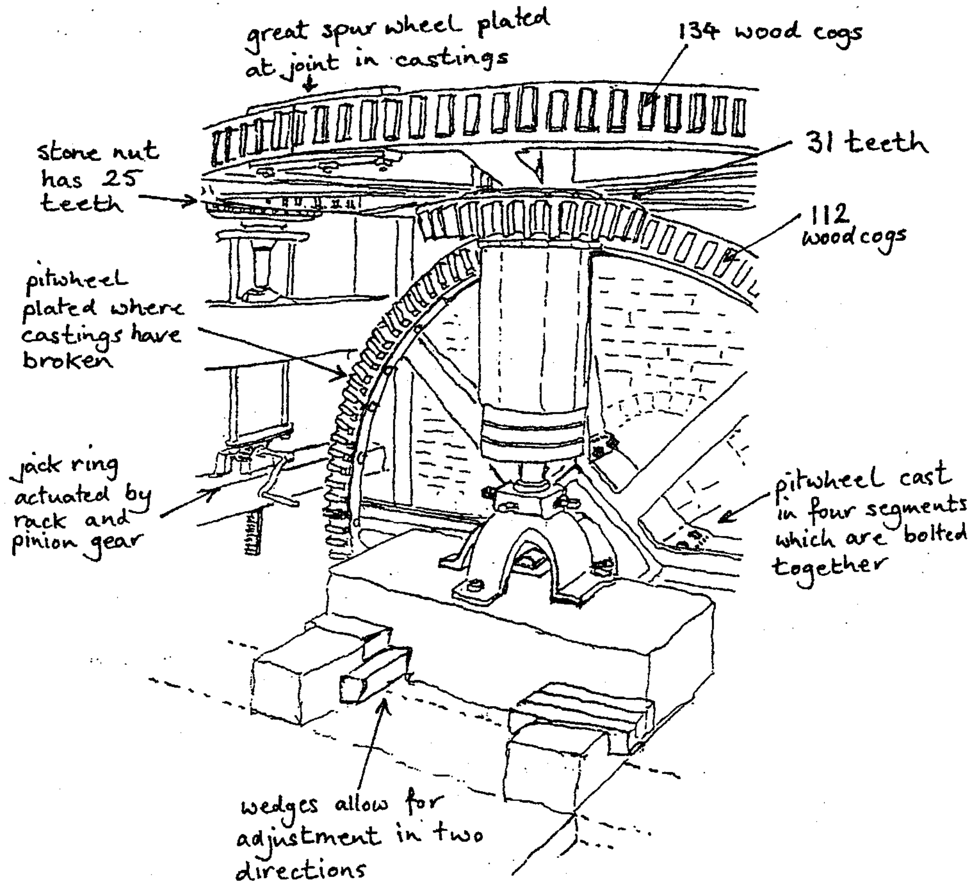


Figure 18. The main drive machinery to the millstones with the tentering gear at the laft

The downstream pair are French burrs, 4ft 1ins in diameter with a $8^{1}/_{2}$ins eye and a similar gimbal rynd is fitted. Once again the damsel is missing though the two holes either side of a circular boss on the mace show that it was the type with two legs. The upright shaft is now circular in section, $13^{1}/_{4}$ins in diameter, but reverts to octagonal 3ft 3ins above the floor. It carries a cast iron mortised bevel crown wheel, 5ft in diameter, which has six arms and eighty four wooden teeth. The crown wheel drove a small cast iron pinion with twenty teeth on a horizontal shaft which carries two wooden pulleys. This shaft continues across the wheelpit before emerging at the rear of the building where it carries a six arm pulley, about 4ft in diameter, which could be connected by belt to an engine in an adjoining building. The internal pulleys are fixed together; the inner one, 19ins in diameter with a 4ins rim, probably driving the sack hoist whilst the outer one, 34ins in diameter, drove a dressing machine. The machine itself has gone but a bearing block in the wall shows its position and the four blocked delivery spout holes in the floor suggest it was a wire machine. The sack hoist mechanism is tantalisingly incomplete. Even the final driving pulley and drum are out of position on the floor above but it is clear that this was mounted across the mill downstream of the machinery as the post carrying the tail bearing survives, as does the actuating arm against the partition wall. Being of the standard slack belt type, the hoist must have been driven from directly below. This would have necessitated an additional pair of pulleys in the drive from the crown wheel but no definite evidence of their position was noted. On the top floor of the mill, a 'hutch' in the roof space denotes the position of the top pulley of the hoist but the path of the chain to this pulley is not clear. Of course it is possible that we are seeing the remains of more than one system for lifting grain to the bins. The bins themselves have disappeared, though vestiges of more than one system remain. Too much of the boarding on the upper floors has been renewed over the years since the mill ceased to work to leave clear evidence of the position of the auxillary machinery and fittings.

All the main machinery appears to date from the 19th century, with the exception of the wheelshaft which is known to have been fitted by Alfred H.Summers of Tamworth-in-Arden in 1916. There is no evidence to suggest the form of the machinery it replaced but it is conceivable that it was of the one-step gearing type with a single pair of stones mounted on a low hurst. Such gearing would easily have fitted on the original ground floor of the building leaving the upper two floors for the miller's living accomodation. When the decision was taken to install spur gearing to drive two pairs of stones, there would have been insufficient height for the additional gear which necessitated the lowering of the ground floor level. By deepening the tail race at the same time, a larger, more powerful waterwheel could be fitted to drive the additional machinery. Creating storage capacity on the upper floors would have taken up much of the living accomodation so the cottage adjoining the mill was built on top of the dam.

PART 5 - CONCLUSIONS

There are a number of questions that have been raised concerning the history of the watermill at Chesterton and, in fact, this survey has raised further queries. Consequently there is quite a list of unresolved details to be examined.

Firstly, there is the question of the original use of the mill building. It has always been thought that the building originally served another purpose, being converted to a mill some time later. However a similar theory was held about Chesterton windmill, but recent research has shown that it was built as a windmill in the first place. As the watermill was built at a similar time to the windmill, the possibility that it was purpose built as a watermill must be considered.

Secondly, when exactly was the mill built or when was it converted to a watermill?

Thirdly, what type of milling machinery was in use in the mill originally?

Fourthly, when was the extra floor inserted into the building and did this occur when the extra living accomodation was added (as seems likely)?

Fifthly, when was the current machinery fitted in the mill, as it has every appearance of being Victorian in date, was this fitted when the extra floor was inserted?

And, finally, there is a need to ascertain any information concerning the millers and their families during the period from 1674 to 1758, a period for which no records are readily available.

It was thought that a detailed survey of the mill building together with its remaining machinery might throw some light on possible answers to this tantalising enigma that is Chesterton watermill. Unfortunately that hope has not been vindicated, consequently the questions are still in need of resolution. However the survey has produced a comprehensive record of the mill as it was during the 20th century, with 19th century machinery in a 17th century building. It is possible that some answers might still lie in the Willoughby de Broke Collection, at the Shakespeare Birthplace Trust in Stratford-on-Avon. This record is written in a type of Latin which was found difficult to translate in the time available, consequently there are large parts of this archive still waiting for the enquiring molinologist with experience of 17th century English 'Latinised' script.

The Midland Wind and Water Mills Group continue to carry out and publish original research as a group effort, so if further information concerning the history of Chesterton watermill does come to light it is likely to be published in 'Wind and Water Mills' in the future.

THE WIND AND WATER MILLS OF CRETE

By Alan F. Gifford

Introduction

The wind and water mills of Crete are fascinating! The significant differences between them and those found in Western Europe make them well worth close examination and the writer, during several visits to the island, has been able to examine examples of both the wind and water mills which are scattered around the countryside. The following notes are based on personal observations and on various reports and books which have been consulted. The relevant references are given in a bibliography at the end of this note.

The island of Crete is situated in the eastern Mediterranean and is some 160 miles from east to west, but only about 40 miles wide. The climate is such that the wind generally blows from one direction, the north-north-west, making it possible to use simple, unidirectional, or fixed, windmill structures in many locations. Windmills are generally situated on the north and north-eastern coast, although some are to be found inland, particularly on the high Lassithi plateau.

The rainfall occurs mainly in the winter months, around 200 mm falls each year. The predominantly limestone terrain retains little surface water and the rainfall eventually emerges as myriads of small streams and rivers. Watermills are therefore common in the many mountain valleys, particularly to the north of the Mesarsa plain, in the south central regions of the island.

Watermills in Crete

The Cretan mill works on the basis of conversion of hydrostatic energy into kinetic energy. Water is fed from an artificial pond or directly from a stream, along a narrow aqueduct into an almost vertical masonry fall pipe. Water is jetted out, at about right angles to the vertical pipe, into a wheel chamber where it impacts on a horizontal water wheel and causes this to rotate. A vertical spindle leads from the waterwheel directly to the millstones, i.e. using a direct drive with no intermediate gearing. A potential efficiency of up to 80% has been claimed for these mills, with the speed of the stones between about 125 and 250 r.p.m. In addition Cretan mills need only relatively small amounts of water to operate efficiently and economically, a valuable feature when water is not always readily available!

The main feature of such mills is the elongated tower which houses the fall pipe (see Figures 1 & 2), this together with an associated aqueduct, projects from the hillside rather like the conning tower of a submarine. The tower is slightly inclined towards the hillside and leans back towards the aqueduct.

Figure 1. View along a stone aqueduct to the fall pipe of a Cretan watermill.

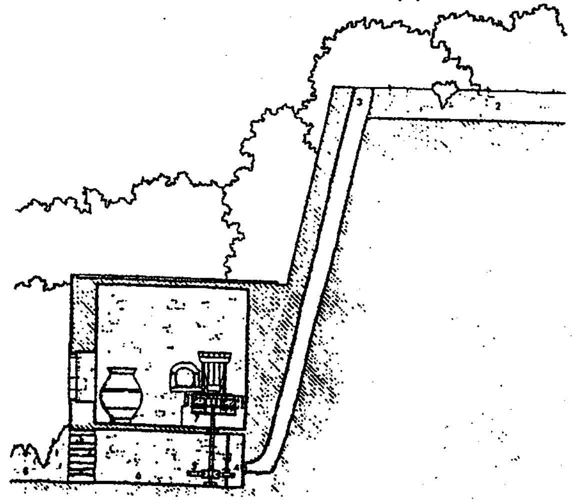


Figure 2. Cross section of a typical watermill showing the inclined fall pipe.

The aqueduct and the tower itself are generally made of ashlar masonry, bonded by very strong mortar. The sub-structure may be of dry stone construction. Some mills have twin towers, each associated with its own vertical fall pipe and pair of millstones. In some older mills the fall pipe is made of annular rings of stone, lined with mortar, presumably to reduce friction losses. At a mill in Zaros which had been demolished the nine rings examined were tapered from about 430 mm diameter at the top to 370 mm diameter adjacent to the outlet hole (see later). The wall of the stone rings was approximately 100 mm thick (see Figure 3).

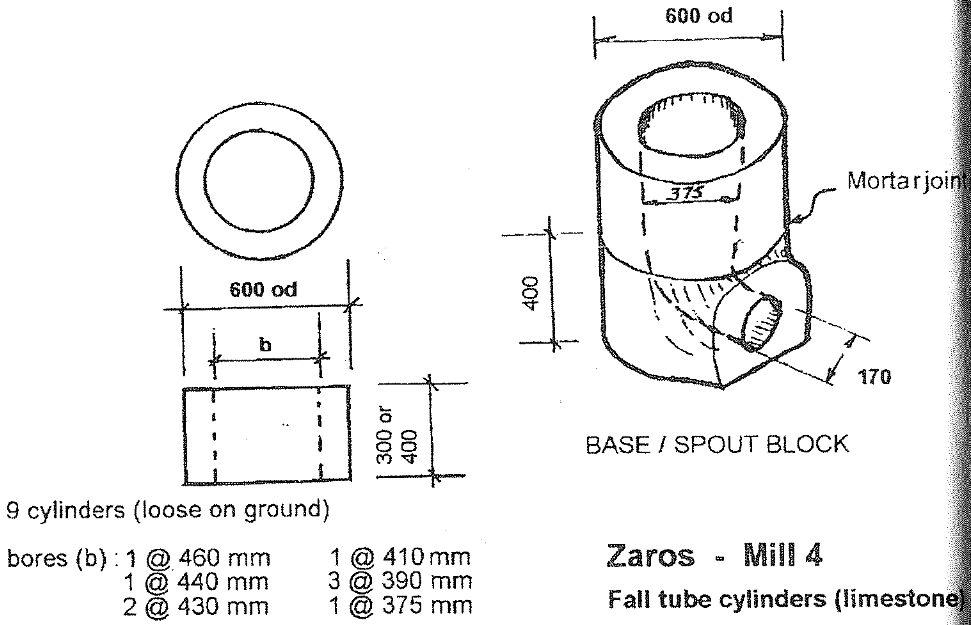


Figure 3. Fall tube cylinders made of limestone at Zaros.

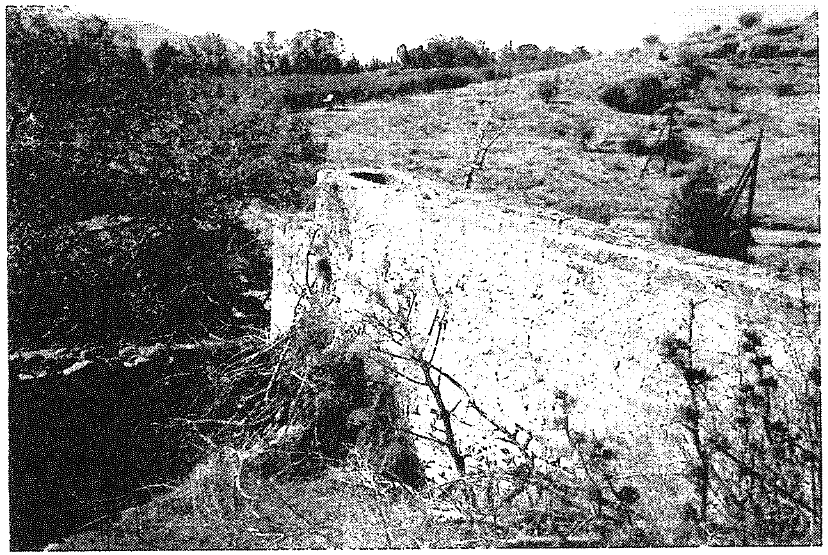


Plate 1. The stone aqueduct, with mill beyond, at Gortys

In some later mills however, the masonry tower structure has been replaced by a much more functional channel and tower, made from reinforced concrete. The fall pipe in such cases had been formed around old oil drums, the ends of which had been cut out. The drums had sometimes been removed, apparently just before the concrete set, but in others had been left to rust away. Such later mills appear to date from the early 1940s.

The fall pipes range between about 5 and 12 metres in height, depending on the site. They may be associated with stone or, more recently, concrete aqueducts several hundred metres in length in order to bring the water to a suitable location for the mill. A typical section of the water channel was 500 mm deep and 450 mm wide. At the lower end of the fall pipe is a block of stone shaped such that the water is turned through right angles into the wheel chamber. An externally tapered hollow wooden nozzle or plug, some 125 mm long, is inserted into the outlet at the lower end of the fall pipe. The tail end of this plug is about 150 mm diameter and there is a central hole, about a 60 mm diameter, through which the water emerges. This constriction further increases the energy imparted by the water onto the wheel. In at least one mill, at Zaros, the size of the outlet could be changed by bolting annular metal rings (or orifice plates) with various sized holes, onto the face of the wooden plug (see Figure 4). The size of orifice plate used was dependent on the availablity of water supplies at the time and the miller at Zaros, Mikhali Franjadakis, advised that the following data was applicable to his mill:-

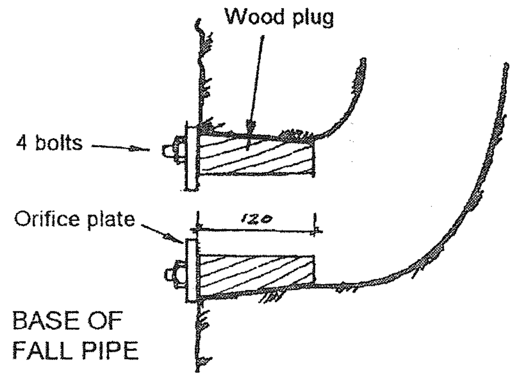


Figure 4. Orifice plate at a mill at Zaros.

Diameter of orifice plate	Output of flour (kg/hr)
50 mm	50
60 mm	60
80 mm	100

When the stream or river supplying the mill does not normally provide enough water, a mill pond may be built to provide reserve capacity. A terraced or slightly sloping terrain is sought in order to keep the length of the retaining walls to a minimum. The pond shape is irregular and varies in depth from 700 mm to 1400 mm. There is normally a gate, or sluice, at the junction with the aqueduct and the tower. This may be operated by a wire or rope in the mill building below to control the flow of water into the tower but in other cases was worked by a simple manual operation.

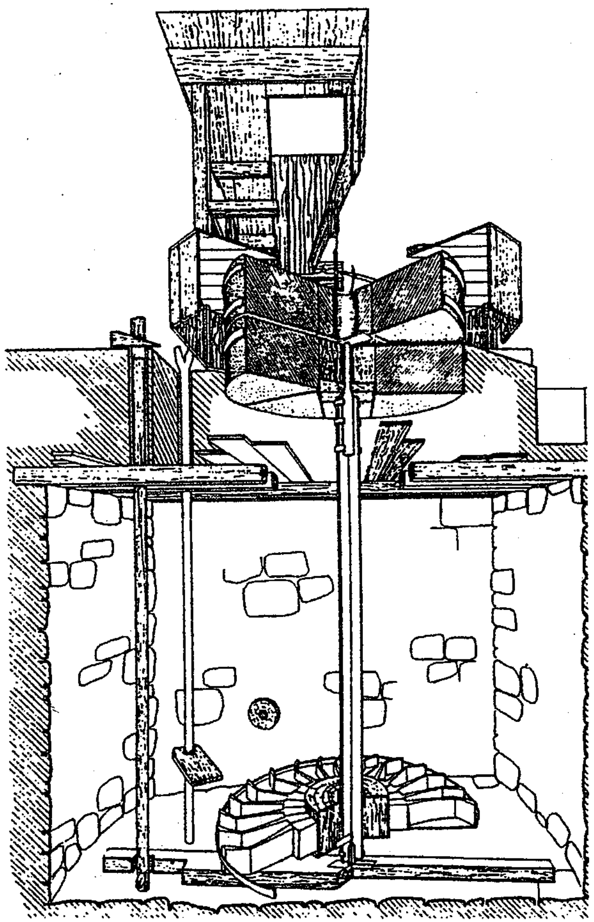


Figure 5. The essential mechanism of a Cretan watermill.

The waterwheels (see Figure 5) were originally constructed essentially of wood, with the diameter varying between 900 mm and 1200 mm. Some examples of this type of wheel can still be found. The wooden core or hub of such wheels is about 300 mm diameter. The curved, shaped, paddle-like blades, are jointed into the hub and their circumference held in place by an iron band. In

later mills the wooden construction was often replaced by a similar sized wheel fabricated from metal strip, with curved vanes and a metal rim (see Figure 6). The hub of the wheel is rigidly fixed to a rigid hardwood spindle (or in later mills a metal spindle) which runs up to the millstones. The lower end of the spindle often sits on an iron ball or stone bearing, lubricated by lard. This can be raised or lowered on a lightening arm to tenter the stones. The necessary control rod is inside the mill, adjacent to the stones, both wedge and screw adjustments were noted.

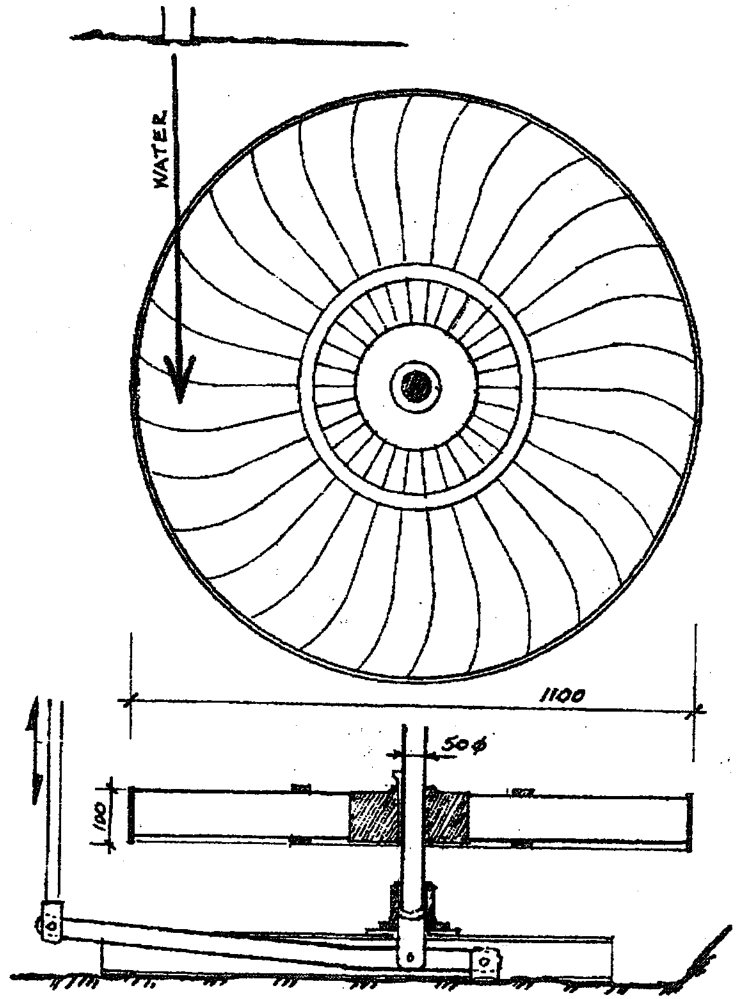


Figure 6. Plan & cross-section of metal waterwheel at Zaros.

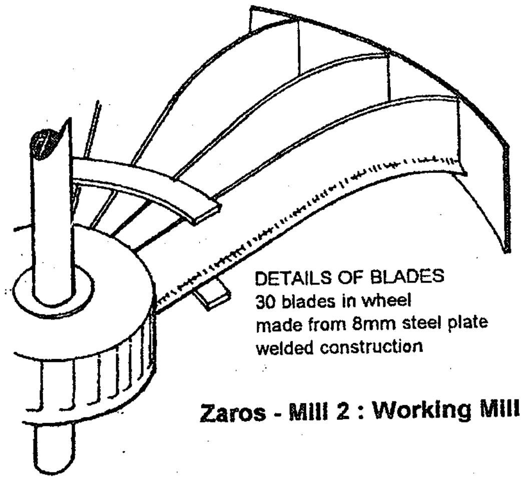


Figure 7. Details of the metal waterwheel at Zaros.

The runner stone is attached to the top of the vertical spindle by means of an iron plate which is dovetailed across the eye of the stone and which fits onto a rectangular metal projection on the spindle.

As previously described the water flow to the drop tower may be controlled by means of either sluice boards or removable plugs, but the actual operation of the waterwheel is regulated by a wooden deflector plate located in the wheel chamber (see Figure 5). This is typically about 400 mm long and 100 mm wide, mounted on a vertical rod and activated by means of a lever located at the side of the hurst. When the plate is turned out of the jet, the water directly hits and rotates the waterwheel. However when the plate is moved into the jet the water is deflected away from the wheel, filling the chamber with spray and thus stopping any rotation.

In the working mill at Zaros flow is controlled in an unusual manner by using a tube to deflect the water flow away from the wheel (see Figure 8). A 1200 mm length of 150 mm diameter horizontal steel tube is pivoted at one end on a wooden beam in such a manner that the other end can be moved transversely into the water jet. In this case the water passes through the tube and over the top of the wheel, straight into the tailrace. When a heavy metal rod, which has its free end located near the mill stones, moves the free end of the tube to the side of the jet, then the water jet directly hits the waterwheel and causes it to rotate.

The mill buildings, normally made of local stone, are purely functional, containing essentially the millstones, associated equipment and storage areas, although some basic living quarters were noted in a few mills. Most mills have only a single pair of stones but those with twin towers had two pair of stones, one associated with each tower. The stones normally have a wooden vat totally enclosing them but in some cases the top of the runner stone was not covered. The corn is fed into the stones down a chute which may be activated by a form of trailstick running on the surface of the runner stone. This stone may then have radial grooves in the top surface to improve the shaking or feeding action

of the grain into the eye of the stone. In some cases a damsel similar to the traditional British damsel was seen to be fitted. The stones are not normally furrowed or dressed, as in Britain and elsewhere, but are regularly 'pecked' with a sharp bill over the entire surface area. At least one metal stone crane was seen, in a mill at Zaros.

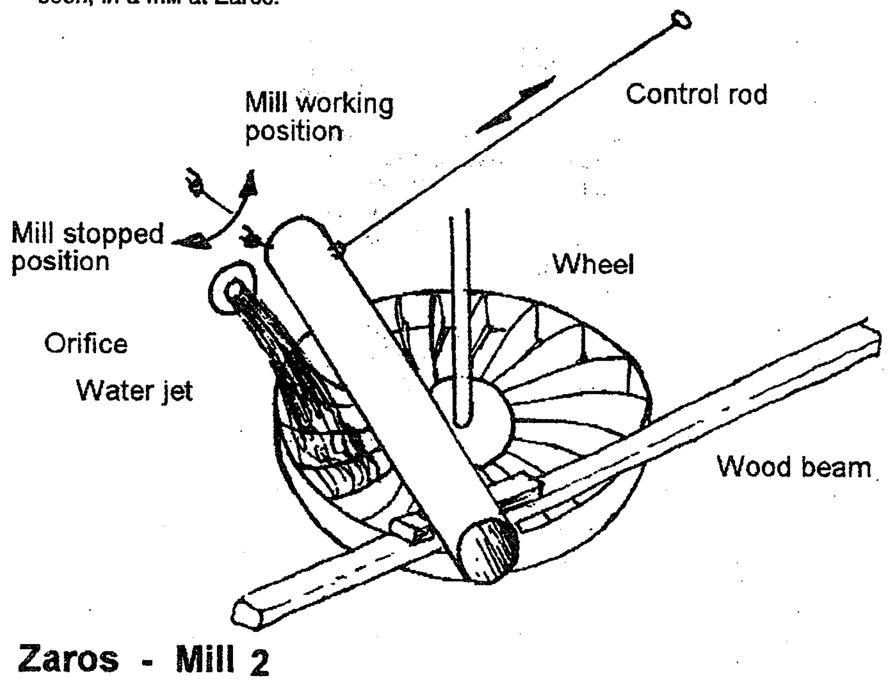


Figure 8. Water jet deflector at a mill at Zaros (jet hitting the wheel).

The millstones are quarried in small pieces, often on the island of Milos or the island of Kimolos, to the south of Greece and imported into Crete. The stone, which is of volcanic origin, has been identified as a Siliceous Trachyte containing about 97.2% of SiO_2. It appears to be similar to French Burr Stone but does not have quite so many voids. The pieces are assembled into complete millstones in the same way as French burr stones, i.e. bound with a circumferential iron band, or bands, and with the back sealed with plaster. The number of segments making up the stones has been found to be in excess of twenty. The stones, which are typically about 1000 mm to 1200 mm in diameter, start life at about 250/300 mm thick, but as in other countries, end their lives much thinner! In a number of cases the central core of the millstone, (typically 300 mm square) which contains the eye of the stone, was found to be made of hardwood rather than stone. The reason for, or the benefit of this, was not clear. No monolithic millstones have been found in Crete to date.

Water mills were often owned by several individuals who all input work to the mill, depending on their financial stake. The poorest owner often ended up running the mill. The reward for his efforts was about one twentieth share of what he ground!

Many large monolithic edge runner stones are to be found on the island which were used for crushing olive oil seeds. These are made of different material from the millstones, probably local limestone.

It was also established that conventional millstones, normally used for grain, were also used at appropriate seasons of the year, for crushing or bruising olive oil kernels. It appears that for this operation the gap between the stones was set very high, the kernels were fed into the hopper and the bruised product emerged at the edges of the stones ready for pressing to extract the oil. This possibly explains why large iron crushers or presses were sometimes to be found in corn mills. The clean up process to return to flour milling must have been tedious!

Water power was also used in the island for processing and cleaning woollen carpets and woven cloth, often in association with a corn mill. A bowl shaped concrete container, about 3 m in diameter and 1.5 m deep was built into the tail water flowing from the mill and a jet of water fed directly onto the material in the bowl, surplus water simply overflowed to the next mill. We did not identify the use of any detergent or scouring medium being used. The material was tumbled for many hours and was cleansed and thickened during the process.

Traditional fulling mills were also used and the complete wooden structure of a four hammer mill has been found in a ruined building at Argouropolis, in the west of the island. This type of mill again used a masonry fall pipe with the jet of water driving a vertical waterwheel mounted on a large wooden shaft which activated cams to operate hammers (see Figure 9). The damp woollen cloth was apparently folded 'concertina fashion', inserted into the stock and hammered for about 30 minutes. It was then removed, re-wetted and the process repeated for at least 24 hours. The resultant felt-like material thickened up considerably compared to the original cloth and was said to be both wind and rain proof. Parts of a dismantled two-hammer fulling mill have also been found in the mill complex at Argiropolis.

Apart from the wheels on these two fulling mills only one reference to a vertical waterwheel on the island has been found. Calvert reported that in the early 1970s there was a 3.2 m by 0.73 m undershot wheel at a corn mill at Almyros, on the coast in the north of the island. The site has been visited and although there are traces of associated water channels, all the mill building and machinery have long since disappeared.

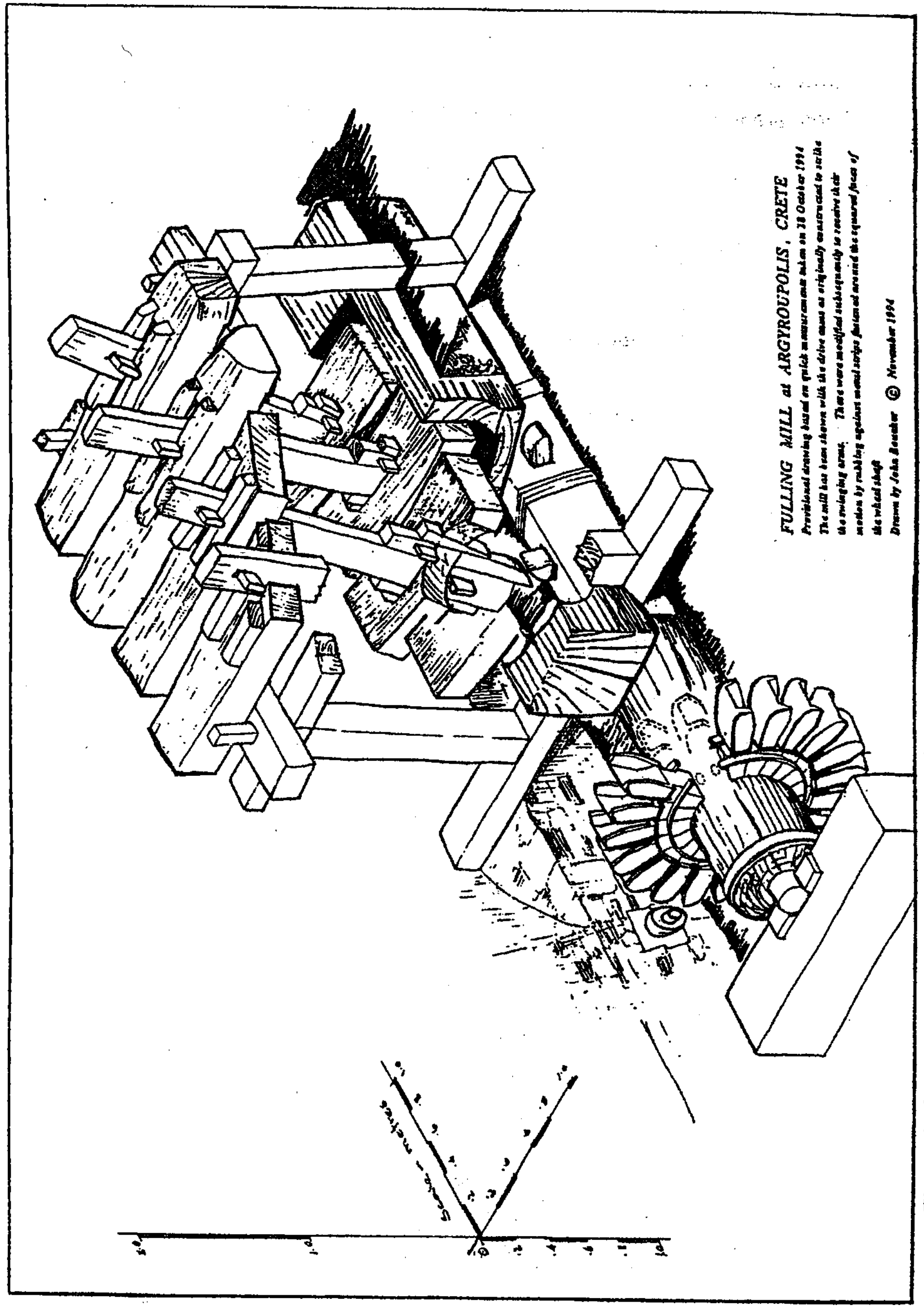


Figure 9. Sketch showing the main features of a four wooden hammer fulling mill discovered at Argyropoulis.

Windmills in Crete

There are three types of windmills commonly encountered in Crete:-

A stone corn mill which is uni-directional which will be referred to as a 'fixed mill' (see Figure 10). The local name for such mills is 'mono kairos' or single weather.

A stone tower corn mill, upon which the cap can rotate, such that the sails can face into the prevailing wind (tower mill).

An irrigation mill with canvas sails and a tail vane mounted on a metal or stone tower, used for pumping water (wind engine) (see Figure 11)

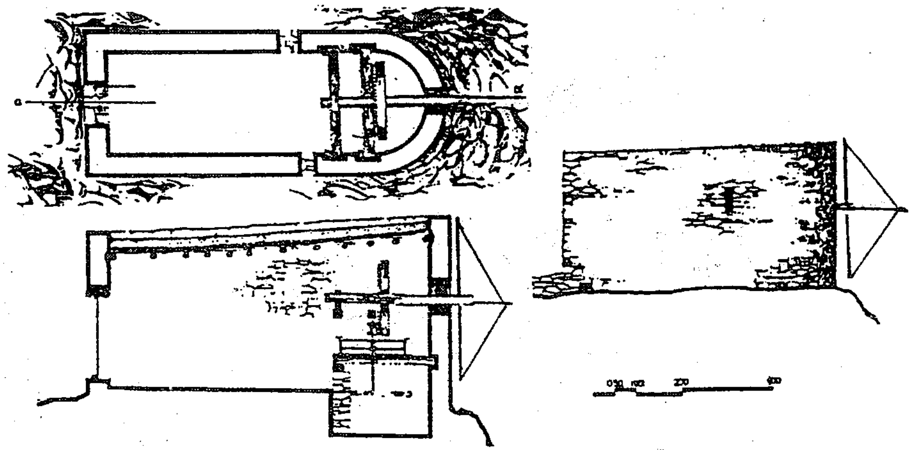


Figure 10. Plan, elevation and cross-section of a typical Cretan 'fixed mill'.

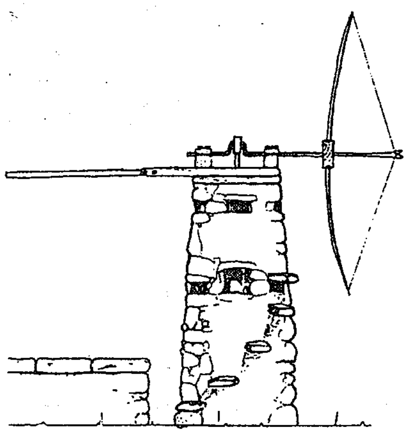


Figure 11. A Cretan wind engine with a stone tower, used to pump water.

The Unidirectional (Fixed) Mill

The prevailing winds on Crete are such that in many locations the complexity of a cap can be avoided by building the structure to normally face into the wind at all times. Favoured locations are often on the top of mountain ridges, where rows of up to 24 mills can be found, although some smaller groups were seen across ridges in valleys.

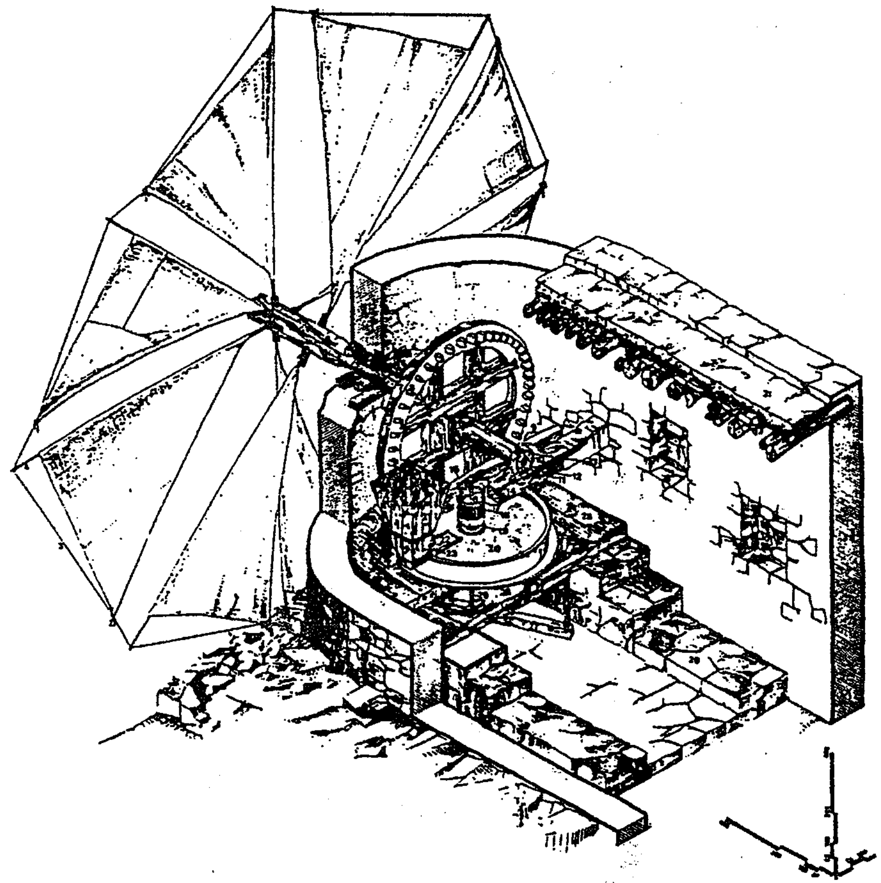


Figure 12. Cut-away view inside a fixed mill showing the machinery.

The mills are all semi-circular at their front end so that the wind flows smoothly round them. They are rectangular at the rear. The entrance is normally at the rear and there may be one or two small windows in the side of the mill. They always have a flat, slightly sloping roof from front to back of the mill, with a low balustrade which has gaps to let any rain water get away. Sometimes such mills have a second storey, possibly to increase the height or provide storage space. The mills are typically about 6.5 m long, 3.5 m wide and between 3 and 6 m high, with walls 0.5 to 0.75 metres thick. There is often a small yard at the rear of the mill. Corn and flour were taken to and from the mills by mule or donkey. The miller normally lived close by, either attending to several mills or travelling to the mill when it was operating.

The flat roof is a weak feature of Cretan mills, being made of rough transverse timbers covered with bracken or thorn twigs. On top of this flat stones were laid, with a weak cement/sand coating placed on top. In many cases such roofs were found to have collapsed into the deserted structure and clearly they must have required regular maintenance.

The machinery (see Figure 12) is largely made of wood with essentially only the quant, which carries the stone nut (lantern pinion) and drives the stones, made of metal. Pine is largely used in the construction, with bearings and gear teeth being made of a harder wood, such as olive. The source of the large timbers is not clear and may have been imported. No cast iron gears have been observed.

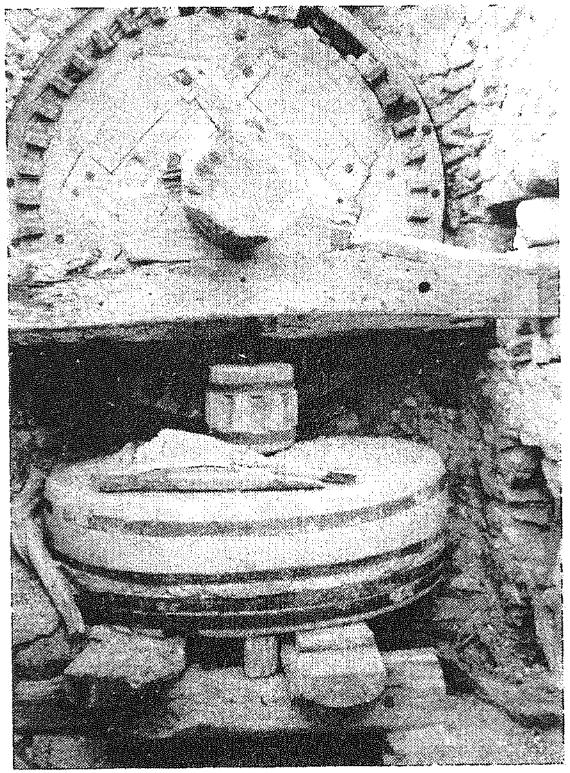


Plate 2. Machinery inside an abandoned fixed mill on the Lassithi Plateau.

The brake wheels (there seems no other name by which to call them even though there is no separate brake mechanism fitted) were of a very heavy double sided clasp arm construction, 1.4 to 1.6 m diameter, with 39 or 40 cogs most common. One report suggests that braking was by a heavy rope fixed at one end to the masonry of the mill with the other end wrapped around the wind shaft to bring it to rest by frictiion, but this technique has not been witnessed. Alternatively the gap between the stones is closed!

The single wooden stone nuts all had 8 wooden cogs, giving a drive ratio of approximately 5:1. The upper end of the stone spindle runs in a hard wood bearing, inset into a separate 'stone nut beam' located in front of the beam which supports the windshaft i.e. adjacent to the brake wheel. In some mills the spindle is held in place by a wooden cover plate, bolted or screwed to the beam. Alternatively the spindle and its bearing fit into an 'L'-shaped groove on the underside of this beam and are held in place by a wooden wedge (see Figure 13). To gain access to the stones the entire beam and stone nut assembly can be removed. This is achieved by both ends of the beam fitting into the masonry walls of the building, held in place by large pieces of masonry and by wooden wedges. The lower end of the spindle or quant forks and fits on either side of the flat rhynd to provide the drive to the runner stone. The rhynd itself runs on the top of a spindle supported on a 'tenter beam' set below the stones. Adjustment of the gap between the stones is again by a lightening rod and wedges, set adjacent to the hurst.

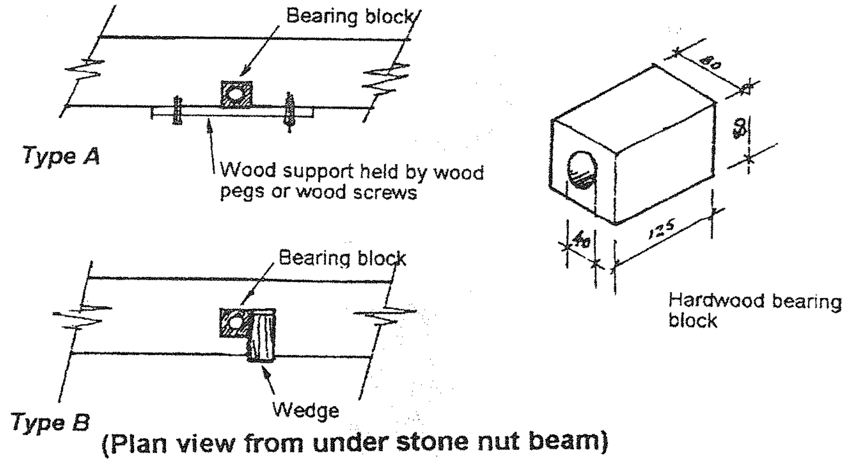


Figure 13. Stone nut retention devices found on fixed windmills.

The typical wooden wind shaft is about 4.3 m long and some 400 mm square or octagonal in front of the 300 mm diameter neck bearing and projecting about a metre in front of the mill (see Figure 14). The bearings seen were normally 'wood/wood' although a few stone bearings were noted. The projection of the windshaft has five or six holes mortised right through, on a staggered pattern, into which the sail spars are fitted. A 'bowsprit' extends in front of the windshaft and the sail spars are tensioned to each other and to the bowsprit by rope, chains or wires. The canvas 'Cretan' sails are furled round the spars when out of use and are progressively unfurled by unwrapping them to increase the sail area, as required.

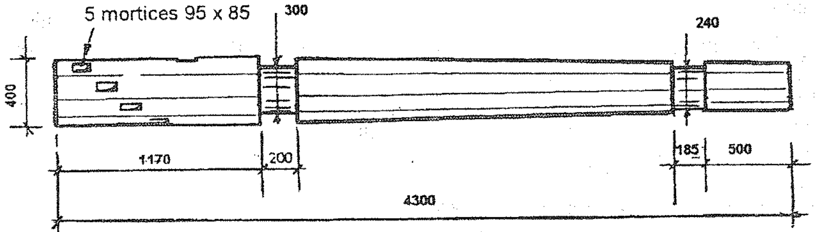


Figure 14. Details of a decagonal wooden windshaft, Ambelos Pass, Lassithi.

As in water mills, the millstones are all of segmental construction, rather like French burr stones, apparently imported from the island of Mylos. The diameter of the stones in the unidirectional mills was between 1.0 metre and 1.5 metre. No mills of this type which had multiple pairs of stones have been seen and there is no record of more than a single pair of stones. It is in fact difficult to conceive how such a feature could work.

The wooden vat, hurst, shoe, etc. are quite simple, sometimes standing on three legs, with a damsel, as used in Britain, being often replaced by a trail stick in contact with the upper surface of the runner stone (similar to the watermills), or by the shoe running directly onto the square stone spindle.

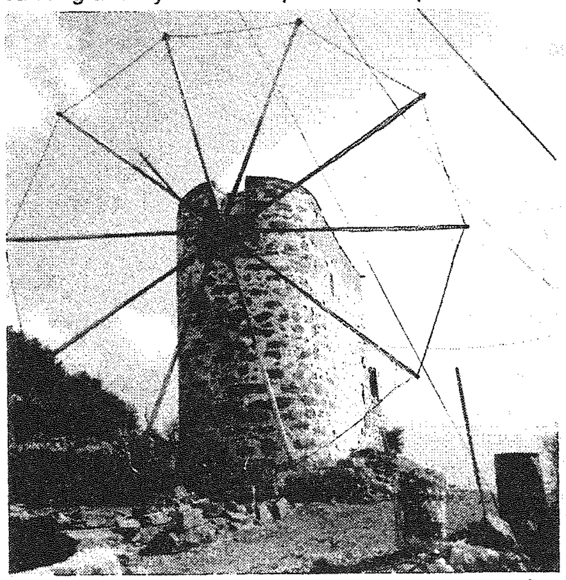


Plate 3. The working fixed axis corn mill, Kato Pines, Crete.

Tower Mills

The tower mills are built of stone and are normally circular in plan, sometimes with a slight batter to the cap. They have two or three floors, often with small windows in the wall to admit light. The windshaft, gear mechanism, sails and stones, etc. are similar to those of the 'fixed mill', the main difference being in presence of the rotatable, normally conical, cap. It was noted that often a group of fixed mills would contain one or two tower mills, probably so that some work could continue on the rare occasions when the wind did blow from the wrong direction.

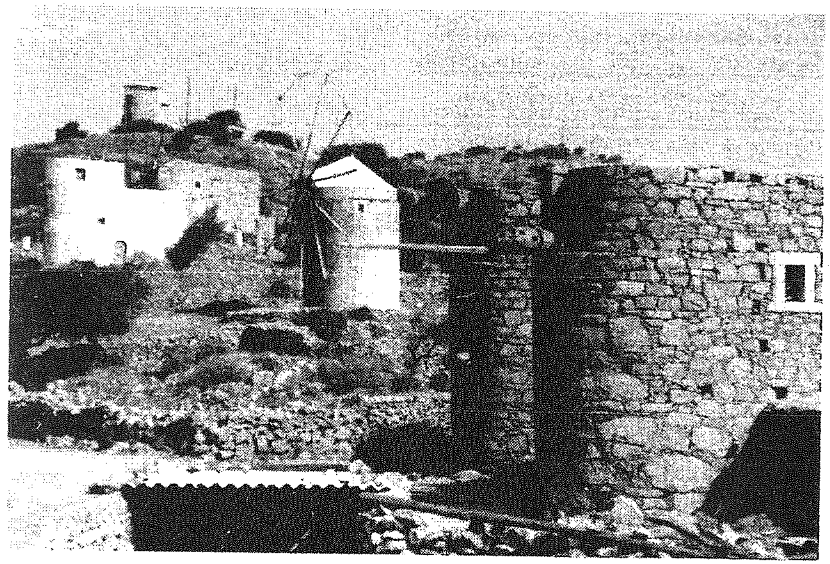


Plate 4. A row of stone fixed axis windmills and one tower mill at Kato Pines.

The conical cap is built onto a heavy wooden frame which sits on a wooden 'dry' curb attached to the top of the tower wall. A series of holes about 300 mm apart and about 60 mm diameter are drilled in both the cap frame and the curb. When the miller wishes to turn the cap, wooden pegs are inserted into adjacent holes and a long lever is used inside the mill, between the pegs, to move the cap progressively to face into the wind. An alternative, though similar approach, was to build short lengths of radial timbers, about 150 mm diameter, into the masonry below the cap frame, equally spaced about 600 mm apart round the mill. These projected about 300 mm inside the cap and were used to lever against, as described earlier, to wind the mill.

The windshaft in tower mills was noted to run across the diameter of the mill and was supported on opposite sides of the cap frame, with the brake wheel approximately central. The stones in tower mills appeared to be larger than in the fixed mills. One pair of stones lying outside a tower at Elounda was 1.5 m diameter and 300 mm thick. No tower mill has been visited which was actually working, although some are still in operation, for example at Xero Pines, on the north-east coast.

Wind Engines

These machines are similar in construction to those found elsewhere in the Mediterranean area, e.g. Majorca. Large numbers of such irrigation devices existed throughout the island, variously quoted in guide books as up to 10,000, with the largest concentration in the mountain plateau at Lassithi.

Each wind pump (see Figure 15) consists of an iron pump mounted over a stone lined well, up to seven metres deep and two metres diameter. Canvas sails are mounted on either an angle iron, or stone tower, and these turn an eccentric on the metal wind shaft. This operates the water pump through a long metal connecting rod. The towers vary in height from about 3 to 6 metres. A tailpole mounted on the rear of the machine carries a triangular wooden or metal vane which turns the sails to face into the wind. To stop the pump operating, the sails are moved by means of a rope attached to the vane, such as to be at right angles to the wind direction. The canvas is then furled or unfurled by progressively pulling the sails round by hand.

Metal towers appear to have largely replaced the earlier slender stone towers which had the sails and eccentric drive to the pump mounted on a wooden or metal carriage. Some of the stone towers, however, still survive at Limnes and on the Malia marshes, one of which has now been restored to working order.

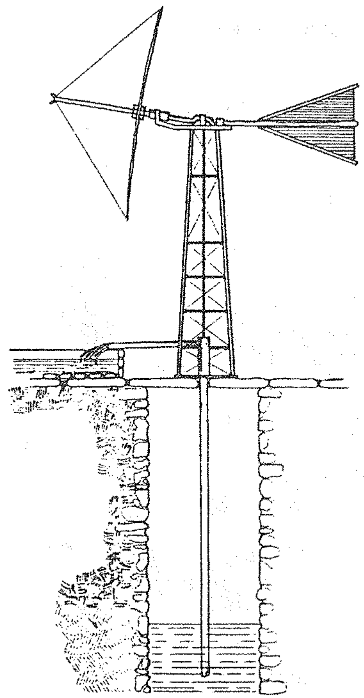


Figure 15. Cretan wind engine with a metal tower for pumping water.

A number of wind engines are still working on the Lassithi Plateau, being used for irrigation purpose by farmers, but many others are now disused and ruined, having been replaced by electricity or petrol engines, or by using piped water. However much of the old equipment is easily accessible for examination, in some cases lying where it fell on the ground. A very few examples were seen of operational Australian type wind engines, for instance in the village of Limnes.

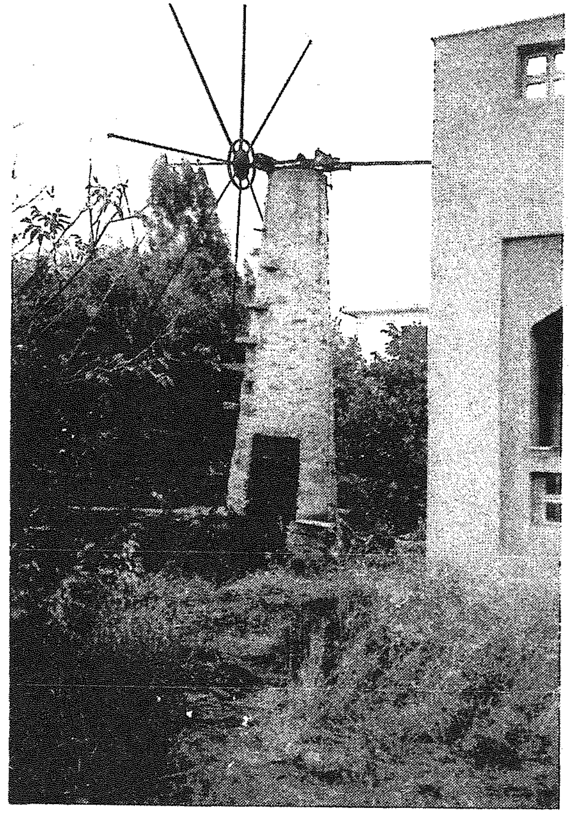


Plate 5. Restored stone wind engine in Limnes.

Other Milling Activities

In a number of cases examples were seen of conventional millstones still being used, but now driven by electricity. Such operations generally used a traditional hurst, shoe, etc. However in a commercial mill in Mires the vat was continously fed by an electric driven archimedean screw. In the same building the main grinding operation was by a set of relatively new Russian roller mills.

Comment

Few windmills or watermills are still in operation or even preserved at the time of writing. The demise of the traditional mills in Crete appears to have accompanied a change from growing large amounts of corn to cultivation of irrigated vegetable crops, coupled with the advent of both electricity and piped water. The tourist value of mills has not yet been recognised, other than in very isolated cases. However very dated photographs of windmills, when they were still operational, often appear in tourist publicity brochures. The extent of both wind and watermill remains is presently quite significant in Crete but it is feared that within a few years, since the nature of the buildings which contain the machinery tends to be relatively fragile, much will have disappeared.

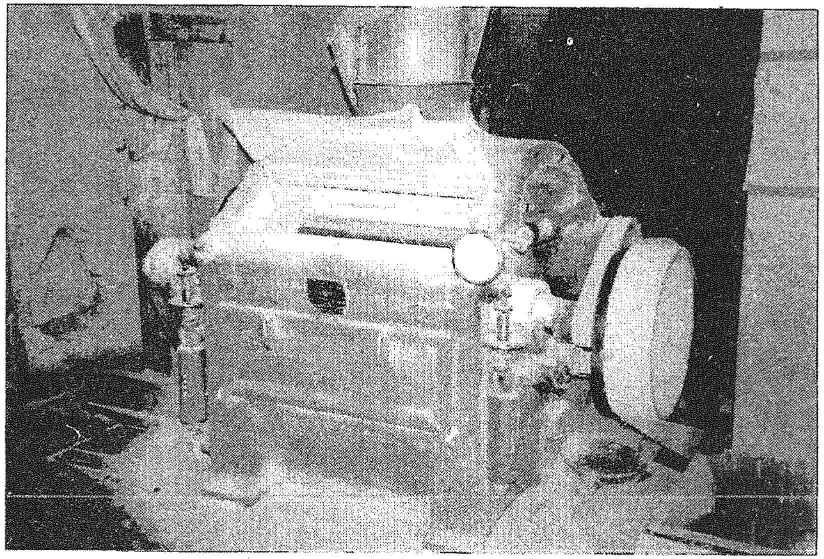


Plate 6. Modern Russian built roller mill in daily use in Mires.

Thanks and Appreciation

My thanks and appreciation are due to John and Chris Henshall, British residents living in Crete, and to the British travel company, Island Holidays, who initially identified many of the mills described. Thanks are due to John Boucher, who has kindly prepared some of the diagrams used to illustrate this artricle and who prepared the excellent isometric drawing of the fulling mill, based on the dimensions taken at the mill. Also to Robin Clarke for his careful review and comment on the script.

Useful Reading

1. Limona-Trebela, Eleni, *Windmills of the Aegean Sea,* International Molinological Society, 1983.

2. Calvert, N.G., *On Watermills in Central Crete,* Transactions of the Newcomen Society, **Vol XLV**, 1972-3, p 217-222.

3. Calvert, N.G., *Windpower in Eastern Crete,* Transactions of the Newcomen Society, **Vol XLIV**, 1971-2, p 137-143.

4. Rahtz, P.A., *Medieval Milling,* Medieval Industry, CBA Report 40, 1981.

5. Vaos, Z. & Nomikos, S., *Windmills in the Cycladic Islands,* Dodoni Editions, 1993.

6. Harverson, M.H., *Variations in Design Illustrated by Reference to Cretan Watermills,* Proceedings of the Thirteenth Mills Research Conference, November 1996.

7. Calvert, N.G., *The 'Mono Kairos' Windmills of Lassithi,* British School of Athens, 7, 1975, p 51-57.

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